Community and Vertical Farm

"Sensory Garden Community Gardening Clip Art - Fruit Garden Cliparts - Unlimited Download. Kisspng.com." Kisspng.com, www.kisspng.com/png-sensory-garden-community-gardening-clip-art-fruit-188818/download-png.html.

Zixuan Kang, Marine Maisonneuve, Bhanu Garg, Kyle Wengryn, Colin Stewart

ENGL 1101-L2 Liminal Spaces and Obscure Places

Instructor: Dr. Alexandra Edwards

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II. Project summary

The idea that we propose is to transform half of the Burger Bowl (green field) into a student sustained farm. This student sustained farm revolves around the concept that students who volunteer can receive free fruits and vegetables and the leftover fruits and vegetables can be sold to the general student body to support funding for the farm.

With the use of a greenhouses, fruits and vegetables would be accessible in winter seasons and there would be reduction in the carbon footprint by decreasing transportation. Furthermore, this renovation is expected to improve the overall health of the student body by providing accessible fruits and vegetables. By analyzing the societal, economical, and environmental benefits, it can be clearly stated that this is a sustainable project.

One section of the field will be a traditional farm. By having the students run the farm, the farm requires minimal maintenance by a third party. Students who decide to volunteer can also gain valuable experiences in running a farm. The student sustained farm proves itself to be beneficial from the point-of-view of two parties: school and students.

Another section of the field will be a vertical farm built inside a greenhouse. This would allow for research on vertical farming and its sustainability. Vertical farming is a relatively new concept, and the farm's productivity compared to traditional farms and sustainability are largely unknown. Numerous experiments and more evidence are required to form a valid conclusion, and this project provides researchers an opportunity to gather data, analyze it, and apply them in future experiments.

After funding is secured, planter boxes can be built with the help of student volunteers. The greenhouse is going to be built with an outside contractor, but the inside can be set up by current students and professors providing valuable hands-on experience applicable in the real world.

Once the the farm is constructed, it will become an ongoing project with an emphasis on student learning and feedback. Surveys would be critical to gauging the effectiveness of the farm and what could further improve.

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A.General Plan

Introduction

According to recent research published in The Atlanta Journal-Constitution, the Georgia Tech campus is a food desert which is defined by the U.S. Department of Agriculture as low-income communities located more than one mile from a reliable source of fresh produce and other healthy whole foods, and so it is. It's not surprising that you need to walk nearly one mile to either one of the Publix near campus to buy some fresh strawberries or lettuce. What's worse is that we still can not be one-hundred-percent sure that the products there are fresh and nutritious as depicted in the advertisement. In order to ameliorate the situation, we are going to transform half of the Burger Bowl Field into a collection of vertical gardens where people can plant fruit trees and different kinds of vegetables in their greatest convenience. It doesn't mean that the university will pay more money to hire trained and highly-qualified staff to manage the farm, as the whole project will be student-based, which means it will be operated, managed and harvested only by students. To achieve this goal, we divide the whole plan into four phases, namely the design phase, the validation phase, the troubleshooting phase, and the expansion phase.

Sherlock Worldpress. "No burgers at Burger-Bowl Field Really" The Social? Georiga Tech, https://sherlocck.wordpress.com/2014/09/04/no-burgers-at-burger-bowl-field-really/

This is the Burger-Bowl Field currently, the land to be used by the farm is to the left of the walkway.

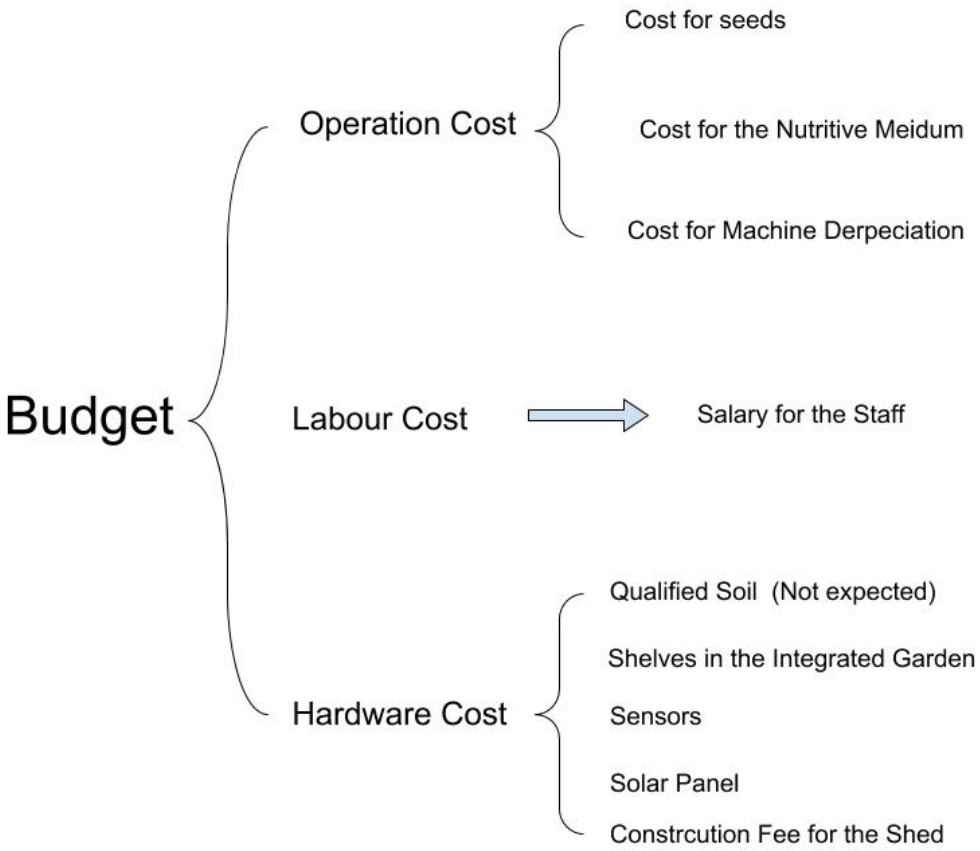
Phase 1: Planning and Designing

We have fully noticed that residents on the west campus love to do sports and entertainments during leisure time in the Burger Bowl Field, and this project will take half of the Burger Bowl's area. We anticipate that there will be an arduous debate since this decision will have a huge impact on their life. As a result, the first thing we must address is the concerns of the west campus community. To reconcile the conflict of interest, and we will try our best to achieve an agreement about how to best take advantage of the lands.

At least three months before the meeting, posters will be posted throughout the campus to inform people that there will be such an event happening and assure that they have an explicit notion of what we are going to do and our goals. The next step is to conduct a poll among the students. We will make sure that the number of residents on the west campus who get polled is at least two times more than the number of residents on east campus since the west campus is more influenced. Every respondent will be required to provide us with brief comments so that we know what concerns them the most.

We are also fully aware of the fact that there is already a community garden on campus, but it is very different in the design and intention of our project. That garden mainly focuses on permaculture which emphasizes the integration of human and nature and the main method they plant is through traditional farming (Visit https://sos.gtorg.gatech.edu/georgia-tech-community-garden for more information) whereas our project concentrates on the supply of fresh fruits and vegetables which enables people to get more healthy food in great convenience. We will discuss more deeply into the comparison and offer solid evidence to prove that later in the document.

The budget approximation which includes the operating cost, the labor cost, and the hardware cost will also be conducted during Phase 1 since it's important for us to apply for sponsorship. We will design this project to be an on-campus job which implies students will be paid monthly. The cost of buying a whole system from a blue chip, such as IntelinAir, Indigo AG, etc, is usually high and we don't really need such high-tech equipment to operate the farm. As a result, we will develop an App on our own to supervise the whole farm (temperature, humidity, etc.) according to the data we collected from the sensors on the farm. We will consult some major companies to decide the emolument level based on the data we will have collected as well.



Phase 2: Construction of the Conventional Farming Area and Testing

We decide to operate the conventional farm first since more people have the experience of managing a traditional farm and costs are much less than the integrated vertical garden. The construction and the recruitment will be ongoing at the same time period. We plan to utilize the upcoming summer vacation, when there are not too many people on campus, to construct the traditional farm and the spring semester before to get people involved in the project.

We are going to accomplish this through recruiting. Students who are quite interested in the program are warmly welcomed. Another way is to cooperate with the already existing community garden. We can work with them and some of their staff can sometimes help us. It won't take students who are admitted into the program not much time with the help of the sensors and the apps which will enable the whole system work by themselves. What the students need to do is observe, analyze the data on the phone and get involved when it is needed.

When it comes to construction, we will first assess whether the soil in the Burger Bowl Field is sufficient and qualified enough to support plant growth. If the soil is not suitable, we will buy the nutritious soil from somewhere else which may cost 48$ to 90$, or we can haul the dirt for free from a construction or excavation site. We don't expect to have problems through this process since the soil of the Burger Bowl Field has supported the grass to grow for a long time.

Kang, Zixuan, "Photograph of my farm.", 2016

This a part of the farm Zixuan Kang was in charge of in his high school.

The App development will take place during the summer. We plan to establish three technology groups, namely the user interface group, the back-end group, and the compatibility group. The people in charge of the development will be selected from who we recruited during the spring semester.

With all the hardware developed, we still need trees to grow. Since the growth cycle of a tree is too long, we will buy half dozen of seedlings and plant them behind the trees which are the leeward

side so that vegetables and fruits will be protected from the wind. Students are welcomed to buy the fruits at an approximately 20% lower than the market price and they are truly fresh and pure natural.

In addition to the construction, the test and should also be executed. Collaborating with the West Village Dining Hall will be able to improve the efficiency and productivity of the project. Since the farm is rather small right now, we can only support a few kinds of seasonal fruits and vegetables, but small also means the cost of fault is rather small. That will be a great opportunity for us to evaluate the vegetables and fruits we provided and improve the quality based on the survey from the West Village Dining Hall. The survey will be conducted during the time a person is waiting for his/her food and won't take too long.

Phase 3: Creation and development of the Vertical Farm

This part of the space is a major part of the transformation. It consists of a building where fruits and vegetables would grow off-season and in great quantities. In function of the technology used, the exterior of the building would be different. There are two types of efficient crop growing technology for vertical farming: hydroponic and aeroponic. If we used the first one, the building would be a rectangular glass box where vegetables and fruits would be positioned on circular shelves, as shown in the visualization 2, where water mixed with nutrients would be the method of growing crops: these plants would be soil free. This method would be cost-effective, with the ability to produce vegetables in greater quantity and in less time. An example of this method is the picture below.

Milliron, Luke. "*Hydroponic Strawberry Crop*". Spring 2010, Palmerston North, New Zealand, https://bit.ly/2OCTqNh

This is an example of a hydroponic culture of strawberries in New Zealand.

The second option would be a technology called aeroponics. It would be harder to implement and more costly in the short term. However, this technique, as for hydroponics does not require soil and has the advantage to use 98% less water than hydroponic farming. Additionally, it can produce vegetables up to 3 times faster, which in the long term would be more environmental-friendly and cost-effective. This set up would also require a rectangular building, but the materials could be more freely chosen. This is because the building would have red and blue LED lighting. By not using the yellow spectrum, the environmental footprint is reduced.

The vertical farm would require a constant temperature and humidity as well as an efficient system for air renewal. Plants would grow on the designed shelves so that we could increase our production capacity.

We would like the architecture students to design the outer structure of the farm (the structure would be reviewed several times) and involve biology majors as well as specific engineering majors. By putting the students in the center of the project and mixing several majors, we could have a better variety of ideas. We consider holding a contest for inventions related to the farm. The winners would have their technology reviewed and installed on the farm; it also would permit students to be more familiar with the project and lower apprehension for the project.

This part of implementation will be, by far, the most challenging and costly part of the project. However, this investment will be well worth it at the end (expanded upon in phase 5, Merit and Broader Impact). In addition, by separating traditional farming and the creation of vertical farming in two different phases; we will have more time to find sponsors for the development of the farm.

The environment that vegetables and fruits grow in will be fully controllable. We can improve the quality of the products based on a test period that will be conducted on a specific dining hall.

Phase 4: Creation of a Survey and Improving the Farm

After the traditional farming and the vertically integrated farm become mature, we will cooperate with the biology and the Environment Engineering Department and convert 40% of the whole base into a lab. Students and staff in the departments can use the lands for the experiment for free and the controllable environment can provide almost every “best condition” they want. The ideal conditions provided will help testing of the different areas and their potential for growth and expansion. This hands-on experience gained would be invaluable to students interested in this area of research and design. The various methods of farming in the field will give a good contrast between them and offers the optimal space to experiment. During this time students and staff may troubleshoot the workings of the farms and correct any inefficient processes.

cnrteaching. “Genetics and Plant Biology.” Employee Discipline & Termination, nature.berkeley.edu/advising/majors/genetics-and-plant-biology.

A testbed for plant paramter variation.

The ongoing revision of the farm will provide a sense of freshness to the design of the structure. To test the effectiveness of the farming techniques, the test performed would involve providing vegetables and fruits grown at the farm to a dining hall and inquiring students at the dining hall to fill out a short online survey. This survey would include questions pertaining to the quality of the product and its availability. The information gained would help in determining the scale of production of each type of fruits and vegetables. Additionally, this may provide evidence for the possible changing of nutrients for the plants or soil parameters.

The nutrients received by the plants are critical to their growth and yield. There are six major contributing elements along with many essential elements required only in small amounts. Potentially the most essential element for plant growth is nitrogen. It is found in all plant cells and can be directly put in the soil or absorbed from the air. Phosphorus helps plants transfer energy from the sun to their cells and hastens growth greatly. Potassium helps plants resist diseases and improves the fruit quality by facilitating the movement and production of starches, sugars, and oils in plants. Calcium is critical for root growth and health, along with the proper and healthy development of leaves. Magnesium is vital for photosynthesis as it is a key component of chlorophyll, the green coloring of most plants responsible for the absorption of sunlight to process into energy. Sulfur is heavily involved in the energy-producing processes in plants and is a large part of amino acids in plant proteins.

The trace elements necessary for optimal plant growth are measured in very small quantities and are lethal in large amounts. Iron is present in many compounds absorbed by plants that help regulate growth. Manganese is used in several processes throughout that plants including chloroplast development and photosynthesis. Copper constitutes part of several enzymes and assists in plant metabolism of proteins and carbohydrates. Zinc plays a small role in a wide range of processes, such as stem elongation and leaf expansion. Boron strengthens the cell wall and helps it develop quickly. Molybdenum is needed to synthesize proteins from soluble nitrogen compounds.

The composition of the soil underlying each plant is crucial to its correct and fast growth and has five key factors. The cation exchange capacity (CEC) is the number of negatively charged sites on the soil particles and a higher CEC is generally considered optimal for plant growth. The amount of organic matter present in the substrate is essential as an amount of four to five percent is the most fertile. The sodium absorption ratio (SAR) can be used to predict water infiltration problems and a SAR of greater than 10 is considered detrimental to plant growth. The pH of soil denotes whether the soil is neutral, acidic, or alkaline. Having non-neutral soil may cause problems growing certain types of plants with metal deficiencies being the most prominent issue. The electrical conductive (EC) measures the salinity of the soil, each plant's yield and growth will suffer above a certain EC threshold unique to each plant.

Given feedback from students at the dining halls caretakers of the farms would adjust the parameters to output the desired fruit or vegetable. With continued use of surveys and updated responses from students the farm would gradually improve and never stop innovating.

Phase 5: The Expansion and the Future of the Project

The fifth and last stage of the transformation of half of the Burger Bowl into a farming area would be future advances that are minimal but central to the project.

First, one of the primary aspects of the future evolution of this project would be technological advances. After the first installations that will make the core of the farm, we want the farm to make strides towards sustainability and autonomy. The first step to achieve autonomy is to implement sensors to monitor the farm activity. We will need several types of captors to acquire data on the plants' health. For instance, we would be notified if the plant lacked nutrients or if the plant had some type of sickness. This would allow quick resolution.

The second stage of technological advancements put in place to make the farm more sustainable and more environmentally-friendly would include the following. Initially, a rain collector to help with the water needed for the plants and solar panels could be installed on the roof of the vertical farm. If the farm is in the glass, we could put some new transparent solar panels on the windows.

The final category of technological advances is linked to the first two categories: cost-effective solutions. This project is going to be a big investment in the beginning. However, we can make it profitable with these solutions. By automating the farm, we need less labor and reduce the

variable cost of the farm. By making the farm environmentally-friendly, we would use less energy. By using the resources we collect ourselves, it will cost less money. Finally, we plan on developing the student market we mentioned in stage 2 by adding the products of the vertical farm and allowing students to buy off-season vegetables and fruits 20% less than the market price. This revenue would help lower the variable cost of the farm.

Tifotter, “weekly organic produce delivery”. January 10, 2007, https://bit.ly/2DlDYD8 .

Fruit and vegetable basket, delivered everyweek by a local farmer of the person’s area.

Even if it is another added cost, the creation of a delivery service could be really beneficial to the farm. Students could pay per semester the delivery of a basket of fruits and vegetables to their door. This system would have two great advantages. First, by having students paying per semester, it would assure an income for every month and because this service does not specify which vegetables or fruits we would give the students, we could give them the surplus the farm has. In addition, this delivery service would serve the health of the students. By being affordable and easy, students would be inclined to eat more healthy and be in a better shape.

The combination of all of these solutions will help make the farm a major part of Georgia Institute of Technology’s campus.

A final transformation to the place would be to add pathways, to make it a part of the prospective students’ tour. This part of the tour would be focused on ecology and sustainability. It would be a great way to appeal to future students; because the university would show how the current world problem is the main priority.

B.Merit

Merit of a Community Garden

Both a community garden and a vertically integrated garden are worth pursuing because of the impact they would have on the Georgia Tech community as well as scientific research.

An outdoor community garden, similar to the one already on campus, would allow for a greater amount of produce in the local Georgia Tech community. The current public resources on campus for fresh produce are the Georgia Tech Community Garden and the Klemis Kitchen. The current community garden underproduces and is not sustainable on a large scale. The Klemis Kitchen is currently also not sustainable due to a lack of permanent staff members, and failure to keep produce available. We want to improve on these and go beyond. A second large-scale community garden would allow for far more people on campus to have access to fresh produce. According to the Atlanta Journal-Constitution, Georgia Tech is considered a food desert. This means Georgia tech is a low-income community located more than one mile from a reliable source of fresh produce and other healthy whole foods.

The implications of a food desert are immense. Georgia Tech students are both low income and have low access to fresh produce. According to Drewnowski and Specter, “A consequence of poor supermarket access is that residents have increased exposure to energy-dense food (“empty calorie” food) readily available at convenience stores and fast-food restaurants” (Drewnowski and Specter, 2004). The lack of fresh produce causes the diet of students to mainly be processed foods with high content of processed fats, sugars, and excessive sodium. The lack of financial stability many college students face continues to worsen the situation. With the high costs and inability to access healthy food, it seems counterintuitive for students at Georgia Tech to pursue healthy food instead of getting food from fast food locations. The dining halls also provide very unhealthy options for most incoming first year students. The lack of transportation also plays a big factor in students ability to purchase food. Many students live on campus and do not own personal transportation. Although Georgia Tech does offer services like the Grocery Shuttle during the weekends, many students are short on time and can not take a few hours to go buy groceries. With low time, money, and lack of finances, it makes sense to always purchase food from the various fast food vendors Georgia Tech provides on campus.

Garden, Beresford. “Fwd: Beresford Park - Community Garden.” Flickr, Yahoo!, 4 Jan. 2015, www.flickr.com/photos/129424831@N05/16164369646/.

An example of a community garden.

Many college students have a lack of education about personal health and nutrition, and without education about nutrition, students will continue to have unhealthy eating habits. After listening to Kevin Lanza, a current Ph.D. candidate for City & Regional Planning at Georgia Institute

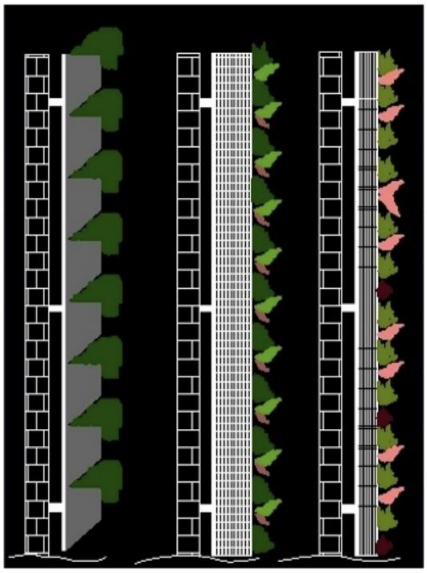
of Technology. Kevin talked about the positive benefits of urban agriculture especially related to community health. Race, location (urban, far away), gender affect food security for individuals. Urban Agriculture is growing, processing, and distributing, of food and other products. The environmental benefits are that plants filter air (ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead) while concrete heats it up. Benefits such as keeping money in town and local businesses; increases property value; social benefits such as increases community strength; public health like easy access, better mental health, and lower type 2 diabetes.

The location of Burger Bowl Field, west campus, near many of the Westside apartments, would give access to thousands of first year students and upperclassmen without meal plans. A community sustained garden also gives many a way to relieve stress. According to Hawkins, gardening is also seemed like a form of physical activity, and help reduce stress. only 43.6% of college students, according to the National College Health Assessment actually get physical activity. Gardening is an opportunity to for many college students to have social interactions, and relieve stress while getting physical activity.

Merit of a Vertical Garden

A vertically integrated garden, inside a greenhouse, is a great way for Georgia Tech to show research initiative in sustainability, and food production methods that require less space. Currently, the Agricultural Technology Research Program at Georgia Tech does research with automation, advanced imaging, and energy systems, among others. These projects can be adapted and further researched in a vertical farm. The conditions of a greenhouse can be controlled, and therefore, the perfect place to test different agriculture methods, sensor data combinations, and processes to maximize yield. There would be many more opportunities for students studying Environmental Sciences to have a chance to conduct research alongside engineers. According to Despommier, “Indoor farming offers many advantages over traditional soil-based agriculture; the most important one being total control of conditions necessary to achieve optimal survival, growth, and maturation of any given crop, thereby ensuring maximum yield per square foot of growing space.” With humans running out of space for farms, and an increase in population requiring food, vertical farming is a growing methodology that needs more research. The merit in Vertical Gardening lies in the opportunities available to all groups of students on campus. So many different groups can be integrated into the project, with EAS, Computer Science, Mechanical Engineering majors and more leading potentially revolutionary projects. Seeing projects such as yield maximization, best design, and data analysis would lead to so many opportunities for students on campus to make an impact in the real world.

Three of the biggest problems facing feasible vertical farming are economics, energy use, and pollution. Vertical indoor farming requires excessive energy to produce crops, both for lighting as well as temperature control. According to calculations, “ producing a head of lettuce and a quarter pound of fish in this model vertical farm uses the energy equivalent of more than eight pounds of coal” because of the excessive energy needed to heat, cool, and provide lighting for photosynthesis, normally taken care of by the Sun. In fact, the energy required exceeds the energy normally used for transportation of food across the country. Although solutions exist, there needs to be research on how to lower energy usage while maximizing yield, some research that could be done at Georgia Tech.



Widiastuti, Prianto, Setia Budi, Ratih, Eddy, Wahyu. "Performance Evaulation of Vertical Gardens." *International Journal of Architecture, Engineering and Construction*, Mar. 2016, www.iasdm.org/journals/index.php/ijaec/article/viewFile/233/230.pdf.

Several different types of vertical farms.

Again, in the rate of photosynthesis also require a necessary increase in carbon dioxide. Due to this, greenhouses often increase levels of carbon dioxide in the constructed atmosphere, sometimes solely burning fossil fuels for this purpose. Pollution continues to be a problem that could be solved with the help of research at Georgia Tech. Another example is the excessive use of water in a greenhouse, often containing supplement nitrates and artificial fertilizers. This water can not flow back into the groundwater and must be treated for contamination. These problems, including clean water recycling, and lower pollution levels could be solved on this very campus through a vertical farm.

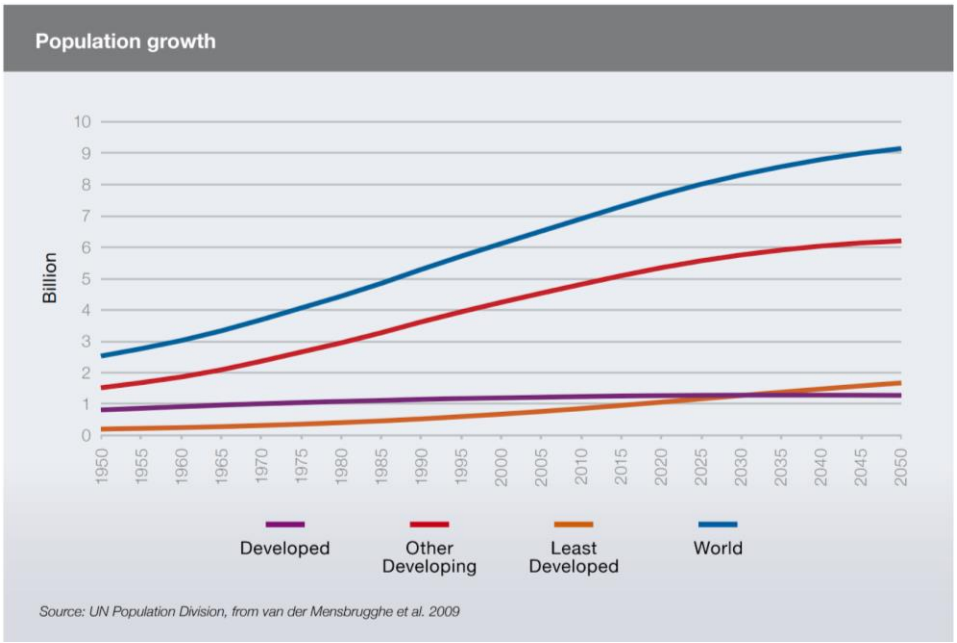
When energy, space usage, and pollution are problems with our current farming system, vertical farming can only be feasible if it is better than traditional methods. The one other problem with vertical farming is economic sustainability, and this can easily be studied with research alongside the dining halls. Considering the price for crops and the cost it takes to bring them to the dining halls, compared to the cost of producing the same amount in the vertical farm. With the projected population increase through the decades, feeding is the masses currently not sustainable. With vertical farming, it could be feasible to keep the population alive.

A community garden creates comradery, teaches students about nutrition, lowers stress, and is an easy way for students to have access to food living in a desert. A vertical garden creates an opportunity for Georgia Tech students to research methods of food production. Students can lead the way to make farming sustainable and yield maximum productivity, while still requiring less space than traditional farms. Both are great ways to get students involved in the Georgia Tech community and have broader impacts on this communities lives.

C. Broader Impacts

The local effects of the proposed vertical garden are only a fraction of the potential that the design holds. Integration of this system on Georgia Tech's campus will impact the entire field of alternative harvesting in terms of advancing knowledge in biology as well as the structural engineering involved in achieving the greenhouse effect.

First, agricultural biology is becoming increasingly vital to the movement towards sustainability in the modern world. According to the United Nations Food and Agricultural Organization (FAO), the world is on track to lose the resource capacity to feed the entire population as soon as the year 2050. The image below from the article predicts the population levels in countries of varying levels of development. All levels demonstrate gains of the population as far as the year 2050 with only subtle decreases in rate past 2035. Thus, the ratio of resources to people is decreasing rapidly and consequently increasing the demand for research in sustainability. The research garnered from this project would significantly improve current knowledge in sustainability and has the potential to increase the efficiency of future projects. Different soils, modified seeds, and growing conditions can all be varied to achieve maximum efficiency. Aside from the agricultural advancements, the garden would provide students with more opportunities to conduct research in an area they enjoy. Therefore, the younger generations in agricultural technology will be given an advantage in exposing themselves to their field. The long-term goal is to integrate this system into other university campuses worldwide and provide students of all levels of expertise more opportunities for research.

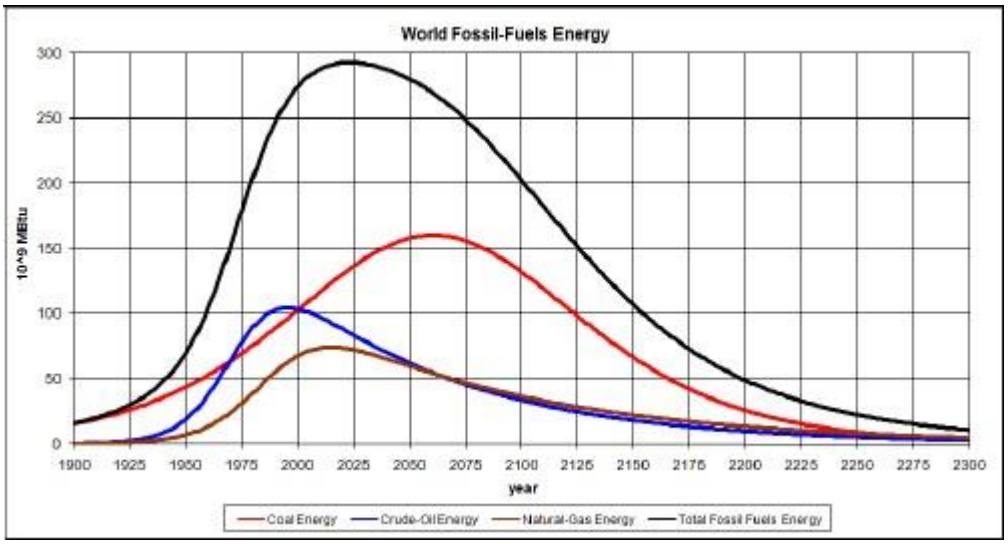


High-Level Expert forum. "How to Feed the World 2050." Global Agriculture towards 2050, 12 Oct. 2009,http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf

A population growth chart of the world since 1950.

Examples of diminishing supply of resources in our current world include fossil fuels. As technology improves and demand for fossil fuels increases, the depletion of the resource becomes increasingly problematic. According to Dr. David Roper, a professor at Virginia Polytechnic Institute, we are entering a period in time where a "world intensive" conservation program needs to be implemented. The graph below uses computational extrapolation to predict the future of available

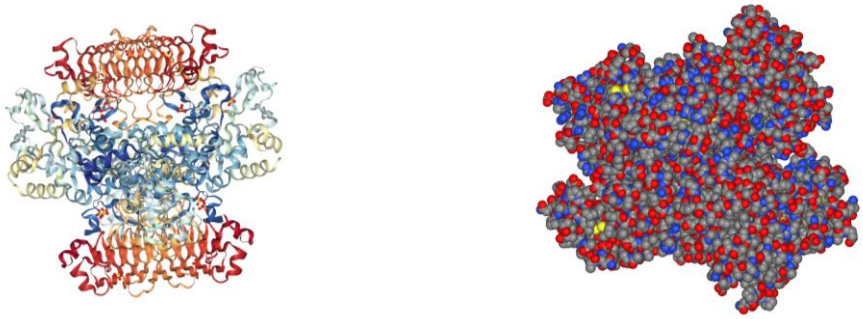
fossil fuel energy such as coal, crude oil, and natural gas energy. The year 2050 shows a downward sloping trend in all datasets, which is consistent with the prediction by the FAO mentioned previously. One of the uses of fossil fuels is for power nuclear reactors. Dr. Roper suggests that the remaining resources should be used to develop renewable energy. Including a vertical garden on campus is a single step towards using resources to research plants and their possible contributions to renewable energy.



Roper, David L. "Future World Energy." Energy Future, Virginia Polytechnic Institute, 20 Nov. 2016, www.roperld.com/science/energyfuture.htm.

World consumption of fossil fuels since 1900 broken up into several categories.

At Rutgers University in New Jersey, Kyle Wengryn worked with a team of undergraduate students and professors to analyze genomic DNA of organisms that exhibit bioremedial properties in order to discover potential methods of naturally producing biofuels. Specifically, he worked on the genome of Landoltia Punctata, generally known as "duckweed". Aquatic plants such as duckweed have properties that can be promising for the future of biofuels. For example, according to the National Center for Biotechnology Information (NCBI), duckweed accumulates excessive amounts of starch when under conditions of nutrient starvation (Cui). The nutrient-deprived environments initiate a feedback system in which the plant produces and stores more starch. Research at Rutgers University involves isolating the starch produced and converting it to biofuels such as butanol, ethanol, and biogas. The molecule complex below, nicknamed "AGPase' is one of the many species involved in the synthesis of starches in aquatic plants ("Crystal Structure of AGPase"). A vertical garden at Georgia Tech would allow students and professors to continue research in biofuel sources in plants to combat the steadily decreasing supply of fossil fuels. In addition to food, the garden can be designed to emulate freshwater lakes with flourishing aquatic plants such as algae and duckweed. Having a controlled environment would allow scientists to alter growing conditions and deplete nutrient sources to initiate a starch production response. Thus, the potential for this project extends beyond the production of food as it can pave the way for the future of alternative energy,



"Crystal Structure of AGPase." Protein Data Bank, Rutgers University, www.rcsb.org/3d-view/5L6S.
A moluecule complex involved in synthesis of starches in aquatic plants.

In addition to the science behind the garden, the hardware and physical design are crucial to the success of the project. The effects of a successful design extend beyond agriculture and biology. Many external factors including wind, heat, and altitude will contribute toward the challenge of fabricating a functional structure. Thus, selected materials and design will have an impact on the future of large and small-scale agriculture. For example, the efficiency of modern greenhouses can be increased and non-fertile geographical regions can potentially have the chance to grow goods. Implication of such engineering may also be the solution to increase the longevity and quality of food inside of homes or commercial stores. In conjunction with the projected advancements on a biological level, the mechanical and environmental levels will be equally influenced.

In an age of increasing utility for glass and transparent plastics, the vertically integrated garden can have beneficial impacts towards testing materials that exhibit the greenhouse effect. Instead of traditional glass, the Natural Resources Conservation Service (NRCS) in New Jersey is testing the efficacy of polycarbonate materials. The goal is to decrease the amount of money spent on fossil fuels to heat the gardens and rely more on the properties of the material to retain thermal energy. Below, Table 1 from the NRCS outlines the cost of various fuels for energy. Oil and liquid petroleum (LP) gas are expensive and are generally used in greenhouse heaters. Thus, there is a demand for materials that lower these fixed costs. In table 2 from NRCS, the level of light transmission is measured from different materials. Single layer glass allows the most light to pass through, but it is very energy and cost inefficient. The vertically integrated garden can include a greenhouse section dedicated to testing various materials and improving the efficiency of greenhouse systems. Data from such research will lower the overall money spent on fossil fuels used to power systems and will extend the availability of them as well.

Table 1- 2012 Fuel Price Comparison

Source: US-EIA (2)

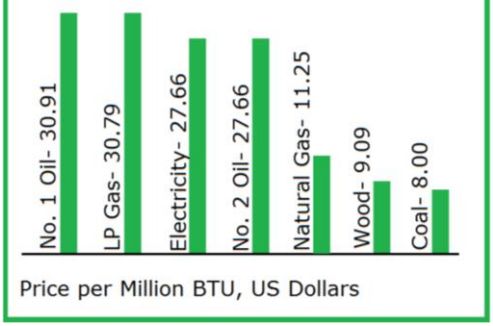


Table 2- Insulation Value of Common Greenhouse Materials

Source: Both (3)

Material	U-Value (1/R-Value)
Single (Double) Layer Glass	1.1 (0.7)
Single (Double) Layer Polyethylene	1.1 (0.7)
Single Layer + Energy Curtain	0.5-0.8
Double Layer + Energy Curtain	0.3-0.5
Twin-Wall Layer Acrylic	0.6
Twin-Wall Polycarbonate	0.6
1/2" Plywood	0.7
8" Concrete Block	0.5
2" Polystyrene Board	0.1

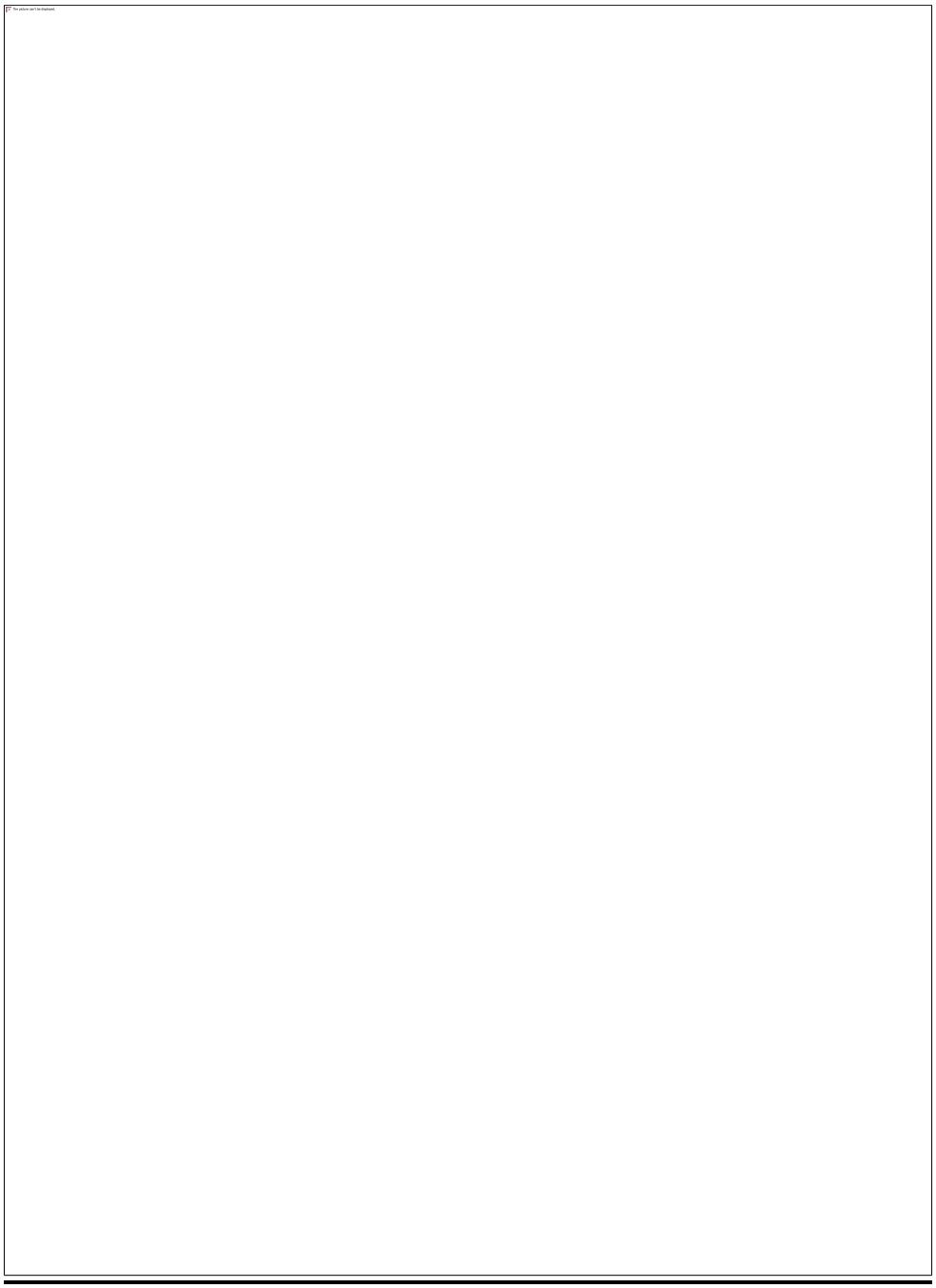
United States Department of Agriculture. "Conserving Energy in Greenhouse Operations." Energy Conservation Series, www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_023110.pdf.

The charts display data detailing costs of fossil fuels and light transmission levels of different materials.

For the aforementioned reasons, the idea of a vertical garden can significantly impact the future of science and technology. Implementing this project extends beyond Georgia Tech and is one step towards discovering viable solutions in fields of energy conservation, agricultural efficiency, and resource sustainability. When deciding if such a project should be approved, Georgia Tech faculty must consider the broader impacts.

V. Visualizations

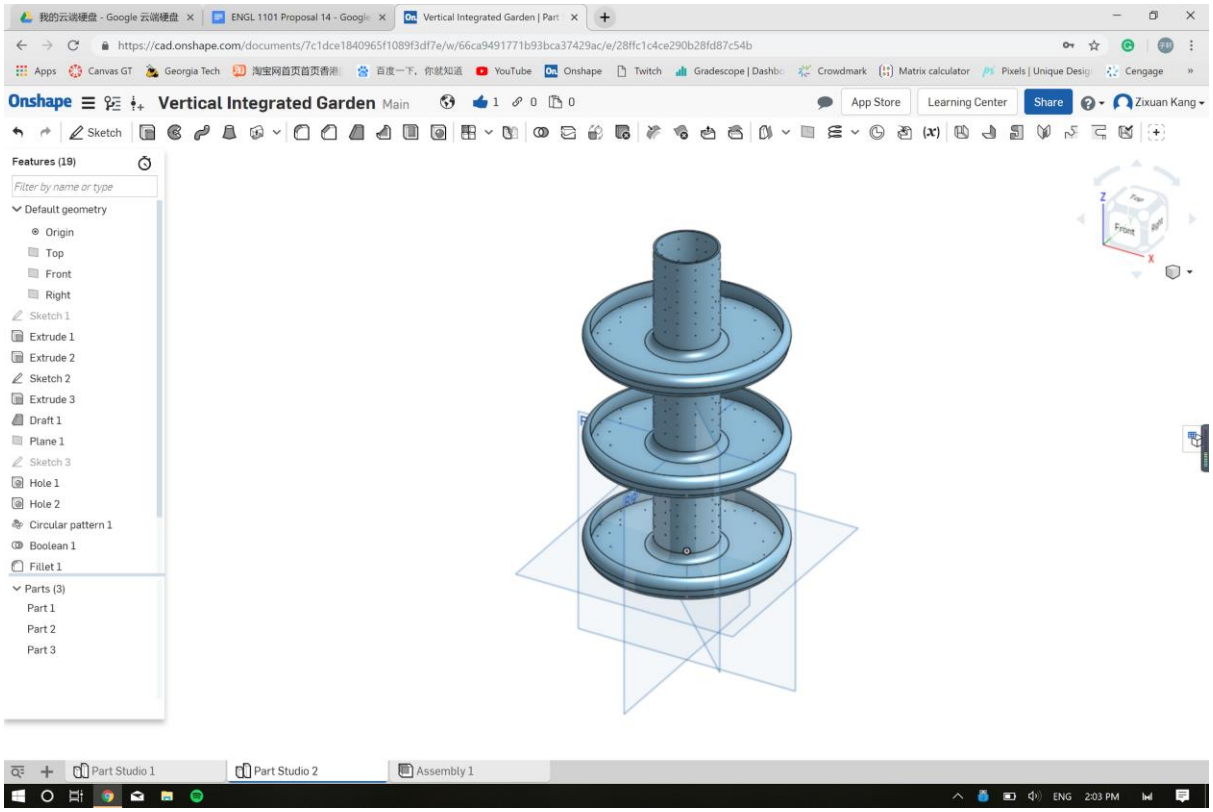
Watercolor of the Project

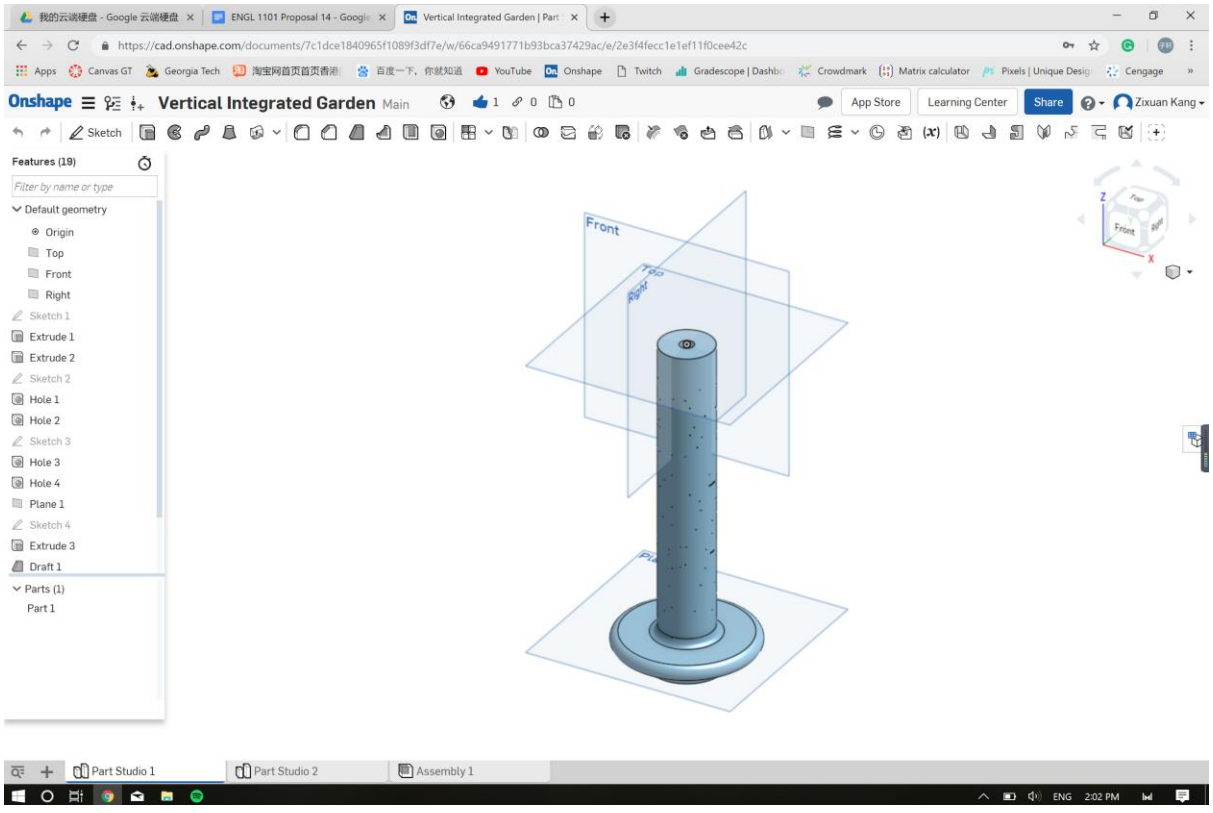


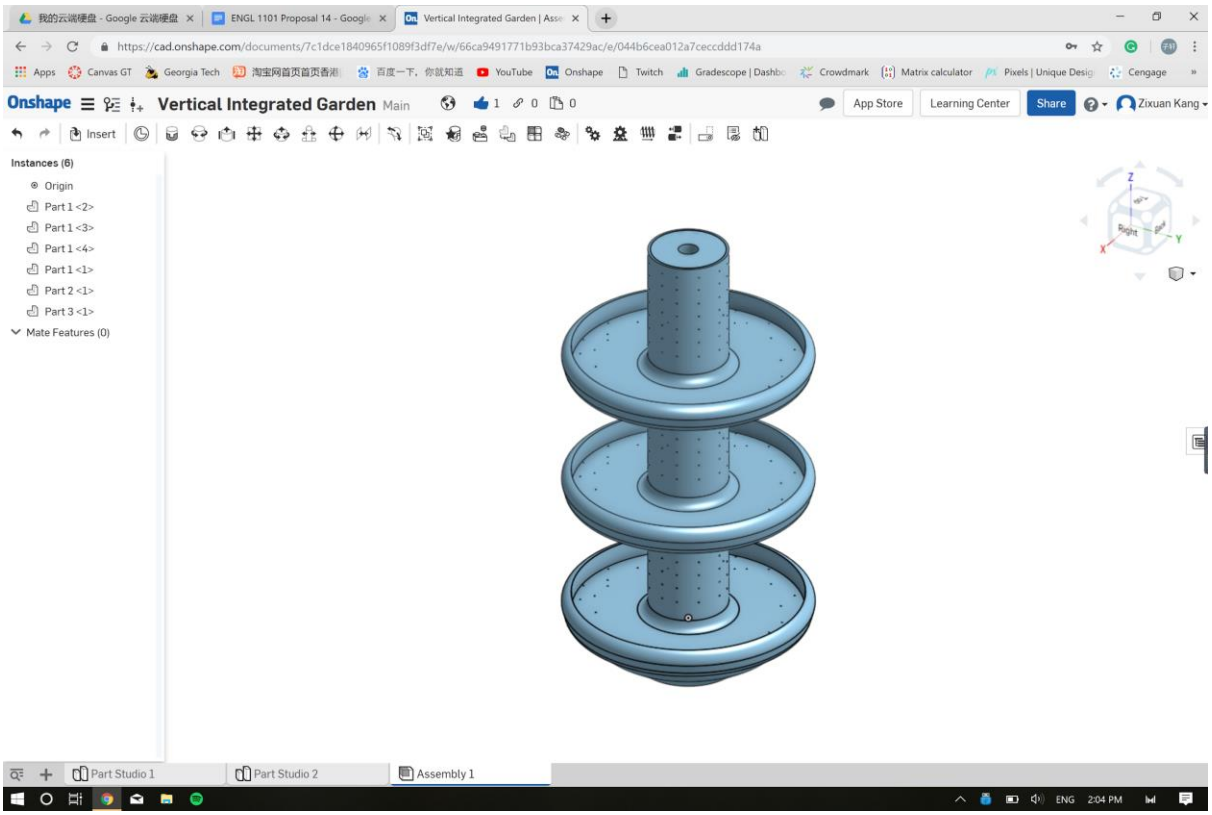
Kathryn Drummonds, “Perspective view of the Burger Bowl, before and after the community and vertical garden”, 12th of November 2018, Atlanta, GA

This is an artistic representation of the Burger Bowl, before and after the project. We can see the building where the vertical gardening will take place and the shelves inside it. We can also notice the trees and crops of the future community garden.

3D Visualization






Onshape
Vertical Integrated Garden
Main
App Store
Learning Center
Share
Zixuan Kang
Insert
Instances (6)
Origin
Part 1 <2>
Part 1 <3>
Part 1 <4>
Part 1 <1>
Part 2 <1>
Part 3 <1>
Mate Features (0)
Part Studio 1
Part Studio 2
Assembly 1

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VII. Individual Contributor Statements

Bhanu Garg

My individual contributions to our Community Farm and Vertical Farm include coming up with the idea, working on the project, and reaching out to the community about our idea. I have attended all except one group meeting, and was at the first meeting where I suggested a community garden. I suggested a community garden because of my past experience starting a community garden at my middle school. I also was not aware of an existing community garden on or near the Georgia Tech campus.

My work on the project started out with sharing resources with my group about what our project should be like. This included presenting resources such as Kimbal Musk's vertical farms, and Dr. Dickson Despommier theory of vertical farming. I also found resources of the healthy benefits of community gardening. For the project proposal I worked on the entirety of the Merits of a community and vertical farm. I found resources, videos, websites, and scholarly articles from different sources explaining the benefits and drawbacks of community and vertical farms. I also found images of a community farm and an example of different set ups in a vertical farm.

One of my major contributions to the group was doing community research and learning a lot more about community gardening and Georgia Tech's food accessibility. Through Dr. Snow and national data I was able to learn that Georgia Tech is a food desert, both with a lack of income and accessibility to fresh produce. I was able to hear Kevin Lanza, a current Ph.D. candidate at Georgia Tech talk about urban agriculture. He explained the pros and cons of urban agriculture, but ultimately how it brings the community together and benefits individuals. I also learned about air pollutants and how urban agriculture can reduce those. Another piece of research I did was related to the vertical farm and the current state of research at Georgia Tech. Currently the Agricultural Technology Research Program at Georgia Tech does research with automation, sensors, etc. I realized that these technologies could be adapted to a greenhouse environment where scientists could analyze ways to maximize yield and control and idealize other factors. I tried to contact someone at the research program but I had difficulties with this.

Some minor work I did was the bibliography and peer editing for my groupmates.

I chose to write about merit because I think it is the essential point of the proposal. The merit of the transformation is the reasoning for why our transformation proposal should be considered. The pros of the transformation and their benefit are defined in merit and I want to be able to convince readers why this is worth pursuing. I also felt obligated to write about the merit of our proposal because it was my idea and I wanted to be able to prove it was worth pursuing. Some of the other work I did like reaching out to the community was so I was could learn more about the pros of our proposal and ask specific questions, something I could not do from online research.

I think the group work experience was great! My group was very motivated to do work although it did not seem like that at the start. When the project was initially assigned, we only had two(me and Harry) of the five members at the first meeting. This was very upsetting because I thought the group members were not motivated to work on the project. I soon learned that everyone was really excited about the proposal. When we met again, we were able to really start working and people were coming up with brilliant ideas and bouncing them off one another. All my group members made great contributions and helped each other out. Our group was also very good at pivoting, like thinking of making a dual research based vertical farm with the community farm in order to be unique. I wish there were more group based projects throughout the semester. I personally

got to learn a lot more about my group mates and it was a good experience to make friends through the project.

My personal view on the transformation proposal is that it can bring a lot of improvement to Georgia Tech in outdoor recreation, something the current community garden fails to do. I think the ability to grow fresh produce for a sizable group of the Georgia Tech community will allow for students to be healthier. This also benefits students and volunteers in the long run because they get the physical activity that 50% of college students lack. If students grow the produce, they will eat the produce, otherwise they will eat unhealthy. Another benefit is that learning about nutrition is a life skill. In terms of the vertical farm, I think its a genius idea! Georgia Tech would be leading the way in sustainable vertical farming. Georgia Tech currently does not focus any of their resources on agricultural research but they should! So many different groups can be integrated into the project, with EAS, Computer Science, Mechanical Engineering majors and more leading potentially revolutionary projects. Seeing projects such as yield maximization, best design, and data analysis would lead to so many opportunities for students on campus to make an impact in the real world.

This is also why I chose to do the merit section of the project proposal.

Kyle Wengryn

My individual contributions to the project include the following: proposing the idea of building the garden vertically, completing the entirety of the "Broader Impacts Section", and working on the presentation that will be shown to the class. In terms of group work, I attended and participated in every meeting I could attend. If I was unable to make a meeting, I made sure I was working actively in the document and using electronic communication to ensure I was meeting deadlines. In class, I worked to use my time wisely and helped plan meetings that would accommodate the majority of the group. I will now describe each individual contribution and how I completed it.

In terms of brainstorming and proposal of ideas, I suggested that the garden should be built vertically in order to accommodate the somewhat limited space in Burger Bowl. Originally, the farm was designed to be more traditional, but I strongly believe that including a vertical element is both space efficient and has the potential for larger impacts around the world. Another reason why I proposed this idea was because of the already existing agricultural research programs on campus. A project of this magnitude cannot be redundant to something already on campus and needs to be able to supplement current research without stepping over. As mentioned in the Merit section, the Agricultural Technology Research Program (ATRP) is making strides towards improving food technology. Installing a state-of-the-art greenhouse would be a unique addition to the ongoing research in agriculture, thus making it worth the cost and labor. Additionally, with the new sustainability building, the Georgia Tech community is already making strides to improve energy usage. A vertical garden housed in a greenhouse can supplement the research being done in multiple disciplines, which is another reason I proposed the idea.

My main focus in the description part of the paper was the "Broader Impacts" section. In conjunction with the local effects, I also believe that the potential for this project extends beyond Atlanta and even the United States. I divided the impacts into two main sections: scientific advancements and hardware advancements. In the scientific advancements, I described current problems involving depletion of fossil fuels as well as how we as humans can combat the issue. I used this section to address a relevant problem in today's society given its role in energy conservation and climate change. In order to support my claims, I researched data regarding population growth and fossil fuel depletion. The solution I proposed to the issue is using the vertical garden to study the potential biofuel sources in aquatic plants. I believe I am qualified to discuss this topic since I have completed extensive research in this area. Given my connection with Rutgers University, I included

sources from the National Center for Biotechnology Information (NCBI) and the Protein Database (PDB). I also chose to propose this solution because it is different than the work being done in ATRP. ATRP is more focused on food production industry, so no research would be stepping on the other. In the hardware advancements, I talked about materials used in greenhouses as well as how they can be improved. To back my claims, I used data from the National Resources Conservation Service (NRCS). Studies have been done to find the most effective material in retaining heat will at the same time being cost and energy efficient. Although some types of glass will let in sufficient amounts of light, they are very expensive and not practical for this project. Therefore, more research can be done to maximize the efficiency of a greenhouse system so it can be implemented all over the world.

After completing the research, working with the group, and formulating a proposal for the vertical garden, I am very impressed with the potential that this project can have. Working in a group for a project of such magnitude was daunting at first, but work was delegated efficiently and every member put in the work. I personally enjoyed working in a group because I am now closer to some of my peers and have learned amazing things about creating a sustainable garden. It was also interesting to see how minds from completely different backgrounds worked together to create something new. In terms of merit, I strongly believe that our idea could transform our campus for the better. Some group members went as far as to create computer models of how the structure would look and we have a foundation of research that we could potentially build upon. Additionally, the local and broad effects of a successful garden can be beneficial for attacking many global challenges including climate change, resource depletion, and pollution. If our idea cannot be feasible, I would hope that universities across the world see these challenges and make their own attempt to fix them.

Colin Stewart

My individual contributions to the project included providing research, writing sections of the project description, completing portions of the presentation, and extensive formatting and editing. I have attended multiple meetings and worked on the project outside of group activities throughout the proposal's duration. I kept a consistent pace throughout the project, although heavy editing did occur during the last week when all parts began to join together to form a cohesive proposal.

I focused primarily on obtaining research, describing the processes involved with constructing and maintaining the farm, and proofreading and rewriting large sections of the proposal to mesh together better. To better understand the process of making the farm a reality, I spent considerable time reading about previous community farms. I collected information about plant nutrients and correct types of soil for certain species and input that into the project description. I wrote stage four and helped with several other stages. These were the more research oriented sections as well as those involved with improving the farm over time and collecting data on its functionality and efficiency. I researched different survey techniques to accurately and quickly obtain data from a large group of individuals concerning a topic to prepare for improving the farm continuous with non-stop feedback. The lifetime of the farm and its continued usage is just as critical as the initial building and developing phases. I concentrated more on the concrete rather than the abstract, a theme more in line with my work habits. The difference between the vertical gardens and the traditional farms was a topic I helped research and develop along with the cost effectiveness of this proposal in relation to both economics and space usage. I chose to concentrate on this information as it interested me and provides the factual backbone of the proposal.

Once the rough outline of the entire proposal was complete, I completed the majority of my work on the project and focused on formatting and editing. I helped write the table of contents, formatted the references into alphabetized MLA citations, formatted and captioned the pictures on the document, and rewrote the project summary to more accurately convey the finished project rather than

the rough idea we started with. This information was done after the majority of the proposal was written because I wanted to ensure that I had the ability to reflect on the e entirety of the project rather than fragmented segments. After ensuring that the proposal was uniform and that there were minimal errors, I read and reread the document numerous times searching for ways to improve the flow of the logic. Many sections were not joined properly and it was clear where one set of ideas ended and another brashly started. I chose to focus on this area as I enjoy working on a rough idea and polishing it until it becomes fit for inspection.

I found the group working experience to be enjoyable as every group member seemed to be enthusiastic at the concept and contributed to the project by both writing the proposal and formulating and improving ideas about the farm. I had never written anything similar to this proposal before and it was initially a challenge to figure out what to focus on. Although at first there were issues with work delegation and absence, these were worked out relatively quickly. As time progressed, the team seemed to work better together and communicate more often and effectively. Everyone was very flexible in their thinking allowing for continued, rapid improvement. It was great to see all group members pooling their collective willpower form different backgrounds and passion to assist and build off each other. By the end of writing the proposal, the teamwork present was enormous and progress towards the presentation progressed at a rapid pace.

Concerning my personal view on the proposal, I believe that it provide a substantial benefit for the community. During my research on work on the project, I became more invested in exploring the paths of both the workings of the farm and its impacts on campus. The idea of an agricultural version of the multiple engineering workshops around Georgia Tech greatly interests me as this would inspire many to pursue research in the field and provide an ideal base to do so. The potential for teaching students about agriculture and nutrition is large and the farm provides a path for student involvement in the community. Additionally, having an easy to reach operational facility and instant feedback allows for the ability to never run out of new projects to be attempted. This community farm or lab workspace does not need to be limited to campus, as the idea in my opinion can have far reaching consequences if properly adopted. If this idea does not become a reality at Georgia Tech, then it is my hope that others will at least take it elsewhere and propagate it.

Zixuan Kang

I have never proposed before, and I was thinking that writing a proposal may not be that difficult. However, the fact nowadays turns out that I was wrong. Writing a project in a group costs me more time, energy and the techniques of communication more than I have ever thought of. It requires every member of the group to try their best to minimize the distance to the final goal.

This time, our group proposes to transform half of the Burger Bowl Field into a collection of vertically integrated gardens and the whole group is divided into five parts. Two people oversee the outline part. Another two people are responsible for the merit and the broader impact part respectively. The left one person takes charge of the summary part and the reference part.

I oversaw the Phase 1 and Phase 2 and Introduction part of the outline description. I chose this part of the Description because this part of the outline is the most challenging one. As an old saying goes "A good start is half of final success." Nearly all the other phases left depend on the first two-part, namely the Design and Construction part. The special status of the first two parts lay many burdens on me, but it also pushes me to work hard and move forward. Through reading various instructions on the internet, I have learned how to construct a basic outline of a proposal which will be used a lot in the future. The article discusses the pros and cons of different kinds of outlines, but the main requirement is that the outline should be explicit and easy to understand so that teammates can simply follow. Through the national data, I realized that the Georgia Tech campus is a Food Desert. Through doing researches of the integrated garden, I realized how to manage and construct an

integrated garden so that my outline will be reasonable and logical. I was especially impressed by the video A guerilla gardener in South LA, as it explains how the whole system works from the perspective of an expert and a man who has experienced the whole process.

Everything is difficult at the beginning, but at the time when I finished, I was pleased that I know every detail of the whole project and plan every strategy to win the final goal. The main content of phase three and four were also designed by me so that the description will be more coherent, avoiding the situation when different ideas struggle to stay together in the same project.

I was also responsible for one of the visualization parts of the proposal. I love 3D Designing and have been using CAD design for four years. As a result, I'm confident of manufacturing a fully-functioning model to demo at the presentation. Although I have been using CAD design for a long time, I have never printed it before. This is my first time that I transform my design from some digital numbers into physical, touchable objects.

The group experience is more or less arduous at the beginning. For the first whole week, the whole group wrote merely one page of description for submitting the first check-in. What's worse is that some of the group members didn't come to our group meeting, lagging our prepared agenda behind and largely shrink our real working days into only a few days. Fortunately, after the reminder from the instructor in class, they finally made some progress, and it was beyond my expectation. It was the time I honestly felt that communication is essential when collaborating with others, especially those who have a considerable difference between their pace of working and yours. Perhaps, they think that there will eventually be someone who will do all the work, but what I still tried to accomplish is to tell them explicitly the stake behind, maybe not from myself, but from someone else who has more authority.

In general, the group experience is surprisingly better than I thought. Everyone is doing his or her best in the field he or she is good at, learning his or her disadvantages and improving them. Everyone maintains the passion for contributing to the group. Although the process is exhausting because we have to use our leisure time to set up meetings, do researches about various resources on the internet and extract the information that the group needs and combine them into sentences that can explicitly tell what the group wants to talk about, what we have accomplished is satisfactory. We also know more about each other as we keep communicating with each other and from the bibliography. For example, I can't even imagine that Marine is a soccer game referee solely from what she appears to be, and it is hard for me to believe that Collin was a member of a signal propagation research at such a young age.

Perhaps because I have some similar experience in my high school, I genuinely think our group's transformation is feasible and has practical significance. It enables students on campus have access to the fresh food source and eat healthier. It provides people who are interested in agriculture with an excellent opportunity to learn about farming. The cutting-edge vertically integrated garden offers a great environment to do the biological and environmental experiment more efficiently.
In a nutshell, I will be satisfactory to whatever we get from the proposal because we have devoted everything we have into this project and I enjoy the time I spent working with my teammates in the short three-week time.

Marine Maisonneuve

At the beginning of the assignment, the group first choose to meet so that we could brainstorm together which space we could transform. Bhanu and Harry had several ideas, as for instance adding a skybridge from the 5th floor of the culc to the 3rd floor of skiles. We finally decided, as a group, to do a community garden. I mentioned the idea that we could do do two parts to the farm:

a traditional, community garden and a more productive farm using technology,. That's when some of my team members said that we should do a vertical gardening.

In this project, I was in charge of writing Stage 3 and 5. However, most of my work was giving feedback on the project and organizing the group. I was also trusted to find who could do our first visualization that would represent our transformation to the space in a broad way. For this, I chose to ask a friend, Kathryn Drummonds, that represented the before and after the transformation of the half of the Burger Bowl with watercolors.

I chose to write about the Stage 3 and the Stage 5 because I thought they were the two most interesting stages in the transformation. The first and second stage are important to the transformation, however Stage 3, being the development of the vertical farm, is essential. This is the part where we integrate science in the project and begin to do a real difference in Georgia Tech's students' lives. As for Stage 5, it is the true beginning of the project, when the project is finally efficient and works at a large scale.

Before I could write about those stages, I had to do research on urban gardening, hydroponic and aeroponic cultures, and vertical gardening. I also had to research environmental friendly solutions and to learn about sustainability. To accomplish this, I read several articles including "An Atlanta Hydroponic Farm Flourishes," where I discovered that an hydroponic farm exists south east of Atlanta. By watching the video " This Farm of The Future Uses No Soil and 95% less Water" by the YouTube channel 'stories', I was introduced an even more environmentally friendly and water efficient farming technique called "aeroponics."

I really enjoyed working on this project because I learned a lot. Initially, I was severely lacking in any agricultural knowledge whatsoever but quickly found out about various technologies used in farming. I think this could even be useful to me on a personal level because part of my family is in traditional agriculture. This project has also been the first time I have taken part in writing a thesis proposal. Being able to come up with an idea, research it, and present turned out to be both interesting and stressful. It is a lot of work but really rewarding because we learn and find ways to impact the world for the better.

I am not used to working with teammates so being part of a group was hard for me. At the beginning, some people had a lot of trouble starting their work. However, as time went by and the deadline approached, people began to work. In order to organize our work and how we should divide it, I first asked everyone what they would prefer to work on. Because we all had different preferences, assigning different parts went very smoothly. I then proceeded to set down deadlines so that we wouldn't be rushed to finish our project, especially during midterms week. My other major contribution in our communication was to give plenty of feedback to all of my teammates parts, even while they were still writing it. This helped to avoid any repetition or misunderstandings so that we would could work together more efficiently. Gradually, my group began to be more united and we all gave each other feedback and proofread each other parts. By having meetings inside and outside of class, we could discuss in depth each other parts, and provide constructive criticism and feedback. I think this was the best quality of our group.

I think our transformation should be heavily considered by faculty. I think this farm could become a real asset for the university. It is a worthwhile project because it is both sustainable and, while it may have an elevated initial cost, has a considerably smaller maintenance cost. By having this farm, as explained in the Broader Impact and Merit sections, students would gain opportunities to eat healthier and learn valuable engineering skills first hand. On a personal level, I think this transformation would benefit me and other students on a subject that matters a lot to me: mental health. Even if it is not usually mentioned, being physically healthier is essential to mental health, and a healthier student body is a better university.

I think our project is worth being a part of Georgia Tech and I enjoyed working on this project.

VIII. Biographical Sketches

Marine Maisonneuve

Marine Maisonneuve is currently an international first-year student at the Georgia Institute of Technology majoring in Electrical Engineering. She is from France where she did all of her middle and high school. She loves to travel and di an exchange year in Michigan when she was 15. She has a job at the CRC: she is a referee. She is also a part of the robotics team of the school called the Robojackets and specifically Robocup where she is part of the Electrical team. She is also part of the badminton club and a glassmaking club. Marine loves to construct objects and built her own 3D printer when she was 17. She would like to make the most out of her college life by trying out different things so that she can expand her knowledge and skills.

Bhanu Garg

Bhanu is a first-year Computer Science student at the Georgia Institute of Technology from Sunnyvale California. He enjoys streetwear and sneaker culture and resells. He also enjoys playing

sports like badminton and swimming. He loves watching movies and TV and one of his bucket list goals is to watch all top 250 IMDB movies. In his leisure, he hangs out with friends or sends memes online. He also likes to hike, go camping, and is an Eagle Scout. He plays video games, like Hearthstone and Overwatch. He spends most of his time online, on Discord, talking to his friends in Georgia Tech, from back home, and in the sneaker community.

Zixuan Kang (Harry)

Harry is currently a freshman majoring in computer engineering in Georgia Institute of Technology from Shanghai, China. In his leisure time, he loves coding and making electronic circuits. Last summer vacation, he became a part of the drone club in Shanghai which focuses on the modification and improvement of drones, especially the aero-videoing type. He also made a program that can do almost all the calculation of matrices and made his first app during the Appathon weekend. He's also the piano accompanist for both the high school and the college choir due to his talent in music and diligence of practicing the piano. So far, Georgia Tech is the best fit for him and he will do his best to try new things and broaden his horizon.

Colin Stewart

Colin is a first-year mechanical engineering student at the Georgia Institute of Technology from near Charlotte, North Carolina. He enjoys flying RC planes and making and launching model rockets and is pursuing a minor in Aerospace Engineering. In several previous summers, he helped research indoor signal multipath propagation and build several small gadgets. In high school he was the founder and president of the chess club as well as team leader in his robotics club for several years. At Georgia Tech he is currently becoming a Prototyping Instructor at the Invention Studio to further his ambitions in engineering and machining.

Kyle Wengryn

Kyle is a first-year student at the Georgia Institute of Technology majoring in Biomedical Engineering. He is also pursuing a minor in Computer Science and wishes to enter the medical device industry. Recently, he was approved to assist a team in developing a breadth of applications that are dedicated to helping patients with a history of strokes or other brain trauma. In his free time, Kyle enjoys playing baseball and watching sports. Before coming to Georgia Tech, he served as an Emergency Medical Technician in his hometown in New Jersey.