The Next Generation of Vertical Farming - Creating a Regenerative Typology of Urban Space and Programming

by

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(Under the Direction of Douglas Pardue)

ABSTRACT

According to the Food and Agricultural Organization of the United Nations, FAO, nearly 80% of the population will reside in urban centers by 2050 and it is estimated that over 220 acres are needed to feed the population of the world. Vertical farms cannot solve the food shortage problem but they can assist in providing local and healthy food to cities. Vertical farms still need to be developed in the energy and lighting aspect before they can work on different sites but the there are a multitude of positives associated with vertical farming, such as eliminating food deserts or revitilizing urban areas. It is important that vertical farming design shifts towards being regenerative; farms should be systems that revitlize their resources and integrate society with nature. This thesis answer the question, “What roles might landscape architects play in making vertical farm systems more ecologically, socially, and economically dynamic?” In order to answer this question, four research methods will be used: literature review, classification, analysis, and projective design (Atlanta, GA).

INDEX WORDS: Landscape architecture, Regenerative, Sustainability, Vertical farming

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DEDICATION

I dedicate this thesis to my family and thank them their support and love.

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CHAPTER 1

INTRODUCTION

Problematic

This thesis will address the benefits landscape architects can provide in the expansion of vertical farming in urban areas. Eight different vertical farming typologies will be analyzed for their social, economic, and ecological benefits that they provide. The typologies chosen are a comprehensive list showing the evolution of vertical farming examples, which include both indoor and outdoor systems with a range of farming methods used for food production. While there are general benefits from vertical farming, it is highly unlikely that one of the typologies will address each category of sustainability, ecological, economic, and social benefits. The eight typologies include external systems, both vertical and horizontal (a green wall and a green roof), indoor systems using multiple growing methods (an aquaponic farm), indoor systems using one growing method (an aeroponics farm), tray growing systems, rotating “farms”, and vertical and horizontal systems that use a variety of systems for food production that includes community programs. After analyzing the typologies against the six criteria it will be evident that the current typologies will not meet all the criteria; a new typology will be created to address the “gaps” that were found and then a specific site will be chosen to design with the third “generation” of vertical farming. Vertical farming produces food sustainably; some examples are the recycling and on-site storage of water, the non-use of harmful pesticides, and if there is a minimal travel footprint – food can be grown and shipped within the city. There are a variety of benefits from the different typologies when looking at ecological or economic factors, but not all of the typologies address a social connection. While there currently are a few systems in place that address an aspect of the three “legs” of sustainability, they could be improved upon. Programming and aesthetics can be improved upon as well as the technical processes and that is where a landscape architect can help. A landscape architect can help with urban agriculture, spatial design, and with the inclusion of social events for different groups of people and levels of income.

Research Purpose

The purpose of this thesis is to analyze existing vertical farming typologies and evaluate whether they are achieving sustainability in order to evaluate ways in which landscape architects may help expand these systems and make them more socially, ecologically, and economically dynamic. Currently many of the existing vertical farming systems are not focusing on incorporating the community or acting as an educational platform. It is important for the systems to have programs that benefit the community because user buy-in is important; if the community is not involved with the farm then they will be impartial to the success of the company. In order for vertical farming to evolve it must become regenerative. Regenerative design entails a system revitalizes its own resources while also connected the needs of the community to integrity of nature. Mutually beneficial programs can achieve this, while working to create sustainable systems that include the needs of the community with natural processes, and landscape architects can attempt to achieve this because of how they design with the community in mind. Through compiling information on the evolution of vertical farming and analyzing a comprehensive list of eight typologies, this thesis will address the question: What roles might landscape architects play in making vertical farm systems more ecologically, socially, and economically dynamic? In order to answer this question, a variety of sub-questions will be asked and include:

- What typologies address all three aspects of sustainability: social, ecological, and economic?
- What criteria must be met in order for a typology to be considered sustainable?
- What social aspects can be incorporated into vertical farms with the help of landscape architects?
- What spatial modifications can be made to farming systems by landscape architects?

Significance

The research of this thesis is necessary because it is vital that vertical farms continue to evolve in order to work towards solving some of the food issues facing the world. According to FAO nearly 80% of the population will reside in urban centers by 2050 and it is estimated that 220 acres are needed to feed the world's population. In addition to the shift in population there is also a current food shortage and multiple countries continue to lack efficient food production to feed its citizens. Vertical farms cannot solve the food shortage problem but they can assist in providing local and healthy food to cities. There are currently several vertical farming typologies that can be divided into two "generations" of vertical farming. The objective of this thesis is to create the next ‘generation’ of vertical farming should be created with the assistance of landscape architects in order for vertical farms to be wholly sustainable and achieve integration with the community. A landscape architect can assist with helping current vertical farms to move past the urban agriculture phase with the creation of a vertical farm that interacts with the surrounding area and the surrounding community. In this thesis the typologies will be analyzed, a new typology will be created to address current “gaps”, and then a site specific design will be created; this will be done through classification schemes, evaluation and diagnosis, and projective design. The creation of the next “generation” of vertical farming will show how the benefits - ecological, economic, and social - can assist some of the food shortage and production issues.

Vertical farming can assist with the global food shortage issue in an environmentally conscious way, such as being space conscious while conserving water, improving a building’s health, and decreasing harmful chemicals and pesticides used in farming. Food production is an important issue today and vertical farming that incorporates hydroponics, aquaponics, and other growing methods should be examined as a tool to help in addition to conventional farming. The vertical farms discussed in this thesis are in cities, which reflect issues such as urban revitalization, water re-use and recycling, and eliminating food deserts. For example, current food distribution is predominantly not sustainable; it requires a larger carbon footprint for travel, and constant refrigeration, which means high energy and cost, the use of chemicals to keep produce appearing fresh during and after transport. Healthy food produced within the city will help with the availability of produce for communities which may not currently have access to it, be it due to high cost, food deserts, or lack of urban agriculture land.

Vertical farming is considered a “cutting edge” idea, even thought it is not a new one. The idea has been discussed, dissected, and researched by a multitude of professionals and students. Professionals of landscape architecture and other disciplines have examined the feasibility of vertical farming, the mechanics of supplying the energy has been researched and models have been made, different lighting techniques have been created in tested, and many other technical aspects of vertical farming have been examined. These are all important things to research and they are necessary for vertical farms to be implemented, but it is also important to look at other pieces of vertical farming. Landscape architecture looks at not only the technical design of landscapes, the economic boundaries of projects, the overall aesthetics; it also incorporates non-tangible factors. Landscape architecture takes into account the mental well being of people, project aesthetics, the educational options within in a landscape, and broader efforts to improve society.

This thesis will prove that there are a variety of non-tangible benefits of vertical farming that may outweigh some of the current technical gaps and how landscape architects can help vertical farming move forward by addressing what is currently lacking. Some of the non-tangible benefits include improving an area through new jobs or rehabbing a blighted building, creating a space for people to learn about healthy food production, and by providing an area for communal gatherings. By evaluating the eight typologies, a set of program elements addressed and analyzed to see how they work together and then they will be used in the projective design to create a complete farming system (made up of smaller production systems, such as aquaponics and bee farms). The factors currently hindering vertical farming can be tackled by landscape architects and then can either create a new farming system or incorporating new program elements into existing typologies. Lack of fresh food, the negative impacts of vacant land, and the lack of education about healthy food in urban areas are severe and important issues and they must be addressed.

Research Methods

The primary research methods used in this thesis, as defined by Deming and Swaffield (2011), will be a literature review, classification, analysis, and projective design. These methods aim to advocate for the incorporation of landscape architects in the designing of vertical farms, which will lead to the next generation of completely wholly sustainable vertical farms in the sense that the systems address ecological, social and economic issues. Classification will help understand the first and second generations of vertical farming typologies and what the next generation needs to achieve to evolve. The first generation of vertical farming includes systems that are focused mainly on food production and start to achieve some ecological benefits while the second generation of vertical farming elaborates on those goals while also looking at including cues to care and integration of the community in their system designs.

Analysis will help evaluate whether the list of eight typologies achieve each phase of sustainability, economically, ecologically, and socially, based on a set of six criteria, as seen in Figure 1.1, that were created in order to ensure that each aspect of sustainability was being addressed. The criteria ranged from low impact achievement to providing an educational platform and are discussed more in depth below. Case studies and material covered in Chapter One help to inform the set of six criteria, which were developed by the author and then used to create the comprehensive list of case studies or the eight typologies. The six criteria, which fall into the categories of economy, ecology, or society, are as follows:

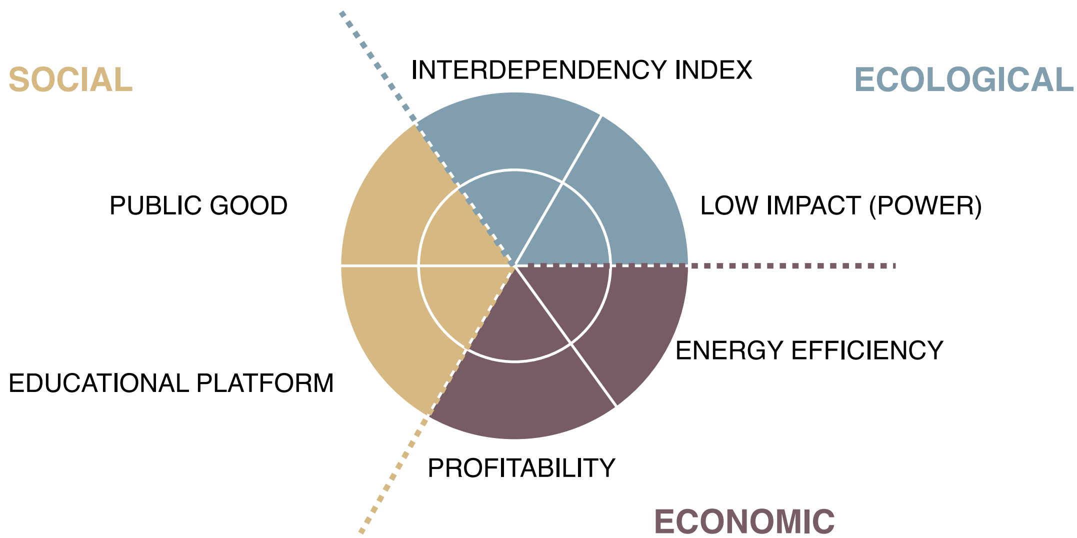

Figure 1.1: Criteria Evaluation (diagram by author)

Ecology

1. Low Impact – It is important to discern if the farming system is creating a strain on the building or the surrounding environment; for example, if a building is being re-used or if a new system was created or if runoff is being reduced through the growing system.
2. Interdependency Index – Vertical farms can strive for sustainable and regenerative success by having the different pieces working together. Aquaponics is a small-scale example of this; a large-scale example is apiaries where the bees help pollinate the plants and also produce honey. The index will help analyze if the vertical farm is successful in offering mutually beneficial program elements; this is key in creating adesign that is not only focused on food production in an ecological manner, but social program elements which work in tandem with food systems.

Economy

1. Profitability – This is an essential element of economic success. While the exact figures from a company may be hard to attain, the inputs and outputs can be analyzed. In addition, the different "money generating" programs can be weighed against the estimated initial costs.
2. Energy Efficiency – The energy efficiency of a system can range from water being recycled on site to which type of lights are being used for growing the produce. The systems should aim to be very efficient, with minimum inputs. When external inputs must be used, they should be minimal, both in terms of energy and cost.

Social

1. Educational platform – Vertical farms can be a great tool to educate the local community on different food production methods. Local children and adults can come to the site to see how healthy food can be produced and how they can be prepared. It is important that the educational benefits can be accessed by a variety of income strata within a city.
2. Public Good – In addition to educational classes, it is important that the farms are working towards improving the public good. Events can vary from revitalization of an area to the inclusion of public events, such as farmers' markets to rehearsal dinners, to meditation experiences but it is crucial, once again, that the events be accessible by a diverse group of individuals from varying economic classes. It is important to see if the vertical farms are interacting with the community and if members of the community feel a connection or sense of integration to the farm.

After analyzing the different typologies against the previous six criteria a site will be chosen, evaluated, and designed in Chapters Six and Seven. This projective design will strive to show how landscape architects can assist vertical farming to be more holistic by including a social aspect through a variety of programming options and help make the vertical farms a part of the surrounding community in Atlanta, GA, accessible by all.

Limitations and Delimitations

Analyzing vertical farming systems leads to a number of limitations and delimitations in this thesis due to the fact that vertical farming is still a "work in progress" and so not all examples are successful; a lot of the economic information unavailable to the public.

As mentioned previously, vertical farming is a cutting edge idea so the number of successful examples is fairly limited. There are a variety of examples that look at green roofs, urban aquaponic systems, and urban hydroponic systems and while there is a connection between these systems and vertical farming, they are not always "complete" in the sense of varying products or for not utilizing the entire building. These different examples will be researched but sometimes the information may be limited due to scale, lack of economic information, and lack of production information. The goal is to analyze and understand where landscape architects can help improve the design of vertical farms.

Thesis Structure

Chapter Two highlights some of the negatives aspects of conventional, horizontal farming and the history of urban agriculture, making a case for people to start thinking vertically. The evolution of vertical farming is discussed; from bare-boned systems in abandoned warehouses, to closed systems with stacked plants, to aquaponic systems open to the public. Chapter Two concludes by identifying how a landscape architect can help address some of the current gaps of vertical farming, which can lead to a new generation of wholly sustainable vertical farming.

Chapter Three outlines the first four vertical farming typologies taking place in urban environments. The typologies in this chapter can be considered the first generation of vertical farming, which includes vertical external systems, horizontal external systems, indoor systems using one growing method, and indoor systems using multiple growing methods.

Chapter Four outlines the next tier of vertical farming typologies that currently exist in cities. The next four typologies can be considered the second generation of vertical farming and include tray growing systems, rotating “farms”, vertical systems beginning to include the community, and horizontal systems that include community programs and events.

Chapter Five begins with analyzing the eight typologies against the six criteria to evaluate which aspects of the three elements of sustainable each typology is achieving. The next phase looks at explanations for why the typologies are not meeting the criteria, whether it is simply lack of progress, fundamental technical issues, or lack of space or demand. The chapter concludes by addressing how landscape architects can help with the evolution of vertical farming by assessing where and why certain typologies have gaps in meeting the criteria.

Chapter Six begins by describing the selected site for the projective design in Atlanta, GA and continues on to discuss the inventory and analysis of the site. Several diagrams show the objectives and goals for the site, which leads to the proposed design program. Chapter Six concludes by presenting the program highlights and how landscape architects were instrumental in including the community into the new program.

Chapter Seven discusses the framework and the design application. The framework and evaluation will be criticized to see if it was the most efficient way to answer the question of this thesis. The elements of the projective design will be assessed and analyzed to see if the vertical farm was successful or if it was missing key elements.

CHAPTER 2

INITIAL VERTICAL FARMING INFRASTRUCTURE

Conventional Farming

Heavy agricultural reliance on chemical fertilizers and pesticides has lead to hazardous impacts on public health and the environment. The estimated environmental and health care costs of harmful pesticide use at the recommended levels in the United States costs roughly $12 billion plus every year (Pimentel et al. 2005). In addition to harmful pesticide use there are other aspects of conventional farming that are high in cost and have negative effects on environmental and human health, such as land use and certain animals integration and placement. Two of the main negative effects are fertilization and erosion. According to the FAO it has been shown that larger fisheries in North America are deteriorating due to runoff of nutrients from fertilizer and animal manure. Also, soil erosion and nitrogen fertilizer run-off from agricultural production in the Midwest area known as the Corn Belt has contributed to the “dead zone” in the Gulf of Mexico (Frankenberger and Turco 2003). Roughly $45 billion is exceeded annually for the costs of public and environmental health losses related to soil erosion (Pimental et. al. 1995).

There are a variety of ways that people are attempting to reduce the negative affects associated with conventional farming. Some of these include different types of organic farming, using best management practices to reduce pesticides, “green” growing food for the growing population but other measures must be taken to ensure that every person is fed.

Urban Farming

Urban farming is growing in popularity but people have been growing and producing food within cities, in Western culture, since the mid-19th century. One third of the country's two million farms in the U.S. are located within cities, producing 35 percent of the fruit, vegetables, chicken, and fish that Americans consume every year (Mees 2012). According to the Green Guerillas, an urban agricultural advocacy group in New York City, community gardens cover about 810,000 square meters throughout the five boroughs and roughly half are for food production. While community garden and other horizontal urban agricultural projects are crucial to city food production, improved quality of life, and the awareness they create of how we use food, it is unlikely that any city has enough space to provide for its entire food needs. Experts have estimated that for London to produce all the food needed to feed the population, it would need to have an agricultural area that is 120-times as large as the city itself (Mees 2012).

Many community-gardening advocates have worked with local governments towards a sustainable local alternative to industrial size farming and some have shifted thinking to move these areas "to the sky". For example, UpGarden in Seattle, WA is a rooftop community garden that was created due to the limited amount of conventional gardening space. The garden was built on an existing garden structure with a tight budget and the help of landscape architects and has been very successful through hard work of community members (OPB, January 20, 2015). Many architects, landscape architects, and entrepreneurs have created vertical farms. The farms vary in production scale, what they produce, and their locations. People are continually pushing to make strides in the field of vertical farming, whether through city laws or real-world implementation of farming systems. It is crucial that urban garden advocates, private and public organizations, and everyday people continue to strive to learn more and progress the idea of vertical farming. When people are actively involved in producing their own food in their own community or neighborhood there is usually a sense of empowerment.

Planning for the Future

In order for vertical farms to be considered there must be sufficient planning, space, and funding. Cities must have a plan to incorporate green infrastructure, such as vertical farms, green roofs, and vertical walls. Vertical farms can be placed in abandoned buildings and because they reuse water they do not need a lot of additional infrastructure from the city but zoning; distribution must be taken into account when choosing a location for vertical farms. The farm will produce food that are distributed locally, so there must be pedestrian access, roads, and transportation infrastructure. Some abandoned buildings may have a certain zoning assignment that may have to be amended. If vertical farming is going to be designed in new structures there should be a requirement that portions of new buildings must be zoned for farming or planting. Toronto created a bylaw in 2009 that required a certain percentage of the roofs of new buildings to be planted and while the greenroofs aren’t focused on food production (due to certain by-laws), the goal is to help buildings design focus on reducing water run-off and addressing energy efficiency (Kaill-Vinish 2009). This is a positive step towards urban farming, but unfortunately, many cities do not have any green infrastructure requirements.

Food production is constantly changing and different groups of people, ranging from lighting technicians to academia, are continually trying to address issues associated with food production, such as cost of transportation, use of pesticides, and lack of open land, etc. Vertical farming produces food sustainably, some examples of this is the water being recycled and held on site and food produced free of harmful pesticides, and locally – food is grown and shipped within the city, instead of hundreds of miles into a city. Vertical farming is being considered as one way to address issues associated with the world food shortage problem while also providing benefits. Benefits vary from organically grown produce, avoiding loss of crops due to inclement weather, a reduction in the carbon footprint, and water is recycled on site (Graff 2009). Produce grown within vertical farms are free from harmful pesticides and herbicides. Due to the crops being grown inside the produce is not affected by drought, excessive rain, early frosts, or extreme weather so there is a reduced loss of crops. Vertical farming also recycles the majority of the water used in the system and re-uses it to irrigate crops or provide water for aquaponic systems (depending on the filtration system). The introduction of plants into an urban area will help with carbon dioxide emissions and furthermore, will not be producing excess carbon dioxide.

Vertical Farm Examples

Vertical farms exist in various cities across the United States and while their production method may vary in general they have a similar aesthetic. From New Buffalo, MI to Chicago, IL, to NYC, NY vertical farms have emerged, typically housed in warehouses or abandoned buildings on the edge or within a city. According to Milan Kluko, president of Green Spirit Farms in New Buffalo, Michigan, which is housed in a former plastics molding factory, "Buildings like this are available throughout the United States. Usually, the just need a power wash and a paint to get up and running again" (Veinott 2014). While the idea of having skyscrapers completely outfitted to accommodate produce farms and livestock may not be achieved right now, there are systems that encompass a variety of green-tech operations in places that vary from airports to malls to parking garages. Indoor vertical farming has a high upfront cost in order to outfit a growing space, which is why underutilized or abandoned buildings, that are already functioning may just need to be tweaked. One of the largest hurdles that vertical farms face is the inefficient component of indoor lighting. According to Blake Davis, a vertical farming expert and professor at Illinois Institute of Technology, plants require lighting for 16 to 18 hours a day when they are not receiving sufficient sunlight (Massa, Wheeler, and Mitchell 2008). A recent report from the energy consulting firm Clean Edge stated that lighting companies, such as Philips, are developing LED lights specifically for growing plants while others are creating sensors that detect lighting levels for various crops (Wells 2014). For vertical farms to be almost completely energy and cost efficient, a solution for the expensive cost of lighting must be solved.

The Issue of Lighting

Artificial light, in large quantities, is usually expensive and not environmentally sustainable, but we do not know that a lower energy bill can be achieved by using red and blue LED lights (Doucleff 2013). Red light can grow lettuce and it has been proven that if you add blue, the produce grows faster and larger. Red and blue wavelengths supply the majority of light needed to grow because the plant's photosynthesis machinery is tuned to absorb red and blue light more efficiently (Doucleff 2013). LEDs have become more energy efficient and can be tuned to specific lengths; the lights are also cooler so they can be placed closer to plants and stacked (unlike fluorescent lamps). Cary Mitchell worked with his students at Purdue University to test how different plant productivity was affected by LED lighting. In one study Mitchell and his graduate students attempted to use LED towers and it cut energy by 75% compared to the traditional fluorescent lamps. They used a tower so that it was possible to turn panels on as the plant grew, using energy only as needed. The experiments that were preformed specialized in using LED lights supplemental to natural light, not to replace it (Massa 2008).

Barry Holtz at Caliber Biotherapeutics, a company that produces vaccines and drugs for medically ill patients, has a vertical growing system that has never seen the light of day. Holtz and his company constructed a 150,000 square foot "plant factory" in Texas that grows 2.2 million plants stacked 50 feet high with LED growing lights beneath the plants (Doucleff 2013). Lights were developed to correctly match the photosynthesis needs of the plants, which led to a twenty percent faster growing rate and energy saved. The indoor growing area gave the company tight control over the expensive crops and they were able to stop disease and contamination. While this project is very successful in terms of efficiently growing plants indoors, Holtz stated that his type of gardening could not replace vertical farming anytime soon due to lighting costs. The product that his company is producing is in such high demand that the high cost of lighting is not a negating factor and the system is efficient in other facets such as reusing all water on site.

Currently the demand for food is not high enough that people will pay such an increased price due to factors such as lighting.

One example using artificial lighting exclusively out of necessity is the South Pole Food Growth Chamber. Dr. Gene Giacomelli, from the University of Arizona, and his colleagues created the South Pole Food Chamber in 2004. The chamber is a semi-automated hydroponic facility in Antarctica that provides station staff with fresh produce everyday. The system uses artificial light. The need for fresh-produce outweighs the cost of lighting. The station can go for several days without receiving natural light, so artificial lighting is common and necessary. Many companies have tried a multitude of ways to tackle the issue of lighting. The Science Barge, run by Ted Caplow (founder of New York Sun works), is a floating hydroponic greenhouse that was moored in Manhattan, NY for three years and has since been moved to Yonkers, NY. The greenhouses were one story high and used solar panels and wind turbines that produced food with near-zero carbon emissions (Charkers 2008). The solar panels addressed the high costs of LED lighting and the project was generally successful due to the size, the greenhouses were only one story high. Caplow stated that a rule of thumb learned on the Science Barge is that to generate enough electricity using solar panels requires an area of about 20 times or larger than the area being illuminated. This is clearly impossible and not feasible in an urban setting (The Economist 2010).

VertiCrop technology addressed the issue of stacking plants and still having a high production rate by vertically stacking hydroponic trays that move on rails, mimicking Henry Ford's assembly line, to ensure even sunlight. VertiCrop technology allows the plants to receive the necessary amount of light all year round and use LED lights only when there is weather interference (Laylin 2012). While VertiCrop, based in Vancouver, CA, went out of business due a poor business plan that included high rent and inflated interest from loans, the idea of rotating systems to help plants receive proper sunlight is an idea that helped spark new ways to help plants receive light. Strides have been made in the field of lighting, both the sole use of LED lights and incorporating LEDs and natural sunlight.

There is also a trend of different types of companies growing plants that never exposed to natural light: Caliber Biotherapeutics is an example of how demand outweighs the cost of lighting. Barry Holtz at Caliber Biotherapeutics, a company that produces vaccines and drugs for human patients, has a vertical growing system that has never seen the light of day. Holtz and his company constructed a 150,000 square foot "plant factory" in Texas that grows 2.2 million plants stacked 50 feet high with LED growing lights beneath the plants (Doucleff 2013). Lights were developed to correctly match the photosynthesis needs of the plants, which led to a twenty percent faster growing rate and energy saved. The indoor growing area gave the company tight control over the expensive crops and they were able to stop disease and contamination. While this project is very successful in terms of efficiently growing plants indoors, Holtz stated that his type of gardening could not replace vertical farming anytime soon due to lighting costs. The product they are producing has a high price that the cost of lighting is not a negating factor. The system is efficient in other facets such as reusing all water on site, so while they aren't able to completely offset the use of LED lighting they are working towards being more sustainable and low impact.

Horticulturist Cary Mitchell, of Purdue University, says that vertical farming is never going to be successful from an energy standpoint and that large warehouses in the suburbs are where "urban" farming should be pursued (Doucleff 2013). The main energy concern is lighting, but there are alternatives to pure LED lighting, which is not energy efficient enough to date. Strides are being made to work towards creating a more energy efficient LED lighting option. At the "Challenges in Vertical Farming" conference sponsored by the National Science Foundation and held at the University of Maryland in September of 2012, it was widely understood that in order for vertical farms to be a sustainable move, LED lighting must be made more energy efficient (Despommier 2012). Even today LED lighting is still not as efficient as it should be, while some companies and individuals are pushing for there to be a more energy efficient model many people are unaware or unconcerned with how harmful continuous LED lighting can be. There are many lighting and design options that could be implemented instead of disregarding the notion completely and there are many professionals from a variety of disciplines who support the idea of vertical farming.

Evolving Vertical Farming

The Association of Vertical Farming, an industry trade group, claims vertical farms use 98 percent less water and 70 percent less fertilizer on average than outdoor farms. Weather fluctuations aren't a factor, and neither is soil management. They can harvest crops as often as 20 times a year, and with their stack-it-high layout, the systems occupy a fraction of the land traditional agriculture requires. There are many examples of produce and fish being produced with simple resources, basic education, and initial funding. One example is in Gaza where private entrepreneurs and the FAO have established intensive and irrigation-based fish farms to help with food scarcity issues. Gaza, a self-governing Palestinian territory, has a large buffer zone that has severely restricted the areas where people can farm and fish. Fish farms have been installed on the roofs and upper levels of existing urban structures. The entrepreneurs and the FAO provided participants with the supplies and training to create the system but the local people are left with the responsibilities (Somerville 2014). These systems are an example of how aquaponic systems can be implemented into existing structures and are very easy to maintain. FarmedHere is a vertical indoor farm that also incorporates aquaponics, located in an old warehouse in Chicago, Illinois. The goal of the company is to produce local produce and local jobs in a sustainable environment. FarmedHere uses no herbicides or pesticides, they grow year ground, and they reuse roughly 95% of freshwater, and they do not deliver their produce for distance over a couple thousand of miles. The company produces a multitude of greens but is looking to expand to soybean crops all inside, which eliminates issues from bugs and weather (Irvine 2013).

Examples of urban vertical farming continue to increase. Skid Row in Los Angeles, often considered a dystopia or a blighted area, has residents who banded together to create an urban community garden of sorts. Residents of the Rainbow Apartments created a vertical garden that is attached to a cinder block wall of a parking lot in the center of Skid Row. The vertical plot evolved from planted vegetables in wooden bins on the rooftop but failed from improper maintenance. The second attempt created a plethora of growth that ranged from watermelon to corn and the residents were in awe. Through help from a nonprofit group called Urban Farming, they were able to install the green wall as part of a Food Chain Project. The Food Chain project enables residents in impoverished areas to grow food in underused spaces at low costs. The Skid Row vertical farm, the gridded greenwall on the facade of the apartment building, is maintained by the Rainbow Apartment residents and in turn they receive the food produced, which they also share with other community members (DiMassa 2008). This vertical farming typology shows not only how vertical farming helps revive a community's appearance and well-being, but also how they can adapt to certain areas easily and for a low cost (depending on scale).

A decade-long analysis of greening abandoned areas in Philadelphia was conducted by a group of researches to see if greening areas reduced violence and vandalism (Branas et. al. 2011). It was shown that the greening of vacant areas reduced gun assaults, vandalism, criminal mischief and residents reported less emotional stress and increased physical exercise (Branas et. al. 2011). The greening of urban spaces has been shown to be a consistent positive and the inclusion of community members only improves the chances of a space being successful.

Other vertical farming examples are examined in the book Carrot City, which include single method production and multi-method production. Carrot City explores different scale farms with different production goals. Eagle Street Farm in Brooklyn, NY is a 6,000-square-foot vegetable farm located on a three-story warehouse. Volunteers help with the farm during growing seasons and the harvest is sold at a seasonal on-site farmers' market and neighborhood restaurants. Carrot City also shows how Brooklyn Grange, a 40,000-square-foot rooftop farm, functions. Brooklyn Grange produces a variety of products and also hosts events such as growing and cooking lessons, company retreats, dinners, and yoga. These two types of rooftop farms show how spaces and functionality vary due to production goals. Brooklyn Grange, and a few other similar type farms, show how vertical farming is evolving to include a variety of growing techniques and more importantly, a social aspect. While these examples are moving vertical farming forward, the farms are still not connected to the mesh of the community.

There are a variety of vertical farms that are currently starting to integrate the surrounding neighborhood, but there are still a variety of gaps that must be addressed. Through analyzing the typologies for what social, economic, and ecological benefits each is providing gaps will arise. Not one system is currently meeting the requirements of what it means to be sustainable. According to William McDonough, an author, it is important that a design can renew its own source of energy and materials, which in turn creates a sustainable building. While it is necessary for the vertical farm systems to be resource and material conscious, especially when focusing on the systems that are helping them function and produce food, there are other program elements that need attention such as educational programs. That is where landscape architects can help; by including a landscape architect in the process vertical farming will expand from just urban agriculture. Community members must be included in the design, whether that is through interactive program elements or classes offered, which is important if vertical farms are going to be widely accepted and incorporated into the urban fabric. If people are not vested in a place or company it often fails or lies dormant. Landscape architects strive to incorporate people and their desires into design. For vertical farms to become more successful in the future, it is key that landscape architects are included in the design phase.

Currently there are vertical farms that function at a building-specific level: they occupy one space and produce food for the local area but are not interacting with the community past the point of sales. Many existing vertical farms that are focused solely on food production do not offer tours and while some have volunteer participation it is only for harvesting activities. The early vertical farms, in urban settings, were established in areas of cities that were economically struggling. This trend happened due to the lower cost of real estate, the lack of an active community, and proximity to city centers (areas to sell food). The next phase of vertical farms started to take the surrounding community more into consideration; certain vertical farms started to expand from solely focusing on the building by produce a variety of crops on site and opening the farm for educational purposes. Some of the site-specific vertical farms have begun to focus on a neighborhood approach where they offer tours and certain educational classes, farmers' markets, and on-site lunches and dinners. Many of the first generation vertical farms offer educational classes that benefit inner city children and adults to teach them about the positives of growing healthy food, while the more elaborate vertical farms tend to serve the wealthier clients by providing a variety of expensive services. The next step of vertical farms should expand to serve an entire community, not just simply the upper echelon. Programs should be tailored to include a variety of demographics and social groups. Landscape architects can assist with program design for a vertical farm to include different production areas and also different areas and elements to include a wide range of community members.

CHAPTER 3

FIRST GENERATION OF VERTICAL FARMING TYPOLOGIES

In the previous chapter the initial efforts at vertical farming infrastructures were discussed and it was evident that many were minimalistic and basic, focusing solely on food production and neglecting diverse programming, community inclusion, or systematic designs. The first four typologies that are addressed in this thesis focus on the first generation of vertical farming, meaning they are predominantly used for food production. Rarely do they expand to consider other goods being produced or other programs offered. Each typology will be understood through evaluating a case study, which will focus on the growing methods, location, and elements housed within the structure.

External Systems – Green Walls and Rooftop Farms

External vertical systems are unique because they can appear on almost any building facade if the right materials are used, and there is ample natural sun and water. An example of an external vertical farm is a "green" or living wall that is producing food. Green walls are popular because they not only provide a pleasing aesthetic; they also have a variety of benefits ranging from food or fauna production to acting as a heating/cooling mechanism for the interior of buildings. In some cases, hanging food gardens are being used in cities where there is a lack of space for traditional community gardens apartment building and was filled with strawberries, watermelon, basil, and other herbs and vegetables. The garden was started by a group of individuals who were previously homeless and were trying to improve the area. The wall went through a few trials and eventually started to produce vegetables, fruits, and herbs successfully (The Los Angeles Times August 14, 2008). Skid Row is an area in downtown LA that has been seen as the largest concentration of homeless people living and sleeping on sidewalks and in a variety of makeshift tarp-camps. Over 2,000 men and women occupy this area and sanitary conditions are often appalling. People often describe an overall bad odor after a visit to Skid Row (CNN March 3, 2015).

In contrast to the sour, unpleasant smells, lavender and scents of different herbs have begun to fill the air in the center of Skid Row since the vertical garden took root. Urban Farming helped the residents create a green wall along a 34-foot-long plot against a cinder block wall adjacent to a parking lot. Green Living Technologies assisted by manufacturing and donating the system of planting grids that the tenants, along with Urban Farming members, planted with lavender, cucumbers, and tomatillos. The produce selection has expanded to jalapeños, strawberries, and other herbs through the work of the Rainbow residents. The green wall produce is harvested by the Rainbow Group but is shared with everyone in the building, the idea of community is very important to the "founders" of the group. (The Los Angeles Times August 14, 2008). Even with the shifting of demographics and attempts by the City to improve Skid Row, the green wall has remained and transformed into a larger garden project and is maintained by the residents. The following images and diagrams show the residents interacting with the green wall and relationship of the wall to the building.


Figure 3.1. Volunteers maintain the Rainbow green wall (Greenroof Projects 2015)


Figure 3.2. A variety of produce was grown (Greenroof Projects 2015)


Figure 3.3. Members of the Rainbow coalition (Greenroof Projects 201)

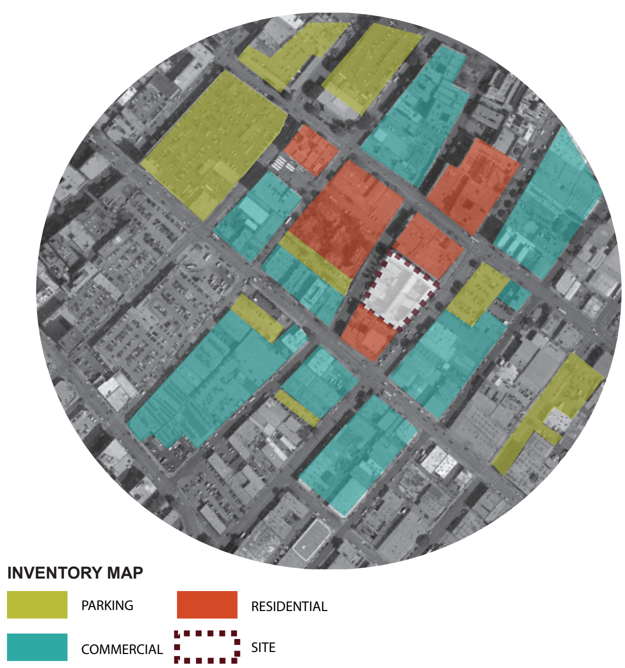

Figure 3.4. Skid Row Inventory Map (diagram by author)

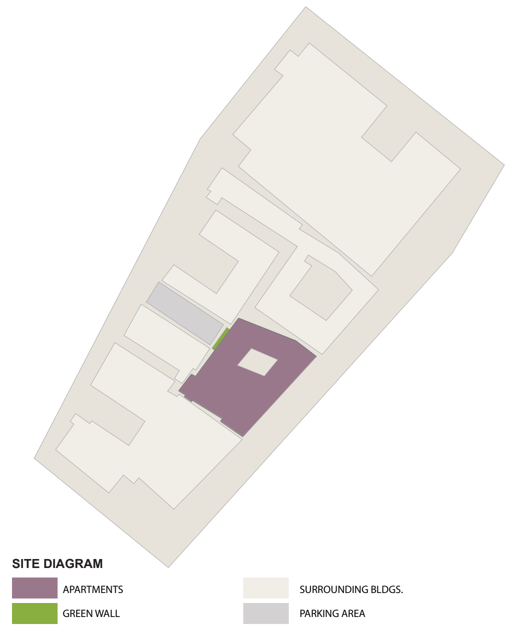

Figure 3.5. Skid Row Site Map (diagram by

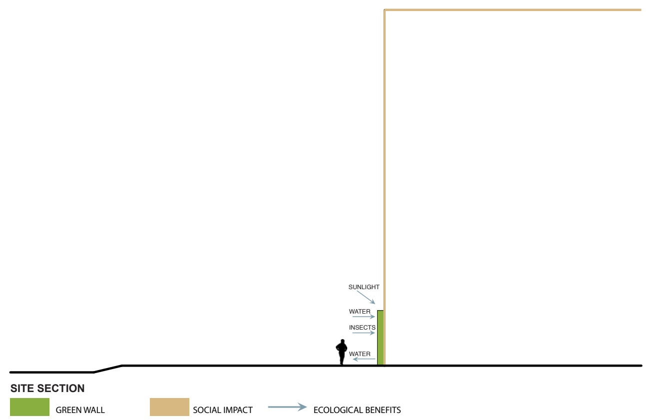

Figure 3.6. Skid Row Site Section (diagram by author)

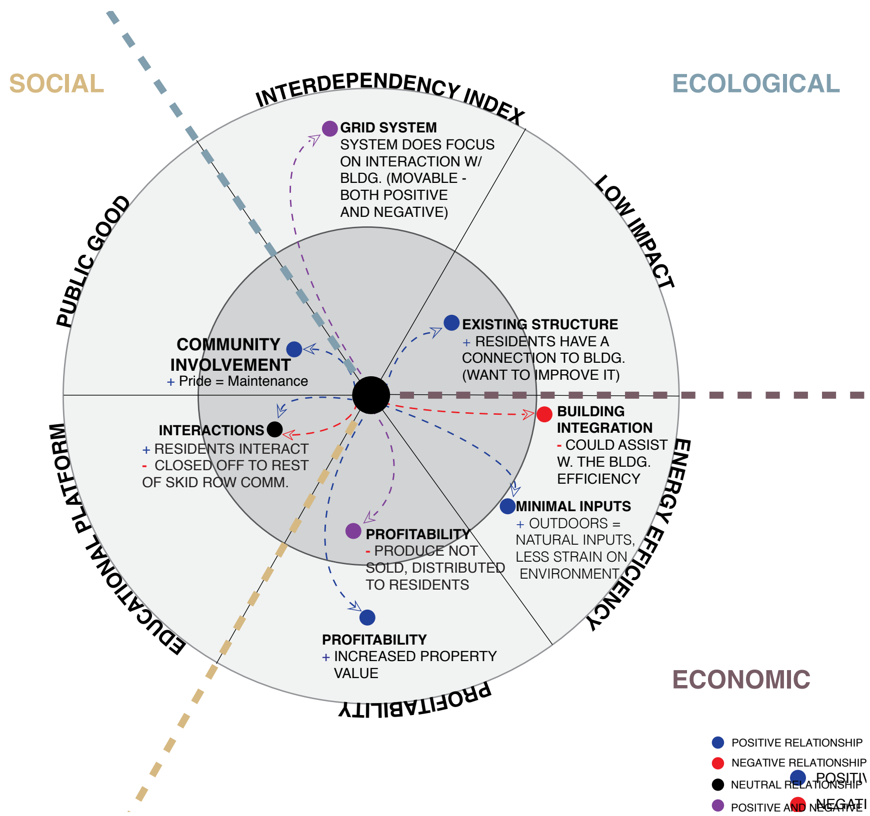

Figure 3.7. Skid Row Relationship Feedback Diagram (diagram by author)

In addition to outdoor vertical growing systems there are outdoor horizontal systems, such as rooftop gardens. Rooftop farms can be achieved through a number of growing methods that include growing plants in planters or boxes or by revamping the existing roof system to support a growing medium (soil mixture, seed, etc.) or by creating a new building that takes the necessary loads into consideration for a rooftop farm/ garden. Rooftop farms are burgeoning in cities as ways to reduce water runoff, manage heating and cooling within a building, and help neutralize wind loads. They can provide a space for urban residents to access a fraction of the natural world. One example of a successful rooftop farm using planters is the Uncommon Ground in Chicago, IL, which is connected to both locations of the Uncommon Ground Restaurant. The Uncommon Ground Farm is a green roof system that uses planters, made from steel and cedar, and organically engineered soil to grow produce.

Uncommon Ground is a company that consists of two community-based restaurants that use local, sustainable, and organically produced food; as seen in Figure 3.11 the surrounding area is predominantly residential with a few commercial buildings immediately surrounding the farm. In 2007 the restaurant expanded to a second location and constructed a green roof during the renovation of the 100-year-old building so that the restaurant could produce its' own organic products and to educate the community (Carrot City, 2011). The building was reconstructed and reinforced to support the rooftop garden. Plants are grown in twenty-eight planter boxes that are covered by a cold frame to expand the growing season, the farm and planters can be seen in Figures 3.8 - 3.10. The roof garden uses a digitally programmed irrigation system for water efficiency and excess water from the roof is collected in rain barrels and used to water the ground-level garden.

The planters can be rearranged to suit varying conditions and requirements; trellises are used to support plants such as tomatoes, beans, peas, and cucumbers. According to the company website, the plants are organic and they rotate throughout the raised beds depending on the season and what is being utilized in the restaurants (Horkman 2014). They use organic seeds and organic soil to ensure that all of their produce used from the farm is completely organic and of a high quality. The roof also has four beehives and a myriad of fresh herbs. In addition, the farm has a mix of different flowers and companion plants encourage pollinators and improve the aesthetic value of the space. Uncommon Ground uses the roof garden to minimize the impact of the restaurant's activities and serve locally grown, organic food. Through the incorporation of a garden aspect the restaurant has increased its tie to the community through a farmers' market, public events, educational programs, and music programs. While the produce used at public events, dinners, and cooking classes are from the roof, most of the events take place within the restaurants themselves. (Carrot City, 2011).

Figure 3.8.Aerial of Uncommon Ground rooftop (Horkman, Jennifer. 2014)

Figure 3.9. Planters are used to grow produce (Horkman, Jennifer. 2014)

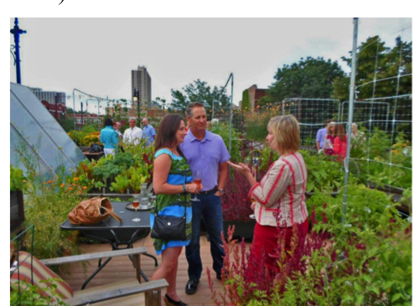

Figure 3.10. Restaurant patrons exploring the farm (Hickory Creek

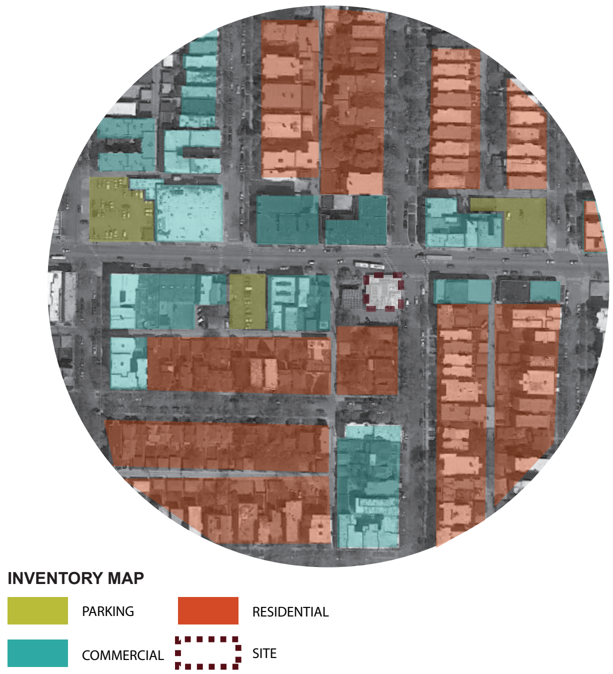

Figure 3.11. Uncommon Ground Inventory Map (diagram by author)

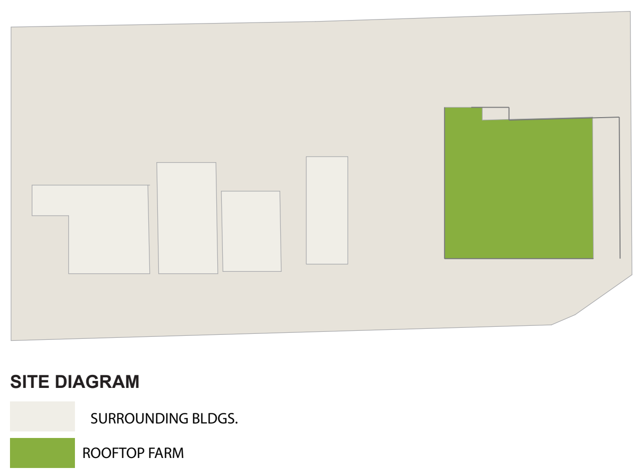

Figure 3.12. Uncommon Ground Site Map (diagram by author)

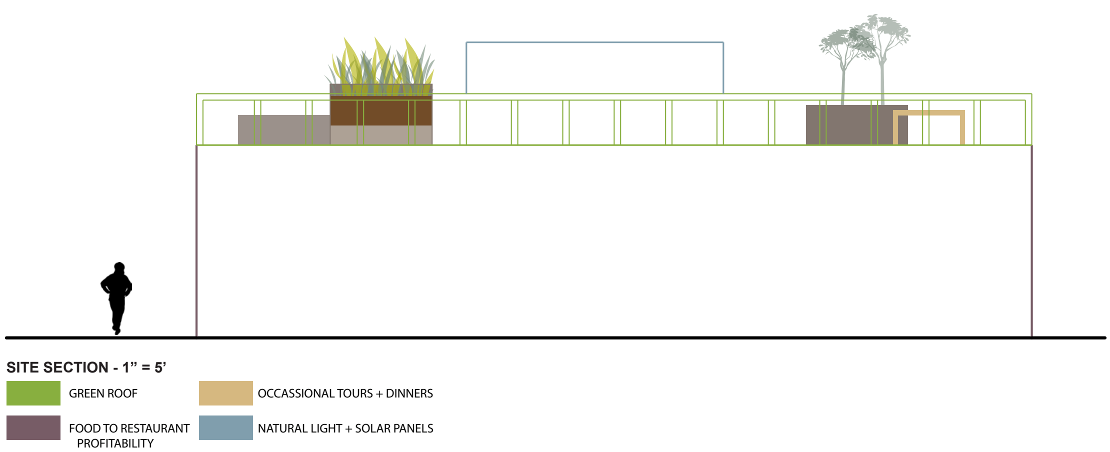

Figure 3.13. Uncommon Ground Site Section (section by author)

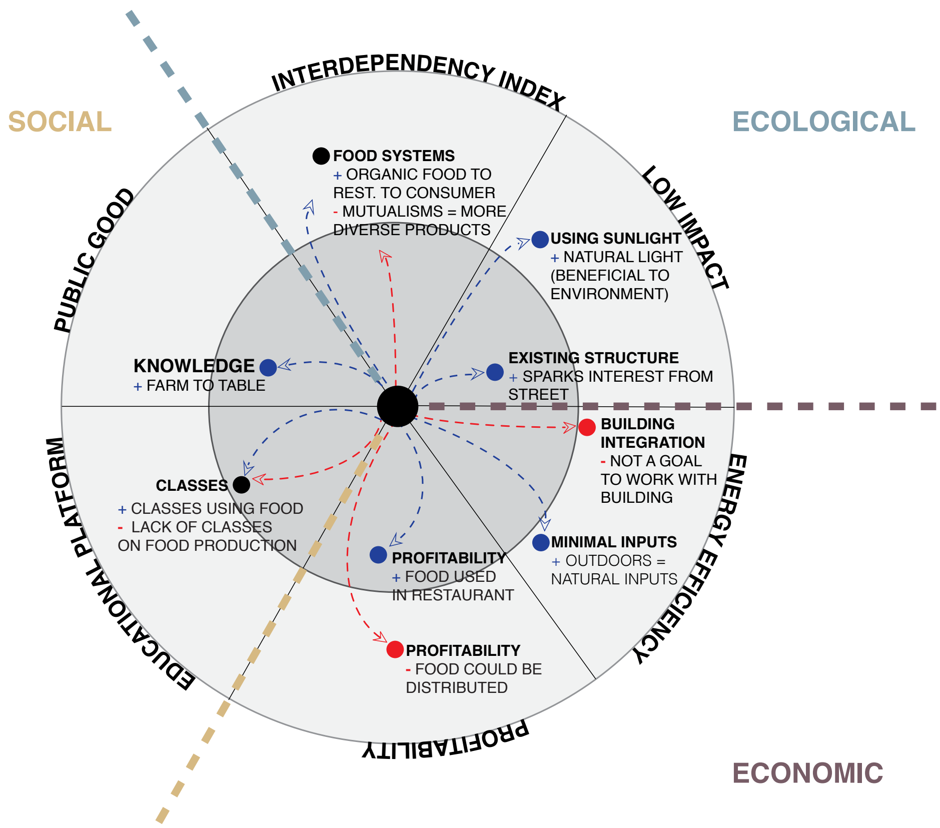

Figure 3.14. Uncommon Ground Outputs Model (diagram by author)

Internal Systems – Aquaponics and Aeroponics

In contrast to the previous typological case studies, there are different indoor farming systems, which vary depending on their growing techniques. Urban Organics is a large-scale indoor farm in St. Paul, MN that uses multiple growing techniques through aquaponics. Aquaponics is a combination of aquaculture (raising fish) and hydroponics (the soil-less growing of plants) and as often used in vertical farming has benefits beyond the production of vegetables and herbs. There are various vertical farming examples that use aquaponics for food production - systems housed in greenhouses, in large outdoor tanks, and in urban buildings (both vacant and in use). Figures 3.15 - 3.17 show the different aquaponic tanks being used and how the plants are actually grown. Urban Organics utilizes a large-scale indoor aquaponics farm housed in the old Hamm's

The farm consists of five functioning floors and when all are operational can produce 14,400 lbs. of greens annually and 3,600 tilapia, which are sold to local restaurants (Star Tribune February 17, 2015). Their produce ranges from parsley to kale to Swiss chard and are available in several local supermarkets. Urban Organics is successful because the people of Minnesota are excited about their access to fresh, USDA certified produce throughout the year. The produce and fish do not travel far to the consumer. The area targeted by Urban Organics identified was a desolate area, with a variety of vacant buildings and food deserts. The goal was to create a "green haven" in the middle of this area for the community and by the community (Urban Organics 2014). The company wanted to create a farm that provided new jobs and increased the morale of a neighborhood. The company's revitalization of the area appears to be successful because other tenants have moved into the Hamm Brewery building. Due to demand, Urban Organics recently opened a new location in St. Paul with plans on following the same template as their initial system but on a smaller level, which will be used solely for production (Star Tribune February 17, 2015). Urban Organics is one of many aquaponic systems but their effort is unique in its approach aiming to improve the surrounding area by revitalizing a historical building and trying to stimulate the economy through jobs and local produce.

Figure 3.15. Urban Organics aquaponic systems (Bluestein, Adam. 2014)

Figure 3.16. Fish tanks house tilapia (Bluestein, Adam. 2014)

Figure 3.17. The roots of the plants are submerged in the fish tanks (Bluestein, Adam. 2014)

Figure 3.18. Urban Organics Site Map (diagram by author)

Figure 3.19. Urban Organics Site Plan (plan by author)

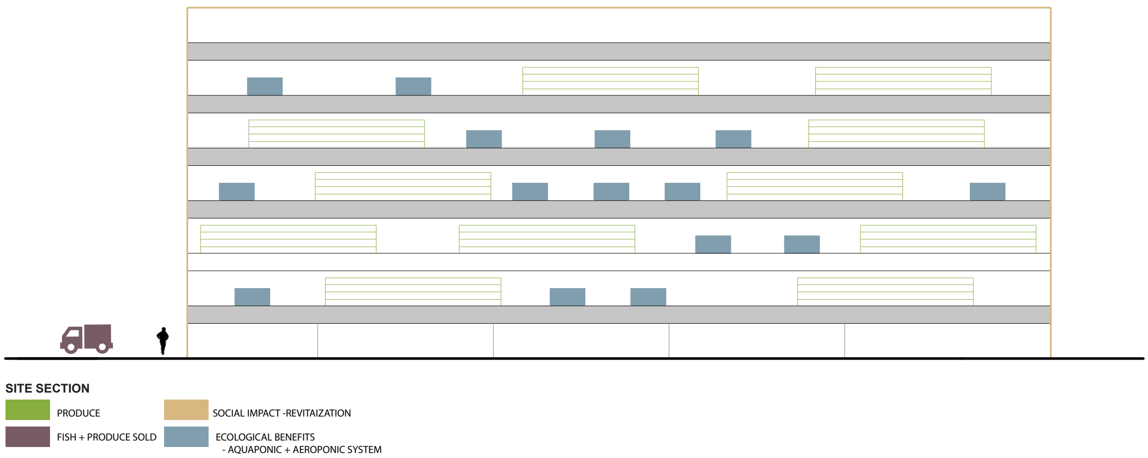

Figure 3.20. Urban Organics Section (section by author)

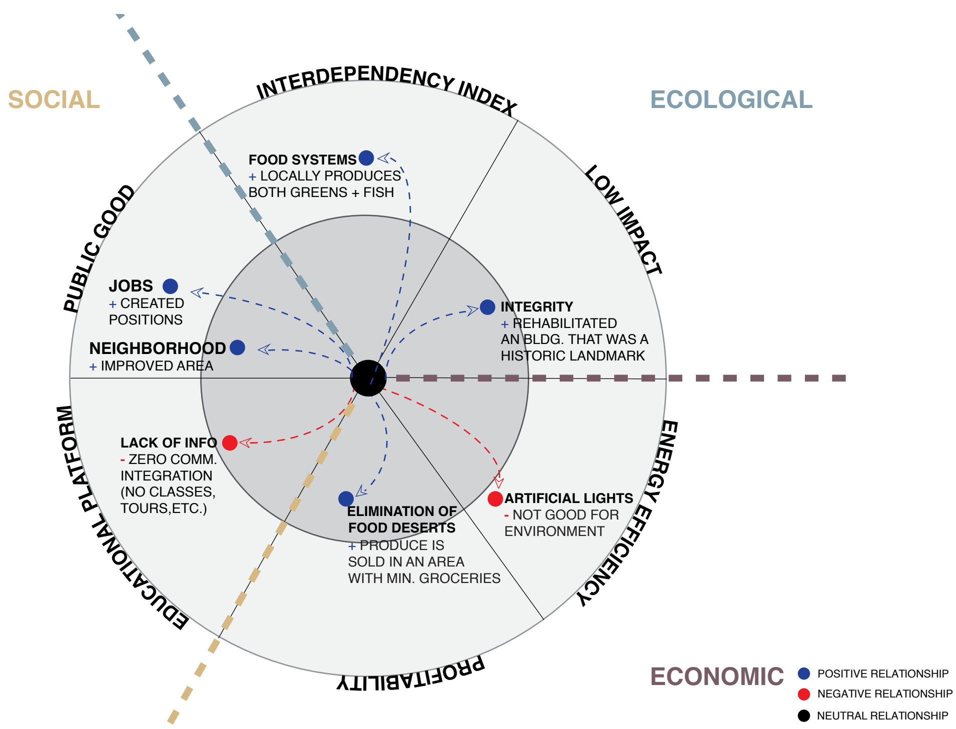

Figure 3.21. Urban Organics Relationship Feedback Diagram (diagram by author)

While many indoor farms focus on hydroponics, aquaponics, or a combination there are some that rely on one method of growing: aeroponics. AeroFarms is located in Newark, New Jersey and was founded in 2004 by a diverse group, which includes a Cornell Professor Ed Harwood, Goldman Sachs, and the City of Newark. AeroFarms does not use natural light or a conventional soil mix; rather, they use a cloth medium for the germination process with LED lighting during the growth process.

According to the company's website, AeroFarms produces hundreds of different leafy greens, herbs, and micro-greens through a closed-looped system. This closed loop system recirculates a nutrient solution and uses 95% less water than field farming. Not only does this method conserve water, it utilizes all possible minerals, resulting to zero runoff. The fact that produce is grown indoors changes the dynamic of pests. Plants are grown in a machine inside the building so pests cannot attack the plants. The growing medium that the company designed is sanitized between growing periods, and the use of pesticides is unnecessary. By removing soil from the growing process any potential of contaminated soil or water is completely avoided (AeroFarms 2014). The greens that are produced are clean and dry upon harvest, which can potentially extend the shelf life from 1-2 weeks to 3-4 weeks. According to the company website, AeroFarm products can be purchased and customized. The systems are comprised of modules that can be stacked vertically (method used at the headquarters) or attached lengthwise.

Due to the elaborate and "sterile" filtration methods and growing system, food-borne illnesses are significantly reduced by controlling the growing medium and by monitoring the growing process. Food-borne illnesses can cost food businesses immensely and also harm the reputation of a restaurant or farm. The Company's team of engineers and horticultural scientists use cameras, sensors, and a variety of algorithms to gather and analyze data about the different greens. (Wall Street Journal December 10, 2015). The team is able to make changes based on what causes different seeds to grow into plants with certain characteristics. This allows buyers to customize the greens for their menus. While allowing them to control the greens through growth adaptation the farm has sold a number of their greens with an identifying white-label to local stores and plans to expand to a food-service business model in 2016. (Wall Street Journal December 10, 2015).

Figure 3.22. LED lights and trays used at AeroFarms (Kanso, Heba. 2014)

Figure 3.23. AeroFarms uses aeroponics trays to grow produce (Kanso, Heba 2014).

Figure 3.24. AeroFarms Site Inventory Map (map by author)

Figure 3.25. AeroFarm Site Plan (plan by author)

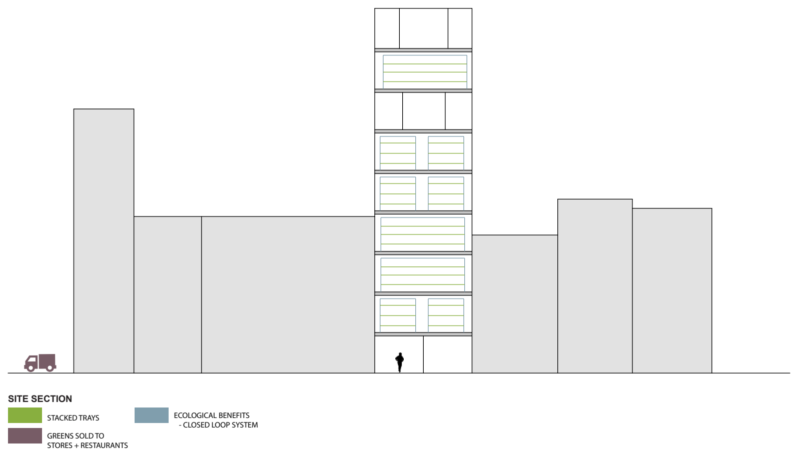

Figure 3.26. AeroFarms Site Section (section by author)

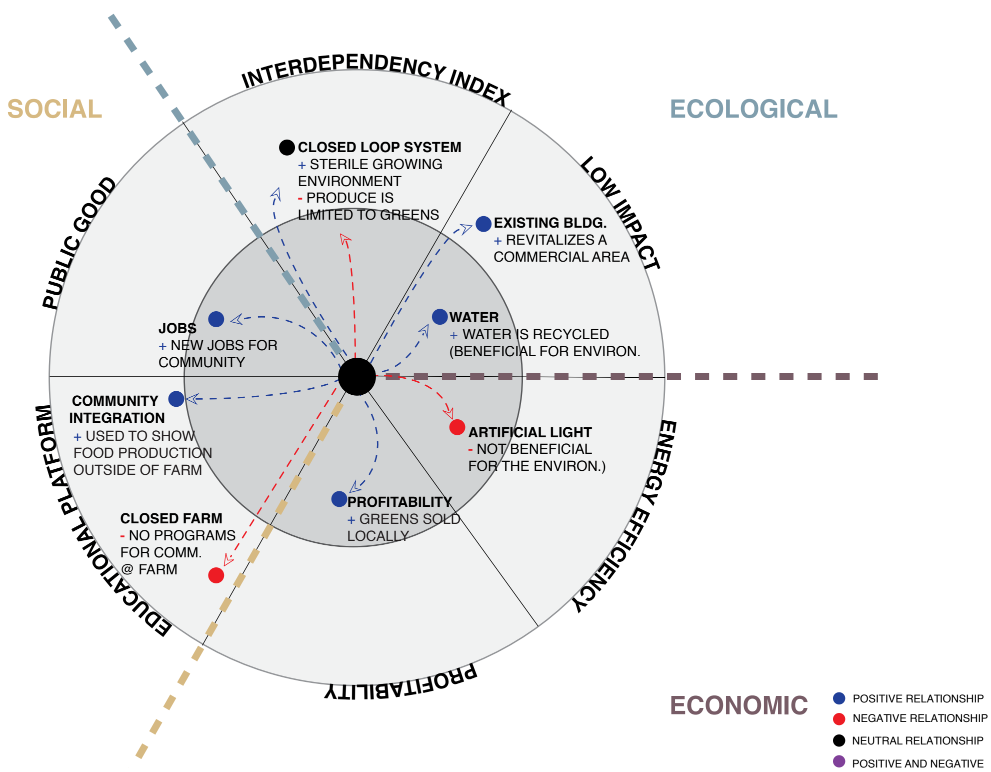

Figure 3.27. AeroFarms Relationship Feedback Diagram (diagram by author)

CHAPTER 4

SECOND GENERATION OF VERTICAL FARMING TYPOLOGIES

The initial vertical farms, or first generation, evolved through trial and error. Some systems were successful, while some failed and through the different companies tweaking their own systems and new companies beginning to create different systems, the next generation of vertical farming began. The second generation of vertical farming ranges from tray systems, to the inclusion of new classes, workshops, etc. into existing frameworks. The second generation goes beyond conventional urban agriculture methods and starts using space in innovative ways, reaching out to the community (in some instances).

Advances in Technology

An example of second generation vertical farming system is a tray or rack system, which is an example of how growing methods have expanded to adapt to potential lack of space. Ecopia Farms is an indoor farm located in an 8,000 square-foot warehouse in Campbell, CA. Ecopia Farms grow organic lettuces, micro greens, and other produce in soil on trays that are stacked on top of each other, covering less than one-fifth of an acre of floor space. The trays and farm are seen in Figures 4.1 and 4.2. The systems used here allow for plants of different sizes to grow instead of just greens. The farm is housed in a controlled indoor environment. The use of trays, which utilize smaller spaces makes it can grow up to 3,500 plants to maturity more than fifteen times per year. The goal in using trays is that they grow and distribute products using less water, land, and fossil fuels than conventional farms (Ecopia Farms 2012). Ecopia Farms grows produce in living soils using only organic materials with no chemicals or sprays. Using proprietary soils (living soils using only certified organic materials), allows for crops to grow to their full potential. The soils are optimized for specific crops and conditions, including crop rotations to enhance soil qualities. Soil is amended and replenished organically post harvest to prepare them for the next crop. The nutrients are not being flushed away by excessive watering so the soil can be reused without waste. Ecopia strives to have low water use. According to the University of California Vegetable Research and Information Center, on average head of lettuce requires around 75 gallons of water to reach harvest. Ecopia uses less than 12 ounces of water per head resulting in each plant receiving the right amount of water through a custom sprinkler system. This process eliminates water waste, field run-off, and evaporation. LED lighting is used to create a purple light which helps the vegetables grow in the stacked tray system. Solar panels on the roof of the farms help to offset the energy use of the lighting used. To grow the same amount of produce grown on the racks, thirty outdoor acres and over thirty times the amount of water would be necessary (CNBC April 2, 2014).

Ecopia is not open for public visits or tours, but they expanded to a delivery system for restaurants (SF Weekly, September 6, 2012). Ecopia Farms offers a progressive way to grow different greens and vegetables and their growing methods are innovative, but currently the community does not have access. Lack of community integration may hinder Ecopia Farms in growing in the future,since people who are detached from the system may not care to learn more about it or care if it succeeds or fails.

Figure 4.1. Ecopia founder, Ko Nishimura, inside the farm (Ecopia Farms. 2012)

Figure 4.2. Ecopia uses different size trays for growing (Ecopia Farms. 2012)

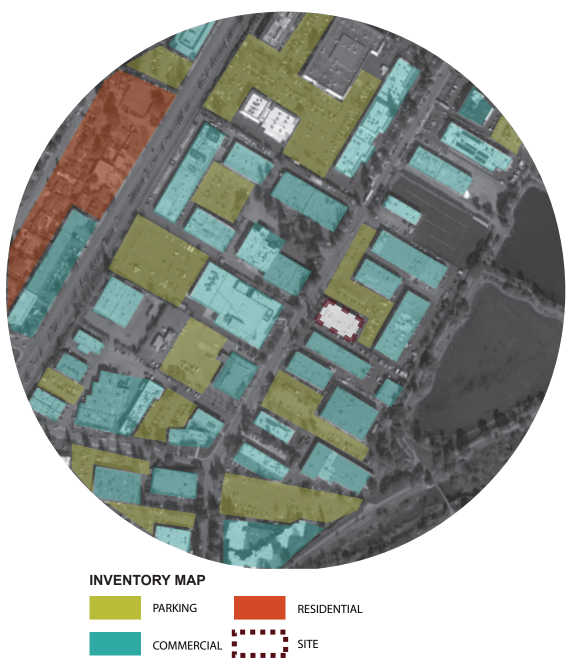

Figure 4.3. Ecopia Farms Inventory Map (diagram by author)

Figure 4.4. Ecopia Farm Site Plan (plan by author)

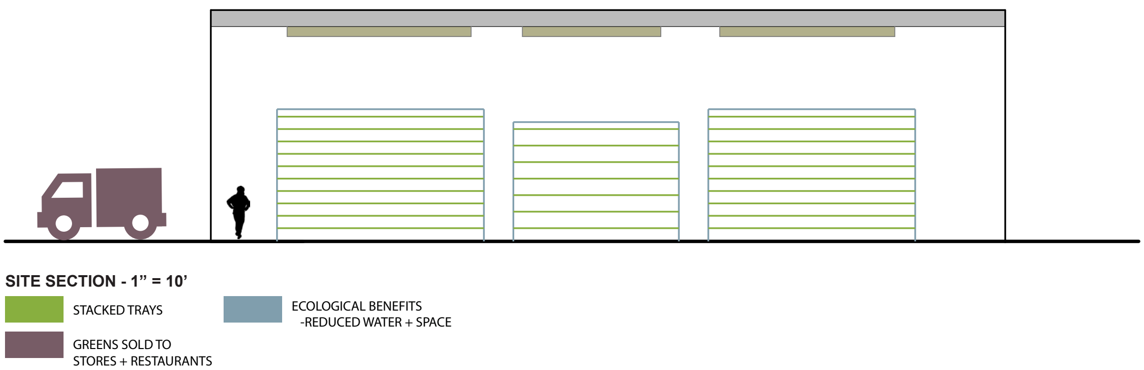

Figure 4.5. Ecopia Farm Section (section by author)

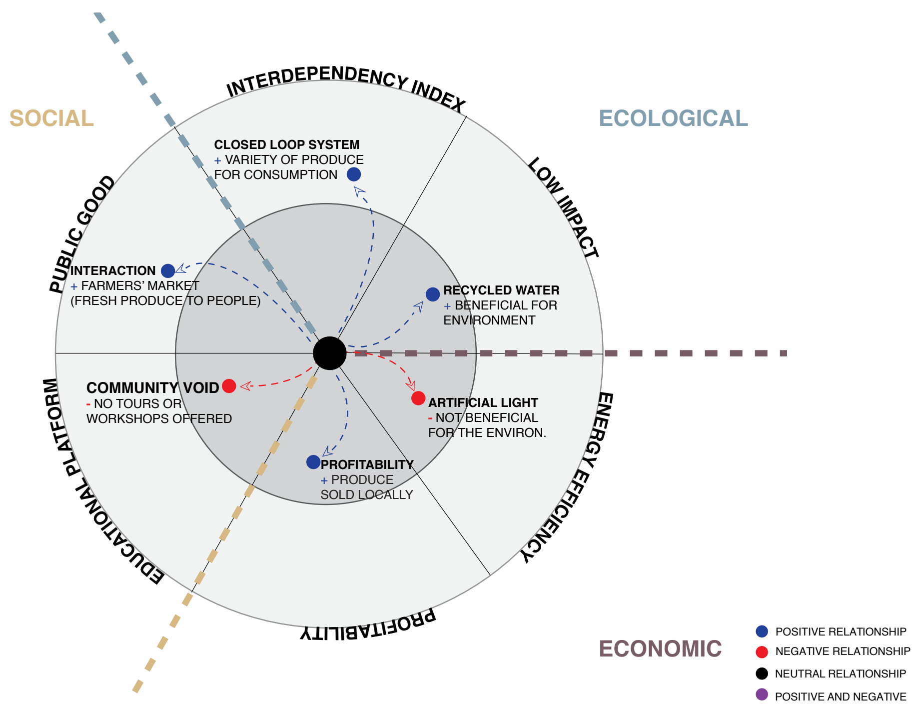

Figure 4.6. Ecopia Farm Relationship Feedback Diagram (diagram by author)

Rotating “farm” units are a more recent idea in vertical farming but they are gaining popularity and have a steady demand already according to Omega Garden International. They are efficient options when dealing with special issues or lighting prices. Omega Garden was established in 1998 in British Columbia, Canada, created rotating growing systems using hydroponic systems to grow crops that range from herbs to strawberries, to eggplants, according to the company’s website (Omega Garden Intl. 2016). Omega Garden created a system called the Volksgarden system, which rotates. The unit is in constant slow rotation in order for the plants to grow uniformly with a light source at the bottom. The system ranges in size from commercial production scale to a home system, as seen in Figures 4.7 - 4.9. The Volksgarden can produce three to five times the comparable weight per average per harvest as a conventional flat or tiered gardens, while using a fraction of the water and space. The Volksgarden system has lights in the middle of the cylinder or what they company calls the “Goldilocks zone”, which means that the plants are close to the light source and receive full growth benefits but are not so close that they are burned or killed (Seedstock Mary 1, 2012). The Volksgarden system is being incorporated into various vacant industrial and commercial buildings in Michigan since the rotating systems can be stacked in different units. Green Spirit Farms in Michigan wants to use the Volksgarden in buildings near large urban markets so that the food is sold locally, which reduces the travel time of produce (Crunch Base 2014). Omega Garden currently sells hydroponic systems but the owner, Edward Marchildon, hopes to eventually create a “You Grew” business plan where consumers pay for the garden system and they have the produce delivered to them so they are free from the actual farm harvesting process (Seedstock Mary 1, 2012). Omega Garden also allows for consumers to purchase and assemble a Volksgarden of their own, so they can experiment with what types of greens and herbs they would like to sell. The Volksgarden allows consumers around the United States and Canada to grow their own, low maintenance, and space efficient garden in their home or business.

Figure 4.7. A carousal Volksgarden (Omega Garden Int. 2016)

Figure 4.8. Units are available for at home (Omega Garden Int. 2016)

Figure 4.9. Volksgarden rotate around a central light (Clark, Melinda. 2012)

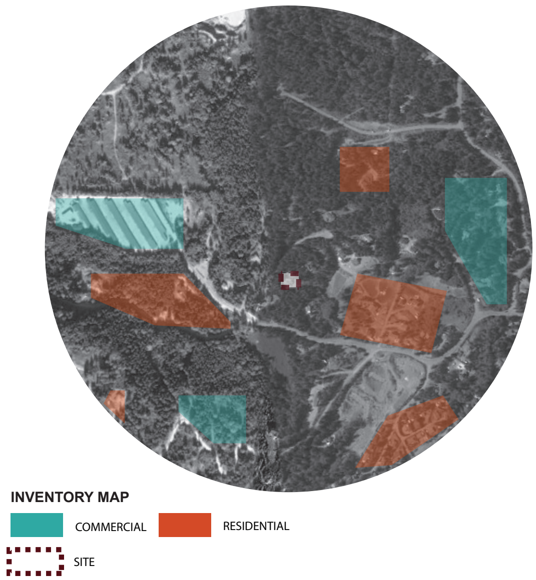

Figure 4.10. Omega Garden Site Inventory (map by author)

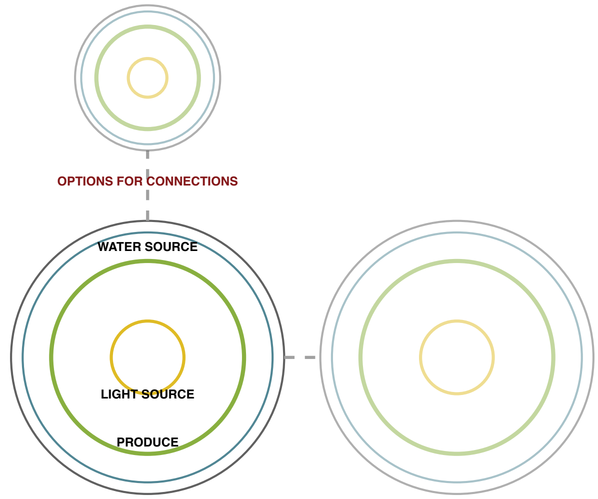

Figure 4.11. Omega Garden Connection Diagram (diagram by author)

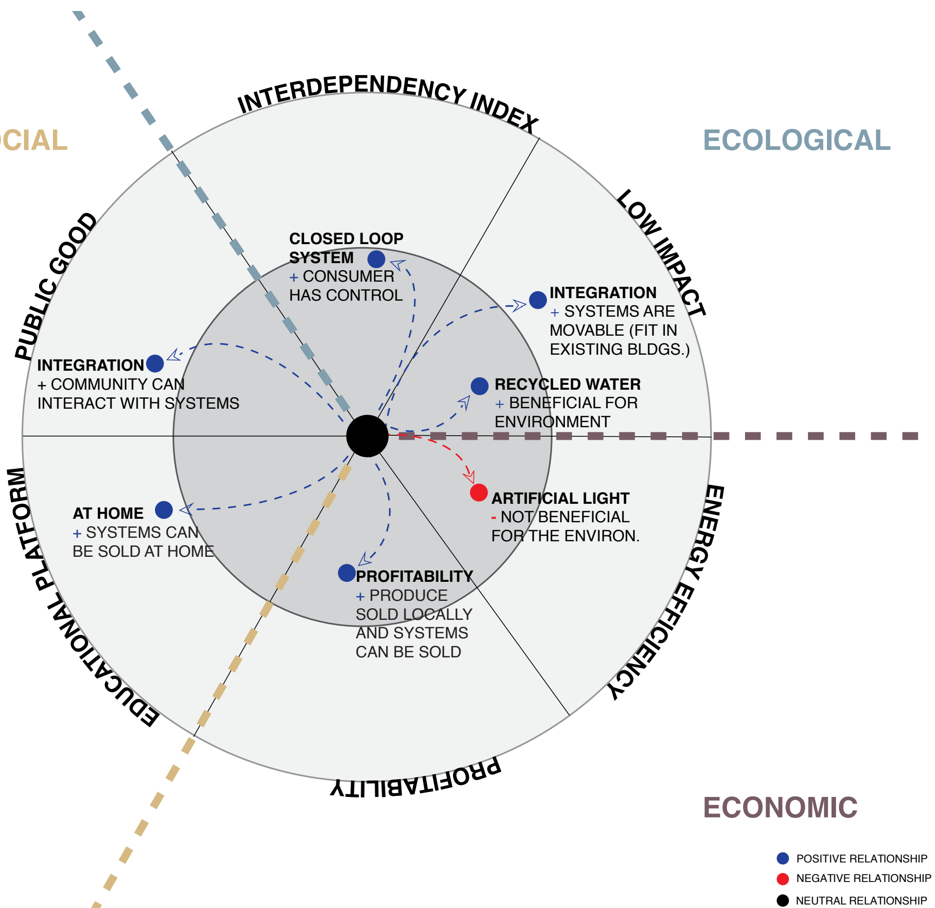

Figure 4.12. Omega Garden Relationship Feedback Diagram (diagram by author)

Beginning to Integrate the Community

While the previous two examples of second generation vertical farming showed how growing methods changed and adapted due to different conditions or needs, here we will discuss farms that have started to integrate non-food products into their repertoire. Some of these non-food services include yoga spaces or rehearsal dinner receptions, etc. The Plant in Chicago, IL is an example of this typological case study. The Plant is located in a 93,500-square-foot former, meatpacking facility. Owner Bubbly Dynamics, deconstructed and then reused 80% of the materials, helping to mitigate costs. The facility currently has demonstration farms, educational facilities, sustainable food businesses, and an outdoor space for a farmers' market and other public and educational events. The Plant continues to expand its facility and offering to the public (The Plant 2016).

The goal of the Plant is to create 125 jobs and create a community hub. The building is dedicated to using a closed loop model through research, education, and development. As a permanent the Plant Chicago will own and operate demonstration farms on site and offer educational programming. The Plant's business incubator consists of permanent tenant spaces that are maintained by Bubbly Dynamics and are occupied by a variety of food producing businesses, research centers, and non-profit demonstration farms. The Plant is funded in part by a $1.5 million grant from the Illinois Department of Commerce and Economic Opportunity (The Plant 2016). The grant funds and a variety of donations have helped Bubbly Dynamics gain momentum to be able to renovate the building. The tenants were able to band together to not only provide services to be sold at the farmers' market but to also provide jobs and act as educational platforms. For example, there are workshops offered through the Plant to educate people about seed sowing, mycology (the growth of mushrooms), and aquaponics.

There is an aquaponics farm that uses tilapia (freshwater fish) to help grow greens indoors and also create educational programming and research opportunities. In addition to the aquaponic farm, there are a variety of current tenants. Some of the businesses include Bike-a-Bee, Great American Cheese Collection, Pleasant House Bakery, Salty Prawn, 4 Letter Word Coffee, and Rumi Spice, with a brewery coming soon. In addition to products being sold to local vendors the Plant has a Farmer's Market, educational classes for children, and closed loop labs and growing workshops. Occasionally they hold events such as Back to School Community BBQs, Monster Food Truck Rally, live music, art exhibits, holiday events, and fundraising events (The Plant 2016). Tours take place on Saturdays and cost a minimal fee, with children being exempt. The Plant hopes to expand through tenants, classes (a potential at home aquaponic kit), and through structural adaptation. The plan for the Plant is to convert the building into a net-zero energy food business incubator over time through an anaerobic biodigester that could make waste into biofuel (The Huffington Post 2012). The Net-Zero energy system will be completely enclosed and will capture the methane from waste which will be burned, to produce electricity and the process heat needed for the future brewery. With a biodigester the Plant would be a self contained entity having a closed loop system making their products on-site and processing all the waste.

Figure 4.13. The Plant is located in an old factory in Chicago, IL (Cobb, Tara. 2014)


Figure 4.14. Tours of the Plant are offered every Saturday (Plant Chicago, 2016)


Figure 4.15. One tenant of the Plant is an aquaponics farm (Weibel, Barbara. 2014)

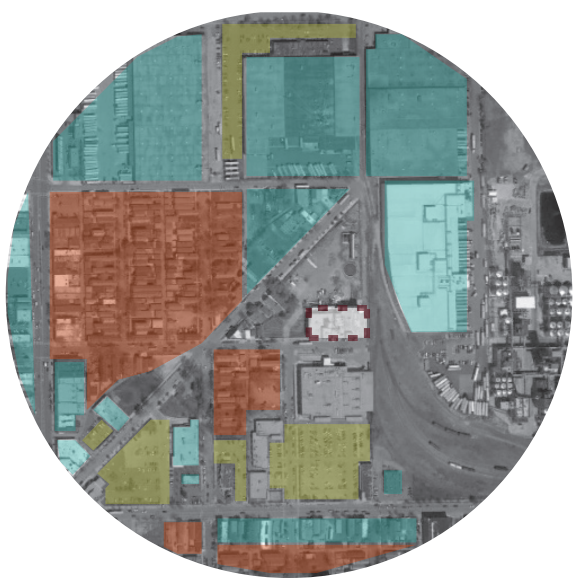

Figure 4.16. The Plant Site Inventory Map (map by author)

Figure 4.17. The Plant Site Plan (plan by author)

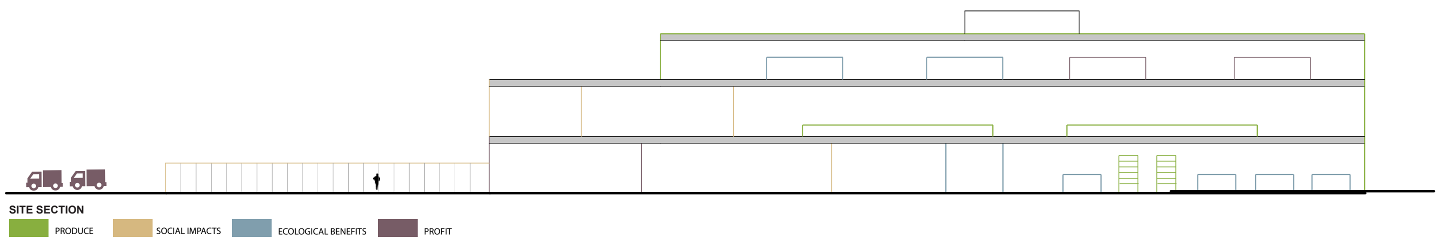

Figure 4.18. The Plant Site Section (section by author)

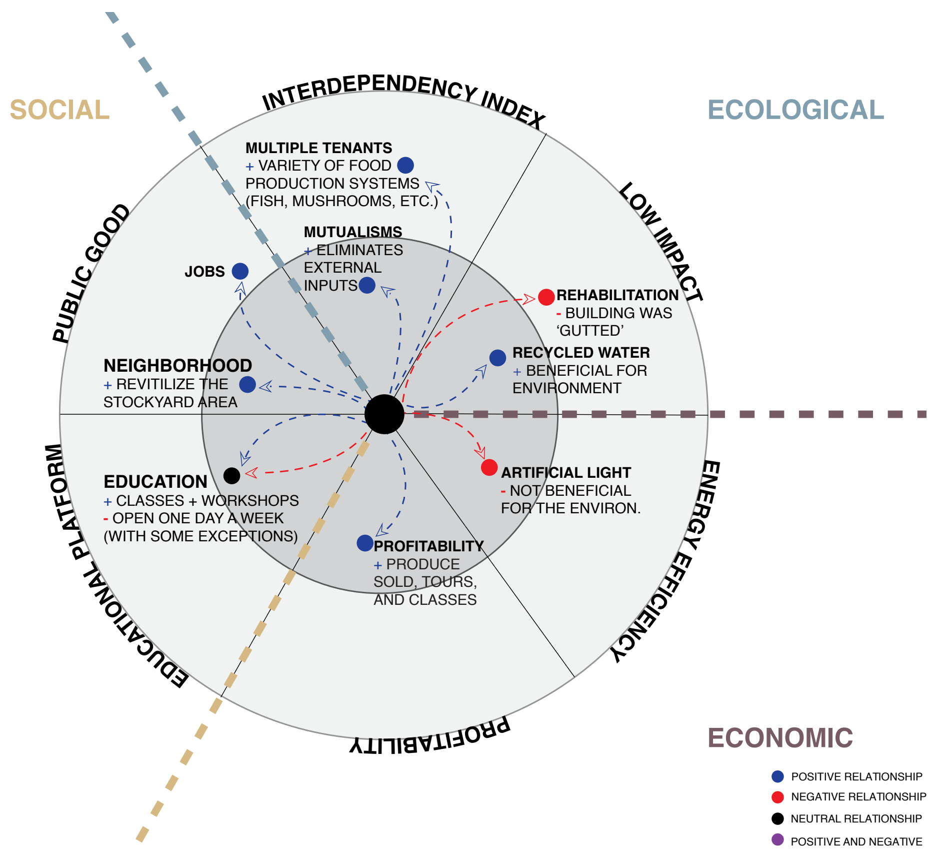

Figure 4.19. The Plant Relationship Design (diagram by author)

Brooklyn Grange started in 2010 and includes two farm locations, in Queens and Brooklyn, NY. Both locations produce a variety of goods and host different social occasions. According to the Company's website, Brooklyn Grange et al. are rooftop soil farms that grow over 50,000 lbs. of organically grown produce per year. According to Carrot City, Brooklyn Grange was established in Queens, NY over the course of a three week period in the Spring. The farm covers over 40,000 square-foot and is on the roof of a six-story building. Brooklyn Grange, at the Brooklyn location, is one of the largest green roof systems in the world. The company produces a multitude of ever-changing salad mixes, heirloom tomatoes, and a variety of produce that rotates depending on the season. In addition to produce the site also has hens that produce eggs, a bee apiary that produces honey, and hot sauce from a pepper, spice, and herb mix. "There is nothing more rewarding than sitting down at the end of a good day of working with your hands, watching the sun set over a healthy, productive farm, and enjoying some freshly picked vegetables as a team," according to Anastasia Cole Plakias, the vice president and co-founder in an interview with Mark Miller, for National Geographic (Miller 2014). The goal of the company is to create a healthy and organic source of produce and other items that people can readily access, through farmers' markets, events, and a community supported agriculture, CSA, program. The company offers a CSA program where local residents can have a weekly supply of freshly picked produce for 24 weeks (mid-May through November) for a price of $25/week. The residents have the option to pick up their orders at the two farm locations.

Brooklyn Grange goes beyond just producing food; it offers two farmers' markets, in both locations, yoga classes, public and private workshops, tours, dinners, and private events. The workshops include green roof consultations, dairy farm workshops, hot sauce workshops, how to make perfume from your garden, etc. The events vary from "Butcher Paper Dinners", which include crawfish and lobster boils, Make Your Own BBQ, grill outs, and the events vary from receptions and weddings to corporate retreats. The events are open to the public, for a fee, and range throughout the seasons and times of the day. The tours are public and private and some are in conjunction with the Bike and Subway Tours, City Growers, and the Refugee and Immigrant program. There are Get Up and Ride tours that have members ride around the city with one of the stops at the farm in Queens. K-12 age children, who work with City Growers, help connect urban communities with agriculture elements through educational farm explorations. The Queen based farm helps refugees and immigrants work at the respective farm to help the individuals build their resumes. The different educational platforms serve a variety of community members and are a step in the right direction. Unfortunately, Brooklyn Grange are only soil based roof systems, they do not utilize the rest of the building. (Brooklyn Grange. 2012).

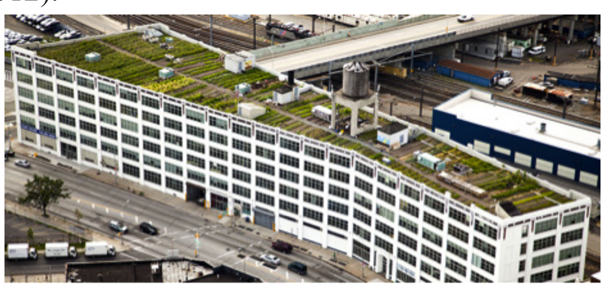

Figure 4.20. An aerial view of the rooftop farm in Queens, NY (Brooklyn Grange. 2016)

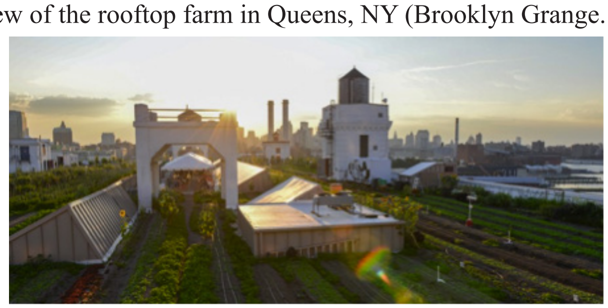

Figure 4.21. View of the city from the rooftop farm in Queens, NY (Brooklyn Grange. 2016)

Figure 4.22. Honey made from bees at the Farm is sold locally (Brooklyn Grange. 2016)

Figure 4.23. Workshop participants work on wood carving (Brooklyn Grange. 2016)

Figure 4.24. Members of a party enjoy a dinner (Brooklyn Grange. 2016)

Figure 4.25. BG Navy Yard Site Analysis (diagram by author)

Figure 4.26. BG Queens Site Analysis (diagram by author)

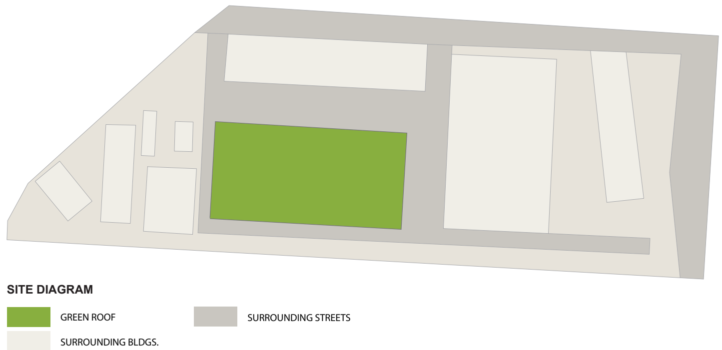

Figure 4.27. BG Navy Yard Site Plan (plan by author)

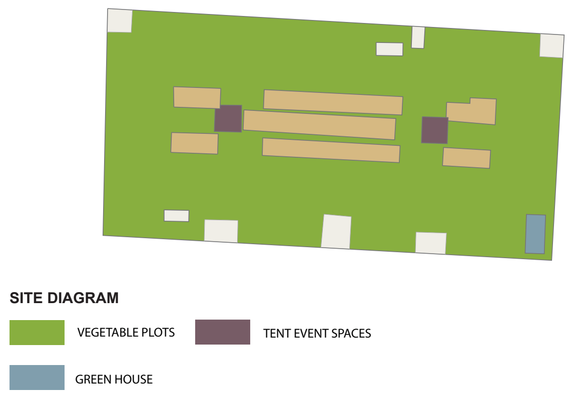

Figure 4.28. BG Navy Yard Roof Plan (plan by author)

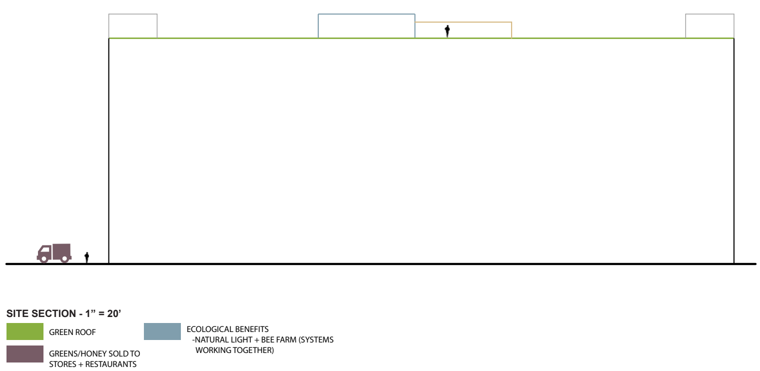

Figure 4.29. BG Navy Yard Section (section by author)

Figure 4.30. BG Queens Site Plan (plan by author)

Figure 4.31. BG Queens Roof Plan (plan by author)

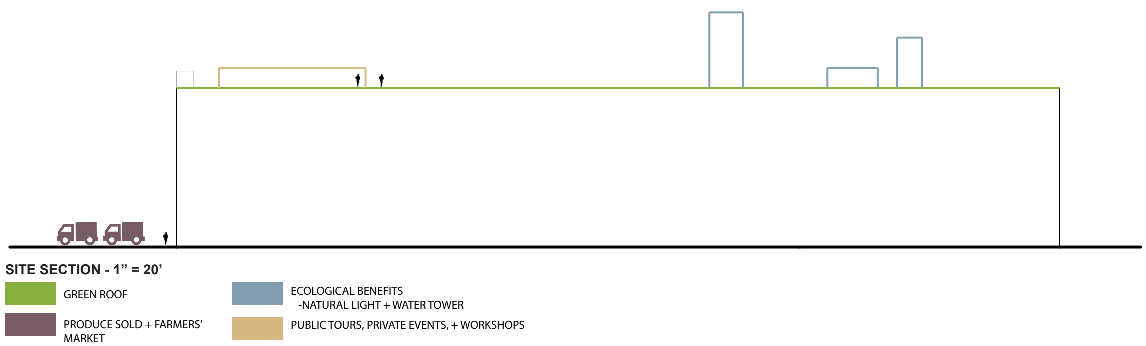

Figure 4.32. BG Queens Site Section (section by author)

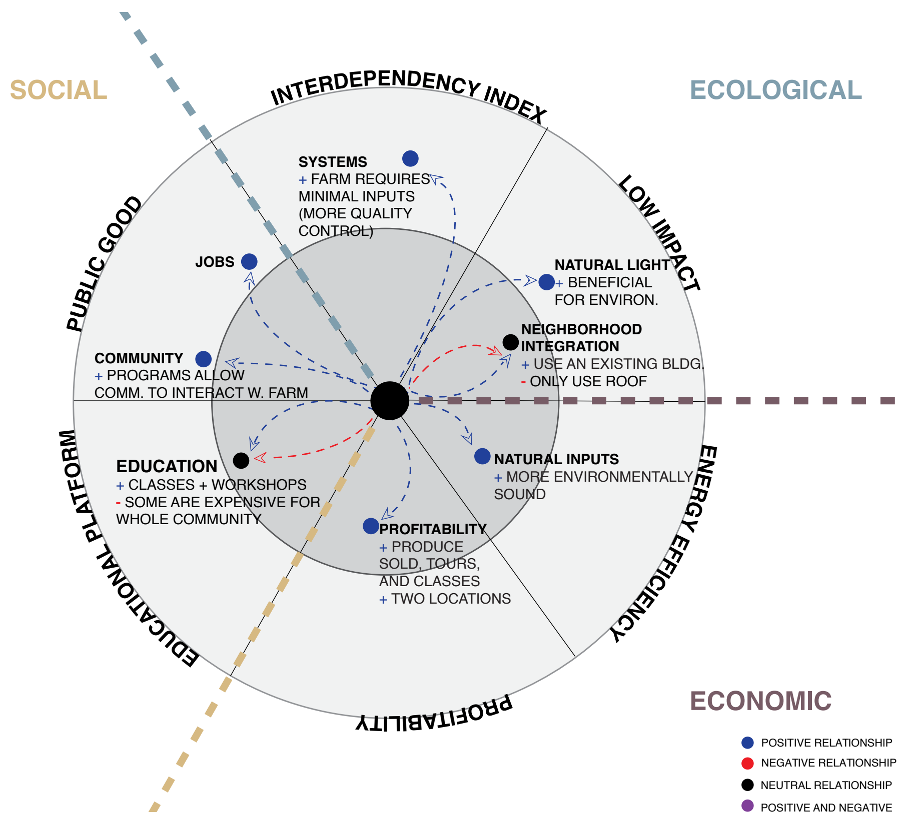

Figure 4.33. BG Relationship Feedback Diagram (diagram by author)

CHAPTER 5

CRITERIA EVALUATION OF THE TYPOLOGIES

In order to analyze how each type of vertical farming is meeting the three elements of sustainability, or not, it is necessary to have a set of criteria for which the typologies must be consistently assessed. The criteria must be easily understood, the information being evaluated must be accessible, and each criteria must be related to one of the elements of sustainability (ecology, economy, social). There are six criteria that each typology will be analyzed and they include working towards the improvement of the public good and serving as an educational platform (social elements), having an interdependency index and being low impact (ecological elements), and profitability and overall energy efficiency (economic elements). These elements cover a comprehensive spectrum of how different program elements, growth productions, and materiality can achieve sustainability, whether independently or by working together. As seen in the diagram below, Figure 5.1, the elements are separated into the three categories and organized by three colors. There are ranges of how a system can achieve optimal functionality, which is represented by the two rings of circles.

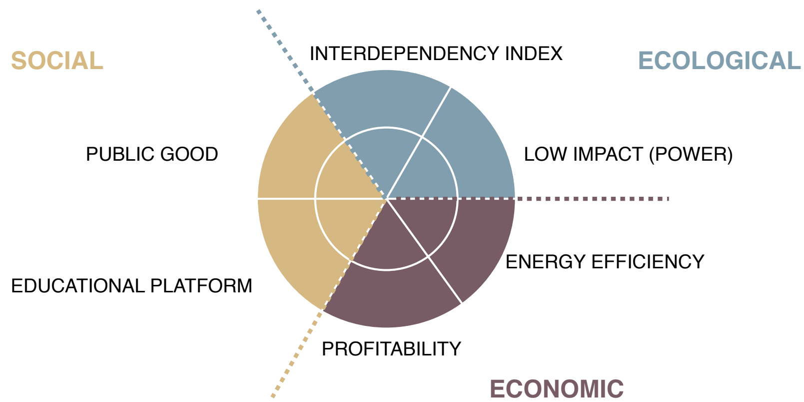

Figure 5.1. Example of the Criteria Evaluation Diagram (diagram by author)

When assessing the typologies it is important to focus on where pieces are "missing", if the diagram is weighted on one side then it may mean that one of the three elements of sustainability is not being addressed. Diagrams that show most of the criteria being achieved are clearly more successful than diagrams that are either missing the second tier of criteria or are heavily weighted to one side. For example, the AeroFarm typology assessment shows how there are clearly social and economic elements lacking within the system, the system is only achieving the initial level of public good, energy efficiency, and profitability. The diagram expresses more success in achieving the ecological portions because of the closed loop system aspect of the system (interdependency index) through the use of an existing building and their aim to recycle water they are very successful in being a low impact system.

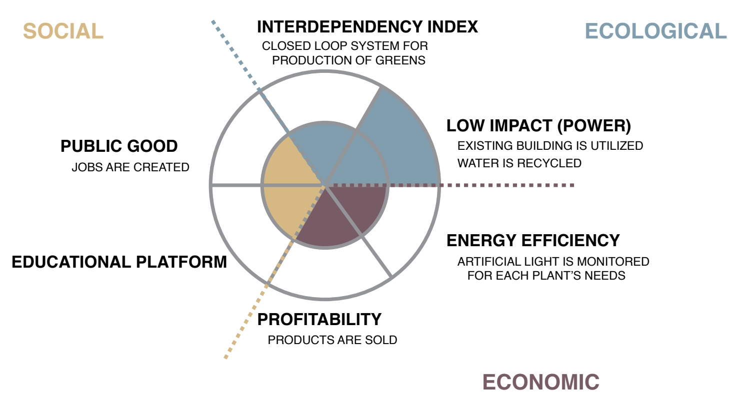

Figure 5.2. AeroFarm Evaluation Example (diagram by author)

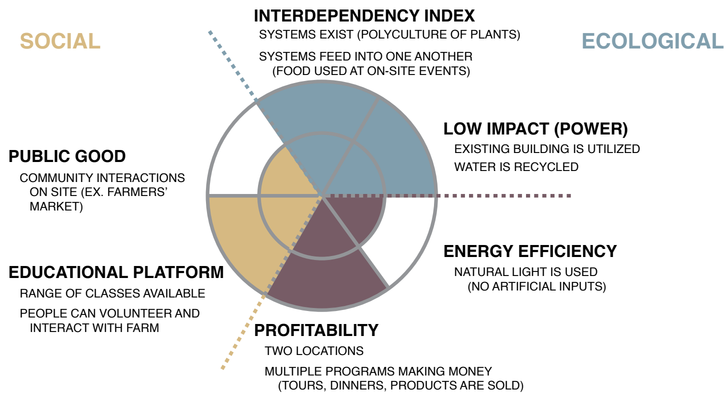

Figure 5.3. Brooklyn Grange Evaluation Example (diagram by author)

In contrast to the AeroFarms example, the Brooklyn Grange Rooftop system, seen above, achieves all of the elements, but does not meet the interdependency index and public good at the full potential. This is due to the scale and location of the farms. Brooklyn Grange et al. tends to gear most of their elements towards middle or higher economic strata, with the exception of their refugee work program. Also, due to the fact that it is solely a roof garden, the number of systems working together is limited. The analysis diagrams help highlight which criteria are met and to what extent. A table was created to show how it was determined if each criteria was being met and by which element of the farming system. The areas where the farm elements are not achieving the aspects of sustainability are opportunities for the inclusion of a landscape architect to help transform the typologies through a more sustainable and regenerative design.

The diagrams in this chapter display how each typological case study is meeting the six criteria and where they are not. The studies were analyzed based on program, spatial utilization, and integration within the community and surrounding neighborhood. The following table, Table 5.1, explains how it was determined what elements of the farming system achieved, or did not achieve, each piece of criteria:

TYP.	PUBLIC GOOD	EDUC. PLATFORM	INTERDEPEN. INDEX	LOW IMPACT	PROFITABILITY	ENERGY EFFICIENCY
SKID ROW	- Started by comm. by the community - Helps improve (aesthetics and dietary) a desolate area	- Teaches a low income area about healthy food consumption - Trial and error on gardening	- External and sep. system - Not benefiting the structure and visa versa	- Interdependent, not producing strain on bldg. or environ. (no waste, etc.)	- Food is not sold, distributed to tenants - Helping improve the area visually	- Only external inputs (water +sun) - Mainten. is key, but no artificial lighting, etc.
U.G.	- Occ. tours are held - Providing local and organically grown food - Farmers' Market	- Some educ. classes --> cooking and growing from seeds	- Food and rest. ro people - Farmers' Market is community	- Re-conf. bldg. to ensure support of loads - Containers are low impact	- Farmers' Market - Reduce costs in restaurant - Food used for cooking classes	- Water input - Outdoor = nat. light
URB. ORG.	- Revitalized area - Provided jobs - Reduced food deserts	- No workshops currently - Food produced locally	- Closed loop (fish and plants)	- Re-used exist. building - Recylces water	- Sell produce and tilapia	- Aquaponics = + - Artif. lights = -
AERO FARMS	- Created jobs - Not usually open to the public, no tours	- Website displays growth procedure - Minimal exposure off site (systems used in schools) - No on-site classes	- Very closed loop system	- Re-used buidling - Recycle water	- Sell greens produced - Systems can be purchased by other entities	- System is efficient and elimin. pests, etc. but artif. light is used heavily
ECOPIA FARMS	- Not open for public tours	- N/A	- Trays recycle water and work as a closed system	- Space efficient - Used old ware-house	- Greens are sold locally	- Use artifical lights heavily
OMEGA GARD. (VOLKS)	- Available for home or larger systems	- Used in larger systems to show condensed veggie production	- Closed rotary system --> min. external inputs (small amount of wate) - Carousel system	- Small space - One light - Recycled water	- Can sell the system + produce	- One artificial light source
THE PLANT	- Revitalized area - Variety of open events held on-site - Not always open	- Variety of work-shops --> aquap., mushrooms, apiary - Tours	- Aquaponic system - Anaerobic digest. - Bike-A-Bee	- Re-const. bldg. - Recycles most water - Moving to recycle all waste and produce energy	- Grants - Sell produce - Farmers' Market - Charge for tours and classes	- Artifical lights - All growth is indoors
B.G.	- Farmers' Market - Refugree program - Yoga, dinners, etc.	- Tours - Cooking classes - Workshops	- Bees --> plants - Crop rotation - Food --> dinners, classes, workshops	- Exist. rooftop that could support loads	- CSA = $ - Farmer's Market - Honey, hot sauce, produce to stores/ restaurants - Workshops	- Re-use water - Natural light

Table 5.1. Criteria Evaluation of Typologies (table by author)

In addition to the table above there was a metrics system created where each typology could meet one of the evaluation criteria. If multiple options were achieved by the typology then the Criteria Evaluation diagram would show that both tiers of a certain criteria were being met. The metrics included:

- **Interdependency Index**
    - Systems exist within the farm
        - Closed loop system
            - Aquaponics system is an example of this
    - Systems feed in to one another
        - Leveraging
            - Bee farm and flower plots work together
            - Waste from one system serves another (ex. digester)
- **Low Impact**
    - Uses an existing site or building
        - Minimal rehabilitation
        - Maximum rehabilitation
    - Recycles water
    - Uses natural sources
        - Natural sunlight is an example
- **Energy Efficiency**
    - Does not rely on artificial inputs
        - Ex. use of artificial lights occasionally vs. heavy use of LED lights
    - Focuses on integration with the building and assisting with energy conservation

- **Profitability**
    - Longevity of the business
        - Business expands to other locations
    - Multiple programs in place to make money
        - Products are sold
        - Classes
        - Tours
    - Increased property value
- **Educational Platform**
    - Classes offered to the public
    - Opportunities for people to access the farm to see healthy food being grown
- **Public Good**
    - Cues to care
        - Improve a blighted building or site
            - Slight outward improvement
            - Significant outward improvement
    - Jobs are created
    - Community members have the opportunity to interact with each other and the farm

As noted in the aforementioned table, the Skid Row green wall excels in being low impact and improving the public good but lacks in achieving profitability, serving as an educational platform and the interdependency index criteria. The green wall is on the exterior wall of the apartment building and uses a simple grid system with minimum inputs (maintenance and water). With the wall being outside, it creates a public aesthetic value while using natural sunlight and creating a sanctuary for bugs in a harsh urban environment. There are more extensive green walls that focus on these issues but the green wall in Skid Row is unique in how residents interact with it, which is significant for success, the community must be served. The green wall began by an initiative from Rainbow Apartment tenants and was able to prosper with the guidance and funding from a non-profit, Urban Farming. The residents maintained and looked after the green wall, they helped to create it and therefore cared about its success; they learned what would grow and what wouldn't through experimentation. Some residents stated that growing fresh produce helped them be more aware of what they were eating (The Los Angeles Times 2008). The green wall not only helped provide fresh produce to a group of individuals who did not have regular access to fresh food, but it also helped to improve a blighted area. Unfortunately, because the green wall was simple and used for experimentation it did not focus on profitability or creating systems that work together. The Rainbow Apartment green wall was created initially as a trial garden and therefore was not established to help with heating and cooling of the building it is attached to, nor did it focus on creating systems (water recycling or pollination processes) that work together.

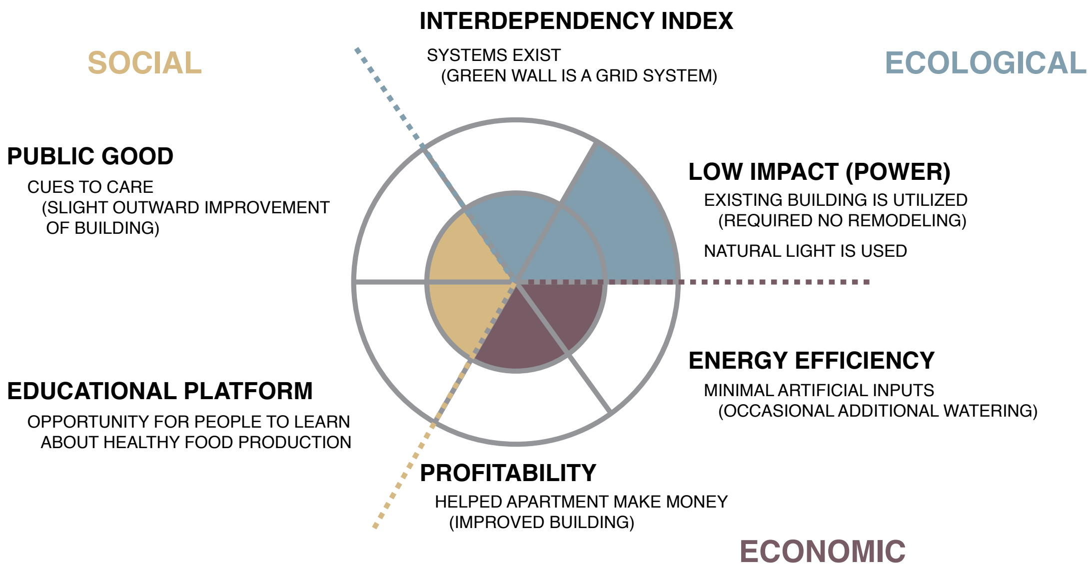

Figure 5.4. Skid Row Green Wall Criteria Evaluation (diagram by author)

Uncommon Ground on Devon St. in Chicago, IL is a unique restaurant because of the green roof that sits on top of the building. The green roof provides fresh produce and herbs to the restaurant below and the sister restaurant across town while also creating a space for people to interact with the ingredients. The Uncommon Ground farm strives in energy efficiency and profitability. The green roof uses natural sunlight for growing and solar panels have been installed and the system requires minimum energy and it has a unique sprinkler system that allows limited water use, while recycling and reducing runoff. The green roof provides produce which is sold at a Farmers' Market and used in the restaurant not only for meals but also for classes and specific events; people can see where their food is coming from and they can learn about the organic farm to table process. While there are cooking classes and events, they usually take place within the restaurant, the farm could be utilized more to help educate people on the processes that are occurring with growing the produce and more events could take place on the roof to get the community involved, such as seed propagation classes or organic soil workshops.

The actual building was restructured in order to support the system but planters are used to help with the loads and to reduce water runoff. The farm could also have systems that relate more to each other, bees could be introduced or a composting system could be in place to help with production (the system would work between the farm and the restaurant). Overall, the rooftop farm has unique aspects but due to the scale it does not achieve all of the criteria to be completely sustainable.

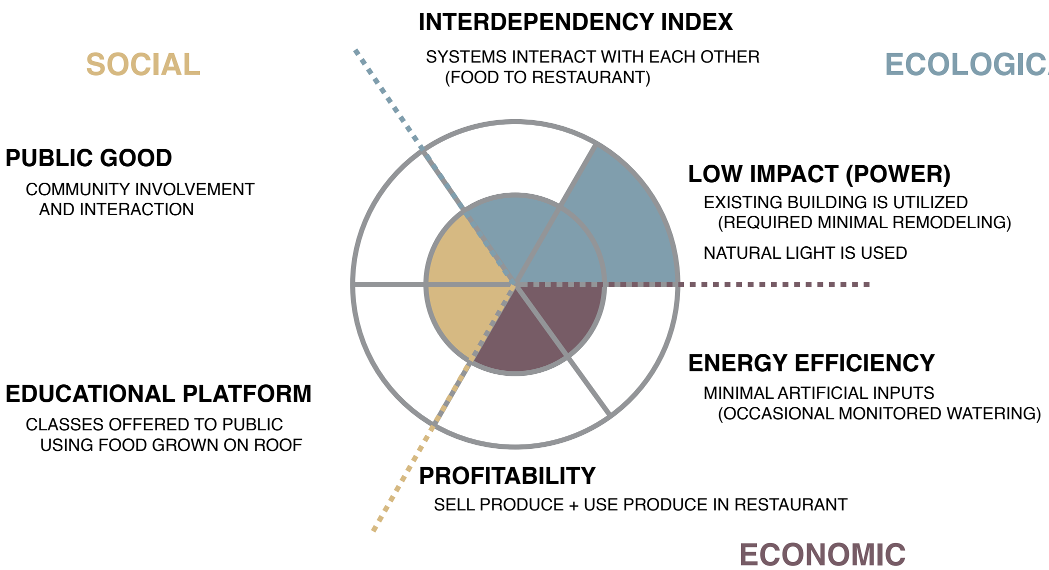

Figure 5.5. Uncommon Ground Criteria Evaluation (diagram by author)

Urban Organics in East St. Paul, MN began with the overarching hope to improve the neighborhood, which was achieved through several small goals. Their website emphasizes how the company could not succeed without the help of the community, and to that end the goals ranged from revitalizing an area with multiple food deserts to providing fresh produce to local stores and restaurants, to stimulating the local job market. Urban Organics is in a previously underutilized warehouse that is now teeming with fish and leafy greens. The founders wanted to provide jobs to the community, to spark involvement, and to help eliminate the distance fresh produce was traveling to reach that area. Urban Organics is growing fish and produce, predominantly leafy greens, in a closed loop aquaponic and hydroponic system through which they are recycling and reusing water and producing multiple goods that can be sold locally. A closed loop system helps to not only recycle water but to reduce the amount of inputs into the system once it has started, the system is low impact and does not put forth strain on the already existing building. While the combination system is successful due to the symbiotic relationship between the fish and the plants, artificial light is necessary to help with the growing process. Aquaponic and hydroponic systems are fascinating and can be achieved on a variety of scales and in a variety of locations. Unfortunately Urban Organics does not currently offer any workshops or classes for local people to be able to learn about how the systems work or how they could in turn create their own, volunteers are welcomed. Urban Organics has been very successful in spite of the aforementioned, both in its production and in creating a system that has improved the surrounding neighborhood.

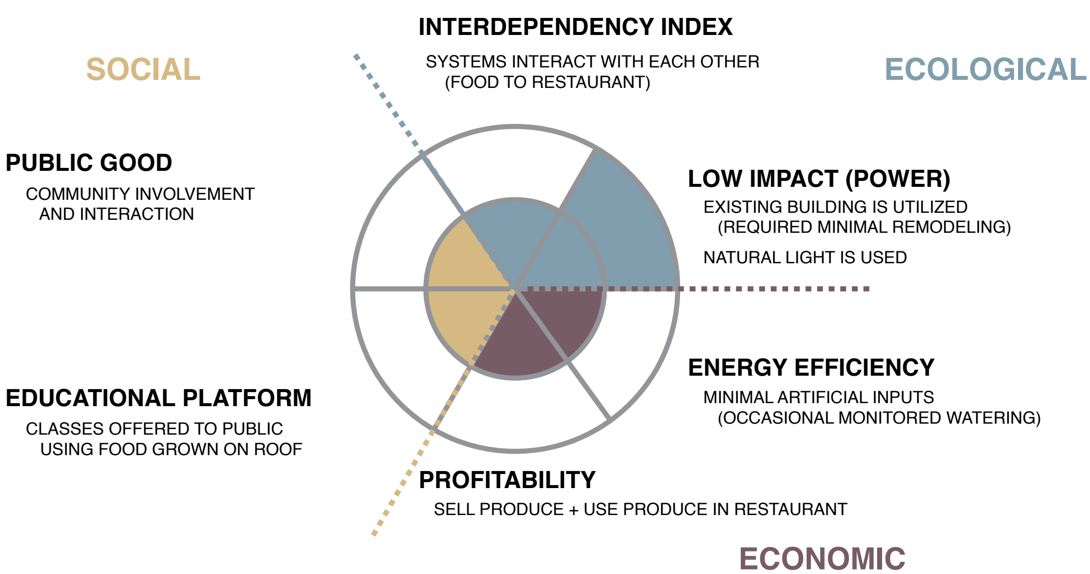

Figure 5.6. Urban Organics Criteria Evaluation (diagram by author)

AeroFarms has flourished in a warehouse space in Newark, New Jersey through a unique aeroponics system where the use of water has been reduced and the growing process has been sterilized through different filter fabrics. The downside is that almost constant use of artificial light for growth. AeroFarms strives to produce a variety of greens through a low impact system, plants can be connected to save space and the building needed minimum changes to be suitable for growing. AeroFarms has a concise growing system with low inputs and maximum controls (everything is monitored and can be adjusted easily) but because it is only using aeroponics there are no other systems, besides the materials, that are working together. The company is using cutting edge technology attempting to produce more greens than conventional farming and with none of the pests, but it falls short due to the lack of focus on integrating the company with the neighborhood whether through tours or educational opportunities. While the system is producing food that can be distributed locally and currently selling the greens to several local stores and restaurants, the company continues on expanding.

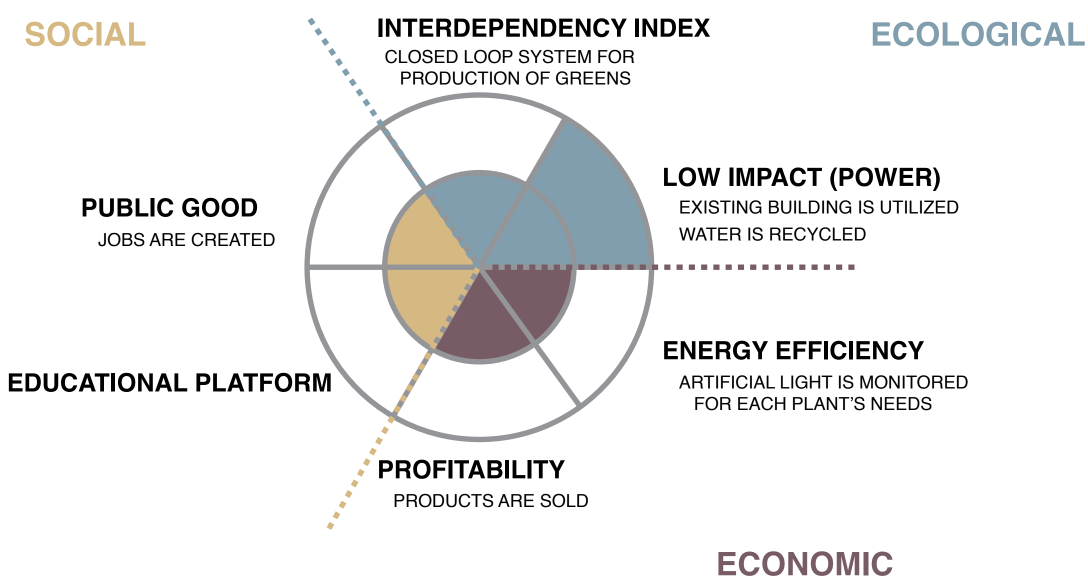

Figure 5.7. AeroFarms Criteria Evaluation (diagram by author)

Ecopia Farms, located in Campbell, CA, is a non-traditional vertical farm because of how they grow their produce. Ecopia uses a tray system which takes up less space and can be done in several environments, Ecopia Farms is housed in a warehouse. The tray system allows for different produce to be grown in different living soils depending on the needs of the plant. The environment can be controlled through the amount of water being used, the indoor space (eliminates pests and disease), and through the amount of light the plants receive. While Ecopia strives to produce up to 3,500 plants fifteen times a year with roughly a sixth of the amount of water used in conventional farming, artificial lights are used, which impacts the energy efficiency of the farm. The tray system helps with growing but it limits the systems that are taking place within the growing process, bugs are not viewed as beneficial and there are zero animals introduced into the system. Ecopia Farms has created a cutting-edge process for growing different herbs, produce, and vegetables but there has not been much accomplished with educating people or improving the surrounding area. The farm is closed to public tours and rarely hosts small events to educate public on what is happening within the farm. Opening up the farm could lead to further development for vertical farming as a whole.

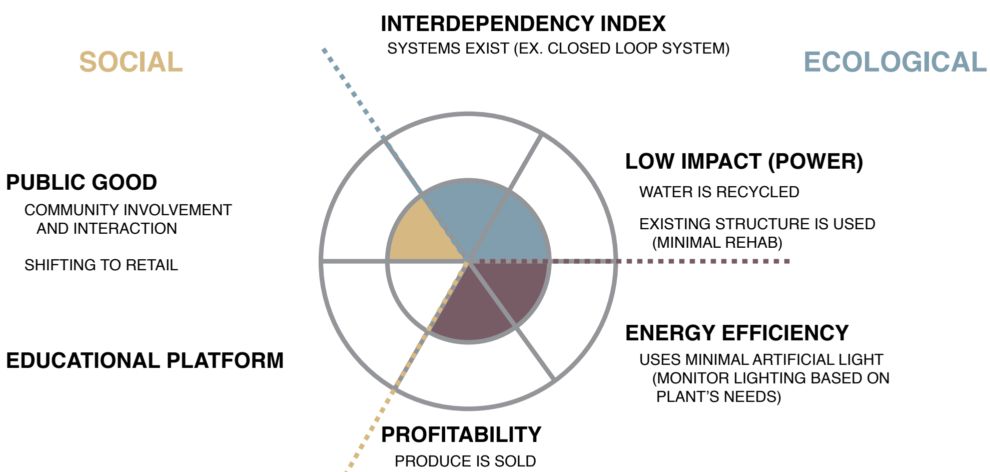

Figure 5.8. Ecopia Farms Criteria Evaluation (diagram by author)

Omega Garden breaks the mold of a traditional vertical farm in the sense that they do not have a main ‘farm headquarters’. Their modules can be sold to individuals or companies and vary in size and production ability. Omega Garden, specifically the Volksgarden model, is a hydroponic rotating system that utilized minimal water and minimal artificial light to produce a variety of greens, herbs, and in some cases vegetables. The system does not require a lot to be successful. It can function in a small space with a small input of water. The central artificial light and rotating system allows for the maximum amount of growth to occur with minimum light without the fear of produce getting singed or overexposure to too much light, making the Volksgarden system energy efficient even with the use of LED lights. Omega Gardens provides the actual rotating system and the consumer can decide what will be grown within the system. The Volksgarden has been incorporated into the Green Spirit Farms in Michigan to help produce food that can be sold locally. When the systems are incorporated into larger scale farms or in homes they start to serve as an educational tool where people can see how food can be produced within a manageable system and for a reasonable cost. As the systems continue to be installed in different settings people will begin to learn more about how vertical farming is possible with minimal space. The Volksgarden not only comes in a variety of sizes but can also be stacked and in some cases function as a produce carousel system.

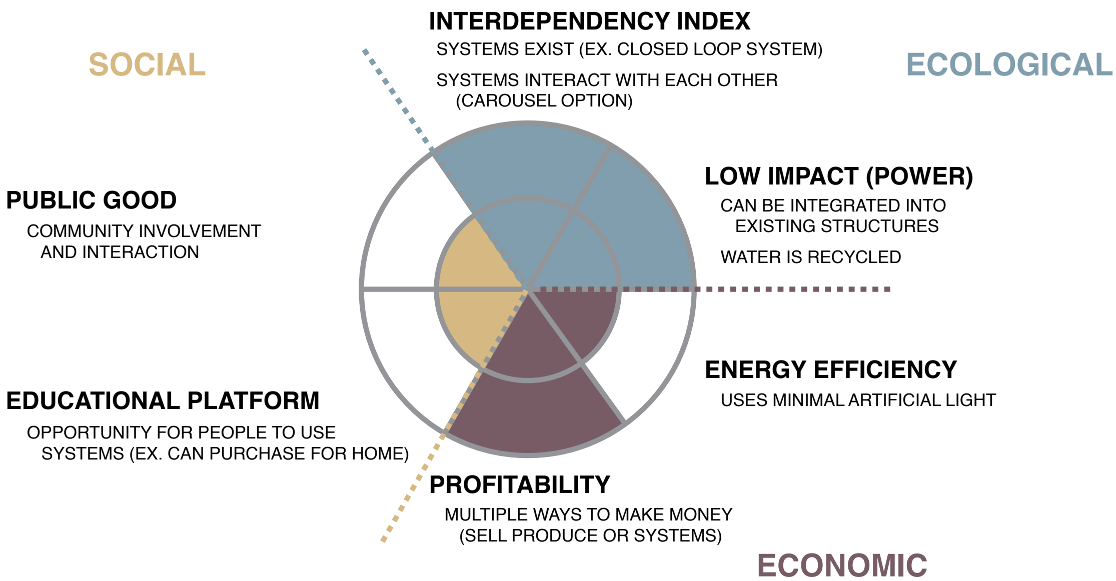

Figure 5.9. Omega Garden Criteria Evaluation (author by diagram)

The Plant in Chicago, IL is considered a second generation of vertical farming because of the programs offered and the extent of how the different systems within the building are working together. The Plant operates in a previously abandoned warehouse in the back of the Yards (old meatpacking area) in Chicago. The farm revitalized the area by utilizing the abandoned building, but also due to the variety of events and tours held on site, helped boost the sense of community in the area including food truck events, a farmers' market, workshops that focus on aquaponics and mushroom growing, and public tours are offered. While the range of programs offered is extensive, currently the plant is often closed and tours are offered once a week. The systems within the building range from aquaponics, to kombucha brewing, to fungiculture, to a variety of stores that rent space within the building and sell their products at the Farmers' Market and to local stores. The systems and stores were chosen based on what they were producing and how they can work together. Many of the systems work together, for example the barley from the beer brewing feeds the tilapia and in the near future the waste from the stores and restaurant feed into the anaerobic biodigester which produces energy for the restaurant (currently using a miniature anaerobic biodigester). There is also a company called Bike-A-Bee which is focused on housing different bee hives in community gardens around Chicago which serve as educational tools and public examples of pollination. The Plant is very successful in interacting with the public and generating a profit but is only partially meeting the criteria for energy efficiency and being low impact. The farm is predominantly growing produce through aquaponics which requires artificial light when they have an outdoor space where some of crops could be grown using natural light. The downside is the building was heavily renovated to achieve a space to house some of the different companies and growing processes, in addition the anaerobic biodigester is still being examined the high amount of waste produced is not all being recycled, which negates the opportunity for the farm to be completely low impact.

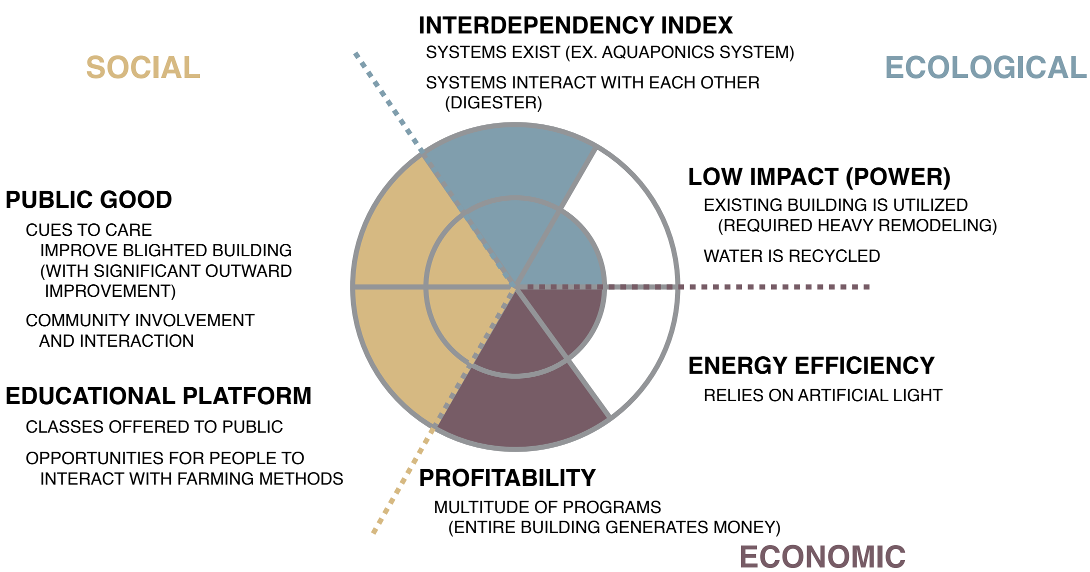

Figure 5.10. The Plant Criteria Evaluation (digram by author)

Brooklyn Grange consists of two rooftop farms in New York, one in Brooklyn in the Navy Yards and one in Queens. The farms vary in size but both are focused on

After reviewing the Criteria Evaluation diagrams it is evident that there are some systems that are working together and more sustainably than others. The Plant and the Brooklyn Grange systems are very successful because they are achieving all six pieces of the criteria on one level or another, but there are opportunities for improvement within each typological case study. Both systems have included social programs, such as tours or private events, which help elevate them to the second generation of vertical farming. Figure 5.12, seen on the next page, displays the eight different typologies Criteria Evaluation diagrams and it is evident where the most of the first generation vertical farming systems are not fully achieving most of the criteria. The diagrams also show how the majority of the second generation vertical farming typologies have evolved and are starting to have systems that work together and are starting to explore ways to include the community.

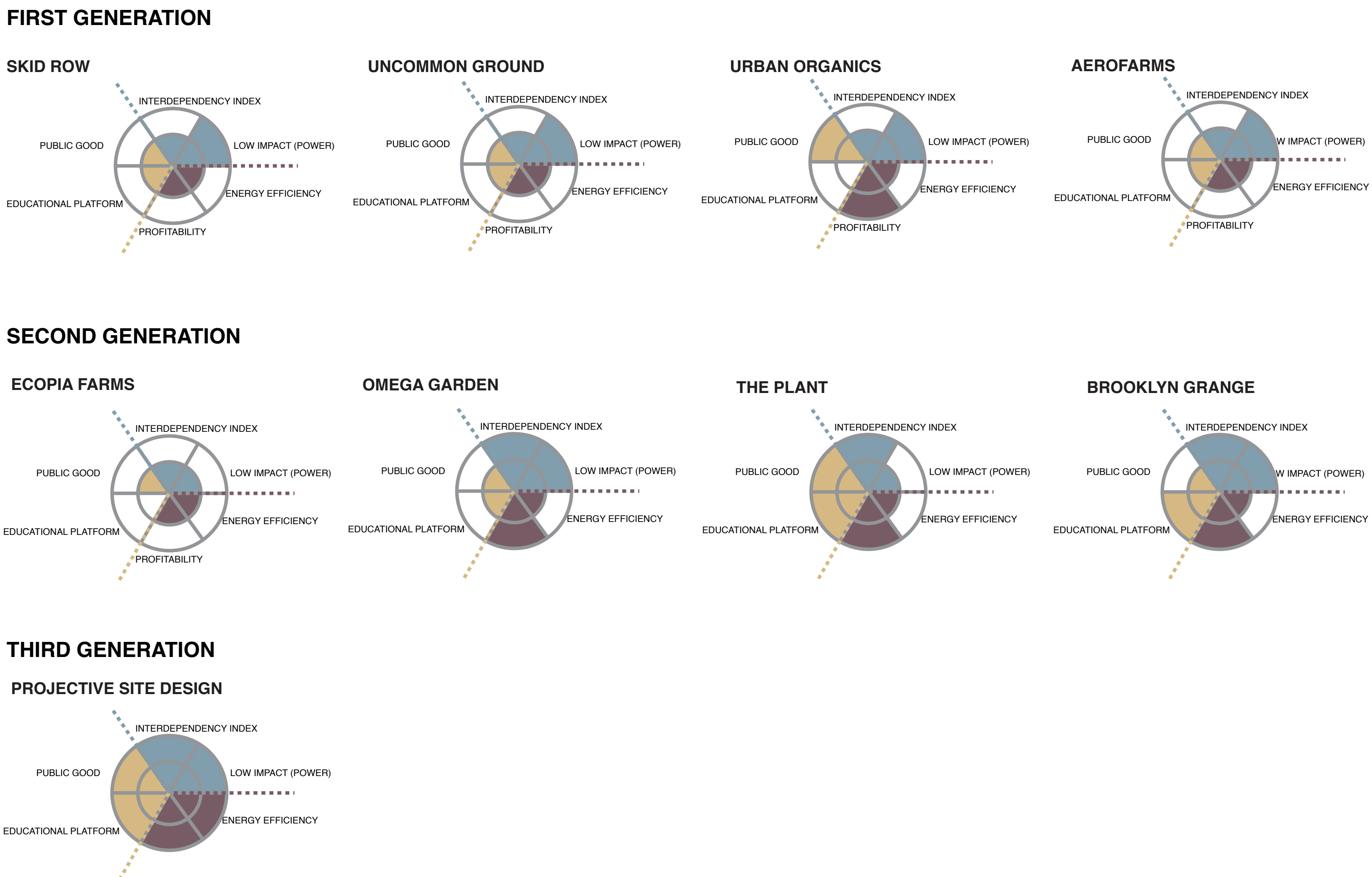

Figure 5.12. Case Study Criteria Evaluation Diagrams (diagram by author)

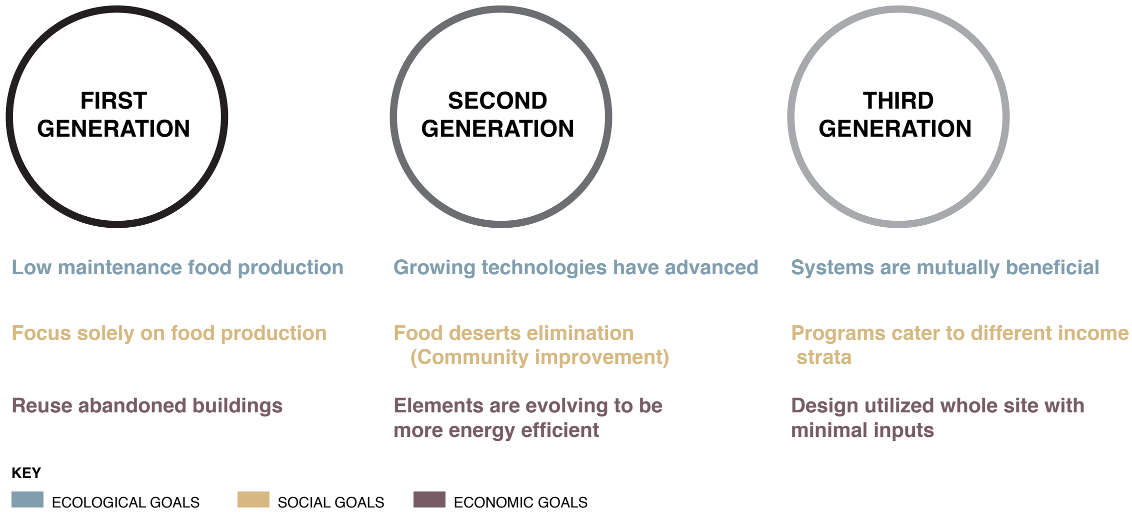

Figure 5.13. Goals of Each Vertical Farming Generation (diagram by author)

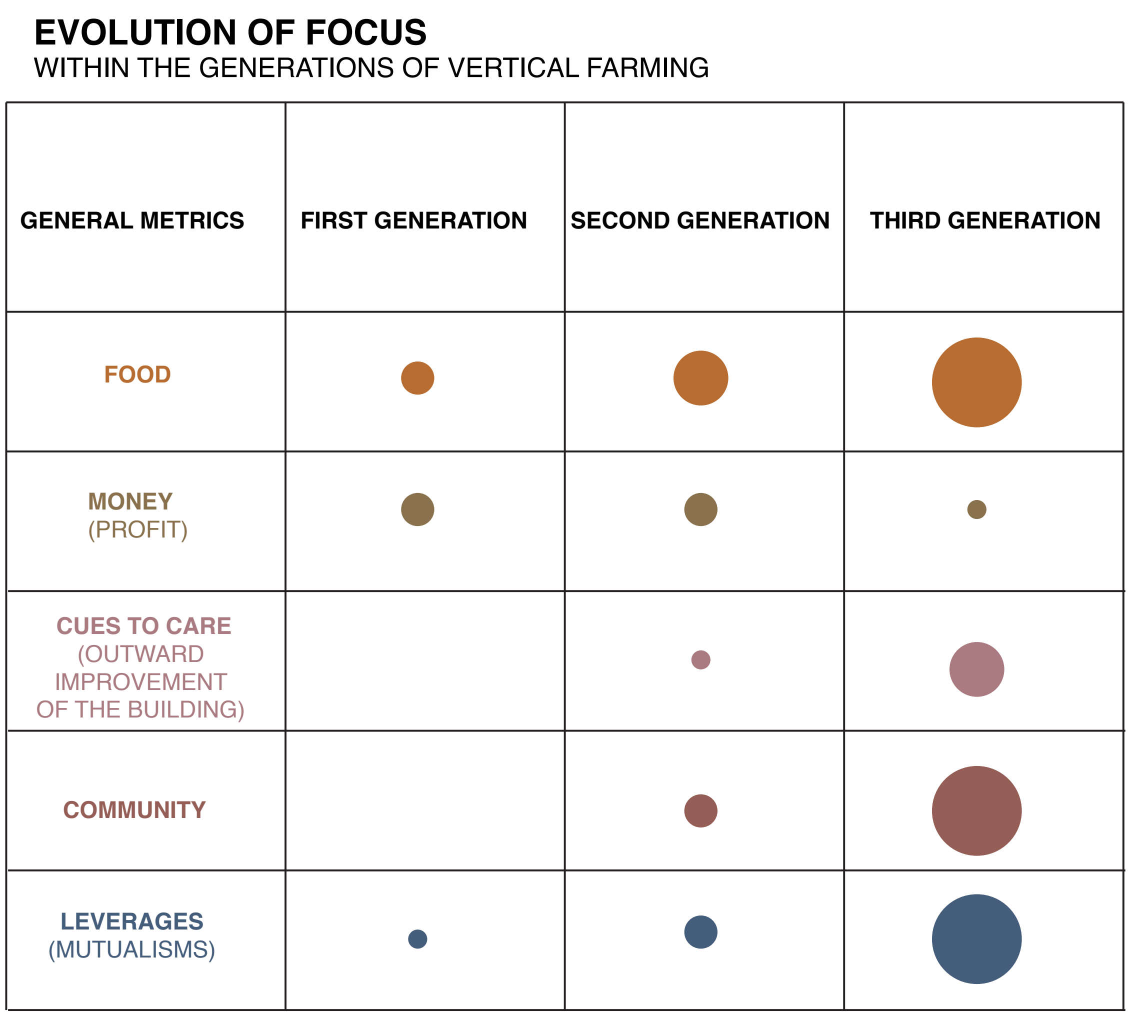

Figure 5.14. Evolution of Focus in Each Generation (diagram by author)

As you view the diagrams side by side, seen in Figure 5.12, it is evident that some systems meet the different criteria more successfully than others; this can be due to system goals, system interactions, and overall program. The first generation of vertical farms were stagnant in their programming elements. While some met the social criteria they lacked a system that had smaller systems working together. The first generation typologies helped provide a base of information on food production but the farms do not focus on aesthetics or integration of the community. The second generation of vertical farming begins to expand from solely focusing on food production to revitalizing areas, providing jobs, and eliminating food deserts. Each typology provides information for how vertical farming can expand going forward and each criteria analysis diagram shows where there are “gaps”; the next step is to address how improvements will be made.

Landscape architects can be instrumental in vertical farming evolving through the incorporation of social systems for different groups of community members and by designing a farm system in which the different elements are working together and helping to feed into one another. Through the study of different typologies and the analysis of which elements of different farming systems are achieving parts of sustainability the next phase of this thesis was to design a potential vertical farm in Atlanta, GA. The design is a loose concept that shows how different program elements can be included and how the programmatic design can lead to the system being not only sustainable, by achieving economic, social, and ecological success, but also regenerative.

CHAPTER 6

EDGEWOOD AVE ATLANTA, GA

Creating the Next Generation of Vertical Farming

After examining a numerous sites, a small two-story building adjacent to an under-utilized green space was selected for the projective design phase of this thesis. The building is located in a neighborhood that is shifting towards a youthful student and young professional environment because of the proximity to Georgia State University and downtown Atlanta. As seen in the analysis map, Figure 6.1, it is evident that the neighborhood is predominantly mixed-use and residential, which lends itself to areas of experimentation and expansion. A seen in Figure 6.1, the variety of building typologies, the diverse community, and the size of the site makes 5 Boulevard Ave SE Atlanta, GA an ideal location for a vertical farm. There are currently not a lot of options to purchase food in the immediate area surrounding the farm and the shift in demographics opens the door for trendier or more experimental projects to exist in the area. A vertical farm would not only provide fresh produce and herbs to the local bars and restaurants, but the other program elements could help serve as teaching tools for a variety of workshop or event opportunities. The building and adjacent green space provide an adequate space for a variety of program elements to coexist, ranging from a space for social gathering, outdoor gardening plots, and aquaponic systems.

Using the analysis of the eight typological case studies it was evident that for a vertical farm to be wholly successful ecologically, socially, and economically, a variety of systems must be in place. The systems must range from different growing methods, to a plethora of systems involving and educating the public, and they must utilize different aspects of the site (for example, using the indoor and outdoor space). In addition to the necessity of a variety of systems being present, it is equally important that the systems are interdependent and work toward functioning as a larger system. The Plant in Chicago, IL is a prime example of how different program elements were chosen to come together and be mutually beneficial. The brewery waste feeds the tilapia, which produces oxygen for the plants. While this is a very specific example and may not be able to be achieved in each case (depending on funding or spatial configurations), it does reflect how different systems need to interact and this interface should be kept in mind when designing a vertical farm. The Edgewood site offers a large amount of space for different program elements. There is a bonafide green space adjacent to the building, which should be acquiesced and utilized as a public event space and for a variety of garden uses. The range of program elements must spatially be compatible, so including a space with indoor and outdoor options is ideal.

The projective design is focused on creating a space that can be utilized by a variety of groups of people at different times and with the capacity to produce a variety of vegetables and other products during all four seasons. Throughout the design process it was crucial to focus on why certain elements of the eight typologies were unsuccessful. Was it due to the fact that certain criteria were not a goal of the farm or was it a more complex reason? Through analyzing the typological case studies against the criteria it was evident which systems had which gaps and how they could be improved upon. The projective design shows how a farm can be both productive and serve as a platform to inform the public as well as better the surrounding community.

The site is located on the corner of two busy roads, Edgewood Avenue and Boulevard Avenue. This location offers three facades of the building for the vertical farm to monopolize and create a street presence, the importance of which takes into consideration what is happening on the outside of the building as well as what is taking place indoors. In order to draw attention to the building and outdoor space, a mural is proposed on the west side of the building, and will have a sight line through the trees and visible from Edgewood Ave. A green wall is proposed on the east side of the building, adjacent to Boulevard Ave. The green wall can also assist with the heating and cooling of the building because of the ample morning sunlight it receives; conversely, the west side is partially shaded from the row of existing trees bordering the sidewalk and makes for a more aesthetically pleasing space.

The outdoor space, measuring roughly 9,300 square-feet, consists of a potential tent event space, a native meadow grass garden, a rain garden, flower plots, a variety of fruit and vegetable plots (produce can range from greens to potatoes to tomatoes and more) and an apiary. The variety of gardens not only serves as an oasis for the public from the surrounding urban spaces but it provides an educational platform in addition to producing food during the spring and summer months. The natural prairie grass garden can serve as a habitat and aid in the public awareness and understanding of succession and the potential natural habitat of “lawns”. The rain garden can help with runoff from the building (if the drainage system is restructured on the roof of the building) and can also show how people can improve their impervious spaces or yards with heavy runoff through the addition of a rain garden or swale. The flower, vegetable, and fruit plots can produce a variety of seasonal options and through the composting site located between them and the soil can be engineered and tweaked to be suitable for all different types of crops. The apiary serves three main purposes: 1. The bee farm can be an educational tool on the pollination process, 2. The bees can help pollinate the flower garden and vegetation in the rain garden, and 3. The bees will produce honey, which can be sold to local companies or on site (at a farmers' market). The outdoor space provides options for production and events to take place and it is supplemental to the indoor systems. The outdoor space would not be successful on its own due to weather restrictions. (Green roofs are not accessible at all times.)

The indoor activities must work in conjunction with the outdoor activities and this can be achieved by the systems feeding into each other or by acting as a companion space. The building is 1,400 square-feet and while it is not as large as some of the warehouses seen in other typological case studies the space can still be used efficiently to produce food and to provide adequate space for other activities. The first floor consists of two main program elements, a digester and an event space that faces Edgewood Avenue and acts as the main entrance to the building. The main event space can be home to several different types of events that range from workshops, cooking classes, private and public parties, and an alternate space for people to sit when outside is not conducive. The digester works in tandem with the composting area but on a larger scale. Waste from events and classes and the aquaponic system processed in the digester to produce energy. The green wall allows for a naturally climate controlled space for people to learn and enjoy the products of the farm. The second floor consists of different stacked plants, an aquaponic system, and a small-scale kombucha brewery. The stacked produce saves space allowing for easy monitoring and adjusting of the growing system and climate. The minimal soil use is crucial in eliminating pests. A rotating system may be used to not only allow trays to be stacked for saving space, but the rotating system allows for minimal artificial light. The aquaponic system serves two functions: produce can be grown all year round in an energy efficient system and the products (produce and fish) grown can be sold. The kombucha brewing system can produce "waste" which would feed the fish and filter to the digester. In addition the kombucha can be sold at events or farmers' markets on and off site. One additional option is to restructure the roof to have ample windows so that artificial lights are used when natural light is not available, hence transitioning aquaponics to being more energy efficient.

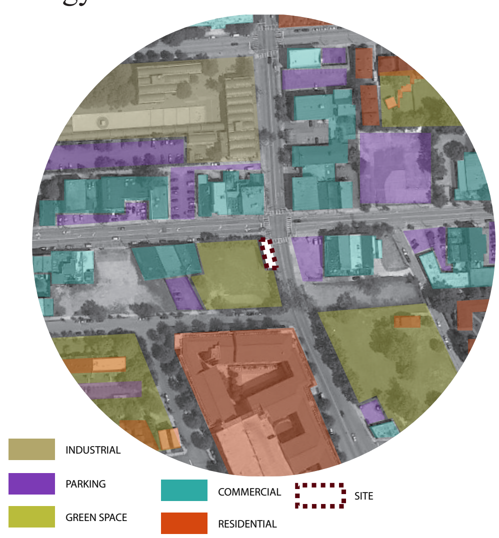

Figure 6.1. Projective Site Inventory and Analysis (diagram by author)

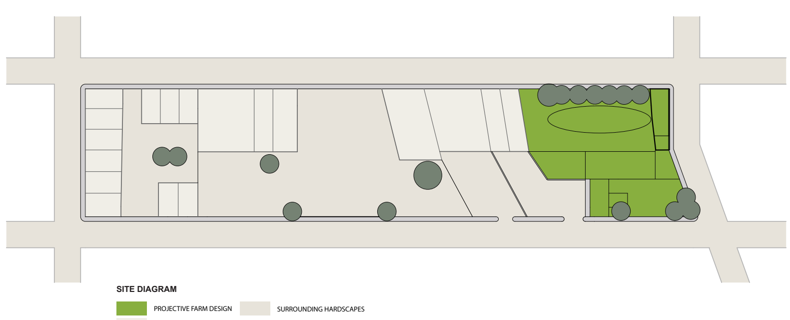

Figure 6.2. Site Plan (diagram by author)

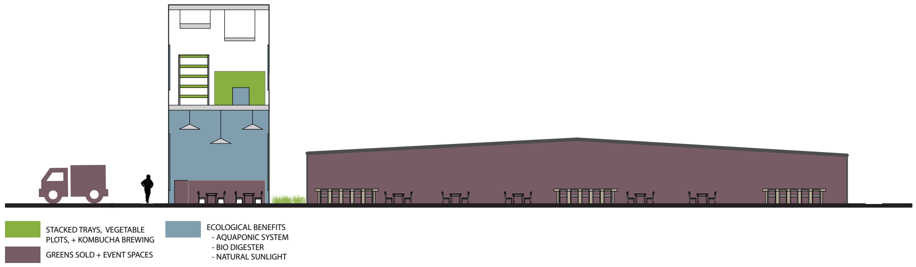

Figure 6.3. Site Evaluation Section (diagram by author)


Figures 6.4. Photo of side of site (photos by author)

Figures 6.5. Photo of front of building (photos by author)


Figures 6.6. Photo of side view of the building (photo by author)


Figures 6.7. Photo of potential green wall location (photo by author)


Figures 6.8. Photo of the back of the building (photo by author)


Figures 6.9. Photo of the current green space (photo by author)

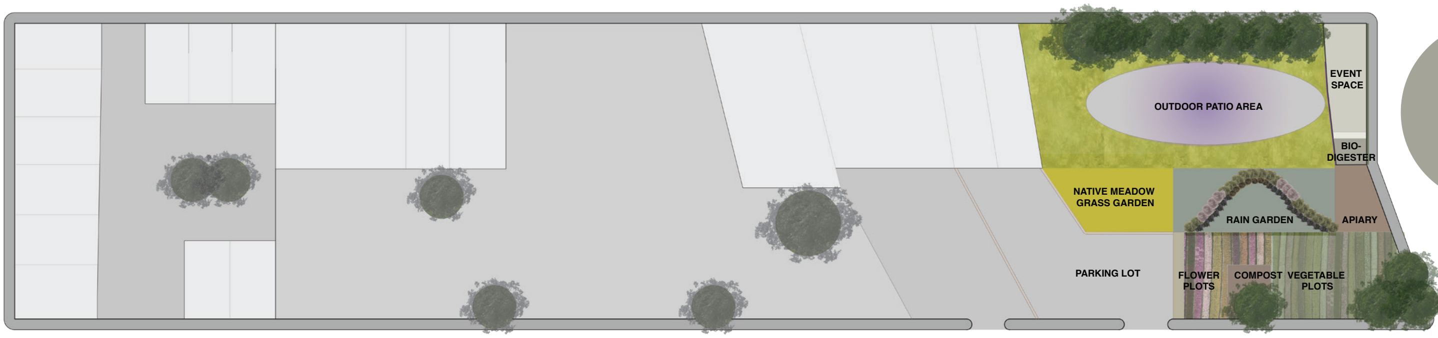

Figure 6.10. Projective Site Plan (plan by author)

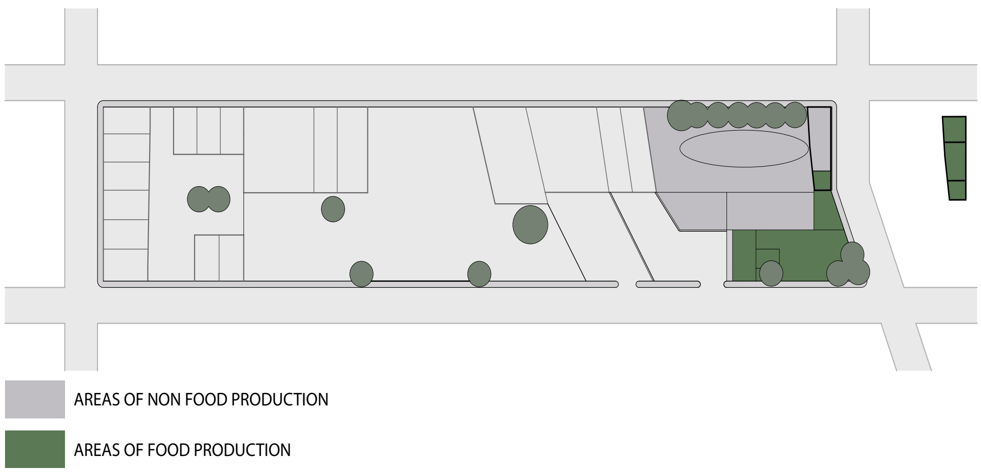

Figure 6.11. Food Production Diagram (by author)

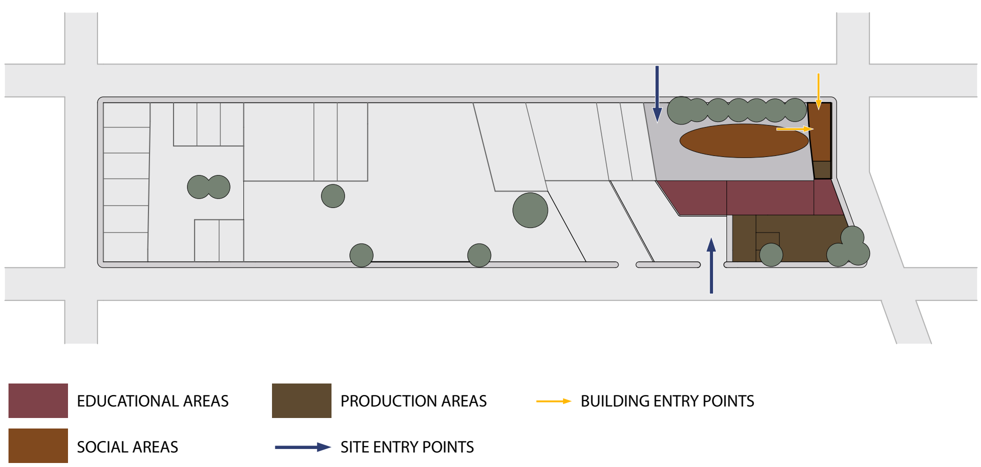

Figure 6.12. Program Elements and Entry Points Diagram (by author)

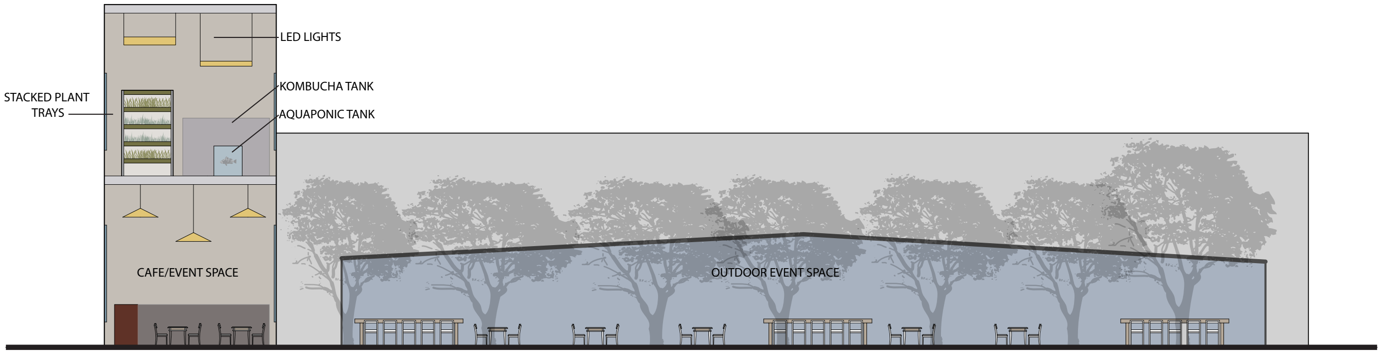

Figure 6.13. Projective Design Section (section by author)

Figure 6.14. Collaged Site Rendering on Boulevard Ave. of green wall (rendering by author)

Figure 6:15. Collaged Site Rendering of Outdoor Space (rendering by author)

As seen in Figure 6.1, the site plan, the different systems are integrated in order to achieve a successful vertical farm. It was important to focus on selecting systems that complemented each other and could be achieved in the spaces available. The mixture of indoor and outdoor spaces was key in making this design work, several of the typologies were only utilizing limited space and that hindered how sustainable the farms were. In addition to the projective design fitting sustainability criteria, it was important for it to serve the community. Community buy-in not only leads to profitability but it also creates a space that people are interested in visiting and are vested in its the success. The goal of any design is to make sure it can evolve and that is has the support of the community; it must be regenerative for it to be successful. The varied programing allows for seasonal changes and/or adjustments to be made in the event of changing demographics within the area and therefore honoring the needs or preferences of the public. It is important for some elements of the design, such as the outdoor garden elements or indoor space, to be flexible in order for the systems to continue to be mutually beneficial while the others such as, aquaponics or the digester, are more permanent in order to focus on year long production. The feedback diagrams below, Figures 6.16 and 6.17, show how the different outdoor and indoor systems work together and feed into one another.

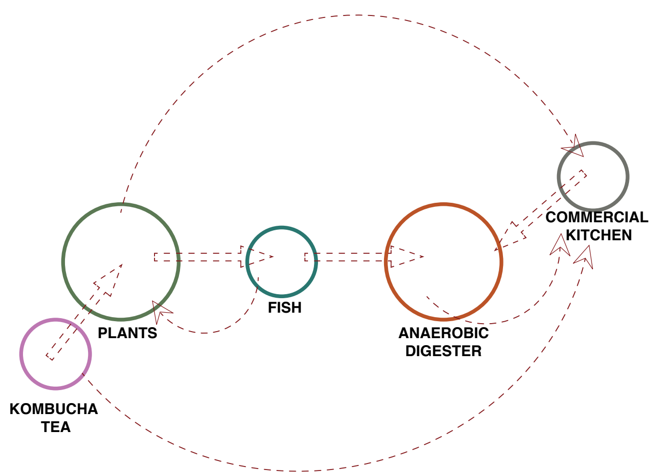

Figure 6.16. Third Generation Vertical Farming - Indoor Feedback Diagram (diagram by author)

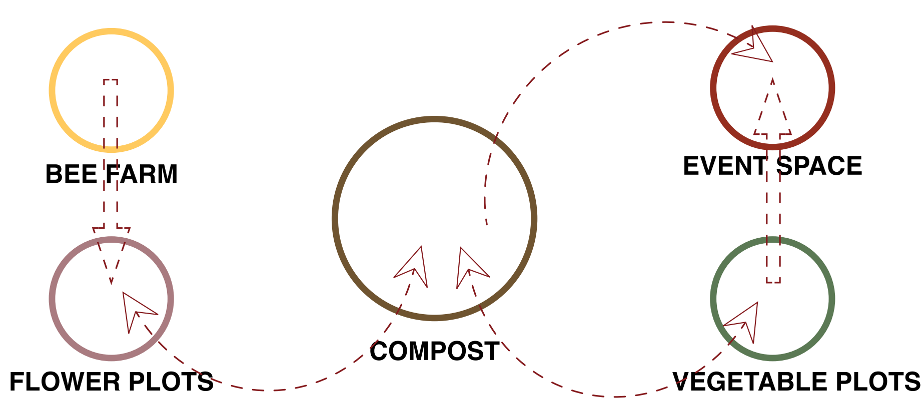

Figure 6.17. Third Generation Vertical Farming - Outdoor Feedback Diagram (diagram by author)

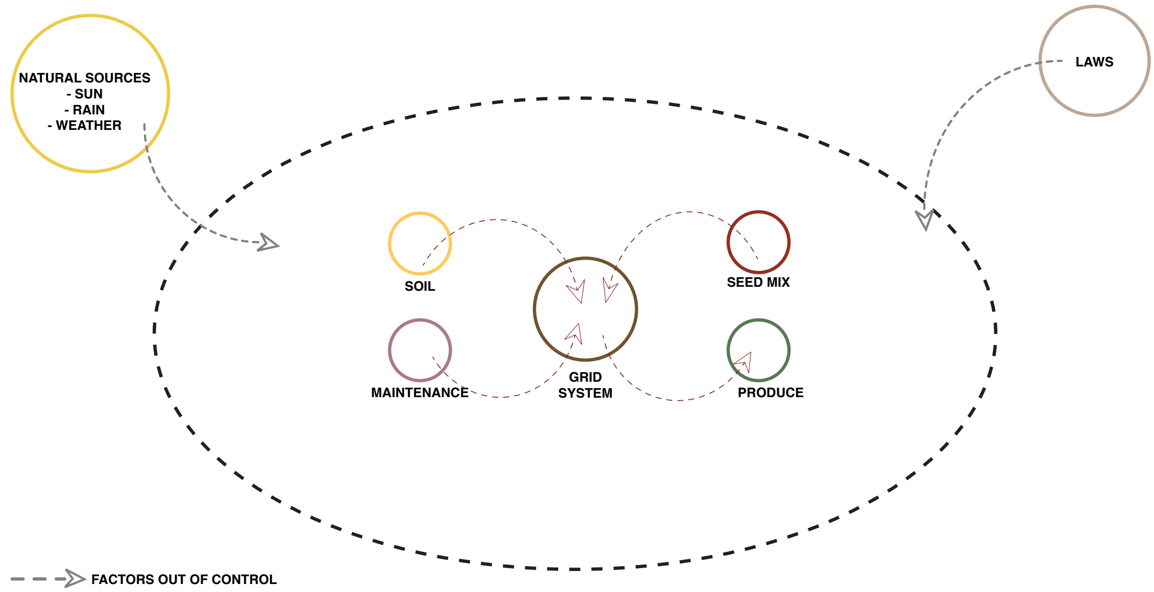

Figure 6.18. First Generation System Feedback Diagram (diagram by author)

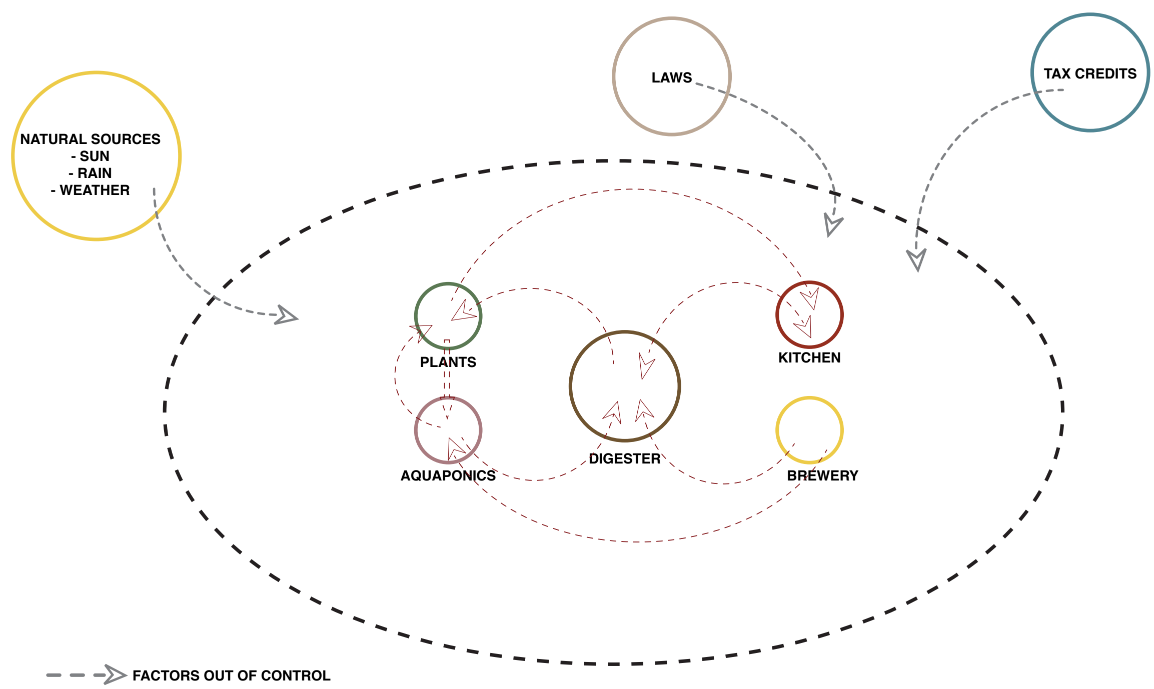

Figure 6.19. Second Generation System Feedback Diagram (diagram by author)

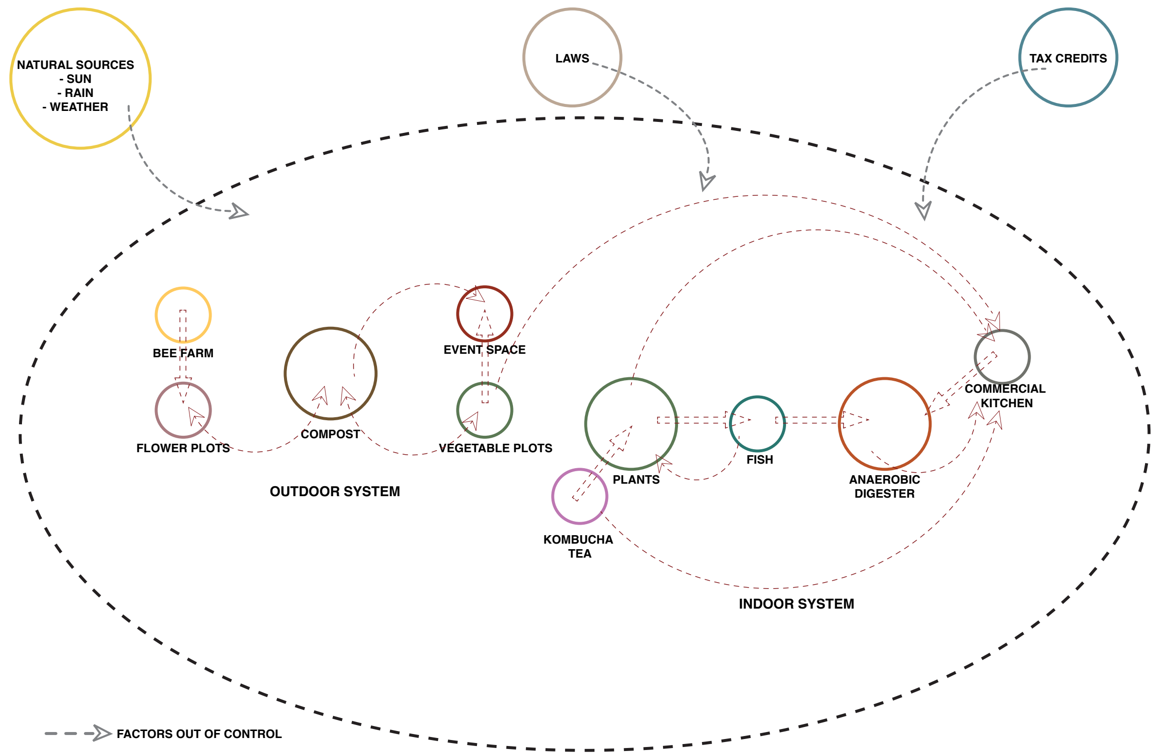

Figure 6.20. First Generation System Feedback Diagram (diagram by author) (diagram by author)

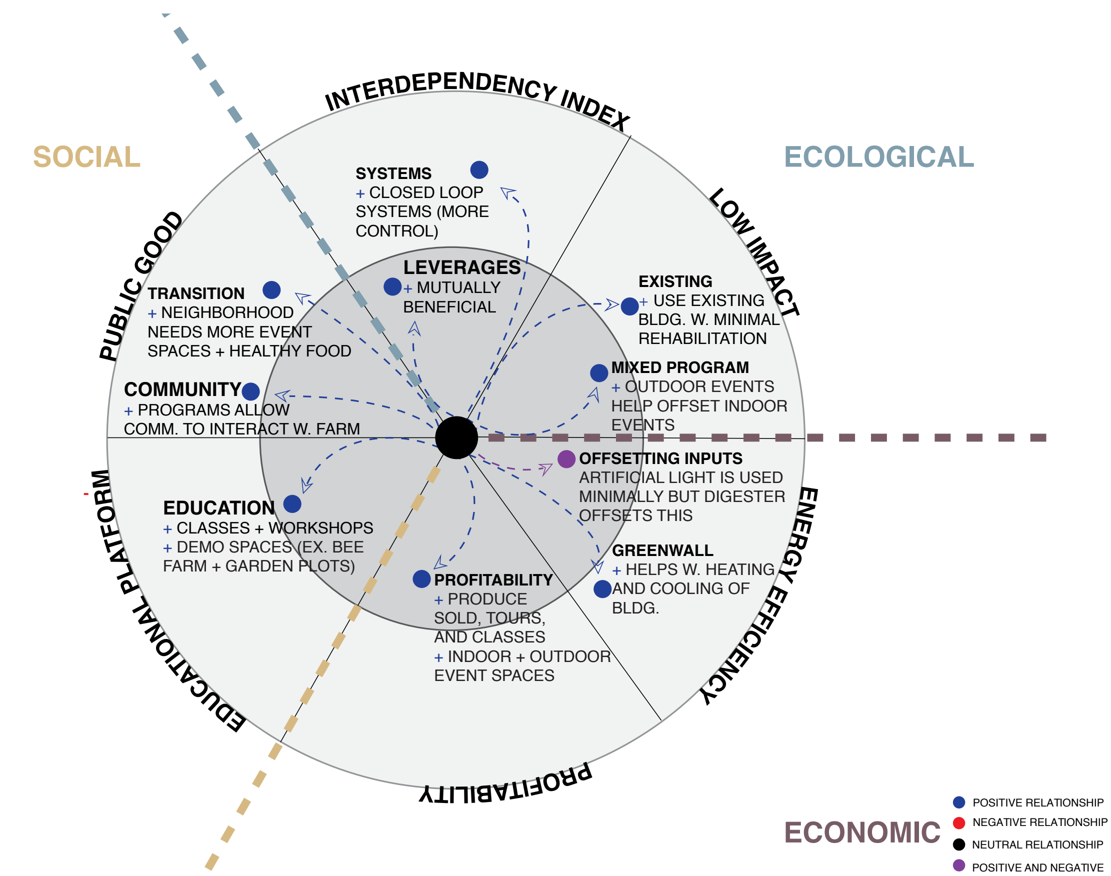

Figure 6.21. Projective Design Relationship Feedback Diagram (by author)

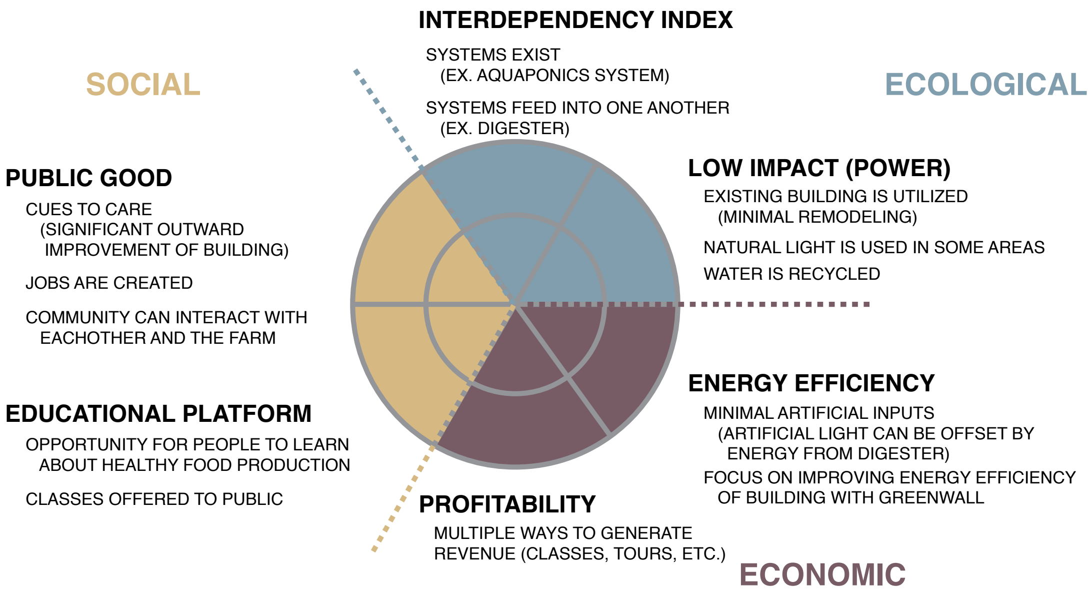

Figure 6:22. Projective Design Criteria Evaluation (digram by author)

The projective design in Atlanta, GA theoretically meets all of the criteria, as seen in the diagram above. In order to know if the design would actually work, it would need to be built and the technical aspects would need to be configured. The design achieves all of the criteria through the use of the indoor and outdoor spaces. The farm uses minimal artificial inputs and offsets them by using natural light for outdoor crops. There are minimal inputs and the system strives to reduce water (aquaponics) and energy (the digester). The outdoor and indoor event spaces offer areas for a variety of community activities to take place; whether it is a farmers' market, a food truck expo, classes on bee farming and pollination, or composting classes. The range of systems offer a platform to teach the surrounding community about different food production techniques and what to do with the different products (fish, produce, flowers, honey, etc.). The system would not work as efficiently if the program elements weren't designed to feed off of one another. The elements were chosen based on what they would contribute and what they need, and were placed on site depending on their surroundings. (For example, the outdoor garden plots, composting, and bee farm are all near each other so that they can work together to produce.) A systematic approach was taken to create a design for the next generation of vertical farming but there are still challenges for landscape architects moving forward.

CHAPTER 7

CONCLUSION AND EVALUATION

Integrating Landscape Architects into the Creation of Vertical Farms

As discussed in Chapter Two, vertical farming is beginning to shift and evolve to focus on aspects other than low maintenance production. The majority of vertical farms in the U.S. are functioning at building-specific levels instead of integrating the system into the surrounding community. As mentioned in Chapter Six, a successful and regenerative vertical farm will not exist unless there is community buy-in; meaning, the community must have a connection to the farm. Other technical issues must be addressed in addition to programming. Cary Mitchell, a professor at Purdue University, claims that vertical farming is ridiculous from an energy standpoint (Doucleff 2013). While there are currently some energy restrictions, such as lighting efficiency, there are ways to let the programming of the system either ease or eliminate some of the functions that require a lot of energy.

While vertical farming has made great strides in the past few years, it is necessary for the systems to continue to expand and grow. Some of the "first generation" farms are stagnant because they were not designed for the future; they were designed solely with production in mind. The "second generation" farms evolving by creating growing systems or programs that move past growth and focus on systems and people. Landscape architects are essential for vertical farming for the next generation, continuing community involvement, spatial planning, and creating energy efficient systems that all work together and benefit one another, and incorporate an engaging aesthetic. As mentioned previously, it is key that vertical farms are planned for the future and have a design that can be transitional and adaptive to the needs of the surrounding neighborhood.

The focus of this thesis was to analyze the past, present, and future of vertical farming through a detailed history, a comprehensive list of case studies, and through a projective design with the inclusion of the inputs of a landscape architect. The information provided in the case studies and analysis portion, Chapters Three through Five, are beneficial to a variety of different groups in the context of vertical farming. Currently, there is not a comprehensive study of typologies, which makes it difficult to understand where vertical farming began and how it has evolved. The analysis of the different farming typologies helps to define what the next direction or step of vertical farming. The projective design portion, Chapter 6, of this thesis focused on a loose diagrammatic design with two main goals: a strong interdependency index and the inclusion of community within the design program. The design is effective because of the elements that function as educational platforms and areas of production. The site lends itself to an indoor and outdoor design, which is key in creating a low impact and energy efficient system. The design was created due to research and proven facts about certain growing methods; however it would need to be examined more thoroughly in order to understand and know if it would actually function as a vertical farm. The technical aspects of each program element were not completely addressed due to lack of existing information and time restrictions. In order to thoroughly understand the technical elements of how the systems would work together and with the building itself, the design would have to be more extensive and that was not feasible within this thesis.

In order for vertical farming to evolve to the next generation, the program elements must shift focus and the systems must work together more efficiently, landscape architects can help achieve these goals. Landscape architects continually strive to address sustainability whether that is through installation of rain gardens or through material choice. Landscape architects can help with the progression of vertical farming methods by looking at new ways to combine growing techniques to be more efficient or through creating new lighting techniques. The different methods used today are starting to become more efficient and requiring less outside inputs but there are still strides that need to be made to make sure that the systems ecologically and economically successful. The systems also need to begin to work together if the entire farming system is to be sustainable and regenerative.

The different program elements need to become not only more efficient in how they interact, they also need to shift to include the community. It is important that the different food production systems start to work together and feed into one another in order for the overall farm system to begin to become regenerative, the design should have the elements located in areas where they can interact with one another. In addition to the program elements becoming more systemic, a social element must be addressed in order for vertical farming to evolve to be more sustainable and regenerative. The social aspect was being neglected in the first generation of vertical farming typologies and is beginning to be addressed in the second generation. By integrating the community into the design and creating programs that they can interact with the vertical farms will not only be more sustainable but the community will care about the farm. When community members feel a connection to a space they will visit more often which can lead to increased revenue for the farm, especially if there are classes or other events being offered, and the surrounding neighborhood will be improved. If vertical farms start to include aesthetic elements in their design then the surrounding community will react positively; aesthetic elements can include creating external spaces people to use or by rehabbing the building so that visual characteristics are improved. Landscape architects are skilled at engaging the public in both subtle and obvious ways, which is important for the community to be involved with the program elements and the aesthetic elements. By creating different areas of experience, like the outdoor event space surrounded by natural grasses and bee farms, people will begin to feel a connection to the site and want to learn more about the program elements.

A continuing challenge for landscape architects will be balancing the aesthetic value and the technical aspects of food production. The aesthetic elements are important within a design because it will help bring people to the site and create a "buzz". In addition to aesthetic elements, such as murals or materiality, the event spaces are very important because they create a space for people to congregate and interact with the farm and site. The diverse growing methods are key to ensure food production all year long without relying on artificial lighting or a lot of additional inputs. As argued in this thesis, the balance of social elements, ecological factors, and economic success will create a new generation of vertical farming, one focused on regenerative design.

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