CREATING VALUE CHAINS FOR SOIL HEALTH AND RESILIENT FOOD SYSTEMS IN WARREN COUNTY

A social enterprise business alternative analysis and strategy recommendations for ByWay Foods

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By Angela Hessenius, Elizabeth Howard, Cleopatra Karanikolas, Catarina Martinez

Academic advisor — Rebecca Vidra, Ph.D.

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Executive Summary

This Master’s Project was conducted for Working Landscapes, a non-profit organization that seeks to advance economic and environmental resilience and build healthy and sustainable rural livelihoods in Warren County, NC. Working Landscapes operates a food processing enterprise called ByWay Foods that dices and bags vegetable products, which are then sold to school cafeterias and other foodservice customers.

ByWay Foods is currently closed for expansion. When they reopen in summer 2021 and begin operating at full capacity, they anticipate generating approximately 25 tons of food scraps annually. Without a plan for recovery, the food scraps will have to be transported to a landfill, losing valuable nutrients and contributing to carbon emissions. This represents a significant missed opportunity to recapture the value of this vegetable waste, especially in Warren County, where the economy relies heavily on agriculture and soils have been severely degraded by a history of intensive cultivation. Therefore, ByWay Foods aims to utilize this waste stream to optimize social, economic, and environmental value by developing a complementary food waste recovery initiative. The intended end-product is a soil amendment that can be sold to local farm operations at an appropriate cost. This will provide a stream of income that enhances ByWay Foods’ financial viability and create a product that improves local soil health. The creation of a closed-loop model supports Working Landscapes’ overall goals of enhancing value chains, sustainable livelihoods, economic opportunities, food security, ecological health, and rural-urban connections in the region.

Our team’s goals for this Master’s Project were to (1) identify the optimal model for processing Working Landscapes’ food waste stream and create economic, environmental, and social benefits in Warren County, and (2) develop a business plan to guide the creation of this food waste recovery enterprise. To accomplish this, we identified and researched the potential alternative food waste management strategies, which included solid waste disposal, animal feed, thermophilic composting, vermicomposting, biogas, and biochar. We also worked iteratively with Working Landscapes to define their values and intended outcomes. We were then able to compare each alternative strategy and to determine which strategies complemented Working Landscapes’ existing resources and aligned with their overarching goals and objectives. We developed our final recommendations based on these research findings and analyses.

Our final product is a recommendation for a mixed-model compost venture (thermophilic compost and vermicompost) that utilizes a phased approach for scaling and leveraging other organic waste resources in the community. Our team has developed a business plan to support the initial stages of our phased approach that involves the development of a pilot program for an aerated static piles (ASP) composting system using a microbin from the vendor O2 Compost. We recommend using ASP as the specific method for thermophilic compost because it is simple, affordable, and scalable. Some of the advantages of working with the recommended vendor, O2 Compost, are that their modular systems are highly scalable and that purchasing the design for their systems comes with lifetime technical support. Therefore, as Working Landscapes develops an effective compost mix (or “recipe”) through the pilot program, they can also work with O2 Compost to determine an
appropriate design for a system that can accommodate ByWay Foods’ entire stream of vegetable scraps as they scale to full food production.

We also recommend that Working Landscapes create a small vermicompost system during the initial stages of the phased approach. Vermicompost can use partially completed compost generated by the ASP system as an input and produces a higher value end-product. Therefore, the use of both thermophilic compost and vermicompost gives Working Landscapes the flexibility to create multiple compost products, including mixed blends, that can be marketed at a range of values to most effectively meet local and regional demand.

Additionally, operating both an ASP and a vermicomposting system at their site in downtown Warrenton, NC, creates excellent educational opportunities to host community visits and demonstrate their successes and lessons learned. This will enable Working Landscapes to engage local students, farmers, and community members and increase their knowledge about food waste recovery and sustainable food systems. These community engagement and educational activities will hopefully inspire other individuals and institutions to begin composting their own food waste, sparking a change in knowledge, attitudes, and behaviors as food scraps are perceived as an asset rather than a waste product. This leadership in food waste recovery is key to achieving Working Landscapes’ vision for creating a circular food economy in the Warren County region.

The tools we provided to our client will help them ensure that ByWay Foods expands in a sustainable, just, and socially responsible manner. By transforming the food waste into a soil amendment product, ByWay Foods will help improve environmental quality and soil health, create local economic opportunities, and provide community members with information and resources to expand composting practices. This can help build a more resilient local and regional food system and create a circular economy in Warren County.
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I. Introduction & Background

Client Organization & Project Goals

Our team developed this Master’s Project for Working Landscapes, a non-profit organization based in Warren County, NC, that was founded by Carla Norwood and Gabriel Cumming in 2010 (Working Landscapes, 2021). Working Landscapes seeks to advance economic and environmental resilience and build healthy and sustainable rural livelihoods in the communities they work in (see Working Landscapes’ Mission and Vision, Table 1).

Figure 1 — Working Landscapes’ Mission and Vision (Working Landscapes, 2021)
Working Landscapes utilizes an asset-based approach to economic development that seeks internally driven solutions that identify and build on the area’s valuable resources, including land, people, and a strong connection to place (Working Landscapes, 2021).

Much of this work focuses on revitalizing local and regional food systems to generate economic opportunities and connect more people to healthy food sources. This involves linking locally grown food to regional markets and low-income consumers. Working Landscapes also promotes value chain development and coordination by aligning stakeholders and decision-makers across the food supply chain to improve outcomes related to health, economic development, and social equity (Working Landscapes, 2021). This work spans several areas, including education, policy development, and operating social enterprises that purchase local produce and sell value-added products to regional customers. Specific examples of programs and activities that Working Landscapes operates include:

- **What’s Growing On**: A farm-to-school education program that engages children and adults in hands-on learning about growing and eating healthy, seasonal food
- **Main Street Kitchen**: A shared-use commercial kitchen that supports food entrepreneurs in preparing their products for regional markets
- **ByWay Foods**: A food processing operation that brings locally grown, fresh-cut produce and prepared foods for wholesale markets

This Master’s Project is linked specifically to ByWay Foods. ByWay Foods dices and bags vegetable products, including collard greens, kale, cabbage, sweet potatoes, and romaine lettuce, which are then sold to school cafeterias and other foodservice customers (ByWay Foods, 2019). By purchasing food from local farmers, creating a value-added product, and supplying local and healthy foods to regional consumers, many of whom are low-income, this venture supports Working Landscapes’ mission of strengthening local and regional food systems and value chains.

ByWay Foods is currently closed for expansion. When they reopen and are operating at full capacity in the summer of 2021, they anticipate generating approximately 25 tons of food waste annually. Without a plan for recovery, the food scraps will have to be disposed of in a landfill, losing valuable nutrients and contributing to carbon emissions. This represents a significant missed opportunity to recapture the value of this vegetable waste, especially in Warren County, where the economy relies heavily on agriculture and soils have been severely degraded by a history of intensive cultivation. Therefore, Working Landscapes aims to utilize this waste stream to maximize social, economic, and environmental value by developing a complementary food waste recovery system.
recovery initiative. The intended end-product is a soil amendment that can be sold to local farm operations at an appropriate cost. This will provide a stream of income that enhances ByWay Foods’ financial viability and create a product that helps improve local soil health. The creation of a closed-loop model supports Working Landscapes’ overall goals of enhancing value chains, sustainable livelihoods, economic opportunities, food security, ecological health, and rural-urban connections in the region.

Our team’s goals for this Master’s Project were to investigate the best model for processing Working Landscapes’ food waste stream to create economic, environmental, and social benefits in Warren County and to develop a business plan to guide the creation of this food waste recovery enterprise. To accomplish this, we defined Working Landscapes’ values and intended outcomes, identified and researched the possible alternative food waste management strategies, and developed our recommendation based on our research findings and analysis (see Methods section). Our final product is a business plan for a mixed-model compost venture that can be scaled to leverage other organic waste resources in the community (see Business Plan section).

The tools we provided to our client will help them ensure that ByWay Foods expands in a sustainable, just, and socially responsible manner. By transforming the food waste into a soil amendment product, ByWay Foods will help improve environmental quality and soil health, create local economic opportunities, and provide community members with information and resources to expand composting practices. This can help build a more resilient local and regional food system and create a circular economy in Warren County.

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Local Context: Warren County

I. Warren County Demographics

The land that now makes up Warren County are the ancestral homelands of the Tuscarora, Haliwa, and Saponi Indians (Bangma, 2006). The modern-day Haliwa-Saponi tribe was formally recognized by the state of North Carolina in 1979, with the majority of enrolled tribal members residing in Warren and Halifax Counties (Bangma, 2006; Haliwa-Saponi Indian Tribe, 2020).

Warren County has a population of approximately 19,731 (U.S. Census Bureau). Warrenton is the largest town and the county seat (National Association of Counties), with a population of 1,188 (Census Reporter, 2019). The county’s racial makeup is 51.4% Black or African American, 40.5% White, 5.7% Native American, 3.9% Hispanic, and 0.4% Asian (U.S. Census Bureau). The county has an aging population, with 26.2% of residents 65 years of age and older (U.S. Census Bureau), compared to the national average of 16.5% (Statista, 2021). The percentage
of persons 25 years of age and older with a bachelor’s degree is 15.8%, compared to the national average of 36.0% (U.S. Census Bureau).

Warren County is rural, dependent on agriculture, and designated as a Tier 1 county, meaning that it is one of the most economically distressed counties in the state. Tier ratings are calculated on the basis of four factors: average unemployment rate, median household income, percentage growth in population, and adjusted property tax base per capita. The 100 counties are ranked from 1 to 100 (with 1 being the most distressed), and then they are classified into three tiers. Warren County is ranked the 11th most economically distressed county in the state.

![Warren County, North Carolina](image)

*Figure 2 — Location of Warren County (Bangma, 2006)*

Yet, in 1860, Warren County was designated as the wealthiest county in the state of North Carolina (Chemtob, 2019). Plantations supporting booming tobacco and cotton textiles industries led to economic prosperity (Warren County, 2009). Following the Confederate loss of the Civil War, Warren County suffered economically and witnessed a decline in the agricultural industry (Warren County, 2009). In the 20th century, the manufacturing industry helped to partially revive the economy, but the steady decline in manufacturing jobs across the nation beginning in the 1980s has negatively impacted the county’s economic situation (Chemtob, 2019). Many residents have migrated to more urban areas. Today, 21.7% of Warren County residents reside in poverty, which is more than double the national poverty rate of 10.5% (U.S. Census Bureau).

Agriculture is the dominant source of revenue for Warren County, centered on tobacco and swine farming (Warren County, 2002). 16% of farmland in the county is used for pasture, 48% used for cropland (primarily tobacco and soybeans), and 29% for woodland product harvest (USDA, 2017). Of the 267 farms in the county, 94 (35%) are family farms, 10 (3.7%) sell directly to consumers, and one farm is a United States Department of Agriculture (USDA)-certified organic farm (USDA, 2017). Most farms in the county are relatively small, between 10 and 49 acres in size (37% of all farming operations). Additionally, about 80% of all farming operations in the county have sales valued at under $100,000 (USDA, 2017).
II. Ecology and Historical Land Use of Warren County

Warren County is situated in the Northeast section of North Carolina, and its Northern side borders Virginia. Counties directly adjacent to Warren include Vance, Franklin, Nash, Halifax, and Northampton. While the latter three are described as belonging to the Coastal Plains region of North Carolina, Warren, Vance, and Franklin (as well as nearby Orange, Durham, and Wake – home to some of the most urban areas of North Carolina) technically belong to the Piedmont region. The Piedmont is a plateau region between the Atlantic Coastal Plains and the Appalachian Mountains. The North Carolina Piedmont is characterized by gently rolling hills (elevations range from approximately 300 feet near the Coastal Plain to 1,500 feet near the Appalachian Mountains). However, the relative size (the Piedmont comprises one-third of the state) and the flatness of the area has made it conducive to agriculture.

The mountain ranges in western North Carolina protect the Piedmont from waves of cold air and associated extreme temperature drops (Exploring North Carolina). Warm ocean currents support the growth of vegetation, and long growing seasons and loamy soils with sand and red clay support crops such as hay, corn, small grains, and the historic cash crops cotton and tobacco, as well as pastureland (Exploring North Carolina). Due to extensive plantation agriculture and monoculture, the Piedmont region’s topsoil has been removed – the removal of the topmost sandy layer exposes clay layers that hold water rather than promoting the transport of water, air, and accompanying nutrients (D. Richter, personal communication February 17, 2021).

The official state soil of North Carolina is the “Cecil” soil, which is extensive in the Piedmont. Cecil soil covers 5% of the state but over 30% of the Piedmont (Exploring North Carolina). Cecil soils are very deep with good drainage and permeability, with a large sandy layer sitting on red clay (Cecil Series). The Cecil series is considered prime farmland by the Natural Resources Conservation Service (NRCS) of the USDA.
Figure 3 — Map of Major Geographic Features of Warren County, NC (Source: WSS, NRCS, USDA)

Figure 4 — Soil Analysis of ~50K Acre Area of Interest in Warrenton-area, Warren County, NC (Source: WSS, NRCS, USDA)
The Web Soil Survey, an NRCS tool, shows that primary soil series (by the percentage of land cover) in Warren County include the following: Appling, Cecil (moderately eroded), Chewacla, Pacolet. Cecil, Pacolet, and Appling soils all have similar properties but have experienced significant erosion. Soil erosion leads to an increase in the relative clay content of soils, which is correlated with lower yields and increased water retention (though this does not increase water available to plants). The North Carolina Piedmont and the Upper Coastal Plain have been and continue to be extensively cultivated (D. Richter, personal communication, February 17, 2021).

Removal of topsoil layers, which are heavy in organic matter, lead to significant phosphorous depletion, some nitrogen depletion, and increased soil acidity, as well as an accompanying increase in the concentration of toxic metals that are more soluble under acidic conditions. These effects contribute to decreased crop productivity and dangerous water runoff. While clay-rich soils can hold high quantities of water, water travels through the clay extremely slowly, causing the water to run off before it can be absorbed into the soil matrix (D. Richter, personal communication, February 17, 2021). Because farmers add synthetic fertilizers to their soils to address this erosion issue, excess nutrients like nitrogen that dissolve easily in water end up in Warren County water bodies and drinking water systems. Soil erosion has therefore led to significant environmental and public health concerns in Warren County and around the globe.

III. Warren County and the Environmental Justice (EJ) Movement

Warren County is also notable because it is often cited as the birthplace of the modern environmental justice movement (Cole & Foster, 2000; Skelton & Miller, 2016). In 1978, Robert Ward of the Ward Transformer Company of Raleigh, North Carolina, hired Robert Burns as a contractor to illegally dispose of fluids tainted with polychlorinated biphenyls or PCBs (Geiser & Waneck, 1994; Taylor, 2014). These contaminated fluids were dumped along more than 200 miles of rural roads in 14 different counties in North Carolina (Geiser & Waneck, 1994; Taylor, 2014). After the contaminated soils were discovered, the state considered several plans before deciding that they would bury the contaminated soil in a landfill (Geiser & Waneck, 1994; Taylor, 2014). The state considered 90 possible sites in its borders and ultimately decided on a site in Warren County in the unincorporated Shocco Township, 3.5 miles south of Warrenton and about 2.5 miles north of Afton (Taylor, 2014).

Local community members were opposed to the siting decision because they argued that this was a clear display of environmental racism and that the site was chosen because the surrounding community was predominantly Black, rural, and poor (Taylor, 2014). At the time the site was chosen, Warren County had the highest percentage of African Americans of any North Carolina County and was one of the four poorest counties in the state (Taylor, 2014). Additionally, the water table of the landfill site is only 5-10 feet below the surface, and the community residents derived all their drinking water from local wells (Geiser & Waneck, 1994; Taylor, 2014). This meant that there was a strong likelihood that the PCBs—a known cancer-causing substance—would eventually leach into the groundwater (Geiser & Waneck, 1994; Taylor, 2014). By the time the waste began being trucked to the landfill in 1982, local activists had organized a group called Warren County Citizens Concerned About PCBs, who protested the arrival of the contaminated waste. These protests made national news and resulted in the arrest of over 500 adults and children over the course of several weeks (Taylor, 2014).
Although these protests did not successfully prevent the landfill from being built, they were monumentally important in demonstrating the power of community-led actions and prompting further investigation into the patterns of disproportionate siting of toxic waste facilities in minority and low-income communities (Taylor, 2014; Geiser & Waneck, 1994). These investigations became landmark studies that defined and revealed patterns of environmental racism in the United States and many parts of the world and mobilized many minority communities to organize around environmental issues, spurring the growth of the environmental justice movement (Taylor, 2014).

The story of the Warren County PCB landfill protests and their power to spark a national movement illustrates that even marginalized communities harbor significant resources and assets. Often, as shown in the case of Warren County residents organizing to protect the rights and health of their community from the threat of toxic wastes, the people themselves and the social ties that bind them are a community’s greatest asset. This recognition is important to our project because our client’s values and goal of seeking to use the resources available in Warren County to generate environmental, social, and economic value are rooted in these principles of asset-based community development. By helping Working Landscapes launch a food waste recovery enterprise, we are supporting their efforts to be a part of leading Warren County and the region to reimagine food waste and its potential for promoting economic development and soil health (C. Norwood, personal communication, February 12, 2021).

Global Challenges, Local Solutions

While the focus of this project is using local assets to create value through a small-scale food recovery enterprise in Warren County, the challenges and opportunities faced in Warren County are also tied to larger-scale trends within regional, national, and international food systems and economies. For example, many of the goals of this project are aligned with global Sustainable Development Goals, as pictured below. This section will briefly contextualize some of the key concepts underlying this project, including sustainable economic development, circular economies and resource reuse, regenerative agriculture, and climate resilience. Table 1 below summarizes definitions of some of these concepts relevant to our project.

Figure 5 — Selected United Nations Sustainable Development Goals related to resilient food systems, sustainable economies, and resource reuse.
Table 1 — Definitions of concepts used throughout this report

<table>
<thead>
<tr>
<th>Definitions of Key Concepts</th>
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<tr>
<td><strong>Food Systems</strong></td>
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<td><strong>Food Loss &amp; Waste (FLW)</strong></td>
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<td><strong>Soil Health</strong></td>
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<td><strong>Regenerative Agriculture</strong></td>
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<td><strong>Value Chains</strong></td>
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<td><strong>Circular Economy</strong></td>
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I. Food Systems

A food system describes all of the actors and operations involved in growing, transporting, supplying, and eating food. The different parts of the food system include food supply chains, food environments, consumer behavior, individual factors, and external drivers. External drivers that push or pull on the system: (1) environment and climate change, (2) globalization and trade, (3) income growth and distribution, (4) urbanization, (5) population growth and migration, (6) politics and leadership, and (7) socio-cultural context. Food systems influence (1) diet outcomes, (2) nutrition and health outcomes, (3) environmental impacts, (4) economic impacts, and (5) social impacts.
growth and migration, (6) politics and leadership, and (7) socio-cultural context. Food systems strongly influence (1) diet outcomes, (2) nutrition and health outcomes, (3) environmental impacts, (4) economic impacts, and (5) social impacts (Food Systems Dashboard). The Food Systems Dashboard, a resource developed by Johns Hopkins University and The Global Alliance for Improved Nutrition, with collaborators at The Food and Agriculture Organization of the United Nations, The Alliance of Biodiversity International and CIAT, Harvard University, City University London, University of Michigan, Michigan State University, and The Agriculture-Nutrition Community of Practice, incorporates all of these features in one comprehensive diagram:

Food Systems

Working Landscapes fits into this system as part of Food Processing and Packaging sector, and their work seeks to address Food Availability and Food Affordability. Their work is affected primarily by drivers Environment and Climate Change, Income Distribution, Urbanization, Socio-Cultural Context. The creation of a food waste recovery program could have positive environmental, economic, and social impacts because it would minimize waste sent to landfills, and, if turned into a healthy soil amendment such as compost, improves the soil health and productivity of agriculture in the area plus creates jobs for those involved in the soil amendment work.

Many argue that our local food systems are entrenched in the global food system and subject to its pressures (and problems) at nearly all levels. Since World War II, global food production has increased as a result of new technological processes. Increases in population and urbanization, as well as consumer preferences for resource-intensive foods, have led to an overall increase in food production. Intensive agricultural processes
quickly strip fields of their soil nutrients, consume high amounts of energy from non-renewable sources, and release greenhouse gases. Agriculture is practiced on about half of the habitable areas of the planet, consumes over two-thirds of our fresh water, and is responsible for one-third of our greenhouse gas emissions (Gladek et al., 2021).

II. Resilient Food Systems, Food Waste, and Food Waste Recovery

The recent transition to global food systems has created streamlined and efficient supply chains that can meet greater demand at lower economic costs (Garnett, 2013; Toth et al., 2015). However, despite food being more affordable, 820 million people are experiencing food insecurities today (Garnett, 2013; FAO, 2015). Additionally, negative socioeconomic and environmental impacts have surmounted as a result of a centralized food system. As the population grows to an expected 8.3 billion by 2030 and more people are affected by climate change worldwide, issues of food security and stability will only worsen (FAO, 2015). The implications of increasing natural hazards, viral outbreaks, and civil unrest will be felt far and wide throughout global food supply chains, directly affecting human health and livelihood assets (Millin, 2020; Toth et al., 2015). As food systems have become more global, societal relationships to food have been drastically altered. Now that individuals are far removed from the equation, it has made it harder to recognize when problems occur until a crisis point, making food system failure a real threat (Toth et al., 2015). Communities such as Warren County that are economically or socially disadvantaged due to disinvestment or disenfranchisement will be particularly vulnerable and ill-equipped to respond to disturbances like hurricanes if not intervened (Hecht et al., 2018).

Our current food system places pressure on farmers to produce a single crop in high quantities - crops like grains and soybeans are then used to create plenty of processed foods. Warren County is no exception - much of the produce grown in Warren County does not stay in the area. In fact, the residents often lack access to fresh produce because of the cost and difficulty of driving a variety of fresh foods to their rural area from produce packagers based in other areas.

Research suggests that food system resilience, or the ability to respond, recover, and adjust under system disturbances, will require rethinking urban landscapes and development by incorporating a spectrum of diverse, self-contained supply-chains and food systems across the community, regional, and global levels (Toth et al., 2015). Specifically, according to the Paris Climate Accord and many food systems researchers, finding solutions to these perturbations can and should become community-oriented (Millin, 2020). By creating local value chains, a community’s capacity to effectively manage and respond to external stresses affecting their socioecological system is increased (Toth et al., 2015).

Food system resilience is very much dependent on healthy ecosystems and the services they provide. Healthy ecosystems offer natural capital that sustains and buffer us against ecosystem shocks such as droughts and diseases that cause crop failures. Yet, this “insurance policy” is becoming increasingly diminished from anthropogenic activities, including intensive and degrading agriculture practices, pollution, and food waste (Bajželj et al., 2020).
The generation of **food loss and waste** throughout food supply chains is a national and global problem. While often referred to together, food loss and waste can be differentiated as the decrease in quantity or quality of available food at different stages in the food supply chain: food loss occurs during production, processing, and distribution, whereas food waste occurs at the retail and consumption stages (ReFED, 2016). Globally, more than 1.3 billion tons of edible food material are wasted every year: this amounts to about one-third of total food production and is enough to feed over 1 billion people (Shurson, 2020; Rajeh et al., 2021). In the United States, between 125 and 160 billion pounds of food—up to 40% of the total food supply—are wasted every year (NRDC, 2017). This massive quantity of food waste has staggering economic and environmental costs and is a significant barrier to achieving food security and sustainability (Shurson, 2020). The annual cost of growing, processing, transporting, and disposing of uneaten food is estimated at $218 billion (NRDC, 2017; Leib et al., 2016). This wasted food is an inefficient use of a tremendous amount of resources, including fertilizers (such as nitrogen and phosphorous), water, land, and greenhouse gas emissions (NRDC, 2017; Shurson, 2020; Leib et al., 2016; Rajeh et al., 2021). Researchers suggest that reducing food waste would be one of the most impactful systematic improvements we could make to bolster long-term food resilience by protecting ecosystem services (Bajželj et al., 2020).

In recognition of these impacts, federal government agencies have set goals to reduce food loss and waste to achieve benefits, including strengthening food security and mitigating climate change. In 2015, the United States Environmental Protection Agency (EPA) and the United States Department of Agriculture (USDA) announced the United States’ first domestic food loss and waste reduction goal, which sets a target of reducing food loss and waste by half by the year 2030 (US EPA, 2016).

Food loss occurs throughout the supply chain and has unique characteristics at each step. Though ByWay Foods does amass food waste from events that prepare food, the primary source of waste for most processing facilities are inedible trimmings, including parts such as cores and peelings left behind. These scraps are not considered food waste since they are inedible with little nutrients (NRDC, 2017). Still, they contribute to many of the same adverse outcomes that spoiled food creates, such as GHG emissions (NRDC, 2017). Additionally, food scraps present a unique challenge: where it is possible to imagine a future in which food waste does not occur or is drastically reduced through better practices, inedible food scraps will always be produced as a byproduct of processing food regardless of how efficient processes are made. This means that creating a holistic solution for food waste and food scraps encompasses both prevention and diversion, requiring the development of innovative solutions accessible across communities if they are to become the norm. Establishing a social enterprise that generates secondary uses for ByWay Foods’ food scraps presents a threefold opportunity to advance a circular economy: creating value from their waste in the form of a compost soil amendment,
eventually expanding to incorporate organic waste from the local community, and providing mentorship to interested organizations in surrounding regions.

IV. Soil Health and Regenerative Agriculture

Due to the Warren County area’s history of plantation agriculture and monoculture, the top layer of soil in agricultural fields has been almost completely removed. Topsoil is lost over time because agriculture replaces natural vegetation that holds soils in place. Harvesting and erosion speed up this process. Losing topsoil exposes highly compacted layers that would normally be deeper in the soil profile. Removal of topsoil layers, which are heavy in organic matter and microorganisms, leads to significant nutrient depletion and increases soil acidity, as well as an accompanying increase in the concentration of toxic metals that are more soluble under acidic conditions (D. Richter, personal communication February 17, 2021). In North Carolina, the deeper soil layers are especially high in clay, which is an especially difficult medium for growing crops. Water (from all sources, including irrigation and rain) is slow to permeate into clay, but once it does, it gets trapped in the clay matrix. This clay-heavy system leads to significantly decreased crop productivity, as well as runoff of fertilizers and pesticides into our water systems (D. Richter, personal communication February 17, 2021).

All of these aforementioned processes lead to decreased overall soil health. The United States Department of Agriculture defines soil health as “the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.” Soil is not an “inert growing medium, but rather is teeming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem. Soil is an ecosystem that can be managed to provide nutrients for plant growth, absorb and hold rainwater for use during drier periods, filter and buffer potential pollutants from leaving our fields, serve as a firm foundation for agricultural activities, and provide habitat for soil microbes to flourish and diversify to keep the ecosystem running smoothly” (USDA NRCS). Topsoil formation is a natural process that takes over hundreds of years to form just one centimeter; the process results from the decomposition of a steady supply of organic material from trees, plants, and animal droppings over long periods of time plus climatic effects (D. Richter, personal communication February 17, 2021). In 2014, the United Nations estimated that we had degraded two-thirds of the planet’s soils, and the remaining amount will be gone in 60 years or less (Arsenault, 2014). Estimates now range from 30 harvests to 100 harvests without any intervention. In the United States specifically, the soil is lost at a rate ten times faster than the rate of its formation (Climate Action: Regenerative Agriculture).

While we can’t speed the natural process of topsoil formation (in the few places where conditions would lead to such a formation), our soil health issues can be improved with soil amendments. While calcium is often added to farmland soils to address the acidity problem, it does not provide a permanent or comprehensive solution. Application of organic matter, such as compost, provides a more sustainable and effective solution because it also restores nitrogen, phosphorous, provides pH balance, and introduces beneficial microbial and fungal activity (Composting at Home). The soil amendments this paper analyzes include compost created through aerobic digestion, compost created through aerated static piles, vermicompost, biogas, and biochar. All of these soil amendments facilitate some degree of waste management, add organic matter to the soil, improve soil texture, increase levels of plant-available water, enhance seed germination, and raise crop yield. Currently,
commercial farmers – especially those with rural, medium-sized farms in more economically modest areas like Warren County – use a combination of affordable, synthetic or processed amendments like liquid and/or powder fertilizer and lime (calcium), plus some amount of manure.

**Regenerative agriculture** is a more sustainable approach to farming and an extensively researched solution to soil degradation. Regenerative agriculture describes a body of farming practices that mimic natural processes and close the carbon loop (Ranganathan et al., 2020). Regenerative agriculture practices include reduced tilling (which minimizes soil disturbance), implementation of cover crops, managed animal grazing, crop rotation, increased biodiversity, and composting (Climate Action: Regenerative Agriculture). Adopting even some regenerative practices, such as creating and applying compost, leads to more productive soils and long-term carbon sequestration, which is an important solution to mitigate global climate change (Climate Action: Regenerative Agriculture).

### III. Value Chains and Circular Economy

Working Landscapes is a regional leader and strong proponent of value chain development (Working Landscapes, 2021). A **value chain** approach to economic development involves connecting local businesses and enterprises to broader regional supply chains. This approach is particularly useful when helping locally disenfranchised and disconnected communities overcome poor market access constraints. Through this lens, strengthening value chains creates resilient local economic conditions through building and connecting existing local assets to regional markets. Working Landscapes works to build stronger linkages between Warren County’s abundant farmland and knowledgeable farmers to nearby urban areas (Working Landscapes, 2021). A critical component in effective value chain development is understanding the context and parameters of final demand (International Labour Organization, 2021), which can only be comprehensively understood by engaging in dialogue with stakeholders, which improves the flow of knowledge and makes value chains more effective and inclusive (International Labour Organization, 2021). Therefore, Working Landscape’s value chain work requires aligning stakeholders across the food supply chain, understanding market opportunities, and understanding value from processing infrastructure investments. Part of this work is accomplished through Working Landscape’s brand ByWay Foods, which processes locally grown produce and sells a value-added product to institutional cafeterias. Working Landscapes also serves as a connector to any local producer interested in accessing regional food distribution networks (Working Landscapes, 2021).
A **circular economy** seeks to rebuild capital, whether financial, manufactured, human, social, or natural. This ensures enhanced flows of goods and services (Ellen MacArthur Foundation, 2017). Working Landscapes seeks to participate in the circular economy by investing in value-adding infrastructure that allows waste to be repurposed into a market commodity. Food scraps that are produced as a byproduct of the food processing activities at the ByWay Foods facility will be repurposed into a value-added soil amendment. In the process, Working Landscapes will divert waste from landfills, create jobs, retain economic value, provide sustainability education opportunities in the community, and improve local soil fertility through the use of their product which will increase the working capacity of local agricultural fields. This regenerative model creates economic, social, and environmental value from what was once a waste input that was inefficient and detrimental to the environment.
Figure 8 — Circular economy diagram showing the distinction between technical and biological cycles (Source: Ellen MacArthur Foundation, 2017).

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough,
Cradle to Cradle (C2C)
II. Methods

Research Questions

To achieve the goals of our project, which were to select the optimal food waste recovery strategy for our client and develop and business plan to guide their implementation of our recommended alternative, we had to collect and analyze data that would allow us to answer some fundamental research questions. These questions and our primary methods for achieving our project objectives are detailed below.

<table>
<thead>
<tr>
<th>Roadmap to Achieving Project Objectives</th>
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<tbody>
<tr>
<td><strong>Project Objectives</strong></td>
</tr>
<tr>
<td>1. Identify the best model for processing ByWay Foods’ vegetable waste stream to create economic, environmental, and social benefits in Warren County</td>
</tr>
<tr>
<td>2. Develop a business plan to guide the creation of this food waste recovery enterprise</td>
</tr>
<tr>
<td><strong>Research Questions</strong></td>
</tr>
<tr>
<td>A. What is the optimal strategy to manage ByWay Foods’ waste stream? Is biochar or compost appropriate, or are there better alternatives?</td>
</tr>
<tr>
<td>B. What are the expected sources and quantities of organic material inputs?</td>
</tr>
<tr>
<td>C. What is the market for the soil amendment products that would be created through a composting, biochar, or another initiative?</td>
</tr>
<tr>
<td>D. Can ByWay Foods’ existing facility be used to house this food waste processing operation, or does a new site need to be identified?</td>
</tr>
<tr>
<td>E. What additional equipment is needed? How much does that equipment cost?</td>
</tr>
<tr>
<td>F. How profitable or financially viable would this enterprise be?</td>
</tr>
<tr>
<td>G. What are the opportunities for scaling this enterprise, and how should ByWay Foods seek to scale its operation?</td>
</tr>
<tr>
<td>H. Who are potential partner organizations and essential stakeholders?</td>
</tr>
<tr>
<td>I. What are the anticipated social and environmental benefits?</td>
</tr>
<tr>
<td><strong>Actions to Address Research Questions</strong></td>
</tr>
<tr>
<td>1. Articulate the client’s values, needs, and intended outcomes</td>
</tr>
<tr>
<td>2. Identify food waste recovery alternatives and select the strategy that best suits the client’s goals and existing resources</td>
</tr>
<tr>
<td>3. Describe the feasibility of a compost, biochar, or other food waste recovery enterprise</td>
</tr>
<tr>
<td>4. Compile information on potential funding sources and provide relevant metrics that funders would want to see</td>
</tr>
</tbody>
</table>

Table 2 — Roadmap to Achieving Project Objectives

Data Collection

Our team used several methods to collect data. We conducted a site visit to ByWay Foods in Warrenton, NC, to see the physical location and resources of the food waste recovery operation, better understand the context of
the project, and establish our goals and objectives with our client. To gather information on the potential alternative food waste recovery strategies that ByWay Foods could pursue, we reviewed the literature on each alternative and compiled our findings for our comparative analysis (see Analysis of Alternative Food Waste Management Strategies section). We also conducted 20 interviews over the course of several months with representatives from a broad range of stakeholder categories (described in Table 4 below) over Zoom and by phone. A comprehensive list of our interviewees is available in the Appendix.

<table>
<thead>
<tr>
<th>Stakeholder Groups for Project Interviews</th>
<th>Who:</th>
<th>Why:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative Experts</td>
<td>Professors at academic institutions, private consultants, individuals at NGO organizations, and project leaders</td>
<td>Understand the logistics, benefits, and limitations of each identified food waste recovery model alternative</td>
</tr>
<tr>
<td>Funders and Government Representatives</td>
<td>State government representatives, private institutions, and individuals at NGOs</td>
<td>Explore funding and partnership opportunities and understand relevant policy and regulatory requirements</td>
</tr>
<tr>
<td>Business Professionals and Entrepreneurs</td>
<td>Individuals at NGOs, project directors, and garden stores in the Triangle</td>
<td>Understand best practices, business logistics and strategies, finances, and market opportunities</td>
</tr>
<tr>
<td>Community Members and Local Markets</td>
<td>Organic waste suppliers, farmers, ByWay Food partners, and local garden stores</td>
<td>Gauge interest, needs, supply, feasibility, and market opportunities</td>
</tr>
<tr>
<td>Project Advisors</td>
<td>Nicholas School of Environment professors</td>
<td>Obtain project guidance and generate ideas</td>
</tr>
</tbody>
</table>

Table 3 — Types of contacts our team interviewed and purpose for speaking with representatives of each stakeholder group
Data Analysis

We synthesized our findings from interviews to compare alternatives, analyze market conditions and financial viability, and guide the recommendations in the business plan. Below is a description of each analytic tool used in this project and its purpose:

- **SWOT and TOWS diagrams**: We created SWOT analyses for each alternative that we explored, providing a visual representation of our research findings. Each diagram details the strengths, weaknesses, opportunities, and threats of their respective alternative. We then generated a final TOWS analysis for our recommended business strategy. A TOWS analysis is a strategic planning tool that goes a step beyond the SWOT analyses by showing the relationships and interactions between relevant threats, opportunities, weaknesses, and strengths, which helps identify strategy options (Weihrich, 1982). Our TOWS analysis incorporates individual SWOT analysis findings and includes business strategies that leverage strengths and opportunities to address weaknesses and threats.

- **Objectives Hierarchy**: The Objectives Hierarchy (OH) is a decision analysis tool used to clarify project objectives and weigh alternatives. It is grounded in the field of value-based decision-making (Arvai and McDaniels, 2001; Objectives Hierarchy, n.d.). The OH illustrates the client’s overarching or strategic objective and the fundamental objectives, which are more specific components that comprise the overall goal. We also developed a means-end network that visualizes what actions must be taken to achieve those objectives. We gauged the relative value our client places on each fundamental objective, which allowed us to qualitatively weigh their importance and guide our comparison of potential alternatives.

- **Logic Model**: The logic model (LM) is a type of roadmap for this social business venture. It is a visual representation of the intended outcomes and the inputs and actions needed to get there (Ernst et al., 2012). Our client can also adapt this Logic Model to use in grant funding applications.

- **Market Analysis**: We utilized Market Analysis to identify potential sources of inputs for Working Landscapes’ composting and/or biochar enterprise and understand the market demand for a soil amendment. Investopedia defines Market research as “the process of determining the viability of a new service or product through research conducted directly with potential customers. Market research allows a company to discover the target market and get opinions and other feedback from consumers about their interest in the product or service.” We identified potential carriers of soil amendment products and factors that would affect consumers’ willingness to purchase this product, including labeling, price, and nutrient composition. To conduct this Market Analysis, we asked specific questions to owners of garden and farm stores in both Warren County and the Triangle region (Durham, Orange, and Wake counties).
Client Co-Creation and Values Alignment

Before we began analyzing alternatives, our team sought out to understand Working Landscapes' vision and fundamental objectives for this business venture. In line with our community-based environmental management training, it was essential for our team to facilitate co-creation with Working Landscapes. To do this, we began the process of creating an Objectives Hierarchy. An Objectives Hierarchy (OH) is a decision analysis tool used to clarify project objectives and quantitatively weigh alternatives based on client values. Our goal was to break down the project's overarching goal into fundamental and sub-objectives that answered the question of "what are we trying to accomplish," and separate these from means objectives (how are we going to accomplish this, which we include in the means network and strategy recommendations).

Over several conversations, we inquired what aspects of the project mattered most to Working Landscapes and what impact they wanted it to have on the community. Creating the model was an iterative process, and it evolved over several versions throughout the project’s development. Once it was at a point that felt intuitive and representative of our client’s values, we presented a deconstructed list of sub-objectives to Working Landscapes for feedback. They then weighted the sub-objectives from five (being most important) to one. This process could have been extended by several steps to calculate suitability scores for each alternative based on weights. We did find this necessary for our research.

Ultimately, the intention was for the OH to be an internal-facing model that we would use as an academic exercise to align our team and guide our conversations with interviewees. The OH helped us ask questions and align our recommendations with the best alternative for Working Landscapes and their priorities. Additionally, this would help formulate outcomes for the business venture logic model. The intention of creating the logic model was to create an outward-facing diagram for funders and partners wanting to see the full vision and roadmap to achieve meaningful outcomes.

Lastly, rather than using the OH to create indicators for calculating alternative scenarios, evaluation questions were created for measuring success using logic model components and priority sub-objectives. The data collection plan outlines evaluation question indicators and tools for collecting data.
III. Analysis of Alternative Food Waste Management Strategies

One of the main objectives of this project was to develop a recommended strategy and business model for how ByWay Foods should handle the 25 tons of food scraps they are projected to generate annually as soon as their food processing facility begins operation again. To select the optimal strategy, we analyzed several different food waste alternatives to determine which would be optimal approach based on ByWay Foods’ existing resources and Working Landscapes goals and values.

Several options exist to create value from food waste, such as animal feed, anaerobic digestion, and compost (NRDC, 2017). According to the Hierarchy to Reduce Food Waste and Grow Community (Figure 9 below), diverting food waste to animals (second tier) is more preferred than secondary uses such as anaerobic digestion and composting (third-tier and down). However, in the context of community building, size is central to the preferred alternatives, which is emphasized in this version of the hierarchy (Platt, 2018). More preferred methods include smaller, decentralized operations that allow for a combination of increased nutrient returns, require lower inputs, and facilitate community autonomy. Home composting (tier 3) is not directly applicable for ByWay Foods since it will be operating as a business that produces food waste at a scale larger than backyard composting. Through education, mentorship, and collaboration, it is possible to indirectly facilitate food waste reduction in the topmost tiers (strategies which are discussed at greater length in the alternative section).

![Figure 9 — Food Waste Recovery Hierarchy. This model was adapted from the Environmental Protection Agency (EPA)’s more food waste hierarchy to include a holistic, community-based approach at organic waste management (Platt, 2018).](image-url)
The Objectives Hierarchy below visualizes the breakdown of Working Landscapes' vision and fundamental objectives. As is shown in the top box, the overarching goal for this business venture is to maximize the value from ByWay Foods' food waste stream, and in doing so, to help create a circular food economy in Warren County and the surrounding area. From there, the fundamental objectives were expressed as increasing environmental health, socio-economic opportunities, social capital, and project feasibility. These fundamental objectives were then divided into several sub-objectives that helped narrow down what could be measured. At the bottom, Working Landscapes weighted values for the sub-objectives from one (being less important) to five (being most important) are expressed to help weigh alternatives relative priority values.

Figure 10 — Objectives Hierarchy representing a breakdown of Working Landscapes' goal into fundamental and sub-objectives for their food recovery social enterprise. The circles with numbers 5-1 represent Working Landscapes' how much weighted value they put on each objective.

In the following sections, we will discuss the applicable alternatives (solid waste disposal, animal feed, thermophilic compost, vermicompost, anaerobic digestion, and biochar) in relation to ByWay Foods’ values. In combination with the Objectives Hierarchy, we created individual SWOTS to analyze each alternative’s strengths and weaknesses. Later in the report, we consider external opportunities for increasing the quantity of organic waste inputs, such as manure and woody debris, and discuss which alternatives are best suited for scaling.
Option 1: Solid Waste Disposal

If the organic waste is disposed of as solid waste, no new infrastructure for another food recovery program would be needed. Working Landscapes would only require the capacity to collect and store the food waste on-site and transfer it to the Warren County Transfer Station, which is located less than 1.5 miles from downtown Warrenton. Several bins and a truck would meet this need. Avoiding the need to develop a new system on-site for managing Working Landscapes’ food waste would be the main reason to pursue solid waste disposal as an option. Yard waste is also accepted at the Warren County Transfer Station; therefore, this option could accommodate the disposal of woody debris (Warren County Public Works, 2013).

However, the financial cost of disposing of waste at the Warren County Transfer Station is high. Tipping fees at the Warren County Transfer Station are $67 per ton (NC DEQ, 2019). Therefore, in total, disposing of ByWay Foods’ projected organic waste would cost $1,675 per year. This additional cost would significantly reduce the profitability of ByWay Foods’ operation, as it accounts for approximately one third of ByWay Foods’ projected net income (Working Landscapes, 2020). There would also be additional labor and fuel costs to transfer the waste to the site. Another problem with solid waste disposal is that as the amount of waste generated increases, this option only becomes more expensive and logistically challenging (e.g., running out of space to store waste on-site). Therefore, reliance on solid waste disposal could present a limitation on scaling as the food processing venture grows.

Disposing of food waste in landfills also creates significant missed economic development opportunities for North Carolina. States that are willing to accept trash shipments benefit from an economic development opportunity through disposal fees (Davis, 2015). Therefore, disposing of waste in landfills allows economic benefits to flow out of the state (Davis, 2015). North Carolina exports the majority of its waste out of state (Davis, 2015; NC DEQ, 2020). Most of the waste produced in Warren County is exported to the Brunswick Waste Management Facility in Lawrenceville, VA (NC DEQ, 2020).

It is also widely known that landfills have a variety of negative environmental and social impacts from local to global scales. As waste in landfills degrades and breaks down, they produce gases and leachate, both of which can threaten human health and environmental quality. Landfill gases consist primarily of methane and carbon dioxide, both important greenhouse gases (GHGs) that contribute to anthropogenic climate change. Globally, landfill sites contribute 20% of total anthropogenic methane emissions. Additionally, landfill gases contain low concentrations of many other chemicals, some of which are toxic pollutants and others that can negatively impact nearby vegetation and ecosystems. Leachate (the liquid that percolates through the waste deposited in a landfill) contains a wide variety of chemicals, including hazardous, toxic, or carcinogenic contaminants. If not properly controlled and managed, leachate can pose serious threats to environmental quality and human health by entering surface water, soils, and/or groundwater. For example, nitrate and phosphates that enter surface water bodies can cause eutrophication, and plants can uptake trace metals such as lead, zinc, cadmium, and mercury that retained in the soil, affecting crop growth and entering the food chain, becoming a potential threat to animal and human health (Danthurebandara et al., 2013).
These pathways of exposure, including inhalation of toxic air or contaminated drinking water, can lead to adverse public health outcomes (Danthurebandara et al., 2013; Norton et al., 2007). Studies have demonstrated that proximity to solid waste landfills increases risks of negative birth outcomes, including low birth weight, congenital malformations, and prematurity, and site-specific cancers (Danthurebandara et al., 2013; Norton et al., 2007). The presence of landfills has other socioeconomic consequences as well, including nuisances such as odor, noise, and pests (Danthurebandara et al., 2013). These negative attributes can also lead to depressed property values depending on the distance from the landfill (Danthurebandara et al., 2013). Because of unequal siting patterns, solid waste landfills and their associated risks are an issue of environmental injustice (Norton et al., 2007). In North Carolina, solid waste facilities are disproportionately located in communities of color and low wealth (Norton et al., 2007). Therefore, actions that prevent the generation of waste—which creates the need for new and expanding municipal solid waste facilities—are imperative in order to promote environmental justice (Norton et al., 2007).

One of the primary motivations of this project is to avoid contributing food waste to landfills. The sheer financial cost of disposing of food waste in a municipal landfill is a significant deterrent. Moreover, the myriad consequences of landfills for environmental and human health and their contributions to anthropogenic climate change motivate the client to find an alternative solution to managing their food waste stream. Instead, by taking a circular economy approach, the food ‘waste’ is seen as a resource that can be used to generate value instead of being disposed of in a way that harms communities and ecosystems.
**Strenghts - Internal**

- **Operations:** Avoids development of new on-site waste management system.
- **Feasibility:** All food waste is accepted; most woody debris is accepted.

**Weaknesses - Internal**

- **Economic:** Disposing of food waste is projected to cost ByWay Foods $1675 per year.
- **Environmental:** Contributes to landfill gases and leachate, contaminating ground water and fueling climate climate.
- **Social:** Increases the need for more land devoted to landfills, plus landfills depress nearby housing values and property values.
- **Health:** Contributes to odor, noise, and pests.

**Opportunities - External**

- **Economic:** Incinerators are not allowed in Warren County.
- **Economic:** Time saved could be spent investing in something else.

**Threats - External**

- **Economic:** Space in landfills continues to shrink, increasing biomass bans and limitations on scaling.
- **Economic:** Would be exporting a valuable economic opportunity; potential for other businesses to capitalize on this wasted value.
Option 2: Animal Feed

The Food Waste Recovery Hierarchy (Figure 9, p. 27) shows that edible food should be kept in the human food supply whenever possible and that when food is no longer edible for humans but still safe for animals, those food scraps should be used to feed animals (Leib et al., 2016; Shurson, 2020; Rajeh et al., 2021). Using food scraps to feed animals has been a common practice in every country for centuries (Leib et al., 2016; Shurson, 2020). However, in recent decades, the traditional, informal farm-scale practice of feeding food scraps to animals has declined precipitously (Leib et al., 2016). Following several disease outbreaks linked to the use of animal products in livestock feed, a series of federal and state laws and regulations were enacted to minimize the risk of pathogen transmission from feed to animals and animals to human food (Leib et al., 2016; Shurson, 2020). In response to these legal changes, the practice of utilizing excess food to feed livestock became more industrialized; large-scale food processing and feed production facilities continue to capture and repurpose the byproducts of human food manufacturing into commercial feedstock for animals (Leib et al., 2016). With this shift in scale, scope, and methods, many smaller but significant sources of uneaten food suitable for use as animal feed have gone unused (Leib et al., 2016). Given the potential of using food scraps as feed for animals to realize significant economic and environmental benefits, there is rising interest in utilizing safe and properly treated food scraps from a wide array of sources of animal feed, and the EPA promotes directing leftovers to livestock as one of several methods to reduce food waste (Leib et al., 2016).

One important advantage of using food waste as animal feed is that it can save money for farmers and food-producing businesses and institutions. Since feed is one of the costliest inputs for animal agriculture, farmers can economize by sourcing food scraps to be used as a feedstock or feed supplement (Leib et al., 2016). The diversion of food scraps as animal feed can allow businesses and institutions that serve food to realize significant cost savings compared to conventional solid waste disposal through reduced tipping fees charged by landfills and waste haulers (Leib et al., 2016).

In addition to economic benefits, feeding food waste to animals can also reap significant environmental benefits. In addition to diverting waste from the landfill (and thereby reducing emissions of greenhouse gases, including methane), feeding food scraps to livestock has the potential to reduce the amount of commodity crops needed to support the livestock industry (Leib et al., 2016). Because the production of these commodity crops requires vast amounts of resources, lessening the amount of these crops grown to feed to animals would result in lower amounts of energy, water, land, and other resources used in the food supply chain (Leib et al., 2016; Shurson, 2020). Repurposing food waste into animal feed can therefore reduce the pressure on land and water use and minimize the negative environmental impacts of agricultural production, including soil and water degradation, loss of biodiversity and habitats, and contributions to climate change (Shurson, 2020).

When considering feeding animals as a strategy for managing food waste, it is extremely important to examine the legal and regulatory context. Feeding food waste to animals must be done in a safe, responsible, and legal manner; this protects the health and safety of animals and humans (Leib et al., 2016). There are both federal and state requirements concerning the type of animals that may be fed food scraps and the kind of food scraps that may be fed to animals (Leib et al., 2016). The federal regulations serve as a floor, and state regulations are
often stricter (Leib et al., 2016). This array of federal and state regulations is complex and can be difficult to navigate (Leib et al., 2016). Therefore, it is important before beginning any operation that would provide uneaten food to animals to ensure that one is in compliance with all the legal requirements that they are subject to.

In North Carolina, a license is required to feed animal waste to swine (Leib et al., 2016). This presents an opportunity for our client since their food waste stream is entirely made of vegetable trimmings, so they would not face any regulatory obstacles in providing that waste to farmers to feed their animals. On the other hand, our client would likely be subject to requirements under the Food Safety Modernization Act Preventive Controls Rules for Animals (“Preventive Controls rule”) under the Food Safety Modernization Act (FSMA), which regulates byproducts of human food production that will be used as animal food (Leib et al., 2016). This rule requires human food facilities that will use human food byproducts as animal food to follow specified current Good Manufacturing Practices (CGMPs) for holding and distributing human food byproducts (Leib et al., 2016). These CGMPs must be followed to ensure that facilities prevent the human food byproducts from becoming contaminated and cover processes for holding, labeling, and distribution (Leib et al., 2016). For example, the byproducts must be held in containers that protect their contents from contamination, they must be labeled to identify the byproducts by their common name, and shipping containers must be examined to ensure that the byproducts will not be contaminated (Leib et al., 2016). If our client were to begin marketing and selling human food byproducts to farmers to use as feed for animals, it would be essential to make sure that all proper protocols are followed and legal requirements are adhered to.

Another consideration is that not all food sources are equal in nutritional efficiency (defined as the proportion of gross energy (total calories) and nutrients in a feed ingredient that is digested, absorbed, and used by an animal for productive purposes) for animal diets (Shurson, 2020). There is considerable variation in energy, nutrient content, and digestibility within and across different types of food waste sources (Shurson, 2020). Managing variability in energy and nutrient content and digestibility within and among food waste sources remains a challenge to optimally repurposing food waste as inputs to animal diets (Shurson, 2020). While studies have shown that many food waste streams are rich sources of energy and digestible nitrogen and phosphorus and can be equivalent or superior to traditional crops used as animal feed such as corn and soybean meal, fruit and vegetable waste sources are not the most nutritionally valuable feed ingredients (Shurson, 2020). Therefore, our client’s food waste stream that is comprised of only vegetable trimmings may not be the most valuable potential food source to be used in animal diets.
Animal Feed
SWOT Analysis

**STRENGTHS - INTERNAL**
- **Economic:** Low-cost investment.
- **Economic:** Farmers save money on feed inputs.
- **Economic:** Businesses and haulers can save money from reduced fees for landfills and waste haulers.
- **Economic:** Lessens the amount of crops farmers have to grow exclusively for livestock.
- **Environmental:** Diverts waste from landfills.

**WEAKNESSES - INTERNAL**
- **Economic/Feasibility:** Farmers must acquire licenses to feed pigs cafeteria scraps.
- **Economic:** Unlikely to generate many jobs or much revenue.
- **Animal Health:** Potential for contamination and pathogens that could be harmful to the animals, particularly if ByWay Foods coordinated food waste scraps from their own facility plus nearby businesses and cafeterias.
- **Feasibility:** Fruits and vegetables are not necessarily the ideal or most nutritious diet for all animals; may not be appealing to many farmers.

**OPPORTUNITIES - EXTERNAL**
- **Economic/Feasibility:** No permit is required for feeding animals exclusively vegetable cuttings.
- **Economic/Feasibility:** Many livestock farmers in Warren County.

**THREATS - EXTERNAL**
- **Economic/Feasibility:** If byproducts are being sold, then specific protocol must be adhered to for holding, labeling, and distribution.
Option 3: Thermophilic Composting

Composting is the act of producing a nutrient-rich soil amendment from the decomposition of organic matter aided by microorganisms, water, and internally generated heat. Compost is the end-product of composting, which requires inputs of both green matter (nitrogen-rich) and brown matter (carbon-rich) in a balance that supports decomposition activity. Common sources of green matter include food waste and - perhaps counterintuitively due to its color - animal waste. Brown matter includes fibrous plant materials like leaves and wood, although leaves are preferred for their ability to break down faster than thick, woody pieces. Composting is performed at relatively moderate to warm temperatures, with an ideal temperate of the inside of a traditional compost pile (made by alternating layers of green matter and brown matter) reaching 140 degrees Fahrenheit (Types of Composting and Understanding the Process). The end-product is a soil-like mixture that is rich in nutrients, organic matter, and helpful fungi and bacteria. When added to soil, it enhances soil structure, aeration, drainage, and nutrient availability (Sherman, 2018).

All composting projects, regardless of scale, have to choose a method of promoting decomposition: on-site piles (often very small operations), aerated static piles, tumbled piles, in-vessel, or vermicomposting (Types of Composting and Understanding the Basics). The first option is for small amounts of food waste and organic matter inputs to produce small, handy amounts of compost in a backyard environment. The next two options require relatively large amounts of an indoor facility or outdoor space to create large piles of green and brown inputs that eventually decompose, either without or with the help of physical manipulation of the piles to facilitate oxygenation. Vessel composting can produce large amounts of compost in a small amount of time because the vessel is often a more technical, controlled environment (which also contains odors and avoids attraction of pests), but requires more expensive equipment like dehydrators and digesters. The last option - vermicomposting - utilizes the feeding behavior of worms (added to the composting pile) to aid in the decomposition process (will be explained in the next section).

Personal, community, and industrial composting are becoming increasingly more popular (Rasul, 2019). A local, Raleigh-based organization, CompostNow, is one of these rapidly growing community composting companies. “[Community composters are] grassroots organizations [that] help individuals, organizations and food service providers divert compostable waste like food scraps, paper products and coffee grounds from the landfill...[they] stay true to the "community" in their classification by operating closed-loop systems that value waste as an asset. They provide the nutrient-rich end-product created through their business model to clients, local farms or gardens in the communities where they operate” (Rasul, 2019). These companies work to increase the United States’ rate of recycling and composting, which was around 30% in 2015 (Rasul, 2019).

Compost operations can be extremely beneficial to communities and environments. Availability of inputs and fixed costs will have to be explored, as well as the presence of a market for compost-based soil amendment. Local farmers’ and community members’ compost needs depend on what they intend to grow in their soil. In comparison to biochar (more thoroughly examined below), compost is a more nitrogen-rich soil amendment (Sanchez-Garcia et al., 2016). Fruits and vegetables that require especially high amounts of nitrogen include nightshades (peppers, eggplants, tomatoes) and cucurbits (squashes, melons, cucumbers).
Thermophilic Compost

SWOT Analysis

STRENGTHS - INTERNAL

- **Economic**: Low start-up costs if using static or tumbled piles.
- **Economic**: Higher volume of outputs than vermicomposting.
- **Economic/Feasibility**: Small operations do not need permitting.
- **Environmental**: Soil amendment that improves aeration and water holding capacity; avoids unnecessary waste transport impacts.
- **Operations**: Requires very little technology and maintenance if using static or tumbled piles.

WEAKNESSES - INTERNAL

- **Economic**: Requires high volume of inputs plus additional inputs like leafy debris.
- **Economic**: Lower sell price in comparison to vermicompost.
- **Social**: High odor and high potential for pest attraction.
- **Feasibility**: Must reach a high internal temperature which can be difficult to achieve, especially in winter months.

OPPORTUNITIES - EXTERNAL

- **Economic**: Can be sold for $13 - $35 per cubic yard; no competitor compost facility exists in the area. Could be very appealing for smaller-scale farms and home gardening stores.
- **Environmental**: Greatly increases soil aeration, water holding capacity, and nutrient capacity. Adds significant numbers of helpful bacteria and fungi to soils.
- **Social**: A great tool for compost education.
- **Expansion**: Well-run operation could expand to accommodate waste from local restaurants, institutional partners, and the community at large.
- **Expansion**: Investment in technologies such as food dehydrators and food digesters allows for more rapid composting and easy scaling.
- **Feasibility**: Many different composting technologies which can be used and adapted over time.
- **Operations**: Can make use of available streams of leaf waste, woody waste, and manure in addition to the food scraps.

THREATS - EXTERNAL

- **Economic**: High relative cost of compost may not compete well with other organic amendments like manure, or synthetic fertilizers.
- **Economic/Operations**: Permitting would have to be navigated if operation were to scale.
- **Environmental**: Changes in climate could render system ineffective or slow.
- **Health**: Pathogen transfer (if present) to consumers would be traced back to the facility.
- **Social**: Potential for lack of public support for scaling because of smell and other nuisances.
Option 4: Vermicomposting

Vermicomposting is the decomposition of organic waste via microorganisms and specific species of earthworms. The two more popular species are *Eisenia fetida* and *Lumbricus rubellis*. The earthworms are technically secondary feeders - they eat the microorganisms that digest the food waste. The end-product, after undergoing biological, physical, and chemical transformations, becomes a valuable soil amendment that is rich in nutrients essential for crop growth (Sherman, 2018). Sometimes the end-product is referred to as vermicast; the term vermicast can be helpful to distinguish vermicompost from vermicompost, and the term comes from the phrase earthworm castings which means earthworm feces.

In contrast to composting, vermicomposting does not create heat (Sherman, 2018). Vermicomposting is more akin to livestock production and requires a commitment to animal husbandry to ensure the worms are healthy, productive, and properly cared for (Sherman, 2018).

The majority of vermicomposting operations occur in shallow containers covered with lids and punctuated to allow for air flow. Populations of worms can double in 30 days - 90 days under the correct conditions. The success of vermicompost depends heavily on the animal husbandry practiced by the facility. The ideal temperature for the worms is 55 to 77°F (12.7 to 25°C). Like thermophilic composting, vermicomposting requires trial and error to find the right ratio of food: worms and external conditions like ambient temperature and moisture level. The worms may prefer some foods over others; for example, worms seem to consume greens more effectively than citrus peels. Most new worm farmers start with one pound of worms per square foot of a bin.

Additional husbandry tips including not stirring the mixture once the worms have begun feeding and not adding any items with coloring, chemicals, plastics, or fabrics. Worm bins must stay relatively warm and relatively moist. The food must be added in a chopped format, but this is especially conducive to the ByWay Foods operation.

The final vermicompost product will be complete in 4 weeks but needs to be separated from the worms so that they can begin a new operation, and the final product must be dried before use or bagging for the market.
**VERMICOMPOST SWOT ANALYSIS**

**STRENGTHS - INTERNAL**

- **Economic:** Highest value soil amendment (cost per ounce); low start-up costs (worm + bins).
- **Environmental:** High density soil amendment that improves aeration and water holding capacity; avoids unnecessary waste transport impacts.
- **Social:** Need for constant tending provides employment opportunities.
- **Health:** Can reduce E-coli levels if present.
- **Operations:** Can be conducted indoors; minimal smell.
- **Feasibility:** Modular system that can easily be expanded to accommodate more bins.

**WEAKNESSES - INTERNAL**

- **Economic:** Small relative output. Higher associated labor costs due to need for constant tending; upfront cost of worms, bins, dryer, sifter; harvesting requires time to separate worms from final product.
- **Environmental:** Potential for pest attraction. Will not initially be enough created to tackle the soil health problems of farms in Warren County in any significant way.
- **Social:** Downtown location may cause discomfort due to unfamiliarity of worms/negative associations with worms.
- **Health:** Cannot kill most pathogens since no heat is added; cannot kill weed seeds.
- **Operations:** Cannot break down woody bits; high knowledge of worm husbandry required.
- **Feasibility:** Worms are "picky eaters" and may not like the food waste from the facility.

**OPPORTUNITIES - EXTERNAL**

- **Economic:** Can be sold for $300 - $1400 per cubic yard; no competitor vermicompost facility exists in the area. Could be very appealing for flower and home garden industries.
- **Environmental:** Greatly increases soil aeration, water holding capacity, and nutrient capacity. Adds significant numbers of helpful bacteria and fungi to soils.
- **Social:** A great tool for compost education; worms can be given to the public, community partners for at-home vermicomposting.
- **Expansion:** Well-run operation could expand to accommodate waste from local restaurants, institutional partners, and the community at large.

**THREATS - EXTERNAL**

- **Economic:** High cost of vermicompost may not compete well with other cheaper compost amendments, other organic amendments like manure, or synthetic fertilizers.
- **Environmental:** Changes in climate could cause health issues or death for worms.
- **Health:** Pathogen transfer (if present) to consumers would be traced back to the facility.
- **Operations:** Changes in site features such as humidity, temperature, maintenance, food flow, would all cause health issues or death for worms; not as active in the winter months.
Option 5: Anaerobic Digestion

Anaerobic digestion (AD) is a popular way to handle agricultural waste and wastewater treatment because it requires relatively low energy inputs and handles bacterial and viral pathogens well. Additionally, biogas, a renewable energy byproduct, and liquid fertilizer are produced as byproducts. Agricultural waste such as manure is ideal for AD because it is easily decomposed. While AD is most commonly used for its highly effective capabilities to handle municipal sludge, there have also been cases where it was used for vegetable waste (Chen et al., 2008). AD technology works similarly to the way our stomachs digest food through symbiotic relationships with gut bacteria. While varying in exact execution, reactors consist of an airtight chamber that houses a liquid mixture of microbes and suspended solids, also known as the slurry (Tilley et al., 2014). During fermentation, a series of microbes work together to excrete enzymes that hydrolyze and ultimately break down plant or animal material in the reactor’s oxygen-deprived environment (Coker, 2014). Byproducts of the fermentation are methane and CO2 (biogas) and a nutrient-rich liquid solution (digestate) (USEPA, n.d.). The technology used for biogas production is usually referred to as a biogas reactor or anaerobic digestor (Tilley et al., 2014).

For digestion to take place, the slurry must first be inoculated with bacteria. A balance of acid and methane forming bacteria must be maintained to keep the reactor stable (Chen et al., 2008). It can take several weeks for the bacteria to be well-established. Once inoculated, a steady stream of materials such as manure, wastewater sludge, and food or garden scraps must be provided; Inputting new organic material displaces the volume of slurry and pushes out digestate into the collection vat while gas accumulates, rising to the top valve where it is to be collected, also mixing the slurry as it exits (Tilley et al., 2014). Digesters should be kept at a temperature range that complements the specific microbes, for example, between 95-104°F (Coker, 2014). Inability to keep the slurry maintained at appropriate temperatures or accumulation substances such as ammonia, heavy metals, and sulfide inhibit bacteria. The instability of AD operations has prevented larger-scale adoption (Chen et al., 2008).

Both biogas and the digestate byproducts of AD can be productively used. Biogas is comprised of 50-70% methane and 30-50% CO2, making it possible to use for heat or electricity generation (Winquist et al., 2019). The digestate is what is left after AD and is rich in nutrients. Solids are typically separated from the wet mixture, which is then dried for transportation purposes. Both dry and liquid products can be applied directly as fertilizer to crops or gardens (USEPA, n.d.). Reactors vary in size and capacity from single households to ones that deal with waste from several farms. Reactors can be specifically engineered tanks or covered effluent ponds (lagoons), so production can vary greatly. Notably, AD is most effective for organic material with high water content and small particle size, whereas composting is most efficient when particles are ½ inch to 2 inches (Coker, 2014).

Essentially, AD can be a great option for rural communities since it can handle both animal manure and food waste. Biogas is also an attractive product because, when used locally, it can take part in decentralizing energy production, further bolstering self-reliance within the community (Winquist et al., 2019). However, AD is not efficient at handling large particulates or woody debris. Since this initiative is not focusing on animal waste, we do not recommend undertaking AD.
**STRENGTHS - INTERNAL**

- **Economic**: Final products of gas and fertilizer are both high value.
- **Environmental**: The fertilizer is a high-density soil amendment that improves aeration and water holding capacity; avoids unnecessary waste transport impacts.
- **Operations**: Relatively low energy inputs required; diverse final product types and applications including renewable energy source and liquid fertilizer for soils.
- **Feasibility**: Minimal smell; small scale can handle between 200-5000 tons of organic waste per year.

**WEAKNESSES - INTERNAL**

- **Economic**: Small relative output. Expensive upfront costs for machinery. Hard to rescale after equipment has already been purchased and installed. To be most efficient, hydrolysis steps should be kept separate, which means more tanks to purchase.
- **Environmental**: Secondary emissions created from using the final gas product.
- **Health**: Does not kill all pathogens.
- **Operations**: Cannot break down woody debris.
- **Operations**: Requires expert installation and maintenance.
- **Operations**: Takes time to "seed" and become operational; high instability.

**OPPORTUNITIES - EXTERNAL**

- **Social**: Can educate public about household-scale reactors for toilet/household waste.
- **Expansion**: Biogas could fuel ByWay Foods’ operations.
- **Expansion**: Could be part of a mixed-model venture; various inputs to keep the operation going in the community; ideal for handling manure.

**THREATS - EXTERNAL**

- **Social**: Negative associations in the community because of improperly managed swine farms in North Carolina.
- **Economic**: Competition with Smithfield lagoons.
- **Economic**: Permitting to acquire and policies to follow.
- **Environmental**: Changes in climate could cause slow digestion; gas production is minimal at temperatures below 59 degrees Fahrenheit.
- **Operations**: Must maintain a steady supply of organic material to keep the bacteria alive.
Option 6: Biochar

Biochar, a type of charcoal, is produced when organic matter such as food, wood, manure, or leaves undergo thermal decomposition at temperatures below 700 degrees Celsius with little to no oxygen. Biochar distinguishes itself from traditional "charcoal" in its characteristic uses. Biochar can be incorporated into the soil to improve soil fertility by filtering water and contaminants while providing aeration. The application of biochar to reduce nutrient losses and the need for fertilizer inputs has yet to be demonstrated in field experiments and thus is still being evaluated (Farm Energy Extension, 2019). If biochar is evaluated to be an effective tool for improving soil fertility, nutrient runoff could be reduced due to the lessened need for chemical inputs (Farm Energy Extension, 2019). Biochar is also used to sequester carbon (C) and reduce greenhouse gasses (GHG) (Lehmann and Joseph, 2009; Rajapaksha et al., 2016). Growing scientific consensus is emerging regarding biochar’s effectiveness at removing CO2 from the atmosphere (Farm Energy Extension, 2019). That said, the net carbon footprint of biochar as a soil amendment is widely variable and depends on many things such as the feedstock used, the process by which it is produced, and its chemical composition (Farm Energy Extension, 2019). The use of biochar as a soil amendment is an ancient practice that dates back at least 1000 years. Indigenous people of the Amazonian basin would use it to make Terra Preta, or "Amazonian dark earth," an extremely fertile agricultural soil (Lehmann and Joseph, 2009). Although biochar was used in the distant past, the term was only recently coined when more attention to soil management techniques began emerging in the literature (Lehmann and Joseph, 2009).

Pyrolysis or the thermal decomposition of materials at high temperatures, of biomass can be done in a variety of ways. Each pyrolysis method results in biochar of varying properties, which will affect its ability to act as a soil amendment and provide economic value (Field et al., 2013). The various pyrolysis methods and biochar types will result in different chemical configurations, pH, ash content, and cation exchange capacity (Lehmann and Joseph, 2009). “Designer biochar,” or biochar that has been specifically engineered to complement present management scheme and soil needs, is best effective and remediating soils (Major, 2010; Rajapaksha et al., 2016).

While biochar has the potential to produce significant environmental and economic benefits, a full lifecycle assessment reveals other business considerations (See Figure 9); energy byproducts of the pyrolysis process, GHG offsets, and the production of biochar as a product are all potential sources of revenue. However, there is significant variation in profitability, depending on how pyrolysis is conducted - slower processes typically favor more profitable outcomes. Additionally, higher-temperature deaccession produces biochar with higher GHG-sequestration profitability (Field et al., 2013).
There are fixed costs, such as equipment, and variable costs, such as labor and energy required (dependent on the size and location of the operation) associated with operating any business that detracts from total income (Lehmann and Joseph, 2009). Depending on the size of biochar particulates, economic value can also be lost during the application and transportation phases if not administered correctly. For example, a significant amount of fine biochar particulates can be lost to the wind (see Figure 12). Adding moisture is an easy solution to this specific problem, but other considerations, such as erosion after application, can add to inefficient resource use. These issues go to show that producing biochar should be planned holistically (Major, 2010).

Currently, the market for biochar as a soil amendment application is in its infancy. Costs are therefore at a premium of $1.29 per pound or $2,580 per ton on average in the US (Farm Energy Extension, 2019). As such, biochar as a soil amendment is primarily reserved for application in high-end specialty markets, though this will likely gradually change over time, particularly if its ability to lessen fertilizer inputs is demonstrated reliably in field experiments.

Fine ash production associated with the production of biochar poses a risk for respiratory disease (Six, 2014). There is also an inherent fire hazard risk associated with the storage and handling of biochar. Fire can occur by the exothermic reactions that are produced when the fine biochar particulates react with the water and oxygen molecules in the air, causing ignition. The best ways to mitigate this hazard are by storing it in an anoxic facility, adding anti-inflammatory chemicals, increasing water content, or preparing biochar-compost mixtures. The chosen method and the transportation regulations will also affect production costs (Major, 2010).
Figure 4. Clockwise from top left: Biochar losses during handling, transportation to the field, application with a lime spreader and incorporation with a disc harrow during the establishment of a biochar field trial in St-Francois-Xavier-de-Brompton, QC Canada. Photos by B. Husk.

Figure 12 — Biochar product loss from Major, 2010.
# SWOT Analysis

## Strengths - Internal

- **Economic**: High value soil amendment.
- **Environmental**: Changes soil properties with the longest-term benefits; associated with exceptionally highly fertile soils.
- **Operations**: Closed containers; mobile kilns; minimal smell.
- **Feasibility**: Can pyrolyze nearly anything (including wood, manure, food waste).

## Weaknesses - Internal

- **Economic**: Relatively highest start-up costs for equipment and production costs because of high energy inputs.
- **Economic**: High product cost with low familiarity (underdeveloped market).
- **Operations**: Difficult to make a consistent product.
- **Operations**: Product loss in delivery and distribution.
- **Social**: Lack of understanding of the product and different possible uses/applications.

## Opportunities - External

- **Economic**: Increasing environmental regulations may provide incentives for farmers for using biochar for its carbon storage potential; increasing popularity and demand for carbon markets.
- **Economic**: Large amounts of carbon-heavy woody debris in Warren County.
- **Environmental**: Greatly increases soil aeration, water holding capacity, and nutrient capacity. Adds significant numbers of helpful bacteria and fungi to soils. Associated with extremely high fertility.
- **Environmental**: Quickly growing field which is also quickly gaining popularity in the regenerative agriculture space.
- **Expansion**: Ongoing research shows a variety of uses, even as an additional to animal feed.
- **Expansion**: Synergistic effects between vermicompost and biochar.
- **Expansion**: Only one other biochar producer in North Carolina.

## Threats - External

- **Economic**: Existing stump dump sites currently take the majority of woody debris and are currently cheaper and more convenient.
- **Economic**: Many more, far less complex, alternatives for generating value from woody biomass, such as mulch.
- **Operations**: Permitting could be complex because of incineration features.
- **Operations**: Competitive field; few local biochar operation examples may also be unwilling to share knowledge and trade secrets.
IV. Selected Alternative: Mixed-Model Compost and Vermicompost

Overview

Working Landscapes' goal for this venture is to maximize the Value from ByWay Foods waste stream and help create a circular food economy in Warren County and the surrounding region. By implementing a new social enterprise business, they hope to increase environmental health, socio-economic opportunities, and social capital. It is also important to increase the feasibility of the overall project for this to be a sustainable business venture that can later scale operations and expand impact. There were several product alternatives that our team considered, including biogas, thermophilic composting, biochar, vermicomposting, and more. Using the objectives hierarchy/means-ends network and the combined TOWS analysis (located at the end of this section as figures 14 and 15), we evaluated alternatives based on their ability to meet Working Landscapes top priorities, which were increasing Warren County's ability to be a regional leader in food recover, increasing soil health for farmers, decreasing GHGs, increasing value chains. Based on these analyses, we recommend that ByWay foods pilot a compost-vermicompost system to address their immediate food scraps. Once established, the operation can expand to include a biochar facility to take in woody debris and institutional cafeteria waste.

Aerated Static Piles (ASP) and Vermicompost

We recommend using ASP as the specific method for thermophilic compost because it is simple, affordable, and scalable. Some of the advantages of working with the recommended vendor, O2 Compost, are that their modular systems are highly scalable and that purchasing the design for their systems comes with lifetime technical support. Therefore, as Working Landscapes develops an effective compost mix (or “recipe”) through the pilot program, they can also work with O2 Compost to determine an appropriate design for a system that can accommodate ByWay Foods’ entire stream of vegetable scraps as they scale to full food production.

We also recommend that Working Landscapes create a small vermicompost system during the initial stages of the phased approach. Vermicompost can use partially completed compost generated by the ASP system as an input and produces a higher value end-product. Therefore, the use of both thermophilic compost and
vermicompost gives Working Landscapes the flexibility to create multiple compost products, including mixed blends, that can be marketed at a range of values to most effectively meet local and regional demand.

Additionally, operating both an ASP and a vermicomposting system at their site in downtown Warrenton, NC, creates excellent educational opportunities to host community visits and demonstrate their successes and lessons learned. This will enable Working Landscapes to engage local students, farmers, and community members and increase their knowledge about food waste recovery and sustainable food systems. These community engagement and educational activities will hopefully inspire other individuals and institutions to begin composting their own food waste, sparking a change in knowledge, attitudes, and behaviors as food scraps are perceived as an asset rather than a waste product. This leadership in food waste recovery is key to achieving Working Landscapes’ vision for creating a circular food economy in the Warren County region.

The tools we provided to our client will help them ensure that ByWay Foods expands in a sustainable, just, and socially responsible manner. By transforming the food waste into a soil amendment product, ByWay Foods will help improve environmental quality and soil health, create local economic opportunities, and provide community members with information and resources to expand composting practices. This can help build a more resilient local and regional food system and create a circular economy in Warren County.

Meeting Community Needs

Any project or program should ensure that it meets a need that exists in the community that it intends to serve. Our client, Working Landscapes, is embedded in Warren County and has strong connections with community members and a robust understanding of the local challenges and assets. As a result of this deep community awareness, Working Landscapes’ recognizes that there is a strong need in Warren County for both improved soil health and increased recovery of waste resources, which informed the project objectives from its inception. The creation of a local composting initiative in Warren County would fill a gap that currently exits since the closest composting facilities are in Raleigh and Durham (see Figure 13) (Kachook, 2021). Additionally, the Warren County Solid Waste Management plan mentions that the county has a 20% waste reduction goal by 2022 and that organic waste is one of the largest sources of waste; yet, they do not have a plan for reducing their organic waste or food waste (Warren County Solid Waste Management Plan, 2011).

"You hear crazy things like a cup full of healthy soil has like 40 quadrillion living organisms...If I go and dig in our fields that have been managed by neighboring farmers for soybeans for decades, there's nothing in those fields. It's embarrassing. That's where we're starting from."  -Carla Norwood, Working Landscapes

Conversations with both our client and others familiar with Warren County support our recommendation to begin with a pilot program. Since one of the ultimate objectives of this project includes creating a soil amendment product that local farmers will utilize, it is important to consider the perceptions, attitudes, and barriers that this constituency may have towards changing their agricultural practices and applying compost to
their land. While applying an organic soil amendment can have significant benefits for soil health, farmers also need to factor in the economic cost of applying any amendment to their land in their decision of whether to use this product (D. Richter, personal communication February 17, 2021; P. McKenzie, personal communication, February 18, 2021). We also learned that the type of soil amendment Working Landscapes will generate will be ideal for small-scale, intensive growers rather than larger farms (P. McKenzie, personal communication, February 18, 2021).

Working Landscapes’ ties to the community put them in an excellent position to pilot their compost and vermicompost products by working with a small number of local farmers and gardeners who would be willing to apply the products. This strategy is appropriate for the community context and complements our recommendation of starting with a pilot compost project. As Working Landscapes begins to generate a high-quality soil amendment product, their local farmer partners can evaluate the product’s efficacy and communicate any challenges they may have. As the compost and vermicompost initiative is scaled up, Working Landscapes can both sell their soil amendments to both lucrative markets in the Triangle as well as offer these products to local farmers and growers in the area at a discounted price. They will have greater success in encouraging the use of these products by communicating stories of successful adoption by other local community members.

Figure 13 — Map of regional composting facilities color-coded by type of waste accepted. Retrieved from greenblue.org (Kachook, 2021).
Figure 14 — TOWS analysis that supports final strategy recommendations.
Maximize value from ByWay Foods' food waste stream, helping to create a circular food economy in Warren County and the surrounding region.

Increase environmental health
- Decrease environmental impacts of food waste in landfills
  - Provide farmers with soil amendment at affordable price
  - Turn waste into soil amendment

Increase socio-economic opportunities in Warren County
- Increase soil health for farmers in Warren County
  - Provide support to farmers that is tailored to their needs
  - Show farmers how to create their own soil amendments
- Increase economic development in Warren County
  - Provide support for farmers to create soil amendments
  - Provide support to farmers to create soil amendments

Increase social capital
- Increase local-regional value chains/networks
  - Increase community knowledge of food waste value
  - Increase community leadership
- Increase Warren County's capacity for food recovery
  - Create learning opportunities such as classes, mentorship, and training
- Increase community knowledge of food waste value
  - Provide composting demonstration site where individuals and classes can come to

Figure 15 — Objectives Hierarchy with Fundamental Objectives and Means Network.
V. Recommendations and Expansion Options

Recommendation 1: Pilot Project

We recommend that Working Landscapes begin by implementing a pilot project that allows the client to prototype their compost mix on-site. There are many benefits to piloting the project before committing to costly composting or other value-added infrastructure. A small-scale pilot project is quick to assemble and relatively inexpensive. This allows for staff to receive hands-on training in composting best practices in a manageable way, which will ensure a larger-scale project is easier to implement later on. As Peter Moon from O2 compost says, “you learn about 80% of what you need to know in the first week to 10 days.” As Working Landscapes staff works on the pilot project, a sense of ownership will develop, which will also ensure the success of a larger-scale project in the future. Throughout our conversations with subject-matter experts, the importance of organizational commitment and a sense of ownership throughout the entire company was highlighted on multiple occasions. The composting initiative should feel less like an extra thing to do and more like a fun and important aspect of operations. Additionally, a pilot project will quickly illuminate any logistical constraints for the organization to resolve and demonstrate the logistical possibility of a composting system to stakeholders. A well-run and functional pilot project is critical in establishing confidence with decision-makers, neighbors, grantors, investors, farmers, customers, and everyone involved.

We recommend implementing O2 Compost’s Micro-Bin pilot project system.

These bins are “free-standing boxes that are equipped with a simple pipe-on-grade aeration system. Several design options are included in the training manual that comes with the Micro-Bin kit... [which] can vary in size, but typical[ly] is 4’x4’x4’” (O2 Compost, 2021). For $725 plus shipping, the kit includes an operation manual, an aeration blower that operates on a dial cycle timer, a temperature probe (important for ensuring the compost is reaching the necessary curing temperatures), aeration manifold fittings, and lifetime technical support.

Composting material is placed inside the bin, which will sit uninterrupted, for approximately 21 days until sufficient temperatures have been reached and a final product is generated. The blower, which operates on an automatic timer and will run one minute every twenty minutes, enables this pilot to be very low maintenance.
There is no turning of the material required; therefore, the only labor involved in the pilot project is in initially inputting the material and keeping a log of temperatures and conditions to monitor the product as it chemically breaks down. The bin can sit on bare soil or a concrete slab as infiltration is not a concern with this technique.

These boxes hold approximately 2.5 cubic yards of volume. At Working Landscapes anticipated waste generation rate of 52,000 pounds of food waste per year, assuming a bulk density of 350 pounds/cubic yard, the facility will generate three cubic yards per week of vegetable waste. Bulking agents, or carbonaceous material (typically wood waste), are also required for the organic waste to break down into a finished compost product. Through consultation with O2 Compost, it was determined that a bulking agent approximately double the volume of vegetable waste would be needed to maintain an appropriate carbon to nitrogen ratio. At three cubic yards per week of vegetable waste, therefore, six cubic yards of the bulking agent is required for a total of 9 cubic yards per week. As it takes three weeks to become a finished product, this pilot project system handles 2.5 cubic yards out of a total of 27 cubic yards that are produced every three weeks. The pilot project, therefore, handles approximately 10% of the facility’s total waste generation.

The pilot project is not a long-term solution and will later need to be expanded to handle the total waste generation of the facility as well as later phases of the composting venture when Working Landscapes is able to augment their waste stream with additional organic waste that is received from a partner network. However, it is a critical first step in the overall success of our client’s waste recovery initiative.

**Expansion Options:**

1. **Vendor:** O2 Compost: Compost Systems and Training

![Figure 17 — O2 Compost Design Proposal](image-url)
2. **Vendor:** Green Mountain Technology

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<tbody>
<tr>
<td>Intermodal Earth Flow, 20’ Repurposed Shipping Container</td>
<td>$71,435 – Base price</td>
<td>0.5 tons/day or 1,000 pounds/day and GMT assumes bulk density of 350 pounds/cubic yard is (~2.86 ) cubic yards/day, which is 2.2 times greater than total waste at WL’s anticipated (~1.3 ) cubic yards/day.</td>
<td>Relatively modest footprint. Fully self-contained system. Material takes 21 days to process through the Earth Flow, after which it can be loaded into a pile for final curing of 1-2 months.</td>
</tr>
<tr>
<td>Modified Pre-Engineered ASP Single Zone Option (in 40’ high cube shipping container already onsite)</td>
<td>$1,500 to add aeration to the container, $6,299 for blower and WebMacs technology</td>
<td>Undefined, but on-site shipping container is 40’ so will hold greater volume than the Intermodal Earth Flow</td>
<td>WL would be responsible for supplying piping to convert the container, fittings, drainage, electrical service, and water systems</td>
</tr>
</tbody>
</table>

Table 4 – Expansion options and costs from Green Mountain technology

**The Earth Flow Intermodal**

![Intermodal Earth Flow GMT](image)

*Figure 18 — Intermodal Earth Flow GMT*
Figure 20, below, depicts Green Mountain Technology’s 3-Zone Aerated Static Pile Offering. However, GMT has proposed modifying this design to conform to the unused shipping container already on Working Landscape’s site. Their design would function similarly to what is shown in Figure 20 but would be in a single zone as opposed to three and would sit fully contained inside the shipping container.

ASP system could eventually be retrofitted to provide ambient heating for vermicomposting system (idea mentioned by Tom and confirmed by Peter). Stone Barn Foods Center for Agriculture captures heat using a valve system. Products generated in phase 1 can be given away to WL’s Network of 30 farmers, be used as fundraisers for schools, or sold locally.
**Recommendation 2: Compost Learning Lab & Regenerative Agriculture Education**

In order to increase awareness of regenerative agriculture in the community, we recommend a Compost Learning Lab. The Lab could be modeled after successful examples all over the United States. For more specific information, an excellent resource is Chapter 10 of “The Worm Farmer’s Handbook” by Rhonda Sherman: Vermicomposting Operations Around the World. The closest example (geographically) is the NC State Compost Learning Lab (CL2), which is a, “education, research, and demonstration site in the heart of the 1500-acre Lake Wheeler Road Field Laboratory in Raleigh, North Carolina.” The site contains 26 examples of composting that range from backyard composting to medium-scale operations, plus a 40-feet by 30-feet Worm Barn (NC State Compost Learning Lab). Personal communication with Rhonda Sherman, world-renowned vermicompost expert, encouraged us to consider a similar Compost Lab for Warrenton based on her direct experience with the popularity of worm farming (R. Sherman, personal communication, December 2, 2020).

Services that a Composting Lab could provide include field trip visits for school children, partnerships with local schools and universities, and courses and workshops for extension educators, recycling coordinators, farmers, entrepreneurs, teachers, food service managers, composting facility operators, Master Gardners, general community members, and tourists (NC State Compost Learning Lab). Additionally, the Lab could design longer training courses that offer more information and certifications of completion, ranging from a couple days to a couple weeks. They could also consider Community Workdays; for example, the nearby Duke Campus Farm is able to utilize volunteer labor from the community in exchange for free vegetables and flowers. A Warrenton Compost Lab could have volunteers assist with any number of work tasks and leave home with compost, vermicastings, or worms for their own home operation. ByWay Foods could create a take-home guide to backyard composting and vermicomposting to help volunteers begin the process at home and have the ability to share the resource with colleagues, friends, and family.

Another aspect to consider, although more complex, is the possibility of community composting. This would allow for community members to bring their own home food waste, but it carries the risk of community members bringing items that are not able to be composted, toxic to humans, or toxic to the worms. Even items that can be composted under some conditions, like meats, may carry pathogens that don’t die if the thermophilic composting process is the system is not designed to handle that kind of input. The pilot system we are recommending will allow ByWay Foods to test the right composting recipe for fruit and vegetable waste, so it would need to change semi-dramatically to be able to handle meat and dairy products.

“If you’ve never handled vermicomposting before, it’s very lovely. It’s full of life--it’s black, and well moisturized...but mostly the microbiome is one of its best properties. It just adds so much life to your garden. The worms are fascinating. They’re like, my little buddies. It’s good to know when they are doing well and when they are healthy.” - Tom Smith, Community Vermicomposter
Recommendation 3: Leverage Partnerships

One of the most significant local resources is NC State Cooperative Extension Service. NC State Extension faculty and staff deliver research-based solutions to local issues through programs and partnerships focused on agriculture, food, health, and nutrition. In particular, Rhonda Sherman is a state extension specialist whose areas of expertise include vermicomposting, composting, recycling, and waste reduction. Rhonda is one of the leading experts worldwide on vermicomposting, which makes her an incredible resource for developing vermicomposting systems. She is also the founder and director of the NC State Compost Learning Lab (CL2), which is an education, research, and demonstration site that contains 26 types of backyard composting and vermicomposting units and areas for hands-on training activities (as mentioned above). The Compost Learning Lab is also the site of the NC State Annual Vermicomposting Conference, which Rhonda organizes and is the world’s only annual conference on large-scale commercial vermicomposting. This two-day conference teaches participants how to start or expand an earthworm or vermicompost production facility and covers key issues for vermicomposting operations from earthworm husbandry to feedstocks and equipment to selling products. Given the tremendous value of these resources in North Carolina, Working Landscapes has access to some training and knowledge that will help ensure their success in developing a vermicomposting operation.

In addition to NC State Extension’s composting work, their Warren County Center is another resource with local knowledge. NC State Extension’s mission of educating and bringing science-based solutions to farmers is a natural fit for a partnership with Working Landscapes to promote the application of compost and other regenerative agricultural practices. Our team spoke with Paul McKenzie, an extension agent who promotes home-scale composting in Warren County. By partnering with NC State Extension, Working Landscapes can enhance the impact of the learning lab model of the compost and vermicompost system to help inspire Warren County residents to create their own backyard composting systems.

Similarly, we recommend that Working Landscapes connects with the Soil Health Institute in Morrisville, NC, to help measure soil health outcomes. Measuring carbon benefits and long-term soil health outcomes can be tricky. Notably, Yield is not the most suitable metric for the benefits of increased soil health. Improved soil health means fewer inputs are required and will also increase the health and abundance of crops. Instead, profit (total revenue-expenses) or inputs/yield is a more meaningful metric for gauging long-term benefits of soil health (EIT Food, 2020; LaCanne et al., 2018; Milichuck, 2020). By partnering with The Soil Health Institute, Working Landscapes will receive assistance with determining best practices and data collection for soil health outcomes.

The North Carolina Composting Council, Inc. (NCCC) is a state-level affiliate of the U.S. Composting Council. NCCC is a non-profit, membership-based organization dedicated to the development, expansion, and promotion of the composting industry based upon sound science, principles of sustainability, and economic viability. NCCC has a wealth of informational resources to support composting at all scales, from backyard to industrial. Given NCCC’s mission, the Council would likely be eager to support Working Landscapes’ efforts at establishing a local composting initiative in Warren County.

Another valuable partnership opportunity is with the Institute for Local Self-Reliance’s (ILSR) Composting for Community Initiative. ILSR is a national non-profit research and technical assistance organization that
champions local self-reliance, meaning that local communities and citizens have the authority, capacity, and responsibility to exercise power over their lives. To achieve these goals, ILSR partners with allies across the country to build local power and fight corporate control. Their Composting for Community Initiative works to advance local, neighborhood-scale composting programs that bring benefits to communities, including job creation, climate protection, and waste reduction. This Initiative provides resources to community composters, including training programs, forums and workshops, webinars, and reports. They also convene the Community Composter Coalition, a national network of community composters to share lessons learned and inspire new operations. This Initiative has a wealth of information and resources that can help Working Landscapes as they implement their pilot composting program and connect them to organizations that have developed similar programs. ILSR is another valuable partner whose mission is in alignment with Working Landscapes and can offer them support both by linking them to a larger network of similar institutions across the country as well as knowledge and expertise on building a successful community-scale composting initiative.

<table>
<thead>
<tr>
<th>ORGANIZATION</th>
<th>GENERAL CONTACT INFORMATION</th>
<th>SPECIFIC CONTACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North Carolina Composting Council (NCCC)</strong></td>
<td>Email: <a href="mailto:info@carolinacompost.com">info@carolinacompost.com</a></td>
<td>Gary Gittere, Kate Sullivan, Carl Sigel</td>
</tr>
<tr>
<td><strong>NC State Cooperative Extension Service, Composting</strong></td>
<td>Email: <a href="mailto:extension.ncsu.edu">extension.ncsu.edu</a></td>
<td>Rhonda Sherman</td>
</tr>
<tr>
<td><strong>Soil Health Institute</strong></td>
<td>Phone: (919) 230-0303</td>
<td>N.A.</td>
</tr>
<tr>
<td><strong>NC Cooperative Extension Service, Warren County</strong></td>
<td>Phone: (252) 257-3640</td>
<td>Paul McKenzie</td>
</tr>
<tr>
<td><strong>Institute for Local Self-Reliance (ILSR), Composting for Community Initiative</strong></td>
<td>Email: <a href="mailto:communitycomposting@ilsr.org">communitycomposting@ilsr.org</a></td>
<td>Brenda Platt, Neil Seldman</td>
</tr>
</tbody>
</table>

*Table 5 — Partner Contacts*
VI. Business Plan

Summary

Food Waste Recovery Enterprise Business Plan

ByWay Foods is a mission-driven healthy food enterprise operated by Working Landscapes, a 501c3 nonprofit based in Warren County, NC. At our downtown Warrenton, NC facility, we have produced fresh-cut vegetables for wholesale markets since 2013. We are undertaking an ambitious facility expansion and launching a new brand (ByWay Foods). We will build a financially viable, socially responsible venture that sells $444,000 per year of chopped, washed local produce to twenty or more foodservice customers, representing 240,000 pounds of collards, cabbage, kale, romaine, sweet potatoes, cucumbers, and potentially other products.

The processing and cutting of produce at our facility generate organic waste that, if sent to landfills, will negatively impact the environment by generating methane emissions. We aim to grow a profitable operation that positively contributes to the social, environmental, and economic landscape in the Warren County region. We, therefore, seek to capture and recover the value of organic waste generated at our ByWay Foods facility by generating a soil-amendment product from our organic waste stream. This food waste recovery venture will maximize the social, economic, and environmental value that will result in a compost soil amendment product that is intended to be sold to partner farms and home and garden stores in the region. The creation of a closed-loop model supports Working Landscapes’ overall goals of enhancing sustainable livelihoods, economic opportunities, food security, ecological health, and rural-urban connections in the region.

This business plan contains the following information:

1. Opportunity/problem statement
2. Operations plan
3. Market analysis
4. Funding Plan
5. Outcomes and Theory of Change
6. Measures for Success
This mixed-model compost venture will begin with the most immediate organic food waste stream at the ByWay Foods facility and eventually incorporate other community waste streams, including other sources of food waste (like local restaurants), leaf litter, and eventually, woody debris. Working Landscapes would be filling a gap that currently exists since there are no/few composting facilities and it is difficult to source organic compost in the area; local garden stores sense demand for a local, nutrient-rich compost product.

Opportunity/Problem Statement

Organic waste generated by ByWay Foods’ processing activities is associated with the production of greenhouse gas emissions, a negative externality. Food waste is one of the largest components of landfills in the United States. Warren County, NC, experiences a similar issue of organic waste in its landfills and has set a goal to reduce waste to landfill by 20% by 2022. Working Landscapes seeks to treat this waste problem in its facility and its region as an opportunity by utilizing its waste assets to create a sustainable soil amendment product that will reduce waste, create sustainable livelihoods, and revitalize overworked soils in the Warren County region.

Operations Plan

The table below includes expected costs associated with equipment demands for the pilot project. O2 Compost System’s pilot bin is able to handle 2.5 cubic yards of volume or about one-third of the waste generated on-site per week. The pilot product will need to be tested in a lab so that Working Landscapes is able to accurately market the compost product. Penn State’s College of Agricultural Services offers comprehensive compost product testing for the fee listed below. Finally, it is estimated that the pilot project will require approximately 12 hours per month in additional labor (approximately 1 hour/month to load the initial bin with food and wood scraps, approximately 30 minutes per M-F to check on the compost pile and record temperatures/visual assessments, and an additional 2 hours of training needed to educate staff about the composting system and process). In total, at a rate of $15/hour, it is expected labor demands for the pilot project will be $180/month. This is not expected to increase significantly at later phases of implementation.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>O2 Compost System Pilot Bin</td>
<td>$725.00</td>
</tr>
<tr>
<td>Penn State Compost Testing</td>
<td>$75.00</td>
</tr>
<tr>
<td>Labor (Monthly)</td>
<td>$180.00</td>
</tr>
<tr>
<td>Total</td>
<td>$980.00</td>
</tr>
</tbody>
</table>

Table 6 – Expected operational costs for pilot project
Market Research

Is there an accessible market for ByWay Foods’ final compost amendment product(s)?

In order to understand the demand for the outputs of this proposed mixed-model compost venture, market research was conducted. While ByWay Foods’ 25 tons of food waste will not produce enough compost to address soil health in all of the farmland in Warren County, the revenue generated from sales from the mixed-model compost product in Warren and other counties can go back to the community from the financial support it can offer to Working Landscapes’ other programs.

A variety of industries were researched, including market gardens (small scale, intensive farming that sells directly to consumers in spaces like the Farmer’s Market), as well as home garden stores, flower shops, and houseplant stores. Analyses focused on trends, competitor products, labeling, and buying patterns.

Contacted potential vendors include: Wildwood Nursery & Garden Center (Henrico, NC), Barnes Supply Co. (Durham, NC), Durham Garden Center (Durham, NC), Gunters Greenhouse (Durham, NC), For Garden’s Sake (Durham, NC), Fifth Season Gardening (Carrboro, NC), L R West True Value (Warrenton, NC), Always-In-Bloom
Flowers (Warrenton, NC). Paul McKenzie, Horticulture Extension Agent, provided extremely helpful information on the economic viability of applying a compost amendment product for larger-scale farmers, smaller-scale farmers, market gardeners, gardening stores, and flower vendors. McKenzie recommended piloting compost application with market gardeners, farmers who are supportive of Working Landscapes’ mission, and flower vendors.

Some important takeaways from this first round of market research include that vendors in both areas (Warren area and Triangle area) are attracted to products from local organizations, and competitor products are manure and mushroom compost as well as synthetic fertilizers that often come in a powder or liquid form but don’t persist (in the soil, in a beneficial way) in the environment like compost does.

In the Warren area, a product that contains the term “organic” will be mostly ignored since consumers will assume they’re paying more but not really getting an additional benefit. The 2nd cheapest option or the cheapest option is often the most popular. In the Triangle area, there is more variety; home gardeners in the triangle are more accustomed to expensive soil blends that contain compost and/or worm castings, and are willing to pay for – and understand the benefits of – potting soil blends that contain amendments.

Organizations that create compost products in other parts of the country, have created novel blended products so that consumers get the benefits of vermicompost without the huge price tag. While vermicompost requires more labor and care, the resulting product is super nutrient-rich and valuable. Compost sells for about 13 to 35 dollars per cubic yard, and Vermicompost sells for about 400 to 1300 dollars per cubic yard. Therefore, products can be created for different markets in various sizes (i.e. 5lbs, 10lbs, 20lbs) and various ratios (i.e. 5% vermicompost, 10% vermicompost).

- Industry Viability Summary
  - Commercial Farming – Unlikely
  - Market Farming - Likely
  - Household Farming – Very Likely
  - Commercial Flower Businesses - Likely
  - Houseplant – Very Likely

Funding Plan

Given Working Landscapes’ status as a 501(c)(3) non-profit organization and the overarching goals of this social enterprise to bolster economic opportunity and improve environmental quality in Warren County, Working Landscapes is in an excellent position to apply for grant funding that can assist in providing necessary upfront capital costs to launch these food waste recovery projects. The following is a list of grant funding opportunities that Working Landscapes can apply for in the near term, especially to cover costs of necessary equipment.
<table>
<thead>
<tr>
<th>FUNDER</th>
<th>GRANT</th>
<th>DESCRIPTION</th>
<th>AWARD RANGE</th>
<th>AWARD CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC DEQ Recycling Business Assistance Center (RBAC)</td>
<td>Recycling Business Development Grant</td>
<td>RBAC seeks viable, well-planned proposals from recycling businesses and nonprofit organizations in North Carolina. For the purposes of this grant program, a recycling business is defined as a business or a nonprofit organization that accepts, collects, and/or recycles materials from outside sources to create a value-added feedstock for intermediary processing or end-use recycled product manufacturing. The goal is to build lasting, private-sector capacity to divert materials from the waste stream and create jobs in North Carolina. Grant money is intended to assist with capital costs for physical infrastructure to increase the capacity or improve the efficiency of a recycling operation. Grant money cannot be used to cover land purchases, salaries, labor costs, general operational expenses, marketing, or the cost of contract processing.</td>
<td>Up to $60,000</td>
<td>50% cash match of the requested grant amount</td>
</tr>
<tr>
<td>USDA National Institute for Food and Agriculture (NIFA)</td>
<td>Community Food Projects (CFP) Competitive Grant Program</td>
<td>The purpose of the CFP is to support the development of projects with a one-time infusion of federal dollars to make such projects self-sustaining. Examples of CFP Projects include, but are not limited to, community gardens with market stands, value chain projects, food hubs, farmers’ markets, farm-to-institutions projects, and marketing &amp; consumer cooperatives. All projects must involve low-income participants.</td>
<td>Not to exceed $125,000 in a single year or $400,000 over four years</td>
<td>100%</td>
</tr>
<tr>
<td>USDA National Institute for Food and Agriculture (NIFA)</td>
<td>Agriculture and Food Research Initiative (AFRI) Competitive Grants Program--Sustainable Agricultural Systems (A9211)</td>
<td>Seeks creative and visionary applications that take a systems approach for projects focused on the following themes: (1) sustainable agricultural intensification; (2) agricultural climate adaptation; (3) value-added innovation; and/or (4) food and nutrition translation. These projects are expected to significantly improve the supply of affordable, safe, nutritious, and accessible agricultural products, while fostering economic development and rural prosperity in America. Outcomes of the</td>
<td>$1,000,000 - $10,000,000</td>
<td>Letter of Intent deadline: January; Application deadline: April</td>
</tr>
</tbody>
</table>
work being proposed should result in societal benefits, including promotion of rural prosperity and enhancement of quality of life for all those involved in food and agricultural value chains from production to utilization and consumption.

| North Carolina Composting Council (NCCC) | Strategic grants | NCCC is proud to support the efforts of other non-profit groups working toward keeping organic materials out of the waste stream and developing composting programs. To that end, the NCCC gives strategic grants in varying increments upon request. | Varying amounts | -- |

*Table 7 – Grant funding opportunities*
### BYWAY FOODS SOIL AMENDMENT SOCIAL ENTERPRISE VENTURE LOGIC MODEL

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
<th>Outcomes</th>
<th>Long-term: Impact/Change in Condition</th>
</tr>
</thead>
</table>
| Money  | Production of value-added soil amendment products | Interest in value creation from organic waste increases | Norms and Social Capital  
Warren County's economy is more circular, bolstered by jobs and value created from organic waste, creating a skilled workforce and value chain connections between regions  
Increased capacity and self-reliance of region to use organic waste as an asset shown by other social enterprise businesses establishing  
Regional policy and governance encourages and supports waste aversion |
| Federal Funding, State Funding, Grants, Private Funding, Donations, Staff capacity and knowledge, Food recovery manager, Volunteers, Interns, Partnerships, Local Institutions, Duke University MEM students, Farmers, contractors, and community stakeholders, Facilities.  
~2 acres of land in downtown Warrenton with old cotton gin  
Land on personal and partner farms  
Organic waste, Energy for operations, equipment | Small/mid-scale farmers, Supply chain stakeholders such as local and regional garden stores, restaurants, and business owners, Community institutional cafeterias such as schools and senior homes, Local and regional K-12 students, Community members, staff, regional NGOs, and food recovery stakeholders  
Job and value-chain creation leadership through training and mentorship, Advances in food recovery research and policy | Direct Behavior Change/Actions  
Warren County understands effects and values of food waste, they take measures to reduce or reuse it where possible and shape regional food recovery initiatives  
Regional institutional cafeterias and independent contractors divert organic waste (food and woody debris) divert waste from landfills  
Farmers produce and apply soil amendment or other regenerative practice  
Indirect Behavior/Spillover  
Excited students take knowledge home, some encourage their household to adopt practices while others apply knowledge and interest later on | Direct Ecological impacts  
Waste has been consistently diverted from landfill in Warren County and regenerative practices applied, significantly lessening climate footprint and improving water/air quality  
Farmers' livelihoods are improved by increased soil productivity, lessening the amount of inputs needed and creating healthier ecosystems |
| Situation Statement | Warren County sees food waste as an asset to community development; community has the capacity and self-reliance to expand and circular economy practices, improving quality, soil health, and climate footprint. Working Warren County is a regional leader in creating value chains from food waste, consulting on several other local food waste recovery initiatives. |

*Figure 22 — Logic Model, adapted from Evaluating Your Environmental Education Programs, Chapter 2 by Ernst, et al. Outcomes adapted from Krasny, 2020; Eversole and Luke, 2014.*
The 25 tons of food scraps that By Way Foods is projected to generate per year can become an asset to community development. Working Landscapes' goal is to maximize the value from ByWay Foods' waste stream, using it to create a circular food economy in Warren County and the surrounding region. Using food waste recovery as a vehicle to create value chains, Working Landscapes envisions a future where the region has the capacity to lead regional initiatives. In doing so, the region will improve its soil health, climate footprint, and community self-reliance. To achieve these outcomes, ByWay Foods will produce and provide soil amendments and their services to community members and farmers and offer educational programs to partners, farmers, k-12 students, and community members.

Working Landscapes' vision for a healthier ecosystem and community is outlined above in a logic model. To uphold accountability for the desired outcomes, Working Landscapes should establish an evaluation plan.

**Measures for Success**

The table below summarizes a recommended data collection plan. This plan's scope covers top priority evaluation questions based on values articulated by Working Landscapes in the Objectives hierarchy. This plan covers five questions that focus on farmers, partners, and community members. The evaluation questions are:

1. In what ways are farmers improving soil health in Warren County as a result of our intervention?
2. How has soil health improved for farmers as a result of our intervention?
3. How does this program influence community knowledge, attitude, and awareness of food waste and its connection to climate?
4. Has the amount of greenhouse gas emissions decreased from landfills as a result of our intervention?
5. How is network/value chain creation serving our community as a result of our intervention?
6. Has Warren County's Capacity for Food recovery leadership increased as a result of our intervention?
7. Who are we serving?

The main questions are broken down into sub-questions that portray different ways to measure intervention outputs and their expressed outcomes. Some longer-term outcomes are harder to measure, so we recommend measuring more immediate outcomes or use a proxy such as specific outputs.

Working landscapes is specifically interested in measuring soil health and carbon benefits. Notably, Yield is not the most suitable metric for the benefits of increased soil health. Improved soil health means fewer inputs are required and will also increase the health and abundance of crops. Instead, profit, total revenue-expenses, is a more meaningful metric for gauging long-term benefits of soil health. Additionally, one of the most important outcomes to Working Landscapes is Network and Value chain creation. To measure this outcome, Working Landscapes could create a partner survey. To create this survey, Working Landscapes should interview partners and mentees to understand where they are establishing relationships related to food waste recovery and soil amendments. If there are geographical or industry-related patterns, a yearly survey could then be created with these results. Either way, the goal would be to visualize the established community networks.
### Evaluation Question 1: In what ways are farmers improving soil health in Warren County?

<table>
<thead>
<tr>
<th>1.1 Outcome: To what extent are farmers using soil amendments?</th>
<th># of acres of farm that soil amendments are applied</th>
<th>Self-report survey or interview</th>
<th>Post-intervention (either giving amendments or taking workshop)</th>
<th>Short term outcome (In line with SDG indicator 2.4.1, see appendix B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 Outcome: Do farmers believe they will implement regenerative practices after workshop/training?</td>
<td>Likert scale 1 being &quot;probably not&quot; to 5 being &quot;yes I intend to&quot;</td>
<td>Self-report survey</td>
<td>Post-program intervention</td>
<td>Intermediate outcome (In line with SDG indicator 2.4.1, see appendix B)</td>
</tr>
</tbody>
</table>

### Evaluation Question 2: How has soil health improved for farmers?

<table>
<thead>
<tr>
<th>2.1 Outcome: How has soil organic matter and soil horizons improved on farms?</th>
<th>Presence of soil layers</th>
<th>Soil survey</th>
<th>Pre and post-intervention/ comparative to other farms not using soil amendments/ regenerative practices</th>
<th>This is a long-term outcome; it will be important to establish a plan to measure this early on. Consider working with local researchers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2 Outcome: How have carbon sequestration abilities improved on farms?</td>
<td>Amount of carbon sequestered per year as a result of healthy soils</td>
<td>Calculation/ estimation of soil abilities</td>
<td>Pre and post-intervention/ comparative to other farms not using soil amendments/ regenerative practices</td>
<td>This is a long-term outcome; it will be important to establish a plan to measure this early on. Consider working with local researchers.</td>
</tr>
<tr>
<td>2.3 Outcome: How has farmer profit improved as a result of soil health?</td>
<td>% increase since intervention (implemented over several years)</td>
<td>Self-report or interview</td>
<td>Pre and post-intervention/ comparison to other farms not using soil amendments/ regenerative practices</td>
<td>This is a long-term outcome; it will be important to establish a plan to measure this early on. (In line with SDG indicator 2.3.1)</td>
</tr>
</tbody>
</table>

### Evaluation Question 3: In what ways does this program influence community knowledge, attitude, and awareness of food waste and its connection to climate?
### Evaluation Question 4: Has the amount of greenhouse gas emissions decreased from landfills as a result of composting food scraps/waste?

<table>
<thead>
<tr>
<th>4.1 Output: What quantity of soil amendment are we generating?</th>
<th>Amount of soil amendment in tons or volume</th>
<th>Audit</th>
<th>Yearly</th>
<th>If partners or farmers are also generating soil amendments, it would also be valuable to extend a survey out to the community to include their numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2 Output: What amount of food waste are we diverting?</td>
<td>Amount of food recovered in tons or volume</td>
<td>Audit</td>
<td>Yearly</td>
<td>(In line with SDG indicator 11.6.1, see appendix B)</td>
</tr>
<tr>
<td>4.3 Outcome: How much GHG emissions are we diverting?</td>
<td>Amount in tons or convert to the tangible amount (equivalent to X amount of cars)</td>
<td>Calculation based on food diversion</td>
<td>Yearly</td>
<td>Long-term; Unless you are working with a research organization, this could be tricky. While an important metric, it may be too difficult to know exactly how much GHGs are diverted. How important is it to get the exact number? Could you use a</td>
</tr>
<tr>
<td>Evaluation Question 5: How is network/value chain creation serving our community?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5.1 Output:</strong> How many institutions are we working with to reduce food waste?</td>
<td>% break down of product distribution by receiver category</td>
<td>Internal documentation audit</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td><strong>5.2 Output:</strong> How many entities are receiving our products?</td>
<td>% break down of product distribution by receiver category</td>
<td>Internal documentation audit</td>
<td>Yearly</td>
<td>It would also be valuable to track where partner soil amendments are going in a partner survey</td>
</tr>
<tr>
<td><strong>5.3 Output:</strong> How many partnerships have we established?</td>
<td># of partners</td>
<td>Internal documentation audit</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td><strong>5.4 Output:</strong> Where are our partners and products located?</td>
<td>Locations on a map</td>
<td>Partner survey</td>
<td>Yearly</td>
<td>Great opportunity for an intern to do a community network mapping exercise</td>
</tr>
<tr>
<td><strong>5.5 Outcome:</strong> In what ways are our partners benefiting from value chain creation?</td>
<td>Open-ended self-report</td>
<td>Interviews or focus groups</td>
<td>Yearly</td>
<td>Interview data would need to be coded for common themes</td>
</tr>
<tr>
<td><strong>5.6 Outcome:</strong> How many roles have been created dealing with food waste recovery in Warren County or with partner organizations?</td>
<td># of x,y,z roles</td>
<td>Partner survey</td>
<td>Yearly</td>
<td>(In line with SDG indicator 8.3.1, see appendix B)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation Question 6: Has Warren County’s Capacity for Food recovery leadership increased? (These can also be measured using Evaluation Questions 3 and 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6.1 Outcome:</strong> To what extent do students believe they will participate in food recovery initiatives in the future?</td>
</tr>
<tr>
<td>Evaluation Question 7: Who are we serving?</td>
</tr>
<tr>
<td>7.2 Output: How many farmers are receiving our soil amendments?</td>
</tr>
<tr>
<td>7.3 Output: How many school groups/children are visiting to learn about composting?</td>
</tr>
<tr>
<td>7.4 Output: How many mentee/mentor relationships have we established (and who are they)?</td>
</tr>
<tr>
<td>7.5 Output: How many interns or student partners have gained food waste recovery and value chain job training?</td>
</tr>
</tbody>
</table>

Table 8 – Data collection plan
VII. Opportunities and Considerations for Scaling

According to the Warren County Solid Waste Management Report, the majority of Warren County’s solid waste is residential at 79%, followed by non-residential at 17%, only 1% is from land clearings or inert debris (such as yard waste, branches, and stumps), the last 3% is from construction. The plan also notes that there is an unknown amount of land clearing and inert debris disposed of at privately owned sites, which we talk about more in the biochar section below. Food waste is not separated from organic matter in the plan, and the amounts of organic waste are not specified; however, the plan mentions that organic matter is one of the most prevalent sources of solid waste in Warren County. In the future, it will be necessary to consider how ByWay Foods wants to expand beyond Phase 1 (addressing their immediate food scraps/waste stream) to maximize community food recovery. Essentially, scaling could take two main forms, each with its own pros and cons to consider.

1. The first option would be to expand internal composting operations to take in community waste. According to the 2017 NRDC report, “Restaurants and Institutional food service providers together generate approximately two to four times the waste of grocery stores, retail supercenters, and wholesale distributors combined.” By functioning as a central hub for food recovery, ByWay Foods would be able to produce large quantities of soil amendments that could be given or sold to the community. It is more likely that revenue would be generated in this manner. Additionally, a closed-loop soil amendment delivery service could be established for farmers in exchange for organic waste. Establishing this service would require partnerships with local haulers to transport organic waste. However, by taking in community waste, ByWay Foods introduces many layers of complexity, requiring considerations such as handling pathogens and state permitting. Even after expansion, it may not be feasible to give farmers enough soil amendments for their needs. To bypass this challenge, it would be important to begin working with a couple of small farmers to establish a working closed-loop system. Overall, the internal composting approach could more directly impact value chains and increase jobs. Additionally, it would be easier to ensure service outcomes as well as to measure food recovery impact.

2. The second option would be to expand the compost learning lab initiatives. Expansion of the learning lab would entail teaching farmers/institutions how to produce their own amendment, enabling self-sufficiency and furthering leadership potential. To reach more farmers, it is first necessary to gauge their needs then provide relevant services such as compost and regenerative practice training. Small biochar kilns can even be mobilized. Additionally, organizations such as Common Compost, mentioned above, have constructed a business model that employs vermicompost housing sites. This innovative method establishes partnerships between the food hub and community organizations/institutions that agree to house a modular vermicompost unit that they feed their food waste to. The host would then pick up the castings. Housing sites offer a unique way to avoid collecting organic waste at a central hub while also providing a learning opportunity for the community. Overall, this option is more in line with ByWay Food’s values to increase community capacity to lead food recovery initiatives. Additionally, there is
potential to have a greater impact on farmers when using the learning labs as a vehicle for creating solutions to address deeper-rooted issues to improving their soil health. However, this approach will require intentional evaluation efforts to ensure that community-wide knowledge and behaviors are being positively influenced.

The option chosen will likely be a combination of both approaches so that expansion is feasible and done in such a way that works with the strongest community partnerships. The final expansion consideration is how a biochar facility would fit into either approach.

**Preliminary Biochar Assessment**

Biochar is also a factor that should be considered in expansion, but it is slightly separate from food waste recovery. Our recommendation for biochar is encapsulated in this quote from Tom Miles, director of the US Biochar Initiative:

> “And if you’re going to get into making biochar, either you’re going to have a relationship with somebody who is already using biochar and takes in the product and gives you enough money wholesale to make it worth your while, or you have to have somebody in your staff that becomes an expert on biochar production and marketing so you can create those markets you didn’t have connections with previously.” - Tom Miles (All About Biochar, 2019)

While food waste can be pyrolyzed, creating high-quality biochar products is a complicated science, requiring an exact formula and predictable feedstocks. If created correctly, biochar can be a unique soil amendment, offering lasting benefits that are not attainable through compost alone (J. Lehmann, personal communication, March 5, 2021). Additionally, there would be an opportunity to incorporate workshops into the Community Compost Lab because farmers could make their own biochar using small kilns. Once Working Landscapes acquires additional land, this would be a great opportunity to provide a space for contractors to donate their wood waste. However, the quality of biochar can still vary unless a specific formula is established. On top of that, processing wood and biochar creates significant fire hazards if not done correctly (P. Mitchell, personal communication, April 2, 2021). There is potential to establish a community biochar facility that could pyrolyze large quantities of food waste and woody debris, but it would be imperative to have expert guidance and facilitation.

We recommend that biochar is incorporated as a complimentary service after ByWay Foods has addressed on-site waste using compost for several reasons. Firstly, creating value from the organic waste stream coming from Byway Foods operations is the greatest priority. This waste stream consists of a marginal amount of vegetable cuttings (25 tons of waste per year). Our research has shown that only small-scale operations are possible with the current amount of waste, which favors composting operations as they require minimal investments, equipment, and no permitting. In contrast, biochar operations have steep learning curves, costly equipment and
transportation, and fire hazard risks. Vegetable matter is also better suited for compost because more nutrients are retained. As indicated previously, biochar is predominantly created using woody biomass.

However, our conversation with Michael Wollett, a local contractor, revealed that there is a significant source of untapped woody debris in Warren and neighboring counties. Michael informed us that contractors like himself who clear and grade wooded lots for construction must pay to haul the woody debris offsite. While any marketable trees are sent to a local sawmill, most of the woody debris must be disposed of at sites known as “stump dumps,” while the regulatory term for these sites is Land Clearing and Inert Debris (LCID) sites. There are only a small number of stump dump sites within the Warren County area, and they charge contractors a fee per load to dispose of the woody waste (M. Wollett, personal communication, February 11, 2021). The map below, generated from the NC DEQ website, shows the locations of registered LCID sites in Warren County (indicated by the blue diamonds), which likely include some of the “stump dump” sites that contractors utilize to dispose of their woody debris. It is worth noting that the site in Warrenton is part of Warren County Transfer Station which accepts many kinds of waste in addition to woody debris and charges a tipping fee per ton of waste (unlike the stump dumps, which charge per load).

![Map of Land Clearing and Inert Debris (LCID) sites in Warren County and the surrounding region](image_url)
The total amount of woody debris collected by these sites is unknown, as noted in the Warren County Solid Waste Management Plan (Warren County Solid Waste Management Plan, 2011). However, many tons of woody biomass might be available. Michael estimated that there are approximately seven out of ten contractors in the area who currently must pay to deposit woody debris at dump stump sites (the other two or three contractors operate their own dump sites). Michael approximated that he hauls off waste from about one large clearing job per month, which yields about 30 dump truckloads, with each truck load carrying 10-12 tons. Other larger contractors in the area might complete a job of that size every week. Based on this available information, there are significant quantities of woody debris that could be captured, and that local contractors would benefit from having an alternative to paying these stump dump sites to dispose of their woody biomass. This represents an opportunity to utilize the woody debris for a more useful purpose, such as creating wood chips, mulch, or biochar compared to how they are disposed of now—at the LCID sites, the woody waste is simply required to be covered with dirt (M. Wollett, personal communication, February 11, 2021).

With the additional source of woody debris available in the community, there is certainly value, both economic and environmental, in installing a biochar operation once ByWay Foods has addressed their vegetable scraps. By doing this, biochar can be offered as a complimentary service, creating a source of carbonaceous material for the compost (by sharing processed feedstock) and an economic opportunity to combine compost and biochar as a product. Notably, biochar application is most beneficial when mixed with compost. Application without compost can result in negative short-term impacts (Jamieson, 2013).

“Biochar itself does not provide nutrition or moisture. But it has all this ability to adsorb – or take up – other substances. So you could say it needs to be charged up with these substances first. When you mix organic matter like compost with biochar, you’re charging the biochar with nutrients and water. It can then make them available to plants.”-Dr. Kelby Fite (Jamieson, 2013)

Additional benefits from combining compost and biochar include easier transportation and application and mitigation of fire hazards. It should be noted that biochar is an expensive endeavor and likely could not be sustained by giving the amendment away. However, there is a potentially diverse market for its wide uses, including landscape companies and city governments (C. Sigel, personal communication, November 6, 2020).

A final reason to consider combining a compost and biochar operation is that research has shown that compost worm species are attracted to char particles that result from fires, particularly in the Amazon; biochar composting could be conducted in the future by Working Landscapes.

The famous Amazonian Terra Preta soils are exceptionally fertile, hypothesized to be so because of the combinatory power of the biochar and the worm castings that result from biochar consumption (Biochar Vermicompost). This blended product that results is called biochar vermicompost (not to be confused with a soil amendment that includes biochar and vermicompost made in separate spaces). Experiments in biochar composting with the composting worms most commonly used in the northern hemisphere, Eisenia fetida, show that compost worms preferentially consume biochar, feeding the worms a blend including 8% biochar leads to
the production of 66% more cocoons (Biochar Vermicompost). The end-product is not only produced more quickly because of the high production of the worms, but it also creates a more efficient system and more fertile end-product because of the high available mineral nutrients in biochar.

Research on biochar vermicompost additionally shows that the process decreases the heavy metal content in vermicompost (Khan et al., 2019). Much remains to be studied, however, including the ideal proportion of biochar for biochar vermicompost, ideal worm population density, pH, and moisture content (Weyers and Spokas, 2011). Even if biochar vermicompost is not conducted, the addition of biochar and vermicompost in agricultural beds still have synergistic effects that increase soil health, increase crop production, and decrease pollution emissions (Wu et al., 2019).

**VIII. Conclusion**

ByWay Foods anticipates that their expansion will be completed and that the food processing hub will begin operating again in June of this year. The research, analysis, and business plan provided by this Master’s Project will equip ByWay Foods with the tools they need to begin implementing our recommended mixed ASP composting and vermicomposting model. Beginning with a pilot program requires a small investment and gives Working Landscapes the ability to experiment and develop expertise in their composting management skills and protocols. This will set them up for future success as they scale up their enterprise to incorporate more food scraps and other sources of organic waste.

The immediate impact of this Master’s Project is that Working Landscapes will be able to divert their food scraps from the landfill and develop a valuable soil amendment product that will provide a suite of environmental, social, and economic benefits. Ultimately, this project aims to serve the local communities in Warren County. Working Landscapes will accomplish this by creating jobs and training their employees in composting skills, as well as partnering with local farmers and growers who can trial their compost product.

In the longer term, we expect this initiative to grow into a thriving community-scale composting and vermicomposting enterprise that will serve as a model for how communities can utilize food waste as an asset to enhance local environmental quality and socioeconomic opportunity. This initiative is one important step towards realizing a circular food economy in Warren County, regenerating soil health, and positioning Warren County as a leader for resource reuse and innovation.
## IX. Appendices

### Appendix A: Contact Information

<table>
<thead>
<tr>
<th>NAME</th>
<th>ORGANIZATION</th>
<th>TITLE</th>
<th>AREA OF KNOWLEDGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carl Sigel</td>
<td>Oil, climate change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daniel Richter</td>
<td>Duke University</td>
<td>Professor of Soils and Forest Ecology</td>
<td>Soil</td>
</tr>
<tr>
<td>Neil Seldman</td>
<td>Institute for Local Self-Reliance</td>
<td>Director, Waste to Wealth Initiative</td>
<td>Small business, waste aversion, value chains</td>
</tr>
<tr>
<td>Emily Burnette</td>
<td>NCDEQ, Organics Recycling</td>
<td></td>
<td>Compost, policy, permitting</td>
</tr>
<tr>
<td>Garry Gittere</td>
<td>McGill Compost</td>
<td>Sales and Marketing</td>
<td>Compost, farmers, business</td>
</tr>
<tr>
<td>Brenda Platt</td>
<td>Institute for Local Self-Reliance</td>
<td>Director, Composting for Community Project</td>
<td></td>
</tr>
<tr>
<td>Kate Sullivan</td>
<td>McGill Compost</td>
<td>Project Manager</td>
<td>Compost, equipment</td>
</tr>
<tr>
<td>Joshua Humphreys</td>
<td>Croatan Institute</td>
<td>President and Senior Fellow</td>
<td>Value chains/supply chains and biochar</td>
</tr>
<tr>
<td>Rhonda Sherman</td>
<td>NC State Extension</td>
<td>Extension Specialist in the Department of Horticultural Science</td>
<td>Vermicompost, compost, recycling, and waste reduction</td>
</tr>
<tr>
<td>Erin White</td>
<td>Community Food Labs</td>
<td>Director/Founder</td>
<td>Design thinking, food systems</td>
</tr>
<tr>
<td>Jacob Hannah</td>
<td>Reuse Corridor, Coalfield Development</td>
<td></td>
<td>Woody debris, composting initiatives, reuse corridor</td>
</tr>
<tr>
<td>Bethany Cartledge</td>
<td>St. Vincent de Paul</td>
<td>Economic &amp; Development Director</td>
<td></td>
</tr>
<tr>
<td>Amy Parsons-White</td>
<td>Marshall University</td>
<td>Sustainability Manager</td>
<td></td>
</tr>
<tr>
<td>Deborah Gallagher</td>
<td>Duke University</td>
<td>Professor</td>
<td>Business plans</td>
</tr>
<tr>
<td>Michael Wollett</td>
<td></td>
<td>Landscaper</td>
<td>Woody debris</td>
</tr>
<tr>
<td>Grant Murray</td>
<td>Duke University Marine Lab</td>
<td>Professor</td>
<td>Interviews, ethnography, CBEM</td>
</tr>
<tr>
<td>Betsy Albright</td>
<td>Nicholas School</td>
<td>Chair, Environmental Economics &amp; Policy Program</td>
<td>Value-based decision making, objectives hierarchies</td>
</tr>
<tr>
<td>Paul Mckenzie</td>
<td>NC State Extension</td>
<td>County Extension Agent</td>
<td>Home scale composting</td>
</tr>
<tr>
<td>Peter Moon</td>
<td>O2 Compost</td>
<td>Environmental Consultant</td>
<td>Compost</td>
</tr>
<tr>
<td>Tom Smith</td>
<td></td>
<td>Community Vermicomposter</td>
<td>Vermicompost, community</td>
</tr>
<tr>
<td>Joahannes Lehmann</td>
<td>Cornell University</td>
<td>Professor</td>
<td>Biochar</td>
</tr>
<tr>
<td>Bethany Cartledge &amp; Laura Bennett</td>
<td>St. Vincent de Paul / Cascade Alliance</td>
<td>Economic &amp; Development Director</td>
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*Table 5 – List of Interviewees*
**Appendix B: Sustainable Development Goals**

### RELEVANT U.N. SUSTAINABLE DEVELOPMENT GOALS, TARGETS, AND INDICATORS

#### SUSTAINABLE DEVELOPMENT GOAL 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

The **UN explains**: "It is time to rethink how we grow, share and consume our food. If done right, agriculture, forestry and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centred rural development and protecting the environment. Right now, our soils, freshwater, oceans, forests and biodiversity are being rapidly degraded. Climate change is putting even more pressure on the resources we depend on, increasing risks associated with disasters such as droughts and floods. Many rural women and men can no longer make ends meet on their land, forcing them to migrate to cities in search of opportunities. A profound change of the global food and agriculture system is needed if we are to nourish today’s 815 million hungry and the additional 2 billion people expected by 2050. The food and agriculture sector offers key solutions for development, and is central for hunger and poverty eradication."

<table>
<thead>
<tr>
<th><strong>Target 2.3:</strong> Double the productivity and incomes of small-scale food producers</th>
<th><strong>SDG INDICATOR 2.3.1:</strong> Production per labour unit</th>
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<tbody>
<tr>
<td>UN definition: By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.</td>
<td><strong>Definition:</strong> Indicator 2.3.1 is the volume of production per labour unit by classes of farming/pastoral/forestry enterprise size.</td>
</tr>
</tbody>
</table>

| **Target 2.4:** Sustainable food production and resilient agricultural practices |
|---|---|
| UN definition: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality. | **SDG INDICATOR 2.4.1** Sustainable food production |
| **Definition:** Indicator 2.4.1 is the proportion of agricultural area under productive and sustainable agriculture. |

#### SUSTAINABLE DEVELOPMENT GOAL 8: Promote inclusive and sustainable economic growth, employment and decent work for all

The **UN explains**: Roughly half the world’s population still lives on the equivalent of about US$2 a day. And in too many places, having a job doesn’t guarantee the ability to escape from poverty. This slow and uneven progress requires us to rethink and retool our economic and social policies aimed at eradicating poverty.

<table>
<thead>
<tr>
<th><strong>Target 8.3:</strong> Promote policies to support job creation and growing enterprises</th>
<th><strong>SDG INDICATOR 8.3.1</strong> Informal employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN definition: Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.</td>
<td><strong>Definition:</strong> Indicator 8.3.1 is the proportion of informal employment in non-agriculture employment, by sex. This is measured as employment in the informal economy as a percentage of total non-agricultural employment. This includes all jobs in unregistered and/or small-scale private unincorporated enterprises that produce goods or services meant for sale or barter.</td>
</tr>
</tbody>
</table>
Target 8.4: Improve resource efficiency in consumption and production
UN definition: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead.

Target 8.5: Full employment and decent work with equal pay
UN definition: By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.

Target 8.6: Promote youth employment, education and training
UN definition: By 2020, substantially reduce the proportion of youth not in employment, education or training.

SUSTAINABLE DEVELOPMENT GOAL 11: Make cities inclusive, safe, resilient and sustainable
The UN explains: The challenges cities face can be overcome in ways that allow them to continue to thrive and grow, while improving resource use and reducing pollution and poverty. The future we want includes cities of opportunities for all, with access to basic services, energy, housing, transportation and more.

Target 11.6: Reduce the environmental impacts of cities

SDG INDICATOR 8.4.1
Material footprint
Definition: Indicator 8.4.1 is material footprint, material footprint per capita, and material footprint per GDP. Material Footprint (MF) is the attribution of global material extraction to domestic final demand of a country. The total material footprint is the sum of the material footprint for biomass, fossil fuels, metal ores and non-metal ores.

SDG INDICATOR 8.5.1
Hourly earnings
Definition: Indicator 8.5.1 is the average hourly earnings of female and male employees, by occupation, age and persons with disabilities.

SDG INDICATOR 8.5.2
Hourly earnings
Definition: Indicator 8.5.2 is the unemployment rate, by sex, age and persons with disabilities.

SDG INDICATOR 8.6.1
Youth employment, education and training
Definition: Indicator 8.6.1 is the proportion of youth (aged 15–24 years) not in education, employment or training.

SDG INDICATOR 11.6.1
Solid waste management
Definition: Indicator 11.6.1 is the proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities. This indicator measures the share of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated. Data is only available at the regional (not national) level.

SDG INDICATOR 11.6.2
Urban air pollution
Definition: Indicator 11.6.2 is the annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted). This indicator measures the population-weighted exposure to ambient PM2.5 pollution; that is, concentrations of suspended particles measuring less than 2.5 microns in diameter.
### SUSTAINABLE DEVELOPMENT GOAL 12: Ensure sustainable consumption and production patterns

The UN explains: Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty.

| Target 12.3: Halve global per capita food waste | SDG INDICATOR 12.3.1  
Global food loss  
Definition: Indicator 12.3.1 is the global food loss index. |
| UN definition: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses. |

| Target 12.5: Substantially reduce waste generation | SDG INDICATOR 12.5.1  
National Recycling Rate  
Definition: Indicator 12.5.1 is the national recycling rate, tons of material recycled. Limited data is available for recycling rates globally. Data on quantities of recycled municipal waste are available for OECD countries. This is shown here in absolute terms (the quantity of municipal waste recycled, measured in tonnes per year) and recycling rates, which measure the percentage of total waste generated that is recycled. |
| UN definition: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse. |

| Target 12.8: Promote universal understanding of sustainable lifestyles | SDG INDICATOR 12.8.1  
Understanding of sustainable lifestyles  
Definition: Indicator 12.8.1 is the Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are mainstreamed. |
| UN definition: By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature. |

### SUSTAINABLE DEVELOPMENT GOAL 13: Take urgent action to combat climate change and its impacts

The UN explains: Affordable, scalable solutions are now available to enable countries to leapfrog to cleaner, more resilient economies. The pace of change is quickening as more people are turning to renewable energy and a range of other measures that will reduce emissions and increase adaptation efforts.

| Target 13.3: Build knowledge and capacity to meet climate change | SDG INDICATOR 13.3.1  
Education on climate change  
Definition: Indicator 13.3.1 is the number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula. |
| UN definition: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. |

Adapted from the United Nations Sustainable Development Goals retrieved from https://sdgs.un.org/goals

*Table 6 – UN Sustainable Development Goal Targets and Indicators*
Appendix C: Porter’s Forces

*Porter’s Five Forces:* Our team used the Porter’s Five Forces model to examine potential market competition for a soil amendment product. The Five Forces model is an analysis tool developed by Michael Porter that is frequently used to understand how five key forces affect the structure and competitiveness of an industry and inform corporate strategy; the five forces are 1) Threat of new entrants, 2) Bargaining power of suppliers, 3) Bargaining power of buyers, 4) Threat of substitutes, and 5) Rivalry among existing competitors (Porter, 2008). We used the information we identified in each of the Porter’s Forces categories to formulate some of the recommended strategies in the TOWS analysis and the business plan.

<table>
<thead>
<tr>
<th>PORTER’S FORCES</th>
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| **Threat of New Entrance** | -Large biogas operations are frequently established in rural areas with CAFO operations which provide a means to take care of large quantitates of manure  
-Once partnerships are established with farmers and local institutional cafeterias, threat of entrance is low for the county  
-Gardening stores sell a variety of compost products |
| **Customer Bargaining Power** | -Farmers will only pay a small fee for soil amendments  
-Products labeled as organic in gardening stores can be seen as too expensive |
| **Competitive Rivalry** | -CharGrow Biochar in Raleigh, Chapel Hill, and Greensboro  
-No organic waste composting facilities in a 50-mile radius (Closest is Durham Compost Facility) |
| **Supplier Bargaining Power** | Food waste from partners – x amount institutional cafeterias that ByWay Foods partners with, x restaurants in the area  
- Institutional cafeterias can simply throw away organic material instead of partnering with WL to provide waste stream  
- There is currently no legislation banning food waste from landfills in NC  
- Farmers could want the food scraps to feed to livestock  
Woody debris – 10 contractors in the area  
- Contractors can pay Dump Stumps to take their debris  
- Contractors can get paid by logging companies to give them their large stumps,  
- Some contractors have their own grinder or chipper to take care of debris, they can then give away or sell mulch  
Produce (Ability of ByWay Foods to supply their own organic waste) – estimated 50 tons of produce scraps per year  
- Farmers that supply vegetables and produce could have a bad season and not be able to supply a steady amount  
Misc.  
- Warren County does not have an operational incinerator |
| **Threat of Substitute products** | -Farmers can and some currently do use manure or a mix of chicken litter and mulch to add nutrients to their soils. |
| **Opportunity for Complementary products/services** | -Compost + biochar mixed product  
-Learning Lab for regional k-12 schools  
-Close-looped soil amendment service for farmers that supply produce  
-Organic Waste pick up at drop off locations |

*Table 7 – Porter’s Competitive Forces*
Appendix D: Supplementary Figures and Tables

Figure 24 — Reasons and logic behind food systems failure retrieved from Chodur et al., 2018.
**Figure 1.** Ten factors identified through semi-structured interviews with food system stakeholders in Baltimore, MD, that may affect food system organizational resilience, mapped along the resilience curve.

**Figure 25 —** Factors contributing to an organization’s food system resilience pre, during, and post-disturbance, retrieved from (Hecht et al., 2018).
Figure 26 — Relationship between reducing food waste and food system resilience. Arrows representing linkages between the two theories of change retrieved from Bajželj et al., 2020.
## Warren County, North Carolina (NC185)

<table>
<thead>
<tr>
<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
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<tbody>
<tr>
<td>AaA</td>
<td>Altavista fine sandy loam, 0 to 3 percent slopes, rarely flooded</td>
<td>79.5</td>
<td>0.1%</td>
</tr>
<tr>
<td>AnB</td>
<td>Appling sandy loam, 2 to 6 percent slopes</td>
<td>4,012.4</td>
<td>7.0%</td>
</tr>
<tr>
<td>ApB</td>
<td>Appling sandy loam, 2 to 8 percent slopes</td>
<td>3,369.5</td>
<td>5.9%</td>
</tr>
<tr>
<td>BpC</td>
<td>Bethlehem-Tussahaw-Pacolet complex, 8 to 15 percent slopes</td>
<td>294.6</td>
<td>0.5%</td>
</tr>
<tr>
<td>CaB</td>
<td>Cecil sandy loam, 2 to 6 percent slopes</td>
<td>3,901.1</td>
<td>6.8%</td>
</tr>
<tr>
<td>CeB</td>
<td>Cecil sandy loam, 2 to 8 percent slopes</td>
<td>11,101.2</td>
<td>19.3%</td>
</tr>
<tr>
<td>Cfb2</td>
<td>Cecil sandy clay loam, 2 to 8 percent slopes, moderately eroded</td>
<td>19.8</td>
<td>0.0%</td>
</tr>
<tr>
<td>ChA</td>
<td>Chewacla and Wehadkee soils, 0 to 2 percent slopes, frequently flooded</td>
<td>2,634.3</td>
<td>4.6%</td>
</tr>
<tr>
<td>CuC2</td>
<td>Cullen clay loam, 8 to 15 percent slopes, moderately eroded</td>
<td>11.9</td>
<td>0.0%</td>
</tr>
<tr>
<td>EoB</td>
<td>Enon-Wynott complex, 2 to 8 percent slopes</td>
<td>7.5</td>
<td>0.0%</td>
</tr>
<tr>
<td>EoC</td>
<td>Enon-Wynott complex, 8 to 15 percent slopes</td>
<td>19.9</td>
<td>0.0%</td>
</tr>
<tr>
<td>HeB</td>
<td>Helena sandy loam, 2 to 6 percent slopes</td>
<td>1,303.4</td>
<td>2.3%</td>
</tr>
<tr>
<td>HeC</td>
<td>Helena sandy loam, 6 to 10 percent slopes</td>
<td>325.1</td>
<td>0.6%</td>
</tr>
<tr>
<td>HnB</td>
<td>Helena sandy loam, 2 to 8 percent slopes</td>
<td>542.2</td>
<td>0.9%</td>
</tr>
<tr>
<td>HnC</td>
<td>Helena sandy loam, 8 to 15 percent slopes</td>
<td>766.6</td>
<td>1.3%</td>
</tr>
<tr>
<td>LoC</td>
<td>Louisburg-Ashlar-Wake complex, 6 to 10 percent slopes, rocky</td>
<td>155.3</td>
<td>0.3%</td>
</tr>
<tr>
<td>LwC</td>
<td>Louisburg-Ashlar-Wake complex, 8 to 15 percent slopes, rocky</td>
<td>39.3</td>
<td>0.1%</td>
</tr>
<tr>
<td>M-W</td>
<td>Miscellaneous Water</td>
<td>5.9</td>
<td>0.0%</td>
</tr>
<tr>
<td>MpB</td>
<td>Mattiponi fine sandy loam, 2 to 6 percent slopes</td>
<td>951.2</td>
<td>1.7%</td>
</tr>
<tr>
<td>PaB</td>
<td>Pacolet sandy loam, 2 to 6 percent slopes</td>
<td>2,369.3</td>
<td>4.1%</td>
</tr>
<tr>
<td>PaC</td>
<td>Pacolet sandy loam, 6 to 10 percent slopes</td>
<td>1,689.7</td>
<td>2.9%</td>
</tr>
<tr>
<td>PaD</td>
<td>Pacolet sandy loam, 10 to 15 percent slopes</td>
<td>4,805.5</td>
<td>8.3%</td>
</tr>
<tr>
<td>PeB2</td>
<td>Pacolet sandy clay loam, 2 to 6 percent slopes, moderately eroded</td>
<td>141.0</td>
<td>0.2%</td>
</tr>
<tr>
<td>PeC2</td>
<td>Pacolet sandy clay loam, 2 to 10 percent slopes, moderately eroded</td>
<td>12.6</td>
<td>0.0%</td>
</tr>
<tr>
<td>PhB</td>
<td>Pacolet sandy loam, 2 to 8 percent slopes</td>
<td>2,029.3</td>
<td>3.5%</td>
</tr>
<tr>
<td>PhC</td>
<td>Pacolet sandy loam, 8 to 15 percent slopes</td>
<td>8,233.8</td>
<td>14.3%</td>
</tr>
<tr>
<td>PhE</td>
<td>Pacolet sandy loam, 15 to 30 percent slopes</td>
<td>627.7</td>
<td>1.1%</td>
</tr>
<tr>
<td>PpB2</td>
<td>Pacolet sandy clay loam, 2 to 8 percent slopes, moderately eroded</td>
<td>79.4</td>
<td>0.1%</td>
</tr>
<tr>
<td>PuC</td>
<td>Pacolet-Urban land complex, 2 to 10 percent slopes</td>
<td>688.6</td>
<td>1.2%</td>
</tr>
<tr>
<td>SeB</td>
<td>Sedgefield-Iredell complex, 2 to 8 percent slopes</td>
<td>29.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>StA</td>
<td>State fine sandy loam, 0 to 3 percent slopes, rarely flooded</td>
<td>7.9</td>
<td>0.0%</td>
</tr>
<tr>
<td>TxE</td>
<td>Tussahaw-Bethlehem-Pacolet complex, 15 to 35 percent slopes</td>
<td>104.5</td>
<td>0.2%</td>
</tr>
<tr>
<td>Ud</td>
<td>Udorthents, loamy</td>
<td>132.1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Ur</td>
<td>Urban land</td>
<td>83.0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Area</td>
<td>Percent</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>VaB</td>
<td>Vance sandy loam, 2 to 6 percent slopes</td>
<td>433.2</td>
<td>0.8%</td>
</tr>
<tr>
<td>W</td>
<td>Water</td>
<td>214.0</td>
<td>0.4%</td>
</tr>
<tr>
<td>WaD</td>
<td>Wake-Ashlar-Wedowee complex, 10 to 15 percent slopes, rocky</td>
<td>118.0</td>
<td>0.2%</td>
</tr>
<tr>
<td>WaF</td>
<td>Wake-Ashlar-Wedowee complex, 15 to 50 percent slopes, rocky</td>
<td>9.3</td>
<td>0.0%</td>
</tr>
<tr>
<td>WeB</td>
<td>Wake-Louisburg-Saw complex, 2 to 6 percent slopes, rocky</td>
<td>339.0</td>
<td>0.6%</td>
</tr>
<tr>
<td>WkB</td>
<td>Wake-Louisburg-Saw complex, 2 to 8 percent slopes, rocky</td>
<td>52.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>WoB</td>
<td>Wedowee sandy loam, 2 to 6 percent slopes</td>
<td>1,597.3</td>
<td>2.8%</td>
</tr>
<tr>
<td>WoC</td>
<td>Wedowee sandy loam, 6 to 10 percent slopes</td>
<td>782.5</td>
<td>1.4%</td>
</tr>
<tr>
<td>WoD</td>
<td>Wedowee sandy loam, 10 to 15 percent slopes</td>
<td>777.3</td>
<td>1.3%</td>
</tr>
<tr>
<td>WwB</td>
<td>Wedowee sandy loam, 2 to 8 percent slopes</td>
<td>68.0</td>
<td>0.1%</td>
</tr>
<tr>
<td>WwC</td>
<td>Wedowee sandy loam, 8 to 15 percent slopes</td>
<td>2,314.6</td>
<td>4.0%</td>
</tr>
<tr>
<td>WwE</td>
<td>Wedowee sandy loam, 15 to 30 percent slopes</td>
<td>83.8</td>
<td>0.1%</td>
</tr>
<tr>
<td>Totals for Area of Interest</td>
<td></td>
<td>57,586.9</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

*Table 9 — Web soil survey of Warren County, retrieved from USDA.*
Figure 27 — Net food waste GHG emissions produced through different management schemes, measured in metric tons of CO2e per short ton of food. From NRDC, 2019.
X. References


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