Addressing Lafayette College's Food Waste Issue and Diversion Rate Goals

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Introduction

In 2011, the United Nations Food and Agriculture Organization (FAO) released its Food Wastage Footprint and Climate Change report that assessed the amount of global food losses and waste and its effect on the world. The 2011 assessment found that about one-third of all the food produced in the world goes to waste. This is equivalent to about 1.3 billion tons of food, a large enough amount to feed the global undernourished population. The FAO also estimates that this amount of food waste is responsible for about 8% of total anthropogenic greenhouse gas emissions and has an equal contribution to global warming as global road transport emissions. The FAO report declares that if food wastage were a country, it would be the third largest emitting country in the world ("Food Wastage Footprint and Climate Change", 2011). These humanitarian and environmental consequences of food waste from the FAO's report have inspired movements to reduce global food waste. Since 2011, the FAO has established Sustainable Development Goals (SDG) that target "halving the per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains" ("Food Loss and Food Waste", n.d.). To achieve this and improve the global food diversion rate, or amount of food diverted from landfills, the FAO has conducted educational outreach programs to influence consumers and change their individual attitudes, habits, and food-related consumption.

Similar to the FAO's food waste goals, Lafayette College has aimed to increase its on campus diversion rates. This began when former president Daniel Weiss signed the American College and University Presidents Climate Commitment in 2008. After calculating its emissions and conducting a campus-wide energy audit, Lafayette College

created its first Climate Action Plan. After reevaluating its emissions in 2019, Lafayette College edited its original plan and approved the Climate Action Plan 2.0. The Climate Action Plan 2.0 provides a comprehensive framework for how Lafayette will achieve carbon neutrality by 2035. This framework includes several milestones for various areas such as building and facilities energy use, minimizing waste, and transportation emissions. Concerning diversion rate milestones, this revised plan calls for a 5% increase in the current diversion rate of 14% by 2020, an overall diversion rate of 40% by 2021-2025, and finally a diversion rate above 60% by 2026-2035 (“Climate-Action-Plan-2.0”, n.d.). A more in depth description of the goals laid out in the Climate Action Plan 2.0 can be seen in Figure 1. Our report addresses these goals from the Climate Action Plan and analyzes three different alternatives Lafayette College could use to achieve these

Timeline

Phase 1: Immediate Opportunities for 2019-2020

- Increase recycled, composted, and reused materials by 13 tons during the 2018-2019 academic year to achieve a 5 percent increase in diversion rate through building on prior successes.
- Research ways to expand the campus composting program.
- Continue the food recovery program and find new opportunities for capturing student-generated food. Quantify how much food is donated.
- Expand opportunities for reuse and recycling, while also enhancing online communications about these programs with members of the campus community.

Phase 2: Recommendations for 2021-2025

- Boost the overall diversion rate above 40 percent by 2024.
- Accomplish this in part by instituting a campus-wide composting system to remove food waste, pizza boxes, napkins, and other compostable items from the landfill and by enhancing recycling, reuse, and waste-minimization programs.
- By 2021, ensure that there are recycling bins wherever there are trash bins and employ best practices for recycling information, infrastructure, signage, etc.

Phase 3: Recommendations for 2026-2035

- Boost the overall diversion rate to 60 percent by 2035.

Figure 1: CAP Diversion Rate Goals ("Climate Action Plan 2.0", n.d.)

diversion rates in the future. Specifically, this report focuses on methods to divert a greater portion of Lafayette's food waste from landfills.

Thus far, Lafayette has managed to create an on-campus composting program that, when operating at full capacity, can deal with about half of the plate waste from one of the main dining halls on campus. The current program consists of a pulper at each dining hall and two Earth Tubs. The two types of equipment involved in the process are pictured in Figure 2 and 3 respectively. Lafayette installed this equipment in 2010 after receiving funds from the Pennsylvania Department of Environmental Protection (PaDEP) Composting Infrastructure Development Grant (Luker, 2008).

Figure 2: Waste Xpress Food Pulper (Pulper/ Extractors, n.d.)

Figure 3: Lafayette's Earth Tubs, (As created by authors)

Dining services uses the pulpers to break the food waste into smaller pieces and increase the amount of compostable waste. The end product falls into buckets that are brought to loading docks behind the dining halls. Members from the Office of

Sustainability, including five student compost managers, collect the buckets and bring them to the Earth Tubs located on Bushkill Commons as shown in Figure 4. The student compost managers then operate the Earth Tubs and create compost that is transported and used at LaFarm. The compost can be used directly as mulch or can be cured for thirty days before being used as a soil amendment. The goal of this process is to have a closed loop food system in which food waste is composted and used at LaFarm to grow food for the dining halls.

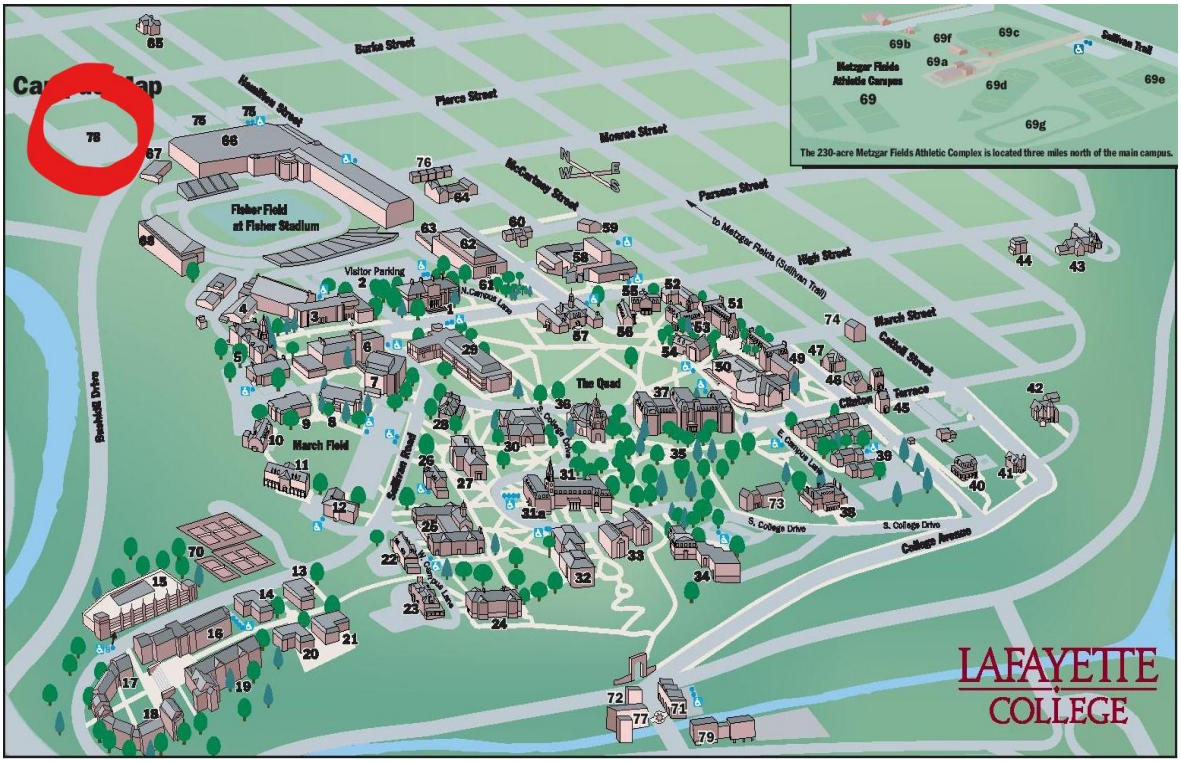

Figure 4: Earth Tubs Location, ("Campus Map", 2016)

There are several issues with the current system described above. The Earth Tubs can only handle about half of the food waste from Upper Farinon when operating at full capacity. At Marquis alone, there is about 1,090 pounds of student plate waste per week that does not go through the Lafayette composting process (Christopher Brown, personal communication, October 31, 2019). In a 30 week academic year, this equates to 32,700

pounds of plate waste per year going to landfills rather than being composted. Furthermore, the loading docks at each dining hall are often full with pulped food waste and cannot handle all of the pulped product produced (Lisa Miskelly, personal communication, November 7, 2019). All of these issues point to a need for an expanded composting program that can deal with the amount of food waste from Upper and Marquis. This expansion could take the form of one or a combination of three alternatives: investing in more digesters (like the Earth Tubs), using windrow composting at LaFarm, or outsourcing the excess food waste to a third party for composting. By improving Lafayette's ability to compost its food waste, these alternatives could help the college reach its diversion rate targets for the future.

The first alternative is to purchase more digesters similar to the Earth Tubs. This alternative is an attractive option because there is already a process in place for this method of composting. The challenging part of this option is actually finding a digester that would satisfy the needs described above. Unfortunately, Earth Tubs have been discontinued, so the college would have to purchase other digesters from either the same company or a different company (Green Mountain Technologies, 2018). Moreover, any product that can handle the amount of food waste Lafayette students produce will be a significant cost to the school and will probably require another grant. To help guide Lafayette's selection process for digesters, this report provides cost estimates and capacity comparisons for two digesters that can handle Lafayette's food waste. Another important factor for this alternative is a location for a new digester. Currently, the two Earth Tubs are located at Bushkill Commons. Considering the size of digesters required for the volume of Lafayette's food waste and the size of Bushkill Commons, Lafayette

will have to designate a new area for the digesters. Finally, the Office of Sustainability will either have to invest in more labor to operate the added digesters, or they might reduce the need for labor if the new system is automated.

The second alternative for expanding the composting program is to implement a windrow composting system at LaFarm. Windrow composting is a composting method that piles organic matter into long rows. With this option, since windrow composting takes more organic material, Lafayette could divert more of its food waste from landfills. There are multiple challenges associated with a windrow composting system. The Office of Sustainability would have to expand its staff to meet the labor demands of windrow composting. The food waste would also have to be transported to LaFarm rather than to the Earth Tubs. Additionally, conducting the composting process at LaFarm might draw push back from Forks Township because of zoning ordinances and the smell. Windrow composting also requires equipment that the college would either need to purchase or rent. The college does own enough space at LaFarm to use windrow composting and could use this new composting method as an educational tool for its students.

The final alternative is to outsource the excess food waste to a composter in Easton. This would require Lafayette to work out a deal with a third party and establish a price and transportation plans for the food waste. Lafayette has had talks with an outside composter, American Biosoils, about taking food waste in the past. Communication between the two parties were inconsistent, however, and Lafayette's composting program had not been fully established yet (Lisa Miskelly, personal communication, November 7, 2019). Based on pricing from American Biosoils, $55 per pickup and $50 per ton collected ("American Biosoils & Compost", n.d.), this alternative could be a cheap option

for Lafayette that does not require any costs for expanding the on-campus program. The college may have to adapt its waste process, though, as some composters, including American Biosoils, do not accept pulped food waste due to contamination risks. That would mean Lafayette would either have to set some food waste aside for outsourcing or completely eliminate the use of the pulpers altogether. By shifting the composting process off campus, Lafayette would also have to consider that outsourcing could eliminate the educational aspect of having an on-campus composting program. This would be a significant consequence given that the educational aspect was the driving force behind the establishment of the on-campus composting program. With respect to achieving Lafayette's diversion rate goals, outsourcing could be especially effective in diverting all of the college's excess food waste from landfills as long as the outside composter has the capacity to take this amount of organic material.

Overall, one of these three options would most likely be the best decision for Lafayette. Any sort of change would require the creation of a position or office solely responsible for composting on campus. Control over the composting program has mainly fallen on the Assistant Director of Food and Farm, Lisa Miskelly, by default, so the focus has been on maintaining the composting process rather than improving it. A position for just the composting program would free up resources and allow for more attention towards expanding the program. Any expansion would also require increased funds from the Office of Sustainability for increased labor costs, transportation costs, or any other costs specific to the alternative. If Lafayette wants to reach a diversion rate of 60% by 2035, then the current culture surrounding food waste on campus, the views of faculty and staff involved in campus composting, the physical process of composting, and the

economic and technical feasibility of changing current composting practices must be accounted for.

Social Context

Introduction:

The reason we are concerned with diverting food waste from landfills is because a surplus of food is being generated in the first place, and not enough of leftover food is donated to populations in need. Composting is the last resort for recovering food waste before it is sent to landfills where it creates methane, which is a potent greenhouse gas. ("Food Recovery Hierarchy", n.d.). Lafayette College's focus on diversion rates comes from the Climate Action Plan 2.0. The school supported the implementation of a CAP for two main reasons. First, the CAP reduces Lafayette's contributions to the devastating effects of climate change. Second, in a society where environmentalism has become increasingly valued, having a CAP can improve the standing of the school and make it more desirable to prospective college students.

Context 1: Consumerism & Other Reasons Food Waste is Bad

Without consumerism, we would not have to worry about diversion rates in the first place. Yet, in high income countries, we see patterns of wasteful food distribution and consumption. As the Food and Agriculture Organization of the United Nations points out in Figure 5, on a global scale, consumption is responsible for the largest carbon footprint of the five steps of the food supply chain: agricultural production, handling and storage, processing, distribution, and consumption ("Food Wastage Footprint and Climate Change", 2011). Most carbon emissions come from the final step of the food supply chain because "harvesting, transportation and processing accumulates additional

greenhouse gases along the supply chain," ("Food Wastage Footprint and Climate Change", 2011). Therefore, before we increase diversion rates, it would be ideal to reduce the amount of food going to waste from individuals' plates as this can reduce the amount of money and energy wasted along the food supply chain. Furthermore, reducing the amount of food waste from industrialized countries could lead to improved distribution of food to countries that need it ("Reduce Wasted Food by Feeding Hungry People", n.d.).

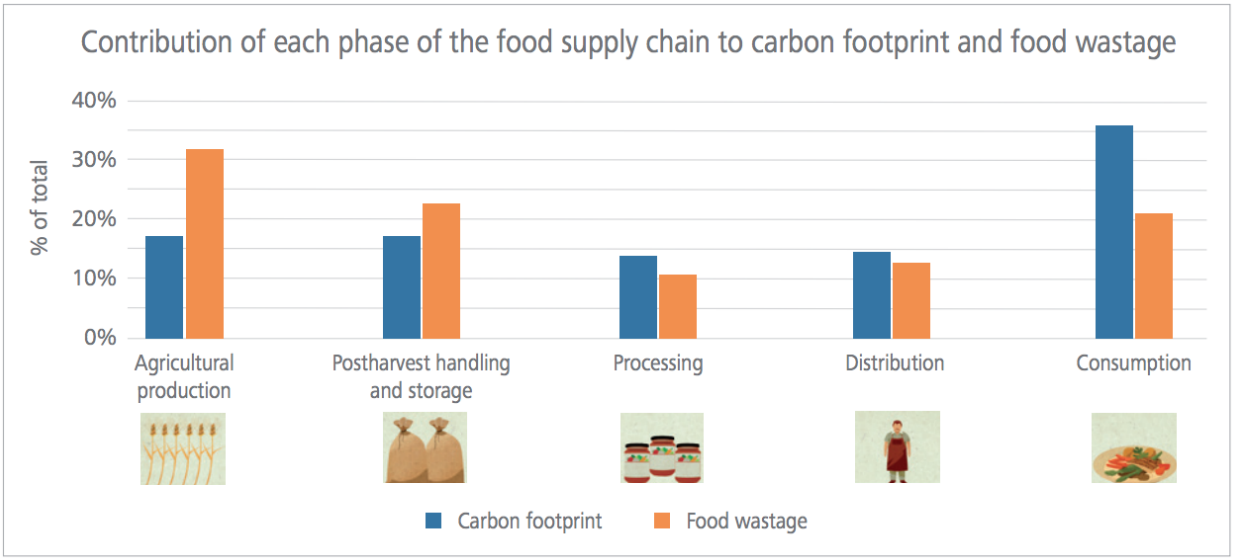

Figure 5: FAO Contribution Chart, ("Food Wastage Footprint and Climate Change", 2011).

These methods for dealing with food waste are outlined in the EPA's Food Recovery Hierarchy as shown in Figure 6. In summary, the hierarchy ranks methods for dealing with excess food from most preferred to least preferred. The most preferred method is reducing the amount of food being distributed, as this would in turn reduce the energy and money wasted on food production ("Food Recovery Hierarchy, n.d.). Next, any food that is leftover should be donated to populations that experience food insecurity. After this, it is preferred that food waste be given to animals. If the previous options are

unavailable or unable to be completed, then the next preferred method is using food scraps to generate alternative forms of energy. Composting, which is what we are focusing on, comes after industrial use as the second to last preferred option for managing food waste. The last resort would be to send food waste to landfills. This shows how low our project falls in the order of preference for dealing with surplus food. Before we resort to composting, there are better ways to deal with food waste.

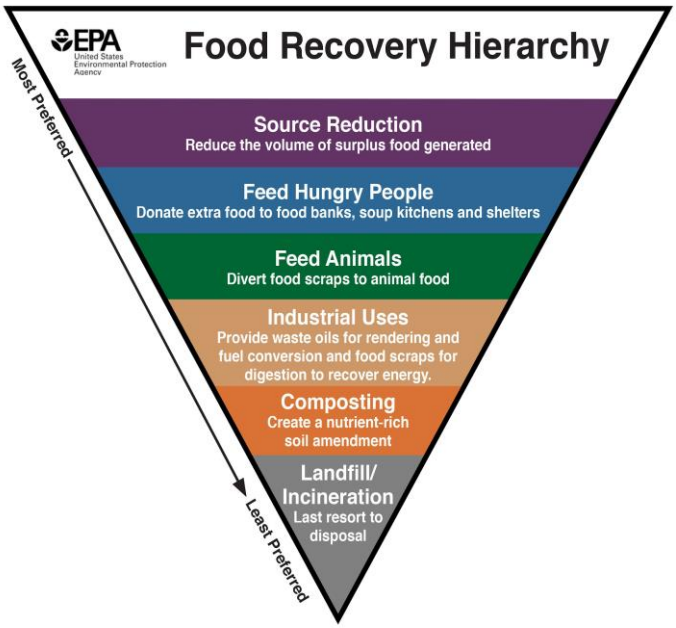

Figure 6: EPA's Food Recovery Hierarchy, ("Food Recovery Hierarchy", n.d.).

Implied within the first level of the Food Recovery Hierarchy is that wasted food results in wasted energy and wasted money. Therefore, the most ideal way of dealing with food waste is to eliminate it in the first place. According to the FAO, one trillion US dollars are lost each year due to food waste. These costs are associated with the labor required to produce, handle, and distribute food as well as the resources and energy necessary to generate food ("How to Prevent Wasted Food Through Source Reduction", n.d.). Additionally, the amount of energy wasted as a result of food waste made up 2% of

the United States' annual energy consumption as of 2010 (Cuéller and Webber, 2010). Considering this data is from nine years ago and the fact that this number was a lower bound at the time, we can assume the wasted energy from food waste is in this ballpark with increased population and pushes to reduce greenhouse gases. When dealing with food waste, it is necessary to understand the money and energy that is also wasted.

Just as much as money and energy are a concern, so is the amount of people that do not have regular access to food. Not only is food waste an issue of the environment and economy, but it is also a moral issue. While many people are disposing of edible food, populations are at the same time lacking access to food (Papargyropoulou et al, 2014). In 2017, 11.8 percent of American households "had difficulty providing enough food for all their members due to a lack of resources" ("Reduce Wasted Food by Feeding Hungry People", n.d.). At the same time, Americans were disposing of millions of tons of food, much of which could have been redistributed to populations that are in need. Organizations such as the Food Recovery Network, of which Lafayette has a chapter, makes efforts to redistribute food from dining halls that goes uneaten to communities in need. In this case, money and energy are still used, but more food is diverted away from landfills.

While eliminating food surplus and donating to hungry populations are the ideal methods for dealing with the issue of food waste, our project is focusing on composting, which is the second to last preferred option of the Food Recovery Hierarchy. Although, we recognize that options exist for reducing food waste that are better for the environment, economy, and overall population, composting is still a useful method for dealing with food waste that could significantly help Lafayette reach its CAP goals.

Context 2: CAP- Environmental

A major goal of the Lafayette Climate Action Plan is to educate students and be a leader for reducing climate change impacts. Recently, the effects of climate change have become very apparent in many parts of the world, and colleges across the country have begun to implement climate action plans as a way of reducing the negative environmental effects that the school and their students have on their surrounding environment.

The general idea of a climate action plan is to create an inventory of all the greenhouse gas emissions generated both directly and indirectly by the college's campus. These include fuel burned on site for heating, facilities, and maintenance vehicles, as well as emissions that come from any off site power plants that generate electricity for use on campus. One major concern with climate action plans is that they do not work as intended, however if they are implemented correctly and have long term goals and solutions, then they can be very effective in reducing the environmental impact associated with large campuses (Moore, 2018).

The Lafayette College Climate Action Plan 2.0 includes several sections such as Buildings and Facilities Energy Use, Minimize Waste, Transportation, and Curricular Integration. Each of these sections outlines the current practices on campus and how their negative effects can be mitigated to assist in reaching carbon neutrality by 2035. The section of the Climate Action Plan that our reports focuses on is the ways to minimize waste. In this section, the college has set a goal of achieving 60% diversion rates by 2035. This means that by 2035, three-fifths of the amount of waste created on campus must be diverted away from landfills. When waste breaks down in landfills, it releases methane gas, which is a greenhouse gas that is more potent than carbon dioxide. Thus, a

diversion rate of 60% will help reduce Lafayette's contribution to atmospheric methane gas. In order to get to this diversion rate, Lafayette has implemented recycling initiatives such as green move out, in addition to increasing recycling and composting around campus ("Climate-Action-Plan-2.0", n.d.).

In 2008, Lafayette College purchased two Earth Tub Composters, which are able to handle about half of the food waste generated from one of the two major dining halls on campus. In order to increase this amount to reach the 60% diversion rate goal, the college will need to implement a larger composting program, educate students about the negative environmental effects of food waste, and encourage them to produce less food waste ("Climate-Action-Plan-2.0", n.d.)

In 2005, a Bon Appétit manager at Saint Joseph's College of Maine realized he could cut plate waste in half just by removing trays from dining halls ("Lafayette Dining Service's Sustainable Practices, Sustainability, Lafayette College," n.d.). Several years later, Lafayette caught on to this movement and removed trays from all dining halls on campus. This helped to reduce food waste as students were limited by the amount of food they could carry to the table at once. However, the two main dining halls on campus are buffet style, as shown in Figure 7, where students serve themselves. Especially at these two locations, students are inclined to take large servings so they do not need to stand in line multiple times. This is going to become an increasingly large issue as the student body continues to increase.

Figure 7: Upper Farinon Dining Hall, (As created by authors)

Context 3: CAP - School Standing

The other main reason Lafayette created and approved a Climate Action Plan was to enhance the school's reputation and bolster its standing compared to other schools and universities. This has been a developing trend among schools and companies as the climate change issue has become more established. More organizations have pushed for environmentally related efforts because they look good to the public and may attract more customers, or students in the case of schools. The increased attention to being an environmentally conscious establishment has produced competition, especially among colleges and universities. This can be seen in almost any school ranking system nowadays. For instance, *College Magazine* publishes a yearly article about the top ten

environmentally friendly colleges and universities (Croy, 2019). Similarly, The Princeton Review produces an annual Guide to Green Colleges that profiles 413 colleges with commitments to green practices and programs ("The Princeton Review Guide to Green Colleges: 2019 Edition Press Release", 2019). The guide also includes a yearly list of the top 50 Green Colleges ("Top 50 Green Colleges", n.d.). With all of this competition, it is important for Lafayette to compare its green initiatives against what other schools are doing. The rest of this section will summarize what some of the top green schools are doing, what some of the differences between these schools' environmental goals and Lafayette's are, and why these differences may exist.

One college that is consistently in the top ten green school rankings across a variety of publications is Colby College in Waterville, Maine. Colby College achieved carbon neutrality in 2013 and was one of the first four colleges or universities in the U.S. to do so. Colby started tracking its success in environmental sustainability with its Climate Action Plan, published in 2010. The plan called for carbon neutrality by 2015 and outlined an assortment of commitments to improve and monitor Colby's progress to carbon neutrality. Besides becoming carbon neutral by 2015, the plan also included goals such as reducing greenhouse gas emissions by 41%, designing new facilities to achieve a minimum LEED silver standard, and to develop aggressive education and outreach programs ("Colby College Climate Action Plan", 2010). For waste management and recycling, many of the initiatives for this area were already in effect before the publication of Colby's plan. Thus, the plan does not have any specific diversion rate or recycling goals that can be compared to Lafayette's. Nevertheless, Colby's recycling programs and policies have been effective contributor to Colby's environmental goals.

Colby purchases 100% recycled paper products and has a RESCUE (Recycle Everything, Save Colby's Usable Excess) program that donates and recycles clothing, furniture, appliances, and other items ("Colby College Climate Action Plan", 2010). In terms of food waste, Colby composts over 100 tons of pre- and post-consumer waste through outsourcing and implemented tray-less dining in 2008, which saved approximately 79,000 gallons of water and 50 tons of food waste ("Sustainable Dining", n.d.).

Another college that has traditionally performed well in green school rankings is Dickinson College in Carlisle, Pennsylvania. Like Colby College and Lafayette College, Dickinson signed the American College and University Presidents' Climate Commitment in 2008. This led to the publication of Dickinson's Climate Action Plan in 2009. The plan states a central goal of achieving carbon neutrality by 2020. Dickinson's plan has a different organization from Lafayette, though, and divides its initiatives into four main areas: purchased electricity, on-campus fuel combustion, transportation, and offsets (Sheriff, 2019). Dickinson has since then established targets and focused more on progress in these four areas. For recycling and waste management, Dickinson's only statement is that the school is committed to reducing materials consumption, reusing materials, and recycling and composting ("Dickinson College Climate Change Action Plan", 2009). Other than this, Dickinson does not provide a specific diversion rate goal. For its food waste program, Dickinson relies on windrow composting at its five acre college farm. As part of its Farm to Fork to Farm program, Dickinson is able to collect and compost all of its food waste. Dickinson also has an established monitoring system for tracking campus waste in its Waste Minimization Sustainability Dashboard which is updated every fiscal year ("Sustainability Dashboard: Dickinson College", n.d.).

Compared to other schools' Climate Action Plans, Lafayette's CAP has fairly similar goals and milestones, but with different target years. Lafayette's diversion rate section is much more detailed and has a specific diversion rate goal that most other schools do not have. This could be explained by two reasons. The first is that Lafayette is a highly residential school which means a large percentage of its students and faculty eat on campus. Therefore, dealing with food waste and increasing diversion rates may have more of an impact on Lafayette's sustainability goals. Another explanation for this disparity is that other schools already have successful waste management and recycling programs in place. Among the top 50 schools for the Princeton Review's Green Colleges rankings, every school diverts at least 50% of its waste from incinerators or solid-waste landfills ("The Princeton Review Guide to Green Colleges: 2019 Edition Press Release", 2019), compared to Lafayette's current 14% diversion rate. Both Dickinson and Colby, schools that are similarly residential to Lafayette, divert 100% of their pre- and post-consumer waste. Based on this overview, Lafayette has effectively defined what needs to be achieved for diversion rates. However, Lafayette could mirror some of the other colleges' recycling practices in order to achieve the same success other schools have experienced, and to improve its environmental standing among colleges and universities.

Political and Policy Context

Introduction:

There are two important political components to consider when analyzing a societal problem. The first are the individuals or groups affected by the problem and those who could potentially be involved with the solution of the problem. The other are the policies that currently influence the problem and could possibly factor into the

solution. This section of the report provides an analysis of these two political aspects by outlining the various stakeholders of the food waste issue and the Lafayette and Easton policies that influence both the problem and a potential solution.

Stakeholders

Many actors are involved in the process of increasing diversion rates, from those who are responsible for implementing a new system, to those who are affected by the outcome and by climate change in general. While every person on this planet is seeing some outcome of climate change, some populations are disproportionately affected. Minority groups and individuals with low incomes are often hit harder because either their neighborhoods and cities are exposed more to poor air quality, or their voices aren't heard in the ongoing fight for clean air (Worland, J., 2019). Non-industrialized countries also see the impacts of climate change to a greater extent because they do not have the means to adapt to the ever changing climate. For these reasons, political action addressing problems that contribute to climate change, including the food waste issue, are important for those who do not have the influence to change how they are affected by climate change. This idea is especially prevalent when considering the other impacts associated with food waste, including world hunger and access to food. Despite the FAO reporting that one-third of the food produced in the world goes to waste and the EPA reporting that 96% of uneaten food in the U.S. ends up in landfills (Waliczek, T., McFarland, A., & Holmes, M), the world malnourished population rounds out to about 795 million people (World Hunger Statistics). Political actions could effectively address this inequality as well by reducing food waste and redistributing food resources to increase food access for the malnourished.

As for who has contributed to the problem, most people who have available access to food are largely responsible given the waste data from the FAO and the EPA. Studies have found that college students are large contributors to this food waste issue. Bon Appétit, the food caterer for Lafayette and 100 other schools and universities, recently conducted a study about college students' food waste. A portion of the report can be seen in Figure 8 below. With a sample of twenty different Bon Appétit cafes across the country and plate scrapings from more than 12,000 individuals, the catering service found that college students waste more than twice as much food per meal as corporate employees. On average, college students were found to waste 112 pounds of waste per student per year. Moreover, the study found that people in an all-you-can-eat environments produce more food waste than in pay-as-you-order ones (Bon Appétit's Bravo Newsletter 2019 Volume 3). All of these findings highlight an overall societal problem in college students' dining choices. These findings also apply to the food waste problem at Lafayette since the students are mostly responsible. According to Resident District Manager for Dining Services, Christopher Brown, students at Lafayette are creating more food waste than ever before (personal communication, October 31, 2019). With the impending expansion of the school and the addition of another dining hall, the amount of student food waste will continue to grow. At buffet style dining halls, students frequently take more than what they'll eat, or they'll try a little bit of everything and then go back for the food they decided they liked best. If students were aware of how their plate waste affected the larger sustainable food loop, they might be more mindful of their dining habits. Otherwise, dining services cannot inform students how much food they

should put on their plates. This is an important aspect to be aware of in the effort to increase diversion rates.

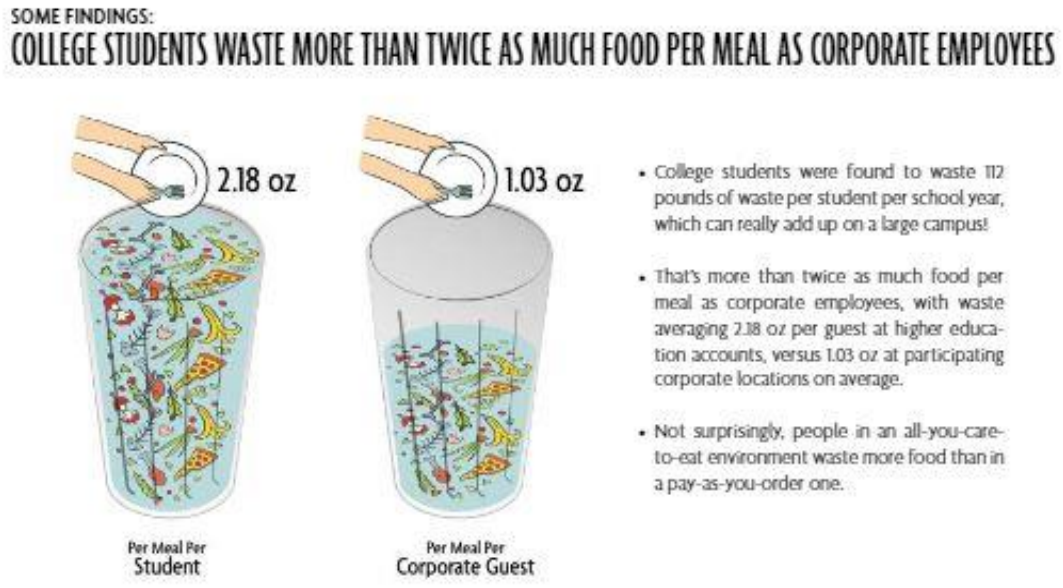

Figure 8: Bon Appétit Plate Waste Study, (Bon Appétit's Bravo Newsletter 2019 Volume 3, 2019)

Since dining services at Lafayette are responsible for preparing and distributing food, they also play a role in contributing to food waste. Fortunately, the staff have already made major efforts to reduce back of house food waste to as little as possible. They use a practice called scratch cooking in which food is prepared as close to eating time as possible. When serving trays start to get empty, the next batch gets prepared. This way, there are no full batches of food that never makes it to the line. The food that is left at the end of the night unfortunately cannot be donated because there is a risk of contamination. Therefore, it is either discarded or put through the pulper. Any food that is leftover in the kitchen can sometimes be repurposed for the next day (Christopher Brown, personal communication, October 31, 2019). At grab and go style dining halls such as Gilbert's and Lower, plate waste is less of a concern because students are given a set amount of food and the food is made to order. With predetermined portion sizes, waste at

these location comes from food packaging rather than food waste since students cannot select the amount of food they receive. Buffet-style dining halls are the largest contributors, but dining services have adopted several practices to reduce their back of house waste.

The solution to increasing diversion rates has a variety of stakeholders. The Office of Sustainability is currently the most involved with composting on campus. The responsibility for the program falls under Assistant Director of Farm and Food, Lisa Miskelly. She would be responsible for implementing any changes to the system and maintaining connections with any third parties involved. Lisa also manages a group of five student compost managers who deal with maintaining the compost system. Specifically, the student compost managers are responsible for picking up food waste from Upper, loading food waste into the Earth Tubs, operating the Earth Tubs, and monitoring and recording the compost temperatures. Student compost managers who want an expanded role can also develop and manage research to improve the system and present information about the compost program to classes, clubs, events, or conferences ("Now Hiring Student Compost Managers!", n.d.). The student compost managers will be impacted by any changes as their job description will most likely change as the system changes.

Closely connected to the Office of Sustainability is LaFarm. LaFarm is Lafayette's two acre cultivate plot located three miles from campus on Sullivan Trail in Forks Township. It is part of Lafayette's Sustainable Food Loop since it produces food for the dining halls, recycles nutrients from the on-campus composting program, and serves as an educational opportunity for students and faculty research ("LaFarm", n.d.).

Right now, LaFarm covers about half of its 6,000 pounds of produce with compost created by the school and the other half is purchased from an outside source at a discounted price from American Biosoils (“Food & Farm”, n.d.). If the compost created by the school is increased, which is the goal, then there will be more compost than LaFarm can use. Lisa Miskelly suggested that other farmers who use the land around LaFarm could be encouraged to use Lafayette’s compost output (personal communication, November 7, 2019). The rest of the compost created by the school is used around campus for landscaping purposes. Grounds Maintenance is responsible for distributing the compost around campus, so they would also be impacted by an increased output.

Any company that is involved in the suggested solution will be a major stakeholder. If outsourcing is the best option, then the third party responsible for taking our food waste will be involved with the school frequently. It will be important to maintain a strong relationship with the outsourcing company because the composting schedule at Lafayette is variable. This variability is due to the multiple dining locations on campus and the catering events that take place outside of the dining locations. Often times, companies that offer pick-up services have trouble dealing with multiple pick-up locations and changing pick-up times or locations. Therefore, Lafayette establishing one place for waste and maintaining a positive relationship with an outsourcing partner would contribute to a successful composting process. Further, any problems can be dealt with more easily if Lafayette has a close connection with the company. The same applies for any companies that Lafayette would purchase a digester from. As they are machines, digesters are likely to experience malfunctions and require operations and maintenance

work. Again, establishing a solid partnership with the digester company will lead to more productive outcomes if any issues come up with the systems.

In the end, the composting program is an initiative for the students. Although the program does have its environmental benefits for the school, it also provides valuable educational and research opportunities for Lafayette students. This second trait is a key reason behind the composting program's existence. According to Professor Kney of Civil Engineering, the composting program at Lafayette does not generate money (personal communication, October 25, 2019). The reason the program got started in the first place was because of student interest and faculty support. The program has also inspired other student programs related to food waste including Lafayette Environmental Awareness and Protection (LEAP), and the Food Recovery Network. LEAP is Lafayette's student environmental advocacy group that uses rallies and campus projects to promote discussion and awareness of environmental issues (LEAP). The Food Recovery Network is a national non-profit organization that helps students at colleges and universities recover perishable food that would be wasted at dining halls and donates it to those in need ("Food Recovery Network", n.d.). With these programs in place, students have already begun to address the food waste issue at Lafayette and would likely be part of any future solutions. As long as students continue to push for composting on campus and gain educational experience from the program, then Lafayette has a reason to maintain campus composting. Student run clubs such as LEAP and the Food Recovery Network reflect the values held by students around issues of sustainability and food waste. As much as students are part of the problem, they are also part of the solution.

Lafayette Commitments & Policies

Lafayette has a number of commitments and policies related to sustainability and energy conservation. For instance, the Lafayette Energy Policy serves as a comprehensive document that identifies energy and water conservation and efficiency as a campus issue and develops better ways to operate to reduce Lafayette's environmental impact ("Energy Policy", n.d.). The policy addresses a multitude of areas including buildings, new renovations and construction, lighting, heating, cooling, water usage, transportation, and others. Depending on Lafayette's control within each area, the policies for each section can be either general policies, like Lafayette's LCAT should be promoted, or specific, such as room temperature should be maintained at between 76 and 78 degrees Fahrenheit during air-conditioning season ("Energy Policy", n.d.).

To date, Lafayette has three main commitments and policies that affect the on-campus composting program. The first is the American College and University Presidents Climate Commitment which former president Weiss signed in 2008. Institutions involved with this group agree to conduct an emissions inventory and energy audit, declare a target date for carbon neutrality with set milestones, integrate sustainability into the school's curriculum, and publish a climate action plan ("The Presidents' Climate Leadership Commitments", n.d.). Thus, this commitment led to the other major Lafayette environmental policies. One of these is the Climate Action Plan that includes the three target diversion rates for 2020, 2025, and 2035. In regards to composting practices, the Climate Action Plan provides broad suggestions but no specific strategy for achieving the diversion milestones, especially for addressing excess food waste. The other Lafayette environmental policy is the campus energy policy which includes a recycling section with

fairly general policies. Specifically, the recycling section states that the Office of Sustainability and Facilities Operations are responsible for the campus recycling program and should expand the program when it is economically feasible ("Energy Policy", n.d.). The Office of Sustainability has used this policy to create a number of recycling initiatives. Most of these initiatives, like the Recycling Strategy, have aimed to teach students what can and cannot be recycled and where certain items can be recycled. A part of this Recycling Strategy can be seen in Figure 9 below. In terms of composting initiatives, there have not been any efforts outside of the creation of the on-campus composting program described earlier in the report. If the college were to expand the composting program resources, a composting policy or educational composting initiative could help the college build student awareness and achieve its diversion rate milestones.

Figure 9: The Recycling Strategy's "Recycling Spots", ("Energy Policy", n.d.)

Lafayette College could institute stricter policies related to recycling, waste management, and food waste that could have a significant effect on the amount of waste

going to landfills. There are several examples of waste management policies is cities that do just this. New York, Seattle, and some cities in California have enacted laws that make it mandatory to sort organic waste from garbage for both organizations and homeowners (Waliczek, T., McFarland, A., & Holmes, M, n.d.). Although Lafayette already sorts its waste efficiently, having a concrete rule published by the school could provide solid backing for green waste management at the school. Having a rule in place now could also establish a precedent that affects future waste practices. In particular, a waste rule now from Lafayette could influence the waste practices of students from the upcoming expansion or in the new dining location for the McCartney expansion. There are also policies in Massachusetts that have banned businesses and institutions from improperly disposing of one or more tons of commercial organic waste a week (Waliczek, T., McFarland, A., & Holmes, M, n.d.). A Lafayette policy like this that sets a limit on the amount of waste that can go to landfills per week could serve as a powerful regulation that supports a strong composting program.

Easton Codes

Any initiatives from Lafayette dealing with energy conservation or climate change are also subject to any relevant Easton codes. This could apply to a number of potential alternatives that Lafayette could choose for its composting program. For instance, if the college decides to increase their composting program by moving the composting to the college farm, there are certain zoning ordinances that must be considered. Both Earth Tub style composters and windrow composting would require certain permits or petitioning to be placed at LaFarm. The college currently owns about 80 acres of commercial farmland surrounding LaFarm and the Metzgar Fields Sports

Complex. This land is zoned as Recreational / Educational / Municipal (REM) as can be seen in Figure 10 below. Although there is plenty of land to implement a larger composting program at LaFarm, this land does not specifically allow composting on a commercial scale ("Forks Township Zoning", n.d.). Forks Township, the area where this land is located, allows commercial farming, but does not mention commercial composting for areas zoned as REM. There are other areas that specifically allow composting with certain setbacks and requirements such as minimum lot area of 25 acres. Because the school would be able to use this composting as an educational program for students and the Easton community, the school might be able to get the composting approved considering the large amount of acres that the school owns ("Forks Township Zoning", n.d.). The same situation could potentially apply to the addition of composting sites on-campus if Lafayette were to be a part of Easton's expansion to its own composting program.

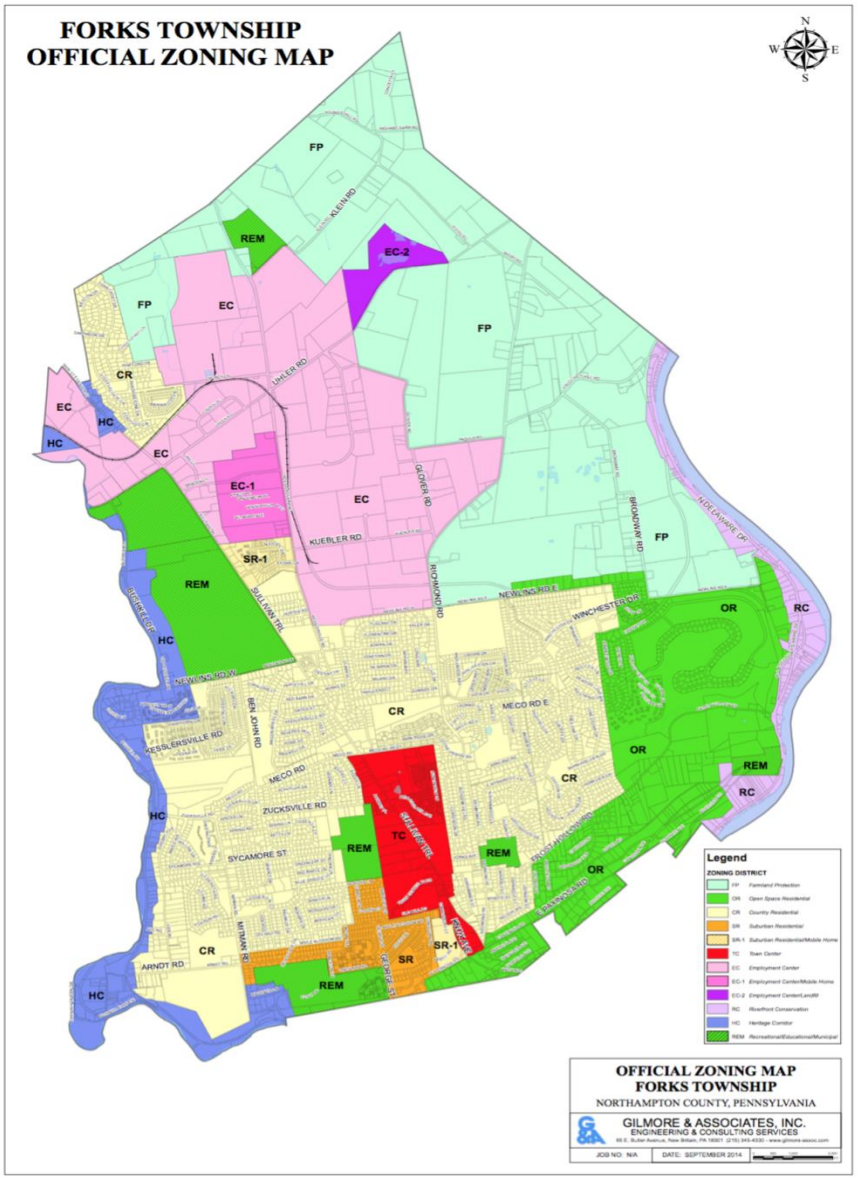

Figure 10: Forks Township Zoning Map, ("Forks Township Zoning", n.d)

Technical Context

Introduction

The current composting system at Lafayette College consists of two Earth Tubs from Green Mountain Technologies and two food pulpers that are located in the two main dining halls, Upper Farinon and Marquis. Between Fall 2018 and Fall 2019, the Earth tubs have taken between 150 and 179 pounds of food waste per day, which is equal to

about half of the plate waste from one of the two major dining halls (FoodWasteCollectionEarthTubs(Upper_Plate_Waste), 2019).

Under ideal circumstances, the Earth tub can process up to 500lb/day of biomass. Biomass consists of a mixture of food waste and dry bulking agent (Luker, 2008). The process of using an Earth Tub can be simplified into four steps. First, the tub must be loaded through the loading hatch with a mix of food scraps and wood chips. Next, the operator closes the lid and rotates it while the internal auger mixer mixes and shreds the material. After the active composting cycle is complete, shoveling is needed to remove the rest of the compost that is leftover after the auger discharges the majority of the compost. Finally the compost can be used as mulch or as a soil amendment (Luker, 2008). The food pulpers located in Marquis and Upper Farinon break down food waste further before it is loaded into Earth Tubs so that we can double the amount of food waste we load into the Earth Tubs.

The two Earth Tubs are located at Bushkill Commons as displayed in Figure 4 from the introduction. Grounds Crew is responsible for picking up food waste from dining locations and bringing it to Bushkill Commons. Student Compost managers and Lisa Miskelly are responsible for overseeing the functioning of the Earth Tubs, and then Grounds Crew comes back in to distribute compost around LaFarm and on campus.

The current compost program is often at capacity (Christopher Brown, personal communication, October 31, 2019). Assuming the amount of food waste created by students at Upper Farinon and Marquis is equal, then the two major dining halls are responsible for producing about 2,500 pounds of food waste per week. This is based on the 1,090 pounds of plate waste created per week in Marquis (Christopher Brown,

personal communication, October 31, 2019). In order to get to a diversion rate of 60% by 2035, the compost program at Lafayette must be expanded or modified to allow for the processing of more food waste.

Lafayette could increase its composting capabilities with one of two routes. The first would be to expand the on-campus composting program. The other option would be to shift composting responsibilities off campus. After researching composting methods and other composting programs at colleges, the best alternatives for Lafayette's composting program would be to either invest in more digesters like the Earth Tubs, use windrow composting at LaFarm, or outsource the composting to a local composter or recycling center.

Alternative 1: More Digesters

The first alternative that we have considered to increase food waste diversion rates at Lafayette is an in-vessel composting system, otherwise known as a digester. Generally, digesters are units in which food waste, yard scraps, and a dry bulking agent such as wood chips or cardboard are combined to create soil amendment or mulch (Luker, 2008). This method of composting is what is currently being used at Lafayette, Princeton, and many other colleges. Many companies produce in-vessel composting systems that process food waste using different techniques. We have chosen to focus on products from For Solutions and Green Mountain Technologies.

Green Mountain Technologies is a composting company located in Bainbridge Island, Washington. They produce a variety of in-vessel composting systems that can process between 50 pounds and 10 tons of biomass per day. We have worked with Green Mountain before since they created the digesters that make up Lafayette's current

composting program, Earth Tubs. In October of 2018, Green Mountain Technologies announced it would be discontinuing Earth Tubs because "the manufacturer who created the molded tub and lid was unable to continue production" and they "were unsuccessful in finding alternative manufacturers" (Green Mountain Technologies, 2018). However, Green Mountain has other, larger, in-vessel composting systems that could help Lafayette compost nearly all of the food waste created on campus.

A representative at Green Mountain Technologies recommended their 20 Foot Intermodal Earth Flow model based on our estimated amount of food waste created in the two major dining halls of 2,000-2,500 pounds per week (personal communication, November 18, 2019). A crude image of the system can be seen in Figure 11. The Intermodal Earth Flow uses an upcycled shipping container lined with insulation and stainless steel. Technical aspects of this system include an auger for mixing, which is powered by a gear motor, an aeration system that controls for odor. The whole system has a footprint of 20 feet length x 8 feet width and requires 330V for motors and fans (Green Mountain Technologies, 2019).

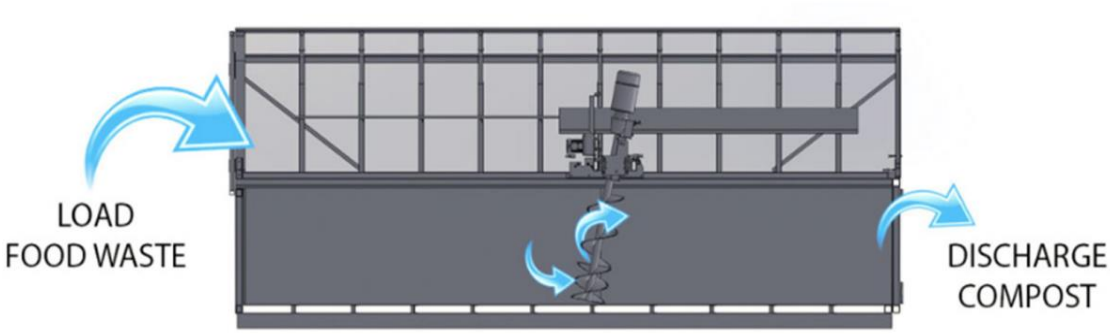

Figure 11: Intermodal Earth Flow, (Green Mountain Technologies, 2019)

The process of using an Intermodal Earth Flow is straight forward. First, food waste and bulking agents are manually loaded through the loading doors. The representative from Green Mountain Technologies suggested a 1:1 ratio of food scraps to

bulking agent (personal communication, November 18, 2019). Next, the programmed auger mixes for about 30 minutes between one and four times per day. The final step involves removing the finished product from the discharge end of the shipping container after the 14-21 day cycle is complete (Green Mountain Technologies, 2019). This product can either be used immediately as mulch, or it can be left to cure for one to two months and used as a soil amendment. Because the system is automated, it would require the work of one person for one hour per day over a five day period. We can assume that the amount of student workers needed for this method would remain the same to the current composting program because labor would still be needed to transport food waste.

The 20 Foot Intermodal Earth Flow has a processing capacity of 1,178 pounds of feedstock per day. Since we would be using the recommended 1:1 ratio of food waste to bulking agent, this would allow Lafayette to compost up to 589 pounds of food waste per day. From Marquis and Upper, we are currently creating about 500 pounds of food waste per day, so this extra space will be valuable for the future expansion of the school and the hope of one day composting from all dining halls on campus and within dorms.

Another company that we considered getting a digester from is For Solutions in Lancaster, Pennsylvania. We found out about For Solutions by researching the composting program at Princeton University. The Sustainable Composting Research at Princeton (S.C.R.A.P.) Lab, initiated September of 2018, uses the Model 1000 in-vessel composting system from For Solutions shown in Figure 12 ("About – S.C.R.A.P. lab", n.d.). This model size has a processing capacity of 5,000 pounds per week, which is fitting for Princeton's undergraduate student population that is double the size for Lafayette.

Figure 12: The Model 1000, ("About – S.C.R.A.P. lab", n.d.).

Nick Smith-Sebasto, Founder and Executive Chairman of For Solutions, recommended their smallest in-vessel composting system, the Model 500, based on the estimated 2,000 to 2,500 pounds of food waste created per week (personal communication, November 18, 2019). An image and process for using the model can be seen in Figure 13. This model has a footprint of 26 feet length x 6 feet width x 11 feet height and requires 240V ("For Solutions Info Sheet", 2018). This model has a processing capacity of 2,500 pounds of feedstock per week. For Solutions advises the use of 4:1 ratio of food waste to drying agent (Nick Smith-Sebasto, personal communication, November 18, 2019). Therefore, the system would only be able to accommodate a maximum of 2,000 pounds of food waste per week. Considering this is about where Lafayette is at now just from Upper Farinon and Marquis, this model will not be well suited for the expanding student population if we want to get to a point where all food

waste is composted. However, the goal is to get to a diversion rate of 60% by 2035, which this system should allow for.

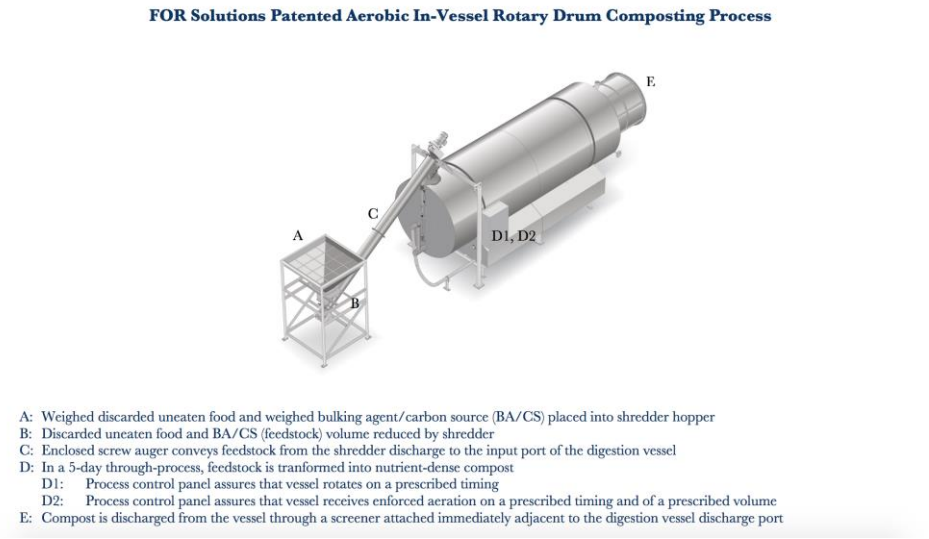

Figure 13: Digester Process Model, ("For Solutions Info Sheet", 2018)

The process for using the Model 500 is relatively similar to the Intermodal Earth Flow. It begins with loading food waste and the appropriate amount of drying agent into the loading hopper, the upper opening of the system. A shredder located at the bottom of the opening shreds the food to pieces roughly the size of a sugar cube. This eliminates the need for the pulpers which are currently used in Marquis and Upper. The drying agent and food scraps are then carried up a conveyor belt into the system which is automated to create compost within five days (Smith-Sebasto, 2019). This compost can then be used for mulch or soil amendment.

Alternative 2: Windrow Composting

The second alternative for increasing composting on Lafayette's campus is through windrow composting. Windrow composting is the process of composting food and other biodegradable materials. These materials are piled in long rows called windrows, and are turned periodically. The piles must be large enough to generate and

maintain heat but also allow oxygen to flow into the center of the pile. The turning can also help with oxygen infiltration into the pile core, which is necessary for the decomposition process. This system is often used by municipalities or food processing companies as it can handle large volumes of waste such as grass clippings, grease, food, and animal byproducts such as push and poultry waste ("Types of Composting and Understanding the Process," 2015, n.d.).

Although windrow composting can handle much larger amounts of material than nearly any other method of composting, it also requires the largest amount of space. This means that composting would need to take place off of Lafayette College's campus, most likely at the college farm, LaFarm. Lafayette College currently owns nearly 80 acres of land surrounding LaFarm, so conversion of several acres could easily be done at little cost to the college. These compost piles generally range from 5-8 feet tall and 10-16 feet wide at the base, and can be as long as needed to allow for the necessary volume of material to be incorporated into the rows (Richard, 1995).

Figure 14: Windrow Compost at Dickinson College, ("Compost – Dickinson College Organic Farm", n.d.)

Because windrow composting can handle the largest amount of material compared to other forms of composting, all of the debris generated on the college's grounds would be able to be composted at LaFarm. The college would easily be able to meet its target diversion rate of 60% that is outlined in the Climate Action Plan with windrow composting, and it would be able to compost as much as 100% of food waste from campus if the proper collection processes were put in place.

Many of the difficulties associated with this composting process have to do with transportation. Food waste that is generated in the dining halls on campus would need to be transported to LaFarm daily. This would most likely fall on student compost workers who are hired by the college. These students would be responsible for picking up food waste from the dining halls and transporting it to the composting site at LaFarm and placing it in piles. There are also additional costs for this transportation, as the college would need to use another truck in this collection process. If student compost workers are unable to collect compost, it would most likely need to be completed by facilities in their daily work. (Lisa Miskelly, personal communication, November 7, 2019).

Once all of the material is brought to the compost site at LaFarm, it would be arranged in piles. These piles must be turned periodically depending on the size and temperature of the piles to incorporate oxygen into the compost pile. The temperature of the pile should be between 90° F and 140° F. The turning would need to occur every few weeks to every few months depending on the internal temperature of the pile. Currently the college does not own any of the required equipment to turn these piles. In order to do this, the college would have to purchase a tractor and tillage implement, which combined, would be the single largest cost associated with this type of composting system. In

addition, these piles would require periodic turning, which would require additional labor (Richard, 1995).

A major advantage of this alternative is the large amount of compost that can be generated. The compost would be used to enrich the soil at LaFarm and create better growing conditions for vegetables that will be used in the college dining halls. Because the college would be able to generate more compost than LaFarm needs, LaFarm would not need to purchase additional compost, which is a current practice, and the excess compost could be sold to local residents or donated to community gardens to benefit the community.

Additionally, unlike other types of composting which are not able to operate efficiently in the winter due to the cold, windrow composting at a large scale is able to generate enough heat to work in cold climates. This allows the decomposition process to work year around. Other types of composting would require the college to find different ways to dispose of waste during the winter months.

Alternative 3: Outsourcing

The third and final alternative that Lafayette could implement to address the excess food waste on campus and increase its diversion rates is outsourcing the food waste to a third party in Easton. Several colleges, such as Union College and the University of Massachusetts Amherst, currently practice outsourcing as part of their composting programs (“Sustainability”, n.d.) (“Sustainable UMASS”, n.d.). It is an especially effective option when the school does not have either the resources or space for a large on-campus digesting and composting system. Outsourcing can also be a relatively cheap composting option depending on the prices from the third party

composter. Although outsourcing is not technical in the sense that it requires a mechanical design, there are several technical factors to consider in terms of the third party Lafayette would choose and how Lafayette would transfer its food waste to this third party.

The most important technical aspect of the outsourcing alternative is the selection of the third party composter. The best candidate for a third party composter is a company that is close to the campus and can handle the amount and type of food waste that the school produces. For instance, the University of Massachusetts Amherst annually ships about 1,500 tons (3 million pounds) of food waste and food packaging to Martin's Farm, a local family-owned business that is a 30 minute drive from the UMASS campus ("Composting at UMass", n.d.). Similarly, Union College outsources its food waste to the Ulster Waste Recovery, a recycling center that is a little over an hour away from the Union College campus (Appel, 2018). For Lafayette College, the most logical composting partner would be American Biosoils & Compost, a full-service composting and organics recycling company located about one hour away from the Lafayette campus. Besides its proximity to the Lafayette campus, American Biosoils also has experience working in the Easton area with both Lafayette (for composting waste from large catered events) and the Easton Composting program. Sources that have worked with American Biosoils have criticized the company for its poor customer service and slow response time; though, this could change if Lafayette establishes a concrete partnership with American Biosoils. Either way, Lafayette should note this when considering alternatives for the composting system.

Figure 15: American Biosoils & Compost, ("American Biosoils & Compost", n.d.)

Another technical aspect Lafayette would have to account for is the form of the outsourced food waste. Currently, American Biosoils does not accept pulped food waste because of contamination risks for its compost (Lisa Miskelly, personal communication, November 7, 2019). This is a problem given that Lafayette pulps all of its food waste at the two main dining halls. Lafayette could address this problem with one of two options. First, Lafayette could work out a deal with American Biosoils that would create a closed loop system for just Lafayette and American Biosoils. This option would mean that American Biosoils would accept Lafayette's pulped food waste as long as Lafayette would buy the compost that American Biosoils creates from just Lafayette's waste. There were talks between Lafayette and American Biosoils for such a process when Lafayette began creating its composting program in 2008 and 2009. Professors from Lafayette supported this option because they prioritized the idea of a single, large closed food loop, but dialogue between the two parties broke down because of the slow response rate from American Biosoils and Lafayette's less-established food waste system. With Lafayette's experience in composting now though, this option could be back on the table if Lafayette began a dialogue with American Biosoils again. Lafayette would have to clearly designate a location for waste pickup, give the amount of food waste that would be

picked up, and the amount of compost they would buy back from American Biosoils. The other option would be for Lafayette to either limit the amount of pulped food waste or completely eliminate the pulping process. If Lafayette were to decide to pulp a portion of the food waste, then Lafayette would have to set amounts for food waste to be pulped and not pulped. This option would also require a new food waste collection system that could handle storage of non-pulped food waste. With these two parts in place though, American Biosoils would take however much non-pulped food waste Lafayette provides.

The final important technical aspect of the outsourcing alternative is the transfer of food waste between Lafayette and American Biosoils. American Biosoils does offer pickup services but the pick-up details, including time and location, must be exact and established. Thus, Lafayette would have to designate a single pickup location on campus for all of the food waste and the day(s) for pickup. That would mean the Office of Sustainability and the student compost managers would have to move the food waste from all dining locations and catered events to one location every day or week depending on the timing of pickups. The on-campus food waste location would also need to have enough space to hold all of Lafayette's food waste. If Lafayette were not able to meet these conditions, it could pass on the pickup service and transport the food waste to the American Biosoils location. This option would require Lafayette to invest in the equipment and labor needed to transport the food waste. The equipment would entail a truck with a lift gate as the food waste collection buckets can weigh a large amount. The laborers would need to be either student compost managers or a facilities/grounds employee capable and willing to load the food waste and drive it one hour to the American Biosoils location in Douglassville, Pennsylvania which is shown in Figure 16.

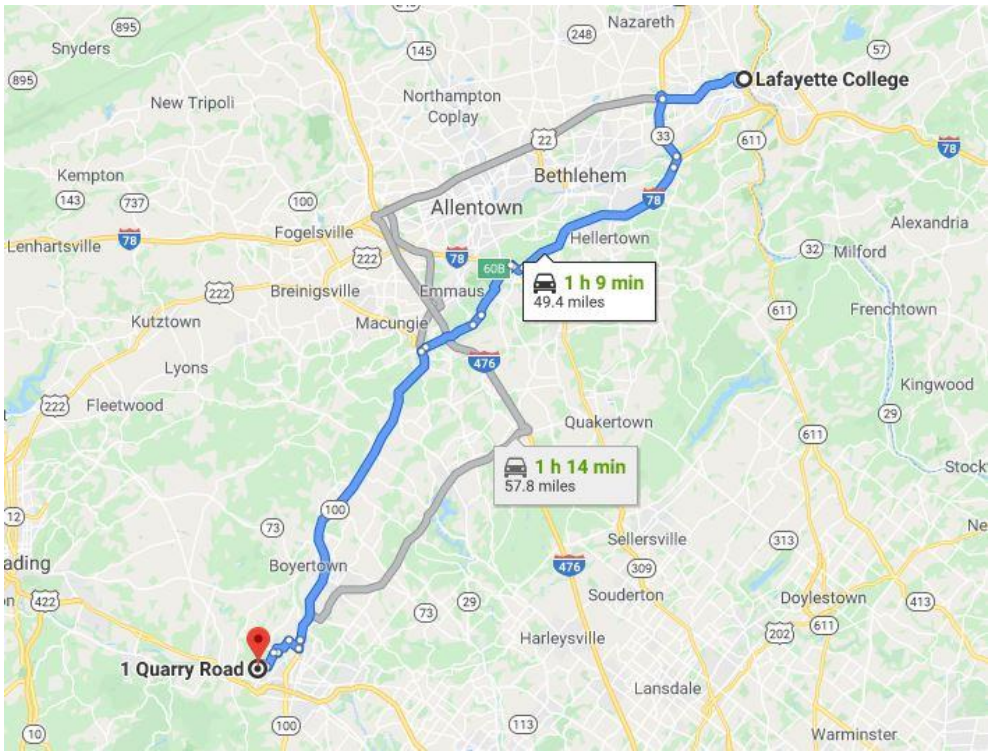

Figure 16: American Biosoils location in relation to Lafayette College, (Google Maps, 2019.)

The outsourcing option would be an effective means for diverting food waste from landfills but would involve several changes to the food collection system that Lafayette would need to authorize. Another factor to consider is that the city of Easton is currently planning an extension to its composting system that could involve composting services in Easton. According to Miranda Wilcha, the Easton Compost Program Coordinator, the city is meeting soon to discuss a possible expansion to the Easton Composting Program for 2020 that would involve more compost site locations around the city (personal communication, November 15, 2019). Currently, there is only one site downtown, but an expansion could involve four or five more sites in the Easton area. If this were the case, Lafayette could partner with Easton and outsource its food waste within the community. One of these additional sites could even possibly be on the

Lafayette campus if the right arrangements were made. This not only means less expensive pickup and transportation fees, but also more community engagement between Lafayette and the city with increased opportunities for joint partnerships and educational opportunities. Therefore, the outsourcing to American Biosoils could be a short term method for addressing diversion rates while Lafayette waits for Easton to launch its expansion.

Technical Conclusion

Expanding the compost program at Lafayette will require technical components whether we choose to add a digester, implement windrow composting, outsource, or use a combination of the three. Each alternative includes different technical aspects. For digesters, we have considered two different systems that use similar automated processes to turn food waste to compost. With windrow composting we have recognized the need for a significant amount of land, most likely at LaFarm, as well as tractor and tillage implement. For outsourcing, we know it will involve a third party composter and possibly a truck with a liftgate if we choose to transport the food waste ourselves.

Economic Context

Introduction

Along with the environmental factors associated with reducing the amount of food waste sent to landfills, there are also many economic factors that play an important role in deciding how this food waste should be handled. In 2008, Lafayette College decided to implement a composting program on campus for educational use. The college purchased two Earth Tubs from Green Mountain Technologies, Inc. These composting Earth Tubs, along with aeration piping, temperature probes, and biofilters each cost

$9,650. Additionally, Lafayette College purchased two food pulpers to be used in the two main dining halls on campus, Marquis and Upper Farinon. By using these food pulpers, we are able to reduce the volume of food waste created in the dining halls. This allows us to double the amount of food waste going into the Earth Tubs (Arthur Kney, personal communication, October 25, 2019).

If Lafayette were to send food to the landfills like it does with the remaining food waste that cannot be composted on campus, it would cost the school $80 per ton. By current estimates, each main dining hall on campus produces between 150 and 200 pounds of food waste per day ("FoodWasteCollectionEarthTubs(Upper_Plate_Waste)", 2019). By composting on campus, the school is able to save these tipping fees at the landfill and is also able to save costs associated with purchasing compost for use at LaFarm. However, in order to operate the two Earth Tubs on campus, food waste must be collected daily from the two main dining halls and brought to the Earth Tub location in the Bushkill parking lot. Since the compost tubs are turned by hand, there are no mechanical parts that require maintenance. The Earth Tubs, besides loading and unloading, only require periodic mixing and are therefore inexpensive to operate.

When trying to decide how to grow the size of the composting program at Lafayette, it is also important to consider how these projects are funded. The two Earth Tubs that the college currently uses were paid for by grants from the Pennsylvania Department of Environmental Protection. Future developments in the composting program must be driven by desire from students involved in on campus composting. Because composting is not a profitable investment for Lafayette, the college will only purchase composting equipment for student education or campus involvement. In order to

increase the amount of food that is diverted from landfills, the school may also have to rely on donations or grants from organizations such as the EPA or DEP. Since composting is an expensive investment that does not produce a profit, it is important for the college to receive grants to be able to afford to implement such systems (Arthur Kney, personal communication, October 25, 2019).

Alternative 1: More Digesters

If Lafayette chooses to invest in a digester system to increase food waste diversion rates, then there are significant costs to consider. The two digesters considered for this alternative contain large upfront costs for the system as well as payments for periodic replacements of parts. Also, the decision would have to be made whether or not we would keep the existing composting program in addition to implementing a new in-vessel system. The Intermodal Earth Flow from Green Mountain Technologies and the Model 500 from For Solutions are both capable of diverting at least 100% of Lafayette's current amount of food waste from landfills. However, according to a representative at Green Mountain Technologies, removing the current system would require finding a buyer as well as renting a lift gate to physically move the system because they do not buy Earth Tubs back (personal communication, December 3, 2019). Otherwise, both of the systems considered are automated; therefore, the number of student compost managers needed and overall labor costs would be reduced. With automation, though, we have to consider the cost associated with the amount of energy required to power each system.

The Intermodal Earth Flow recommended by Green Mountain Technologies has costs associated with its equipment and implementation. The cost for the Earth Flow is $60,000. This covers the shipping container as well as the automated system. The auger,

which is responsible for mixing the food waste and bulking agent combination, will need to be replaced every four years, and right now it costs $1,400. Otherwise, the Intermodal Earth Flow is designed to have a long service life with little to no additional maintenance costs ("The Intermodal Earth Flow", n.d.). Since the company is located in Washington, a shipping fee ranging from $5,000 to $6,000 will be incurred upfront. A startup fee of $7,000 will also be included in the initial cost for the Intermodal Earth Flow. The startup fee covers the cost of sending a representative from Green Mountain Technologies to Lafayette who will teach individuals responsible for composting on campus how to use the system, and they will help get the composting process started. When these costs are considered together, the Intermodal Earth Flow has an upfront cost of about $72,000. All of these prices came from a phone call with a representative at Green Mountains Technology (personal communication, November 18, 2019).

Similarly, the Model 500 from For Solutions has upfront and maintenance costs that are necessary for consideration if this option is pursued. The upfront cost for this system is $187,500. When a shipping and installment fee of less than $5,000 is considered, the upfront cost of the system comes to about $188,000. Similar to the Earth Flow, this model was designed to be sustainable, and therefore requires minimal maintenance. The only parts that will need to be considered for replacement are the motors and blades. The four motors will need to be replaced every 10-15 years, and the blades for shredding will need to be replaced every 15-20 years. Otherwise, this digester does not require a pulper to chop up food waste since it already has a shredder attached to reduce input volume, which can be seen in Figure 13 of the technical section labeled with the letter A ("For Solutions Info Sheet", 2018). Therefore, more research is needed to

figure out what to do with the pulpers if this option is chosen. All of these costs came from Nick Smith-Sebasto, founder and executive chairman of For Solutions (personal communication, November 18, 2019).

Based on the upfront costs and processing capacities of the Intermodal Earth Flow and the Model 500, we concluded that the Intermodal Earth Flow is a more viable option. While there are other costs to consider such as maintenance and labor, both systems require minimal upkeep and are automated which reduces the need for labor. In terms of digesters, the Intermodal Earth Flow is a better option because it is able to compost 45% more food waste than the Model 500 at more than one third of the cost, and arrangements do not need to be made for the pulpers.

Alternative 2: Windrow Composting

The second alternative to increase composting on campus is windrow composting at LaFarm. Windrow composting takes more land than other methods of composting such as using Earth Tubs, but a much larger amount of compost is able to be generated by this method. Lafayette College currently owns around 80 acres of land surrounding LaFarm that is rented to farmers every year. This means the college would not need to purchase extra land to compost on.

There are several other large costs associated with this type of composting however. Compost from on campus dining halls would need to be transported to the composting area at LaFarm daily. In order to accomplish this effectively, there would need to be a dedicated truck for use by the student compost workers to transfer the food waste to LaFarm. The student compost workers already work for Lafayette, so the labor cost would not increase if food waste had to be transported to LaFarm, but it would take

about two hours of their shift each day to collect compost and drive it off campus. Once the compost is piled in rows at the composting site, it is necessary to turn the piles every few weeks to several months depending on the internal temperature of the pile and to incorporate oxygen into the pile (Richard, 1995). This is the largest cost associated with windrow composting as the school would need to purchase a tractor and a turning implement. Based on similar equipment to Dickinson College's windrow system, it is estimated that the combined cost of the tractor and turning implement could be as much as $65,000 plus yearly maintenance. The time spent turning the compost piles would also require several hours of labor to complete (Matt Steiman, personal communication, November 20, 2019).

One major benefit of windrow composting is the increased volume it can handle. This would allow the college to compost all of the food waste from every dining hall, and all the debris from campus grounds maintenance as well. This would reduce disposal costs for the grounds department and increase the total compost that LaFarm is able to create. LaFarm would therefore not have to purchase any additional compost, and would be able to sell excess compost back to the community to increase its revenue used to operate, or give compost to Easton community gardens. Despite the large initial costs of establishing a composting program of this type on campus, it could lead to monetary savings for the college in the long run. Some of these savings include reduced tipping fees at landfills, additional savings from reducing the amount of compost purchased by LaFarm, and as much as $1,200 per year from the reduced demand for garbage bags in dining halls which has been seen at other colleges of similar size ("Compost – Dickinson College Organic Farm," n.d.).

Alternative 3: Outsourcing

The economic context and costs associated with outsourcing are completely dependent on the choices Lafayette and the Office of Sustainability makes with the technical aspects of the system described earlier. In general, all of the costs for the outsourcing alternative would come from the costs of transferring Lafayette's food waste to American Biosoils and any added labor, transportation, or equipment costs if necessary.

In terms of payment to American Biosoils, American Biosoils charges $55 per pickup and $50 per ton of organic waste collected (American Biosoils & Compost, n.d.). Although this price could change if Lafayette agreed to create a closed food loop system with American Biosoils, we will assume the $55 and $50 price tags for any cost estimates. Further, based on data collection from Upper Farinon and Marquis Dining Hall, we estimate that Lafayette produces between 2,000 and 2,500 pounds of food waste per week between the two dining halls. If Lafayette were to leave all of its food waste non-pulped and specify a once-per-week pickup schedule for American Biosoils, the cost of pickup and tonnage fees would amount to $3,150 to $3,525 per 30 week academic year. This cost may increase or decrease depending on some of the routes Lafayette could choose to go. For instance, the cost would decrease if Lafayette decided to pulp some of its food waste and restrict the amount of food waste that it outsources. Likewise, if Lafayette decided on a pickup schedule involving two pickups per week, the costs would significantly increase. Finally, if Lafayette chooses to create a closed food loop system with American Biosoils, Lafayette would also have to pay for the compost American

Biosoils produces; but, American Biosoils could potentially reduce the pickup and tonnage costs if this were the case.

Any labor, transportation, and equipment costs associated with outsourcing would be contingent on the delivery system Lafayette would select. If Lafayette used American Biosoils for pickup, there would most likely be no added costs for labor, transportation, or equipment as the existing student compost managers could move the waste from dining halls to the pickup location. Conversely, if Lafayette decided to transport the food waste to American Biosoils on its own, the college would have to invest in more labor, transportation, and equipment for this process. For labor, the transfer process would require employees or student compost managers to load the food waste into a truck and drive the waste an hour to the American Biosoils facility in Douglassville. The costs of this labor would depend on which type of employees Lafayette would select for this process. The loading process would require a truck with a lift gate because of the weight of the food waste collection bins. If Lafayette's facilities does not have a truck with a lift gate available for this process, Lafayette would need to invest $2,000 to $9,000 into a lift gate for a truck (Staff, W.T.). Finally, Lafayette would have to pay for the fuel costs of the trip between the campus and American Biosoils site.

Economic Conclusion

Although each of these alternatives would be a viable option for increasing food waste diversion rates on campus, it is important to look at the yearly cost for each of these options to help determine what the most economically feasible option for Lafayette is. For this analysis, we used a 15 year cost analysis which can be seen in Figure 17 below. Although these alternatives can all last longer than 15 years if properly

maintained, the Climate Action Plan calls for a carbon neutral campus by 2035, which is approximately 15 years away. If these main systems are paid for by then, the college will be able to focus on increasing efficiency and size of the system implemented.

When considering the initial startup costs as well as operating and maintenance costs of each of these alternatives, outsourcing to a third party company has the lowest cost per school year. When including fee per ton of food waste as well as a weekly pickup fee of $55, it would cost the school around $3,525 per year based on current food waste estimates. Equipment costs for windrow would cost $4,333 per year, but this system would also be able to handle nearly all the waste generated on campus from both the dining halls and grounds debris. The most expensive alternative, investing in more digesters, would cost nearly $6,200 per year to pay for the startup costs and yearly maintenance. Since outsourcing is the only alternative that is cost per ton, the other alternatives would have a reduced cost if the equipment used has a longer life than 15 years. Likewise, neither of the economic analysis for the windrow or digester alternatives take into account depreciation of the equipment.

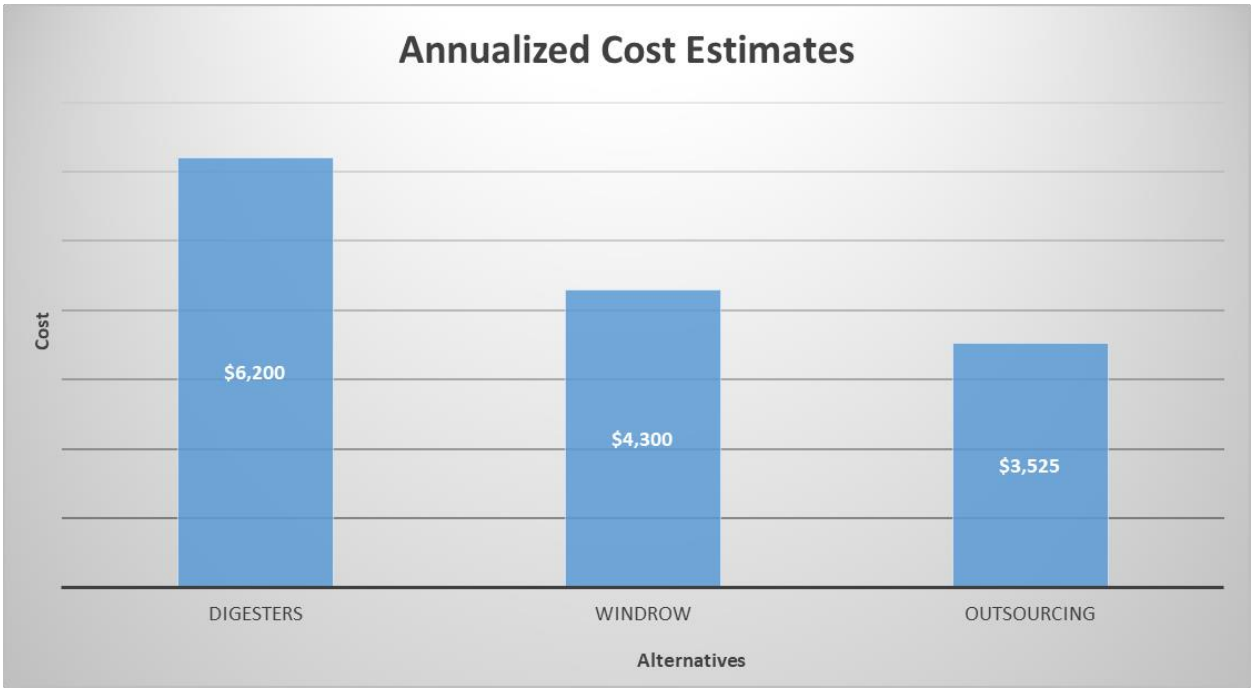

Figure 17: 15 Year Annualized Cost Estimate, (As created by authors)

Regardless of which alternative the school chooses for the composting system, the college would be saving around $3,000 a school year in tipping fees at landfills assuming $80 per ton, as well as reducing the amount of carbon emitted during the transportation to landfills. Additionally, the college farm would not need to pay for compost if the college is able to produce its own compost through windrows or digesters. These savings could amount to almost $1,000 depending on how much compost is required at LaFarm each year.

Although the cost of the outsourcing alternative can be a relatively cheaper composting method for Lafayette, the yearly costs associated with this alternative could dramatically increase if Lafayette chooses to do multiple pickups on a weekly basis. A future partnership with the Easton composting program could also significantly reduce the costs of outsourcing Lafayette's food waste.

Conclusion

Lafayette College's Climate Action Plan provides the framework for the college to achieve carbon neutrality by 2035 as a goal to be at the forefront of environmental change. Many goals are laid out in the CAP that include reducing building and facilities energy use, minimizing waste, and reducing transportation fuel use. In order to achieve the desired 60% diversion rate of waste from landfills, the college needs to grow its composting program to divert the food waste generated in its dining halls from the landfill.

There are several reasons why the school would want to reduce food waste from landfills to help achieve the carbon neutrality goal. Although school standing among other colleges and universities is high on this list, the desire for the school to educate its students about the environmental benefits and how reducing food waste in the dining halls can help the environment is a major goal of the Climate Action Plan as well.

After reviewing many different ways Lafayette could increase food diversion rates from landfills, we picked three different alternatives for composting that could provide the highest diversion rate while being economically and technically feasible for the college. Purchasing more digesters, implementing a windrow composting system, and outsourcing the food waste were the three best alternatives for Lafayette.

After looking at both the technical analysis and economic analysis of the three different alternatives, we have determined that outsourcing food waste to a third party composting company would be the most efficient and economical option for Lafayette. Outsourcing was also an attractive option because it does not require large upfront costs or efforts for initial implementation. The main challenge would be finding a composting

company to partner with, but it would allow the college to compost nearly all of its food waste at the lowest annual cost.

In this report, we analyzed three different alternatives to determine which would be the best for the college to implement. Although we were able to provide a general overview of the three different alternatives, there were several factors from each alternative that would have to be researched further. From alternative 1, we decided the Intermodal Earth Flow would be the best digester for the school to purchase; but, we did not consider the lifetime of the machine or the optimal location for this system on the Lafayette campus. From alternative 2, we found that windrow composting was a viable option for Lafayette in terms of composting capacity and available land. However, we were not able to find a definitive answer as to whether Forks Township and the Northampton County local government would allow windrow composting at LaFarm. From alternative 3, we found a likely partner and the cost of a pickup system, but we could not determine what the actual contract between Lafayette and American Biosoils would entail. In addition to these factors, future research into this topic could determine if just one of these alternatives is beneficial, or if it would be better to implement some combination of the three.

Moving forward, more research into the exact emissions associated with each alternative can provide a better analysis for how our recommendations meet the goals laid out by the Climate Action Plan. While we recognize that each alternative is capable of handling all of the food waste currently produced by Lafayette students, we do not know to what extent the diversion of all food waste meets the 60% overall diversion rate by 2035. Furthermore, it will be valuable in the future to consider the emissions associated

with each option. For digesters, this would mean calculating the amount of energy needed to power each automated system. With windrow composting, we would need to account for the emissions associated with the equipment as well as the emissions due to transportation of food waste. For outsourcing, estimates would need to be made for the amount of emissions that result from transporting food and compost to and from the composting facility. These calculations can provide a clearer image of how expanding Lafayette's composting program will impact the overall diversion rate and emissions produced by Lafayette.

With respect to the current composting system, another aspect to consider would be the two existing Earth Tubs at Bushkill Commons. If the composting program is expanded, Lafayette would have to consider what to do with these two remaining digesters. Although they produce a relatively small amount of compost compared to the other systems, we felt it would be beneficial to keep the two existing Earth Tubs for use as an educational tool. Another consideration for the existing composting program is the office or position responsible for the program. If Lafayette were to expand its composting program, it may be helpful for the Office of Sustainability to hire another full time employee to oversee the composting program at Lafayette College. As mentioned previously, the responsibility for the Lafayette composting program has fallen onto Lisa Miskelly by default. While she has made significant efforts to maintain the current system, Miskelly has many responsibilities and thus can only do so much in terms of the progression of the program. Creating a single position responsible for the composting program can ensure the program's expansion and help Lafayette reach its diversion rate goals. With a new composting position and a detailed plan for outsourcing the college's

food waste, Lafayette should be able to achieve an overall diversion rate above 60% by 2035.

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