Implementing a Food Scrap Composting Program for Multi-unit Dwellings in Downtown Vancouver, British Columbia

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Photos courtesy of
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ENVR 400 April 2012
The University of British Columbia

Environmental Sciences Program
Department of
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Executive Summary

The City of Vancouver established the Greenest City 2020 Action Plan (GCAP) in collaboration with Metro Vancouver to make Vancouver the most sustainable city in the world by 2020. Food scrap composting is one aspect in which we can achieve this goal since food scraps compose of 22% of waste in Metro Vancouver's waste. The purpose of this study is to determine the environmental and social effects of implementing a large scale food-scrap composting pick up program in Downtown Vancouver, as well as challenges that will arise from its implementation. This is a timely project as the City of Vancouver will ban food scraps from entering the landfill or incinerator by the year 2015.

Our objectives are:

1. To understand the current food scrap composting systems in Metro Vancouver. This includes establishing the goals, logistics, target communities and the key individuals/organizations of the food scrap composting pilot projects that are currently running in Metro Vancouver.

2. To quantify, through spatial modeling, the distribution and the number of people in multi-unit dwellings in Downtown Vancouver. These models will include high, medium, and low density scenarios depending on size of dissemination areas (DAs).

3. To establish the mass of food waste produced in Downtown Vancouver's multi-unit dwellings, and the mass that can be reduced through food scrap composting, both in present and future conditions. The GHG reductions were computed through the Waste Reduction Model (WARM).

4. To conduct an assessment regarding the implementation of the project under the categories of:

Environmental benefits and disadvantages: Accessing the results of the WARM model and what these results mean for Downtown Vancouver and the City of Vancouver. Addressing whether the results obtained will help the City of Vancouver achieve the goals outlined in the Greenest City 2020 Action Plan.

Social benefits and disadvantages: Addressing social conflicts such as odours, health concerns, and education of citizens regarding composting.

To achieve our objectives, three different analyses were conducted: a spatial model of truck routes and the density distribution downtown, a statistical model of garbage reduction from the landfill due to this food scrap composting program, and a WARM model to statistically determine the amount of GHGs saved through this program, as compared to a baseline scenario.

The West End area of downtown is the densest and will require the highest amount of compost pickup, and the Waterfront/Gastown area will require the least. Eight trucks per week will be required to transport food scraps from downtown to the Fraser Richmond Soil & Fibre composting facility. Since the distance from downtown to the composting facility is shorter than from downtown to the Vancouver Landfill, 2070 kg CO2e/yr can be saved from composting through transportation fuel consumption alone.

Based on the 2011 population it was determined that Downtown Vancouver produces 48,280 tonnes of garbage a year. Three different scenarios were created to determine garbage and greenhouse gas reduction. The three different scenarios were a maximum (100% participation), an average (70% participation), and a low reduction (40% participation). The mass of garbage saved from the landfill compared to a business as usual situation was between 4240 and 10620 tonnes per year, which is at least a 9% reduction in garbage being brought to the landfill from Downtown Vancouver. Also, there would be between 2180 and 5470 tonnes of CO2e reduction

Since this program was not implemented in 2011, and the population in downtown is expected to rise, reaching 108,500 people in 2020, we created projections, assuming that the program was implemented by 2013. Again, three scenarios were developed that were based on Toronto's participation as well as food scrap composting becoming mandatory. These scenarios were compared against a business as usual case. Based on the most likely scenario, there would be a 20% decrease in garbage produced per year in 2020, and a total cumulative reduction of 69,700 tonnes. From the WARM model it was determined that by 2020 there would be a 32% decrease in CO2e being emitted if food scrap composting was implemented following the most likely scenario.

Our models have determined that banning food scraps will divert 16.5% of garbage from the landfill and incinerator. GCAP's goals are to divert garbage from landfills and incineration by 50% from the 2008 levels by 2020, and our statistical model shows that food scrap composting will keep garbage masses constant at 2008 levels, even with the 20% population growth by 2020. Composting saves 2.070 tonnes CO2e/yr from entering the atmosphere through altering truck transport route of food scrap pickup, as the distance from downtown to the composting facility is shorter than the distance from downtown to the landfill. Overall, 3,830 tonnes of CO2e/yr are diverted from the atmosphere through food scrap composting.

Because these emissions are measured in CO2e, they represent various GHGs that can be diverted from entering the atmosphere. This would improve the air quality in downtown and in Vancouver, thus improving the health of people who live there and contribute to making the City of Vancouver one of the most livable cities in the world. Food scrap composting would also increase the general population's environmental awareness. Implementing this program should be easy as it would be similar to the current garbage pickup program, and due to downtown's dense nature, trucks do not have to travel far to pick up food scraps from the buildings.

The City of Vancouver can provide composting bins upon initial implementation of this program, and charge a small fee for additional ones. A higher participation rate is predicted since downtown's population is composed of a younger population that would be willing to accept environmental initiatives. Downtown will produce 10,620 tonnes of food scrap per year, but the Fraser Richmond Soil & Fibre ltd. facility should be sufficient to handle this amount, as its capacity is 200 000 tonnes. Proper composting needs to be enforced, because organic system can only handle a 1% contamination rate. A factor that may deter people from composting is its smell, but there are simple solutions for that, such as installing carbon filters, lining composting bins with newspapers or paper bags, putting in citrus fruits, or baking soda. Such a food scrap-composting program has been carried out in the City of Toronto, Burnaby, and Portland with at least a 50% success rate.

Recommendations that would ensure the success of implementing a food scrap-composting program would be to educate those that would be composting. Once it is understand why composting is being done as well as the significance, participation rates will increase, and contamination will decrease. Workshops can be conducted in elementary and high schools to install sustainable practices in future generations. Further research will be needed to determine if the aerobic composting that this program suggests is the best method, as anaerobic composting in vessels is also possible. If so, in vessel composting facilities that could be placed within neighbourhoods within downtown or the rest of Vancouver will reduce GHGs produced from transporting food scraps from downtown to the composting facility.

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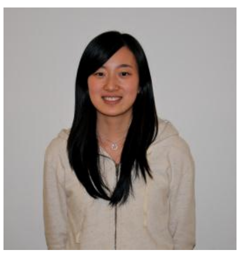
About the Project

This study is a capstone project for the Environmental Sciences 400 course. The primary goal of the project is to understand, evaluate and synthesize relevant environmental information from a variety of quantitative and qualitative information sources. The collaborative research project has spanned terms one and two, and was supervised and guided by course instructors and mentors, Dr. Douw Steyn and Dr. Erin Lane. We are an interdisciplinary team, consisting of students majoring in both Environmental Science and Integrated Science.

Project Team Members



Crystal Sun

Crystal is a graduating UBC student studying Integrated Sciences (Public Health, Environmental Sciences and Microbiology/Immunology). Her fields of interest include environmental and public health, as well as epidemiology. Having worked at both the B.C. Centre for Disease Control (BCCDC) and the GF Strong Rehabilitation Centre, she is proficient in research report writing and statistical analyses of data. She was also employed as an environmental chemist at a testing laboratory, where she conducted experiments in analyzing the BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TN (Total Nitrogen), TKN (Total Killed Nitrogen) etc. for various water samples. She is enrolled in the Master of Public Health (MPH) program at UBC, which will begin in September 2012.

Tiffany Khuu

Tiffany is a fourth year UBC student majoring in Environmental Sciences concentrating in the Land, Air, Water aspects, and minoring in International Relations. She has particular interests in environmental policies and sustainable waste management. Tiffany has taken courses on environmental research, statistical analysis, air and marine pollution, GIS, and environmental economics. She is an active member on campus, being involved in a sustainability club and an international organization. She also has years of experience in public relations and teaching through lifeguarding, teaching swimming lessons and day-camps.

Brittany Cameron

Brittany is a graduating UBC student majoring in Environmental Sciences concentrating in the Land, Air and Water aspects. She has been involved with a variety of clubs and organizations, including being VP events for the University of Calgary ski club. She has also completed a field course assessing the overall habitat quality in the Evan Thomas Provincial Recreation Area and generated a formal report on the topic. Brittany has taken many engineering and physics courses, and is proficient with common statistics programs such as “R” and “Minitab”. She plans to enroll in a Master in Architecture program in the future.

Danielle Samels

Danielle is a graduating UBC student majoring in Environmental Sciences concentrating in the Ecology and Conservation aspects. She is actively involved in many clubs, associations and sports; notably the Science Undergraduate Society (SUS). Danielle has volunteered in taking scientific data in a conservation research project in the Costa Rican Rainforest for 3 months. Danielle has also worked as an environmental coordinator for Kiewit on the Port Mann Highway 1 project throughout May 2011-August 2011.

Aden Sheikh

Aden is a graduating UBC student majoring in Environmental Sciences concentrating in the Ecology and Conservation aspects. He is working as a research assistant on the phyto’pedia project creating profiles of the most common planktonic species in the Strait of Georgia on the Pacific West coast of Canada. The experience and skills he gained from this undertaking will be handy in researching, data collections and retrieving only relevant and quality materials from scientific papers.

Acknowledgement

We would like to thank Dr. Douw Steyn and Dr. Erin Lane for their feedback, suggestions and encouragement. We would also like to thank Monica Kosmak from the City of Vancouver and Garbage Critic for her expertise. Finally, this project would not have been as thorough if not for Dieter Geesing, the Quality Manager from the Fraser Richmond Soil & Fibre Ltd. and his invaluable guidance.

Introduction

1.1. Context

Food wastes make up a large percentage of the total amount of waste produced per household in Canada. It has been estimated that 22% of waste in Metro Vancouver is food scraps. In the City of Vancouver in 2008 alone, 101,521 tonnes of food scraps went into the landfill or incinerator (Pitre-Hayes, 2011). In addition, up to 90% of waste thrown out by businesses, such as supermarkets and restaurants, is food waste (Pitre-Hayes, 2011).

The City of Vancouver, in collaboration with Metro Vancouver has established the Greenest City 2020 Action Plan (GCAP), which is a comprehensive strategy that aims to make Vancouver become the most sustainable city in the world by 2020 (Pitre-Hayes, 2011). One aspect of this plan is to reduce the amount of solid waste entering the landfill or incinerator (City of Vancouver, 2011). In order to achieve the goal of 50% reduction of solid waste entering the landfill, composting organic waste will be mandatory for all dwellings and businesses in the City of Vancouver by 2015 (Pitre-Hayes, 2011). The challenge is to ensure that large scale food scrap composting can be effectively implemented in a timely manner, and that all the necessary infrastructure is in place. The GCAP is important and timely for City of Vancouver as the amount of wastes produced by City of Vancouver's residential units totaled 175, 000 tonnes in 2008 (Table 1). This number is expected to grow proportionally with City of Vancouver's growing population.

Commercial	Single-family residents	Multi-family residents	Construction
239,000 tonnes	63,000 tonnes	72,750 tonnes	97,000 tonnes

Table 1. Estimated amount of solid waste to landfill and incinerator by sector in the city of Vancouver as of 2008, from GCAP 2011.

Food scrap composting is a desirable and timely topic to pursue because such a program contributes to reaching GCAP's 2020 goals. This not only reduces the amount of organic wastes from landfills, but it will also reduce the amount of greenhouse gases (GHGs) produced, thereby assisting the city to reach its climate leadership goal. Similarly, food scrap composting reduces the amount of garbage going to the incinerator thus improve the air quality for the residents living near the incinerator

1.2. Scope of Work

According to the 2011 census, approximately 16.2% of the City of Vancouver population lives in Downtown Vancouver (City of Vancouver Planning Department Information Sheet, 2006). Within this population, 98.3% of the people reside in multi-unit dwellings (City of Vancouver Planning Department Information Sheet, 2006).). This means that almost 100,000 people live in Downtown Vancouver and the majority in multi-unit dwellings. Moreover, 40% of the City of Vancouver's population growth from 2006 to 2011 took place in the Downtown peninsula; an area of about 6 square kilometers (City of Vancouver, 2012). With this in mind, it would be beneficial and timely to determine the amount of food scrap wastes that could be diverted from the landfill, and the associated GHG reduction, due to the implementation of a food scrap composting Program in Downtown Vancouver's multi-unit dwellings.

This report determines the environmental and social effects of implementing a large scale food-scrap composting pick up program in Downtown Vancouver, as well as challenges that will arise from its implementation. Spatial distance and density maps were constructed in order to visualize the program, and to make preliminary assessments about the implementation methods for the City of Vancouver.

Objectives:

1. To understand the current food scrap composting systems in Metro Vancouver. This includes establishing the goals, logistics, target communities and the key individuals/organizations of the food scrap composting pilot projects that are currently running in Metro Vancouver.

2. To quantify, through spatial modeling, the distribution and the number of people in multi-unit dwellings in Downtown Vancouver. These models will include high, medium, and low density scenarios depending on size of dissemination areas (DAs). Comparing the best methods of implementing a food scrap composting program from other cities similar to Vancouver ensures that we have covered most concerns and problems involving food scrap composting. Programs from other cities on multi-unit dwelling food scrap composting also help us determine the logistics in implementing the food scrap composting program in Downtown Vancouver.

3. To establish the mass of food waste produced in Downtown Vancouver's multi-unit dwellings, and the mass that can be reduced through food scrap composting, both in present and future conditions. The amount of garbage produced by multi-unit dwellings in the City of Vancouver is found in the report titled "Greenest City 2020 Action Plan (GCAP)", written by the Deputy City Manager to the Vancouver City Council. This information, along with population growth and downtown population statistics give approximate garbage masses. The GHG reductions were computed through the Waste Reduction Model (WARM).

4. To conduct an assessment regarding the implementation of the project under the categories of:

Environmental benefits and disadvantages: Accessing the results of the WARM model and what these results mean for Downtown Vancouver and the City of Vancouver. Addressing whether the results obtained will help the City of Vancouver achieve the goals outlined in the Greenest City 2020 Action Plan.

Social benefits and disadvantages: Addressing social conflicts such as odours, health concerns, and education of citizens regarding composting.

For this project, Downtown Vancouver is the area between Main St. and Denman St., and bordered by the Burrard Inlet and False Creek (Fig 1, Area 1).

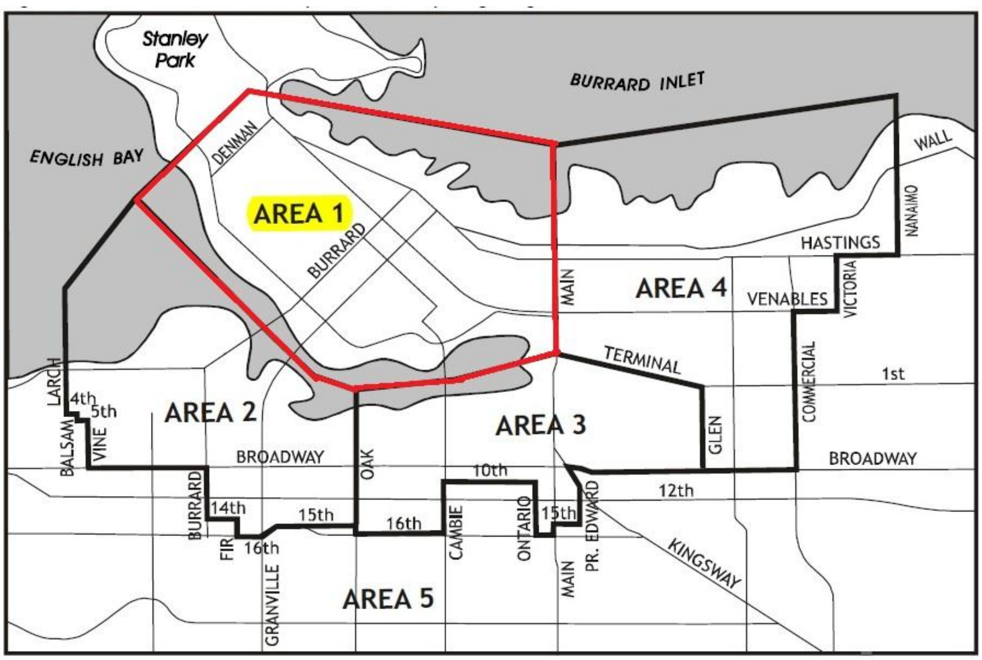


Figure 1: Downtown, Vancouver. (City of Vancouver Engineering Services, 2009)

Background

2.1. Greenest City 2020 Action Plan

In 2009, City of Vancouver, led by Mayor Robertson, proposed the Greenest City blueprint which was aimed at making Vancouver an environmental leader in many aspects. These aspects included energy efficiency, waste reduction and clean air globally by 2020 (City of Vancouver Planning Department Information Sheet, 2012). The Greenest City Action Team (GCAT) was tasked to create a comprehensive report detailing both short and long term goals and actions that will ensure Vancouver becomes the greenest city by 2020. After consulting community members, organization and stakeholders, in 2011, the GCAT created the Greenest City 2020 Action plan (GCAP) which recommended targets, goals and actions in the short and long term for City of Vancouver to become the Greenest City by 2020 (Pitre-Hayes, 2011). The Zero Waste Challenge, part of the GCAP aims to reduce total solid waste going to landfill or incinerator by 50% in 2020, from the 2008 levels (Pitre-Hayes, 2011).

Compostable wastes that include food scraps, food soiled paper and yard trimmings make up to 33% of the city waste (Pitre-Hayes, 2011). Capturing compostables provides the most immediate opportunity to reduce garbage and prevent the release of GHGs contributing to climate change (Pitre Hayes, 2011). After the report was published, the City of Vancouver implemented a pilot program for single-unit residential food scrap collection in City of Vancouver's Riley Park and Sunset neighbourhoods (City of Vancouver, 2011). Additionally, part of the city's medium term actions recommended in the GCAP is to collaborate with Metro Vancouver to ensure that all compostables from multi-unit dwellings are banned from reaching landfills by 2015 (Pitre-Hayes, 2011). This will mean that the City of Vancouver must have the infrastructure to divert, collect and process compostable food wastes (Pitre-Hayes, 2011; City of Vancouver, 2011). Despite this commitment, the City of Vancouver does not currently have a viable multi-unit dwelling composting pick-up program.

2.2. Compost and Benefits of Food Scrap Composting

Composting is the controlled decomposition of organic matter where microorganisms break down leaves, grass clippings, paper products, and other organic materials into soil amendments (Buyuksonmez, *et al*., 1999). The process of composting has been undertaken for centuries. However, it is only within the last decade that the versatility of the technique has been appreciated, and it is now applied to the treatment of a wide range of biodegradable material, including food wastes (Buyuksonmez, *et al*. 1999).

Food scrap composting can divert tonnes of organic material from landfills and reduce GHG emissions. It can also reduce energy use and the cost to treat wastewater or treat contaminated soil from landfills (U.S. Environmental Protection Agency, 2011). The compost created from food scraps is also beneficial as it can be used to enrich soil, remediate contaminated soil, prevent pollution, and offer economic benefits (U.S. Environmental Protection Agency, 2011).

Compost generated through food scraps generally has a better ability to regenerate poor soils, as the process of composting encourages the production of beneficial microorganisms including bacteria and fungi, which can turn organic material into humus, a rich nutrient filled material, that can increase nutrient content in soils and maintain soil moisture (U.S. Environmental Protection Agency, 2011). Composted soils are also shown to bind heavy metals and prevent other harmful environmental residues (volatile organic compounds, polyaromatic hydrocarbons etc.) from migrating to nearby water sources or being absorbed by plants. It also can prevent pollutant runoff from stream water, thereby preventing pollutants from reaching water sources, erosion, and turf loss (U.S. Environmental Protection Agency, 2011). Moreover, compost from food scraps has a commercial value, and be bought by businesses, farm owners and local citizens (U.S. Environmental Protection Agency, 2011).

2.3. Greenhouse Gases

Greenhouse gases (GHGs) absorb long wave radiation from the earth and keep them in the atmosphere thereby causing a warming effect. When organic waste in the landfills decomposes, it releases the gases responsible for this effect such as carbon dioxide and methane (Environment Canada, 2010). The gases produced from landfills consist of approximately 55% methane, 44% carbon dioxide and other odorous and environmentally dangerous gases (Hummer & Lechner, 1999). Approximately 60 million tonnes of methane are released annually from landfills worldwide (Humer & Lechner, 1999). Furthermore, methane is about 21 times more effective in causing warming than carbon dioxide (Humer and Lechner, 1999). Environment Canada (2010) estimates that approximately 20 megatonnes of CO_2e are generated annually from Canadian landfills.

The Vancouver Landfill, which is where all the garbage from Downtown Vancouver is deposited, has had a Landfill Gas Management system in place since 1991. This system controls odour, reduces greenhouse gasses, and a small portion is used to provide heat. In 2010, the Vancouver landfill had a collection efficiency of approximately 52% (Transfer and Landfill Operations Branch, 2010).

2.4. Existing Food Scrap Composting Programs for Multi-Unit and Single-Unit Dwellings in Metro Vancouver

Metro Vancouver is composed of 22 municipalities, one electoral area, and one First Nations treaty (Metro Vancouver, 2011). In 2008, Metro Vancouver's Sustainability Framework was put into place as a part of its Sustainable Region Initiative (Sustainable Region Initiative, 2011). In March 2011, the Zero Waste Challenge was launched in an effort to reduce, reuse and recycle as much solid waste as Metro Vancouver currently produces. All of the food scraps currently collected are brought to the Fraser Richmond Soil & Fibre Ltd. to be composted. The following is a list of the cities and their corresponding food scrap composting programs:

2.4.1 The City of Richmond

In 2010, the City of Richmond initiated a curbside food scrap composting program called the Green Can program. This enables single unit dwellings to compost organic matter that usually would not degrade well in backyard composts. This service is not yet fully available for multi-unit dwellings (apartments, condominiums, townhouses) and businesses despite Richmond's rapidly growing number of multi-unit dwellings. However, the Green Cart Pilot Program is being run from April to December 2011 to test to the feasibility of food scrap composting for some townhouse units (City of Richmond, 2011).

2.4.2 The City of Burnaby

The City of Burnaby so far has the most advanced food scrap composting system within Metro Vancouver. It began a multi-family food scraps recycling program in 2011 (Lowrie, 2011). Similar to Richmond's Green Cart Pilot Program, the City of Burnaby encourages its residents to wrap their food scraps in newspapers, and dispose of them in the larger Green Bins for weekly compost collection (City of Burnaby, 2011).

2.4.3 Other municipalities in Metro Vancouver

The City of Surrey began implementing a Residential Pilot Organics Collection Program in November 2010, in hopes of having a fully established program ready by July 2012 (City of Surrey, 2010).

The City of New Westminster's food scraps collection program began in the fall of 2010, and food scraps are collected weekly along with the rest of their garbage and recycling. In 2011, a proposal to implement a multi-unit food scrap composting pilot program was explored (Lowrie, 2011).

In the City of Coquitlam, the food scrap composting program is identical to that of Richmond (City of Coquitlam, 2011) and has been running for approximately a year.

The Township of Langley and the City of Port Moody also have food scrap composting. In Langley, a Green Can program is available for all the residents who receive curbside garbage collection (Township of Langley, n.d.) and the City of Port Moody participates in a Green Waste Cart collection program.

Currently, Metro Vancouver's North Shore (District of North Vancouver, City of North Vancouver, and the District of West Vancouver), and Corporation of Delta do not have a food scrap composting collection program.

2.5. Composting Facilities

Although the City of Vancouver has a composting unit at the Vancouver Landfill located in Delta, they send all the pure organic waste to the Fraser Richmond Soil & Fibre Facility. This is the only facility located in the Metro Vancouver area capable of composting large amounts of organic waste that might result from the implementation of a food scrap composting in multi-unit dwellings in Downtown Vancouver. The Fraser

Richmond Soil & Fibre Ltd is a private company subsidiary of the Harvest Power Canada Ltd., which presently relies solely on aerobic composting (Figure 2).

Aerobic composting is done with the help of air. Oxygen levels in composting piles and containers are maintained by either forcing air through the materials with fans, or by passive aeration – diffusion and convection (Buyuksonmez, et al. 1999). Passive aeration is commonly supplemented by periodically "turning" the materials. Turning charges the materials with fresh air, releases CO_2 and moisture, and, at least for a short period, enhances natural air exchange (Buyuksonmez, et al. 1999). Turning also distributes organisms, moisture, and nutrients through the materials and breaks up clumps and particles (Buyuksonmez, et al. 1999).

The Fraser Richmond Soil & Fibre Ltd. specializes in a special form of aerobic composting. The facility uses unturned covered aerated static pile (UCASP) technology to produce high quality compost at reduced energy costs. This technology also allows for exceptional compost quality as its high performance system continuously turns the organic waste pile and constantly aerates the material. Further a bio-filtration system is present to capture the released odours from the organic piles as well as to maintain moisture and air balance in the compost. The system is important because aerobic composting methods require specific amounts of moisture and air content as well as a fairly high temperature (45 - 60 degrees Celsius) to efficiently digest and degrade food scraps into compost (Fraser Richmond Soil & Fibre Ltd, 2010).

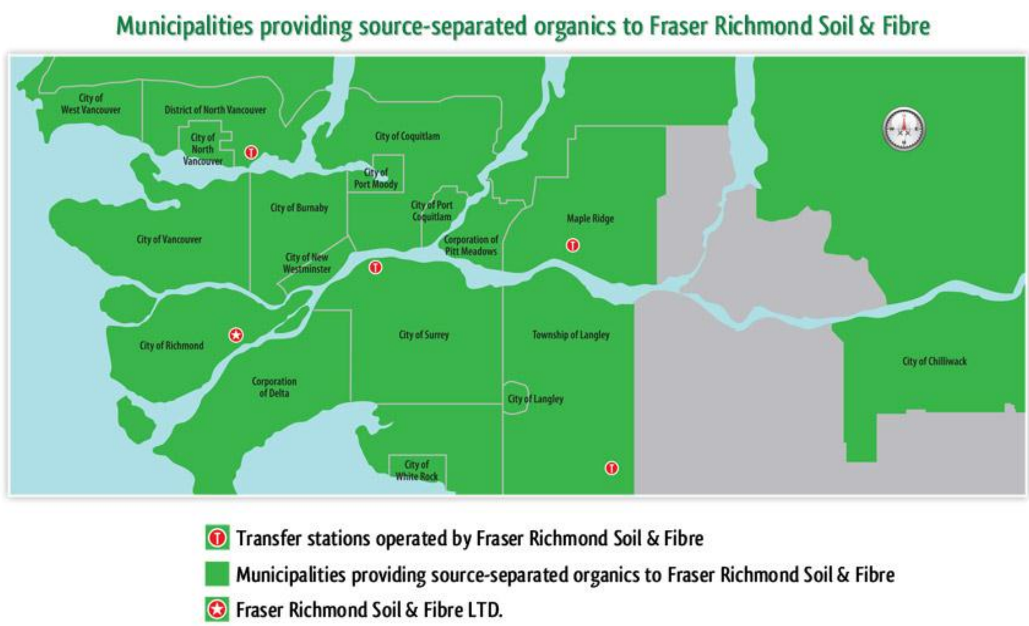


Figure 2: List of municipalities in the Metro Vancouver region serviced by Fraser Richmond Soil & Fibre Ltd (Fraser Richmond Soil & Fibre Ltd, 2010).

Methods

3.1 Spatial Model: Mapping Population Density and Length of Truck Routes

3.1.1 Description of model

The spatial model consists of two separate maps:

Truck route mapping model

The first map is a comparative representation of the average pickup truck route lengths (in km) from Downtown Vancouver to the Fraser Richmond Soil & Fibre facility Ltd., and from Downtown Vancouver to the Vancouver Landfill. From this map, we can determine the amount of fuel saved per year from driving to the compost facility instead of the landfill, and the consequent CO_2 emissions saved with the shorter distance.

This map takes the intersection of Burrard St. and West Georgia St. as the approximate geographic centre of Downtown Vancouver. Variables used include the estimated truck routes, the distance of routes, fuel consumption rate of pickup trucks, and tonnes of food scraps produced in multi-unit dwellings in Downtown Vancouver (tonnes/year). The Fraser Richmond Soil & Fibre Ltd. is located at 7028 York Rd., Richmond, and the Vancouver Landfill is located at 5400 72nd St., Delta.

Population density model

The second map is a spatial display of Downtown Vancouver's population density. This helps determine which areas of Downtown Vancouver, based on the 2011 population census data, would have a greater need for food scrap pickup, assuming that a larger population is directly correlated to a larger amount of food scraps produced.

In density mapping, we chose to use dissemination areas to display population density. Dissemination Areas (DAs) each contain from 400 - 700 persons per geographic unit, and is the smallest density division area provided by Statistics Canada (Statistics Canada Dissemination Areas, 2012). Using these smallest division units, we acquired the most accurate analysis of food scraps production. We used the different sizes of DAs to represent high, medium and low population densities. From this we determined potential high, medium and low volumes of food scraps to be produced from residents of Downtown Vancouver. Furthermore, we calculated the number of pickup trucks that will be needed to collect the food scraps produced.

3.1.2. Purpose of Spatial Model

The spatial model provides a visual and geographical reference of the area in which our research is taking place. It also shows the population density of Downtown Vancouver so that our project can be compared to other cities with similar densities. By running the spatial model through a geographical analysis we were able to calculate the distances from Downtown Vancouver to the Fraser Richmond compost facility and the Vancouver Landfill using existing roads, highways, and adhering to routes specifically destined for truck use.

3.1.3 Assumptions

We have taken the intersection of Burrard St. and Georgia St. as representative of the centre of Downtown Vancouver in respect to the mass of food scrap produced and compost pickup needs. We are only looking at multi-unit dwellings downtown, which does not include businesses, restaurants, community centres, schools, etc. which might add to the total mass of food scraps produced in Downtown Vancouver. Thus, the allocations of trucks needed as proposed in this project will only be representative of residential buildings' needs.

We assumed the food scrap pickup trucks that would be used to be the same type as the current food scrap pickup trucks used for collection in single-unit dwelling food scrap composting pilot projects, which hold 42 tonnes each in total (Geesing, Personal Correspondence, 2012). However, we also assume that in most occasions, pickup trucks do not operate to their maximum capacity per trip, and that operating at ⅔ of their total capacity would be more realistic to allow for unexpected larger loads from multi-unit dwellings. The mass of food scraps we calculated are average masses over the year. However, there may be larger masses of food scraps produced during holiday festivals and during summer months.

We have calculated the mass of food scraps produced in downtown per year to be 10,620 tonnes (see Appendix B). Because we are using data from previous years to project this amount, we are assuming that the mass of garbage and food scrap content in the garbage remains constant. This allows us to calculate the potential amount of total food scrap produced in Downtown Vancouver according to the increase in residential population.

We also assume that it would be desirable for the City of Vancouver to transport all food scraps from Downtown Vancouver to the composting facility instead of the landfill. Aside from the ban of compostable items in landfills to come into play in 2015, we assume that it would also be the choice for economic reasons, since the composting facility is closer in distance to downtown than the landfill, and thus the city would be saving money in fuel costs and driving time. In the calculations of emissions produced from the transport of food scraps to the composting facility or landfill and the subsequent emissions saved, we assume that travel time occurs during minimal traffic times, thus, minimizing idling time from traffic, and at traffic light intersections.
We have also assumed that 22% (Pitre-Hayes, 2011) of residents' garbage is food scraps, and thus will be the number used in this project to calculate the volume of food scraps produced out of the total volume of garbage obtained. Some residents may produce more or less food scraps for compost depending on their diet.

In the population density spatial model, we assumed that the three population density categories in which we labeled the DAs (high, medium, low) represent the range of compost pickup service required (high, medium, low service). This model also assumes that residents will compost appropriately, as some residents may not care enough to compost and may put food scraps into the garbage instead, and some may put non-compostable substances with food scraps, thus harming the composting facility. It will be difficult in multi-unit dwellings to track who the violators are, since most multi-unit dwellings have communal disposal bins.

3.1.4 Limitations

The spatial model representing the amount of compost that can be obtained from each area using the density of the region is limited to purely residential areas: apartment buildings, condos, co-ops, etc. Thus, businesses such as coffee shops, office buildings, grocery stores, restaurants, schools, and other buildings are not included in our estimate. These other buildings can produce a large amount of garbage and compost individually, therefore they would need to be calculated and evaluated in a separate composting program from residences. This information would be helpful in determining what the total amount of food scraps produced in Downtown Vancouver would be, but is beyond the scope of this project.

We did not provide the specific total GHG emissions per pickup truck during food scraps pickup due to limitations in the data that we were able to obtain. Idling during pick up is a large contributor of emissions from the trucks, but the amount of time spent idling will vary according to each street and each building due to where the food scrap composting bin will be placed. Such data was not available to us, and may change over time, thus calculations we may have provided would not have been accurate.

3.1.5 Procedure

Truck route mapping model

To construct the spatial model of the truck routes, the distance from Downtown Vancouver to the landfill as well as Downtown Vancouver to Fraser Richmond Soil & Fibre Ltd. facility were measured using Google Maps (Figure 4). Using the potential tonnes of compost produced in Downtown Vancouver, 10,620 tonnes/yr with the capacity of trucks 2/3rds full (28 tonnes), we calculated that 8 trucks per week are required to collect the compost. The fuel savings from the pickup trucks, using the difference in the distances measured, was then calculated to be 0.648 tonnes of diesel or 2070 kg CO2e/yr saved.

Population density model

To construct the spatial model of the 2011 population density of the multi-unit dwellings in Downtown Vancouver, the 2011 dissemination area census data was obtained from the Statistics Canada website. DAs are areas covering all of Canada composed of one or two dissemination blocks, with a population of 400-700 persons (Statistics Canada, 2012).

Using ArcMap and Adobe Illustrator, the DAs of Downtown Vancouver were mapped and then divided up into three pre-determined categories, according to the geometric area of the DA (Figure 5). The larger area the DA contains, the less dense the neighbourhood. The categories consisted of: high density - DAs whose total areas is less than $0.065km^2$ (purple), medium density - DAs whose total area is between 0.065-$0.35km^2$ (red), and low density - DAs whose total areas is greater than $0.35km^2$ (yellow).

We have calculated current Downtown Vancouver's population to be approximately 97,652 (Lazaruk, 2012) persons living in multi-unit dwellings downtown. Assuming each person produces 0.503 tonnes of garbage per year, consistent with 2006 amounts, and 22% of garbage is food scraps, then in Downtown Vancouver there will be 0.11 tonnes of food scraps produced per person per year, or 10,620 tonnes per year in total. Approximately 8 trucks per week are required, as in the previous model. Each truck can collect the food scraps of about 19 DAs.

3.2 Statistical model: Population of Downtown Vancouver and Projected Growth

3.2.1 Description of Model

In order to determine any GHG or garbage reductions as a result of food scrap composting, the current population of Downtown Vancouver, as well as the projected population was required. The 2011 census determined that Downtown Vancouver's population had increased by 11% from the known 2006 population levels (Lazaruk, 2012). In addition, 98.3% of these residents live in multi-unit dwellings (City of Vancouver Planning Department Information Sheet, 2006). From this, the 2011 population was computed. The 2011 population was assumed to be with minimal error, because Statistics Canada based their population statistics on physically collected census data.

The projected population growth was calculated following previous population growth trends in 2006 (Metro Vancouver, 2010), and using 2011 census data. An error analysis was performed, by comparing previously calculated growth trends, to growth trends using 2011 census data and development plans. The variety of results showed an error of up to 2% in 2015 and 4% in 2020.

3.2.2 Purpose of Using Statistical Models

The purpose of the statistical model was to determine the reduction in garbage traveling to the landfill due to the implementation of food scrap composting. The model was created using Excel. It assumes that 22% of garbage was food scraps, that could be composted (Pitre- Hayes, 2011). The mass of garbage produced per person was kept constant, and the two variables in the model were the downtown population, and the participation rates.

The mass of garbage produced per person per year was computed using the garbage produced in Downtown Vancouver in 2008, and the population of Downtown Vancouver in 2006. Due to the difference in years of data collection, an error of 4% was found.

The statistical model was run to determine present garbage reductions and future garbage reductions (2013, 2015 and 2020) (see Appendix B).

3.2.3 Assumptions

Garbage reduction was calculated based on a low, average and high participation scenario. The average scenario was determined based on Toronto's food scrap composting participation goal. Toronto hopes for 70% participation, and is currently at 50%. Part of Toronto's low participation rate is because of inadequate facilities (Solid Waste Management, 2011). In Vancouver, the pilot programs implemented in September 2011 in the Sunset and Riley Park neighbourhoods have shown higher participation rates than expected. Therefore, for our model we predict a 70% participation rate.

The low participation scenario is estimated at 40%, and the high (maximum) participation scenario is 100%. Participation rates include the percent of people participating, multiplied by their compost efficiency (eg. one unit might only compost 70% of the time).

The models also assume that increases or decreases in wastes in the landfill are due to changes in food scrap quantities, and not from other garbage.

3.2.4. Procedures

i) Determining Present Garbage Reduction (population constant)

Inputting the participation rate into the model, the downtown population, mass of garbage produced per person, and percent of food scraps in compost yields the mass of food scraps that would be composted as opposed to traveling to the landfill. The error was calculated to be 8%, which is the error in the mass of garbage produced per person per year.

ii) Determining Future Garbage Reduction

To determine future garbage reduction it was assumed that the food scrap composting would be fully operational by 2013, with food scrap composting becoming mandatory by 2015. Future garbage reduction due to food scrap composting was found knowing the population in 2013, 2015 and 2020, and creating three possible scenarios.

Scenario #1: High participation rate

Due to strong public demand, food scrap composting will start at 70% (Toronto's goal level), increase to 90% by 2015 and be at 100% by 2020.

Scenario #2: Expected participation rate

Participation starts at 50%, where composting levels are currently in Toronto, then increase to 70% by 2015 due to it being mandatory, and 90% by 2020 as fines have been deployed and the program becomes established.

Scenario #3: Low participation rate

Either due to lack of adequate facilities, or lack of public interest, the program has low initial success (20% diversion). It jumps to 50% in 2015 because of the program being mandatory, and it only reaches 70% by 2020.

Inputting the participation rates and the population data into the model, gave projected masses of food scraps that would be saved from the landfill. The errors were calculated based on both the population projection errors and the volume of garbage produced per person errors.

3.3 WARM Model

3.3.1 Description of Model

The Waste Reduction Model (WARM) is a method to statistically determine the amount of GHGs produced in a baseline scenario, compared to an alternative waste management practice (U.S. Environmental Protection Agency, 2012). This model can perform calculations for 46 different material types; however, for the purpose of this report, only food scraps were used. In this model, the variables were the mass of garbage produced in a baseline scenario, and the garbage produced when food scrap composting was implemented. The WARM model used the masses of garbage produced according to the previous statistical models. Similar to the statistical model, the theoretical GHG reductions were determined for the present, based on participation rates, as well as three future scenarios. All participation rates are scenarios were the same as previously discussed in section 3.2.4.

3.3.2 Purpose of WARM Model

The purpose of the WARM model is to calculate the amount of GHGs in MTCO2e produced from various waste management methods. In our project, we used the WARM model to show the amount GHGs saved by composting food scraps from Downtown Vancouver, instead of having the food scraps disposed of in landfills.

3.3.3 Assumptions

The WARM model was designed to calculate GHGs emitted by including numerical values of a wide range of GHG contributors. We do not have the data required to fill in all those values, so we assume that the model still provides representative scenarios with the data we were able to input.

3.3.4 WARM Model Limitations

The numbers generated in the warm model should be considered approximates. All factors other than the mass of garbage and compost were assumed constant. The WARM model does not provide an error analysis; therefore, a standard 10% error was used for the present day results, which increased to 16% for projections, due to the added uncertainty in future populations.

The element that had the greatest effect on the outputs of the warm model is the efficiency of the gas recovery system. From personal communication with Dieter

Geesing and referring to The Landfill Final Report (2010), there is a maximum of 50% gas collection efficiency per year, which is mainly collected from older garbage. However, there have been plans to increase the collection efficiency to 75% by 2016, which might cause the WARM model output numbers for future scenarios to change from the results depicted here. Exact annual collection data of gas collection efficiency does not exist, therefore, the chosen gas collection efficiency is the most likely option based on available information.

3.3.5 Procedure

To obtain the desired results, a number of other factors were considered in the WARM model:

i) There is a landfill gas control system in place at the landfill, which is recovered for energy

ii) The decay rate of organic matter (K value) was 0.02, which is considered dry (Golder Associates, 2008)

iii) The landfill gas collection efficiency is poor (0-5 years: 0%, 6-7 years: 75%, 8-100 years: 95%)

iv) The distance to the landfill from downtown (based on the distance from the centre point of downtown, Burrard St. and West Georgia St.) is 27.5km, and the distance to the compost facility from downtown is 24km.

Results and Interpretations

4.1 Truck routes

The distance from Downtown Vancouver to the Fraser Richmond Soil & Fibre is 24 km while the distance from downtown to the Vancouver Landfill is 27.5 km (Figure 3). The model shows the length of the truck routes from the center of Downtown Vancouver to the two facilities.

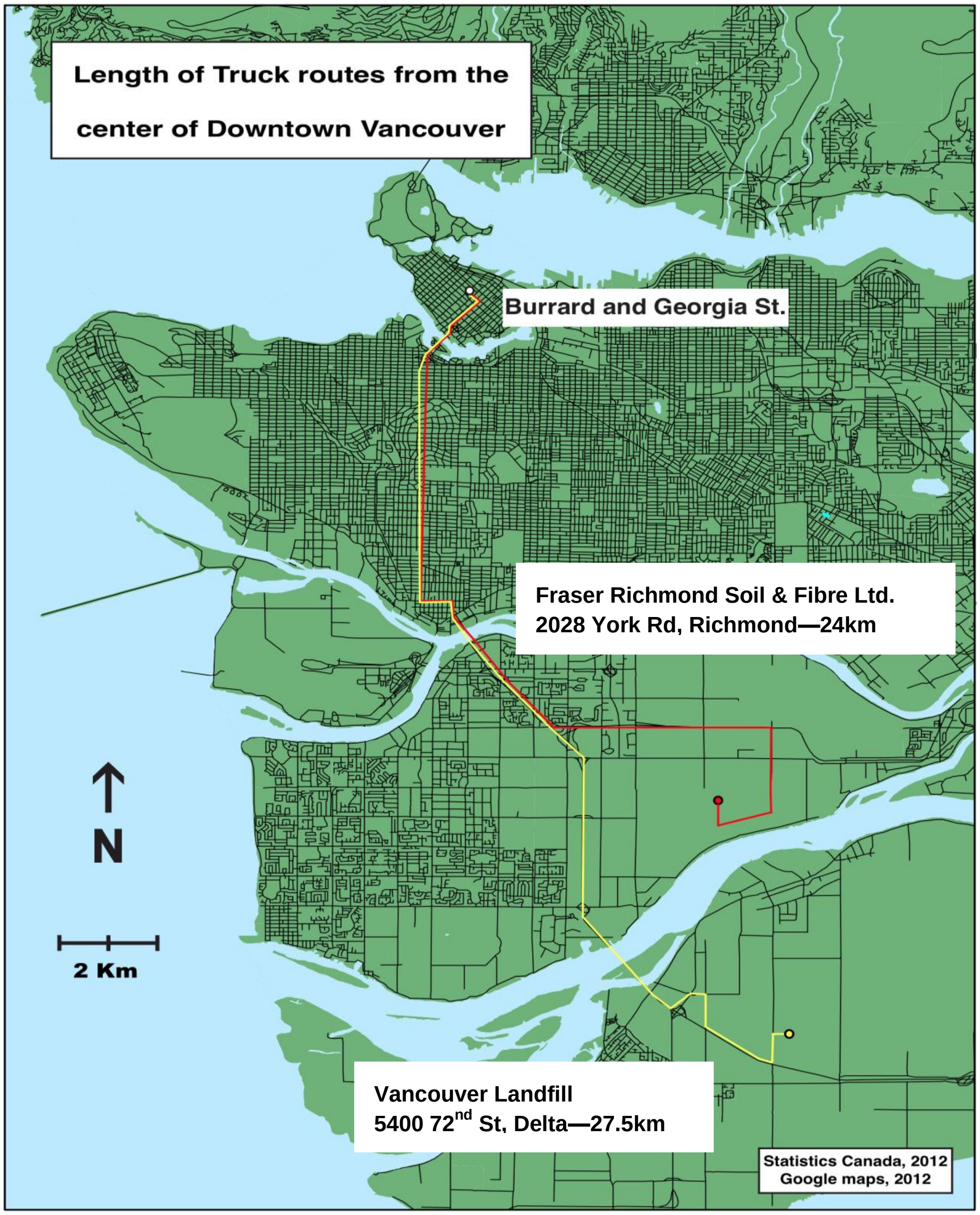


Figure 3. Spatial model depicting the routes lengths to the compost and landfill facilities.

4.2 Downtown Density

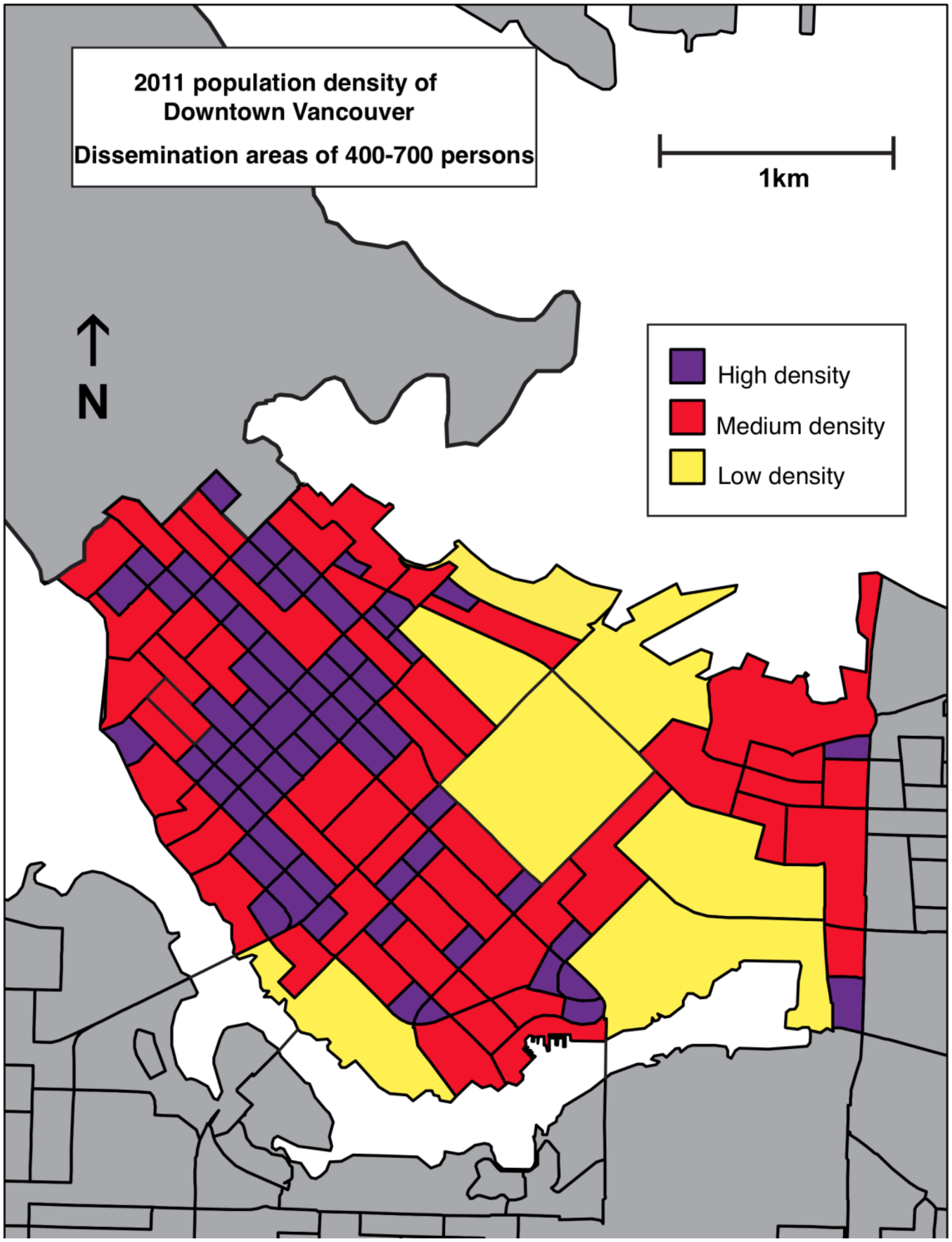


Figure 4. The population density in Downtown Vancouver.

The 2011 population density of Downtown Vancouver (Figure 4), based on dissemination areas demonstrates where the densest and least dense areas of Downtown Vancouver are located. The West End area, from Chico st. to Burrard st. and

South of Georgia is the densest area in Vancouver, and will require the highest amount of compost pickup. The Waterfront/Gastown area will require the least amount of compost pickup. This is important for the City of Vancouver to consider when developing pick up procedures.

4.3 Garbage and GHG reduction from food scrap composting

In Downtown Vancouver, the population is expected to increase approximately 13% by 2020 (Figure 5) (Sustainable Region Initiative, 2009). Presently, the population is at 96,000 people, and it has been estimated that each individual produces 0.503 tonnes of waste each year.

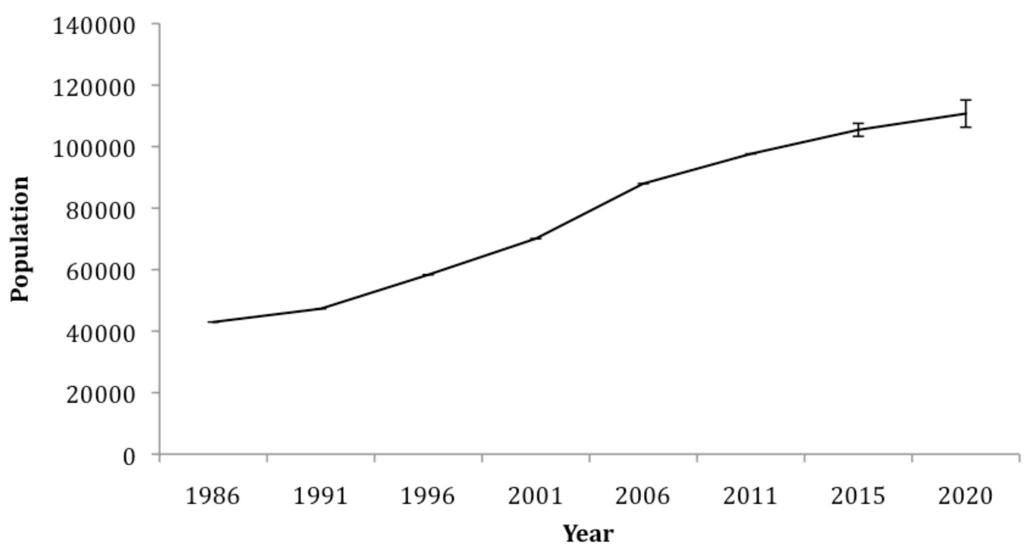


Figure 5: The population of Downtown Vancouver from 1986, including two projected values for 2015 and 2020

	Year		
	2011	**2015**	**2020**
Population	96,000	103,700	108,900
Garbage produced (Tonnes/year)	48,280	52,100	54,800
Mass of food scraps in garbage (tonnes)	10,620	11,500	12,000

Table 2: The projected mass of garbage and food scraps, dependant on the increasing population levels, in Downtown Vancouver’s multi -unit dwellings.

In 2011, Downtown Vancouver produced approximately 48,280 tonnes of garbage, which ended up in the landfill (Table 2) (see Appendix B). This mass of garbage, plus the transportation costs, produced 15,300 Mt CO2e. Of this garbage, 22% of it is compostable food scrap material (Pitre-Hayes, 2011). Had all of the food scraps been composted through large scale composting (maximum reduction scenario), 10,620 tonnes of garbage would have been removed from the landfill, and 5470 Mt less of CO2e would have been released into the atmosphere. This is a 36% reduction in GHGs produced by garbage, and is equivalent to removing approximately 1000 passenger vehicles from the road for a year, as generated through the WARM model.

It is unlikely that all food scraps will end up being composted, especially as the program is initially being implemented. Had 70% of foods scraps in 2011 been composted (average reduction scenario), there would still have been a reduction of 7430 tonnes going to the landfill (Table 3). This reduction would reduce the GHGs released from garbage by 25%.

Finally, even if only 40% of food scraps were composted (low reduction scenario), it would still reduce the mass of garbage taken to landfills by 9% and reduce GHGs by 14%. This reduction in GHG emissions would be equivalent to saving almost 938,782 litres of gasoline per year as determined by the WARM model.

The full uncertainty of these calculations is not known, due to uncertainties in the garbage produced per person, and the WARM model variables. Due the lack of means to calculate the uncertainty in the WARM model, a standard 10% error should be assumed for all GHG calculations. Garbage mass calculations have an error of 8%.

Scenario	Garbage produced (tonnes/yr)	Compost produced (tonnes/yr)	GHG's produced ($MtCO_2e$)	GHG's reduction ($MtCO_2e$)
Business as usual	48,280	-	15,300	-
Maximum reduction	37,660	10,620	9830	5470
Average reduction	40,850	7430	11,470	3830
Low reduction	44,040	4240	13,120	2180

Table 3: The mass of garbage produced in Downtown Vancouver in 2011, and how much compost could have theoretically been removed give the three emission scenarios, compared against the baseline. Garbage calculations have an 8% error. Maximum reduction is 100% participation in food scrap composting. Average reduction is 70% participation in food scrap composting. Low Reduction is 40% participation in food scrap composting. The GHG changes due to the theoretical scenarios of food scrap composting were calculated through the WARM model, all with an error of 10%.

We calculated that composting food scraps would require 8 trucks a week, which saves 0.648 tonnes of diesel per year and 2070 kg CO2e/yr saved from transportation alone (see Appendix B). This is not substantial, but considering that the material will be composted versus thrown away saves a lot of area in landfills and over time will be very helpful for the City of Vancouver to achieve its Greenest City 2020 Action Plan.

4.4. Projected Garbage and GHG Reductions from Food Scrap Composting

The results in Table 4 assume that a food scrap composting program will be implemented in 2012, and become fully operational for 2013. The program will see increased participation when food scrap composting becomes mandatory in 2015, and will continue to increase as the program becomes more established. Because the exact participation in food scrap composting is not known, three scenarios have been created (Table 4).

Scenario	**Year**		
	2013	**2015**	**2020**
Business as usual	No diversion	No diversion	No diversion
Scenario 1	70% diversion	90% diversion	100% diversion
Scenario 2	40% diversion	70% diversion	90% diversion
Scenario 3	20% diversion	50% diversion	70% diversion

Table 4: The percent of food scraps being composted as opposed to entering the landfill in three scenarios. The three scenarios are a high success rate (scenario 1), a most likely scenario (scenario 2) and a conservative scenario (scenario 3).

Figure 6 demonstrates that if food scrap composting was implemented by 2013, there would be between a 51,200 and 86,100 tonne cumulative reduction in garbage entering the landfill by 2020. The most likely scenario shows that in 2013 garbage would be reduced to 44,000 tonnes/year, would go up to 44,100 tonnes/year in 2015, due to the increasing population, and would then drop to 43900 tonnes/year by 2020 as the program became established. By 2020, assuming the most likely scenario, there would be a 20% decrease in garbage/ year, and a 16.5% decrease in overall garbage since 2013. These calculations were performed using a baseline value of 52,100 tonnes garbage/ year in 2015 and 54,800 tonnes garbage/year in 2020.

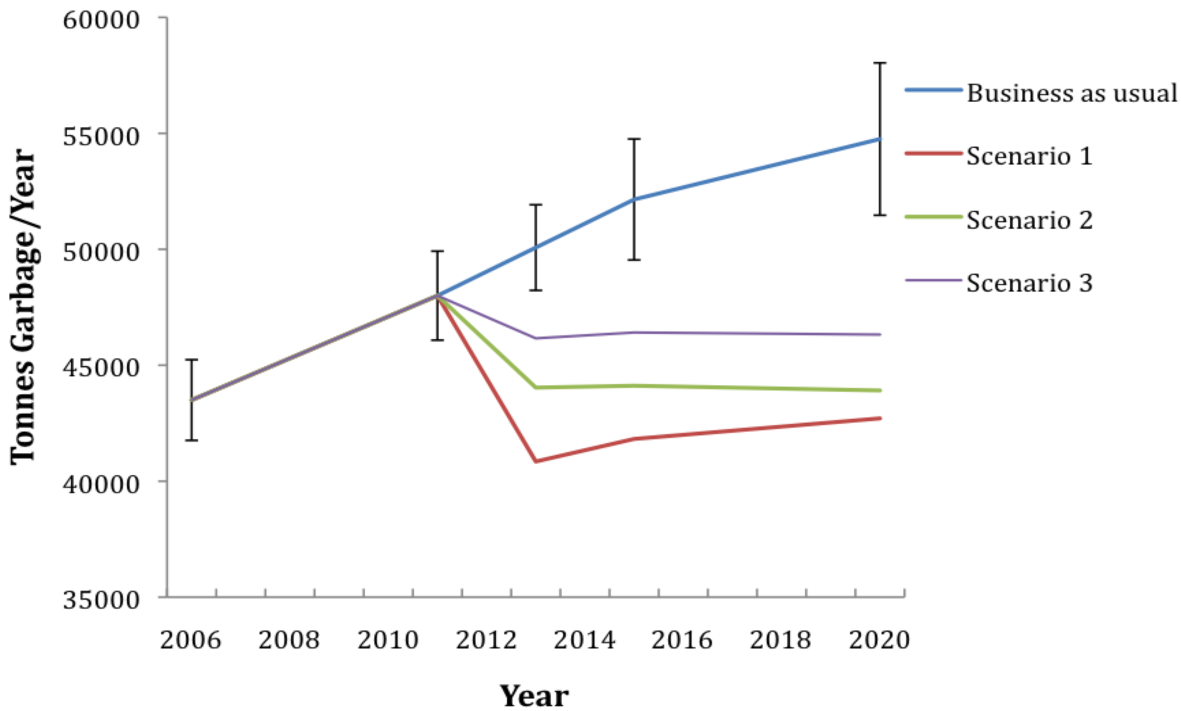


Figure 6: The projected volume of garbage produced until the year 2020 given three composting scenarios. Scenario 1 depicts the optimistic case, scenario 2 depicts the most likely case, and scenario 3 depicts the conservative (discussed in table 3).

Using the WARM model, various GHG emissions were calculated using the scenarios listed in Table 3. The results demonstrate that if food scrap composting was implemented in 2013, then by 2020 there would be between 26,000 Mt and 44,000 Mt less CO2e in the atmosphere (cumulative over 7 year period) (Figure 8). Given the most likely emissions scenario, CO2e being released into the atmosphere from food scrap composting would be 13,100Mt/year, 12,400Mt/year, 11,800 Mt/year in 2013, 2015 and 2020 respectively. In 2020, this CO2e value is a 32% decrease in GHG emissions due to food scrap composting, compared to a business as usual scenario. Cumulatively, over the seven-year period, there would be an overall decrease of CO2e by 26.5%, based on scenario 2.

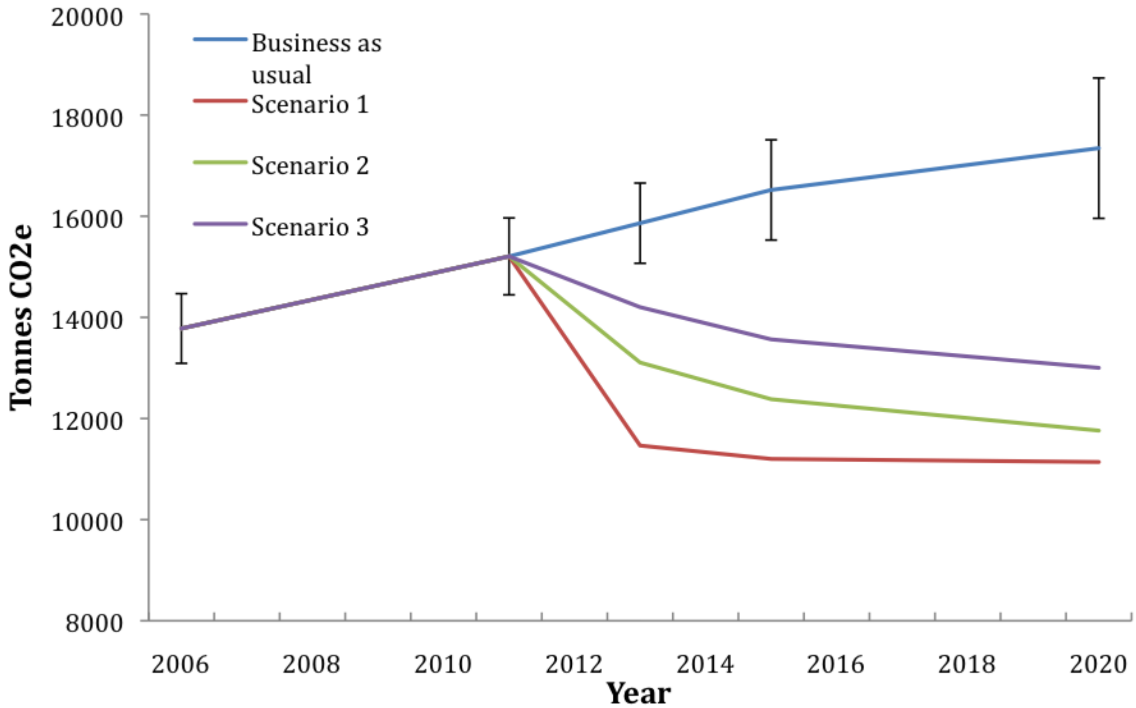


Figure 7: The projected volume of CO2e released into the atmosphere until the year 2020 given three composting scenarios. Scenario 1 depicts the optimistic case, scenario 2 depicts the most likely case, and scenario 3 depicts the conservative case (discussed in table 3).

Discussion

5.1 Environmental Benefits and Disadvantages

Food scrap composting is a beneficial process as it reduces the amount of garbage foing into the landfill and the amount of greenhouse gases released into the atmosphere. Given that the participation rates of food scrap composting are between the assumed limits of 40-100%, there would have been between 4240 tonnes and 10,620 tonnes of garbage diverted from the landfill in 2011. This is between 9% and 14% of the total garbage entering the landfill from Downtown Vancouver per year. If this reduction in garbage was to continue, and other districts also began to compost their food scraps, then it could lead to fewer landfills being created, and an alternative to garbage incineration.

If food scraps were to be banned from landfills over the next 9 years, according to the most realistic scenario, there would likely be a 16.5% decrease in overall garbage entering the landfill from Downtown Vancouver, which would amount to 69,700 tonnes. According to the Greenest City Action Plan 2020, Metro Vancouver hopes to reduce the garbage traveling to the landfill or incinerator by 50% from 2008 levels. In 2008 Downtown Vancouver produced 43,500 tonnes of garbage. If food scrap composting were implemented, then the level of garbage would remain at this level in 2020, as opposed to increasing to 54,800 tonnes in 2020. Therefore, food scrap composting would be necessary if the Greenest City Action Plan 2020 hopes to achieve its goals.

Removing food scraps from Downtown Vancouver's waste stream will not only save room in the landfills but, also save 0.648 tonnes of diesel per year in the best case scenario, or 2.070 tonnes CO_2e /yr alone in transporting food scraps to the composting facility, rather than the landfill. Combined with the benefits of food scraps entering a composting facility as opposed to the landfill, we can predict a total CO_2e savings of 3,830 tonnes per year. The Greenest City Action Plan hopes to reduce emissions levels by 1,020,000 tonnes CO_2e in 2020 in Metro Vancouver, compared to a do-nothing scenario (Pitre-Hayes, 2011). Food scrap composting in Downtown Vancouver alone would only contribute 0.55% to this emission reduction (Appendix B). This number may seem like a very small contribution because our program does not include other major contributors to the waste generated in the City of Vancouver, such as businesses, institutions and construction. Hence, it is a small contributor to achieve the Zero Waste Goals.

5.2 Social Advantages and Disadvantages

Composting in general will increase the environmental awareness of a population which, can be propagated to cities all around the world. It will ensure that the City of Vancouver will remain one of the top livable cities in the world for the future; which is an implied goal of the Greenest City Action Plan 2020. Composting in a multi-unit dwelling will also reduce the amount of garbage present as well smell of the garbage, because compost is taken out and picked up more frequently. As these emissions are measured in CO_2e, they represent various GHGs that can be diverted from entering the atmosphere. This would improve the air quality in downtown and in Vancouver, thus improving the health of people who live there and contribute to making the City of Vancouver one of the most livable cities in the world.

One of the main disadvantages of composting in multi-unit dwellings is the smell. This can be solved easily by installing carbon filters to indoor containers, lining bins with newspaper or paper bags, using citrus fruits, using baking soda or simply taking out the compost more frequently (Defoer & Van Langenhove, 2011). Another disadvantage to some is that composting is difficult to implement, requires too much effort and/or can be confusing. With education and further research, the Vancouver population will understand that composting is easy and beneficial.

5.3 Logistics

Composting is a more fragile system than recycling, because the decomposition process is based on an organic system of chemical processes. Composting can only handle less than 0.1% contamination (Kosmak, 2012), because contaminants will not break down, and will alter the chemistry of the soil, thus making it unusable.

Implementing composting into everyday lives of Vancouver citizens will not be as difficult as imagined. Compost pickup will be very similar to garbage pickup, and depending on the layout of the multi-unit dwellings, residents can take out their compost at the same time they take out their garbage. We suggest that the City of Vancouver provide bins for residents to use within their units when piloting the project in multi-unit dwellings. After deeming the pilot a success they can provide composting bins to all residents. Discounted bins can be bought from The City of Vancouver if a replacement bin is required. The basic composting bin should have either a carbon filter or a special lid to help minimize smell and ensure that people will not be turned off by the project (Solid Waste Management, 2011). Based on the Downtown Vancouver population density map, the most dense area is the West End, which is the area near Denman and Davie street. As mentioned earlier, 98.3 % of downtown's population reside in multi-unit dwellings therefore, we assume that compost pickup will be very similar to garbage pick-up.

The Fraser Richmond Soil & Fibre Ltd. composting facility can hold 200 000 tonnes of compost (Geesing, 2012). The current suggested composting system for multi-unit dwellings for Downtown Vancouver will add a maximum of 10,600 tonnes/yr. This material is dense; however, its addition would not add enough volume for another system to be necessary. Also, much of the new soil produced at Fraser Richmond Soil & Fibre Ltd. does not leave the facility right away. If necessary, this soil could be more readily removed such that it did not take up space.

5.4 Comparison of Methods and Results to Other Cities

The model with maps of truck routes, distances and population densities has been used all over the world. Population density of areas is used daily to determine water usage, garbage output, electricity usage and much more information regarding resource uses. The information that was used for this model was mostly census data thus, it is public data that is used by many companies across Canada. Our results are the most current, as the census was released in February 2012.

The model of density mapping regarding multi-unit dwelling composting was used in the City of Toronto for their food scraps “Green Bin Program” program, initiated in 2009. A plan was made, based on a model, to reach 70% waste diversion from the landfill by 2012. The plan included diversion initiatives, such as the launch of the Green Bin Program, surveys as well as promotion and educations (Solid Waste Management, 2011).

In the City of Toronto, as well as the City of Burnaby, the modeling of food scraps has been done. A multi-family unit and commercial/ institutional collection service was initiated in 2002 using yard wastes and was expanded as a multi-family food scraps collection in December 2010. Using a model, approximately 217 tonnes of green waste per year was collected and diverted (City of Burnaby, 2011).

Other cities including the City of Toronto and the City of Portland have implemented pilot food scraps composting. The City of Toronto implemented a food scraps “Green Bin Program” in 2009 with a goal to reach 70% waste diversion from the landfill by 2012. The plan included diversion initiatives, such as the launch of the Green Bin Program, surveys as well as promotion and education. The City of Toronto has currently reached a 50% participation, much of which was due to problems with the composting facility. Due to fewer foreseeable problems with the facility, and a strong implementation technique, we predict Vancouver’s participation to be higher.

In addition, according to the census 2006, Downtown Vancouver consists of a younger population demographic compared to the rest of Metro Vancouver (Statistics Canada, 2006). About 23% of people aged 25-34 of Metro Vancouver’s population live in Downtown Vancouver. Younger populations have most probably been exposed to “green living” for the majority of their lives, thus, composting may be easier to implement. A younger population is also more likely to take action and participate in sustainability programs that the City of Vancouver implements.

5.5 Overall limitations of this project

5.5.1 Lack of economic analysis

This project focused on the environmental and social benefits and disadvantages food scrap composting. In order to complete a complete analysis, an economic cost-benefit assessment should also be carried out.

5.5.2 Scattered data sources used in models

The parameters used in the models used the most recent data available; however, due to the lack of much research done in this area, the data had to be retrieved from widespread sources. There may be additional errors to our calculations due to many steps of projecting and combining data from multiple different years to achieve a result.

Recommendations

Food scrap composting in multi-unit dwellings in Downtown Vancouver is a beneficial project, both for its individual benefits, as well as serving as a model for multi-unit dwellings in other locations in Vancouver and elsewhere. To ensure maximum success, the following recommendations are suggested:

6.1 Education

A compost education program is required to educate the users of the system on the benefits of food scrap composting, the items that they can and cannot compost, and the compost collection times. Education is vital to ensuring the success of the composting program.

Because most of the residents in the multi-unit dwellings in Downtown Vancouver are young, working individuals (City of Vancouver Facts, 2006), it is also important to target the educational programs to these individuals. A website detailing answers Frequently Asked Questions (FAQs) should be easily accessible by the public online.

Workshops can be held at elementary and high schools to raise awareness of the benefits of food scrap composting to children, who can then bring these good practices home. As children are the next generation of society, good practices instilled in the younger generations will bring long term benefits for the environment and society.

The purpose of the education program is not only to educate people on the benefits associated with food scrap composting but also to increase public awareness of the composting program in an attempt to recruit more people into the program. The program should be aimed to be self-sustaining.

6.2 Further Research Needed

6.2.1 In-vessel composting

In this paper, we only analyzed the effect of aerobic composting on the reduction of the amount of greenhouse gases (notably CO2). It is, however, not the only composting facility available in Vancouver. The University of British Columbia (UBC), for instance, has an in-vessel system which is a fully enclosed, automated compost unit. This system is situated on a concrete composting pad and the main portion of the system is made of stainless steel. The internal leachate collection systems do a good job in keeping out vectors such as rodents, rats and raccoons. In addition, this facility makes little noise and is able to eliminate odours by its bio-filtration system.

The City of Vancouver should research on the feasibility of implementing such a system in multi-unit dwelling unit neighbourhoods in Vancouver. This way, significant emissions and driving time can be reduced from the transportation of food scraps to the Fraser Richmond Soil & Fibre Ltd. facility.

6.2.2 The Fraser Richmond Soil & Fibre Ltd.

The facility is approaching capacity, because the amount of organic matter they receive for composting is greater than the amount of soil that gets sold or removed from the facility. There are unused piles of soil in the facility that require removal in order for the facility to be able to take in increased loads organic matter for composting. This facility was built on the site of an old landfill, thus it was relatively easy to convert into a composting facility as area permits were already in place. It will be near impossible to build another similar facility in Metro Vancouver due to space requirements (Geesing, Personal Correspondence, 2012).

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Appendix A

Definitions

Aerobic composting: Process of composting using nitrogen and involving oxygen and aerobic microbes, generally characterized by high temperatures, absence of foul odors and more rapid than anaerobic composting.

Anaerobic composting: Process of composting not involving oxygen, biproducts include ammonia and methane, generally characterized by lower temperatures, higher odours and slower rates.

CO2e: Equivalent carbon dioxide is the concentration of CO2 that would cause the same level of radiative warming as a given type and concentration of greenhouse gas such as methane and nitrous oxide. Expressed as parts per million by volume.

Compost: A mixture of decayed and decaying organic matter that is commonly used as fertilizer.

Composting: The process of decaying organic matter (such as plant material) by aerobic bacteria or fungi.

Dissemination Area (DA): Smallest density division area provided by Statistics Canada, each contain from 400 - 700 persons per geographic unit.

Downtown / Downtown Vancouver: City Center of Vancouver, Canada. The intersection of Burrard St. and West Georgia St. represent the center of Downtown Vancouver.

Food wastes/ Food scraps: Organic food waste from vegetable or animal origins, commonly from a kitchen.

Garbage/waste: Discarded matter that is found useless and worthless.

Greenhouse Effect: Phenomenon when certain gases that absorb and trap heat cause a warming effect on the Earth.

Greenhouse Gas (GHG): Gas in the atmosphere that absorbs and emits radiation within the thermal infrared range causing a warming effect on the Earth. The primary gases include water vapour, carbon dioxide, methane, nitrous oxide and ozone; most of these being human generated.

Metro Vancouver: Common name of the board of inter-municipal administrative body known as the Greater Vancouver Regional District (GVRD) in British Columbia, Canada.

Multi-unit dwelling: Housing classification where multiple separate families in units live in one contained building. Common form is an apartment building

Single-unit dwelling: Housing classification where a single family in a single unit lives in a single building. Common form is a house.

Appendix B

Sample Calculations

Population Calculations (From Figure 5):

Year	Population	Population Multi-unit dwellings	% increase (Multi-unit dwellings)	Error (%)
1986	42960			0
1991	47288			0
1996	58348			0
2001	70091			0
2006	87975	86479		0
2011	97652	95992	11	0
2015	105464	103672	8	2
2020	110738	108855	5	4

Table 1a. The populations found from Census data, and the projected populations determined from projected growth rates. The multi-unit populations were found by multiplying the population by 0.983 (the % of residents living in multi unit dwellings (City of Vancouver Planning Department Information Sheet, 2006))

Calculating Garbage Produced (From Table 2):

It was known that each individual produces 0.503 tonnes garbage/year.

Therefore,

0.503 tonnes garbage/year x population= amount garbage produced

In 2011: 95992 x 0.503= 48,300 tonnes

Calculating Mass of Food scraps:

22% of the garbage produced is foodscraps (Pitre-Hayes, 2011)

Amount of garbage produced x 0.22 = amount food scraps in garbage

In 2011: 48,300 x 0.22= 10,620 tonnes

Calculating Scenarios from 2011 data (Table 2)

The three scenarios were 100% participation (Max Reduction), 70% participation (Avg Reduction) and 40% participation (Low Reduction).

Business as usual (BAU) was 0 reduction.

For Scenario 1:

The BAU was multiplied by 0.78, since 22% would have been composted

48,280 tonnes/year x 0.22=37, 660 tonnes/year

This was repeated for scenario 2 and scenario 3, except they were multiplied by 0.846 and 0.912 respectively, because this incorporated the participation rates

The compost produced was found by subtracting the total garbage produced in the BAU scenario, by the garbage produced in the scenario

Maximum reduction scenario:

48,280 tonnes/year – 37660 tonnes/ year= 10, 620 tonnes/year

All the calculated GHG results were directly from the WARM model.

Any calculations to determine % reductions were directly from Table 2.

Eg. to determine the reduction in mass of garbage take to the landfill (low scenario): 44040 tonnes/year / 48,280 tonnes/ year= 0.912

Therefore, there was a 9% reduction.

Calculating future food scrap reductions (From Figure 6)

To generate Figure 6:

For business as usual: The population was multiplied by 0.503 tonnes/ person

For the Scenarios: BAU (at given year) was multiplied by: 1-(0.22 x scenario % success)

These variables were imputed into an excel model, and generated Table 2a.

Sample Calculation: Scenario 1, Year: 2015

52147 tonnes/year * [1-(0.22 x 0.9)]= 41822 tonnes/year

	Year				
	2006	2011	2013	2015	2020
Population (people)	86479	95992	99832	103672	108855
BAU (tonnes)	43499	48000	50073	52147	54754
1 (tonnes)	43499	48000	40848	41822	42708
2 (tonnes)	43499	48000	44035	44116	43913
3 (tonnes)	43499	48000	46159.5	46411	46322
BAU error (tonnes)	1740	1920	1846	2607	3285

Table 2a. The raw numbers for the three different scenarios used to generate Figure 7

Cumulative Calculations:

The amount of garbage produced yearly was calculated for 2013-2020. This assumed that the population increased at the same rate between 2013 and 2015, and then 2015 and 2020 (Table 3a).

The sum of the garbage from 2013-2020 for all scenarios was determined.

The difference between the BAU and the scenarios gave the cumulative mass reduction of garbage entering the landfill over the 7 year period.

	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	Sum
BAU	50074	51110	52147	52668	53190	53711.2	54232.6	54754	421886
1 (tonnes)	40848	41335	41822	41999	42176	42353.6	42530.8	42708	335773
2 (tonnes)	44035	44076	44116	44075	44035	43994.2	43953.6	43913	352197
3 (tonnes)	46160	46285	46411	46393	46375	46357.6	46339.8	46322	370643

Table 3a. The mass of garbage produced from 2013-2020 (all years)

GHG Future Emissions

All GHGs were calculated using the WARM model. The results from table 2a were inputted into the model and the results were computed. The results are summarized in Table 4a.

The cumulative results were calculated in the same way as for the food scrap reductions.

Scenario	2006	2011	2013	2015	2020
BAU	13780	15,206	15,863	16520	17,346
1 (tonnes)	13780	15,206	11465	11201	11140
2 (tonnes)	13780	15,206	13107	12382	11761
3 (tonnes)	13780	15,206	14202	13565	13002
BAU error (tonnes)	689	760	793	991	1388

Table 4a. The results from the WARM model.

Calculation of how much this will contribute to total GHG reduction goals

(GCAP)

In 2020:

Mass of reduction: 17346 tonnes-11761 tonnes= 5585 tonne reduction

Goal is 1,020,000 tonne reduction (Pitre-Hayes, 2011)

5585 tonnes/1,020,000 tonnes=0.00548

Spatial Model 1: length of truck routes

Distance from Downtown to landfill:

Origin: approximate central point of Downtown Vancouver = intersection of Burrard St. and Georgia St.

Destination: Vancouver Landfill: 5400 72nd Street, Delta, BC

Shortest Distance (following existing roads and highways) = 27.5km (or 17.1 miles)

Distance from Downtown to compost facility:

Origin: approximate central point of Downtown Vancouver = intersection of Burrard St. and Georgia St.

Destination: Fraser Richmond Soil & Fibre Ltd.: 7028 York Road Richmond, BC

Shortest Distance (following existing roads and highways) = 24 km (or 14.9 miles)

Food Scraps per year (from above)

10,620 tonnes/year

Divide this amount by 52 weeks/year and 5 workings days/week and we can figure out how many trucks needed/ week or day

(10620 tonnes/year) * (1 year/52 weeks) = 204.23 tonnes/week

Number of trucks needed:

Each truck can hold 42 tonnes of compost (Geesing, 2012):

If each pickup truck was filled to its maximum capacity:

(204.23 tonnes/week) / (42 tonnes/truck) = 4.86 trucks/week → 5 trucks / week needed to collect food scraps from Downtown Vancouver

⇒assuming that each truck is filled to the max is not practical and does not allow room for potential larger loads

- Thus, assuming that each truck will be filled up to ⅔ of its total holding capacity:

(42 tonnes/truck) * (2/3) = 28 tonnes/truck

(204.23 tonnes/week) / (28 tonnes/truck) = 7.29 trucks/week → **8 trucks/week needed to collect food scraps from Downtown Vancouver**

Amount of fuel saved by bringing food scraps to composting facility rather than landfill:

(8*27.5km) - (8*24km) = (28 km / week)* (52 week/yr) =1456 km/yr

Garbage pickup trucks use 305,197,033 gal/yr at avg 4.4 mpg (for trucks <40 000 miles/yr). (Anderson et al., 2006).

Most garbage pickup trucks run on diesel fuel, which has a density of 0.832 kg/L.

When garbage trucks can go 4.4 mpg:

(4.4 mile/gal) * (1.61km/mile)* (1 gal/3.7854 L) = 1.87 km/ L

Diesel: (1 tonne / 1000 kg)* (0.832 kg/L) = 8.32 x 10^4 tonne/L

(1.87 km/L) / (8.32 x 10^4 tonne/L) = 2247.6 km/tonne of fuel

If we save 1456 km/ yr in distance from going to compost facility instead of landfill,

(1456 km/yr) * (1 tonne/ 2247.6 km) = **0.648 tonnes/yr saved in diesel fuel**

CO2 equivalent (CO2e) saved per year by transporting food scraps to the composting facility instead of the landfill:

Diesel fuel conversion to CO2e: 2.6676 kg CO2e / L (Environment Canada, 2010)

(0.648 tonnes/yr) * (1000 kg/ 1 tonne) / (0.832 kg/L) = 778.8 L/yr

(778.8 L/yr) * 2.6626 kg CO2e/L = **2073.68 kg CO2e /yr saved**

<u>Spatial Model 2: Density/ spread of multidwellling complexes</u>

2011 Dissemination Area map of Canada including Downtown Vancouver in GIS format obtained through Statistics Canada

Using population calculated above:

Area: 5.79 km^2 (City of Vancouver Planning Department Information Sheet, 2006)

95992 persons/ 5.79 km^2 = 16,578.93 persons/km^2

Only 98.3% (City of Vancouver Planning Department Information Sheet, 2006)

16578,93 persons * 98.3% = 16297 persons living in multi-unit dwellings downtown