Estimating the feasibility of implementing a vermicomposting program to address food waste in the Pylaia-Chortiatis municipality, Greece

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Abstract

Given the exponential rise in food waste, the European Union has issued directives to address the harmful environmental effects. With a focus on the Pylaia-Chortiatis municipality in northern Greece, we developed a public-private business model to effectively treat collected food waste. The municipality has evaluated resident interests and drafted a proposal for a food waste collection program, although nothing has yet been implemented. Informed by an analysis of the pertinent literature and interviews with waste management company representatives, both locally and globally, the scalable business model indicates that vermicomposting, a composting method utilizing worms, offers an efficient and lucrative approach to assist municipalities in complying with environmental legislation.

Executive Summary

Food waste generation is currently a serious problem all over the world. Food waste disposal methods such as landfilling create greenhouse gas emissions and leachates which are detrimental to the environment. Many countries are striving to address this problem; however, Greece is lagging on this initiative and consequently under pressure and threat of monetary fines from the European Union. Greece is currently required by law to separately collect and treat food waste; however, Greece is not currently practicing food waste collection and treatment. Pylaia-Chortiatis, a municipality in northern Greece that is part of the greater Thessaloniki metropolitan area, is currently under pressure from the national government to implement a food waste management strategy. The municipality responded to this pressure with a proposal in 2015 for a municipal waste collection program. The plan has not been implemented, and does not address waste treatment after collection.

The purpose of this project was to investigate different methods for the Pylaia-Chortiatis municipality to treat food waste on a large scale and the possibility of using a vermicomposting approach. To accomplish this, we explored municipal waste treatment methods private waste management programs in the United States and the European Union . We interviewed four waste management companies from the United States, specifically: New York Compost Program, Boston Zero Waste, Bootstrap Compost, and Veteran Compost. We also contacted Avfall Sverige in Sweden, Dansk Affaldsforening in Denmark, and Eco Parc Barcelona. Finally, an email interview was conducted with A.F.I.S., a battery recycling company based in Athens that operates in Pylaia-Chortiatis. The purpose of these interviews was to understand how successful programs treat large quantities of waste, challenges these programs face, partners that the programs utilized, and if they function as a business, how this is managed. To obtain a better understanding of the local context of Pylaia-Chortiatis, we interviewed representatives of local businesses and organizations. We conducted interviews with Elias Ordolis, Managing Director of A.F.I.S., Antonis Petras, the Director of Technical Works & Environment Office at the American Farm School, and Alexandros Kallis, the commercial manager for all farm products at the American Farm School. We conducted interviews with the American Farm School because we were interested in the possibility of including the American Farm School as a potential partner in waste treatment operations. Through these engagements, we were able to develop a business model for a scalable vermicomposting operation that includes a detailed cost analysis of business start-up costs, and a presentation to convey the profitability of this business to potential shareholders.

Given our collaborative engagements with the American Farm School, and their placement within the Pylaia-Chortiatis municipality, we developed this business model with the school in mind, although it is applicable to other private entities. For the American Farm School we proposed two stages in the development of a food waste management system, as a public-private partnership with the municipality: the first was a small in-house pilot program, which could lead, in the second phase, to a larger program involving treatment 3.5 tonnes per week of food waste collected from the municipality. The model was altered to best represent challenges and characteristics of the region, such as legislation and perception of recycling. This model will be applicable to multiple waste management businesses of different sizes throughout the area.

There are many methods of treating food waste. We have seen that precomposting followed by vermicomposting is the optimal method. Our interview with Veteran Compost revealed that, while composting followed by vermicomposting may take more steps than just composting, it results in much higher quality compost product that is highly marketable. Veteran Compost is able to sell their vermicompost for $1.14 per liter whereas their compost sells for $0.25 per liter, making it 4.56 times more profitable.

Our investigations revealed that the industry of food waste treatment is growing rapidly for a variety of reasons. There is a growing demand for alternative food waste treatment methods to reduce the impact of food waste on the environment. Additionally, tipping fees to dispose of food waste in landfills is becoming more expensive. Massachusetts for example has enacted commercial food waste ban that prohibits companies that produce more than one ton of waste per week from using landfills (Rosengren, 2016). Many privately owned food waste treatment programs have used vermicomposting and composting to develop a very successful business as the market expands.

Nevertheless, the industry presents a variety of challenges, including the lack of initial capital investment. Funding is crucial in order to buy equipment, pay employees, and other necessary expenses. If companies opt to work in partnership with municipalities, they may receive government grants or funding collected through taxes and fees to residents. Operating independently, they may be able to attract capital from private investors, or take out bank loans, or self-finance. Once a funding structure is established, it is important to maintain funding and to secure additional funding if needed . If the business is dependent on municipal grants as a funding source, losing funding can significantly hinder operations. Another common problem encountered is the lack of employees. Some programs have difficulties finding skilled employees in the field, potentially stifling business operations.

The organizations that we interviewed noted that starting and growing participation, both for participants of municipal programs and customers of private programs is another difficult factor. As food waste composting is a new industry, many people do not know about the environmental risks of food waste, the value of composting, or the potential resources that can come from food waste. Therefore, a variety of knowledge generation and marketing techniques need to be implemented in order to promote participation for both types of organizations. Furthermore, programs are maximizing efforts to cater to their audience by adapting their programs to be as simple and convenient as possible. For example, the New York Composting Project has adapted their policies over the years to make it easier for residents to participate. At first, the food waste had was collected in a specified bin because their compost methods at the time could not separate bags. However, gradually over time, the New York Compost Program altered their treatment technologies to allow food waste to be collected in any type of bag.

Some organizations also noted that the complexity of siting regulations can inhibit developing businesses. Different regions may have their own sets of laws and regulations for businesses that have to be taken into account. For instance, in order to obtain a permit for composting in the United States, the facility has to be a certain distance from property lines, bodies of water, and residential and commercial buildings. This makes it more difficult to find a space to compost and treat food waste. Legislation can also change periodically, so businesses have to constantly adapt in order to remain compliant. If laws and regulations are not followed, serious fines can ensue, delaying operations and causing the company to lose income and time. Legislation however, can be beneficial, as referenced in the article written by Rosengren (2016), the Massachusetts waste ban has generated $175 million in economic activity.

Quality control in the production of compost plays an important role in determining the value of any form of compost. Contamination of food waste from packaging, disinfectants from cleaning, and plastics resulting in potentially hazardous compost was a serious concern for the municipal programs as it negatively influences the quality of the product. Many measures such as education, reduced access to food bins, and specialized equipment and facilities were implemented in order to reduce contamination.

Business development was noted as an important consideration for growing compost operations. This manifested in two different ways: interacting with the market and developing business relationships. Interacting with consumers was important for both municipal programs and private businesses. Adapting to the motivations of participants and customers was also important, as seen when the New York Compost Program adapted their methods of waste treatment to better suit the needs of the residents. The easiest methods of increasing public participation in composting programs were found to be catering to what people want, and having flexibility in the treatment methods.

Relationships between the municipalities and businesses played an important role in business development as well. None of the organizations we interviewed had operations spanning collection, transportation, and treatment of all the food waste they handled. Each formed relationships with a mixture of other private businesses, volunteer groups, government organizations, and non-governmental organizations to support their operations. Some cases involve purely private efforts, in which the municipality benefits because of reduced tipping fees, but has no involvement. Other cases involved a public-private partnership, in which the municipality was actively involved in some capacity.

After consulting with a number of organizations and learning about different methods of waste treatment, we evaluated the potential for each method in Pylaia-Chortiatis. We determined that composting proceeded by vermicomposting is the most efficient treatment process and creates the most lucrative and highest quality product. Regarding local context, Greece is currently experiencing an economic crisis. As a result, Greeks are not willing to pay as much for compost and vermicompost as people in wealthier countries. This is an important consideration for Pylaia-Chortiatis. Our interview with Antonis Petras of the American Farm School, revealed that Greeks care less about quality than quantity as a result of the economic crisis. Because of this, vermicompost prices in our model were reduced by 66% from the original €1.72 per kg in view of Greece's current financial situation. Some of the waste treatment strategies employed in the United States and in European countries needed to be altered for Pylaia-Chortiatis specifically.

The primary focus of our project was developing a business model to present to organizations varying in size from startups to large scale municipal recycling companies. This business model was created in order to show private businesses there can be viable opportunities to partner with the municipality to help treat the growing food waste problem. The project proposes that the organizations compost then vermicompost the waste collected by the municipality. This method produces a product that is high in quality and high in demand in agricultural applications, while removing food waste from the environment. If other organizations adopted this business model, it would ease the economic and environmental burden of food waste on the municipality of Pylaia-Chortiatis.

The business model outlines how a business will receive waste collected by the municipality, and what materials are necessary to start the business, as well as what relationships with public or private organizations can be useful. After the collection and treatment process, we developed a pro forma income statement to outline the potential costs of developing and maintaining such a program. Revenue and profit were also highlighted to incentivize entrepreneurs to participate in a highly lucrative market. The business model provides the basis for small or large organizations to grow and develop and consequently, reduce the impact food waste has on the environment.

A separate business model tailored to the characteristics of the American Farm School was created as well. For the pilot program at the American Farm School, it was calculated that profits could range from -€33,395 to -€3,595 for the first year and between €21,603 and €49,317 in subsequent years assuming the school vermicomposts its current 1,272.5 L of food waste a week. These ranges are dependent on the selling price of vermicompost, which would be in between €1.0125/L on the low end and €1.7196/L on the high end. If the pilot program was successful and the school wanted to scale up to a municipal level program, it was calculated that the program would cost between €220,000 and €380,000 due to initial investments for the first year. Every year concurrent, they would make between €179,000 and €339,000 by vermicomposting 3.5 tonnes of food waste a week; 3.5% of the municipality's food waste.

Authorship

Our team had a very specific collaborative writing style. As a group we have slightly different writing styles so it was important that we collaborate in a way where the final report sounded like one person. We split into groups of two in order to write the individual sections. The groups of two would write and edit as they went. After the section was done, the two groups would look at each other’s sections for further edits. Once whole chapters were completed, a full read through was conducted by all members at the same time to discuss and make final edits. The partner groups and section each person worked on would change between drafts of the report. Comments would be made where appropriate and decisions would be made unanimously by all members.

MacKenzie Conlen, Nick Cunha, Erika Snow and Daniel Sochacki contributed equally in researching and writing the report. Each member contributed to the following aspects of the project:

- Background research
- Interviews
- Final presentation
- Writing and revising of the project report
- Project deliverables

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From left to right: MacKenzie Conlen, Nicholas Cunha, Christos Vasilikiotis, Daniel Sochacki, Erika Snow

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Introduction

Rapid population growth across the world in the last several decades has led to an increased consumption of food and with that, an exponential increase in food waste (Roser & Ortiz-Ospina, 2017; Sprung, 2012). Food waste refers to the discarding of food or food scraps along the entire food supply chain from primary production to the household consumer (Food and Agriculture Organization of the United Nations, 2014). Food discarded by retailers and consumers in the most developed countries could feed all of the world's 870 million hungry people (Burgess, 2015). According to the European Commission (2018), in 2010, the European Union's total waste production amounted to 2.5 billion tons; 36% was recycled while the rest was landfilled or incinerated. Today, the average European is currently producing half of a ton of waste every year and in some countries more than 80% still goes to landfill (European Commission, 2018). Food waste thrown in landfills decomposes and emits methane, which accounts for some 7% of global greenhouse gas emissions (Parry, James, & LeRoux, 2015). Furthermore, food production consumes vast quantities of water, fertilizer, and land which cost around $400 billion a year (Parry, James, LeRoux, 2015). The fuel burned to process, refrigerate, and transport food, further contributes to the environmental and monetary costs of wasted food.

The most effective method of addressing food waste production is to reduce the amount of food waste produced. According to an informative website hosted by the Washington Post, with content supplied by the organization Sub-Zero (2018), waste reduction can start where the food originates by reducing the amount of food produced. Sixteen percent of food waste is lost at the farm due to harvesting, packaging, shipping and storage ("Solving the problem of food waste," 2018). Several different food waste treatment methods can be used to reduce the environmental risks associated with food waste. These include onsite composting, aerated turned windrow composting, aerated static pile composting, anaerobic composting, and vermicomposting. Various versions and combinations of these strategies of food waste recycling have been integrated into waste management plans in municipalities and countries around the world.

Food discarded by retailers and consumers in the most developed countries could feed all of the world's 870 million hungry people (Burgess, 2015).

While these recycling methods are viable options for for waste treatment, the primary means of food waste disposal in Greece is through landfilling and illegal dumping (Ezeah & Byrne, 2014). This runs counter to the European Union (EU) 1999 Landfill Directive, which seeks to reduce the amount of biodegradable waste in landfills. Within the first 5, 10, and 15 years of the directive, European countries were expected to reduce the amount of waste in landfills to 75%, 50%, and 35% of the total amount landfilled in 1995, respectively (Council Directive 1999/31/EC). If a member state does not comply with the directive , the European Union has the right to take action through the courts, which often result in fines that are collected by ttaxes on residents ("Applying EU law," 2018). Greece has been penalized by the European Commission with fines of over €10 million, and is required to pay €14.25 million for every six months that it remain out of compliance (European Commission v Hellenic Republic, 2014). Greece is struggling to implement waste management methods. According to Chukwunonye Ezeah and Timothy Byrne (2014), experts in waste and environmental management, the central government of Greece has not been able to establish or meet targets and anticipates that lower level municipal governments will develop viable solutions. Katia Lasaridi, an expert in environmental technology and waste management, identifies that in Greece heavy bureaucracy impedes the development and implementation of alternative waste management programs (Lasaridi, 2009). It should be noted that the article was written in 2009 at the outset of the economic crisis. One could argue that with cuts to public services, municipalities may have less capacity to carry out these much needed reforms.

In order to address the large amount of waste being sent to landfills, the municipality of Pylaia-Chortiatis in Central Macedonia developed a plan that outlines a waste management system to collect and separate waste in the local region (Goulias, Chitidou, Safarikas, 2018). For organic wastes including food wastes, this plan includes household pickup, local drop off points, household composting, and awareness initiatives for composting and waste separation. The plan outlines estimated costs, estimated waste reduction rates, and willingness to participate through a survey of residents. Although the report from the municipality of Pylaia-Chortiatis offers a thorough discussion of a municipal collection plan for food waste, and indicates that residents are committed to such efforts, it fails to detail how to manage the food waste once it is collected. Taking into account the information presented in the report and drawing on the food waste composting approaches implemented in other countries, this project aimed to explore options to address the recycling of food waste once it is collected in Pylaia-Chortiatis, adding a new aspect to the municipality's waste management plan. To assess the feasibility of a food waste treatment program for Pylaia-Chortiatis, we developed a vermicomposting business model. The model outlines the necessary materials, key operational details, and the nature of the program's relationship with the municipality. While this plan was developed for Pylaia-Chortiatis, it serves as a viable and scalable model for managing food waste. The application of this model allows for small or large organizations devoted to food waste recycling to grow and develop, thereby reducing the impact food waste has on the environment.

PROJECT GOAL

This project aims to explore options to address the recycling of food waste once it is collected in Pylaia-Chortiatis

Background

Negative effects of increasing food waste on the environment and the global economy

A growing global population has resulted in an increased demand for consumable goods including food, a significant amount of which goes unused. According to the United Nations, the global population is currently 7.3 billion, and projected to reach 9.7 billion by the year 2050 (as referenced in Elferink & Schierhorn 2016). With this growth in population comes a growing demand for food; estimated to increase by 58% to 98% by the year 2050 (Elferink & Schierhorn, 2016). According to the European Commission (2018), the European Union's total waste production in 2010 amounted to 2.5 billion tons, of which one third comes from food waste (Capobianco, Cappelli, Vang, & Whitcomb, 2017). In addition, the Food and Agricultural Organization estimates that approximately one third of food produced for human consumption is either lost or wasted through production and postharvest handlings and storage (Abeliotis, Lasaridi, Costarelli, & Chroni, 2015).

The most common method of waste and food waste treatment is through the use of landfills due to the relatively low cost of such a disposal strategy (Lim, Lee, & Wu, 2016; Sim & Wu, 2010). According to research conducted by Dominic Hogg and Eunomia Research & Consulting (2018), in Austria it costs €67/ton to landfill waste, as compared to €363/ton to incinerate waste, and €94/ton to compost food waste. Similar cost trends of each type of waste management are observed in other countries in the European Union. However, unused food that is left to rot in landfills has a negative effect on the earth's natural resources, the environment, and the global economy (Abeliotis et al., 2015). Furthermore, while developed areas sometimes have waste containment systems that trap gases and contain leaks within landfills to prevent contamination of nearby areas, many countries do not have these technologies and resort to open dumping. Open dumping leads to detrimental environmental effects including higher levels of greenhouse gas emissions (Lim et al., 2016; Sim & Wu, 2010; Kitsantonis, 2008). These greenhouse gases damage the environment and are known to be one of the largest contributors to climate change and other environmental problems around the world (Franchetti, & Kilaru, 2012).

Greenhouse gases are not the only consequence of sending food waste to landfills. As organic waste is mixed in with other wastes, hazardous chemicals are leached into the liquids resulting from the decomposition process (Loni, Hussein, & Alrehaili, 2013). These liquids are called leachates, and, when not treated properly, are released into the environment and contaminate nearby soil and water sources (Lim et al., 2016). A study conducted by Gaitanelis, Kaminiotis, Zafirakou, Darakas, and Gianni (2012) tested the ground water surrounding a landfill in Thessaloniki, Greece for leachates. Study findings indicated that "in the case of untreated leachates, the contaminants can infiltrate the aquifer and consequently pollute the agricultural products causing harmful effects to the public health" (Gaitanelis, et al., 2012, para. 18). These contaminants can be hazardous to the people that use the water and soil. Therefore, it is important to separate and treat food waste so that the toxins within the leachate do not harm the environment or the nearby inhabitants of landfills.

Addressing food waste through reduction or recycling

The most effective method of addressing food waste is to reduce the amount of food waste produced. Reducing food waste can help solve the problem of feeding the projected 9.3 billion people by the year 2050 (Lipinski, Hanson, Lomax, Kitinoja, Waite, & Searchinger, 2013). Furthermore, a large amount of food is thrown away because it does not satisfy the consumers' expectations of how the food should look either due to spoilage during shipping or due to abnormal appearance (Rowland, 2017). The *Washington Post*, with content supplied by the organization Sub-Zero (2018), the food waste resulting from spoilage occurs largely because efforts in place to ensure an appropriate environment for food during transportation and storage are insufficient to prevent food from rotting and becoming unappealing. The Food and Drug Administration just recently passed the Food Safety and Modernization Act that by 2018 calls for all food transport fleets to maintain appropriate temperatures during shipping to prevent food from spoiling ("Solving the problem of food waste," 2018). This will ensure an appropriate environment during shipping to better ensure the quality of the food when it arrives at its destination.

Proper education also needs to be put in place to inform the public on reducing food waste to preserve the environment. The European Union states that a nation's primary goal in relation to waste management is prevention. Some analysts in the United States believe that the best way to address the waste management problem, with the least financial impact, is to build consumer education programs and standardize food labeling in hopes of lessening the food waste generated ("27 Solutions to food waste," 2018; Directive 2008/98/EC). The European Union recommends programs set out by other European nations which tend to focus on consumer education, proper food packaging, and waste recovery programs ("Good practices in food waste prevention and reduction," 2018). These techniques have shown to help reduce food waste. A study done on reasons for household food waste by Helén Williams, an expert in food science and technology, and colleagues found that approximately 20 -25% of waste was due to packaging (Williams, Wikström, Otterbring, Löfgren, Gustafsson, 2012). Additionally, households educated in reducing food waste disposed of less than those that weren't. The British "Love Food Hate Waste" campaign, for example, employs educational strategies about the harmful effects of food waste and strategies on how to prevent food waste (Love Food Hate Waste, 2018). According to a report by Karin Schanes, Karin Dobernig, and Burcu Gözet (2018), experts in sustainable consumption, this program has helped prevent 137,000 tons of food waste since 2007.

While consumer education programs are an efficient way to prevent waste generation, there will be food waste produced in any country regardless of the prevention programs in place.

In addition to food waste reduction, there are several methods of food waste decomposition that could be used to alleviate the environmental hazards of food waste. These include onsite composting, aerated turned windrow composting, aerated static pile composting, anaerobic composting, and vermicomposting. According to the Environmental Protection Agency (EPA) (2016), onsite composting is mostly used with smaller operations with less waste. It involves creating a pile of organic waste and letting it compost on its own, moistening it as needed. This can take up to two years to create a final compost product, but manually turning the pile to aerate it can speed up the process to between three to six months (EPA, 2016). Due to the small amounts of waste it can handle and long processing time, this process would not be very useful on a municipal scale.

In addition to food waste reduction, there are several methods of food waste decomposition that could be used to alleviate the environmental hazards of food waste.

Aerated turned windrow composting is more suited for large scale operations. According to the EPA (2016), this type of composting involves forming the waste into rows of long piles called windrows. These windrows are aerated periodically by either manually or mechanically turning the piles. This method allows for yard trimmings, grease, liquids, and animal by-products to be composted, reducing the need to separate these materials. However, aerated turned windrow composting requires "large tracts of land, sturdy equipment, a continual supply of labor to maintain and operate the facility, and patience to experiment with various materials mixtures and turning frequencies" (EPA, 2016, para. 13). This process can take from nine to twelve months to create a final product using manual turning, however, this time can be decreased using mechanical turning ("Turned Windrow Composting," 2018).

Another form of composting is aerated static pile composting, which consists of organic waste mixed in a large pile. Oxygen can be incorporated in two ways. Layers of loosely piled bulking agents such as wood chips or shredded newspaper can be incorporated so that air can pass from the bottom to the top of the pile. Alternatively, the pile can be placed over a network of pipes that blow air into it using sensors and air blowers. This method does not require as much time, giving a final product within three to six months. However, this method is not as suitable for use in a municipality as it does not work well for composting animal byproducts or grease from food processing industries (EPA 2016). Consequently, this method would require more processing and separation of the waste before it can be composted. In addition, given the monitoring required, and the adjustment of the pile using sensors, air blowers, pipes, and fans, aerated static pile composting can also be expensive (EPA, 2016).

Yet another method to treat food waste is anaerobic composting. The Planet Natural Research Center (2018) explains that anaerobic composting is different from aerobic composting in that it uses a different group of organisms. Anaerobic composting uses a closed container to deprive the system of oxygen. Consequently, anaerobic organisms produce a highly acidic byproduct which digests the food waste and removes all pathogens from the compost (Wright, Inglis, Stehman & Bonhotal, 2003). Anaerobic composting is advantageous to aerobic composting in that it is not necessary to turn the compost pile. The basic process of anaerobic composting is fairly maintenance free, however, the waste does not decay uniformly and the process can take up to one year (“Anaerobic composting,” 2018). A study examining the utility of this approach suggests that an additional drawback to this treatment method is that the bacteria used in anaerobic composting produces a sulfurous smell due to a byproduct produced by the microorganisms (Matthews, 2014). As a result, more treatment methods are necessary to contain the odors and byproducts of anaerobic composting (Matthews, 2014).

Another possibility to dispose of organic waste is through the use of vermicomposting. Vermicomposting is a similar process to composting, except the food scraps are fed to worms, which consume the bacteria from the decaying food waste. Vermicomposting is a similar process to composting, except the food scraps are incorporated with worms, which feed on the bacteria from the decaying food waste. This converts the food into worm castings, which can be harvested and used as a nutrient rich fertilizer (Capobianco et al., 2017). Vermicomposting produces better quality fertilizer compared to traditional composting because the unique digestive system of the worms filters out pathogens and heavy metals in the food waste (Sosnecka, Kacprzak, & Rorat, 2016). Additionally, vermicomposting has the ability to treat one ton of waste in just 30 days (Pandit et al., 2012). Worms are able to process 25 -33% of their bodyweight in food waste per day (Rhonda Sherman, personal communication, April 20). According to a study assessing the ability of earthworms to stabilize bio-waste in soil, researchers found that, “Earthworm participation enhances natural biodegradation and decomposition from 60% to 80% over conventional aerobic and anaerobic composting” (Pandit et al., 2012, p.2). One of the key factors of vermicomposting is the survival of the worms, so maintaining the worms and their environment is imperative for the entire system to function effectively. For example, pH and moisture are two of the most important limiting factors that determine the survival of the worms (Capobianco et al., 2017). Given that vermicomposting is able to treat large amounts of raw material, has a fast turnaround time, and requires minimal maintenance, it is a suitable means of treating municipal solid waste.

Various versions and combinations of these strategies of food waste recycling have been integrated into waste management plans in municipalities and countries around the world. For example, the New York City Department of Sanitation (2015) implemented a compost project involving both the municipality and public-private partnerships. It includes household pickup of food wastes from participating residences, drop-off locations for food wastes, and education programs on individual composting and vermicomposting. The food waste that is collected is then composted using a variety aerobic composting methods, including aerated turned windrow composting and aerated static pile composting. The organization Greenovate City of Boston (2018), implemented a composting project called Boston Zero Waste that involves drop-off sites for food wastes, access to home composting and vermicomposting equipment, as well as education on the subjects. The wastes from the drop-off sites are composted anaerobically. Table 1 summarizes the characteristics of each method and shows a comparison between these methods of composting.

Composting Method	Duration	Advantages	Disadvantages	Labor Required	Suitable for large scale program
Onsite Composting	-Up to 2 years (3 to 6 months if manually turned)	-Low effort	-Long duration	-Moistening and turning (optional)	-No
Aerated Turned Windrow Composting	-9 to 12 months (manual turning) -Can be less with mechanical turning	-Less prior separation of non-compostable materials required	-Large space needed -Sturdy equipment -Continual supply of labor	-Maintain and operate facility -Monitoring	-Yes
Aerated Static Pile Composting	-3 to 6 months	-Fast process -Less labor as a result of automated system	-More prior separation required -Expensive	-Monitoring required	-Yes
Anaerobic Composting	-Up to a year	-Generally maintenance free	-Bacteria produces a sulfurous smell -Long processing time	-Minimal monitoring	-Yes
Vermicomposting	-As little as one month (can take longer)	-Fast process -Higher quality and more expensive product	-pH and moisture need to be adjusted to keep worms alive	- Moisture, pH, and temperature monitoring -Worms need constant supply of food	-Yes

Table 1. Table comparing different composting methods

Evaluating the problem of food waste in Pylaia-Chortiatis, Greece

Food waste is a particular problem in Greece. Based on the study of food waste in Athens conducted by Konstadinos Abeliotis and colleagues (2015), experts in sustainable development and solid waste management, food waste production on a household scale is estimated to be about 98.9 kg/individual/year in Greece. Study results indicate that 30% of this food waste is avoidable, meaning that it was disposed of due to expiration or because it was no longer wanted. The rest of the food waste is considered unavoidable, meaning that it is not or was not edible under normal circumstances, such as skins and bones (Abeliotis et al., 2015).

This household waste, in addition to commercial waste, makes up the large portions of municipally generated waste. The most popular method in Greece to manage food waste is through the use of landfills (Lim, Lee, & Wu, 2016; Sim & Wu, 2010). As shown in Figure 1, this method is used to a much higher degree when compared to other countries in the European Union.

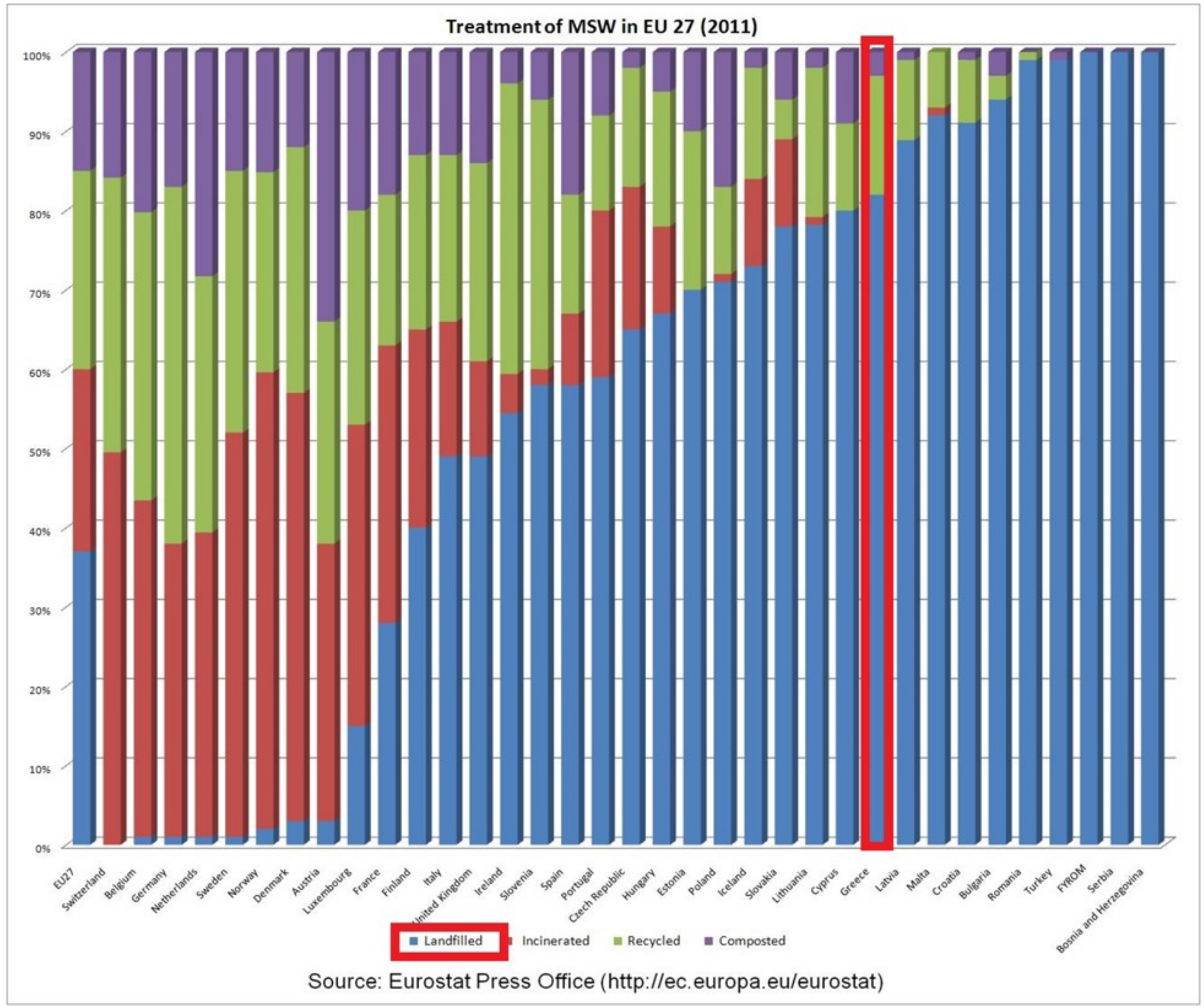

Figure 1. Chart showing waste management treatment methods throughout the European Union.

According to Abeliotis et al. (2015), a total of 5.67 billion kg CO_2-equivalent of greenhouse gas emissions per year are associated with food waste in landfills in Greece. More than 75% of this figure stems from poor food waste management. Additionally, a total value of 77.8 kg of CO_2-equivalent per capita of greenhouse gas emissions is estimated to be associated with food loss in households in Greece. According to the results of Abeliotis and colleagues' (2015) study, 56% of these emissions are from avoidable food waste in Greek households.

There is currently motivation throughout Greece, specifically in the municipality of Pylaia-Chortiatis, to alter the way food waste is handled due to increasing pressure from the European Union. The European Union has enacted waste management legislation that member countries such as Greece transposed into national legislation. If countries fail to comply with the regulations, they can face fines and legal action by the European Commission ("Applying EU law," 2018). There are two main directives that impact the food waste legislation in Greece, and specifically Pylaia-Chortiatis: the Waste Framework Directive and the Landfill Directive. These directives have been transposed into law at the national level by the Ministry of Environment, Energy and Climate Change ("Country Factsheet Greece," 2018).

The Waste Framework Directive focuses on establishing programs that highlight the prevention, reuse, recycling, recovery, and disposal of waste (Directive 2008/98/EC). The Greek law that has incorporated the demands of this directive is Law No. 4042 (N. 4042/2012). The law mirrors the directive very closely, and while it is more specific to Greece in certain aspects, much of it strongly reflects the original document.

While the Waste Framework Directive and Law 4042 address the overarching problem with waste, including the need for waste management plans, records and controls, and a waste hierarchy, they do not feature specific information about food waste and its treatment. The Landfill Directive, however, is more specific in its requirements and has a larger focus on food waste disposal and treatment. The Landfill Directive has been translated over to Greek law through the Joint Ministerial Decision US29407/3508/2002 - Government Gazette B-1572/16-12-2002. This law also mirrors the European Union directive very closely, and it specifically holds the Ministry of the Environment, Physical Planning and Public Works responsible for the national reduction strategy (FEK B'1572 /16.12.2002).

The Landfill Directive and the Joint Ministerial Decision require member countries to explore alternative waste management opportunities for municipal and biodegradable waste. The Landfill Directive focuses on safe and treated landfills and alternative disposal methods of hazardous waste, non-hazardous waste, sludge, and municipal waste, which is made up significantly of biodegradable food waste. European nations are required by the Landfill Directive to reduce the amount of landfilled biodegradable waste, which is defined as food, garden, and paper wastes (Council Directive 1999/31/EC). Countries in the European Union are required to reduce the amount of biodegradable waste landfilled to 75%, 50%, and 35% of the total amount landfilled in 1995 within five, ten, and fifteen years of initiating the directive, respectively (Council Directive 1999/31/EC). The directive ultimately leaves the alternative disposal method up to the nation's discretion.

In Greece, there are three government entities at varying levels that are responsible for the implementation of these laws. The Ministry of the Environment, Energy and Climate Change is responsible for national policy development. The Thirteen Administrative Regions are responsible for regional implementation, and the Municipality is responsible for organizing the collection of waste ("Country Fact Sheet," 2018). A visual of how these entities and roles they play in waste management regulations can be seen in Figure 2.

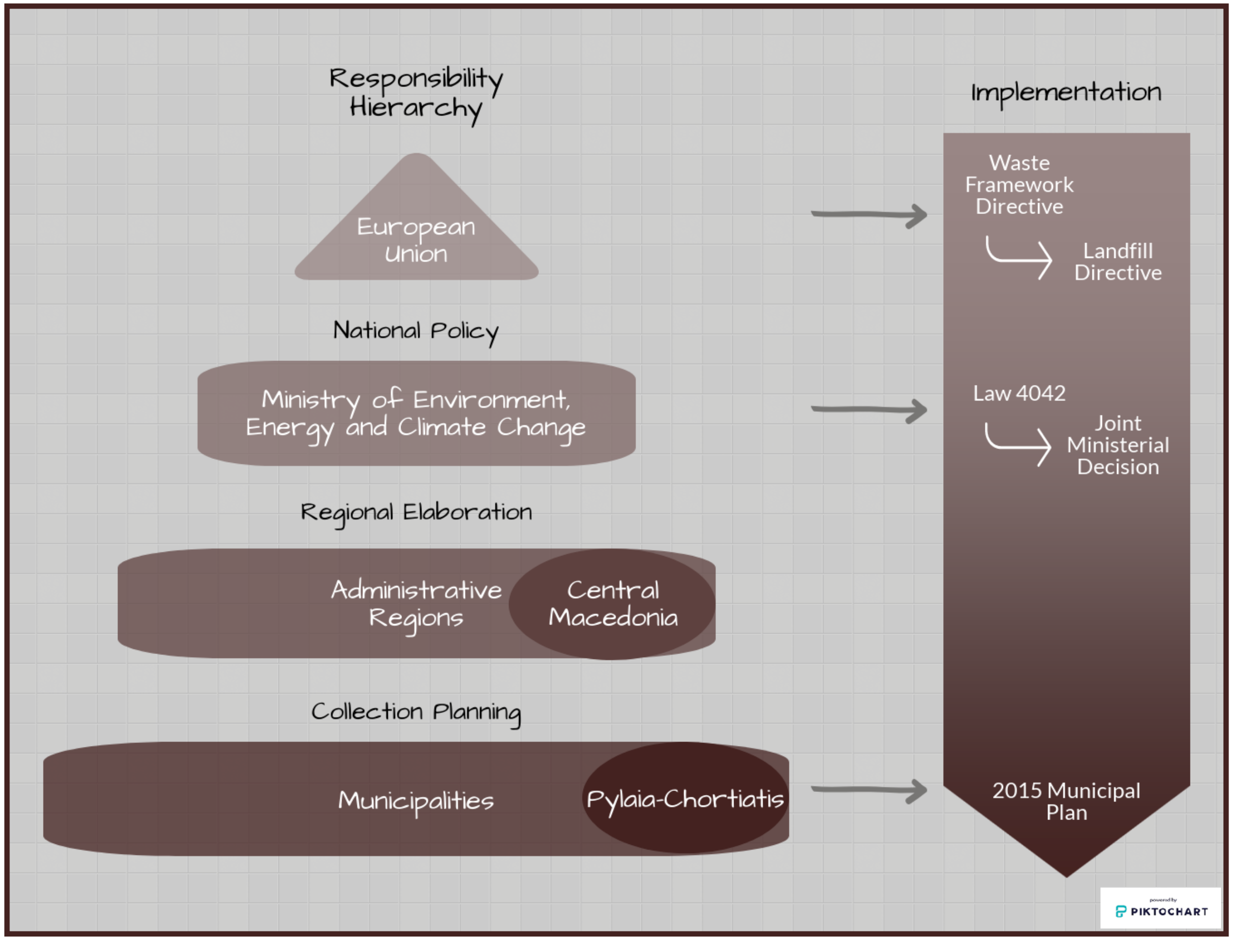

Figure 2. Diagram showing how the levels of government influence waste management regulations

Even with this structure in place, Greece is struggling to implement these waste management directives. In his analysis of Greece's compliance with the Landfill Directive, Lasaridi (2009), identifies key challenges which include a lack of public education and awareness, few pilot programs, and poor governmental organization. Consequently, the EU has fined Greece as a result of poor performance with respect to the Landfill Directive. As of 2014, the European Union mandated that Greece pay €14.5 million every six months in penalty for not complying with the Landfill Directive. This sum will decrease by €80,000 for each unsanitary landfill that is taken out of commission. Additionally, the country must pay a lump sum of €10 million (European Commission v Hellenic Republic, 2014).

Greece is about to face more pressure due to the Sustainable Development Goals the European Union set out to achieve in 2015 ("EU Actions Against Food Waste," 2018). These goals include increasing awareness, reducing food waste generation, and cutting the global food waste per capita in half all by the year 2030 (A/RES/70/1 - Sustainable Consumption and Production, 2018). The European Commission plans to do this in four different ways. The European Commission will establish a food waste measurement strategy, create the European Union Platform on Food Losses and Food Waste, clarify the European Union food waste legislation, and improve food labeling ("EU Actions against Food Waste," 2018).

Specifically in Pylaia-Chortiatis, Charissios Goulias and colleagues (2015), working with the municipality, approximated that 30.4 million kilograms of waste was created in 2014, remaining constant from the 30.6 million kilograms generated in 2011. Of this waste, 93.49% was sent to a landfill in Thessaloniki, the neighboring municipality. In order to address the large amount of waste being sent to landfills, the municipality of Pylaia-Chortiatis has created a plan that thoroughly discusses the details of a municipal level waste management strategy to collect bio-waste in the local region. The objectives of this plan are to reduce the total amount of municipal solid waste in landfills by 48%, the amount of paper, plastic, metal, and glass by 65%, and the amount of bio waste by 40% by the year 2020. The plan also aims to raise public awareness of reusing materials and home composting through campaigns implemented by the municipality.

Developing a food waste management strategy in Pylaia-Chortiatis

As part of the assessment to evaluate the implementation of a food waste management strategy in Pylaia-Chortiatis, and in accordance with Council Directive 1999/31/EC, a survey of residents was conducted and a comprehensive plan for food waste collection was proposed (Goulias et al., 2015). Table 2 offers an overview of the demographics of resident survey respondents. Based on the information in Table 2, it is apparent that most of the people who responded to the survey live in Panorama and Pylaia and are between 43 and 53. While an important group, the survey appeared to target only a small proportion of residents that are perhaps not representative of the municipality as a whole (Goulias et, al., 2015). Survey results indicate that all respondents (100%) believed that there is a need to separate food waste and 93.9% believed that it will help residents to solve problems with waste at the municipal level. Respondents also believed that the municipality should invest in waste management because it will bring economic benefits and new jobs, while at the same time improving the quality of the environment. The majority (94.1%) indicated that they would like to participate in a food waste recycling initiative organized by the municipality. These data reveal that there is a desire and support for a municipal food waste management system.

Description	Total population (N=70,110)	Survey demographics (% of responses)
Households		
Panorama	5,975	35.3
Pylaia	11,860	35.3
Hortiatis	6,179	5.9
Asvestohori		8.8
Filyro		5.9
Exotica		5.9
Total	24,014	
Employment Level		
Employed	27,334	40
Looking for a job	4,646	
Student	13,900	
Retiree	11,062	4
Domestic Labor	6,144	
Other	7,024	26
Type of residence		
Detached House		34.4
Two-family House		31.3
Flat		28.1
Other		6.3
Age Range*		
<19	16,741	<3.7
20-29	7,954	<3.7
30-39	11,643	29.6
40-49	11,679	59.3
50-59	9,248	<3.7
60-69	6,493	0
70+	6,352	0
Education Level		
Primary	9,070	0
Post Graduate	27,107	28.1
Tertiary	21,689	53.1
Other	6,427	

*age categories for survey were slightly different: <18, 18-29, 30-42, 43-53, 54-65, >65

Table 2. Statistical data of socio-demographics of Pylaia-Chortiatis compared to demographics of survey respondents (Goulias et al., 2015)

Having conducted a comprehensive assessment of the municipality, Goulias et al. (2015) presents several food collection strategies, varying by population density and sector (public or private). For areas with densely populated communities, as well as for businesses such as restaurants and supermarkets, centralized bins are suggested. These bins would be located within close proximity to most restaurants and homes in the area. Households and businesses would put their food waste into these centralized bins, and waste collection trucks would come to empty them. For less populated areas, a door-to-door collection method is suggested where each household would have its own food waste bin that would be emptied onto a truck during collection. The proposal also suggests to give out 1,000 free composting bins to the residents for in-home use, in addition to the collection bins. Table 3 below shows how the home composting bins would be distributed across Pylaia-Chortiatis in relation to the demographic data.

Bucket Distribution in Pylaia-Chortiatis		
Settlement		**Buckets**
Panorama		350
Pylaia		350
Asvestohori		100
Country		50
Filyro		75
Chortiatis		75
	Total	1000

Table 3. Distribution of home food waste composting bins throughout the municipality of Pylaia-Chortiatis (Goulias et al., 2015)

The plan calls for fourteen Green Points to be distributed across the region of Pylaia-Chortiatis (Goulias et al., 2015). Green Points are collection points where the municipality can drop off waste collected throughout the municipality. They play an important role in recycling systems and are being implemented in many European Union countries and around the world. The distribution of the Green Points excluding the primary central municipal Green Point can be seen in Figure 3. The yellow dots in the picture represent the locations of each point. The main purpose of these collection facilities is to sort and separate different materials and waste streams. Green Points target reuse and recycling, reducing transportation and waste management costs, improving the marketability of recyclable materials, and reduction of waste for burial. The program proposed by the municipality outlines a plan to operate a Municipal Central Green Point in Pylaia, where recycled materials collected from the 14 satellite Green Points will be driven to the central collection point for further management and treatment.

Figure 3. Illustration of Green Points distributed throughout Pylaia-Chortiatis

In addition to the initial setup of the waste management program, the plan included the modernization of the entire waste collection infrastructure by replacing existing collection bins, purchasing new waste collection trucks, and creating new jobs (Goulias et al., 2015). With these methods in place, the proposed plan aims to divert 15,467.83 tons of the total municipal solid waste, 9,247.16 tons of paper, plastic, metal, and glass, and 5,698.07 tons of the produced bio-waste annually (Goulias et al., 2015). This initiative is estimated to cost the municipality about €3.3 million and projections estimate that €2.66 million is needed to separate, sort, and process the food waste. See Table 4 for a detailed breakdown. Funds to cover these and the setup costs (the collection bins and sensitization campaigns) are expected to come from the European Structural and Cohesion Funds (ESPA) (Goulias et al., 2015).

Title Recommended Action	Phase A Budget (2016-2018)	Phase B Budget (2018-2020)	Description of Expenditure	Financial Source
Initial awareness campagn for waste reduction			Promote the reuse of materials to mitigate waste for collection	ESPA-Identical Resources
Supply of composting bins to public	€ 50,000.00		€ 50.00 per 260 L bucket	ESPA
Separate collection of food waste	€ 350,000.00		1. Bucket & biodegradable bags and 1 refuse vehicle to make the collection 2. Awareness campaign has been incorporated into the corresponding category	ESPA-Identical Resources
Separate collection of materials through creation of Green Point	€ 600,000.00		1 central inter-municipal Green Point	ESPA
Separate collection of materials through creation of 14 Green Points	€ 420,000.00	€ 420,000.00	6 Satellite Collection Green Points (€ 60,000.00 each) in Phase A and 6 satellite Green Points in Phase B of the project	ESPA
Design and initial implementation and campaign sensitization	€ 50,000.00		Campaign implementation to raise awareness among citizens, programs/actions already in place and for the new proposed actions (separate collection of bio-waste and Green Points)	ESPA
Community recycling reward card	€ 50,000.00		Construction of card management systems, card issuance	ESPA
1. Organizing systematic management and control 2. Improvement of existing facilities and utilities	€ 220,000.00		Replace existing bins with submerged 4-bladed bins in areas with increased density in town squares	ESPA-Identical Resources
Total	€ 1,740,000.00	€ 420,000.00		
23% Tax	€ 400,200.00	€ 96,600.00		
Total with Tax	€ 2,140,200.00	€ 516,600.00		

Table 4. Investment cost of Local Plan for collection of bio-waste (Goulias et al., 2015)

Methods

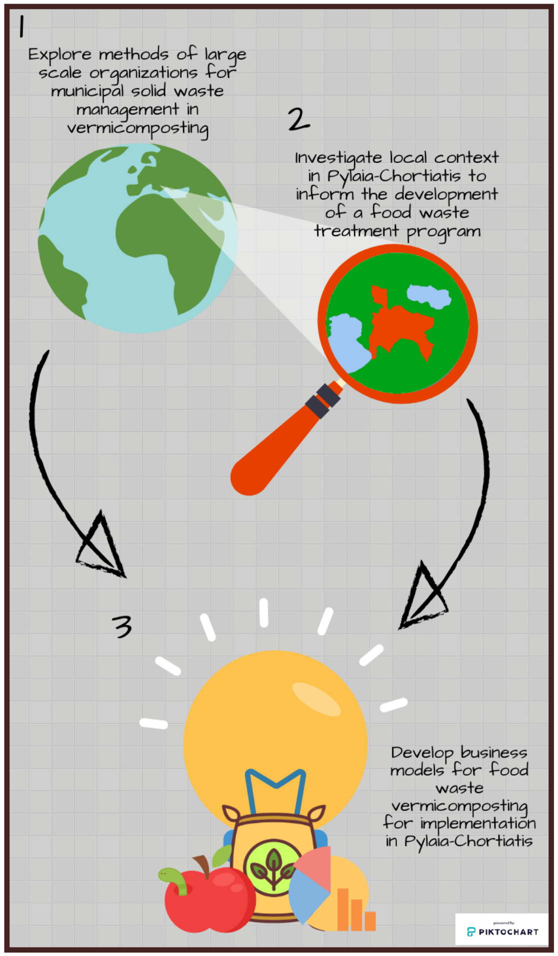

Figure 4. Image outlining our methods

The goal of our project was to identify the steps that need to be taken in order to implement a municipal vermicomposting program in Pylaia-Chortiatis, Greece. To accomplish this goal we pursued the following objectives: A visual of how these objectives fit together can be seen in Figure 4.

Objective 1: Explore methods of large scale organization for municipal food waste management in vermicomposting

In order to understand the methods of collection, separation, and treatment involved in large scale municipal food waste management, we interviewed representatives of composting programs from around the world. During these interviews we addressed possible roadblocks encountered during initialization, the startup strategies employed, partnerships with non-governmental or non-profit organizations, and types of waste management treatment systems employed. The full list of questions can be found in Appendix A.

We contacted several organizations across the United States and Europe that have similar functions to the program we were looking to develop. The organizations can be grouped into two categories: municipal waste management programs and private waste treatment companies. We wanted to obtain information from municipal programs in order to understand how a large-scale waste management system operates and what factors need to be taken into consideration when planning such an endeavor. Specifically, we looked to understand what type of treatment methods are employed for food waste, and what happened to the product post-treatment. Additionally, we reached out to private waste treatment companies to gain an understanding of what makes a successful business in the private sector of this industry. Specifically, we wanted to understand how these private organizations recognized food waste as a business opportunity and motivations for creating the business besides monetary gains. From both public and private sector organizations, we were looking to understand what types of roadblocks were commonly encountered, what types of partnerships were formed with outside organizations, and what costs were involved in each program.

In total, we contacted representatives from 24 private businesses and 11 municipal programs through email or embedded contacting forms on their websites. These organizations had the most straight forward contacting details and best exemplified the type of program we were looking to develop. Nineteen organizations responded to our requests. Many of the responses we received requested clarification of our project and what information we were looking for. After responding with follow-up emails and a second round of emails to those programs that did not respond, we received six sources of information from the 35 organizations that we contacted. Four of the programs agreed to interviews, which were scheduled accordingly to fit the preferred meeting times for their respective time zones.

The waste treatment programs EcoParc Barcelona and the Swedish Avfall Sverige could not interview with us given their lack of availability, but were still able to answer our questions via email. We received pertinent sources and information from these programs, including presentations and virtual tours of their facilities and waste treatment processes. They were also able to answer the same questions that we asked during the interviews via email. Additionally, we interviewed with representatives from the New York City Compost Project and the Boston Zero Waste Initiative over Skype or WhatsApp. The interviews were audio recorded with the permission of the participants and later transcribed for analysis. *Table 5* provides a detailed representation of all the companies we contacted organized by the type of program and location of the organization. The programs we interviewed with or received information from can be seen highlighted in orange.

Questions for organizations:

Municipal waste management

● Treatment methods

● What happens post-treatment

Private waste treatment companies

● How they recognized food waste as a business opportunity

● Motivations for the business besides money

Both

● Common roadblocks

● Types of partnerships

Region	Type	Organization	Date Contacted	Responded (Y/N)	Interview via voice call(Y/N)	Interview via email (Y/N)
USA	Municipal	**New York Composting Program**	**2/20/2018**	**Yes (3/6/2018) Marguerite Manela**	**Yes (3/24/2018)**	**-**
		Boston Zero Waste Pilot	**3/22/2018**	**Yes (3/22/2018) Susan Cascino**	**Yes (4/05/2018)**	**-**
		California Recycle	3/22/2018, 4/11/2018	Yes (4/17/2018)	No	No
		Milwaukee Organics Collection	3/30/2018	No	-	-
		San Francisco Composting Program	3/22/2019, 4/11/2018	No	-	-
		New Jersey Recycling	3/30/2018	No	-	-
	Private	Vermico	3/30/2018	No	-	-
		Curb to Compost (Silverthrone, CO)	4/2/2018	No	-	-
		EcoScraps (South Jordan, UT)	3/22/2018, 4/11/2018	No	-	-
		Good to Grow	4/3/2018, 4/16/2018	Yes (4/10/2018)	No	No
		Vermi- Green	3/22/2018	Yes (4/11/2018	No	No
		CompostNow (Raleigh, NC)	3/22/2018, 4/11/2018	No	-	-
		Bootstrap Compost (Boston, MA)	**4/11/2018**	**Yes (4/19/2018) Emma Brown**	**Yes (4/24/2018)**	**-**
		Radix Composting (Albany, NY)	4/11/2018	Yes (4/11/2018)	No	No
		Uncle Jim's Worm Farm	4/11/2018	Yes (4/11/2018)	No	No
		Compost Crusader (Milwaukee, WI)	3/22/2018	Yes (4/7/2018)	No	No
		US Composting Council	3/30/2018, 4/11/2018	Yes (4/17/2018)	No	No
		Compost Express (Milwaukee, WI)	4/11/2018	No	-	-
		Shadyside Worms (Pittsburg, PA)	4/11/2018	Yes (4/18/2018)	Waiting	No
		Bennett Composting (Philadelphia, PA)	4/11/2018	No	-	-
		Veteran Compost (Aberdeen, MA)	**3/22/2018**	**Yes (4/2/2018) Justin Garrity**	**Yes (4/11/2018)**	**-**
Canada	Municipal	Township of Langley, Brtish Columbia	3/22/2018	Yes (4/26/2018)	No	No
Australia	Private	Circular Food	4/16/2018	No	-	-
Europe	Municipal	Ajuntament de Barcelona	3/22/2018	Yes (3/27/18)	No	No
		Avfall Sverige (Sweden)	**3/23/2018**	**Yes (3/26/2018) Caroline Steinwig**	**No**	**Yes (3/26/2018)**
		Europe Direct City of Athens	3/22/2018	No	-	-
		Dansk Affaldsforening (Denmark)	**4/16/2018, 4/20/2018**	**Yes (3/16/2018) Nana Winkler**	**Yes (4/24/2018)**	**-**
	Private	**EcoParc (Barcelona, Spain)**	**3/22/2018**	**Yes (3/22/2018) Carlota Roses**	**No**	**Yes (3/23/2018)**
		22@ Barcelona (Barcelona, Spain)	3/22/2018	Yes (3/23/2018)	No	No
		NIBIO Vermicomposting (Norway)	3/22/2018, 4/11/2018	No	-	-
Pylaia-Chortiatis	Municipal	-	-	-	-	-
	Private	**AFIS Battery Recycling***	**3/29/2018, 4/11/2018**	**Yes (4/11/2018) Elias Ordolis**	**No**	**Yes (4/17/2018)**
		Compo Sana*	3/30/2018	No	-	-
	Compost Distributors	Agro Flora*	3/30/2018	No	-	-
		Flora Bella*	3/30/2018, 4/11/2018	Yes (4/4/2018)	No	Waiting for response
		Compost Hellas*	3/29/2018, 4/11/2018	No	-	-

Table 5. List of organizations that were contacted region, type of program, and responses (*Company not based in Pylaia-Chortiatis but sells or operates in the region)

After interviews were conducted, we used a thematic coding analysis to identify overarching themes. We applied techniques identified by psychologists Carl Auerbach and Louise B. Silverstein (2003) to analyze all the data and outline our consequent findings. The first step in this process was to pick out relevant phrases, sentences, or ideas from the responses. Next, we looked for repeating ideas across the different interviews. This made it easier to identify themes in the responses. After identifying themes, we categorized how they related to the project at hand and distributed the responses into these themes accordingly (Auerbach & Silverstein, 2003). We then analyzed the other materials we received from various organizations and compared the information to the interview responses. From this combined data, we organized and identified what these waste management programs had in common and what aspects contributed to the overall success of the programs.

Objective 2: Investigate local context in Pylaia-Chortiatis to inform the development of a food waste treatment program

In order to understand how other municipal food waste management methods could be applied in Pylaia-Chortiatis, we explored the context of the area by engaging with local business owners and subject matter experts and analyzing the demographic data found in the 2015 municipal waste management report by Goulias and colleagues. The demographic data was necessary to understand the distribution of the population throughout the region in order to determine how the food waste management plan would work in the municipality. Engaging with local business owners and subject matter experts helped us further understand characteristics and problems specific to Pylaia-Chortiatis that local recycling businesses may have encountered. In addition to the information gathered from Objective 1, this information provided us with a better vision of what a food waste treatment program might look like in Pylaia-Chortiatis.

We reached out to many local organizations such as composting retailers, various recycling companies, government officials in the municipality, and staff and faculty of the American Farm School. However, we were only able to consult with representatives of A.F.I.S. S.A., a battery recycling company, and the American Farm School. Through our email correspondence with A.F.I.S., we asked what start-up strategies were employed, if the municipality had a role in their business operations, and how they viewed battery recycling as a profitable industry. The questions we asked and the corresponding answers can be found in Appendix C. During our face-to-face conversation with Antonis Petras, Director of Technical Works & Environment Office at the American Farm School, we discussed the costs involved in constructing a food waste treatment facility, potential vermicompost markets, and the potential for the municipality to provide the food waste for a large-scale vermicomposting operation. Additionally, we conducted a face-to-face interview at the American Farm School with Alexandros Kallis, Commercial Manager for the Farm and all Farm products, to learn about the marketing strategies employed by the American Farm School to advertise and distribute goods.

Despite the few responses we received, we were able to understand local marketing strategies, waste treatment methods, and restrictions imposed by legislation using deductive analysis as opposed to the coding strategies used previously. Multiple interviews were conducted at the American Farm School and other organizations in Pylaia-Chortiatis to confirm some of the theories we developed from consulting with waste management companies in the United States and Europe. Furthermore, these interviews informed us on the current incentives behind recycling, the potential for recycling food waste, and the role of the municipality in these organizations' operations. The full list of interview questions can be found in the Local Recycling Companies portion of Appendix A.

Objective 3: Develop strategies to establish a business model for food waste vermicomposting

In order to decide on what treatment strategy could be most effective, both having a positive effect on the environment and producing a profit, we first researched and analyzed different methods of composting and vermicomposting to gauge the pros and cons of each. We considered the duration of each method to decompose food waste, the costs and efficiency of each method, and the sale price of each end product. We contacted different waste management companies and were able to determine which method is superior for treatment of food waste with respect to environmental impact and profitability for the municipality or for a private company.

After analyzing the data gathered in Objectives 1 and 2 as well as our background research, we were able to identify a business opportunity for vermicomposting food waste, and developed a corresponding business model. Additionally, to form the business plan, we created a business model canvas, which is a tool created by Alexander Osterwalder from Strategyzer to refine ideas that address a business opportunity. The canvas is spilt into nine categories, which can be seen to the right.

Once the canvas had been refined, we used the information from the cost structure and revenue streams categories to begin the process of creating pro forma income statements that further detailed the projected finances of the business model. Some important considerations involved in these income statements were the projected revenue, fixed costs, variable costs, and net profit for the business model.

Collaboration with other organizations would allow for a more efficient method to treat food waste throughout the municipality of Pylaia-Chortiatis. We decided that the American Farm School could serve as a potential collaborator to the municipality. This organization is capable of processing large amounts of food waste, as it has the necessary space for a large-scale vermicomposting operation. The American Farm School would serve as a drop-off site for municipal food waste. The school would then be able to use the produced vermicompost on their own fields and gardens, or they could sell the product. In particular, we were concerned with how much food waste the school could compost with respect to the total amount of food waste produced in Pylaia-Chortiatis. We calculated the space requirements necessary to process a proportional amount of the municipality's food waste. Based on the space available at the American Farm School, we determined that they could process 3.5 percent of the municipality's total food waste per year. We spoke to Dr. Vaggelis Vergos, the Dean of School of Professional Education and Extension to gauge whether or not there would be such motivation to implement a program at the American Farm School. In addition, our interview with Antonis Petras helped us to understand the logistics behind space constraints, building permitting, and costs to create a program at the American Farm School.

Business Model Canvas

1. Value proposition: the value a product or service provides

2. Customer segments: the specific market(s) on which a business is hoping to capitalize

3. Revenue streams: the ways in which a business makes money

4. Channels: the ways in which a product or service is delivered to the customers

5. Customer relationship: the type of relationship the business maintains with its customer segments

6. Key resources: the most important resources for the business venture

7. Key activities: the most important activities for the business venture

8. Key partners: important relationships formed with other entities in order to gain key resources or complete key activities

9. Cost structure: the biggest costs involved in running the business

Organizational characteristics for municipal food waste management using vermicomposting and composting methods

Food waste recycling can be a very lucrative business in view of a growing market for compost and vermicompost

Food waste treatment is a rapidly growing industry worldwide. Communications with New York City's Composting Program, Boston's Zero Waste pilot program, Veteran Compost in Maryland, Bootstrap Compost in Boston, Ajuntament de Barcelona's composting program partner Eco Parc Barcelona, Dansk Affaldsforening (Danish Waste Association), and Avfall Sverige in Sweden, revealed that there is an expanding market that influences the establishment of programs and businesses. Marguerite Manela, the Senior Manager of Community Composting & Compost Distribution at the New York City Department of Sanitation stated, "It's still growing. The demand [for compost] is much higher than the supply" (Marguerite Manela, personal communication, March 24, 2018).

As the market for recycled food waste products grows, companies and municipalities are able to expand their businesses. Veteran Compost started with just one person and very rudimentary composting equipment. The founder and president of Veteran Compost, Justen Garrity, stated, "I started building up piles by hand and I was my only employee. And now we have 16 full time employees and a dozen trucks and equipment and stuff like that" (personal communication, April 11, 2018). Furthermore, Garrity mentioned that Veteran Compost has grown from having a single initial site to having four sites that are approximately three acres in size (personal communication, April 11, 2018). Emma Brown, Senior Project Manager from Bootstrap Compost in the greater Boston region stated that Bootstrap Compost started in a similar manner as Veteran Compost with the founder composting in their backyard and distributing the produced compost to friends and family. The company achieved success as the demand for waste treatment and compost products grew. Bootstrap Compost now partners with municipalities in Boston and has diverted 2,881,387 lbs of food waste from landfills (Emma Brown, personal communication, April 24, 2018). The New York City Composting Program has also made significant progress. It started out as a small program with volunteer groups and nonprofits collecting and composting wastes from the four botanical gardens in the city. Currently, they are a large government run program that collects food waste from all of New York City. In addition, the program has seen a significant rise in participation since its start as a citywide program. From 2014 to 2017, they did not distribute compost widely or very formally, but in 2017, they started major compost give-away event that caused a major traffic jam due to its popularity (Marguerite Manela, personal communication, March 24, 2018).

There are many problems to consider when starting a composting or vermicomposting business

As the food waste recycling industry grows, businesses face a number of problems regarding development and operation. Some of the underlying problems encountered by organizations stem from a lack of available resources. One example of this is that some programs have a hard time developing and expanding because they cannot find enough employees to continue growing. Manela of the New York City Composting Program said “[current production is] higher than our operations can manage. So you know right now we’re just limited by staffing capacity” (personal communication, March 24, 2018).

Furthermore, municipal organizations struggled to find people to participate in their operations. During an email interview with Elias Ordolis, managing director of A.F.I.S. battery recycling company in Greece, he mentioned that the organization had difficulties sensitizing the public to the idea of recycling and the benefits that it has on the environment (personal communication, April 17, 2018). In addition, New York City’s program initially struggled to find people that were interested in composting because “[there are] a lot of people in NYC who don’t know what compost is and don’t know that food scraps can be transformed into a resource” (personal communication, March 24, 2018). According to Manela, New York City is always trying new methods of advertising their program and related events. She notes that on occasion, advertising is effective and a lot of people show up to events, and other times it is not (personal communication, March 24, 2018).

Governmental impediments also cause problems for developing businesses. Elias Ordolis of A.F.I.S. revealed the deep bureaucratic structure that prevents the company from privatizing, stating “Many times approvals needed by the Ministry delay us in implementing effective strategies.” (personal communication, April 17, 2018). The full email interview with A.F.I.S. can be seen in Appendix C. Additionally, in order to obtain a permit for composting in the United States, the facility has to be a certain distance from property lines, bodies of water, and residential and other commercial buildings. This makes it more difficult to find a space to compost and treat food waste. Garrity of Veteran Compost stated “even when you’re doing something beneficial like us it’s pretty tough to find siting, so we spend most of our time just trying to find a parcel of land that’s even useable” (Personal communication, April 11, 2018). According to representatives from the American Farm School, some residents in the area have filed complaints against the smell of the manure composting facility, which has resulted in increased pressure from the municipality to move this facility. (Christos Vasilikiotis, personal communication, April 13, 2018). Legislation can also change periodically, so it is important to keep up with changes and adapt when necessary. Garrity of Veteran Compost stated, “When I got started eight years ago in Maryland, it was 150 dollars and an eight page word document. And now it’s grown into this thing where it takes me several years to permit a facility” (personal communication, April 11, 2018).

Additionally, product quality was found to be an essential part of marketability. Quality control plays an important role in determining the value of any form of compost. Contamination of food waste, for example, from packaging, plastics, and disinfectants was a serious concern for the municipal programs as it negatively influences the quality of the product. Many measures such as education, reduced access to food bins, and specialized equipment and facilities were implemented in order to minimize the effects of this contamination. Specifically at City of Boston's community composting pilot, they attempt to minimize contamination by educating potential participants by giving them access to a survey that teaches what wastes are acceptable and how to prepare food waste adequately for composting (Susan Cascino, personal communication, April 5, 2018). Additionally, Veteran Compost uses screening technology to reduce debris in the compost prior to vermicomposting to yield a higher quality product (Justen Garrity, personal communication, April 11, 2018). Additionally, Veteran Compost uses screening technology to reduce debris in the compost prior to vermicomposting to yield a higher quality product (Justen Garrity, personal communication, April 11, 2018).

Figure 5. Chart summarizing the main challenges encountered by different organizations

Funding for composting and vermicomposting businesses differ

Lack of funding can also be a large problem for many organizations. Susan Cascino, Recycling Policy Director for the Environment, Energy & Open Space Cabinet for the Boston Zero Waste Pilot, indicated that the food waste composting pilot at farmers markets was originally funded by a grant from the government (personal communication, April 5, 2018). The program was successful at first, but the grant ran out and they did not have any other form of funding. Despite its popularity and success, they were forced to suspend the program until more funds were available.

Funding sources vary from one organization to another, and they can also differ between starting a business and maintaining a business. When asked about how he started his business, Garrity of Veteran Compost stated, “I just used the money I had in my pocket so we bootstrapped [started up his business with his own resources] into the industry” (personal communication, April 11, 2018). Additionally, Brown from Bootstrap Compost noted that the owner of the company started with his own resources and funding from friends and family as well (personal communication, April 24, 2018). In contrast, the New York City Program was funded by the Department of Sanitation within the government, and as referenced earlier, the Boston program started out with grants from the government (Marguerite Manela, personal communication, March 24, 2018; Susan Cascino, personal communication, April 5, 2018).

In order to maintain their operations, the New York City Composting Program and the Boston Zero Waste pilot are both funded by their respective municipalities through resident taxes. This adds an incentive for the residents of both programs to participate in the program since it does not cost them any extra money. Alternatively, Dansk Affaldsforening (Danish Waste Association) requires that all residents pay a standard monthly waste treatment fee to the municipality in order for their waste to be collected (Nana Winkler, personal communication, April 24, 2018). This fee is the primary source for funding the program. Unlike the municipalities of New York City and Boston, Veteran Compost and Bootstrap Compost, as private operations, charge for their services and products to fund their operations. In addition, Elias Ordolis of A.F.I.S. mentioned that they do not receive funding for their operations. Their operations are funded purely by the fees that they charge their consumers for collecting and recycling the batteries.

There are pros and cons to all of these sources of funding structures. Veteran Compost and Bootstrap Compost are both funded by participants, so they do not rely on government grants or outside organizations to provide funding for their operations. However, because they rely on the market to fund their operations, their income can fluctuate. In contrast, the New York City Compost Program and Dansk Affaldsforening (Danish Waste Association) are funded through required government payments, which eliminates the possibility of losing funding for the program because it is required for all New Yorkers to pay this tax. In contrast, as referenced earlier, the Boston Zero Waste program was funded by a government grant, and when the grant ran out the program suffered detrimental setbacks.

Strategies for creating a marketable product vary across organizations

A variety of strategies can be employed to create a marketable product. This depends mainly on the food waste treatment method of the program or business. In every program that was explored, aerobic composting was used to some degree. It is used more commonly than anaerobic digestion because the process is less sensitive to changes in variables and inputs. For example, according to Manela, the New York City Composting program has piloted some anaerobic digestion systems, but they have not grown significantly because the systems require a great deal of precision (personal communication, March 24, 2018). Despite this, Dansk Affaldsforening (Danish Waste Association) treats their food waste using anaerobic digestion to receive biogas instead of compost. It does so because according to Nana Winkler, Dansk Affaldsforening earns more money from selling the resulting biogases than they would from selling compost (personal communication, April 24, 2018). Furthermore, some companies use vermicomposting to treat food waste because it is a fast treatment process and yields a fertilizer that contains more nutrients than traditional compost.

Some of these treatment methods can be combined. For example, aerobic composting can be used alongside vermicomposting. According to vermicomposting expert Rhonda Sherman, this method is optimal (personal communication, April 20, 2018). Justen Garrity of Veteran Compost notes that composting removes pathogens from the final product and stabilizes the temperature so that it is not too high for the worms. Additionally, vermicomposting speeds up the treatment process and produces a very high quality end product (Justen Garrity, personal communication, April 11, 2018). Veteran Compost uses this method, which takes around three months in total to execute - four weeks for aerobic composting and two months for vermicomposting. Garrity of Veteran Compost also mentioned that while composting followed by vermicomposting may take more steps than just composting, it results in much higher quality compost product that is highly marketable. Garrity stated, “Worm poop [Vermicompost] is great because per pound it's the most money you could really make on a product and so we consistently sell out of that product. We can't make enough of the stuff” (Justen Garrity, personal communication, April 11, 2018). Veteran Compost is able to sell their vermicompost for $1.14 per liter whereas their compost sells for $0.25 per liter - 4.56 times more profitable. A layout of these different strategies can be seen in Table 6.

Program	Type of Program	Type of Processing	Pro	Con
New York Composting Program	Municipal pick up and drop off	Composting	Not as selective towards materials, compost as product	Slow process
Boston Zero Waste Initiative	Pilot municipal collection	Composting	See above	See above
Denmark Waste Association	Municipal pick up and drop Off	Anaerobic Digestion	Yields natural gas that has variety of purposes	Selective towards materials
Bootstrap Compost	Private community pick up	Composting and vermicomposting	Vermicomposting is relatively fast and yields a higher quality end product than composting	Worms have to be fed and looked after periodically
Veteran Compost	Private community pick up	Composting and Composting before vermicomposting	See above	See above
EcoPark Barcelona	Processor for a municipal drop off	Composting, anaerobic digestion	Receive both compost and natural gas as products	Require more facilities and employees to supervise the different methods
Avfall Sverige	Municipal contractor	Composting, vermicomposting, and anaerobic digestion	Variety of treatment methods and end products	Require more facilities and employees to supervise the different methods

Table 6. Pros and cons table comparing different composting methods of based on the different organizations that were contacted

Interacting with the market and the relationship between municipalities and businesses are important aspects of business development

Business development, both in regards to interacting with the market and business relationships, is an important component of food waste management considerations. Interacting with consumers was important for both municipal programs and private businesses. The idea of adapting to the motivations of participants and customers was particularly important. One of the easiest methods of increasing public participation in a program is by catering to what people want and having flexibility in composting or vermicomposting methods. New York City's composting program adjusted to the needs of residents by simplifying regulations on the food bins (Marguerite Manela, personal communication, March 24, 2018). According to Manela, the composting program started off with only allowing food waste to be collected in bins or compostable bags, and they asked that residents wash their bins after each collection. They found that people were not participating because many did not want to wash the bins, and the bags were deteriorating and not easily accessible to the public. After seeing that participation was not increasing as planned, they allowed New Yorkers to use one large plastic liner, and adjusted their sorting techniques to accommodate. This resulted in a higher participation rate. New York's contamination management has continued to improve, and now allows for residents to use any type of bag to collect their food waste. Since then, the New York Compost Program has seen a huge increase in participation in the program (Marguerite Manela, personal communication, March 24, 2018).

Relationships between both municipal and private programs, and other organizations play an important role in business development. None of the organizations we interviewed had operations spanning collection, transportation, and treatment of all the food waste they handled. Each formed relationships with a mix of other private businesses, volunteer groups, government organizations, and non-governmental organizations to support their operations. Some cases involve purely private efforts, in which the municipality benefits because of reduced tipping fees, but has no involvement. Other cases involve a public-private partnership, in which the municipality is actively involved in some capacity. Veteran Composting chose to run a privately organized program. Garrity of Veteran Compost, said it was best to have a decentralized model for collection and treatment instead of a central treatment hub. This way if there is a problem with one of the sites it is likely that it would not affect all operations. Alternatively, due to their high production rates, Dansk Affaldsforening (Danish Waste Association) and the New York City Compost Program use a strategy where they partner with a private, hauling company to collect their food waste (Nana Winkler, personal communication, April 24, 2018; Marguerite Manela, personal communication, March 24, 2018). Waste is collected at curbside by the private hauler and dropped off at the centralized waste treatment facility.

None of the organizations we interviewed had operations spanning collection, transportation, and treatment of all the food waste they handled. Each formed relationships with a mix of other private businesses, volunteer groups, government organizations, and non-governmental organizations to support their operations. Some cases involve purely private efforts, in which the municipality benefits because of reduced tipping fees, but has no involvement. Other cases involve a public-private partnership, in which the municipality is actively involved in some capacity.

Motives for engagement in food waste recycling

Individuals have different motives for participating in municipal versus private organizations. Private organizations appeal to individuals that want to help the environment. Veteran Composting noted that a majority of residents decide to participate in the curbside collection program because it makes them feel better about their impact on the environment, echoing the view of Elias Ordolis, Managing Director of A.F.I.S., who noted that people from all over Greece participate in the battery recycling program because they want to help the environment (personal communication, April 17, 2018). Justen Garrity of Veteran Compost also mentioned that some people participate because they want to receive compost for their own purposes. He also noted that restaurants and businesses participate in their program because it is less expensive than municipal waste collection (personal communication, April 11, 2018). Bootstrap Composting incentivizes participation in a similar manner, noting that residents participate in order to help the environment. Similarly to Veteran Compost, some people participate because they want compost in return for their food waste, but many of them do not take it (Emma Brown, personal communication, April 24, 2018).

Alternatively, municipal programs aim to appeal to everybody and tend to offer more incentives to entice participation, such as free compost. The New York Department of Sanitation has gone through numerous efforts to advertise their composting program, including providing online brochures, hosting composting classes, and advertising through local media. As previously mentioned, one of their larger publicizing efforts is their compost giveaway, which occurs several times a year (Marguerite Manela, personal communication, March 24, 2018). These efforts help inform New Yorkers about the benefits of composting and how easy it is to participate in their program. Seeing how easy it is to engage in a program and the outcome of recycling food waste motivates residents to participate in the program.

The American Farm School has developed methods to market and distribute their products

Investigating the marketing efforts of the American Farm School was important to understand how the products of the farm school are distributed and sold. Alexandros Kallis, the commercial manager for all farm products at the American Farm School illuminated the marketing strategies that could be used for selling vermicompost. The American Farm School employs an outside agent that is responsible for marketing and distributing goods to local supermarkets and grocery stores. In addition, the American Farm School is treated like any other business in the eyes of the municipality, so it does not receive municipal funding or tax breaks. Kallis was unable to provide a definitive answer when asked if the distributor would take on the sale of vermicompost in addition to the farm goods. He noted that the distributor is only able to market and sell food products and that a majority of advertisement is done by word of mouth. However, the farm school is looking to expand their social media presence and Kallis said it would be possible to advertise the sale of vermicompost on social media pages. This information can be used to estimate the methods which vermicompost produced by the American Farm School would be marketed and advertised.

A vermicomposting business at the American Farm School could be feasible with the appropriate modifications

An interview with Antonis Petras, the Director of Technical Works & Environment Office at the American Farm School, was conducted to obtain an understanding of the available resources of the American Farm School. We also sought the opinion of Dr. Vaggelis Vergos, Dean of School of Professional Education and Extension, in order to gauge the feasibility of using the American Farm School as a location for vermicomposting a portion of the municipality's food waste. According to Petras, the school currently creates and sells its own manure from its cows, but the product does not sell very well. This may be due to the absence of advertising or the economic crisis affecting the amount of money that people want to spend. He mentioned that they currently earn about €2,000-€2,300 a year from this operation (personal communication, April 19, 2018). Drawing from this interview, the potential location for a vermicomposting facility and the estimated cost of building and establishing the program were determined. This data informs the local context of recycling in Greece and Pylaia-Chortiatis in order to develop a business model for the region.

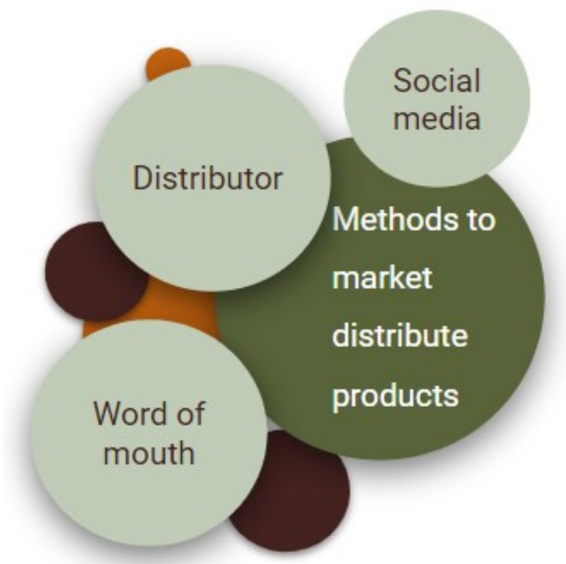

Figure 6. Image depicting the three main methods the American Farm School uses to market and distribute their goods

Developing a food waste management business model for private businesses and large scale municipalities

In order to visualize a vermicomposting business model for Pylaia-Chortiatis, we created a business model canvas , which can be seen below in Figures 7 and 8. The canvas is divided into nine segments and allows users to easily answer all the fundamental questions any business start-up must solve. As seen in Figure 7, it allows users to define the value propositions, customer segments, channels, customer relationships, revenue streams, key partners, key activities, key partners, cost structure specific to their business idea.

The developed business model begins with the value provided to customers. This is a high quality, organic product that is environmentally friendly and cost-efficient. The target customers are gardeners and farmers, with the understanding that there are probably other types of people interested in the product. The model aims to reach these customers through partner channels such as compost retailers, and so the business' relationships with these customers will be impersonal. Additionally, the business will create revenue solely off of selling the vermicompost product. Some key resources for the business operations will be a composting manager to run the facility, food waste, worms, and any equipment necessary to the vermicomposting process, including vermicomposting units, temperature controls, and an irrigation system among other things. Some activities essential to the success of the business will be to develop the worm population and ensure prime conditions, to establish relationships with the compost retailers, and to provide educational material to potential consumers about the benefits of vermicomposting. Additionally, it will be important to form a relationship with the municipality in order to gain access to more food waste as the business and market grow. Finally, considerations for the cost of these operations need to be taken. These costs will include the vermicomposting equipment, worms, wages for any employees, construction of the facility, and maintenance fees, including utilities. If it becomes necessary, forming a partnership with investors could help cover some initial costs.

As the business progresses and a relationship is formed with the municipality, the business model will shift slightly, as can be seen in the canvas displayed in Figure 8. Due to this mutually beneficial relationship the municipality can then be considered a key partner. The municipality will provide food waste and could possibly reimburse the business. In return, the business will provide an environmentally friendly and inexpensive alternative to landfilling that will help fulfill the municipality's waste management plan and help the municipality comply with European Union regulations. With the increased amount of food waste coming into the business, the facilities will need to be updated, which could again require investors.

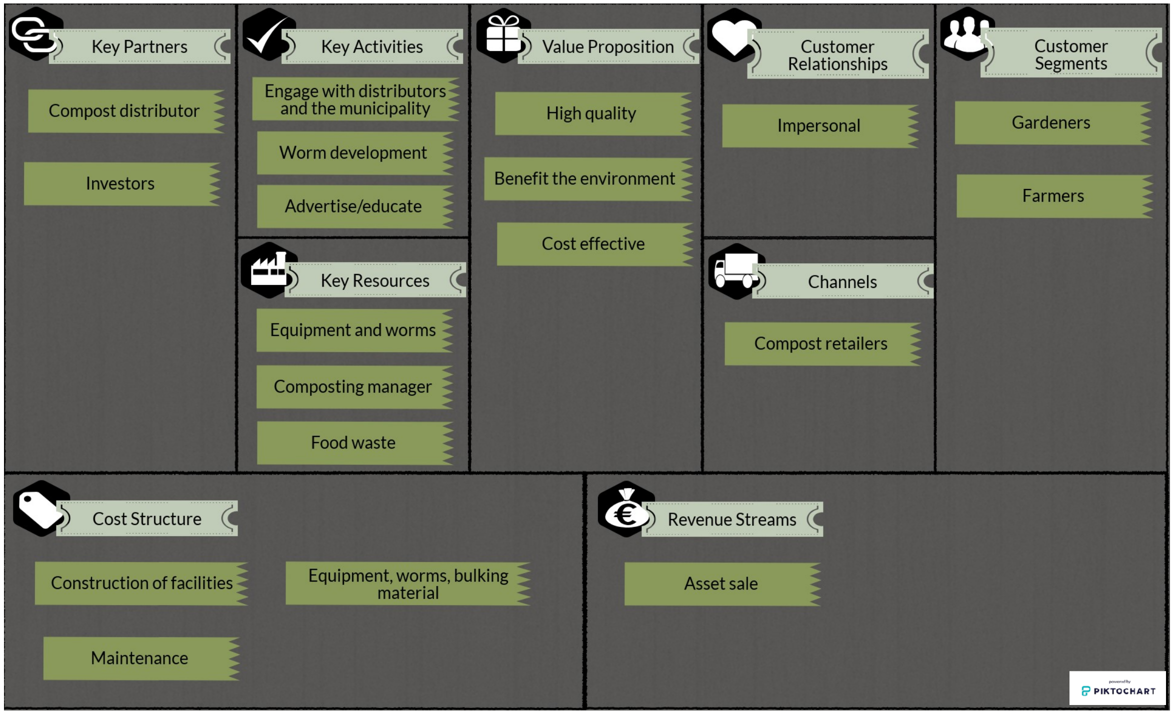

Figure 7. (Left) Business model canvas for a small private vermicomposting business

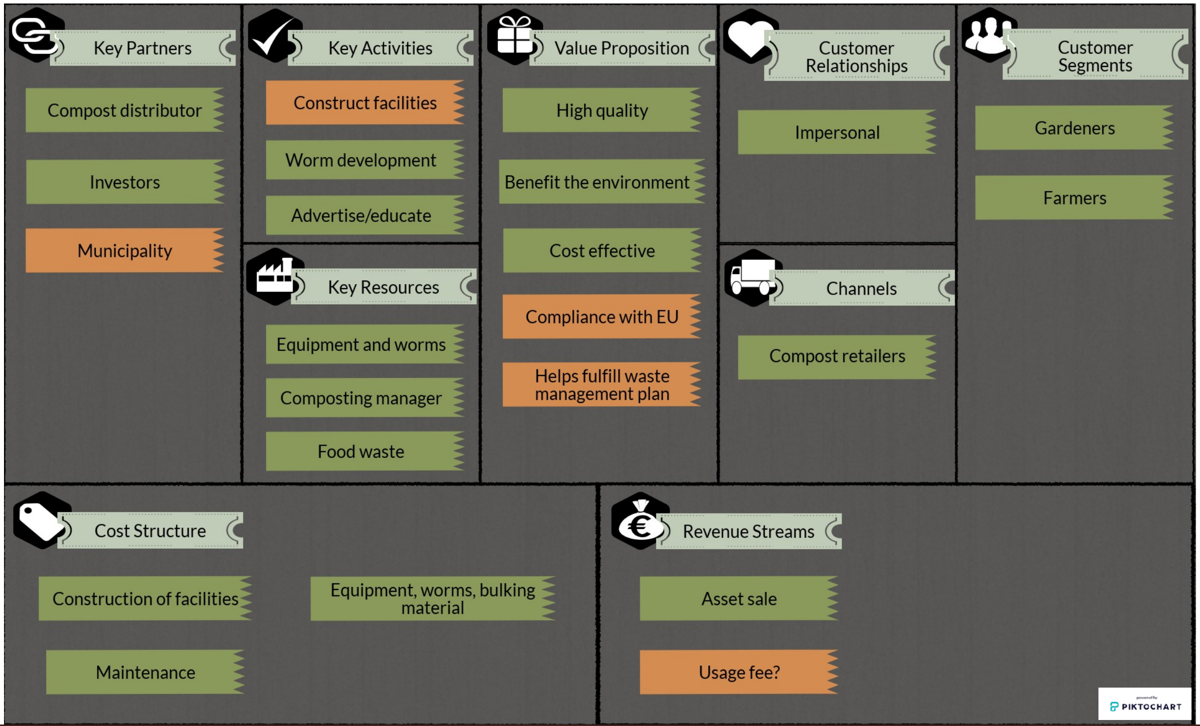

Figure 8. (Right) Business model canvas for a vermicomposting operation in collaboration with the municipality of Pylaia-Chortiatis

In addition to these business model canvases, value proposition canvases were developed in order to further our understanding of the relationship between the product and market. According to Strategyzer, an organization designed to assist businesses, a value proposition canvas is a tool designed to help the user visualize how a product or service provides value for the intended customer (“Strategyzer’s Value Proposition Canvas Explained,” 2017). This canvas is broken into two halves: the value map and the customer profile. The customer profile is further split into the jobs a customer is trying to complete, the pains they experience while doing a job, and the gains they are looking to achieve. The value map is split into the products and services a business provides, and the pain relievers and gain creators those products and services give to the customer (“Strategyzer’s Value Proposition Canvas Explained,” 2017). The value proposition canvas developed for the vermicomposting business can be seen in Figure 9 below.

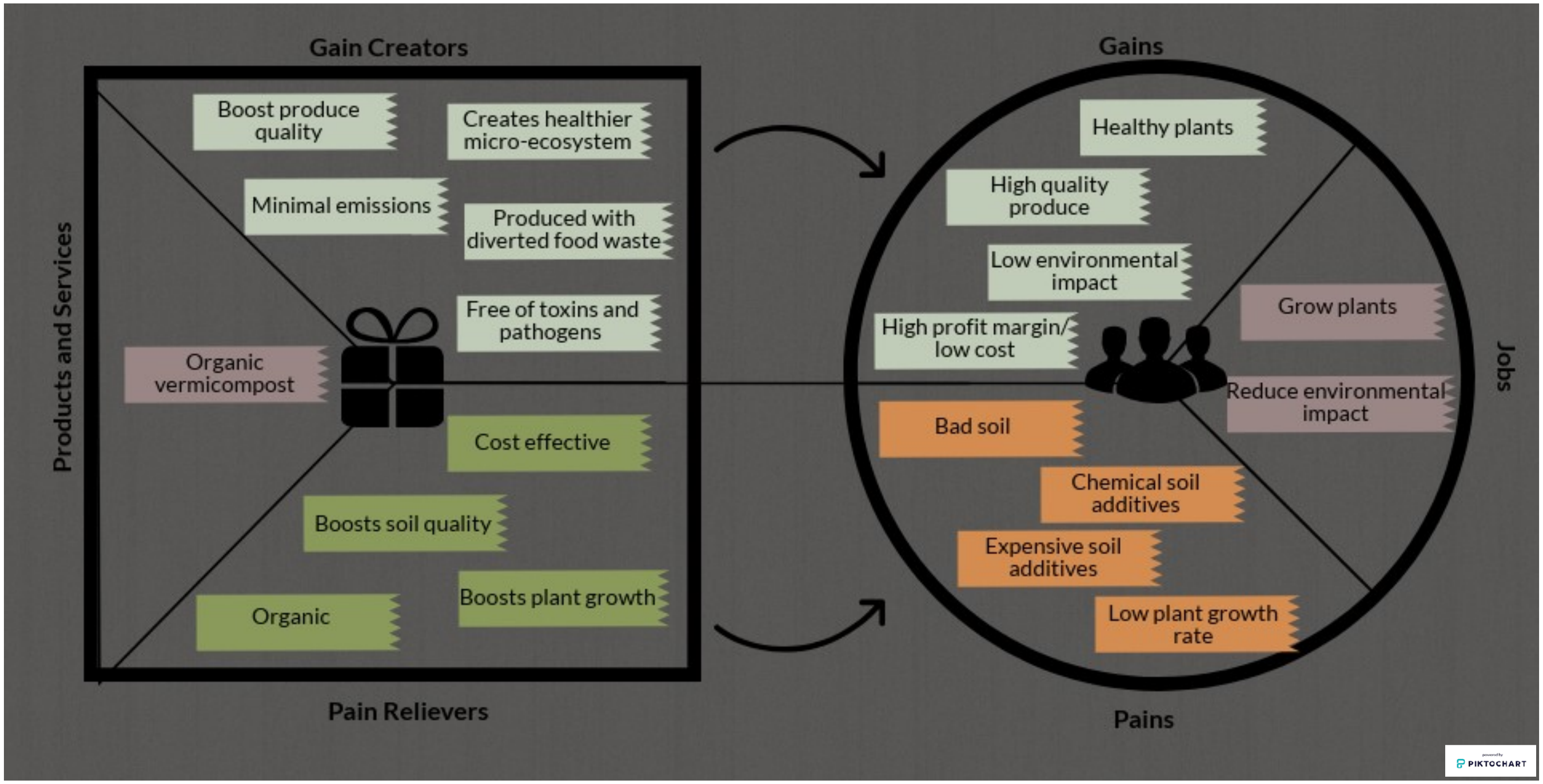

Figure 9. Value proposition canvas for vermicomposting business outlining

Assessing the costs of developing a vermicomposting program in Pylaia-Chortiatis

Along with the business model canvases, pro forma income statements, which are based on financial projections, were used to help understand the financial viability of such a vermicomposting business. The American Farm School was used as a case study to gather some initial data, but the findings are applicable to any small vermicomposting business. Additionally, data from large scale vermicomposting operations Worm Power and Vermigrand, were used as a part of these calculations. Worm Power is a manure processing company based in Avon, New York that composts then vermicomposts at a large scale. Vermigrand is a vermicomposting business, based in Austria, that will build and set up large scale vermicomposting facilities for its customers.

The amount of food waste produced in relation to the pilot program was first required in order to calculate the program's projected revenue. Using the American Farm School as a model for such a pilot program, the average food waste produced in a week was calculated. The high school cafeteria produces about 19 50L bins of waste per week (personal communication, April 17, 2018). This was assumed to all be food waste. It is important to note that there is also a canteen in the Perrotis Residence Hall, but it does not generate any measurable amount of food waste (personal communication, April 17, 2018).

Annual food waste from cafeteria

$$\frac{50\ L * 19}{wk} * 52\ wk = 49{,}400\ L$$

Ninety-one people currently live at the American Farm School (Christos Vasilikiotis, personal communication, April 18, 2018). Additionally, the average density of food waste is 22-45 pounds per cubic foot ("Volume to weight Conversion Factors," 2016). Given literature that indicates that the average person in Greece produces 98.9 kg of food waste per year (Abeliotis et al., 2015), the total food waste produced by residents of the American Farm School per year was estimated.

Density of food waste

$$\frac{33.5\ lb}{ft^3} * \frac{1\ kg}{2.2046\ lb} * \frac{ft^3}{28.3168\ L} = 0.537\frac{kg}{L}$$

Annual food waste from people

$$\frac{98.9\ kg * 91}{yr} * \frac{1\ L}{0.537\ kg} = 16{,}800\ L$$

These two calculations provided a total volume of food waste produced at the American Farm School, which was then used as a guideline for the rest of our calculations.

Annual total food volume

$$49{,}400\ L + 16{,}800\ L = 66{,}200\ L$$

Bulking agents are also an important consideration in the vermicomposting process. They are necessary to help stabilize the system's moisture content and gas emissions (Guidoni et al., 2018). According to a study done by Lucas Lourenço Castiglioni Guidoni, a Sanitary and Environmental Engineer, and his colleagues, a ratio of 7:3 of food waste to bulking agents was necessary for the highest quality end product. This ratio is optimal because it allows for proper microbiological development, takes less time to obtain a final product, yields a better initial carbon-to-nitrogen ratio, and higher final mineral content as opposed to 1:1 or 3:7 mixtures (Guidoni et al., 2018). From this, the necessary annual volume of bulking agent was calculated.

Annual volume of bulking materials

$$66{,}200\ L\ food\ waste * 0.30 = 19{,}900\ L\ bulking\ material$$

The total weight of raw goods (food waste and bulking agent) to be treated was then calculated. This was done by using the average density of food waste previously calculated. Based on our conversations with experts it is apparent that bulking agents such as wood chips would be well suited for this program (Rhonda Sherman, personal communication, April 20, 2018). The average density of wood chips was found to be 0.38 grams per cubic centimeter ("Substances: Wood Chips, Dry," 2018).

Density of wood chips

$$\frac{0.38\ g}{cm^3} * \frac{1\ kg}{1000\ g} * \frac{1000\ cm^3}{1\ L} = 0.38\ kg/L$$

Annual total weight of raw materials

$$(volume\ food\ waste * density\ food\ waste) + (volume\ bulking * density\ wood\ chips)$$

$$\left(66{,}200\ L * \frac{0.537\ kg}{L}\right) + \left(19{,}900\ L * \frac{0.38\ kg}{L}\right) = 43{,}100$$

$$35{,}500\ kg + 7{,}560 = 43{,}100\ kg$$

Once the weight of raw materials entering the composting and vermicomposting system was calculated, the amount of vermicompost produced in a year was then found. This was done with the assumption that there would be a 50% reduction in weight throughout the entire process, based on information given by vermicomposting expert Rhonda Sherman (personal communication, April 20, 2018).

Annual vermicompost output

$$43{,}100\ kg * 0.50 = 21{,}600\ kg$$

Finally, the low end and high end revenue projections from the vermicompost output were calculated by using the low end and high end prices for vermicompost.

Since prices of vermicompost were not readily available in Greece, the projections were based off of the price of compost in Greece and the prices of compost and vermicompost in the US. The highest and lowest prices for compost found in the Greek hardware store, Praktiker, were used. The highest listed compost price at Praktiker was for Compo Sana and the lowest was for Compost Hellas. The price of vermicompost and compost from Veteran Compost were also considered for this calculation.

High end price of vermicompost

$$\frac{price\ of\ compost\ in\ US}{price\ of\ vermicompost\ in\ US} = \frac{price\ of\ compost\ in\ Greece}{price\ of\ vermicompost\ in\ Greece}$$

$$\frac{\$0.2472/L}{\$1.1351/L} = \frac{€0.3745/L}{price\ of\ vermicompost\ in\ Greece}$$

$$price\ of\ vermicompost\ in\ Greece = €1.7196/L$$

Low end price of vermicompost

$$\frac{price\ of\ compost\ in\ US}{price\ of\ vermicompost\ in\ US} = \frac{price\ of\ compost\ in\ Greece}{price\ of\ vermicompost\ in\ Greece}$$

$$\frac{\$0.2472/L}{\$1.1351/L} = \frac{€0.2205/L}{price\ of\ vermicompost\ in\ Greece}$$

$$price\ of\ vermicompost\ in\ Greece = €1.0125/L$$

Antonis Petras indicated that due to the economic crisis in Greece, the market for vermicompost may not be as abundant as it is in other countries, and suggested that we explore the program's revenue projection for the vermicompost price at €1 per kilogram (personal communication, April 19, 2018).

Recommended price by the American Farm School

$$€1/kg$$

The additional information needed to make these projections was the density of vermicompost, which was taken from the label on a bag of vermicompost found at The Home Depot (2018).

Inverse density of vermicompost

$$\frac{0.75\ qt}{1\ lb} * \frac{1.1012\ L}{qt} * \frac{2204.62\ lb}{t} = 1{,}820\ L/t\ or\ 1.82\ L/kg$$

Volume of vermicompost produced

$$21{,}600\ kg * \frac{1.82\ L}{kg} = 39{,}300\ L$$

To the right are the revenue projections for a vermicomposting pilot program.

Low end annual revenue

$$39{,}300\ L * \frac{€1.0125}{L} = €39{,}800$$

High end annual revenue

$$39{,}300\ L * \frac{€1.7196}{L} = €67{,}600$$

Revenue from Petras' value

$$21{,}600\ kg * \frac{€1}{kg} = €21{,}600$$

After calculating the annual revenue projections, the variable costs, or the cost of the goods sold (COGS) were calculated. The cost of goods sold include the cost of producing and selling the product. The only predicted costs for this process were the bulking agent and the packaging of the final product.

Based on our conversation with Petras from the American Farm School, wood chips are imported from Bulgaria for heating homes because Greece does not manufacture wood chips (personal communication, April 19, 2018). The price of wood chips in Bulgaria was found to be between €45 and €100 per tonne. The average of these values (€72.5) was used to estimate bulking costs (“Bulgaria Biogas Fossil Fuel Price/t,” 2015).

Annual cost of wood chips

$$7{,}560\ kg * \frac{1\ t}{1000\ kg} * \frac{€72.5}{t} = €548$$

Petras also mentioned that the American Farm School pays 17 cents per kilogram to package the compost they produce from cow manure (personal communication, April 19, 2018). This was used to estimate the cost of packaging for the pilot and municipal programs.

Annual cost of packaging

$$21{,}600\ kg * \frac{€0.17}{1\ kg} = €3{,}670$$

The projection for cost of goods sold can be seen to the right.

Annual COGS

$$€548 + €3{,}670 = €4{,}220$$

The next step was to calculate the operating expenses, or fixed costs. Operating expenses are costs that do not change based on production.

First, the payroll for this operation was calculated. The minimum wage in Greece is €683.76 per month, and according to Petras payroll should account for 14 months in order to compensate for work done during holidays like Christmas and Easter (Eurostat, 2018; personal communication, April 19, 2018). From our conversations with Christos Vasilikiotis, it was decided that only one employee would be necessary to take care of the vermicomposters and gather the food waste from residents and the cafeteria. He suggested that only two hours a day would be required to run the operation, so the inclusion of one employee in the costs is a generous assumption (personal communication, April 17, 2018).

Annual cost of employee salaries

$$\frac{€683.76}{month} * 14\ month\ equivalent * 1\ employee = €9{,}572.6$$

Next, the Social Security tax was calculated. As of 2018, businesses are required to pay 24.06% of payroll for Social Security (Trading Economics, 2018).

Annual social security tax

$$€9{,}572.6 * 0.2406 = €2{,}303$$

Next, the cost of setting up the vermicomposters and the worms necessary to keep up with the flow of raw materials being put into the system was estimated.

The first step in this was to calculate the volume of material entering the vermicomposters. When material is composted to completion, the weight is reduced by about 50% on average (Rhonda Sherman, personal communication, April 20, 2018). The assumption that by the time the composting process was complete, 25% out of the total 50% reduction in weight would have been consumed because due to halving the composting time.

Annual material entering vermicomposters

$$43{,}100\ kg * 0.75 = 32{,}300\ kg$$

Dr. Vasilikiotis emphasized the importance of a regular feeding schedule for the worms, and recommended that the worms be fed every day. Worms eat between 25% and 33% of their body weight per day (Rhonda Sherman, personal communication, April 20, 2018; Justen Garrity, personal communication, April 11, 2018).

Material added to system every day

$$\frac{32{,}300\ kg}{365\ d} = 88.5\ kg/d$$

A rate of 25% of their weight per day was assumed for the calculations. The low end of the margin was chosen with the understanding that it would be easier to find more food waste if the worms ate more than expected as opposed to managing excess food waste if the worms could not keep up.

Worms needed

$$\frac{88.5\ kg\ material}{0.25} = 354\ kg\ worms$$

Through these calculations, the total cost of worms necessary for the operation was found., which can be seen to the right.

Total cost of worms

$$354\ kg\ worms * \frac{€24}{0.24\ kg} = €35{,}400$$

Next, the number of vermicomposters needed to hold the worms was calculated.

From our conversations with both Garrity and Sherman, it was determined that approximately one square foot of surface area was required per pound of worms (Justen Garrity, personal communication, April 11, 2018; Rhonda Sherman, personal communication, April 20, 2018). From this value, the total surface area needed for the operation was estimated.

Worms to surface area ratio

$$\frac{1\ lb\ worms}{ft^2} * \frac{1\ kg}{2.2046\ lb} * \frac{10.7639\ ft^2}{m^2} = 4.8825\ kg/m^2\ worms$$

Using the vermicomposters that Dr. Vasilikiotis had built for his own research as a model, it was assumed that each vermicomposter had about 0.5 square meters of surface area and cost about €120 to construct (personal communication, April 18, 2018).

Surface area needed

$$354\ kg * \frac{m^2}{4.8825\ kg} = 72.5\ m^2$$

From this information, the number of vermicomposters was calculated.

Vermicomposters needed

$$\frac{72.5\ m^2}{0.5\ m^2} = 145\ vermicomposters$$

The total cost of these vermicomposters can be seen to the right.

Cost of vermicomposters

$$145 * €120 = €17{,}400$$

Both the cost of the vermicomposters and the worms would be one-time fees. The composters last many years, and the worms reproduce at a rate to match their available resources, so the worm population would stay relatively constant (Christos Vasilikiotis, personal communication, April 17, 2018). However, a buffer of €2,000 was included for any unconsidered costs, or any unforeseen circumstances including vermicomposter maintenance or purchasing additional worms.

Once the revenue, COGS, and total operating expenses were calculated, the net annual profit was calculated. All of these projections can be summarized in the following pro forma income statements.

Pilot Program High

Pro Forma Income Statement	Year 1	Year 2	Year 3
Revenue	**67,600**	**67,600**	**67,600**
Cost of Goods Sold (COGS)	4,220	4,220	4,220
Gross Profit	63,380	63,380	63,380
Gross Margin %	93.76%	93.76%	93.76%
Operating Expenses (Fixed Costs)			
Payroll	9,572	9,572	9,572
Marketing/Promotion	300	300	300
Social Security Tax	2,303	2,303	2,303
Vermicomposters	17,400	0	0
Worms	35,400	0	0
Other	2,000	2,000	2,000
Total Operating Expenses	**66,975**	**14,175**	**14,175**
Net Profit	**-3,595**	**49,205**	**49,205**
Profit Margin	**-5.32%**	**72.79%**	**72.79%**

Pilot Program Low

Pro Forma Income Statement	Year 1	Year 2	Year 3
Revenue	**39,800**	**39,800**	**39,800**
Cost of Goods Sold (COGS)	4,220	4,220	4,220
Gross Profit	35,580	35,580	35,580
Gross Margin %	89.40%	89.40%	89.40%
Operating Expenses (Fixed Costs)			
Payroll	9,572	9,572	9,572
Marketing/Promotion	300	300	300
Social Security Tax	2,303	2,303	2,303
Vermicomposters	17,400	0	0
Worms	35,400	0	0
Other	2,000	2,000	2,000
Total Operating Expenses	**66,975**	**14,175**	**14,175**
Net Profit	**-31,395**	**21,405**	**21,405**
Profit Margin	**-78.88%**	**53.78%**	**53.78%**

Pilot Program Petras Value

Pro Forma Income Statement	Year 1	Year 2	Year 3
Revenue	**21,600**	**21,600**	**21,600**
Cost of Goods Sold (COGS)	4,220	4,220	4,220
Gross Profit	17,380	17,380	17,380
Gross Margin %	80.46%	80.46%	80.46%
Operating Expenses (Fixed Costs)			
Payroll	9,572	9,572	9,572
Marketing/Promotion	300	300	300
Social Security Tax	2,303	2,303	2,303
Vermicomposters	17,400	0	0
Worms	35,400	0	0
Other	2,000	2,000	2,000
Total Operating Expenses	**66,975**	**14,175**	**14,175**
Net Profit	**-49,595**	**3,205**	**3,205**
Profit Margin	**-229.61%**	**14.84%**	**14.84%**

Figure 10. Pro forma income statements for pilot program

After confirming that there was a business opportunity within the pilot program, the operation was scaled up to a capacity where the business could handle 3.5% of the municipal food waste produced every week. This value was chosen by comparing and scaling the available land at the American Farm School with that of the manure vermicomposting facility Worm Power. Worm Power houses their pre-composting and vermicomposting equipment in an 89,000 square foot facility that processes ten million pounds of dairy manure a year (Herlihy, 2013). From these numbers, the amount of waste processed was scaled down to what the American Farm School would receive from the municipality. We assumed that both values scaled down linearly, as the amount of waste that can be processed by worms is constant. The amount of land necessary to treat 3.5% of the municipality's 5,170,000 kilograms per year of food waste, combined with bulking agents was calculated to be 480 square meters. With this amount of land, the business would process 3,500 kilograms, or 3.5 tonnes, of food waste every week.

Food waste processed by Worm Power

$$\frac{10{,}000{,}000\ lb}{yr} * \frac{1\ yr}{52\ wk} * \frac{1\ t}{2204.62\ lb} = 87.23\ t/wk$$

Municipality food waste

$$\frac{5.17 * 10^6\ kg}{yr} * \frac{1yr}{52\ wk} * \frac{1\ t}{1000\ kg} = 99.4\ t/wk$$

Scaled down to 5 tonnes per week

$$\frac{3.5\ t/wk}{99.4\ t/wk} * 100\% = 3.5\%\ of\ municipality's\ waste$$

The amount of land necessary to treat 3.5% of the municipality's 5,170,000 kilograms per year of food waste, combined with bulking agents was calculated to be 480 square meters. With this amount of land, the business would process 3,500 kilograms, or 3.5 tonnes, of food waste every week.

Necessary surface area

$$\frac{Worm\ Power\ food\ waste}{Worm\ Power\ surface\ area} = \frac{Municipal\ food\ waste}{required\ surface\ area}$$

$$\frac{87.23\ t/wk}{89{,}000\ ft^2} = \frac{5\ t/wk}{surface\ area\ required}$$

$$required\ surface\ area = 5{,}100.\ ft^2 * \frac{1\ m^2}{10.7639\ ft^2} = about\ 480.\ m^2$$

Using information gathered from Worm Power, Dr. Vasilikiotis, and Petras, we selected plots of land at the American Farm School that are suitable for a vermicomposting facility and comply with the building permits that the school is subject to. Figure 11 below shows a satellite image of the potential space the school has available for building a vermicomposting facility. The yellow plot represents 184 square meters and is only suitable for the pilot. The green plot represents an area of 559 square meters for the municipal program, even allowing for 79 square meters of extra room. This room could be used as an excess storage for food waste, for storage of the final product, or for an expansion as the business grows. It would even have enough room to first house the pilot, and then to expand to the municipal program if it were successful.

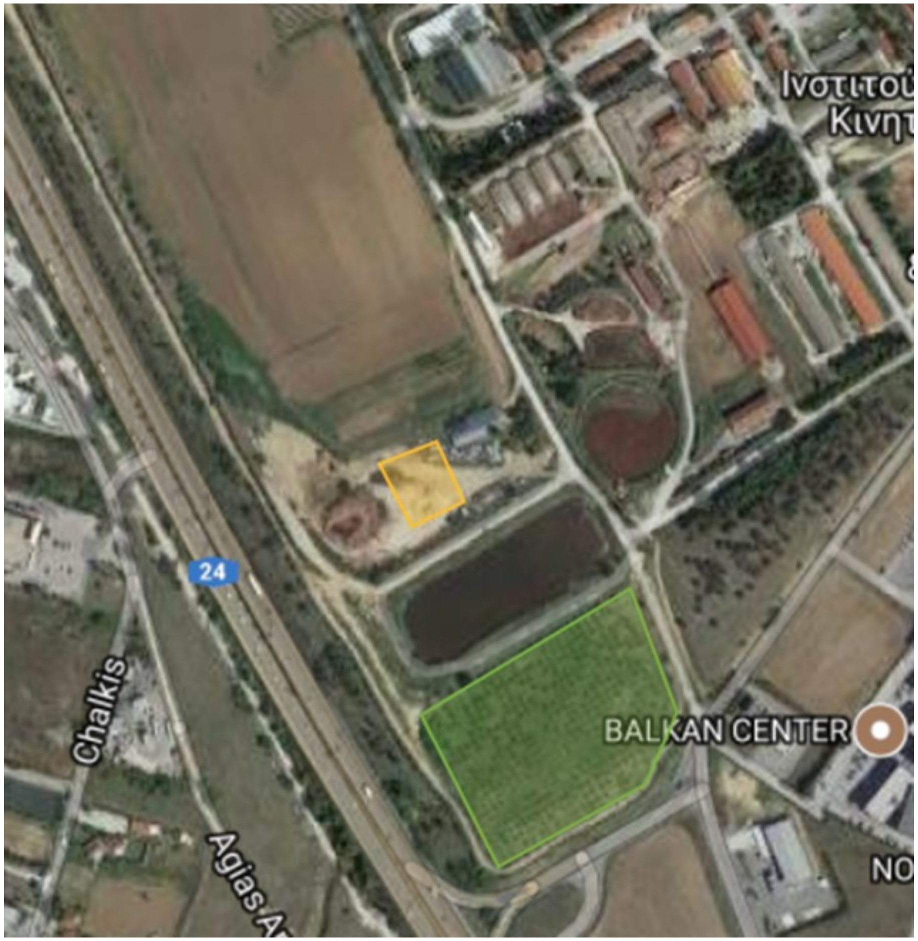

Figure 11. Satellite image of the potential space the American Farm School has available for building a vermicomposting facility.

Figure 12. Possible plot of land for pilot program (outlines in yellow in Figure 11).

In order to estimate the revenue gained from this input, the volume of vermicompost produced in a year was calculated.

Annual volume of vermicompost

$$\frac{1{,}820\ L}{t} * \frac{5\ t}{wk} * 0.5\ reduction\ rate * 52\ wk = 237{,}000\ L$$

The projected price of vermicompost previously calculated was also used to find the high end and low end projected revenues, which can be seen to the right.

High end revenue

$$237{,}000\ L * \frac{€1.7196}{L} = €408{,}000$$

Low end revenue

$$237{,}000\ L * \frac{€1.0125}{L} = €240{,}000$$

Revenue from Petras' value

$$\frac{2.5\ t}{wk} * 52\ wk * \frac{1000\ kg}{t} * \frac{€1}{kg} = €130{,}000$$

After estimating the revenue, the COGS were calculated using the same method as the pilot program calculations. However, much of these calculations were based on Vermigrand, a company in Austria that builds and installs large scale vermicomposting systems. The company requires that they take 4% of the company's revenue every year and is included in our calculations.

Annual cost of bulking agent

$$\frac{1.5\ t}{wk} * 52\ wk * \frac{€72.5}{t} = €5{,}660$$

Annual cost of packaging

$$\frac{€0.17}{kg} * \frac{2.5\ t}{wk} * 52\ wk * \frac{1000 kg}{t} = €22{,}100$$

Annual payment to Austria

$$revenue * 0.04 = payment$$

Next, the operating expenses were calculated. As referenced earlier, many of the operating expenses were modeled after projections found from Vermigrand. These projections included the cost of construction and the anticipated labor hours needed to run the whole system.

Anticipated weekly labor hours

$$\frac{4.95\ hr}{d} * \frac{480\ m^2}{200\ m^2} * \frac{5\ d}{wk} = 59.4\ hr/wk$$

Payroll was calculated the same way as in the pilot, but this time with two employees due to the number of hours required for the size of the operation (Vermigrand, 2018).

Annual employee salaries

$$\frac{€683.76}{mo} * 14\ mo * 2\ employees = €19{,}145$$

Social security tax was calculated using the same methods as the pilot.

Cost of Social Security

$$€19{,}145 * 0.2406 = €4{,}606$$

Finally, the cost of setting up the facility was calculated. All of the calculations were based on the Vermigrand projections, except the cost of constructing the building, which was based off of our conversation with Petras, who told us that the average cost would be between €600 and €800 per square meter (personal communication, April 19, 2018). This value did not include electricity or HVAC, but it was assumed that those would be included in the indoor construction projection given by Vermigrand (Vermigrand, 2018). Petras also mentioned that on average, permitting a building would cost between 8% and 10% of the cost of construction (personal communication, April 19, 2018).

Cost of Austrian company license

$$€15{,}000 * \frac{480\ m^2}{200\ m^2} = €36{,}200$$

Cost of building construction

$$480\ m^2 * \frac{€700}{m^2} = €336{,}000$$

Cost of permitting

$$€336{,}00 * 0.09 = €30{,}200$$

Cost of indoor construction

$$€29{,}200 * \frac{480\ \mathrm{m}^2}{200\ \mathrm{m}^2} = €70{,}100$$

Cost of heating system

$$€6{,}700 * \frac{480\ m^2}{200\ m^2} = €16{,}100$$

Cost of sieve

$$€7{,}000 * \frac{480\ m^2}{200\ m^2} = €16{,}800$$

Cost of barn loader

$$€29{,}200$$

Cost of worms

$$€10,400 * \frac{480\ m^2}{200\ m^2} = €25{,}000$$

Generally, a corporate tax would be included in the operating expenses. However, communication with A.F.I.S. revealed that companies in Greece involved with collection and recycling of waste are exempt from these taxes (Elias Ordolis, personal communication, April 17, 2018). Finally, a buffer was included for any expenses that may have been overlooked. Once the revenue and all costs were calculated, the net profit for the company was found. The summary of these projections can be found in the pro forma income statements below.

Municipal Program High

Pro Forma Income Statement			
	Year 1	Year 2	Year 3
Revenue	**408,000**	**408,000**	**408,000**
Cost of Goods Sold	44,080	44,080	44,080
Gross Profit	363,920	363,920	363,920
Gross Margin %	89.20%	89.20%	89.20%
Operating Expenses (Fixed Costs)			
Payroll	19,145	19,145	19,145
Facility Setup	560,000	0	0
Marketing/Promotion	1200	1200	1200
Social Security Tax	4,606	4,606	4,606
Other	5,000	5,000	5,000
Total Operating Expenses	589,951	29,951	29,951
Net Profit	**-226,031**	**333,969**	**333,969**
Profit Margin	-55.40%	81.86%	81.86%

Municipal Program Low

Pro Forma Income Statement			
	Year 1	Year 2	Year 3
Revenue	**240,000**	**240,000**	**240,000**
Cost of Goods Sold	37,360	37,360	37,360
Gross Profit	202,640	202,640	202,640
Gross Margin %	84.43%	84.43%	84.43%
Operating Expenses (Fixed Costs)			
Payroll	19,145	19,145	19,145
Facility Setup	560,000	0	0
Marketing/Promotion	1200	1200	1200
Social Security Tax	4,606	4,606	4,606
Other	5,000	5,000	5,000
Total Operating Expenses	589,951	29,951	29,951
Net Profit	**-387,311**	**172,689**	**172,689**
Profit Margin	-161.38%	71.95%	71.95%

Municipal Program Petras Value

Pro Forma Income Statement			
	Year 1	Year 2	Year 3
Revenue	**130,000**	**130,000**	**130,000**
Cost of Goods Sold	32,960	32,960	32,960
Gross Profit	97,040	97,040	97,040
Gross Margin %	74.65%	74.65%	74.65%
Operating Expenses (Fixed Costs)			
Payroll	19,145	19,145	19,145
Facility Setup	560,000	0	0
Marketing/Promotion	1200	1200	1200
Social Security Tax	4,606	4,606	4,606
Other	5,000	5,000	5,000
Total Operating Expenses	589,951	29,951	29,951
Net Profit	**-492,911**	**67,089**	**67,089**
Profit Margin	-379.16%	51.61%	51.61%

Figure 13. Pro forma income statements for municipal program

Although the pro forma income statements provide valuable information, it is important to note that some of the numbers are subject to change. The cost of marketing for both the pilot and municipal levels was estimated based off of correspondence with Justen Garrity from Veterans Compost who said that the company spent minimal amounts of money on advertising ($100 a month) due to their online marketing strategy (personal communication, April 28). The larger scaled program in this case is much smaller than Veteran Compost operations, therefore its assumed that the marketing could cost around €1,200 even if different strategies are employed. The cost of insuring the facility and utilities costs were included in the buffer value of the pro forma, which was calculated as 20% of the projected revenue. Additionally, the cost of the bulking agent may not be necessary, especially if the American Farm School were to implement this model. According to our sponsor Christos Vasilikiotis, the American Farm School, following common Greek practice, burns the trimmings from their olive trees and grapevines (personal communication, March 20, 2018). Consulting with Rhonda Sherman revealed that these trimmings could be used as bulking agent (personal communication, April 20, 2018). Even for a business separate from the American Farm School, trimmings such as these should be easy to find in the area for low prices or even for free. Another important consideration for the pilot program at the American Farm School is that payroll may not cost as much as anticipated because there are a small amount of labor hours required. According to Antonis Petras of the American Farm School this employee would have other jobs on campus and therefore, their paycheck would be funded by multiple budgets (personal communication, April 19, 2018).

It is also important to note that the business model is scalable, with the limiting factors being the size of land available for the facility, the available market for the product, and the amount of waste the municipality produces. Although the calculations were based on 3.5% of the total municipal food waste, the latter should not be a concern for many years.

Finally, based on the projected net profit in the €1 per kilogram model, selling the vermicompost for such a low price is not recommended. The pilot program would take 16 years to pay off, as opposed to the first and second years for the other models. This would make it difficult to pay for the initial costs of the municipal model, which would then take an additional 9 years to recuperate from initial investments, as opposed to the alternatives of second or fourth years.

Conclusions

The best way to treat food waste while simultaneously producing a highly marketable product is to pre-compost the food scraps, and then to vermicompost that product for further refinement and enrichment. Considerations in the development of a vermicomposting business strategy include funding, legislation, possible partnerships, and quality control.

Based on the pro forma income statements, it is not recommended to sell the vermicompost product for less than €1 per kg. The projections for the €1 per kg would not provide enough profit to be worth the initial start-up costs. The vermicompost product should be sold for in between €1.0125/L on the low end and €1.7196/L on the high end to make an adequate profit.

Additionally, we determined that the establishment of a vermicomposting business is feasible in Pylaia-Chortiatis and that a public-private partnership could benefit the municipality and provide a significant revenue stream for the American Farm School. This partnership would provide the municipality with a method of treating waste, which brings the municipality closer to becoming compliant with the waste management directives enacted by the European Union.

Finally, we determined that the establishment of a vermicomposting business is feasible at the American Farm School. The high or low prices suggested for selling vermicompost could provide additional income for the school, foster positive relations with the municipality, and provide an outlet for educating the public on environmental issues.

If other organizations adopted this business model, it would ease the economic and environmental burden posed by food waste on the municipality of Pylaia-Chortiatis. With interested business owners and residents willing to participate and divert food waste from landfills, the municipality would have a stronger incentive to start separating and collecting food waste.

Next Steps

To encourage individuals or companies interested in starting a vermicomposting business, we created a presentation for that outlines different business methods and important considerations needed to create a successful business, which could be pitched to potential stakeholders. This presentation can be found at Appendix D.

We were not able to have a discussion with waste management officials in the municipality of Pylaia-Chortiatis, and we recommend involving the municipality to understand their opinion of waste management was limited. Interviews with the municipality could clarify why the collection plan is not currently operating, how likely is it for the development of a treatment plan, and how willing the municipality would be to partner with a vermicomposting business.

And finally, a more in-depth study into the business model is recommended. This could include researching the interests and concerns of the customer segments, and researching the local context of some of the costs involved in the business, such as the cost of building insurance and advertising in the region.

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Appendix A

Program Interview Questions

We are a group of students from WPI in Massachusetts. We are interviewing both municipal composting programs and independent composting companies in order to understand what happens after organic waste is collected. We are also interviewing those involved in the municipal government of Pylaia-Chortiatis, Greece. We want to understand problems associated with the implementation of a municipal composting program and further develop the existing plan by analyzing treatment methods for the food waste. We believe that vermicomposting is an efficient way to help divert food waste from landfills that could be introduced into the community. Please know that your participation in this interview is completely voluntary and you can withdraw at any time. Your name and any identifying information will not be used in reports or presentations without your consent. With your consent we would like to reference the contents of this interview in our reports and presentations. Upon your request, a copy of the contents of this interview can be communicated to you. You can reach us at vermicompostingd18@wpi.edu. The team would like to thank you very much for your participation.

Municipal Scale MSWM Companies

Explore methods of large scale organization for MSWM in vermicomposting/composting

- Interview to understand:
  - What were possible roadblocks?
    - Legislation
    - Funding
  - What startup strategies were employed?
    - Do you receive federal grants/funding and awards
    - Do you receive funding from private companies?
    - Company acquisition/merge?
  - Do you have partnerships with NGO/non-profit organizations?
    - How have you formed these partnerships
    - Partnerships for pickup/drop off
    - Potential for vermicomposting/composting outside of larger organizations? (AFS and Community gardens)
    - How successful are these relationships, good participation?
  - What types of MSWM systems do they employ post collection?
    - Incineration
    - Anaerobic
    - Vermicomposting/composting

- What are some costs of waste treatment?
  - Jobs
  - Transportation
  - General costs

- What happens with the post-waste treatment process?
  - Is biogas sold?
  - Is compost sold/given away

- Statistics on the success or how much waste has been diverted from landfills?

Local recycling companies

Investigate local recycling context in Thessaloniki with respect to private organizations (Blue bell glass/plastic/paper/aluminum, battery recycling, composting companies)

Interview local companies to understand:

- What were possible roadblocks?
  - Legislation
  - Funding

- What startup strategies were employed?
  - Did you receive federal grants/funding and awards
  - Did you receive funding from private companies?
  - Company acquisition/merge
  - Understand the incentives behind recycling:

- Do you make money from recycling batteries?
  - Do you make more for recycling glass/plastic/paper/aluminum?
  - Other incentives?

- Do you have partnerships with NGO/non-profit organizations?
  - How have you formed these partnerships
  - Partnerships for pickup/drop off
  - How successful are these relationships, good participation?

- What are some costs of waste treatment?
  - Jobs
  - Transportation
  - General costs

- Gauge the potential for recycling food waste
  - How did you identify this as a potential market?
  - Why would someone want to do this?
  - Who buys the recycled product?

- Monetizing environmental impact of recycling?

- Determine the role of the municipality in private organization?

Does the municipality provide funding for private organizations?

Statistics on the success or how much waste has been diverted from landfills?

Composting and Vermicomposting companies

Investigate recycling context with respect to private organizations (composting and vermicomposting companies)
- Interview local companies to understand:
  - What were possible roadblocks?
    - Legislation
    - Funding
  - What startup strategies were employed?
    - Did you receive federal grants/funding and awards
    - Did you receive funding from private companies?
    - Company acquisition/merge
  - Understand the incentives behind recycling
    - Do you make money from recycling food waste?
    - Other incentives?
  - Do you have partnerships with NGO/non-profit organizations?
    - How have you formed these partnerships?
    - Partnerships for pickup/drop off
    - How successful are these relationships, good participation?
  - What are some costs of waste treatment?
    - Jobs
    - Transportation
    - General costs
  - Gauge the potential for recycling food waste
    - How did you identify this as a potential market?
    - Why would someone want to do this?
    - Can they make money off it (i.e. selling vermicompost/compost)?
    - Monetizing environmental impact of recycling of food waste?
  - Determine the role of the municipality in private organizations
    - Does the municipality provide funding for private organizations?
  - Statistics on the success or how much waste has been diverted from landfills?

Appendix B

To whom it may concern,

We are a group of students from Worcester Polytechnic Institute (WPI) in Massachusetts. The goal of our project is to identify strategies to encourage food waste vermicomposting through a vermicomposting program in Pylaia-Chortiatis, Greece. We have thoroughly read over the Municipal Waste Management Plan created by the municipality in 2014-15 and would like to complement this plan by proposing a method for implementation. In order to do so, we are planning to:

- Interview individuals involved in the municipal waste management sector.
- Gauge the current perspective on the municipal waste collection plan
- Gauge the possibility of creating a vermicomposting program through the municipality.
- Create a food waste treatment process to complement the proposed collection method.
- Provide an analysis of vermicomposting vs traditional composting methods and decide which will work best for the collection plan developed by the municipality

We believe that vermicomposting is an effective and efficient way to help divert food waste from landfills that could be introduced into the Pylaia-Chortiatis region. We can be contacted at vermicompostingd18@wpi.edu.

Thank you for your time,

MacKenzie Conlen
Nicholas Cunha
Erika Snow
Daniel Sochacki

Appendix C

A.F.I.S. Interview responses

What were possible roadblocks?

The need to sensitize the public to the new concept of recycling and the long term benefits that recycling will have on the environment.
To alleviate suspicions by the trade of our non-profit character. (AFIS is a non profit organization which has been assigned by the Ministry to recycle portable batteries).

A deep bureaucratic structure by the Ministry did not allow us to move with the pace of a private company. Many times approvals needed by the Ministry delay us in implementing effective strategies.

Has legislation impacted the development of your company?

Yes to a great extend as laws are modified so as to transform an efficient private company to comply with the rules of the public sector.

Has a lack of funding affected development of your company?

Not at all. AFIS has only 3 employees, keeps costs under control and has managed to maintain a reserve of about 2 million euros to cover current and future needs.

Are there corporate taxes the company has to pay for recycling as a business?

Based on the law there are no taxes for all companies involved with the collection and recycling of waste.

What startup strategies were employed?

Intensive advertising to create awareness to the public and trade about the need of recycling portable batteries.

Involve all cooperates so as to feel they participate and contribute to the program of AFIS.

Fast expansion allover Greece through providing recycling bins free of charge to schools, supermarkets, Municipalities, hospitals, army camps, public and private companies, shops etc. Today AFIS has the highest distribution coverage in E.E. with 6 bins per thousand population when the E.E. average is 1,8 bins per thousand population.

Simplification of procedures so as to facilitate the public to order a bin or to request collection of the batteries when the bin is full. Ordering of the bin is through a form in our website, or through mail or fax. For the collection of batteries there is 24 hour answering service, 7 days a week.
A policy of responding within 24 hours to all request made (citizens, students, municipalities, cooperates, battery importers, Ministry etc.).

Did you receive government or municipal grants/funding?

No this is not allowed.

Did you receive funding from private companies?

Based on European and consequently Greek law, all battery importers must collect their waste of batteries sold. (The same applies for packaging, electric appliances, tires, etc). As these importers do not have the mechanism to do so they pass this responsibility to Recycling Schemes (as AFIS) at a cost, called "contribution fee" which is used by the Recycling Schemes to finance their operations.
The above fee is passed to the final price the consumer pays.
Beyond that, no other funding is received by private companies.

Do you have partnerships with non-government organizations/non-profit organizations?
Yes to the extent that we place recycling bins to their premises and collect the batteries. In certain cases we also do some presentations on the AFIS program.

How have you formed these partnerships?

There is no formal agreement beyond the above mentioned cooperation.

Partnerships for pickup/drop off?

There are special agreements with collectors of batteries and we pay them by the number of visits (collections) to our customers.

How successful are these relationships?

So far very successful, as we try to maintain a 50%-50% cooperation in all levels.

What are some costs of waste treatment?

Cost of separating and recycling of mixed batteries is done in European factories and it amounts between € 270 to € 300 per ton.

How much are the employees paid?

The employees are working with AFIS for 14 years and the average salary is € 1.450 per month.

What are costs for transporting the batteries?

The total cost of transporting is € 300.

Are there any other significant costs?

The cost of collection is around € 1.110 per ton collected.

How does recycling fit into the market?

It was not a fit. It is an obligation arising from the law.

How did you identify this as a potential market?

It was not an identification. It was requirement by the law.

Why would someone want to recycle batteries?

To protect the environment and safe energy.

Do you charge a fee for collecting the batteries?

The importers pay us for every battery they sell.

What is the end product of the recycling?

Various metals such as iron, zinc, lithium, copper, magnesium, etc. which are sold to the industrial sector

Who buys the recycled product?

The industrial sector

Does environmental impact play a role in the company's motivations?

Very much so**.** The idea that we work and serve for the improvement of the world we live provides us with a very strong motive. Particularly when the results are good.

Does the municipality have a role in your business?

Very limited, to the extent that we place recycling bins to their premises and collect the batteries

Do you have any statistics on the success or how much waste has been diverted from landfills?

Our collection and recycling rate is 40% of the batteries sold in the Greek market.
There are no statistics for the waste from landfills.