



**Food Waste Management + Climate Action:
National GHG Reduction Potential**



Prepared for the National Zero Waste Council

February 2017

Food Waste Management + Climate Action: National GHG Reduction Potential

This study was prepared for the National Zero Waste Council to estimate greenhouse gas reduction potential associated with intensifying food waste prevention and enhancing food waste management.



ACKNOWLEDGEMENTS

The study was initiated at the request of the National Zero Waste Council's Food Working Group. The study benefitted from critical input and review by Ann Rowan, project manager, and her Metro Vancouver colleagues: Joanne Gauci, Andrew Marr and Conor Reynolds.

Many local governments and organizations supported this project, sharing detailed local waste management data that informed estimates of current food waste material tonnage and GHGs:

- Alberta Innovates
- City of Calgary
- City of Edmonton
- City of Halifax
- City of Toronto
- City of Winnipeg
- Cowichan Valley Regional District
- District of Squamish
- Fundy Region
- Metro Vancouver Regional District
- Waste Diversion Ontario

The study was prepared by Alex Boston (Boston Consulting) and Belinda Li and Tamara Shulman (Tetra Tech).



Table of Contents

I - Introduction + Synopsis.....	1
Study Objectives	1
Study Organization + Synopsis	1
Food Waste quantity and GHG Analysis Methodology	3
II – Solid Waste, Food + Climate Science + Policy Context.....	Error! Bookmark not defined.
Solid Waste, Food and Climate Change Science	6
Food Waste Management Practices	7
National Policy Context: Climate Change, Waste + food	10
III - Current Food Waste Management + GHG Profile.....	12
Baseline Food Waste Management Profile	12
IV - 2030 sustainable Food + Waste management + GHG Profile.....	14
Food Waste Prevention Future Overview + Canadian Policy Context.....	14
2030 Food Waste Prevention and Sustainable Waste Management Future	15
V - Conclusion.....	20
Key Findings + Recommendations	20
Further Study	20
Works Cited	22

I - Introduction + Synopsis

STUDY OBJECTIVES

This study estimates material tonnage and greenhouse gas emissions (GHGs) associated with food waste in Canada, the largest share of which is disposed in GHG-intensive landfills. A tenable course for intensifying food waste prevention and sustainable management is charted, and associated material tonnage and GHGs calculated. This sustainable food waste future is situated within the national policy context, drawing linkages to climate change mitigation obligations and broader complementary commitments specifically a national food strategy and UN Sustainable Development Goals.

STUDY ORGANIZATION + SYNOPSIS

The study is organized in five sections.

I - INTRODUCTION + SYNOPSIS

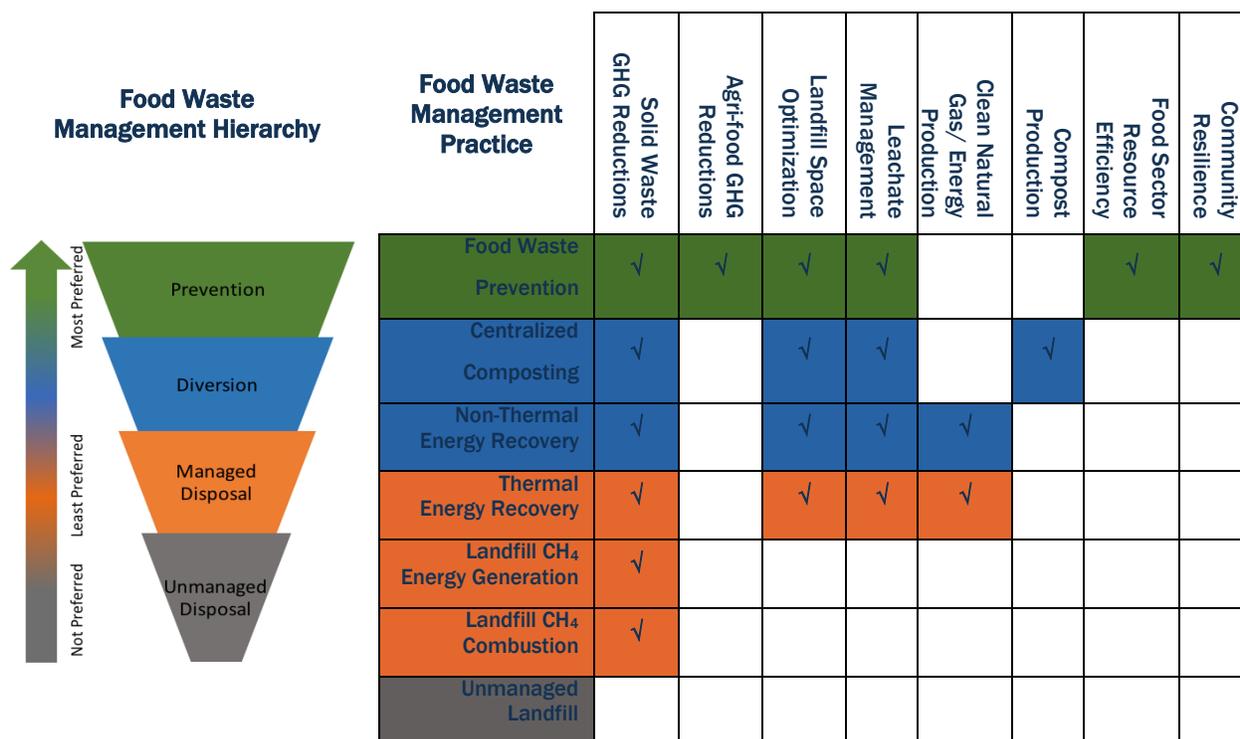
This section introduces the study, provides a synopsis and describes the essential methodology.

II - SOLID WASTE, FOOD + CLIMATE SCIENCE + POLICY CONTEXT

This section establishes the solid waste, food and climate science + policy context.

Food waste is the largest share of landfill organics. Landfills are Canada’s primary approach to solid waste management, responsible for a large share of Canada’s methane emissions a short-lived, highly potent GHG gas. While only 4% of Canada’s total annual GHGs, landfill solid waste is a moderately sized sector approximately equivalent to total natural gas combustion in all commercial and institutional buildings.

There are a range of management practices to reduce GHGs from food waste and landfills. As well as GHG reductions in solid waste and agri-food sectors, there are many socio-economic and environmental co-benefits.



Canada has emerged late in the climate game with earnest plans that must be bolstered to meet targets that match ambitious objectives under the Paris Agreement. A 44 million tonne (Mt) gap between projections for the Pan Canadian Framework on Climate Change and Clean Growth and Canada's target creates an opportunity to advance a sustainable food waste prevention and management framework. This opportunity fits neatly within priorities identified in the Statement on a North American Climate, Clean Energy, and Environment Partnership. This statement acknowledges the strategic significance of landfill methane and Canada's commitment to halve food waste by 2030 under the UN Sustainable Development Goals. Canada's National Food Strategy commitment creates a further opportunity to align food waste prevention, sustainable solid waste management and climate action.

III - CURRENT FOOD WASTE MANAGEMENT GHG PROFILE

This section quantifies food waste in material and GHG tonnage by three management practices in 2015:

- Diversion accounting for 20% of food waste in centralized composting and 3% in anaerobic digestion.
- Managed Landfills including 2% of food waste in thermal energy recovery, 13% in landfills with methane energy generation, 12% in landfills with methane flaring.
- Unmanaged Landfills where there is no significant methane management, accounting for 49% of waste.

Different management practices have different GHG intensities and very different implications. Centralized composting accounts for 20% of food waste and 5% of GHGs. Landfills account for nearly 50% of food waste and 85% of GHGs. Direct GHGs associated with traditional food waste management are 4.1 Mt of CO₂e per annum.

IV – 2030 SUSTAINABLE FOOD + WASTE MANAGEMENT + GHG PROFILE

This section projects a future scenario in which food waste tonnage in materials and GHGs in 2030 is gradually reduced by improving three accepted classes of waste management:

- **Prevention:** preventing 20% of food waste from entering the waste stream, rising from ostensibly 0% in 2015.
- **Diversion:** redirecting 40% of food waste from landfills, mostly to centralized composting, rising from 25%.
- **Managed Landfills:** sending equal shares of waste to landfills with methane capture for energy generation and landfills with methane flaring (30% of food waste); and reducing food waste to unmanaged landfills to 10%.

Adopting this path would cut direct food waste GHGs from 4.1 to 1.5 Mt of CO₂e per year by 2030. This 2.6 Mt reduction could shrink the 44 Mt gap between the Pan Canadian Framework commitments and Canada's 2030 Target by 6%. From a full life cycle perspective, this path would result in an 8.1 Mt reduction of CO₂e, a large share of which is from reduced energy use associated with using food previously discarded as waste and avoiding the production and procurement of new food.

This market transformation assumes that proactive approaches to reducing food waste and GHGs would be adopted across Canada. In doing so, it would help Canada meet climate change and sustainability obligations made on the international stage, specifically the Paris Climate Treaty, as well as one of the UN Sustainable Development Goals. At the same time, contributions could be made to domestic agendas currently under development, specifically filling the gap in the gap in the Pan Canadian Framework on Climate Change as well as the development of the National Food Strategy.

	Prevention practices	Diversion practices	Managed disposal strategies
Paris Agreement Obligation	√	√	√
Pan Canadian Framework Commitment		√	√
Pan Canadian Framework 44 Mt Gap	√	√	√
N American Climate + Environment Framework Obligation	√	√	√
UN Sustainable Development Goal 12.3 Obligation	√		
National Food Strategy + Ag Policy Update	√		

V - CONCLUSION

This study has two key findings and associated recommendations:

- There are strong synergies between sustainable food waste management and national climate change, and food and agriculture sustainability priorities. Articulating these linkages can consolidate support for this agenda.
- The climate change mitigation potential from sustainable food waste management is conclusive and modest. Enhanced life cycle analysis would demonstrate greater GHG reduction potential.
- Several study areas could advance sustainable food waste management and climate change mitigation:
 - Data Collection
 - Policy Mapping
 - Triple Bottom Line Cost-Benefit Analysis
 - Expanded Sustainable Waste Management Analysis
 - Enhanced Life Cycle Analysis

FOOD WASTE QUANTITY AND GHG ANALYSIS METHODOLOGY

Solid waste management practice data and specifically food waste management practice data are not readily available. It is inconsistently collected, of variable quality, and uses different methodologies from one subnational jurisdiction to another and one local jurisdiction to another. There were two principal analytical stages for assessing material tonnage and GHG quantification of food waste management practices that are germane to this study.

1. Baseline Food Waste Management Practice Analysis

This study collected readily available local data on food waste management practices from a diverse sample of local governments or authorities that manage solid waste on behalf of local governments from across Canada. The data sets included a combination of composition data (relative proportion of food waste in the garbage and organics streams where applicable), and tonnage data (total quantity of garbage and/or organics).

The average composition of food waste in the garbage and organics streams were calculated from this diversity of local data, then applied to the total quantity of garbage and organics to extrapolate tonnages by management practice on a per capita basis. Adjustments were made by weight for the variability in management practices across the country. Average food waste material tonnage was then triangulated with US data to ensure estimates were reasonable.

This approach allowed all food waste material tonnage to then be categorized according to management practice. Two approaches were then taken to quantify GHGs according to management practice:

- A methane commitment methodology was used to quantify GHGs associated with a given material quantity of food waste according to management practice. For landfills, methane is released over the span of a few decades from the anaerobic decomposition of food waste. For other management practices (composting, thermal and non-thermal energy recovery), the associated GHGs are released within the year that the food waste is generated. This methodology aggregated the decades of methane emitted from landfills into a single year to permit comparison between management practices as well as better understand the contribution of a given management practice to Canada's overall emissions.
- A lifecycle analysis methodology was used to quantify GHGs associated with a given material quantity of food/food waste according to management practice across all stages in the life cycle including production, processing, transportation and disposal. This methodology notably provides useful insight into the immense GHG benefits associated with food waste prevention.

2. Food Waste Prevention and Sustainable Solid Waste Management Future Analysis

The portfolio of food waste management practices developed for 2030 were informed by a combination of factors including: national policy commitments and sub-national and local policy alignment, technology trends, realistic rates of market transformation, appropriate scale of infrastructure by urban region (e.g. capital intensive anaerobic digestion facilities that are only built commercially at large scales were not deployed in small urban regions).

Future food waste material tonnages were assigned to management practices and GHGs were then quantified with both calculation methodologies.

Future food waste material tonnage was assumed to be stable based on an analysis of the last 25 years that shows municipal solid waste generation steadily grew and has levelled off over the last decade.¹

¹ Municipal solid waste material tonnage steadily grew between 1990 and 2003 and has remained relatively stable since (Environment and Climate Change Canada, 2016: 2). The most recent year for which the data is available is 2014: 20.3 Mt. Ten years earlier, 2004: 20.6 tonnes. Underlying this assumption is that waste and food waste per capita is slowly dropping and that the population grows over this period from 35.9 million in 2015 to 41 million in 2030, based on Statistics Canada population projections, Medium Growth Scenario 1 (Statistics Canada, 2010).

KEY DEFINITIONS

- **Edible Food:** Any substance — whether processed, semi-processed, or raw — intended for human consumption. “Food” includes drink, and any substance that has been used in the manufacture, preparation, or treatment of food. “Food” also includes material that has spoiled and is therefore no longer fit for human consumption. It does not include cosmetics, tobacco, or substances used only as drugs. It does not include processing agents used along the food supply chain, for example, water to clean or cook raw materials in factories or at home (FLW Protocol Steering Committee, 2016, p. 15).
- **Inedible Parts of Food:** Components associated with a food that, in a particular food supply chain, are not intended to be consumed by humans. Examples of inedible parts associated with food could include bones, rinds, and pits/stones. “Inedible parts” do not include packaging. What is considered inedible varies among users (e.g., chicken feet are consumed in some food supply chains but not others), changes over time, and is influenced by a range of variables including culture, socio-economic factors, availability, price, technological advances, international trade and geography (FLW Protocol Steering Committee, 2016, p. 15).
- **Food Loss:** Any edible and inedible parts of food, that are removed from the food supply chain to be recovered, recycled or disposed. Food loss encompasses food waste. (FUSIONS, 2014)
- **Food Waste:** Losses occurring at retail, food service and consumer stages are termed food waste to factor in behaviour at those stages. (Gustavsson et al., 2011; Parfitt, Barthel, & Macnaughton, 2010)

II – Solid Waste, Food + Climate Science + Policy Context

This section establishes the solid waste, food and climate science + policy context.

Food waste is the largest share of landfill organics. Landfills are Canada's primary approach to solid waste management, responsible for a large share of Canada's methane emissions, a short-lived, highly potent GHG gas. While only 4% of Canada's total annual GHGs, landfill solid waste GHGs is a moderately sized sector approximately equivalent in size to natural gas combustion in all commercial and institutional buildings.

There are a range of management practices to reduce GHGs from food waste and landfills. As well as GHG reductions in solid waste and agri-food sectors, there are many socio-economic and environmental co-benefits.

Canada has emerged late in the climate game with earnest plans that must be bolstered to meet targets that match ambitious objectives under the Paris Agreement. A 44 Mt gap between projections for the Pan Canadian Framework on Climate Change and Clean Growth and Canada's target creates an opportunity to advance a sustainable food waste prevention and management framework. This opportunity fits neatly within priorities identified in the Statement on a North American Climate, Clean Energy, and Environment Partnership. This statement acknowledges the strategic significance of landfill methane and Canada's commitment to halve food waste by 2030 under the UN Sustainable Development Goals. Canada's National Food Strategy commitment creates a further opportunity to align food waste prevention, sustainable solid waste management and climate action.

SOLID WASTE, FOOD AND CLIMATE CHANGE SCIENCE

Waste, Food, Landfills and Climate Change

Landfills are Canada's primary approach to solid waste management. When organic material decomposes in landfills anaerobically (without oxygen), landfill gas is generated. Landfill gas is composed of approximately 50% methane (CH₄) and approximately 50% carbon dioxide (CO₂) with trace amounts of a wide range of other gases. Methane is the operative anthropogenic GHG as landfilling has increased GHG contributions to the atmosphere above pre-industrial levels. Rather than anthropogenic, carbon dioxide is treated as biogenic as it is part of the natural carbon cycle whereby plants and animals assimilate and store carbon dioxide during their lives and then lose it during death when a portion is emitted into the atmosphere. This cycle has been ostensibly constant.

Environment Canada currently calculates the heat trapping potential of one tonne of methane emissions to be 25 times more potent than one tonne of carbon dioxide measured over a 100-year period. Because CH₄ is a short-lived GHG relative to CO₂, its potency over 20 years is 86 times greater, and is thus an increasingly important focus for many climate change mitigation efforts (IPCC, 2013).²

Landfill gas is initially emitted in a spike shortly after organic material disposal. Emissions subside somewhat after several years and then incrementally drop over several decades. The multi-decade time lag between waste disposal and emissions is profoundly different from fossil fuel sectors where emission generation is immediate upon combustion (and emission reductions are immediate upon feedstock cessation).

Canadians dispose 20 Mt of solid waste in landfills annually.³ More than half of residential and commercial waste is organic and by far the largest share is food waste.⁴ A significant portion of this waste food is edible.

² While Environment Canada uses a Global Warming Potential of 25 based on its 100-year life, the IPCC updated its CH₄ GWP calculation to 34 – a 20% increase – in Assessment Report Five (2013). Countries will likely shift to this CH₄ GWP eventually. Furthermore, the 100-year life standard used for calculating GWP is accurate but also somewhat arbitrary. Because of the time sensitivity for driving deep GHG reductions, a growing number of scientific agencies emphasize action on CH₄ which has a life of just 12 years, and that the IPCC's 20-year life standard should also be calculated for key GHGs like CH₄ (which is 86 times CO₂).

³ Canadians have disposed more than 20 Mt of waste annually for more than 15 years, according to Statistics Canada data used as a basis for Canada's National Inventory Reports (Environment and Climate Change Canada, 2016)

One third of food produced for human consumption is wasted. The cost of food waste in Canada is estimated to be at least \$31 billion annually. In terms of the economic value of food waste, consumers account for 47% of this waste, followed by processors (20%) and then the retail sector (10%). (Value Chain Management International, 2014)

Waste GHGs in Canada

While not huge, at 26 megatonnes of CO₂e per year in 2014, landfill solid waste disposal is a moderately sized GHG sector within Canada's overall inventory (4% of the country's total 732 Mt total GHGs).⁵ Solid waste is larger than petroleum refining (17 Mt – 2% share), pipelines (10 Mt – 1% share), mining (excluding oil sands mining) (8 Mt – 1% share). Annual solid waste GHGs from landfills are approximately the same quantity as on site fossil fuel combustion in commercial buildings (31 Mt – 4% share).⁶

Solid waste GHGs from landfills has remained relatively constant over more than two decades; 1990 – 24 Mt; 2005 – 28 Mt; 2014 – 26 Mt. Relatively constant emissions, however, belies significant dynamism in solid waste management over this period:

- Today, more than one third of landfill methane is captured, rising from 20% in 1990. Half this methane is utilized for energy. The other half flared.
- Waste exports to the US increased 38-fold, peaking in 2007 and are now modestly declining.
- Landfill waste disposal peaked in 2002 and has since modestly declined. Current levels are 25% above 1990.
 - On a per capita basis, waste disposal has decreased more than 10% since 1990 due to diversion.
- Organic diversion has steadily risen with significant paper recycling, some yard and urban tree waste composting, and most recently residential curbside composting and growing commercial composting.

Critically important in these dynamics is that while 25% more waste is going to landfills relative to 1990, GHGs are stable due to improved landfill management in large landfills and growing organic diversion. The emission reduction impact of organic diversion is only partially registering in inventories due to the time lag time between disposal and landfill gas generation.

FOOD WASTE MANAGEMENT PRACTICES

There are a variety of practices for managing food (and organic) waste. Each has a different cost/benefit profile.

PREVENTION

- **Prevention:** This strategy includes activities that reduce the generation of food waste at source, as well as recover wasted food for human and animal consumption, e.g. diverting surplus prepared foods from catering services to people in need. As well as cutting GHGs in landfills, some strategies will reduce GHGs in the agri-food sector as food processors and retailers avoid disposing nutritious food. This strategy would be supported with behavior change campaigns in commercial and residential sectors.

⁴ Most food waste composition analysis finds residential waste to be >50% organics (including paper) with the largest portion by far being food, about 80%. Industrial/commercial/institutional (ICI) food waste is also >50% organic (including paper), about 50% of which amount is food waste (Metro Vancouver + Tetra Tech, 2014).

⁵ Mt of CO₂e is an abbreviation of millions of metric tonnes of CO₂ equivalent. Carbon dioxide (CO₂) is the primary greenhouse gas being added anthropogenically to the atmosphere and as such is the “currency” which other GHGs are compared to for equivalency. The heat trapping potential (global warming potential) of one tonne of methane is calculated as 25 times more potent than one tonne of CO₂ over a 100 year life so would be expressed as 25 tonnes CO₂e.

⁶ Analysis is based on Canada's latest inventory submitted to the UN Framework Convention on Climate Change (Environment and Climate Change Canada, 2016) as well as analysis from select previous inventories (Environment Canada, 2014)

DIVERSION

- **Centralized Composting:** Centralized composting involves collecting organics from residential and commercial sources and bringing them to an industrial composting facility. Industrial composting includes both enclosed (in-vessel or under a cover), or open (windrow or aerated piles) systems. Centralized composting is often the more viable diversion strategy when there is a smaller population compared to non-thermal energy recovery. As well as reducing food waste and GHGs, this practice reduces landfill siting challenges. It does, nevertheless, create new siting challenges, albeit smaller in scale.
- **Non-Thermal Energy Recovery (e.g. anaerobic digestion):** Non-thermal energy recovery converts food waste and typically mixed waste into biogas (mostly consisting of methane) that can be used for energy generation or conversion to clean natural gas. A solid byproduct can be further composted into an organic amendment. Generally, thermal energy recovery is more favourable around larger urban regions where the large scale of these advanced facilities is cost effective. As well as fuel or energy sales, high capital costs are typically offset with grants, energy offsets, premium prices for natural biogas. In addition to reducing food waste and GHGs, this practice reduces landfill siting challenges. It does, nevertheless, create new siting challenges.

MANAGED DISPOSAL

- **Thermal Energy Recovery (e.g. incineration, gasification):** Thermal energy recovery typically converts mixed waste (including food waste) into gases at high temperatures (with or without combustion). Solid byproducts from this process include ash and slag. Energy can be recovered by using the heat for co-generation, or through gasification, collecting and refining the syngas. Thermal energy recovery is lower on the food recovery hierarchy and is considered as a form of food waste disposal. As well as reducing food waste and GHGs, this practice reduces the volume of waste going to landfills.
- **Landfill - CH₄ Energy Recovery:** Landfilling with methane capture for energy generation involves collecting methane from landfills, then either using the gas directly for energy generation or refining it into clean natural gas for other uses. Regulation is increasingly supporting landfill gas recovery resulting in more landfills implementing these types of systems.
- **Landfill - CH₄ Capture + Combustion:** Instead of capturing methane for energy generation, this strategy captures methane and flares it on site. This strategy converts methane to carbon dioxide, which is a significantly less potent greenhouse gas. It is more common at smaller landfills that do not produce enough methane to cost effectively support landfill gas recovery systems, but still require some form of landfill gas management.

UNMANAGED DISPOSAL

- **Landfill – Unmanaged:** Unmanaged landfills do not have a system to capture landfill gas. These landfills are Canada's largest sources of methane emissions in the solid waste sector. These landfills may have a bio cover comprised of a layer of compost applied as a final cover over landfills. Bio covers modestly reduce methane emissions as a share of gas is oxidized and stabilized by the compost. The growth in centralized composting permits cost effective bio cover management. Unmanaged landfills are more common in rural and remote areas, or at older landfills that have not been retrofitted with landfill gas collection systems. This type of landfill is less common in medium to large urban regions.

Food Waste Prevention and solid Waste Management Practice Hierarchy + Benefits

Each management practice has a different profile of socio-economic and environmental costs and benefits, most of which vary somewhat by location. They can be organized into a coherent hierarchy according to climate change mitigation potential and resource sustainability.

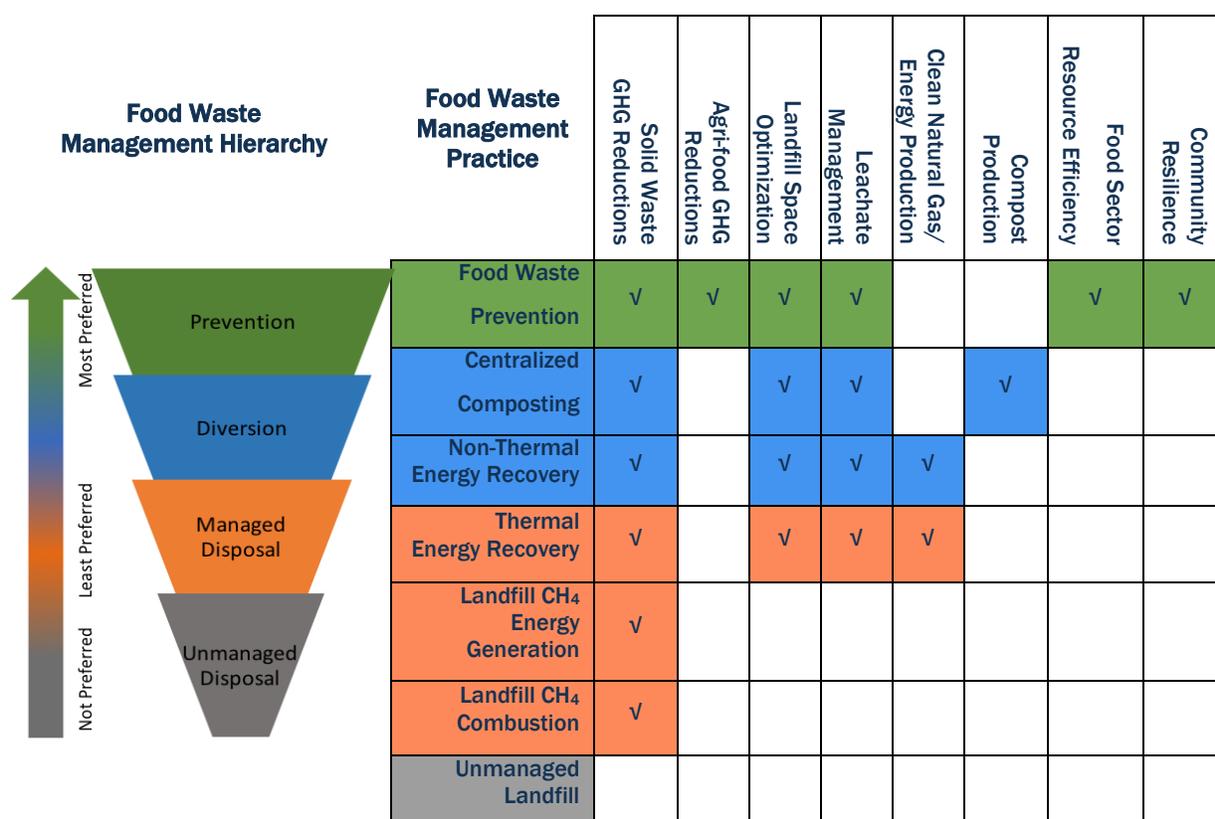


Figure 1: Food Waste Management Practice Hierarchy and Benefit Summary

These benefits are summarized, accordingly:

- **Solid waste sector GHG reductions**
- **Agri-food sector GHG reductions**
- **Resource efficiency + cost management** from avoided waste in food production, processing and consumption
- **Community Resilience** associated with diverting nutritious food from landfills by retail, institutional and commercial food services or processors to food banks
- **Landfill space optimization** and reduced landfill siting conflicts from food waste prevention and diversion
- **Reduced landfill leachate** with reduced organic disposal
- **Clean natural gas production**, energy generation and the displacement of fossil fuels
- **Soil amendment production**, i.e. compost

Quantifying costs and benefits is beyond the scope of this study. Enumerating them, notably along with capital and operating costs of the management practice (minus revenue from value-added products) would help optimize an appropriate blend of solutions nationally and regionally.

While this study focusses on food waste prevention and management, all the preferred management practices lend themselves to leveraging broader GHG reductions from landfills and diversion from landfills, notably yard and clean wood waste.

NATIONAL POLICY CONTEXT: CLIMATE CHANGE, WASTE + FOOD

Paris and Pan-Canada Commitments to the Planet: Preliminary targets + Plans

After two decades of delays, Canada played a leadership role brokering the Paris Agreement under the UN Framework Convention on Climate Change in December 2015, notably strengthening its primary aim: “holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.”

On 5 October 2016, Canada ratified the Paris Agreement. Under this agreement, its “Nationally Determined Contribution” (NDC) re-affirmed a target that had been adopted by a previous government: “Canada intends to achieve an economy-wide target to reduce its greenhouse gas emissions by 30% below 2005 levels by 2030.” An interim target has also been re-affirmed: -17% below 2005 levels by 2020.

Scientific critiques of the Paris Agreement conclude the GHG reduction commitments are inadequate to meet its temperature stabilization objectives. A peer reviewed article in *Nature* by an international team of scientists states: “The 2030 global GHG emission levels implied by the NDCs are far outside the range indicated by cost effective likely 2 °C and 1.5 °C pathways. The situation is even less favourable when looking at policies that are currently in place.” (Schleussner, 2016) The Paris Agreement, nevertheless, acknowledges these initial commitments are a floor and includes five year intervals to establish more ambitious targets in line with the objectives.

In February 2016, in its Second Biennial Report to the UNFCCC on climate action progress, the federal government indicated it is expected to be 23% above its 2020 target and 56% above its 2030 target, based on policies adopted at the time. This report was submitted prior to federal/sub-national commitments in December, 2016 to phase out coal by 2030, and phase in a carbon price equivalent to \$50/tonne by 2022, and diverse measures to consolidate federal and sub-national efforts across a diversity of sectors under a Pan Canadian Framework on Climate Change and Clean Growth (Canadian First Ministers, 2016). The Pan Canadian Framework enumerates 175 Mt of emission reduction measures by 2030, leaving a 44 Mt gap with its target. Given the economy’s inertia, these projected reductions seem highly optimistic, assume fullest implementation and maximum impact, and must be complemented by effective growth constraints in other key sectors, notably oil and gas.⁷

The Framework makes only general references to solid waste which is aggregated under a section with agriculture and forestry activities. Renewable fuel generation is the only waste management climate change mitigation measure referenced.

As part of their communiqué, federal and sub-national governments made a commitment to continue to collaborate on efforts to implement the Framework and meaningfully engage Canadians to take ambitious action. Little has been said on filling the 44 Mt gap.

There is great potential to advance food waste prevention and more sophisticated sustainable solid waste management specifically commercial composting and landfill energy generation within the Pan Canadian Framework. The greatest opportunity is in the context of filling the 44 Mt gap necessary to meet Canada’s 2030 targets, and potentially a more ambitious target in line with the Paris Agreement that Canada played a lead role in designing. These food and waste omissions have significant climate change mitigation potential in both solid waste and agri-food sectors, and align with other federal commitments (see below: North America to the UN, and Gate to Plate to Mitigate).

⁷ The veracity of the Pan Canadian Framework’s reduction projections is uncertain. The cornerstone coal phase out and carbon pricing measures are illustrative. The Federal National Pollutant Release Inventory had already projected a 75% decline in coal fired electricity generation based on a 45-50-year retirement age of plants by 2030 (Canadian Electricity Association, 2016). This understanding should have been integrated into earlier BAU GHG projections, submitted in the Second Biennial Report to the UNFCCC. SFU economist Mark Jaccard, one of Canada’s foremost carbon pricing thinkers, indicates \$200/tonne is necessary to achieve significant reductions (2016). He explains, “ninety per cent of the reductions in the last eight or nine years in California are occurring because of the flexible regulations, not because of that very low floor price in their cap-and-trade.”

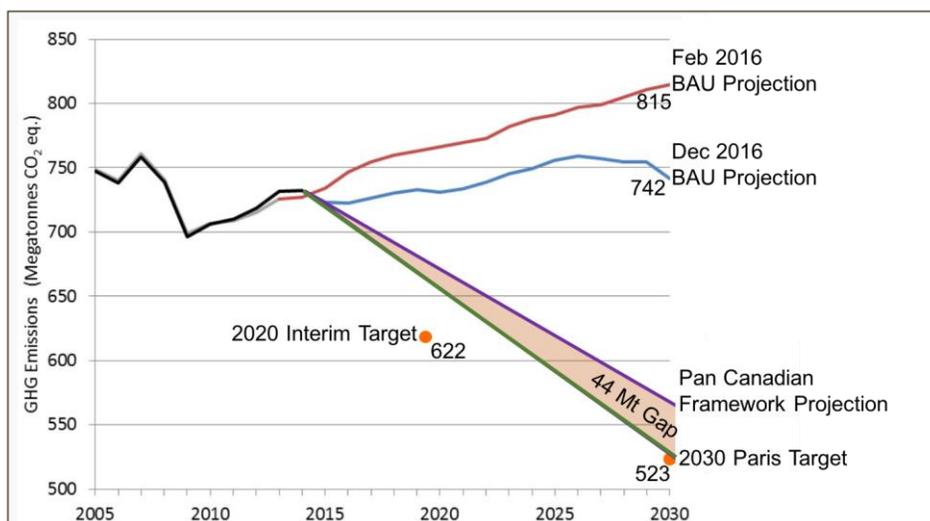


Figure 2: Current, Projected and Target GHGs Levels using Environment and Climate Change Canada data. The 44 Mt Gap between the highly optimistic 2030 Pan Canadian Framework projection and the 2030 Target create an opening to advance a more robust food waste prevention and sustainable solid waste management agenda.

North America to the UN: Food + organic Waste + Methane pledges + Partnerships

To help define directions for their Paris commitments, Canada, US and Mexico issued a joint *Statement on a North American Climate, Clean Energy, and Environment Partnership* in June, 2016. A major focus was “to develop and implement national methane reduction strategies for key sectors such as oil and gas, agriculture, and waste management, including food waste.” Methane was prioritized because it is a short-lived, high impact GHG.

The statement outlined a commitment to “decrease methane emissions from landfills and the agricultural sector:”

- “Reduce and recover food waste in North America, in line with Target 12.3 of the UN Sustainable Development Goals, which envisions a 50% reduction in global food waste by 2030.”
- “Take actions to reduce emissions from landfills – the third largest source of methane globally.”

The previous Canadian government adopted the SDGs in 2015, and while there is no formally developed plan, the current government has made many references to the SDGs in speeches by the prime minister and in documents for consultations on the Federal Sustainable Development Strategy and the International Assistance Review.

This trilateral commitment provides specific and substantive direction to advance a broad agenda for food waste prevention and sustainable waste management.

Gate to Plate to Mitigate: A National Food Strategy

The Minister of Agriculture Lawrence MacAuley was asked to craft Canada’s first national food strategy as part of his ministerial mandate from the Prime Minister. Several priorities are specifically identified: domestic food production; safe, healthy and high quality food. The Minister, consistent with directives across cabinet, was requested to seek opportunities to advance climate change mitigation and adaptation. The commitment to climate action was strongly reinforced in a joint federal-provincial-territorial ministers of agriculture “Calgary Statement” (July, 2016) where “environmental sustainability and climate change” was identified as a priority area for updating both federal and federal-provincial policy frameworks on Canada’s agriculture and agri-food sector (Joint Federal, Provincial, Territorial Ministers of Agriculture + Agrifood, 2016).

With strong climate change and environmental sustainability commitments, food waste prevention and sustainable food waste management should be central considerations in a national food strategy and updated agricultural and agri-food policy frameworks. These tenets naturally align with the North American leaders’ statement on food waste prevention and solid waste management, and the UN Sustainable Development Goal 12.3 on food waste reduction adopted by Canada.

III - Current Food Waste Management + GHG Profile

This section quantifies current national food waste tonnage in materials and GHGs according to three classes of management practices:

- **Diversion** accounting for 20% of food waste in centralized composting and 3% in anaerobic digestion.
- **Managed Landfills** including 2% of food waste in thermal energy recovery, 13% in landfills with methane energy generation, 12% in landfills with methane flaring.
- **Unmanaged Landfills** where there is no significant methane management, accounting for 49% of waste.

Total GHGs associated with this food waste baseline amounts to 4,091,402 tonnes of CO₂e per annum (4.0 Mt). The contribution of each management practice underscores the immense contrast in GHG intensity. Centralized composting accounts for 20% of food waste and generates 5% of GHGs. Landfill account for 50% of food waste and 85% of GHGs.

BASELINE FOOD WASTE MANAGEMENT PROFILE

Diversion

Diversion practices account for 20% of food waste in centralized composting and 3% in non-thermal energy recovery (i.e. anaerobic digestion) in 2015.

DIVERSION ESTIMATE BASIS

Approximately 1.3 Mt of food waste are diverted annually (equivalent to a 23% diversion rate) from landfills. This quantity only includes materials collected and processed at a centralized facility; and excludes on-site, community or backyard composting.

There is very limited data on the quantity of diverted food waste in Canada, as it is not common for detailed food waste categories to be used to characterize organics feedstocks. Food waste diversion quantities and composition were obtained from municipalities with available data, representing large urban, medium urban, and rural regions. Per capita estimates were generated for each of these types of population archetypes, then extrapolated based on census populations. Based on existing waste composition studies, the fraction of wasted food (i.e. food that could have been eaten) was approximately 60%.

The quantity of food waste processed via centralized composting versus non-thermal energy recovery (anaerobic digestion) is currently not tracked in Canada.

As there are only a few anaerobic digestion facilities in Canada, the capacities of these facilities were added together to estimate the quantity of food waste that is anaerobically digested.

On average, approximately 80% of the feedstock of anaerobic digesters is estimated to be food waste. The resultant estimate is approximately 190,000 tonnes per year of food waste managed through non-thermal energy recovery. Assuming the balance of diverted food waste goes to centralized composting, that is approximately 1.1 Mt per year.

Managed + Unmanaged Disposal

Managed disposal practices account for 2% of food waste thermal energy recovery (e.g. incineration), 13% in landfill methane energy generation, 12% in landfill methane flaring, and 49% in unmanaged landfills.

MANAGED + UNMANAGED DISPOSAL ESTIMATE BASIS

4.3 Mt of food waste are estimated to be disposed in landfills annually across Canada. Approximately 97% (4.2 Mt) is landfilled and 3% (130,000 tonnes) processed through thermal energy recovery, using estimates based on a study commissioned by the Canadian Council of Ministers of Environment (Giroux, 2014). Based on existing waste composition studies, the fraction of wasted food that is disposed is approximately 70%.

Food waste destined for landfills was further subdivided into estimates for landfills based on their GHG intensity, using data from the latest National Inventory Report, which reported emissions from 1990 to 2014 (Environment and Climate Change Canada, 2016). Of the methane gas generated from landfills in 2014,

34% was captured. Of the captured methane, 51% was combusted to generate energy, and the other 49% was simply flared. This study assumes the proportions of captured methane generally correlate with the quantity of food waste disposed in each landfill category (i.e. 34% of food waste is disposed in landfills with methane capture), the estimates of landfilled food waste are divided as follows:

- Landfill – CH4 Capture + Combustion: 690,000 tonnes
- Landfill – CH4 Energy Generation: 720,000 tonnes
- Landfill – Unmanaged: 2.7 Mt

Baseline Food Waste Management Summary

The equivalent quantity of GHGs associated with each management practice is presented in the following table. The calculations of the GHGs were based on the emission factors in Canada's Greenhouse Gas Inventory (Environment and Climate Change Canada, 2016). For all management practices, carbon dioxide emissions are excluded as they are treated as biogenic sources (i.e. emissions associated with natural degradation of materials) versus anthropogenic sources (i.e. caused by human activity). In other words, only methane and nitrous oxide (where emission factors were available) were included. In the case of thermal energy recovery, methane emissions are considered negligible (Environment and Climate Change Canada, 2016). For landfilling, methane releases over the span of a few decades are presented as the total emissions from decomposition, not just the emissions in the year that the food waste was placed in the landfill. This is to help communicate the net impact of a given quantity of organics according to management practice. These numbers underscore the contrast in GHG intensity by management type. Centralized composting accounts for 20% of food waste and generates 5% of GHGs. Landfills account for 49% of food waste and 85% of GHGs.

Food Waste Management Practice	Food Waste Quantity (tonnes/year)	% of Food Waste	GHGs (tonnes CO2e/year)
Diversion: Centralized Composting	1,087,773	20%	206,024
Diversion: Non-Thermal Energy Recovery, e.g. anaerobic digestion	192,000	3%	9,091
Disposal: Thermal Energy Recovery, e.g. incineration, gasification	128,736	2%	0
Disposal: Landfill CH4 Energy Generation	721,770	13%	225,553
Disposal: Landfill CH4 Capture + Combustion	693,465	12%	216,708
Disposal: Unmanaged Landfill	2,747,221	49%	3,434,026
Total Diverted / CO2e	1,279,773	23%	215,115
Total Disposed / CO2e	4,291,191	77%	3,876,287
Total Food Waste / CO2e	5,570,964	100%	4,091,402

Table 1: Base Year Food Waste Quantity and GHG Tonnage

IV - 2030 sustainable Food + Waste management + GHG Profile

This section projects food waste tonnage in materials and GHGs out to 2030 based on gradually improving three accepted classes of waste management beyond current 2015 rates. The 2030 food waste prevention and sustainable waste management future is defined as:

- **Prevention:** preventing 20% of food waste from entering the waste stream, rising from ostensibly 0% in 2015.
- **Diversion:** redirecting 40% of food waste from landfills, mostly to centralized composting, rising from 25%.
- **Managed Landfills:** sending equal shares of waste to landfills with methane capture for energy generation and landfills with methane flaring (30% of food waste total); and reducing food waste to unmanaged landfills to 10%.⁸

This shift to food waste prevention and more sustainable waste management practices described above would result in 2.6 Mt of CO₂e reductions annually. This could reduce the 44 Mt gap between the Pan Canadian Framework commitments and the 2030 Target by 6%.

Lifecycle analysis of the 2015 base year and the 2030 future reveals larger reductions, specifically 4.5 Mt per annum reduction in GHGs associated with food waste prevention, and a total 8.1 Mt reduction relative to 2015. A large share of these GHG reductions would be accrued in agriculture and agri-food sectors in the form of avoided energy use in processing, and some would be accrued beyond Canada's borders associated with food imports.

FOOD WASTE PREVENTION FUTURE OVERVIEW + CANADIAN POLICY CONTEXT

Projections of 2030 food waste tonnage in materials and GHGs are based on gradually improving three classes of waste management practices that prevent food waste, divert waste to recover value and reduce the share of waste going to landfills without any form of methane management (see Section 1 for a fuller discussion of these practices).

These management practices are all accepted, cost-effective approaches already deployed at local scales coast to coast. This study assumes a realistic mix and phase in rate of best practices that take into account appropriate scales of certain types of infrastructure by urban region, and policy development, capitalization and infrastructure development time. This realistic market transformation would help Canada meet obligations made on the international stage, and domestically fulfill agendas currently under development (see Section 1 for a fuller discussion of these national agendas).

	Prevention practices that reduce the quantity of food waste disposal	Diversion practices that redirect waste from landfills towards practices that recover renewable energy or environmental value	Managed disposal strategies that capture landfill methane for energy or flaring
Paris Agreement Obligation	√	√	√
Pan Canadian Framework Commitment		√	√
Pan Canadian Framework 44 Mt Gap	√	√	√
N American Climate + Environment Framework Obligation	√	√	√
UN Sustainable Development Goal 12.3 Obligation	√		
National Food Strategy + Ag Policy Update	√		

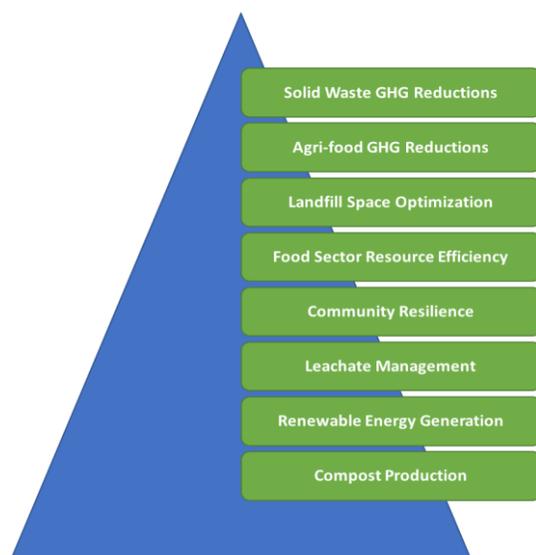
Table 2: Sustainable Food Waste Management Agenda and National Policy Agenda

⁸ With the model developed for this analysis, other assumptions about the impact of applying these waste management practices and strategies could be evaluated. This future scenario was considered achievable with a cross-Canada commitment to reducing food waste and GHGs.

These high-level, national policy commitments would require a suite of focussed, mutually reinforcing policies nationally, sub-nationally and locally to realize widespread management practice adoption. While not fleshed out, policy examples are identified to help illustrate the tangible nature of this agenda.

Policy Type	Federal + Sub-National	Local
Legislated Targets	National Food Strategy: Food Waste Reduction Target	Local Food Waste Reduction Target Per Capita Waste Disposal Target
Regulation	Labeling to reduce “best before” confusion Unmanaged Landfill Phase Out	Residential/commercial organic waste bans
Education	Consumer/commercial food waste reduction social marketing	Food waste separation social marketing, education programs, & resources/toolkits Food waste prevention social marketing, education programs, & resources/toolkits
Incentives + Disincentives	Commercial/industrial food donation incentive	Organic waste landfill disposal fines
Investment	Centralized composting, anaerobic digestion, landfill renewables	Centralized composting, anaerobic digestion, landfill renewables

Table 3: Federal, Subnational, Local Food Waste Prevention + Management Policy Examples



There are a wide range of benefits associated with this agenda that should be taken into consideration, along with capital and operational costs (and revenues) to determine the optimal mix of management practices (see Section 1 for a summary of these benefits).

Figure 3: Food Waste Prevention, Sustainable Waste Management Benefits

2030 FOOD WASTE PREVENTION AND SUSTAINABLE WASTE MANAGEMENT FUTURE

This future prevents 20% of food waste from entering the waste stream, rising from zero in 2015. An additional 40% of food waste is diverted from landfills, mostly to centralized composting, rising from 25%. Equal shares of food waste go to landfills with methane capture for energy generation and landfills with methane flaring, comprising 30% of total food waste. The share of food waste going to unmanaged landfills shrinks to 10% from 49%.

This shift to food waste prevention and more sustainable waste management practices result in reductions of 2.6 Mt of CO_{2e}, annually. Lifecycle analysis of the 2015 base year and the 2030 future reveal much more dramatic reductions, notably a 4.5 Mt per annum reduction in GHGs associated with food waste prevention. A large share of these emission reductions would be accrued in agriculture and agri-food sectors in the form

reduced energy use in processing. A total 8.1 Mt reduction includes reduced organics in food diversion and disposal.

Prevention

By 2030, prevention practices across the entire value chain from production to consumption avoid 20% of food waste going into waste streams.

PREVENTION ESTIMATE BASIS

Along with other UN members, Canada adopted, in September, 2015, Agenda 2030 which has a set of Sustainable Development Goals (SDGs) that are being pursued globally. SDG 12.3 commits Canada, by 2030, to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses (UN DESA).

There are a variety of “food waste” interpretations. As Canada has not yet defined how it will achieve this goal, this study uses the Food and Agriculture Organization definition. The FAO defines food loss as “the decrease in quantity or quality of food”. Food waste is part of food loss and refers to discarding or alternative (non-food) use of food that is safe and nutritious for human consumption along the entire food supply chain, from primary production to household consumer level. Food waste is recognized as a distinct part of food loss because the drivers that generate it and the solutions are different from those of other aspects of food loss (FAO, 2014).

Based on this definition, we assumed that wasted food diverted to composting or non-thermal energy recovery (i.e. anaerobic digestion) is still considered food waste because it is a non-food use of food that is safe and nutritious for human consumption. Therefore, for Canada to achieve the target of halving per capita food waste at the retail and consumer levels, it must be done through waste prevention.

For the 2030 scenario estimates, a conservative approach was adopted, assuming 80% of the target (i.e. 40% of food waste per capita from the retail and consumer levels compared to the baseline year of 2015) would be achieved. Food waste at the retail (including foodservice) and consumer levels accounts for approximately 66% of the value of edible food waste along the food supply chain in Canada (Gooch, Felfel, & Glasbey, 2014). There is currently no existing data that divides the proportion of food waste by stage of the food supply chain by mass, therefore this value was used as a proxy. There are limitations to this assumption because the average value of food products changes along the food supply chain.

There will likely be additional food waste prevention occurring in other parts of the food supply chain, so this study assumed that 10% of wasted food from production, distribution and processing will also be prevented by 2030. In total, across the food supply chain, the reduction of wasted food by 40% from retail and consumer levels and 10% from other parts of the supply chain is equivalent to a reduction of 20% of all food waste (both inedible parts and wasted food) overall, or 1.1 Mt/year.

Diversion

By 2030, diversion practices account for 35% of food waste in centralized composting and 6% in non-thermal energy recovery (i.e. anaerobic digestion) by 2030.

DIVERSION ESTIMATE BASIS

With more municipalities initiating curbside collection programs for residents and encouraging food waste diversion by the ICI sector through a combination of policies and programs, food waste diversion is likely going to increase by 2030. It is uncertain how much this increase will take the form of centralized composting versus non-thermal energy recovery as decision-making variables for choosing between these two management strategies change between each jurisdiction. Generally, thermal energy recovery is more favourable around larger population centres and where there is a large enough incentive (e.g. grant, energy credit, market for biogas) to offset the capital expenditure of a more advanced processing facility. Centralized composting is often more viable compared to non-thermal energy recovery as a diversion strategy where there is a smaller population or limited funding for facility development.

For the 2030 scenario, we assumed that approximately 30% of food waste disposed in 2015 will be redirected to organics processing facilities. We assumed that the breakdown of where this additional material will go would be proportional to the current breakdown of processing facilities (i.e. 87% to composting and 13% to non-thermal energy recovery). In other words, an additional 1.2 Mt/year of food

waste will be diverted from disposal, of which 1 Mt/year will go to centralized composting and 190,000 tonnes/year to non-thermal energy recovery.

Although proportionally more food waste will be diverted from disposal compared to 2015, the study also assumes that some edible food waste will be removed from centralized composting (190,000 tonnes/year) and non-thermal energy recovery (34,000 tonnes/year) from waste prevention (see *prevention subsection above*).

Managed + Unmanaged Disposal

By 2030, managed disposal practices account for 2% of food waste thermal energy recovery (e.g. incineration), 14% in landfill methane energy generation, 13% in landfill methane flaring, and 9% in unmanaged landfills.

MANAGED + UNMANAGED DISPOSAL ESTIMATE BASIS

Through a combination of food waste prevention and diversion efforts, we anticipate that overall, disposal of food waste will decrease by 2030. The quantities of food waste removed from disposal are estimated to be 1.2 Mt/year from diversion and 900,000 tonnes/year from prevention.

We assumed that the decrease in food waste disposal will primarily occur in landfills, and divided the diverted and prevented quantities according to the current breakdown of landfilling activities (i.e. approximately 66% unmanaged, 17% gas capture and combustion, and 17% energy recovery from gas). There is no currently available data on trends in using thermal energy recovery for food waste disposal, so it is not clear as to whether this management strategy will become more or less popular over time. Furthermore, food waste is generally wetter and less ideal as feedstock for thermal energy recovery, so we assumed that there will be no change from 2015 to 2030 in the overall share (but an increase in overall quantity, commensurate with population growth).

With regards to landfills generally, there is a shift towards more landfill gas capture to mitigate methane emissions. For the 2030 scenario, an additional 30% of food waste being disposed in 2015 is redirected unmanaged landfills to managed landfills with methane energy generation or methane flaring. This amounted to an additional 820,000 tonnes/year of food waste reallocated to managed landfills. The current distribution between landfills that capture and combust methane versus those that recover the methane for energy is 49% capture and combustion and 51% energy generation. In the absence of different information on trends, this same ratio was assumed for 2030, equivalent to an additional 410,000 tonnes/year to landfills with methane capture and combustion and 420,000 tonnes/year to landfills with methane capture and energy generation.

Food Waste Prevention + Sustainable Waste Management Summary

The following table summarizes the quantity of food waste and associated GHG tonnage by management practice in 2015 and under the 2030 Food Waste Prevention and Sustainable Waste Management Future. The net contribution of this Future is a GHG reduction of 2,598,000 tonnes of CO₂e (2.6 Mt) based on the collected data.

Food Waste Management Practice	2015			2030		
	Food Waste Material (tonnes/year)	% of Food Waste	GHGs (tonnes CO ₂ e)	Food Waste Material (tonnes/year)	% of Food Waste	GHGs (tonnes CO ₂ e)
Prevention: Avoided Food Waste	0	0%	0	1,123,966	20%	0
Diversion: Centralized Composting	1,087,773	20%	206,024	1,954,672	35%	370,215
Diversion: Non-thermal Energy Recovery e.g. anaerobic digestion	192,000	3%	9,091	345,014	6%	16,336
Disposal: Thermal Energy Recovery e.g. incineration	128,736	2%	0	128,736	2%	0
Disposal: Landfill CH ₄ Energy Generation	721,770	13%	225,553	766,940	14%	239,669
Disposal: Landfill CH ₄ Capture + Combustion	693,465	12%	216,708	743,542	13%	232,357
Disposal: Unmanaged Landfill	2,747,221	49%	3,434,026	508,094	9%	635,118
Total Prevented	0	0%	0	1,123,966	20%	0
Total Diverted	1,279,773	23%	215,115	2,299,686	41%	386,551
Total Disposed	4,291,191	77%	3,876,287	2,147,312	38%	1,107,144
Total Food Waste	5,570,964	100%	4,091,402	4,446,998	79%	1,493,695 (-63%)

Table 4: Comparison of 2015 Base Year and 2030 Waste Prevention and Sustainable Waste Management Future in terms of Food Waste Quantity and GHG Tonnage

ENHANCED GHG REDUCTION POTENTIAL: LIFECYCLE ANALYSIS, EXPANDED ORGANICS

This initial projection is a low estimate of GHG reduction potential from implementing this Future. The methodological approach conservatively estimated waste quantities extrapolating from data collected from higher performing municipalities.

Additionally, intensifying food waste prevention and more sustainable solid waste management practices permits relatively straightforward diversion of other organic materials away from landfills, notably yard waste, wood and even paper.

These estimates also focus on landfill GHGs and preclude consideration of full lifecycle GHG reductions from a Food Waste Prevention, Sustainable Solid Waste Management Future. Lifecycle analysis reveals much more dramatic reductions, notably a 4.5 Mt per annum reduction in GHGs associated with food waste prevention from across the supply chain and a total 8.1 Mt reduction that also includes reduced organics in every waste management practice. A sizeable share of these total emission reductions would be accrued in the agriculture and agri-food sectors in the form of avoided energy use in processing, and a modest share from beyond Canada's borders from avoided waste of imported food. (see Box: Food Waste Management Lifecycle GHGs, below)

FOOD WASTE MANAGEMENT LIFECYCLE GHGS

The Waste Reduction Model (WARM) tool (Version 14) was used to compare lifecycle GHG emissions between two contrasting management portfolios, i.e. the base year (2015) and the 2030 scenario. The WARM tool is a lifecycle assessment tool developed by Environmental Protection Agency (EPA) in the United States to calculate total GHG emissions associated with contrasting waste management portfolios, including source reduction (prevention), recycling, flaring, composting, anaerobic digestion and unmanaged landfilling (EPA, 2016).⁹

As this is a lifecycle assessment tool, it is not meant to be used for GHG inventory reporting, but rather provide a more complete estimate of the full lifecycle GHGs between contrasting portfolios that account for GHGs at different stages in production, processing and waste management. Because the 2015 and 2030 waste management portfolios have highly contrasting GHGs upstream (e.g. from food production and processing), midstream (e.g. transportation) and downstream (e.g. from waste management), this analysis is quite insightful. Thus, beyond the GHG implications to the solid waste sector in Canada's National Inventory Report, this food waste prevention and sustainable waste management agenda would reduce GHGs in other inventory sectors, notably: agriculture, freight transportation and manufacturing. A share of these reductions would be accrued beyond Canada's borders from across the supply chain of imported foods.

Inputs to the WARM tool include quantities of waste destined to each type of management strategy and select parameters to customize the calculations based on region-specific variables. The quantities presented in this report for 2015 and 2030 were used as the base year and alternative scenarios. Where possible, emission factors were adjusted to reflect the average climatic conditions and waste management norms in Canada. Settings selected for the model were as follows:

- Avoided electricity-related emissions, landfill gas recovery rates, landfill moisture conditions, and curing of digestate from anaerobic digestion: Default national averages for the United States
- Anaerobic digestion type: Dry (versus wet), as that is more common for food waste
- Average transport distances: 30 km to composting and landfill facilities, 15 km to non-thermal and thermal energy recovery facilities, based on averages from the GHG Calculator for Waste Management (Environment and Climate Change Canada, 2013).

The results from the analysis are presented in the table below. The results show a net 4.7 Mt lifecycle CO₂e would be emitted in 2015, and by 2030 a total of 8.1 Mt of waste GHGs would be reduced or avoided relative to 2015 across the food supply chain including reduced GHGs in food processing, transportation as well as in waste disposal and diversion from avoided organics. More than 4.5 Mt of this share would be reduced through food waste prevention.

Food Waste Management Practice	2015 Lifecycle GHG tonnes CO ₂ e	2030 Lifecycle GHG tonnes CO ₂ e
Prevention	0	-4,520,527
Diversion: Centralized Composting	-210,853	-378,892
Diversion: Non-Thermal Energy Recovery, e.g. anaerobic digestion	-10,481	-18,834
Disposal: Thermal Energy Recovery, e.g. incineration, gasification	-20,232	-20,232
Disposal: Landfill CH ₄ Energy Generation	286,844	304,795
Disposal: Landfill CH ₄ Capture + Combustion	429,614	460,638
Disposal: Unmanaged Landfill	4,211,492	778,909
Total	4,686,384	-3,394,144

⁹ Although Environment and Climate Change Canada adapted an older version of this tool for use in Canada, it does not have the capability to estimate source reduction emissions, hence the WARM tool was selected.

V - Conclusion

This study has two key findings and associated recommendations:

- There are strong policy synergies nationally between sustainable food waste management, climate action, and food and agriculture sustainability. Articulating these linkages can consolidate support for an integrated agenda.
- The climate change mitigation potential from sustainable food waste management is conclusive and modest. Enhanced life cycle analysis would demonstrate greater GHG reduction potential.

Several study areas could advance sustainable food waste management and climate change mitigation:

- Data Collection
- Policy Mapping
- Triple Bottom Line Cost-Benefit Analysis
- Expanded Sustainable Waste Management Analysis
- Enhanced Life Cycle Analysis

KEY FINDINGS + RECOMMENDATIONS

The study has two key findings and associated recommendations.

- **National Policy Context + Sustainable Food Waste Management Synergies:** There are strong synergies between sustainable food waste management and other national policy priorities, specifically international and domestic commitments to climate change mitigation, and food and agriculture sustainability. The sustainable food waste management agenda should be advanced by linking to these national priorities.
- **Preliminary Food Waste Management GHG Reduction Estimates - Modest; Broader Sustainable Waste Agenda Reductions - Greater:** This study finds climate change mitigation potential from a sustainable food waste management agenda conclusive yet modest. An expanded sustainable waste management agenda would demonstrate greater potential. This could encompass broader organic streams and more detailed management practices for diverse material types. Beyond the GHG implications to the solid waste sector in Canada's National Inventory Report, food waste prevention would reduce GHGs in other sectors, notably: agriculture, freight and manufacturing. Enhanced life cycle analysis could also quantify and allocate GHG reductions to other inventory sectors such as wood products from recovered wood, or road construction from recovered concrete.

FURTHER STUDY

Several study areas could advance sustainable food waste management and solid waste climate change mitigation.

- **Data Collection:** Given data gaps and inconsistent collection methodologies across sub-national and local jurisdictions, it would be helpful to undertake a more comprehensive study that better characterizes food waste and all solid waste material tonnage and GHGs, and generate data collection protocols and a process for adoption. Better data would support better food and waste management policy, planning and investment.
- **Triple Bottom Line Cost-Benefit Analysis:** There are a wide range of benefits and costs associated with different waste (and food waste) management practices. Coarsely enumerating these costs and benefits would help inform decision making regarding an optimal mix of practices at a given milestone.
- **Expanded Sustainable Waste Management Analysis:** Quantifying GHG benefits from a comprehensive approach to solid waste and material management would show significantly greater reductions, such as yard and wood waste diversion from landfills. Enhanced life cycle analysis would further illustrate the GHG benefits.

- **Policy Road Map Design:** This study articulated at a high level policies that could support this agenda. Better policy definition federally, sub-nationally and locally would help underscore the necessary collaboration and coordination by all levels of government to advance a sustainable food waste management agenda.
- **Enhanced Life Cycle Analysis:** Preliminary life cycle analysis shows considerable GHG reduction potential by 2030 from waste prevention across the supply chain (4.5 Mt) as well as significant reductions from better waste management for a net reduction of 8.1 Mt relative to 2015. Enhanced life cycle analysis could better quantify and attribute reductions to specific sectors, including reductions beyond Canada's borders from imported food.

Works Cited

- Calderón, F. a. (2014). *Better Growth, Better Climate: The New Climate Economy Synthesis Report*. The Global Commission on the Economy and Climate.
- Canadian Electricity Association. (2016). *Canada's Electricity Industry State of the Nation*. Ottawa: CEA.
- Canadian First Ministers. (2016). *Pan-Canadian Framework on Clean Growth and Climate Change*. Ottawa.
- Environment and Climate Change Canada. (2013). *Greenhouse Gases (GHG) Calculator for Waste Management*. Retrieved from <https://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=D6A8B05A-1>
- Environment and Climate Change Canada. (2016: 2). *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada Part 2*. Ottawa: Environment and Climate Change Canada.
- Environment and Climate Change Canada. (2016). *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada Pt 1, 2 + 3*.
- Environment Canada. (2014). *National Inventory Report 1990–2012: Greenhouse Gas Sources and Sinks in Canada*. Government of Canada.
- EPA. (2016). *Waste Reduction Model*. Retrieved from <https://www.epa.gov/warm>
- FAO. (2014). *Food waste*. Retrieved from <http://www.fao.org/platform-food-loss-waste/food-waste/definition/en/>
- FLW Protocol Steering Committee. (2016). *Food Loss and Waste Accounting and Reporting Standard Version 1.0*. World Resources Institute.
- FUSIONS. (2014). *Definitional Framework for Food Waste*. Retrieved from <http://www.eu-fusions.org/phocadownload/Publications/FUSIONS%20Definitional%20Framework%20for%20Food%20Waste%202014.pdf>
- Giroux, L. (2014). *State of Waste Management in Canada*. Retrieved from http://www.ccme.ca/files/Resources/waste/wst_mgmt/State_Waste_Mgmt_in_Canada%20April%202015%20revised.pdf
- Gooch, M., Felfel, A., & Glasbey, C. (2014). *\$27 Billion Revisited: The Cost of Canada's Food Waste*. Retrieved from <http://vcm-international.com/wp-content/uploads/2014/12/Food-Waste-in-Canada-27-Billion-Revisited-Dec-10-2014.pdf>
- Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., & Meybeck, A. (2011). *Global Food Losses and Food Waste: Extent, Causes and Prevention*. Rome: Food and Agriculture Organization of the United Nations.
- IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.
- Jaccard, M. a. (2016). *Is Win-Win Possible? Can Canada's Government Achieve Its Paris Commitment . . . and Get Re-Elected?* Simon Fraser University, School of Resource and Environmental Management.
- Joint Federal, Provincial, Territorial Ministers of Agriculture + Agrifood. (2016, July). *Calgary Statement: Towards the Next Policy Framework*. Retrieved from <http://www.agr.gc.ca/eng/about-us/key-departmental-initiatives/developing-the-next-agricultural-policy-framework/calgary-statement-towards-the-next-policy-framework/?id=1468864509649>
- Metro Vancouver + Tetra Tech. (2014). *2013 Metro Vancouver Waste Composition Study*. Metro Vancouver. Vancouver: Metro Vancouver.
- NRCan. (2013). *Energy Efficiency Trends in Canada 1990 to 2012, Ch 3 Residential, Ch 4 Commercial, Ch 6 Transportation*. Government of Canada.
- Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of The Royal Society* , 3065-3081.

Schleussner, C. F. (2016). Science and policy characteristics of the Paris Agreement temperature goal. *Nature Climate Change*, 6 (September 2016).

Statistics Canada. (2012, February). *Population and dwelling counts, for census metropolitan areas and census agglomerations, 2011 and 2006 censuses*. Retrieved from <http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/hltfst/pd-pl/FullFile.cfm?T=201&LANG=Eng&OFT=TAB&OFN=98-310-XWE2011002-201.TAB>

Statistics Canada. (2010, March). *Population Projections for Canada, Provinces and Territories*. Retrieved from <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=520005>

UN DESA. (no date). *Sustainable Development Goal 12*. Retrieved from <https://sustainabledevelopment.un.org/sdg12>

Value Chain Management International. (2014). *The cost of Canada's annual food waste*.