Municipal Composting Programs in Massachusetts: What Works, Where, Why and How?

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Honors Thesis

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This interest in compost (and composting programs/policies) has been the result of me falling in love with science and technology here at Wellesley, while trying to figure out how that gels with my love for cities, good public policy, ethics and values, and more. I’d admit my thesis is a little more in the social-science-policy wheelhouse, but my route here was through DJB Lab. Many people part of this group past and present keep on inspiring me to be bolder, think bigger, and find my place in this world: so I ended up thinking about compost really differently.

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Executive Summary

Given economic and environmental concerns regarding waste disposal including but not limited to greenhouse gas emissions and reduced landfill capacity, composting has emerged as a strategy of choice for municipalities aiming to better manage organic waste streams. This is especially as food waste and other compostable organics currently account for 15.1% of all municipal solid waste (~39.73 million tons) generated in the United States in 2015, with the vast majority of food waste (76.1%) still being landfilled (United States Environmental Protection Agency 2018). When municipalities get involved in composting, the composting process is scaled up: municipal governments can invest and develop composting infrastructure and programs that collect and process organic waste streams arriving by the truckload on a year-round basis. By 2017 estimates, more than 300 communities also have curbside or drop-off food waste collection programs; in addition, five states in the United States have also passed bills that mandate the source separation, recycling, and/or composting of organic waste (Streeter and Platt 2017; Leib et al. 2018).

Embracing municipal composting can push municipalities towards a more sustainable mode of municipal solid waste governance for organic waste in the United States that is focused on diversion and resource recovery, where waste management can create economic and social benefits that accrue to local communities (Figure A). However, there are many challenges to the widespread adoption of municipal composting programs. Past research has pointed to the need for existing yard waste collection and the presence of pay-as-you-throw schemes as crucial for the adoption of municipal composting schemes (Layzer and Schulman 2014). Moreover, socio-economic factors such as median household income in a municipality and overall levels of educational attainment can potentially influence whether a municipality would adopt a program.

This research thus identifies what factors encourage or constrain municipalities from adopting municipal composting schemes. Taking Massachusetts as a case study, this work pioneers studying the adoption of municipal composting schemes at the level of individual towns and cities within the same state. Three main types of municipal composting programs were evaluated: curbside food waste collection, drop-off food waste collection, and compost bin distribution programs. Due to a general lack of studies conducted on how municipal composting schemes function within municipalities of varying socio-economic and waste system characteristics, recycling literature was used to supplement the formation of hypotheses around what some of these factors could be. Using U.S. American Community Survey data estimates and survey data from the 2017 MassDEP Municipal Solid Waste and Recycling Survey, 13 socio-economic and waste system variables were evaluated for their association with the adoption of municipal composting programs in Massachusetts towns. The results are presented in Figure B.
As statistical approaches and empirical findings do not capture the full landscape of how municipal composting schemes operate in reality, three case studies (Town of Dover, City of Salem, Franklin County) were also explored. These case studies demonstrate the impact of waste governance arrangements that are based upon partnerships with the general public, commercial waste processors, and municipal governments. They also show that municipalities can overcome socio-economic and waste infrastructure barriers to implement successful municipal composting schemes, especially if mediated by the influence of commercial composters, location, and the provision of state grants.

This work aims to open up a larger conversation about how municipalities can move forward in adopting municipal composting schemes. In that light, the work presents three major findings and recommendations:

• Firstly, curbside recycling and yard waste collection services have strong associations with program adoption. This indicates that municipal governments must consider the existing waste infrastructure (e.g. collection routes, processing facilities) in municipalities before adopting municipal composting programs, as existing infrastructure can both impede or support transitions to doing composting at a municipal scale.

• Secondly, high educational attainment, high median housing values and a high Gini index score show a strong positive association with all types of municipal composting programs. This prompts concerns about the financial accessibility and public education needed for such programs, and municipal governments would do well to take this into consideration.

• Lastly, some municipal governments have successfully partnered with commercial composters and citizen groups to implement such composting programs, especially for curbside food waste collection. This is a useful partnership model that other municipalities can possibly adopt in order to advance municipal composting.

In sum, the adoption of municipal composting schemes can push municipalities towards forms of municipal solid waste governance that are sensitive to the local context and is conscious of equity and accessibility. The hope is for more municipalities to be part of what is already a growing trend towards municipal composting, and shape the management of organic waste into a system that reaps environmental, social, and economic benefits.
Figure A. Concept map for municipal composting and organic waste governance, from the past, present, to the future. Concept map looks at waste governance in terms of management, mode/core priorities, organic waste matrix, and management options available to municipalities.
**Figure B.** Summary of major findings and variable associations from regression analysis. Blue pluses (+) denote factors that had positive associations with the type of municipal composting program, red minuses (--) denote factors that had negative associations. Tildes (~) denote that the factor had no or insignificant association.

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Introduction

The production of municipal solid waste is an unavoidable function of human activity, especially with increased consumption patterns in the face of rapid population growth, increased urbanization, and greater wealth (Vergara and Tchobanoglous 2012). Waste is associated with human settlement and accumulative processes, and functions both as a descriptive material category but also as a normative judgment of our human behavior: it can be seen as a byproduct of a process, a symbol of excess, or as something that should not become (Hawkins 2006; Hall and Campos 2013; Matthes and Matthes 2018). Accordingly, waste has been problematized as something to be managed and governed, especially in densely populated municipalities. Within municipalities, waste as a material and the producers of waste are both seen as entities to be governed via a specific set of technologies (e.g. policies, laws, programs) and through particular institutional relationships (e.g. public-private partnerships) to achieve set objectives (Bulkeley, Watson, and Hudson 2007).

Municipal solid waste governance is thus a system that addresses these underlying descriptive and normative questions:

1. What kinds of waste matter?
2. What should be done about waste?
3. Why should we manage waste?

This is particularly true of how municipal food and compostable waste is managed in the United States: food and compostable waste has started to matter. With food waste and other compostable organics currently accounting for 15.1% of all municipal solid waste (~39.73 million tons) generated in 2015, this particular category of waste has become an area where governments are increasingly paying attention to (United States Environmental Protection Agency 2018).

A tool of choice for many municipal governments in managing food and compostable waste is **municipal composting**. At its most basic level, composting is the controlled process of turning organic matter into a nutrient-rich soil amendment: combining carbon-based materials in
the right ratios, using techniques that accelerate the decomposition process, and allowing the final product to mature. It is an aerobic and biological process where organic material decomposes via micro-organisms in carefully set conditions (Platt, Goldstein, and Coker 2014). As a waste management process, composting takes place at multiple scales and levels of technological expertise: in technologically advanced composting facilities, at agricultural farms, or in the home (i.e. having your own backyard compost pile).

While composting as a municipal solid waste management strategy was negligible in 1980, the total amount of waste composted nationally rose to 23.4 million tons in 2015 (United States Environmental Protection Agency 2018). Municipal governments are involved in composting both in terms of infrastructure and program implementation: municipal governments can own and finance full-scale composting facilities equipped to receive and process organic waste streams arriving by truckload volumes from generators and waste haulers on a year-round basis. They can also run programs that collect organic waste from commercial and residential entities, and also encourage home composting. It is the latter – program implementation – that this work will focus on, though the two are closely related.

Municipal governments have implemented municipal composting programs that are aimed at diverting food waste away from being landfilled, with prime examples being the curbside or drop-off collection of compostable waste, compost bin distribution programs, as well as commercial food waste disposal bans. These programs have recently expanded across the country; for example, according to a recent 2017 survey on residential food waste collection programs, curbside programs serve more than 300 communities, which is a 87% increase from the 2014 survey (Streeter and Platt 2017). Drop-off food collection programs also serve 318 communities, and are present in 15 states (Streeter and Platt 2017). At the state level, five states in the United States have also passed bills that mandate the source separation, recycling, and/or composting of organic waste: California, Connecticut, Massachusetts, Rhode Island and Vermont; in addition, the six major cities of Austin (TX), Boulder (CO), New York City (NY), San Francisco (CA), and Seattle (WA) have also implemented such bills (Leib et al. 2018).
Yet, the vast majority of food waste (76.1%) is still being landfilled (United States Environmental Protection Agency 2018). There is thus still great potential for municipal composting programs to be expanded further, especially given the environmental impacts of disposing food waste in landfills. As Samantha MacBride writes elegantly in support of composting in her 2012 book *Recycling Reconsidered*:

“If we desire to maximize diversion of waste from disposal in cities, creating a product that will find a local market as commodity or an immediate direct use in public works of the city itself, does it not make sense to concentrate on biodegradable wastes more than we have?” (MacBride 2012)

This is easier said than done. Food and compostable organics are a whole new waste material matrix that municipalities are now aiming to manage in a sustainable manner: it rots and emits odors, unlike inorganic recyclable materials like metal and plastics, and may require the average citizen to get over their original disgust to manage it right. Municipal composting schemes are also relatively new for food waste: it is only a small minority of municipal governments who have begun to experiment with them. That being said, there are strong environmental, economic and social imperatives for municipalities to transition towards more sustainable ways of managing waste.

In order for municipalities to transition to more sustainable modes of municipal solid waste governance regarding food and compostable waste, there needs to be more research done to identify both barriers that reinforce unsustainable municipal solid waste management practices like landfilling, and factors that promote more sustainable waste governance – much of which have historical, socio-economic, and infrastructural dimensions. This is the gap that I aim to fill through this work, with a specific focus on the adoption of municipal composting practices in the state of Massachusetts. Evaluating why particular practices are in place in some municipalities and not others will help us better navigate such transitions, find ways in which particular communities have overcome key system barriers, and also discover new opportunities for municipalities to pursue waste system change.
I first examine the benefits and obstacles in the implementation of municipal composting programs, the historical roots of municipal composting, and the factors shaping municipal solid waste governance in the United States. Next, using existing literature conducted on municipal composting schemes and the close parallel of recycling schemes, I generate hypotheses regarding some socio-economic and waste system factors that could help or hinder the adoption of municipal composting schemes. Using publicly available data from Massachusetts Department of Environmental Protection and American Community Survey estimates, I conduct statistical analyses to identify the impact of these factors on the adoption of different types of municipal composting schemes in Massachusetts municipalities. I then evaluate these findings and generate targeted recommendations for where municipal composting schemes could be expanded, while including some observations gleaned from three case studies.

Most of all, this work aims to open up a wider conversation about municipal composting, municipal solid waste management, and more broadly, our relationship with the waste we create. I have only skimmed the surface of what is possible: this work should serve to encourage more attempts to think critically about how municipalities can manage waste in ways that prioritize decreased environmental impact while providing local communities with economic and social benefits.
Chapter 1: Municipal Composting as Sustainable Waste Management

1.1 Benefits of Composting as a Waste Management Strategy for Municipalities
1.2 Obstacles to the Expansion of Municipal Composting
1.3 Historical Roots of Municipal Composting as Waste Management Strategy
1.4 Modes of Governing Municipal Solid Waste Governance in the United States
1.5 Implications for Municipal Composting and Municipal Solid Waste Governance

Key Insights:

1. Municipal composting has strong environmental and social benefits, but its implementation is fraught with institutional, social and economic barriers across its development.

2. Municipal composting is not new – it has been pursued through yard waste composting in the past, which has present-day implications both in directing the motivations food waste composting and creating infrastructure lock-in.

3. Municipal composting exists within modes of waste governance in the US that are moving away from a disposal paradigm, and is a path forward for municipalities looking to embrace municipal solid waste governance that takes the local context as a starting point.

4. There is a need to evaluate what factors both promote and prevent municipalities from transitioning to better forms of waste management and adopting municipal composting, especially when considering local socio-economic and waste system characteristics.
1.1 Benefits of Composting as a Waste Management Strategy for Municipalities

As compared to other waste management options, the benefits of composting have strong environmental and social dimensions. From a soil systems and carbon perspective, composting sequesters carbon through producing a carbon-rich product from organic waste that acts as a natural fertilizer for soils. The application of compost to local and agricultural soils can improve soil health by preventing soil erosion and adding more nutrients into the soil – all of which will improve plant growth and also improve the capacity of soils for carbon sequestration. As a soil amendment, the application of compost can also help remediate contaminated soils (Diaz 2003). Compost has been used both to create raised beds, as well as cap or dilute lead-contaminated soils that effectively reduce lead exposure for urban gardeners (Clark, Hausladen, and Brabander 2008).

When approached from the perspective of composting being a waste management strategy, supporting composting as a waste management option can allow municipalities to successfully divert organic waste away from landfills. As noted previously, a large percentage of municipal solid waste – especially organic waste such as food waste – is still being landfilled, which has negative implications in terms of climate and greenhouse gas emissions. Municipal solid waste landfills are the third-largest source of human-related methane emissions in the United States, generating 14.1% of the emissions in 2016 (US EPA 2016); by reducing the amount of organic waste headed towards to landfills in the first place, composting will reduce methane emissions from municipal solid waste landfills, much of which is generated from the decomposition of organic waste.

Composting can also be an economically efficient choice for municipalities. A case in point is the City of Seattle, where municipal composting was adopted as waste management strategy in response to a costly waste disposal crisis it faced in the 1980s (Schulman 2016). An increase in landfill tipping fees had forced Seattle’s solid waste utility to raise its rates by more than 80%; as such, leaders in Seattle chose to rethink municipal solid waste management in the city and encourage waste reduction and diversion. It was determined that processing organic waste locally in the city was actually more economical than transporting it to landfills elsewhere in Washington.
and Oregon state, resulting in organics processing facilities being built. Diversion of organic waste away from landfills can thus also reduce the cost of waste disposal for municipalities in the face of reduced landfill capacity and rising landfill tipping costs.

Arguably, municipalities have multiple options for managing organic waste and food waste beyond municipal composting. One major option is biosolids treatment, which focuses on managing sewage waste, though there is active research in forging co-treatment possibilities with food waste (Kim et al. 2017). The other major option is anaerobic digestion, which is an appealing route for municipalities due it being a waste to energy pathway – the process can produce biogas, thus recovering high resource value from waste. There has also been substantial movement in this area: many anaerobic digestion facilities are currently in planning, permitting or construction phases, but it is expected that anaerobic digestion capacity will increase by 4.5 times the 2013 level once these projects are fully functioning (Kantner 2015).

However, what marks composting as remarkably different from these two options is its strong social benefits and its flexibility to be practiced at multiple scales. Composting has been shown to strengthen community bonds, especially when done at a local scale and involving community stakeholders. Community-run composting sites – which are often connected to urban gardening programs – arguably create a culture of awareness and engagement around waste, support local food production, and aid in increasing food sovereignty (Fitzstevens, Sharp, and Brabander 2017; Brolis 2018). In addition, composting facilities are often locally run, and often employ more people to carry out their operations, thus bolstering local employment. The Institute of Local Self-Reliance estimates that on a per ton basis, composting employs four times more people than landfills or incinerators (ILSR, 2014). The product from composting – the compost itself – also often returns back to the community; residents engaged in municipal composting schemes often get access to free compost for use in community gardens.

Composting can thus also reduce the environmental impact of waste disposal from municipalities while also managing public health risks; in addition, it can benefit local environments and communities in a way that other waste management strategies do not.
1.2 Obstacles to the Expansion of Municipal Composting

While there are clear benefits to municipal composting, the adoption of composting at the municipal scale is not without obstacles. These obstacles present themselves at different stages of the waste management process: Figure 1 attempts to summarize a few of these obstacles present for the municipal composting system from the production and collection of food waste to its eventual treatment.

From the scientific angle, it has been identified that there are potential health risks from odors and bioaerosols produced from the composting process. The Institute of Local Self-Reliance also identified the failure to conduct proper odor management as the single biggest cause of adverse publicity, regulatory pressures and facility closures in the organics recycling industry (Platt, Goldstein, and Coker 2014). In addition, improper compost processing can create heightened concentrations of heavy metals in the end product, and a lack of standards for end product quality control (Fitzstevens, Sharp, and Brabander 2017; Sharp and Brabander 2017). Even in the 1990s, several prominent environmental groups opposed mixed waste composting (composting all waste streams such as food, sewage sludge, and compostables together without source separation) on the grounds that the compost produced was unsafe and prone to heavy metal contamination due to lack of control over feedstocks (Magnuson 1992). It was noted that by the
2000s, only the mixed waste composting facilities with sufficient waste flow, financial and political support, good odor and process management and a viable end-market for their compost were surviving (Block and Goldstein 2000).

Beyond the science and technology of composting, there are also concerns about the costs of managing a municipal composting program. Success often depends on the cost of composting being lower than other existing waste disposal methods, especially the cost of landfilling. Full scale municipal composting programs can be extremely costly to sustain; for example, New York City’s curbside composting program cost $15.7 million in 2018, with the revenue from selling compost only netting a measly $58,000 – the high costs and low participation rate meant that the city has had to scale back the program by cutting the frequency of collection (Collins 2018).

From a governance perspective, successful municipal composting programs – particularly, curbside compostable collection programs – also require the support and integration of Public Works departments who are often responsible for collecting and segregating the waste. It is often more difficult to institute municipal composting programs in places where many businesses are competing to haul waste, as residents can switch to lower-cost haulers that do not offer composting if their previous hauler institutes higher-cost compostables collection (Layzer and Schulman 2014).

Socially, getting citizens to participate in composting schemes might also be challenging, with knowledge about the composting process and having a favorable attitude towards composting playing a large role in an individual’s participation (Edgerton, McKechnie, and Dunleavy 2009). Citizen behavior plays a large part in ensuring proper source separation of waste, which is required for municipal composting. Failure to do so can negatively impact composting operations; for instance, residents in Madison, Wisconsin, had placed materials such as plastic, metal and glass in bags meant for compostable waste, which can contaminate a whole batch of organic material collected for composting. This caused the collected organics to be landfilled instead of being composted, and the city’s composting business partner also stopped providing services to the city as a result (Mesch 2017).
1.3 Historical Roots of Municipal Composting as Waste Management Strategy

These factors identified point to obstacles with the adoption of new municipal composting schemes; however, it is important to note that municipal composting is not a new phenomenon. Many of the current barriers impeding the increased expansion of municipal composting, especially as a waste management tool for food waste, do stem from its historical development as a municipal solid waste management strategy. In particular, the focus on yard waste composting in the past has present day implications on municipal composting infrastructure and ownership, and has allowed for cost pressures to still drive the development of municipal composting both in the past and in the present.

Composting only began to be treated as a serious alternative to landfilling municipal solid waste in the late 1980s, when landfill closure and an increase in tipping fees in the 1970s and 1980s created cost pressures on waste management (Melosi 2008). There thus were strong economic and pragmatic reasons to pursue composting on a municipal scale by investing in infrastructure, as well as by enacting legislation and policies that prioritize diversion of organic waste towards composting. Behind the decision to pursue composting was good economics: as long as it was cheaper than landfilling and helped avoid high tipping fees, it would work.

Composting at the municipal scale was subsequently seen as a viable option to divert yard waste away from landfills, or better yet, make yard waste into a valuable product. Yard waste, which mainly comprises of leaves, brush, and grass clippings, was the largest fraction of the organic waste stream then – it constituted close a fifth of America’s total municipal solid waste in the 1970s and 1980s (Porter 2002). Composting yard waste would thus reduce the cost of waste disposal and also potentially generate some revenue from the sale of compost. Action was swift – by the 1990s, more than 20 states had instituted yard waste disposal bans that prevent yard waste from being landfilled, thereby encouraging yard waste to be composted (Kashmanian 1993). With the added policy push of waste disposal bans on yard waste, there was high demand for composting as a waste management strategy, so much so of the 35 million tons of yard waste generated in the US in 1990, an estimated 12% (4.5 million tons) of it was composted (Kashmanian 1993).
However, owing to the move towards yard waste composting being primarily motivated by cost pressures, once cost considerations waned in the mid 1990s due to the building of large, regional landfills, there was no longer an incentive for municipalities to pursue municipal composting as a waste management strategy (Platt and Goldstein 2014).

This past focus on yard waste composting at the municipal scale has resulted in a large proportion of municipal composting infrastructure today still geared towards managing yard waste. As such, recent moves to expand municipal composting for food waste face regulatory and infrastructure challenges brought on by past waste management strategies. A 2014 review of the state of composting in the United States reported that 71% of all composting facilities only composted yard waste, with a large majority of them being municipally-owned (Platt and Goldstein 2014). There is strong infrastructure and regulatory lock-in preventing the expansion of municipal composting for waste streams beyond yard waste: it is noted that for yard waste composting sites to start accepting other compostable materials like food waste, new permits must be acquired; however, most yard waste composting sites are not equipped to handle such new organic material (Platt and Goldstein 2014).

Moreover, out of the 185 full-scale food waste composting facilities present in the United States, most are privately-owned commercial entities – the majority of municipalities do not directly operate composting facilities that can accept food waste and compostable products (Goldstein 2019). Municipalities are hence largely reliant on the expansion of private-sector players into the composting business in order to increase their capacity to compost other waste streams, especially as there is usually a lack of municipal budget to upgrade municipally-owned composting facilities (Platt and Goldstein 2014).

Today, municipal composting is arguably motivated by much more than pure cost considerations. With climate change becoming a greater policy priority in recent years, municipalities aim to manage the disposal of waste in a way that reduces climate impact, especially by reducing landfilling. A 2009 US EPA report advocated that municipalities adopt waste management practices such as recycling and composting of municipal solid waste as strategies to reduce greenhouse gas emissions; in particular, it was estimated that if the national municipal solid
waste recycling and composting rate was increased from its 2006 rate (32.5%) to 50%, 70-80 million metric tons (MMT) of carbon dioxide emissions would be mitigated yearly (United States Environmental Protection Agency 2009).

It is in this context that cities and states have introduced more aggressive waste diversion targets, and utilized various legislative and financial tools to promote composting as a waste management strategy, especially for food waste. Nationally, in 2015, the USDA and the EPA also announced a national food waste reduction goal of 50%, citing resource conservation and climate change as key motivators (USDA 2015). The states of California, Connecticut and Massachusetts have also enacted wide-ranging laws mandating that commercial entities (e.g. schools, offices, retail outlets) must compost or recycle their food waste; Vermont goes even further by mandating the same for residential communities (Platt and Goldstein 2014). Cities such as Seattle have also instituted mandatory enrolment into food waste and yard waste collection services for residents unless residents demonstrate that they compost on site in their backyard (Schulman 2016). States have also put in place grants and loans to encourage municipalities to pilot organics collection programs; for example, in Massachusetts, the Massachusetts Department of Environmental Protection offers grants to municipalities to support organics collection through the Sustainable Materials Recovery Program (MassDEP 2019a).

These environmental considerations notwithstanding, the same cost considerations that motivated the expansion of yard waste composting still hold strong influence on directing the expansion of food waste composting today. In a Biocycle survey carried out in 2017 on food waste collection programs, program administrators stated avoidance of waste disposal costs and meeting waste diversion goals as the top two factors for implementing these programs (Streeter and Platt 2017). This illustrates the dominance of economic considerations on municipal solid waste management even as municipalities pursue waste diversion with municipal composting today.
1.4 Modes of Governing Municipal Solid Waste in the United States

The aims of waste diversion and reducing the costs of waste disposal that motivate municipal composting must be put in context of overall municipal solid waste governance in the United States. In particular, municipal solid waste governance must be seen as systems that have underlying drivers that motivate its implementation and shape its form – together, they constitute defined modes of governing municipal solid waste (Bulkeley, Watson, and Hudson 2007).

In the case of the United States, municipal governments are largely still stuck in a disposal mode of governance for waste, in which economic efficiency, public health, and overall environmental cleanliness are the main governmental rationalities (i.e. the logic that dictates what should be done with municipal waste) for why waste should be managed (Lily B Pollans 2017). Economic considerations appear as a prime consideration in municipal waste governance, whereby financial interests and profit motives drive the use and development of large and low-cost landfills that serve a regional market (Wilson 2007). It is no surprise then, that by 2015 Environmental Protection Agency (EPA) estimates, 52.5% of municipal solid waste in the United States is still landfilled (United States Environmental Protection Agency 2018).

Disposal is not the only mode of governance possible. There are multiple governmental rationalities possible for municipal solid waste governance, and changes in these imperatives create subsequent transitions in how municipal solid waste is governed as a system. For example, Bulkeley, Watson and Hudson note that in the United Kingdom, the traditional disposal mode of governing waste based upon protecting public health and pursuing economic and environmental efficiency has shifted to diversion, which prioritizes reducing the environmental impact of landfilling. In so doing, new modes of managing waste that reduce environmental impact while reaping social and economic benefits have also become better integrated into existing waste management systems (Bulkeley, Watson, and Hudson 2007). Other priorities such as creating resource value, practicing holistic resource management through closing the loop, prioritizing institutional responsibility, as well as increasing public awareness have also been identified to drive the development of waste management systems (Wilson 2007).
Likewise, the disposal mode of municipal waste governance driven by economic rationalities and public health has been challenged in the history of municipal solid waste management in the United States, particularly through federal environmental policy. Much of this can be traced to the reconceptualization of municipal solid waste as a “third pollution” requiring national attention in the 1960s (Melosi 2008). The collection and disposal of wastes produced in American cities was no longer purely approached from the perspective of public health, cleanliness and sanitation, due to fears over groundwater contamination from landfill leachate and increasing concern for environmental protection. Waste disposal became the subject of great concern, prompting federal legislation around the management of solid waste to be enacted in the late 1960s and 1970s. Figure 2 highlights these key pieces of legislation had essential roles in introducing waste management paradigms in the United States that were focused diverting waste, extracting resource value from waste, and reducing the environmental impact of waste.

![Figure 2. Timeline showing major pieces of waste-related federal legislation.](chart)

The Solid Waste Disposal Act was passed in 1965 and aimed to facilitate the implementation of environmentally sound solid waste management and resource recovery systems through funding and research. This was quickly followed in 1970 by the Resource Recovery Act, which broadened waste management to include recycling and the conversion of waste to energy. Both acts had the combined effect of increasing state attention to waste management and formalizing waste governance. As it became federally required for states to have solid waste management plans and designate a single state agency for solid waste management, state waste
management agencies and legislation were enacted in quick succession (Louis 2004). The Resource Conservation and Recovery Act (RCRA) of 1976 (and its amendment, the Hazardous and Solid Waste Amendment of 1984) brought landfilling under tighter scrutiny: under Subtitle D of the RCRA, the location, operating processes, closure, pollution prevention measures for state landfills had to meet strict performance standards. As a result, shortly after main provisions of RCRA took effect in 1980, the number of landfills operating in America declined by almost 50% relative to 1976 numbers (Louis 2004).

Besides these strict environmental standards, there was scarce urban land to build new landfills for solid waste and strong citizen resistance to building new landfills (Melosi 2008). Similarly, the Air Quality Act (Clean Air Act) of 1970 and its amendment in 1976 heavily restricted the incineration of municipal solid waste, further reducing viable options for waste disposal. Under the conditions of shrinking landfill disposal capacity, tipping fees (the charge levied upon a ton of waste received at landfills) skyrocketed, especially in the Northeast: within the span of five years from 1985 to 1990, the tipping fees increased from $12.66 per ton to $64.75 per ton (Melosi 2008). Nationally, there was nearly a three-fold increase in tipping fees from 1985 to 1995, with tipping fees reaching its peak price of $50.06 per ton (United States Environmental Protection Agency 2018).

As a result, municipal solid waste began to be treated as needing to be differentiated into separate waste streams in the 1970s and 1980s, especially to reduce the amount of waste going to landfills. **Waste diversion and resource recovery became a new mode of governing municipal solid waste, prompting the mainstreaming of practices such as recycling as part of municipal solid waste management.** Curbside recycling programs were implemented in many municipalities and were so popular that in the urban Northeast and West Coast, municipalities without curbside recycling programs were the exception rather than the norm (Zimring 2005).

Even more importantly, these new considerations for waste management allowed for new private-public governance models in municipal solid waste management. The combination of recycling needs alongside an increasingly complex solid waste regulatory environment arguably resulted in many municipalities ceding ownership of municipal solid waste management systems
to the private sector. Waste management became big business: some cities privatized their municipal waste management systems, signing contracts with large private haulers to handle both trash and recyclables (Zimring 2005). This has implications in the present: municipal solid waste management is still largely financed and administered at the local level by municipal agencies, while specific unit operations (i.e. collection, transportation, treatment) are increasingly handled by private organizations (Louis 2004).

Arguably, municipal solid waste governance today in the United States is still in the midst of transition away from disposal centric models, they are arguably largely visionary and not widespread. As Pollans defines in reference to the City of Boston’s waste management practices, while priorities such as reducing the environmental impacts of waste are stated in overall solid waste management plans, supportive regulations and infrastructure are still lacking (Lily B Pollans 2017). Municipal composting is a strategy that will be embraced under modes of municipal solid waste governance that do not prioritize disposal, but there are strong financial, social, institutional and political barriers preventing municipalities to transition towards these more sustainable modes (Lily B Pollans 2017).

### 1.5 Implications for Municipal Composting and Municipal Solid Waste Governance

So where do we go from here with regards to municipal composting? I argue that municipal composting as a waste management strategy is what constitutes the aspirational future of municipal solid waste governance, and is a strategy that can account for historical and current waste infrastructure arrangements, navigate the impact of socio-economic characteristics on waste management, and create benefits for the environment, economy and community. Municipal composting finds itself situated within changing modes of waste management that are moving from a disposal mode of governance in the past to that of diversion and resource recovery in the present. A snapshot of these changes is found in Figure 3, which outlines key transitions in three main directions: firstly, the management of municipal solid waste has changed to involve the private sector and more involvement from citizens; secondly, the mode has changed to diversion
and seeing waste as a resource; thirdly, the matrix has changed, with food waste coming to the forefront.

Within this framework, municipalities can choose multiple methods to deal with the organic fraction of their municipal solid waste, especially with the specific matrix of food waste. Municipal composting is just one of these options, but as outlined in Section 1.1, it provides a host of community-centric and localized benefits that cannot be overlooked. This is especially as scholars of environmental policy and waste geography have consistently called for sustainable waste management solutions that take the local context as a starting point, instead of allowing technical, engineering, and economic approaches to completely dominate decision-making for waste management (Vergara and Tchobanoglous 2012; Hall and Campos 2013). Localized socio-economic characteristics such as the median household income of a municipality and average educational attainment of residents may thus have a strong impact on the success of waste management programs like composting; the same goes for other waste system characteristics such as the existing presence of recycling or other waste reduction incentives.

It is thus useful for there to be an examination of what factors constrain or promote municipal governments from instituting municipal composting programs; doing so can also help us identify what is needed to enable effective, sustainable, and equitable modes of governance for municipal solid waste. Evaluating why particular schemes work for specific communities and not for others has potential to answer why municipal composting schemes manifest in the way they do, and also has implications for finding key system elements that might be tweaked in order to better forms of local waste management. The focus of the work in Chapter 2 will thus be on the part of the system highlighted in yellow in Figure 3 – that of municipal composting programs, especially for food waste.
Figure 3. Concept map for municipal composting and waste governance.

Yellow shading denotes the main system of interest for the work and analysis in Chapter 2.
Chapter 2: Evaluating Municipal Composting Program Adoption within Massachusetts

2.0 Chapter Overview

2.1 Overview of Notable Studies on Municipal Composting Programs

2.2 Hypotheses for Factors Influencing Municipal Composting

2.3 Massachusetts as Case Study for Analysis

2.4 Data and Methods

2.5 Results and Discussion of Logistic Regression Analysis

**Key Insights:**

1. There are limited studies evaluating factors that affect the adoption of municipal composting schemes, especially in terms of socio-economic and waste system variables.

2. Recycling studies provide a good (but imperfect!) supplementary parallel to municipal composting studies, so as to help generate hypotheses about what factors could affect the adoption of municipal composting schemes.

3. For food waste collection programs, waste system variables (curbside recycling and yard waste collection services) have stronger associations with program adoption than socio-economic variables.

4. For socio-economic variables, educational attainment and median housing values have strong associations across all types of municipal composting programs. Gini index also shows some association, prompting concerns about the accessibility of such programs.
2.0 Chapter Overview

If we believe in the merits of expanding municipal composting programs and shifting away from disposal-oriented modes of managing food and compostable waste, it is clear from the previous chapter that there needs to be a deeper evaluation of what limits or encourages municipal governments from adopting such programs. This is especially if we are to make these municipal composting programs more easily adopted by municipal governments.

Three key investigative questions motivating this chapter are:

1. *Do socio-economic conditions and waste system characteristics place constraints on what can be possible for managing the organic fraction of the municipal solid waste stream?*
2. *Does it differ depending on what type of municipal composting program it is?*
3. *Will the same factors that have led to the success of recycling programs also lead to the adoption of municipal composting programs?*

As highlighted in Figure 3, three major municipal composting program are evaluated in this work: curbside food waste collection programs, drop-off food waste collection programs, and compost bin distribution programs. These program types were chosen as they are the most common formats in which municipal composting take, especially in managing the food waste produced from *residential* communities, which is of greater interest for this work. While it must be acknowledged that the larger proportion of food and compostable waste is produced from commercial sources, looking at residential municipal composting schemes holds more relevance when looking to design waste management schemes that are localized and sensitive to a municipality’s socio-economic and existing waste system characteristics. Figure 4 provides a quick overview of the key characteristics for each program type, so as to provide some orientation through the chapter.
This chapter first surveys the literature around the adoption of municipal composting schemes, in order to develop working hypotheses around what sort of factors need be taken into consideration. As such literature is few and far between, this chapter also turns to the adoption of municipal recycling programs as a useful working parallel. Taking the state of Massachusetts and its municipalities as a case study for evaluation, this chapter uses an empirical approach to evaluate if these hypotheses are indeed true.

**Figure 4.** Key characteristics of residential-based municipal composting programs.

<table>
<thead>
<tr>
<th>Type of Program</th>
<th>Key Characteristics</th>
</tr>
</thead>
</table>
| **Curbside Food Waste Collection** | • Food waste from residents are picked up by waste haulers weekly/bi-weekly and sent to a composting site (or towards anaerobic digestion)  
• Usually incurs costs for both municipalities and residents: subscription-based services are common  
• Specific bins are also provided to residents to encourage source separation of food waste |
| **Drop-off Food Waste Collection** | • Residents store and drop off their food waste at designated locations  
• Drop-off sites are usually material recycling facilities, community gardens, farmers’ markets, even public transit locations  
• Food waste is then further transported to a composting site (or towards anaerobic digestion) |
| **Compost Bin Distribution Programs** | • Bins are usually provided at a subsidized cost to residents on a voluntary basis  
• Compost production occurs on-site in the resident’s home instead of at a larger composting site  
• Requires extensive education to residents regarding composting techniques |
2.1 Overview of Notable Studies on Municipal Composting Programs

Literature on composting is largely concentrated within specific disciplines: while much has been written on the science and technology of composting, comparatively little work has examined it from a policy and programmatic perspective. Within the United States and North American context, there have only been a handful of academic studies that attempt a factor-based and interdisciplinary approach to studying the implementation and success of municipal composting programs (Park, Lamons, and Roberts 2002; Layzer and Schulman 2014; Platt, Goldstein, and Coker 2014; Lily Baum Pollans, Krones, and Ben-Joseph 2017). Studies on municipal composting have also tended to come from specific government environmental bureaus, non-profit organizations such as the Institute of Local Self-Reliance, and trade journals such as BioCycle.

These studies have evaluated the factors affecting composting at different scales. At the national and state levels, factors investigated are primarily infrastructural, cost, and policy-oriented. A 2014 review of the state of composting in the United States published by the Institute of Local Self-Reliance and BioCycle identified the affordability of composting services and the lack of waste diversion policies as key barriers preventing a further expansion of residential composting programs such as curbside or food waste collection (Platt, Goldstein, and Coker 2014). Narrowing the scope of analysis to that of individual households, scholars have also analyzed factors that relate to towards pro-environmental behaviors, such as avid gardening practices, the influence of family and friends, or increasing convenience (Park, Lamons, and Roberts 2002; DiGiacomo et al. 2018). The impact of education, awareness, and even the type of organic waste composted has been evaluated; for example, it was found that food waste composting was more likely for households who already compost other materials such as yard waste, who are aware of waste reduction targets and subsidized compost bins, and who have completed a college education (Park, Lamons, and Roberts 2002).

However, given that much of waste management is governed at the local level in the United States, studies on composting programs that are conducted at the level of municipalities provide the most relevance (Louis 2004). Studies in this vein have utilized both case study and empirical
approaches to determine the factors with the most relevance to the adoption of municipal composting programs, with two studies being particularly notable. Both of these studies find that waste system characteristics and existing waste management policies have a greater impact on encouraging municipalities to adopt municipal composting programs than other socio-economic factors, but call for more research to further support their findings given a growing trend in municipal composting.

In a 2014 study, Layzer and Schulman adopted a case study approach to evaluate municipal curbside compostable collection initiatives, drawing upon 15 case studies in North America to identify key factors contributing to the success of these schemes (Layzer and Schulman 2014). Looking at the experience of nine large and medium-sized cities, three smaller cities/towns, and three counties, this study identifies six main factors that have contributed to the success of these municipal curbside compostable collection programs, with success defined as high participation and diversion rates with low levels of contamination. These factors are primarily technical and policy oriented: the presence of waste diversion mandates, high or rising landfill costs, nearby permitted processing facility with adequate capacity, preexisting curbside yard waste collection systems, government control over hauling, and presence of pay-as-you-throw (PAYT) schemes with significant price differentials. Most notably, these factors were important regardless of municipality size, demonstrating the heightened influence of waste system characteristics and waste policy environments on composting program adoption.

Supporting the findings of Layzer and Schulman, Pollans, Krones and Ben Joseph also observe that socio-economic characteristics are not good predictors of the adoption of food scrap collection programs in mid-sized cities (Lily Baum Pollans, Krones, and Ben-Joseph 2017). This study utilizes a completely different approach to evaluate municipal composting programs, choosing instead to utilize statistical analysis to capture a wider range of comparisons. Focusing specifically on cities with a population of 100,000 or more, the study utilized a logistic regression model to test for the association of socio-economic factors such as age, income, population density, housing, educational attainment, and the presence of other types of municipal waste management programming on the adoption of food scrap collection programs. As the study was focused on
municipal composting schemes in mid-sized cities, the authors encourage more research that reviews the adoption of such schemes in municipalities of all sizes.

### 2.2 Hypotheses for Factors Influencing Municipal Composting

It is clear that there are few studies evaluating municipal composting schemes and the factors that affect their adoption. It is with this in mind that recycling literature proves useful – there are many such studies that measure the success of recycling programs in relation to a particular geographic area’s demographic or infrastructural characteristics. These studies often utilize econometric analyses to determine the relative impact of such characteristics on the effectiveness of recycling program adoption. Arguably, as recycling and composting are both strategies adopted by municipalities to divert waste, it is reasonable to draw upon the recycling literature to develop specific hypotheses around what factors would determine the adoption of municipal composting programs; that being said, it will also be useful to compare whether the same factors that have led to the success of recycling programs also lead to the adoption of municipal composting programs. This section combines findings from municipal composting and recycling schemes to develop working hypotheses for further testing in the Massachusetts context via statistical analysis.

#### 2.2.1 Waste System Factors

Both municipal composting and recycling studies have identified **unit pricing for waste (e.g. pay as you throw [PAYT] schemes)** as a significant factor for municipalities looking to increase recycling and composting program adoption (Callan and Thomas 1997; Folz and Giles 2002; Sidique, Joshi, and Lupi 2010; Starr and Nicolson 2015; Layzer and Schulman 2014; Lily Baum Pollans, Krones, and Ben-Joseph 2017). There is general consensus around the significant and positive effect of PAYT schemes on the adoption of recycling and composting schemes in municipalities, on the basis of it creating a economic incentive for residential waste generators to reduce and divert waste away from trash disposal. However, it must be noted that unit pricing schemes may only serve as indirect signals for diversion, and there need be significant cost savings
in place for PAYT schemes to provide a sufficient incentive to pursue more sustainable waste management strategies like recycling or composting (Jenkins et al. 2003; Layzer and Schulman 2014).

Having pre-existing curbside collection services related to recyclables and/or yard waste has also emerged as a positive factor (Callan and Thomas 1997; Jenkins et al. 2003; Layzer and Schulman 2014). This is because existing curbside collection services are usually a sign of a municipality having the requisite waste diversion infrastructure to execute municipal composting programs, especially curbside compostable collection. As noted by Layzer and Schulman, cities in the United States that started curbside compostable collection in the early 2000s simply modified pre-existing collection services for yard waste, adding new bins or trucks to take on the collection of food waste (Layzer and Schulman 2014). From a behavioural perspective and drawing from the experience of recycling programs, curbside collection services provide residents with added convenience and cultivate the source separation of waste, increasing the chances of a municipality having a successful program (Callan and Thomas 1997; Jenkins et al. 2003; Layzer and Schulman 2014).

While this may be so, these pre-existing systems may also make it more difficult for municipalities to adopt such municipal composting programs. Pre-existing curbside collection services may structured to run on a seasonal timeframe, such as in much of New England with regards to yard waste collection. Municipalities may find it hard to transition to more frequent collection schedules for food and other compostable waste, as it is an additional strain on waste management resources (Layzer and Schulman 2014). Composting of food waste may require such big behavioural and infrastructural adjustments that some pre-existing waste system dynamics – even if beneficial for waste diversion – do not easily translate to increase the adoption of municipal composting programs (Lily Baum Pollans, Krones, and Ben-Joseph 2017).

2.2.2 Socio-economic and Demographic Factors

Looking within the recycling literature, socio-economic factors have inconsistent explanatory power in determining the success of recycling programs among different units of
analysis; in general, while socio-economic factors are significant, their effect size is small (Hornik et al. 1995). In general, the socio-economic factors of *income, age, and education* have been most studied, and have also been shown to have modest positive associations with the success of recycling (Callan and Thomas 1997; Jenkins et al. 2003; Sidique, Joshi, and Lupi 2010; Saphores, Ogunseitan, and Shapiro 2012; Starr and Nicolson 2015).

It is reasonable to expect the same in the case of municipal composting programs. **Educational attainment** has been found to be positively associated with the adoption of any food waste collection program, underscoring the importance of educational outreach about the benefits of composting in order to garner residential interest (Layzer and Schulman 2014). **Income and age** point to the ease of program adoption for municipalities whose residents who have the ability to pay for such additional municipal composting services and who are at the age where most waste is produced; that being said, there may be a quadratic relationship at play, where municipalities that are at an extremely high median income simply have no incentive to compost – they can easily pay for it to be landfilled (Callan and Thomas 1997; Lily Baum Pollans, Krones, and Ben-Joseph 2017).

**Population size and density** have also been explored as significant factors, particularly in the case of both curbside recycling and curbside compostable collection. Jenkins et al. (2003) noted the effect of population density on increasing yard waste recycling, attributing it the scarcity of outdoor storage space in denser neighbourhoods compelling residents to recycle. The affordability and efficiency of curbside compostable collection programs also vary based upon the population size and density of a municipality, with these factors also likely having a quadratic relationship with the adoption of municipal composting programs (Porter 2002; Lily Baum Pollans, Krones, and Ben-Joseph 2017).

**Measures of race and ethnicity as well as measures of inequality** are hardly included as part of most studies evaluating both recycling and composting program adoption, making it difficult to anticipate the effect of these variables on municipal program adoption. Previous studies have demonstrated variation in waste behaviours among different ethnic groups that may have some bearing on municipalities with particular race and ethnicity profiles, but specific effects can
be hard to determine as impacts of race and ethnicity are closely linked to issues of socio-economic inequality (Johnson, Bowker, and Cordell 2004; Lakhan 2015). However, these factors are still useful to consider, especially in adding greater nuance to discussing the impact of income and education on the adoption of municipal composting programs.

### 2.3 Massachusetts as a Case Study for Analysis

In order to test these hypotheses about the adoption of municipal composting schemes, Massachusetts was selected as a case study for analysis. It is clear from the review of studies surrounding municipal composting that there is a need for more studies that are targeted at the level of towns and cities, especially within the confines of a similar state environment. Massachusetts provides a sufficiently diverse range of municipalities that exhibit different socio-economic and waste system characteristics, while still allowing for comparability in terms of a similar policy environment and regulations (see Section 2.4 for descriptive demographic statistics of Massachusetts municipalities, and Appendix A for 2010 U.S. Census Profile of Massachusetts).

Massachusetts also stands a particularly good case study for analysis due to the presence of robust and publicly accessible data on municipal waste management collected yearly by the Massachusetts Department of Environmental Protection (MassDEP). The MassDEP initiated this data collection effort to assist in the implementation of its 2010-2020 Solid Waste Master Plan, which targets a 30% reduction of waste disposal tonnage (around 2 million tons) by 2020 from 2008 levels (MassDEP 2018b). Specifically, for organic waste, the 2010-2020 Solid Waste Master Plan has set a target to divert 35% of source separated organics waste away from disposal by 2020, especially as organic waste constitutes a quarter of Massachusetts’ waste stream after recycling (MassDEP 2017). As a result, the MassDEP has survey data from the years 2010 to 2017 on the presence and type of waste diversion programs present in Massachusetts municipalities, including information on the amount of waste diverted from landfills and the frequency of waste collection.

In addition, Massachusetts has historically provided strong state-level support for municipalities in pursuing more sustainable forms of waste governance. There has been consistent
state-wide encouragement to municipalities to adopt organic waste diversion policies and implement municipal composting and/or other organics recycling programs. This has been achieved through legislation, grant and program financing, and also a transfer of composting knowledge to the public. In the 1990s, MassDEP supported Massachusetts residents in adopting home composting by providing compost bins at subsidized prices and conducting public training workshops on composting best practices (McGovern 1994). In the 2000s, the MassDEP also launched a program to divert supermarket organic waste towards composting, with MassDEP officials calling commercial organics “one of their priority materials” (Goldstein 2002).

More recently as part of the 2010-2020 Solid Waste Master Plan, the MassDEP implemented the Sustainable Materials Recovery Program (SMRP) in 2010, which is designed to increase the diversion of materials from the solid waste stream through providing grant financing and economic incentives for municipalities to implement reuse, recycling, and composting programs (MassDEP 2018a). Under the SMRP, municipalities can possibly earn payouts for providing residents with affordable compost bins and having curbside organics collection programs with strong educational components; in addition, they can apply for specific grants to purchase wheeled carts to pilot the curbside collection of compostable organics and food waste. Last but not least, in October 2014, the state banned the disposal of commercial organic wastes by businesses and institutions that dispose of one ton or more of such materials per week (Solid Waste Facility Regulations 2014; Commonwealth of Massachusetts 2019).

Municipalities in Massachusetts have demonstrated a growing interest in adopting municipal composting and organics recycling programs, responding positively to the MassDEP’s efforts: The number of municipalities offering such programs has also grown over time, though the modest increase indicates that the state-wide legislation of 2014 had limited impact in encouraging municipalities to adopt such programs at a residential level. Arguably, Massachusetts is only just beginning to strengthen its residential composting programs, especially with regards to food waste and larger-scale programs: to date, only 43 Massachusetts municipalities offer curbside or drop-off food waste collection. In order to support the expansion of municipal composting programs, the MassDEP also reported in 2016 that an additional increase of 150,000 tons of composting capacity is expected for Massachusetts (BioCycle 2018a). There are currently
also 34 sites in Massachusetts that accept diverted food waste material for composting (see Appendix D for MassDEP recognized sites and geographical distribution).

**Table 1.** MA Municipalities with food waste collection programs or compost bin distribution programs, 2010-2017. Data complied from annual MassDEP Municipal Solid Waste and Recycling Survey.

<table>
<thead>
<tr>
<th>Year</th>
<th>Drop-off food waste collection</th>
<th>Curbside food waste collection</th>
<th>Compost bin distribution programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>33</td>
<td>12</td>
<td>n/a</td>
</tr>
<tr>
<td>2011</td>
<td>16</td>
<td>5</td>
<td>141</td>
</tr>
<tr>
<td>2012</td>
<td>13</td>
<td>3</td>
<td>130</td>
</tr>
<tr>
<td>2013</td>
<td>14</td>
<td>4</td>
<td>131</td>
</tr>
<tr>
<td>2014</td>
<td>15</td>
<td>9</td>
<td>147</td>
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<tr>
<td>2015</td>
<td>22</td>
<td>12</td>
<td>147</td>
</tr>
<tr>
<td>2016</td>
<td>25</td>
<td>10</td>
<td>142</td>
</tr>
<tr>
<td>2017</td>
<td>34</td>
<td>12</td>
<td>144</td>
</tr>
</tbody>
</table>

This makes Massachusetts ideal for evaluating if local waste systems and socio-economic characteristics hold strong sway in the face of a state clearly wanting to transition to more sustainable waste governance focused on diversion and resource recovery. Furthermore, taking Massachusetts as a case study also has the added benefit of creating relevant insights for a state looking to craft a new vision for solid waste management for the next 10 years. The MassDEP is currently engaged in stakeholder discussions aimed at creating a robust 2020 – 2030 Solid Waste Master Plan, including updating their strategies for promoting organics recycling and municipal composting amongst small businesses and residents (MassDEP 2019c, 2019e). Results from this analysis would thus be timely and provide guidance for targeted approaches to expand municipal composting schemes.
2.4 Data and Methods

As my goal is to test hypotheses and identify factor-based associations in the Massachusetts municipalities that have adopted municipal composting and organic waste collection programs, I employ logistic regression analysis. Logistic regression creates statistical models that relate continuous or categorical independent variables to a binary dependent outcome (represented by 0 or 1, with 1 determining the outcome of interest). Such analysis allows us to determine if particular independent predictor variables are of statistical significance, the relative magnitude of coefficients, and the direction of association (Hosmer, Lemeshow, and Sturdivant 2013; Harrell 2015). Logistic regression analysis also contributes towards understanding the best combination of values taken by the predictor variables that would result in the maximum likelihood of the outcome of interest, and allows for such results to be translated into odds ratios and predicted probabilities for easier understanding.

Data on municipalities, residential municipal composting programs, and general waste system statistics for each Massachusetts municipality were gathered from the Municipal Solid Waste and Recycling Survey conducted by the MassDEP. Conducted annually since 2009, survey responses are publicly available from MassDEP’s website (MassDEP 2019d). For the regression analyses, the most recent dataset from 2017 was utilized. Out of a total number of 352 municipalities in Massachusetts, 283 municipalities responded to the MassDEP survey in 2017. All 283 municipalities are included in the sample dataset for analysis; municipalities with incomplete or non-responses were excluded.

In this particular case, the binary outcomes examined are whether a Massachusetts municipality has a residential-based municipal composting program in place. Based on the available data, four major categories of municipal composting programs were chosen as binary response variables for analysis:

1. Having any food waste collection program, which is a combination of (2) and (3)
2. Having a curbside food waste collection program
3. Having a drop-off food waste collection program
4. Having a compost bin distribution program
The overall distribution of Massachusetts municipalities with such composting programs in 2017 can be found in Table 2. Table 2 also bins the distribution of these programs by municipality population size, to account for the potential effect of total population on the adoption of such programs and to check for sample diversity. It can be seen that besides municipalities who fall within the 50,000-100,000 population size, food waste collection programs are distributed across municipalities of all sizes. This is even more so for compost bin distribution programs.

Table 2. Sample distribution of composting programs by population stratum, including responses to MassDEP 2017 Municipal Solid Waste and Recycling Survey. Municipalities that did not respond to the survey were excluded.

<table>
<thead>
<tr>
<th>Population Size</th>
<th>Municipalities</th>
<th># of Municipalities with</th>
<th>Food Waste Collection</th>
<th>Drop-off Food Waste Collection</th>
<th>Curbside Food Waste Collection</th>
<th>Compost Bin Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5,000</td>
<td>78</td>
<td>11</td>
<td>11</td>
<td>0</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>5,000 – 10,000</td>
<td>52</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>10,000 – 25,000</td>
<td>84</td>
<td>11</td>
<td>9</td>
<td>3</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>25,000 – 50,000</td>
<td>47</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>50,000 – 100,000</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>&gt;100,000</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>283</td>
<td>43</td>
<td>34</td>
<td>12</td>
<td>142</td>
<td></td>
</tr>
</tbody>
</table>

Drawing upon previous studies related to the adoption of municipal composting programs and the previously determined hypotheses in Section 2.2, a set of waste system and socio-economic variables were gathered for Massachusetts municipalities, and deemed the independent variables for regression analysis. Many of these independent variables are similar to the most recent study conducted by Pollans, Krones, and Ben-Joseph (2017), to allow for closer comparison with their research findings.
The three binary waste system variables evaluated are whether or not each municipality has curbside recycling, curbside yard waste collection, and a pay-as-you-throw (PAYT)/Save-money-and-reduce-trash (SMART) program. Table 3 provides descriptive statistics for these waste system variables, which were also gathered from the 2017 Municipal Solid Waste and Recycling Survey conducted by the MassDEP. While the presence of waste diversion goals was included in the regression analysis conducted by Pollans, Krones, and Ben-Joseph (2017), this factor was omitted. This is on the basis that the MassDEP has set waste diversion goals for the entire state regarding organics; in addition, the previous study has found waste diversion goals to be an insignificant factor influencing the adoption of food scrap collection programs (MassDEP 2017; Lily Baum Pollans, Krones, and Ben-Joseph 2017).


<table>
<thead>
<tr>
<th>Variable</th>
<th># of Municipalities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With</td>
</tr>
<tr>
<td>Curbside recycling</td>
<td>140</td>
</tr>
<tr>
<td>Curbside yard waste collection</td>
<td>176</td>
</tr>
<tr>
<td>Pay-as-you-throw (PAYT) / Save-money-and-reduce-trash (SMART) program</td>
<td>147</td>
</tr>
</tbody>
</table>

As for socio-economic and demographic factors, a total of eleven independent variables were evaluated. Data for these factors were drawn from American Community Survey (ACS) 5-year estimates (2013-2017). Descriptive statistics for these demographic variables are found in Table 4, alongside source codes for ACS data tables. These demographic variables were then treated as continuous dependent variables for regression analysis. This includes the six demographic factors analyzed by Pollans, Krones, and Ben-Joseph (2017), which were previously hypothesized to have associations with the adoption of municipal composting schemes: median household income, total population, population density, housing type (percentage of single-family households), median age, and educational attainment (percentage of population with bachelor’s degree).
Five additional demographic variables were included: measures relating to race/ethnicity (percentage of population being white alone or in combination with other races, percentage of population who speak a language other than English), income inequality (Gini index), median housing value, and home ownership (percentage of owner-occupied housing units). These independent variables were added owing to the demonstrated need for more research that accounts for effects related to race and ethnicity; moreover, any environmental policy need be mindful that it may pan out differently in highly unequal social environments. Housing value and ownership has also been demonstrated to have some influence on pro-environmental behavior. Municipalities and residents may be in favor of such sustainable waste policies if it safeguards housing values, and homeownership has also been found to increase pro-recycling behavior, which may similarly translate to the adoption of municipal composting practices (Ferrara and Missios 2005; Fischel 2009).

For each response variable, two sets of logistic regression analyses were run, producing two separate models for analysis. The first model attempts to closely replicate the regression model developed by Pollans, Krones, and Ben-Joseph (2017), and utilizes similar independent variables as predictors for analysis. The second model utilizes only the five additional socio-economic demographic variables (bolded in Table 4) as predictors for the regression analysis. The independent variables used for both models are shown below in Table 5; both models assume no interaction between predictors. All statistical analyses were run in R version 3.3.2.

There are two major statistical issues that need be accounted for in pursuing logistic regression analysis. Firstly, regression analyses work best when the data is normally distributed. As such, in order to minimize the effect of positively skewed independent variables, the most positively skewed variables of median income, total population, population density, and median housing value were logarithmically transformed for the regression analysis.
Secondly, regression analyses that include multiple variables run the risk of being affected by multicollinearity, where the variables themselves are correlated with one another. This is a cause of concern for this analysis, especially as there is literature supporting correlations between socio-economic factors such as median household income and educational attainment to the adoption of waste policies and infrastructure such as PAYT and curbside recycling (Callan and Thomas 1999; Seacat and Boileau 2018; Gradus et al. 2019). To evaluate the potential effects of multicollinearity, the regression analyses were also run with just one set of variables (socio-economic vs waste system) at a time. While there were small differences in coefficient magnitudes and measures of statistical significance, there was no major difference in model performance; as such, no major adjustments to these models were made.

In addition, in order to allow for the regression coefficients to be compared on the same scale in the regression output, the continuous variables were standardized to have a mean of 0 and variance of 1. The standardized regression results are displayed in the regression tables in Section 2.5. In addition, for particular variables, predicted probability curves were generated to better visualize their associations with the probability of adopting municipal composting programs. These predicted probabilities in Section 2.5 reflect the values present in the dataset without standardization for a more realistic and intuitive interpretation of the results.
Table 4: Independent demographic variables: descriptive statistics. Includes national averages for comparison. Sources refer to tables from 2013 to 2017 American Community Survey 5-Year Estimates. Bolded italicized variables denote additional variables gathered.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (U.S.)</th>
<th>Sample Mean</th>
<th>Std Dev</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median income (dollars)</td>
<td>57,652</td>
<td>86,465</td>
<td>29,627</td>
<td>79,800</td>
<td>31,458</td>
<td>204,018</td>
<td>B19013</td>
</tr>
<tr>
<td>Total population (individuals)</td>
<td>n/a</td>
<td>21,221</td>
<td>45,503</td>
<td>11,680</td>
<td>86</td>
<td>669,158</td>
<td>B01003</td>
</tr>
<tr>
<td>Population density</td>
<td>90.9</td>
<td>1403.8</td>
<td>2511.5</td>
<td>628.4</td>
<td>6.3</td>
<td>19413.4</td>
<td>See note*</td>
</tr>
<tr>
<td>% Single-family households</td>
<td>67.5</td>
<td>75.9</td>
<td>18.0</td>
<td>81.1</td>
<td>14.5</td>
<td>99.8</td>
<td>B25024</td>
</tr>
<tr>
<td>Median age</td>
<td>37.8</td>
<td>44.6</td>
<td>6.0</td>
<td>44.4</td>
<td>21.4</td>
<td>61.5</td>
<td>B01002</td>
</tr>
<tr>
<td>% College degree (25 years and over)</td>
<td>19.1</td>
<td>24.3</td>
<td>7.3</td>
<td>24.5</td>
<td>7.9</td>
<td>41.1</td>
<td>S1501</td>
</tr>
<tr>
<td>% White alone or in combination with other races</td>
<td>73.0</td>
<td>89.3</td>
<td>10.3</td>
<td>92.7</td>
<td>39.8</td>
<td>100.0</td>
<td>B02001</td>
</tr>
<tr>
<td>Gini index</td>
<td>0.48</td>
<td>0.43</td>
<td>0.05</td>
<td>0.42</td>
<td>0.31</td>
<td>0.57</td>
<td>B19083</td>
</tr>
<tr>
<td>Median housing value (dollars)</td>
<td>193,500</td>
<td>377,638</td>
<td>177,025</td>
<td>333,100</td>
<td>108,000</td>
<td>1,198,400</td>
<td>B25077</td>
</tr>
<tr>
<td>% Owner-occupied housing units</td>
<td>63.8</td>
<td>76.9</td>
<td>14.0</td>
<td>80.5</td>
<td>28.4</td>
<td>99.5</td>
<td>S1101</td>
</tr>
<tr>
<td>% Speak a language other than English</td>
<td>15.1</td>
<td>12.2</td>
<td>11.0</td>
<td>8.90</td>
<td>0.6</td>
<td>77.9</td>
<td>S1601</td>
</tr>
</tbody>
</table>

*Population density variable was constructed by dividing the total population for each municipality (gathered from ACS Table B01003) by the corresponding geographic land area from 2010 Census Table GCT-PH1.
Table 5: Independent variables included in each logistic regression model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Continuous Variables</th>
<th>Binary (Yes/No) Variables</th>
</tr>
</thead>
</table>
| Model 1, adapted from Pollans, Krones, and Ben-Joseph (2017) | • Median income (log)  
• Total population (log)  
• Population density (log)  
• % Single-family households  
• Median age  
• % College degree  | • Curbside recycling  
• Curbside yard waste collection  
• Pay-as-you-throw (PAYT) / Save-money-and-reduce-trash (SMART) program |
| Model 2, own choice of socio-economic variables | • % White alone or in combination with other races  
• Gini index  
• Median housing value (log)  
• % Owner-occupied housing units  
• % Speak a language other than English |
2.5 Results and Discussion of Logistic Regression Analysis

This following section reports the most notable findings from the analysis, and compares them with the hypothesized relationships garnered from the literature review. Table 6 provides a concise summary of all variables included in the analysis, denoting which factors were found as significant, as well as the direction and magnitude of significance. The full results of the logistic regression for Models 1 and 2 are reported in Tables 7 to 14, and include the estimated coefficients, standard error, Z value and P values for each variable included in the analysis.

An overview of key findings are as follows:

1. The results from Model 1 support the notion that pre-existing waste collection infrastructure remains key to whether a municipality would shift to more sustainable waste policies, but disagree much of the literature around PAYT schemes encouraging municipal composting program adoption (Layzer and Schulman 2014).

2. Waste system variables prove more important that socio-economic variables within Model 1. The socio-economic variables included in Model 1 are generally poor predictors of municipal composting program adoption, supporting the argument made by Pollans, Krones, and Ben-Joseph (2017) that any municipality of all demographic characteristics could move to adopt municipal composting programs.

3. The socio-economic variables included as part of Model 2 reveal concerns over inequality and housing value that should be taken into account.

The findings also demonstrate that different types of municipal composting program are associated with different sets of independent waste system and socio-economic variables. Apart from education and median housing value, it is difficult to find predictors that are consistently significant across composting program type. This prompts a larger discussion in Chapter 3 regarding on-ground program implementation realities, and the need for municipalities to consider whether particular program types are suitable for their municipality given local characteristics.
Table 6: Summary of regression results by factor and municipal composting program type. Blue pluses denote factors that had positive associations with the type of municipal composting program, red minuses denote factors that had negative associations. Tildes (~) denote that the factor had no or insignificant association.

<table>
<thead>
<tr>
<th>Model</th>
<th>Factor</th>
<th>Any food waste collection</th>
<th>Curbside food waste collection</th>
<th>Drop-off food waste collection</th>
<th>Compost bin distribution program</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Waste System Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Curbside recycling</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Curbside yard waste</td>
<td>~</td>
<td>+</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>PAYT</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Socio-economic Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median income</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Total population</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Population density</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>% Single-family households</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Median age</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>% College degree</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>Additional Socio-economic Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>% White alone or in combination with other races</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Gini index</td>
<td>+</td>
<td>~</td>
<td>+</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>Median housing value</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>% Owner occupied housing units</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td></td>
<td>% Speak a language other than English</td>
<td>~</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
</tbody>
</table>

2.5.1 Waste System Variables from Model 1

Under Model 1, the existence of a curbside recycling program was found to have a significant negative association with the adoption of any food waste collection program (Table 7). This was likely driven by the significantly negative association of curbside recycling with drop-off food collection programs, an unsurprising finding given that 27 out of the 34 municipalities with drop-off programs do not have curbside recycling in place. While one can also likely interpret this as municipalities with curbside recycling gravitating towards adopting curbside food waste collection programs instead, curbside recycling shows no significant association with the adoption of curbside food waste collection programs (Table 8). This indicates that recycling and composting programs are more perhaps more difficult to integrate than expected.
In contrast, the presence of curbside yard waste collection has a strong positive association with the adoption of curbside food waste program; again, this is not surprising given that 11 out of the 12 municipalities with curbside food waste collection programs also offer curbside yard waste collection. This stands in contrast to what was reported in the Pollans, Krones, and Ben-Joseph (2017) study, where yard waste collection was not found to be significant in aiding the adoption of curbside food waste collection programs, however, it is very much in line with the findings of Layzer and Schulman (2014). Together with the results on curbside recycling, it appears that the type of material collected matters. It is likely easier to integrate curbside food scrap pickup with yard waste collection, as both constitute organic feedstock for composting and may possibly be processed at the same composting facility. On the contrary, the collection of recyclables entails other inorganic materials like plastic, which differs from the processing needs of organic material.

Surprisingly, PAYT did not emerge as a significant factor aiding municipalities in the adoption of any municipal composting program. This stands in marked contrast to much of the literature, which argue that PAYT schemes generally support the adoption of waste diversion initiatives such as recycling and municipal composting (Callan and Thomas 1997; Sidique, Joshi, and Lupi 2010; Platt, Goldstein, and Coker 2014; Layzer and Schulman 2014; Starr and Nicolson 2015; Lily Baum Pollans, Krones, and Ben-Joseph 2017). It is possible that the results support the argument that PAYT schemes only work to reduce trash tonnage (which is not examined in this work), and that diverting waste towards municipal composting takes an additional behavioural and economic push (Jenkins et al. 2003). This is especially so as over 50% of Massachusetts municipalities already have PAYT schemes in place (Table 4).

Importantly, none of these waste system factors were found to have significant associations with the adoption of compost bin distribution programs. This suggests that compost bin distribution programs, by virtue of needing minimal municipal-scale infrastructural investment, can be easily implemented in municipalities regardless of the existing waste system in place. Yet, the stagnation in the year-to-year growth of compost bin distribution programs over time shown in Table 2 points to the possibility of other factors at play preventing compost bin distribution programs from further proliferating. One possibility could be the lack of
grant funding to kickstart these programs: it is noted that most of the push for subsidized compost bin distribution came in the 1990s to 2000s, with the most recent large-scale MassDEP grant funding for compost bins ending in 2008 (McGovern 1994, 1997, 2000; MassDEP 2019b).

### 2.5.2 Socio-Economic Variables from Model 1

Among the socio-economic variables evaluated in Model 1, **only educational attainment** – as represented by the percentage of people in the municipality having a college degree – **was significant across all types of municipal composting programs.** This is consistent with the findings of Pollans, Krones, and Ben-Joseph (2017), who note that higher educational attainment is modestly positively correlated with the adoption of food scrap collection programs. Such a result is also unsurprising as higher educational attainment in a population has been found to promote pro-environmental behaviours and policies in a municipality (Callan and Thomas 1997; Jenkins et al. 2003; Ferrara and Missios 2005; Callan and Thomas 2006). Furthermore, as municipal composting programs require a significant amount of public outreach and education in order for them to be successful, it is likely that municipalities with population that is more highly educated would be more willing and able to succeed in implementing municipal composting programs (Platt, Goldstein, and Coker 2014; Layzer and Schulman 2014).

Notably, for both curbside and drop-off food waste collection programs, there appears to be a threshold which needs to be crossed before educational attainment has effects on **increasing the probability of program adoption.** This can be seen from converting the regression results into predicted probability curves in Figure 5. These curves were generated by fitting a sequence of values for educational attainment into Model 1, holding all other continuous socio-economic variables at the median value and assuming all binary waste system variables are present. The y-axis represents the probability a municipality will adopt the municipal composting program, with 1 being the highest probability (100%). The x-axis represents the range of actual values for educational attainment. In the interest of comparing them with the actual sample distribution, these curves are overlaid above the actual distribution of educational attainment values and program adoption by Massachusetts municipalities, with municipalities plotted at 1 on
the y-axis having a program in place, and municipalities plotted at 0 not having a program. Data points are also jittered by a factor of 0.25 in interest of clear visualization.

**Besides compost bin distribution programs, the probability of food waste collection program adoption is near zero for much of the range, and only increases as the percentage of the population with a college degree becomes quite high (above the sample median of 24.3%).** An increase in educational attainment leads to the sharpest increase in the predicted probability of adopting of a curbside food waste collection program. This is likely due to most of the current Massachusetts municipalities with curbside collection of food waste having a relatively high percentage of its population with a college degree (see data points in Figure 5). In comparison, this increase in predicted probability is much more gentle for drop-off programs, suggesting that other factors beyond educational attainment hold more sway.

Only two other socioeconomic variables stand out as somewhat significant for specific composting programs. Median income has a marginally statistically significant (P = 0.088) negative association with the adoption of drop-off food waste collection programs (Table 9). **It is possible that as noted by Callan and Thomas (1997), higher income municipalities have less economic incentive to pursue waste diversion policies.** In this case, residents can afford to trash food waste, instead of having to bear the inconvenience and costs of travelling just to drop off food waste at designated sites – a behavior that was previously observed with drop-off recycling sites (Sidique, Lupi, and Joshi 2010).

Population density also has a slight negative association with compost bin distribution programs (Table 10). It is also notable that population density shows no association with drop-off and curbside food waste collection programs (Tables 7, 8 and 9). This goes against some conventional wisdom that drop-off and curbside organics collection programs require certain economies of scale that heightened population density can provide (Porter 2002). **I hypothesize that these findings about population density are likely due to the structure of how these municipal composting programs are implemented – they are usually pilots and involve a smaller subset of the municipality’s total population.** This will be elaborated on in Chapter 3.
Figure 5: Plots of predicted probabilities for municipal composting program adoption under Model 1 for municipalities with a variable percentage of its population having a college degree, with other continuous socio-economic variables held at the median value of the sample, and all categorical waste system variables being present. Curves are plotted on top of the actual distribution of % college degree values (x-axis) and program adoption by Massachusetts municipalities in the dataset (y-axis, 1 = program present, 0 = program absent).
Table 7: Results of the logistic regressions for Model 1, with the dependent variable being the municipality having any sort of food waste collection program (curbside and/or drop-off).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Any Food Waste Collection Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.529</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>Median income (log)</td>
<td>-0.478</td>
</tr>
<tr>
<td>Total population (log)</td>
<td>0.065</td>
</tr>
<tr>
<td>Population density (log)</td>
<td>0.407</td>
</tr>
<tr>
<td>% Single-family households</td>
<td>-0.110</td>
</tr>
<tr>
<td>Median age</td>
<td>0.104</td>
</tr>
<tr>
<td>% College degree</td>
<td><strong>1.138</strong></td>
</tr>
<tr>
<td><strong>Waste system</strong></td>
<td></td>
</tr>
<tr>
<td>Curbside recycling</td>
<td>-2.150</td>
</tr>
<tr>
<td>Curbside yard waste collection</td>
<td>1.035</td>
</tr>
<tr>
<td>Pay-as-you-throw (PAYT) / Save-money-and-reduce-trash (SMART) program</td>
<td>0.155</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Table 8: Results of the logistic regressions for Model 1, with the dependent variable being the municipality having a curbside food waste collection program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Curbside Food Waste Collection Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-6.861</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>Median income (log)</td>
<td>0.680</td>
</tr>
<tr>
<td>Total population (log)</td>
<td>-0.865</td>
</tr>
<tr>
<td>Population density (log)</td>
<td>-0.122</td>
</tr>
<tr>
<td>% Single-family households</td>
<td>-0.934</td>
</tr>
<tr>
<td>Median age</td>
<td>-0.014</td>
</tr>
<tr>
<td>% College degree</td>
<td><strong>1.540</strong></td>
</tr>
<tr>
<td><strong>Waste system</strong></td>
<td></td>
</tr>
<tr>
<td>Curbside recycling</td>
<td>0.447</td>
</tr>
<tr>
<td>Curbside yard waste collection</td>
<td><strong>3.021</strong></td>
</tr>
<tr>
<td>Pay-as-you-throw (PAYT) / Save-money-and-reduce-trash (SMART) program</td>
<td>0.303</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001
Table 9: Results of the logistic regressions for Model 1, with the dependent variable being the municipality having a drop-off food waste collection program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Drop-off Food Waste Collection Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.355</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>Median income (log)</td>
<td>-0.581</td>
</tr>
<tr>
<td>Total population (log)</td>
<td>0.210</td>
</tr>
<tr>
<td>Population density (log)</td>
<td>0.461</td>
</tr>
<tr>
<td>% Single-family households</td>
<td>-0.249</td>
</tr>
<tr>
<td>Median age</td>
<td>0.231</td>
</tr>
<tr>
<td>% College degree</td>
<td><strong>1.003</strong></td>
</tr>
<tr>
<td><strong>Waste system</strong></td>
<td></td>
</tr>
<tr>
<td>Curbside recycling</td>
<td>-2.628</td>
</tr>
<tr>
<td>Curbside yard waste collection</td>
<td>0.278</td>
</tr>
<tr>
<td>Pay-as-you-throw (PAYT) / Save-money-and-reduce-trash (SMART) program</td>
<td>0.065</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Table 10: Results of the logistic regressions for Model 1, with the dependent variable being the municipality having a compost bin distribution program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Compost Bin Distribution Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.440</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>Median income (log)</td>
<td>-0.264</td>
</tr>
<tr>
<td>Total population (log)</td>
<td>0.457</td>
</tr>
<tr>
<td>Population density (log)</td>
<td><strong>-0.995</strong></td>
</tr>
<tr>
<td>% Single-family households</td>
<td>-0.168</td>
</tr>
<tr>
<td>Median age</td>
<td>-0.294</td>
</tr>
<tr>
<td>% College degree</td>
<td><strong>0.692</strong></td>
</tr>
<tr>
<td><strong>Waste system</strong></td>
<td></td>
</tr>
<tr>
<td>Curbside recycling</td>
<td>0.162</td>
</tr>
<tr>
<td>Curbside yard waste collection</td>
<td>0.677</td>
</tr>
<tr>
<td>Pay-as-you-throw (PAYT) / Save-money-and-reduce-trash (SMART) program</td>
<td>0.244</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001
2.5.3 Predicted Probabilities within Varying Waste System Conditions

What is clear from the logistic regression analysis of Model 1 is that waste system variables hold greater influence than socio-economic variables on the adoption of food waste collection programs. This can be seen both from larger co-efficient sizes for the significant waste system variables in comparison with the socio-economic variables, and from looking at changes in the predicted probabilities of program adoption under different waste system conditions. The latter can be achieved by adjusting the model for either the presence or the absence of the binary independent waste system variables of curbside recycling, curbside yard waste collection, and a PAYT scheme. Figure 6 illustrates these changes in predicted probabilities under four different municipality conditions, plotted along a range of educational attainment values:

1. Three waste system variables are all present (Blue)
2. Three waste system variables are all absent (Red)
3. Curbside recycling collection present, other system variables absent (Green)
4. Curbside yard waste collection present, other system variables absent (Purple)

Looking specifically at curbside and drop-off food waste collection programs, there are pronounced differences in the predicted probabilities between these different scenarios in Figure 6. In the case of curbside food waste collection programs, the predicted probability under the condition where none of the waste system variables are present is extremely low. However, under the conditions of just having curbside yard waste collection, the predicted probability of a municipality adopting a curbside program is much higher in comparison, especially at higher levels of educational attainment. For drop-off programs, the difference in predicted probabilities between the scenario where all three waste system variables are present and where only curbside yard waste collection is substantial, which points to the strong negative association of curbside recycling with drop-off programs.

Notably, these differences in predicted probabilities under different waste system conditions prompt a re-evaluation of the logistic regression models. The models used for this regression are additive models, that is, it does not account for interactions between variables. It is
possible for future works to fit regression models that include interactions between socio-economic variables and waste system variables or between waste system variables themselves; however, in this work, as the aim was more to discover factor associations than to produce a good model, adjusting the models and accounting for goodness of fit was not pursued.

2.5.4 Socio-economic and Demographic Determinants from Model 2

In the case of the socio-economic variables evaluated as part of Model 2, median housing value appears as a significant factor across all municipal composting program types (Tables 12, 13, 14, and 15). Looking at the predicted probability curves in Figure 7, an increase in a municipality’s median housing value leads to a sharp increase in the probability of a municipality adopting a composting program of any type, assuming that all other socio-economic variables are set at the median value of the sample dataset. As these predicted probability curves are overlaid on the actual distribution of the data set, it is noted that municipalities that have food waste curbside collection programs have a relatively narrower range of median housing values than for compost bin distribution programs or drop-off programs. Based on the co-efficient sizes, high median housing values also have a stronger association with increasing the probability of adoption for curbside food waste collection programs than all other municipal composting programs; this points to the increased complexity of implementing curbside food waste collection programs.

These findings support the hypothesis that in places where housing values are high, residents would be in favor of implementing policies that protects this housing value, which includes pro-environmental initiatives (Ferrara and Missios 2005; Fischel 2009). Furthermore, it is likely that the higher median housing values indicate that the municipality has greater fiscal capabilities through property tax revenues, which can prove crucial in terms of a municipality financing municipal composting programs.

Income inequality, as represented by the Gini index score, was found to have a positive association with the adoption of drop-off programs. The effect of income inequality is less pronounced for curbside food waste collection programs and compost bin distribution programs; we can also see in Figure 8 that municipalities with such programs span a wider range
of values for their Gini index scores. It is also interesting to contextualize this with the finding from Section 2.5.2 that high median income has a slightly negative association with the adoption of drop-off programs (Table 9).

These results warrant further investigation: while it is not immediately clear what the full effect of income inequality is, the fact that drop-off programs function in places of high income inequality should prompt affordability and accessibility concerns, and lead us to ask questions about who are willing and able participants of such programs. Moreover, there is a need to disentangle the relationships between median housing value, median income, and income inequality – all of which can have an impact on the adoption of municipal composting programs. In addition, measures of income inequality may also be impacted by population density or other socio-economic factors. As it is also unclear whether these observations are part of the transition to adopting municipal composting programs or persist as pertinent issues years after the program is first instituted, more research can also be done to look more closely at the implementation of municipal composting programs over multiple years. This also motivates using a case study approach to capture the complexity of these variables’ associations with municipal composting programs, which will be further explored in Chapter 3.

Three other socio-economic factors show a negative association with the adoption of compost bin distribution programs: the percentage of population who are white, and the percentage of owner-occupied housing units, and the percentage of the population that speaks a language other than English. **In the case of language, this association indicates that compost bin distribution programs might face more implementation difficulties in implementation in municipalities with more diverse populations, and point to the need for sensitive educational outreach around compost bin distribution programs that take language and culture into account** (Layzer and Schulman 2014). It is unclear why a higher percentage of a municipality’s population being white and higher home ownership results in negative associations with the implementation of compost bin distribution programs.
**Figure 6:** Plots of predicted probabilities under Model 2, for municipalities with a variable percentage of its population having a college degree, with other continuous socio-economic variables held at the median value of the sample. Categorical waste system variables were toggled to create different predictions (see figure legend). Curves are plotted on top of the actual distribution of % college degree values (x-axis) and program adoption by Massachusetts municipalities in the dataset (y-axis, 1 = program present, 0 = program absent).
Figure 7. Plots of predicted probabilities under Model 2, for municipalities with a variable log median housing value, with other continuous socio-economic variables held at the median value of the sample. Curves are plotted on top of the log distribution of median housing values (x-axis) and program adoption by Massachusetts municipalities in the dataset (y-axis, 1 = program present, 0 = program absent).
Figure 8: Plots of predicted probabilities under Model 2, for municipalities with a variable Gini index, with other continuous socio-economic variables held at the median value of the sample. Curves are plotted on top of the actual distribution of Gini index scores (x-axis) and program adoption by Massachusetts municipalities in the dataset (y-axis, 1 = program present, 0 = program absent).
Table 11: Results of the logistic regressions for Model 2, with the dependent variable being the municipality having any sort of food waste collection program (curbside and/or drop-off).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Any Food Waste Collection Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.113</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>% White alone or in combination with other races</td>
<td>0.265</td>
</tr>
<tr>
<td>Gini index</td>
<td><strong>0.792</strong></td>
</tr>
<tr>
<td>Median housing value (log)</td>
<td><strong>0.581</strong></td>
</tr>
<tr>
<td>% Owner-occupied housing units</td>
<td>-0.240</td>
</tr>
<tr>
<td>% Speak a language other than English</td>
<td>-0.152</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Table 12: Results of the logistic regressions for Model 2, with the dependent variable being the municipality having a curbside food waste collection program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Curbside Food Waste Collection Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-3.923</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>% White alone or in combination with other races</td>
<td>0.596</td>
</tr>
<tr>
<td>Gini index</td>
<td>0.458</td>
</tr>
<tr>
<td>Median housing value (log)</td>
<td><strong>1.013</strong></td>
</tr>
<tr>
<td>% Owner-occupied housing units</td>
<td>-0.668</td>
</tr>
<tr>
<td>% Speak a language other than English</td>
<td>0.130</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001
Table 13: Results of the logistic regressions for Model 2, with the dependent variable being the municipality having a drop-off food waste collection program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Drop-off Food Waste Collection Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.340</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>% White alone or in combination with other races</td>
<td>0.169</td>
</tr>
<tr>
<td>Gini index</td>
<td><strong>0.700</strong></td>
</tr>
<tr>
<td>Median housing value (log)</td>
<td><strong>0.477</strong></td>
</tr>
<tr>
<td>% Owner-occupied housing units</td>
<td>-0.299</td>
</tr>
<tr>
<td>% Speak a language other than English</td>
<td>-0.338</td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Table 14: Results of the logistic regressions for Model 2, with the dependent variable being the municipality having a compost bin distribution program.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Compost Bin Distribution Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.016</td>
</tr>
<tr>
<td><strong>Socioeconomic</strong></td>
<td></td>
</tr>
<tr>
<td>% White alone or in combination with other races</td>
<td><strong>-0.613</strong></td>
</tr>
<tr>
<td>Gini index</td>
<td>0.037</td>
</tr>
<tr>
<td>Median housing value (log)</td>
<td><strong>0.313</strong></td>
</tr>
<tr>
<td>% Owner-occupied housing units</td>
<td><strong>-0.562</strong></td>
</tr>
<tr>
<td>% Speak a language other than English</td>
<td><strong>-0.970</strong></td>
</tr>
</tbody>
</table>

^ p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001
Chapter 3: Advancing Municipal Composting in Massachusetts and Beyond

3.1 Targeted Municipalities for Expanding Curbside and Drop-Off Programs

3.2 Case Studies of Municipal Composting in Massachusetts

3.3 Key Considerations for Advancing Municipal Composting

**Key Insights:**

1. The findings from the regression analysis prove useful in crafting identifying municipalities where curbside and drop-off programs can be implemented.

2. There are other factors not captured in the regression analysis that are highlighted by the case studies as important in the adoption of municipal composting schemes: having nearby composting facilities in the region, partnering with commercial composters, and the provision of state grant funding in initiating these programs.

3. Municipal officials who wish to implement municipal composting programs should be conscious of their municipality’s socio-economic and waste system characteristics in order to better gear the programs towards success.

4. Municipal governments should embrace less hierarchical modes of governing municipal solid waste, and work together with citizens and commercial composters to promote the adoption of municipal composting schemes.
3.1 Targeted Municipalities for Expanding Curbside and Drop-Off Programs

The analyses in Chapter 2 highlight particular socio-economic and waste system characteristics that would favor the adoption of municipal composting programs. Using the results of the analysis, it is possible to identify and recommend which municipalities in Massachusetts would be best suited toward adopting such programs in the next few years. This is especially true with regards to the development of curbside and drop-off food waste collection programs, as these programs are currently adopted by a small minority of municipalities in the state. These recommendations are contextualized with existing waste management developments in these municipalities: are there discussions in these municipalities about implementing such programs, or are there pilot programs that have already been put in place? Doing so also helps verify if the findings from Chapter 2 prove useful in making such targeted recommendations.

3.1.1 Recommended Municipalities for Curbside Food Waste Collection Programs

Table 1 provides a list of 10 municipalities which would be suited towards implementing curbside food waste collection programs. As informed by the variable associations identified in Section 2.5, this list was created based on a combination of municipalities with the highest median housing values, have existing curbside yard waste collection services, and an above average percentage of its population having a bachelor’s degree (above sample median of 24.5%).

Amongst this list of municipalities, four municipalities (Newton, Belmont, Somerville and Sharon) have considered, aimed to expand, or are preparing to launch curbside composting pilots. This demonstrates that these municipalities show an appetite for curbside food waste collection, and that the factors highlighted in Chapter 2 – in particular, high median housing value and the presence of curbside yard waste collection services – serve as useful characteristics in identifying which municipalities would be best suited towards implementing curbside food waste collection programs in the future.
The presence of other private services for curbside collection of food waste must also be emphasized: apart from Westwood, residents in all of these municipalities already have the option of getting curbside food waste collection services from a private composter, regardless of whether the municipality eventually moves towards operating a municipal curbside food waste collection program. This further shows that partnering with private composters is a possible route forward for municipalities aiming to implement such programs, especially within the context of strong public interest and action from non-profits. This is similarly noted by Layzer and Schulman (2014) in their review, who argue that non-profit partnerships can promote a culture of composting amongst residents that provides a firm foundation for transitioning to municipally-backed programs. A prime example of this is the Town of Belmont, where the Belmont Composts! project by a local non-profit The Belmont Food Collaborative has been integral in getting residents to enroll in curbside composting services operated by commercial composters such as Black Earth Compost (Tzouvelis 2018).

Table 15. Recommended Municipalities for Curbside Food Waste Collection Programs.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>% College Degree</th>
<th>Median housing value (dollars)</th>
<th>Curbside Yard Waste?</th>
<th>Progress?</th>
<th>Private curbside composter offering curbside pickup?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newton</td>
<td>29.2</td>
<td>845100</td>
<td>Yes</td>
<td>Planning for a curbside composting pilot</td>
<td>Yes</td>
</tr>
<tr>
<td>Brookline</td>
<td>29.5</td>
<td>829300</td>
<td>Yes</td>
<td>No plan</td>
<td>Yes</td>
</tr>
<tr>
<td>Belmont</td>
<td>26.6</td>
<td>759500</td>
<td>Yes</td>
<td>Citizen-led movement to encourage residents to enroll with private curbside composters</td>
<td>Yes</td>
</tr>
<tr>
<td>Westwood</td>
<td>36.7</td>
<td>663000</td>
<td>Yes</td>
<td>No plan</td>
<td>No</td>
</tr>
<tr>
<td>Bedford</td>
<td>29.5</td>
<td>605900</td>
<td>Yes</td>
<td>No plan</td>
<td>Yes</td>
</tr>
<tr>
<td>Andover</td>
<td>34.5</td>
<td>603700</td>
<td>Yes</td>
<td>No plan</td>
<td>Yes</td>
</tr>
<tr>
<td>Milton</td>
<td>31</td>
<td>558700</td>
<td>Yes</td>
<td>No plan</td>
<td>Yes</td>
</tr>
<tr>
<td>Somerville</td>
<td>31.8</td>
<td>558300</td>
<td>Yes</td>
<td>Has had discussions on it and will be revisiting the viability of curbside composting this year; main concerns were about the cost of the program.</td>
<td>Yes</td>
</tr>
<tr>
<td>Nahant</td>
<td>27.7</td>
<td>548900</td>
<td>Yes</td>
<td>No plan</td>
<td>Yes</td>
</tr>
<tr>
<td>Sharon</td>
<td>31.7</td>
<td>518900</td>
<td>Yes</td>
<td>Citizen-led movement to encourage residents to enroll with Black Earth Compost for curbside collection</td>
<td>Yes</td>
</tr>
</tbody>
</table>
3.1.2 Recommended Municipalities for Drop-Off Food Waste Collection Programs

Table 2 provides a list of 10 municipalities who would be suited towards implementing drop-off food waste collection programs. As informed by the variable associations identified in Section 2.5, this list was created based on a combination of municipalities without curbside recycling collection and a sufficiently high percentage of its population having a bachelor’s degree (above sample median of 24.5%). In addition, because high median income was found to have a negative association with drop-off food waste collection programs, and high housing value a positive association, municipalities with a median income close to the sample median of $79,800 while having a high or average housing value were prioritized.

Amongst this list of municipalities, Rockport, Leyden and Aquinnah are the three municipalities who have made advances in adopting municipal composting schemes, with Leyden and Aquinnah having drop-off sites for food waste that are connected to regional solid waste management districts. This suggests that having a nearby organics processing site which serves a particular region may aid in helping to expand the adoption of drop-off food waste collection programs – an argument we will return to when looking at the example of municipalities in Franklin Country (see Section 3.2.3).
Table 16. Recommended Municipalities for Drop-off Food Waste Collection Programs.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>% College Degree</th>
<th>Median household income</th>
<th>Median housing value (dollars)</th>
<th>Curbside Recycling?</th>
<th>Progress?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rockport</td>
<td>29.9</td>
<td>72015</td>
<td>471800</td>
<td>No</td>
<td>No drop-off site, but Black Earth Compost offers private curbside collection</td>
</tr>
<tr>
<td>Ashfield</td>
<td>24.6</td>
<td>72422</td>
<td>274600</td>
<td>No</td>
<td>No plan</td>
</tr>
<tr>
<td>Harwich</td>
<td>26.7</td>
<td>73468</td>
<td>378900</td>
<td>No</td>
<td>No plan</td>
</tr>
<tr>
<td>New Marlborough</td>
<td>24.5</td>
<td>73750</td>
<td>360700</td>
<td>No</td>
<td>No plan</td>
</tr>
<tr>
<td>Williamsburg</td>
<td>25.5</td>
<td>75405</td>
<td>268100</td>
<td>No</td>
<td>No plan</td>
</tr>
<tr>
<td>Leyden</td>
<td>25.6</td>
<td>76771</td>
<td>264800</td>
<td>No</td>
<td>New drop-off program implemented in 2018 as part of Franklin County-wide push (see case study)</td>
</tr>
<tr>
<td>Deerfield</td>
<td>25.1</td>
<td>78949</td>
<td>281800</td>
<td>No</td>
<td>No plan</td>
</tr>
<tr>
<td>Aquinnah</td>
<td>34.1</td>
<td>80250</td>
<td>885400</td>
<td>No</td>
<td>Has a drop off program recently instituted in late 2017 as part of the Martha’s Vineyard Refuse District</td>
</tr>
<tr>
<td>Hull</td>
<td>27.3</td>
<td>80584</td>
<td>377000</td>
<td>No</td>
<td>No plan</td>
</tr>
<tr>
<td>Sturbridge</td>
<td>27.4</td>
<td>84745</td>
<td>284000</td>
<td>No</td>
<td>No plan</td>
</tr>
</tbody>
</table>
### 3.2 Case Studies of Municipal Composting in Massachusetts

While the regression analysis in Chapter 2 produces useful insights into how some waste system and socio-economic variables do impact and constrain the adoption of municipal composting schemes, it is important to recognize many municipalities have navigated around these barriers to implement sustainable programs. In addition, even though the analysis also suggests that waste system variables hold greater impact in determining the adoption of food waste collection programs, there are also cases where socio-economic variables can mitigate these effects. This section thus utilizes three case studies to tease out these complex interactions that can also impact r

The first two case studies relate to curbside food waste collection programs: The Town of Dover and the City of Salem have both adopted curbside food waste collection despite having vastly different socio-economic and waste system characteristics. The last case study relates to drop-off food waste collection programs within municipalities in Franklin County, whose municipalities have some of the lowest median housing values among Massachusetts municipalities. This section does not look at case studies for compost bin distribution programs, owing to such programs being more common in Massachusetts.

These case studies also highlight other factors influencing the adoption of municipal composting programs that cannot be fully captured via empirical methods. This includes the importance of state grant funding in kick-starting these programs, the increasing privatization and regionalization of food waste collection and processing services, and that program success depends on strong partnerships between municipal governments, commercial composters, and citizen groups.
3.2.1 Town of Dover

A relatively small municipality with only about 6000 residents, Dover has the highest median household income ($204,018) and median housing value ($1,006,800) amongst all Massachusetts municipalities with a curbside food waste collection program, and a high percentage of its population having a bachelor’s degree (37.9%). While its socio-economic characteristics are favorable for implementing food waste collection programs, from a waste system perspective, Dover has extremely unfavorable system conditions: it does not provide curbside yard waste and recycling collection nor offer a PAYT scheme for waste disposal. Moreover, in terms of pre-existing waste collection infrastructure, Dover does not offer any curbside pick up of trash (Town of Dover 2019b). Residents need pay to make arrangements with private hauling services such as Dover Trucking, which charges rates of $41 for trash services monthly, and $56.50 for combined recycling services (Calzolaio 2016). Residents can also personally drop off their trash and recyclables at no charge at the Dover Transfer Station.

Yet, despite these unfavorable waste system conditions, the Town of Dover started providing curbside collection of food waste in 2017 as part of a collaboration between the town’s Recycling Committee and the Board of Health (Dover Recycling Committee 2017). This was started on the basis of diverting waste away from being landfill. Most notably, curbside pickup is conducted weekly for residents at no cost – residents need only contact a point person from the Dover Board of Health to enroll in the program, and purchase pails and bins sold at the Dover Transfer Station specifically to store their food scraps (Town of Dover 2019a). To date, 230 families have enrolled in the curbside food waste collection program, and the Town of Dover also reports as part of the annual Municipal Solid Waste and Recycling Survey that a total of 57.2 tons of food waste was collected and composted in 2017 (Dover Recycling Committee 2017).

What can be learnt from municipalities like Dover is that favorable socio-economic characteristics can trump very unfavorable waste system characteristics, contrary what was found as part of the analysis in Chapter 2. High educational attainment likely contributes to Dover residents being more likely to engage in and demand more sustainable waste management practices, especially as Dover’s curbside food waste collection program function on voluntary enrollment:
the onus is on residents to see the program as beneficial, and to join in as part of the program. The high median housing value in Dover also increases the fiscal ability of the Town of Dover to fund a free curbside food waste collection services. Residents do not have to pay to partake in the program, save for small costs incurred in buying food waste collection pails and bins. Based on MassDEP information from the 2017 Municipal Solid Waste and Recycling Survey, Dover’s solid waste management program is funded by property taxes; the high median housing value likely allows the municipality to gain a sizeable amount of revenue from taxation that can finance waste management services.

While the ability to provide such services at low cost to residents improves the accessibility of such programs to residents, such a system is not something that many municipalities can afford, especially without the involvement of a private waste hauler or state grants. Notably in the case of Dover, the food waste collected might not actually be composted – the town points to these food scraps going to “help the local pig farmer” (Town of Dover 2019a). Arguably, owing to the municipality being relatively small and wealthy, Dover’s model of waste management demonstrates a waste hauling partnership that is not commercially driven, not operating at a regional scale, and very financially accessible to residents – which, as demonstrated in the following Salem case study – are the exception rather than the norm amongst municipalities who offer curbside food waste collection programs. This also makes the Dover case extremely difficult to replicate for many other municipalities, but suggests that in municipalities with high median housing values and a population with high educational attainment and high income should have little reason to hesitate in adopting a food waste curbside collection program, even in the face of unfavorable waste system characteristics.

3.1.2 City of Salem

In contrast with Dover, the City of Salem has the lowest percentage of its population having a bachelor’s degree (25.3%), median housing value ($331,300), and median household income ($65,528) among the Massachusetts municipalities with a curbside food waste collection program. While the city does provide curbside recycling and curbside yard waste collection services, based
on our regression analysis, its socio-economic factors are highly unfavorable for the implementation of a curbside food waste collection program. However, Salem has, since 2014, offered the curbside collection of food waste through a private-public partnership with Black Earth Compost, a commercial waste hauler and composter (Luca 2016). Moreover, as the municipality is partnering with a commercial composter, Salem’s program is also able to collect a wider range of organic material such as soiled paper products, beyond just purely food waste (Black Earth Compost 2019b). The program also allows some benefits for residents: residents who are part of the program are able to take home free compost at the end of a year’s participation in the program.

Salem’s implementation path for a curbside food waste collection program offers key lessons for other municipalities with unfavorable socio-economic characteristics but are looking to adopt such a program. As noted by Layzer and Schulman (2014), two other essential aspects that dictate municipal composting adoption and success are access to state or county grants, and extensive public education – Salem has done both. Salem’s program has its roots in a two-year pilot program starting in 2014, which was supported by the MassDEP via grants – including a $30,000 grant specifically to purchase wheeled food waste carts (MassDEP 2016). Under the grant-funded pilot, bi-weekly curbside collection of food waste was provided free for residents who had signed up – the grant was sufficient to support up to 1,500 households, or about 10% of Salem’s total population, with 12-gallon compost bins for curbside collection alongside weekly trash and recycling collection (Bray 2013).

Much of the groundwork for public education and outreach came from the Salem Recycling Committee: an online survey was distributed to gauge residential interest, and door hangers communicating information about the curbside food waste collection program in English and Spanish were distributed to over 6,000 households (Bray 2013). This is a stellar example of designing municipal composting programs that take into account social demographics: Salem has a sizeable (17.6%) Hispanic or Latino population (U.S. Census Bureau 2019b).

While public outreach remains essential, a key challenge for municipalities with socio-economic demographics similar to Salem – a low median housing value and low median income – is to maintain the affordability of the program after grant funding ends. While it was clearly
communicated to residents during the pilot that the cost of the curbside collection service would eventually be borne by residents, the cost proved too much for some residents. This is especially given that trash hauling in Salem is provided for free; while the bins themselves are provided for free by the City of Salem, Black Earth Compost is currently charging $9.99 per month for curbside compostables pick up (Black Earth Compost 2019a; City of Salem 2019). As such, even with favourable waste system characteristics like curbside yard waste collection in place, the City of Salem currently only has about 600 households enrolled in the curbside compostable collection program, a reduction from pilot levels of 1,200 (Luca 2016). It is clear that in order for this program to be further expanded and include more residents, the costs of curbside compostable collection for residents would need to be adjusted.

The Salem case study also highlights the influence of location on the provision of curbside composting programs and the increasing privatization of such services. While the influence of geographical location was not accounted for as part of the logistic regression analysis in Chapter 2, the large majority of municipalities with curbside composting programs are located in the North Shore area of Massachusetts. The clustering of programs in the North Shore area provides some evidence for there being some regional economies of scale when it comes to implementing curbside collection programs, which the regression analysis may have missed in looking only population size and density within individual municipalities. Yet, it must be noted that this regional clustering for curbside collection programs is less driven by municipal cooperation and more by commercial influences: much of the reason why curbside composting programs are concentrated in the North Shore area is due to Black Earth Compost’s intentional expansion into the area, which included the takeover of the compost site originally operated by the Town of Manchester-by-the-sea (MacNeill 2017).

This is particularly important due to curbside compostable collection programs often being implemented through public-private partnerships between the municipal government and private providers.

\[1\] The towns with curbside food waste collection programs that are located in the North Shore area of Massachusetts are Beverly, Hamilton, Ipswich, Manchester, Newburyport, Salem, Swampscott and Wenham; they constitute 8 out of the 12 municipalities with curbside food waste collection presently.
waste haulers. Within such institutional arrangements, municipal governments will be responsible for providing subsidized food waste collection bins and leading public education efforts, but commercial composters like Black Earth Compost will handle the transportation and processing of the collected food waste. Such waste management arrangements have implications for program affordability, which is often based on the number of residents enrolled – in the case of Black Earth Compost, the larger the number of residents in a municipality enrolled in curbside pickup, the lower the cost per resident.\(^2\) This also places the factors of population density and total population in a new context: while likely insignificant for starting new programs owing to there being grant funding to kickstart these programs, it becomes more significant in sustaining such programs at an affordable level to residents.

### 3.1.3 Franklin County

This third case study looks specifically at drop-off food waste collection programs, specifically within the context of the municipalities in Franklin County. Franklin County is made up of 17 municipalities, and 7 of these municipalities operate drop-off food waste collection: Orange, Greenfield, Wendell, New Salem, Northfield, Whatley, Leverett. These towns have median housing incomes that are among the lowest of Massachusetts municipalities having drop-off food waste collection programs; overall, Franklin County has a median income of $57,307, which is much lower in comparison to the state median of $74,167 (U.S. Census Bureau 2019a). Based on the results in Chapter 2, we should see these towns have more difficulty adopting any food waste collection program.

However, the reality could not be any different: towns in Franklin County have a strong record of engaging in municipal composting programs, especially drop-off food waste programs. Motivated by wanting to lower the costs of waste disposal, such programs are expanding in the county. Most recently in 2018, the towns of Bernardston and Leyton have also begun to operate a drop-off food waste collection program, after after Whately in 2003, Northfield in 2008, New

\(^2\) Black Earth Compost currently runs on a pricing model where if over 300 residents sign up for curbside composting services, the cost of curbside pickup is reduced from an original $99.99 for 6 months to $59.99. (Black Earth Compost 2019c)
Salem in 2009, Orange in 2011, Leverett in 2014, Greenfield in 2014 and Wendell in 2016 (Marcus 2018). The experience of Franklin County demonstrates that socio-economic conditions are less of a constraint for drop-off programs, especially when coupled with concerted public outreach efforts to create a culture of composting and food waste collection within the general public. Of note is Franklin County’s targeted attempts at getting schools to compost: all 25 public schools in Franklin County practice food waste separation (BioCycle 2018b).

Towns in Franklin County also benefit from sharing waste infrastructure and food waste processing capacity. Currently, all the municipalities in Franklin County drop off their food waste at one of three sites: Martin’s Farm Compost and Mulch in Greenfield, Clear View Composting, or Bear Path Farm in Whaley (BioCycle 2018b). By leveraging on connections with nearby composting sites in the county, Franklin County municipalities who may not have existing food waste processing facilities within their municipality itself can still find it possible to operate drop-off food waste collection programs. As the composting sites are sited nearby, the costs of transporting such food waste to the facility is also kept low, making the overall cost of operating such programs more affordable for municipalities. In fact, access to food waste processing facilities may turn out to be the most important factor in whether a municipality would adopt a municipal composting scheme: previous interviews with city officials have highlighted their concerns about the availability of such composting sites as essential to making programs feasible (Layzer and Schulman 2014).
3.3 Key Considerations for Advancing Municipal Composting

As it stands, the sustainable management of municipal solid waste is still a challenge for many municipalities, especially for organic waste. As asserted by Pollans (2017), most municipalities in the United States are still trapped in trash, remaining entrenched in disposal-centric modes of municipal waste governance. However, municipalities are also moving slowly in transition to more sustainable modes of waste governance based on diversion and resource recovery. As outlined in Figure 3 in Section 1.5, municipal composting thus needs to be considered both as part of a broader waste management strategy for organic waste, and as a tool to push municipalities towards an ideal mode of municipal solid waste governance that is more context-specific and pursues environmental, social and economic benefits.

The previous chapters and sections have identified key themes, socio-economic variables, and waste system characteristics that can both promote or hinder the adoption of municipal composting schemes. It raises questions about how municipalities can, in a very practical manner, implement such schemes in the future, while taking into consideration the findings from this work. Figure 9 summarizes this work into a concise infographic that would be of use to municipal government officials in making decisions about what type of municipal composting scheme to adopt. This builds on the report by Layzer and Schulman (2014), who had in their report similarly provided a list of questions for municipalities to consider before deciding to implement curbside compostable collection, many of which have motivated this work.

What is clear from both the statistical and case study approaches are that there are many pathways to successful municipal composting program adoption. Hence, while this work presents key factors that prove significant in general in affecting the adoption of municipal composting program adoption, what may work in one municipality may not necessarily work somewhere else. This is because municipal solid waste governance is a complex system that happens at multiple scales and with a variety of institutional arrangements; in the case of municipal composting, it can span the scale of one’s own backyard to city-wide collection and processing services. It is thus even more important for municipal governments to understand their locally specific socio-
economic and waste system context when looking to adopt municipal composting schemes, including the influences of commercial players and regional geography.

Most of all, municipalities should embrace less hierarchical modes of governing municipal solid waste, particularly with regards to food and compostable waste. What is needed is to explore shared responsibility structures with regards to the oversight of municipal composting: it is possible for municipal governments to enter into private-public partnerships with commercial composters with regards to getting the infrastructure set up for municipal composting, but also engage non-profit entities to help with public education. Municipal governments can provide strong leadership by intentionally creating such partnerships and bringing relevant stakeholders to the table.

Shifts in modes of municipal solid waste governance have come about through working in tandem with private sector and citizen groups to advocate for common outcomes with regards to how waste is managed. It is under such arrangements that municipal composting thrives, largely as municipal composting requires a paradigm shift at multiple levels: it takes a personal commitment towards source separating organic waste out from the rest of your trash, the development of new ways to collect and transport that waste, and also creating more places and methods to turn that collected organic waste into high quality compost. In so doing, municipal solid waste – especially food waste – can become a resource beneficial to all, instead of a problem to be contained.
## Figure 9. Key Considerations and Questions for Municipalities in Advancing Municipal Composting Programs.

<table>
<thead>
<tr>
<th>Type of Program</th>
<th>Pre-existing Waste System Infrastructure</th>
<th>Socio-Economic Characteristics</th>
<th>Scale, Location, Other Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost Bin Distribution Programs</td>
<td>• This is less important for the provision of compost bins! 😊</td>
<td>• Does your municipality have high educational attainment, which may determine levels of engagement and awareness with municipal composting programs? If yes, it is a positive!</td>
<td>• Can your municipality receive grant funding to subsidize the provision of compost bins to residents? If yes, it is a positive!</td>
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<tr>
<td>Easy for most municipalities</td>
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<tr>
<td>Drop-off Food Waste Collection</td>
<td>• Does your municipality currently provide curbside recyclables collection? If yes, it is a negative – will people be motivated still to drop off their food waste off-site?</td>
<td>• Are most residents of a high median income, and able to pay off the costs of simply disposing their waste instead of separating it for food waste collection and composting? If yes, it is a negative 😞</td>
<td>• Where is your municipality currently located, and is there a composting site nearby that will accept food waste? If yes, it is a positive!</td>
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<tr>
<td>Easy for some municipalities</td>
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<tr>
<td>Curbside Food Waste Collection</td>
<td>• Does your municipality currently provide curbside yard waste collection? If yes, it is a positive!</td>
<td>• How is income inequality like in your municipality, and will this affect who can access your programs if residents have to bear the costs of curbside collection or travelling to drop-off sites?</td>
<td>• What is the scale of the program? Is there a particular amount of people needed to make the program successful? Who is your target audience?</td>
</tr>
<tr>
<td>Difficult for most municipalities</td>
<td>• Are there commercial companies which currently provide curbside collection services in your municipality, and are they willing to collect food waste &amp; make changes to their collection services? If yes, it is a positive!</td>
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<td>• Can there be regional connections made with other municipalities to support such programs?</td>
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<td>• Is there strong citizen interest and support for food waste collection and composting more broadly? If yes, it is a positive! How can citizen groups be leveraged to promote the program?</td>
</tr>
</tbody>
</table>
Appendices

Appendix A: 2010 U.S. Census Profile of Massachusetts.

Appendix B: Names of Massachusetts municipalities offering curbside food waste collection programs.

Appendix C: Names of Massachusetts municipalities offering drop-off food waste collection programs

Appendix D: MassDEP recognized food waste composting sites and geographical distribution
Appendix A. 2010 U.S. Census Profile of Massachusetts.

2010 Census: Massachusetts Profile

Population Density by Census Tract

- People per Square Mile by Census Tract:
  - U.S. density is 88.4
  - 10,000.0 to 110,107.9
  - 5,000.0 to 9,999.9
  - 1,000.0 to 4,999.9
  - 200.0 to 999.9
  - 88.4 to 199.9
  - 40.0 to 88.3
  - Less than 40.0

State Race* Breakdown

- White (80.4%)
- Black or African American (6.6%)
- American Indian and Alaska Native (0.3%)
- Asian (5.3%)
- Native Hawaiian and Other Pacific Islander (<0.1%)
- Some other race (4.7%)
- Two or more races (2.6%)

Hispanic or Latino (of any race) makes up 9.6% of the state population.

Population by Sex and Age

- Total Population: 6,547,629
- Hispanic or Latino (of any race) makes up 9.6% of the state population.

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Average Household Size of Renter Occupied Units:

- 37.7% Renter Occupied
- 62.3% Owner Occupied

Average Household Size of Owner Occupied Units:

- 2.18 people
- 2.66 people

Housing Tenure

- Total Occupied Housing Units: 2,547,075
- Average Household Size of Owner Occupied Units: 2.66 people
- Average Household Size of Renter Occupied Units: 2.18 people

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This map and list show operations that are willing and able to accept food materials from off-site generators for animal feed, composting, anaerobic digestion, or other processing. This document does not represent the full capacity to manage food materials in the Commonwealth, as there are other facilities that handle food materials from specific businesses or institutions. Those types of operations are not included in this list, but do represent additional management capacity for food materials.

DATA SOURCES:
- Major Roads: MassDOT OTP, MassGIS, June 2014
- Food Material Diversers: MassDEP BAW, November 2018

Map Updated November 2018
MassDEP, BAW. J Cook
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