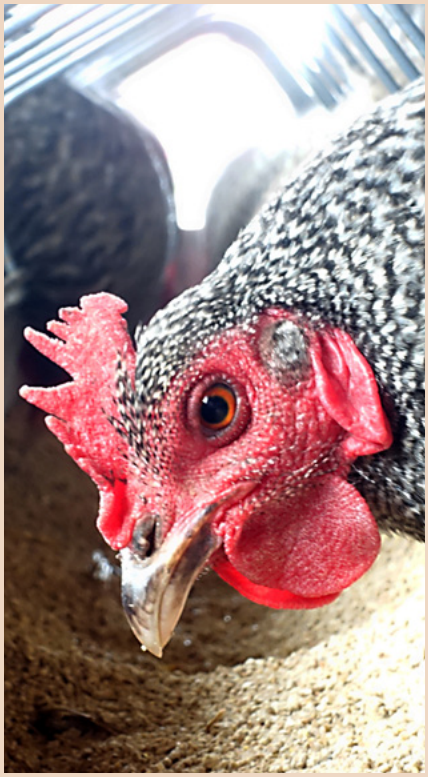
Characterization and Management of

Organic Waste

in North America



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Acknowledgments

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List of Abbreviations and Acronyms

AD	anaerobic digestion, as refers to industrial-scale composting in closed containers
CEC	Commission for Environmental Cooperation
CO_2	carbon dioxide
Conacyt	*Consejo Nacional de Ciencia y Tecnología* (National Council of Science and Technology) (Mexico)
Firco	*Fideicomiso de Riesgo Compartido* (Shared Risk Trust Fund) (Mexico)
Gg	gigagrams (billion grams)
GHG	greenhouse gas
ICI	industrial, commercial and institutional
kg	kilogram
MSW	municipal solid waste
$MTCO_2e$	metric tonnes of carbon dioxide equivalent
PAYT	pay-as-you-throw
Provar	*Proyecto de Apoyo al Valor Agregado de Agronegocios* (Added Value to Agribusiness Support Project) (Mexico)
Sagarpa	*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación* (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food) (Mexico)
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales* (Secretariat of Environment and Natural Resources) (Mexico)
STA	Seal of Testing Assurance (United States)
tonnes	metric tonnes
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
WRRF	water resource recovery facility
WWTP	wastewater treatment plant

Abstract

This white paper presents the findings of the Commission for Environmental Cooperation (CEC) project, North American Initiative on Organic Waste Diversion and Processing. It provides statistics on organic waste generation, diversion, and disposal in Canada, Mexico, and the United States and discusses the environmental benefits associated with reducing organic waste. With a focus on policy and decision makers, this document describes key challenges and gaps that constrain expanded organic waste recovery in North America, as well as relevant policy options and instruments for industry, government and local organizations. It also identifies some best practices, recommends actions to increase organic waste diversion across Canada, Mexico and the United States, and identifies potential areas for regional cooperation.

Executive Summary

The goal of the North American Initiative on Organic Waste Diversion and Processing—a project launched by the Commission for Environmental Cooperation as part of its 2015–2016 Operational Plan—is to enhance North America's capacity to increase organic waste diversion and processing in the residential and industrial, commercial and institutional (ICI) sectors in Canada, Mexico and the United States. Outputs of the initiative include this white paper and a foundational report entitled *Characterization and Management of Organic Waste in North America* (CEC 2017b).

In conducting this effort, the research team encountered two major challenges:

- the lack of a consistent definition of organic waste across the three countries; and
- significant data gaps, especially in the ICI sector.

While Canada, Mexico and the United States all define organic waste differently, and ICI data are lacking or insufficient, the research team found enough consistency in the national data to estimate information on organic waste generation, diversion and disposal in North America. In all, the three countries generate nearly 265 million tonnes of organic waste annually (CEC 2017b). Of this amount, residents and businesses divert approximately 75 million tonnes of organic waste through activities such as composting and anaerobic digestion (referring to industrial-scale composting in closed containers) and otherwise dispose of approximately 190 million tonnes of organic waste (CEC 2017b). Canada and the United States both have an organic diversion rate of 32 percent, while Mexico has a rate of 7 percent (CEC 2017b).

The research team also found that the disposal of solid waste contributes nearly 200 million metric tonnes of carbon dioxide equivalent ($MTCO_2e$) in greenhouse gas (GHG) emissions each year in North America—the majority of which arises from organic material mixed in the solid waste (CEC 2017b). Expanding efforts to divert and properly manage organic waste could help avoid up to 100 million $MTCO_2e$ in GHG emissions annually (CEC 2017b). Organic waste diversion also has economic benefits in terms of job creation at the project level, as well as regionally and nationally, and a subsequent increase in gross domestic product. Organic waste processing facilities, from their onset, generate project design and construction jobs, followed by jobs related to the management, collection and processing of waste, and ancillary jobs resulting from the processed end-product (i.e., compost uses in agriculture) (ReFED 2016). The potential positive economic impacts of organic waste diversion are significant; for example, diverting 100 percent of the 141.5 million tonnes of organic waste (residential and ICI) disposed of in the United States in 2014 would generate an estimated savings of US$14 billion and create over 320,000 jobs (calculation based on factors from Goldman and Ogishi 2001).

To expand organic waste diversion and processing, key recommendations for government policy makers and other stakeholders—from businesses to academia—are as follows:

- Improve data collection and data sharing across North America, to improve opportunities for data tracking and reporting.
- Better engage the ICI sector to increase the diversion, processing, measurement and reporting of activities and data.
- Provide ongoing and consistent outreach and education to support the potential concerns of local residents, provide guidance and instruction on proper sorting practices, and advertise the benefits of end-products.
- Increase landfill and waste-to-energy tipping fees for organic waste, to make alternatives such as composting and anaerobic digestion (referring to industrial-scale composting in closed containers) more competitive.
- Analyze options for banning organic materials from landfills.
- Promote or expand incentives (e.g., grants, low-interest loans, feed-in tariffs, renewable portfolio standards) to spur growth related to expanded infrastructure.
- Focus on improving market circumstances and harmonizing markets for end-products derived from organic waste across North America.
- Help residents and businesses to purchase products made from organic waste.

The following are recommended activities for trilateral collaboration:

- Examine opportunities for cross-border collaboration to improve markets for end-products created through organic waste diversion and processing.
- Collaborate to better document end-markets.
- Expand collaborative efforts to achieve sustainability goals, including zero-waste and circular economy.
- Improve data collection and transparency.

Introduction

The Commission for Environmental Cooperation (CEC) is an intergovernmental organization comprising Canada, Mexico and the United States, under the North American Agreement on Environmental Cooperation. The CEC was created to address regional environmental concerns, help prevent potential trade and environmental conflicts, and promote effective enforcement of environmental law. The CEC's Council[1] commissioned this project, the North American Initiative on Organic Waste Diversion and Processing, to enhance North America's capacity to increase organic waste diversion and processing in the residential and industrial, commercial and institutional (ICI) sectors in Canada, Mexico and the United States. Outputs of the initiative include this white paper and a companion foundational report, entitled *Characterization and Management of Organic Waste in North America* (CEC 2017b).

1. The CEC Council is composed of the heads of Environment and Climate Change Canada, the US Environmental Protection Agency, and Mexico's Secretariat of Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales*—Semarnat).

Properly managed organic waste represents an opportunity to create a closed-loop system for sustainability, low environmental impact, and beneficial use. Organic waste can be managed to provide water, energy, climate and air quality benefits. Through better organic waste management, North America can:

- generate pharmaceutical, cosmetic, household and industrial products (via rendering or other organic-waste industrial processes);
- produce animal feed from rendering and from food scraps recovered in ICI and residential food waste collection programs;
- create a local source of energy through conversion of organic waste into biofuels or through recovery of biogas (in the case of anaerobic digestion [AD—referring to industrial-scale composting in closed containers]);
- avoid methane emission (via composting) and reduce GHG emissions (through AD or other organic waste industrial uses) by avoiding the release of methane from landfills and by displacing fossil-fuel-derived energy;
- make digestate that serves as a feedstock in compost production or as animal bedding, or create effluent that can be used as a liquid fertilizer; and
- improve soil water retention and supply nutrients to the soil, through the use of compost as a soil amendment, as well as restore wetlands and control erosion.

Growth and investment in organic waste diversion and processing also face a host of challenges, among them the following:

- low cost of landfill disposal in some of the areas without bans on landfill disposal of organic waste or other organic waste diversion initiatives;
- adequate quantity and quality of uncontaminated organic feedstock from residences and businesses;
- permitting of new facilities for organic waste diversion and processing, or expanding of existing facilities, given concern for odor, noise, and traffic; and
- limited, inadequately developed or less-understood markets for end-products;
- competition from alternatives such as fossil-fuel-derived fertilizers (e.g., organic fertilizers are typically less concentrated than synthetic fertilizers, requiring use of a greater quantity of them [Oregon State University 2008]);
- limited infrastructure to support organic waste diversion and processing;
- education for the public or employees (e.g., in restaurants) about the importance of organic waste separation; and
- contracts and agreements to support long-term and reliable markets for feedstock, power, gas, digestate, compost or animal feed.

Report Overview

Building on this project's foundational report, *Characterization and Management of Organic Waste in North America,* this paper explores the challenges and potential areas for improvement in the diversion, measurement, recycling and processing of organic waste (including food waste) from residential and ICI sources in Canada, Mexico and the United States. The foundational report summarizes the findings of the North American Initiative on Organic Waste Diversion and Processing, on policies, programs, projects, lessons learned, best practices, and markets to promote diversion and processing of organic waste. Based on these findings and the identified challenges and information gaps, the foundational report recommends actions to increase diversion and processing of organic waste and to promote greater cooperation across North America. Ultimately, its intent is to raise awareness of recommended best practices, policies and other approaches for reducing organic waste.

This paper is divided into three parts:

Part 1 synthesizes the key findings of the foundational report, *Characterization and Management of Organic Waste in North America,* as used to characterize organic waste diversion and processing in the three countries and across North America.

Part 2 provides an overview of North American organic waste policies, programs, regulations and best practices.

Part 3 examines the cross-cutting and country-specific challenges, gaps, and recommendations, as well as opportunities for trilateral collaboration.

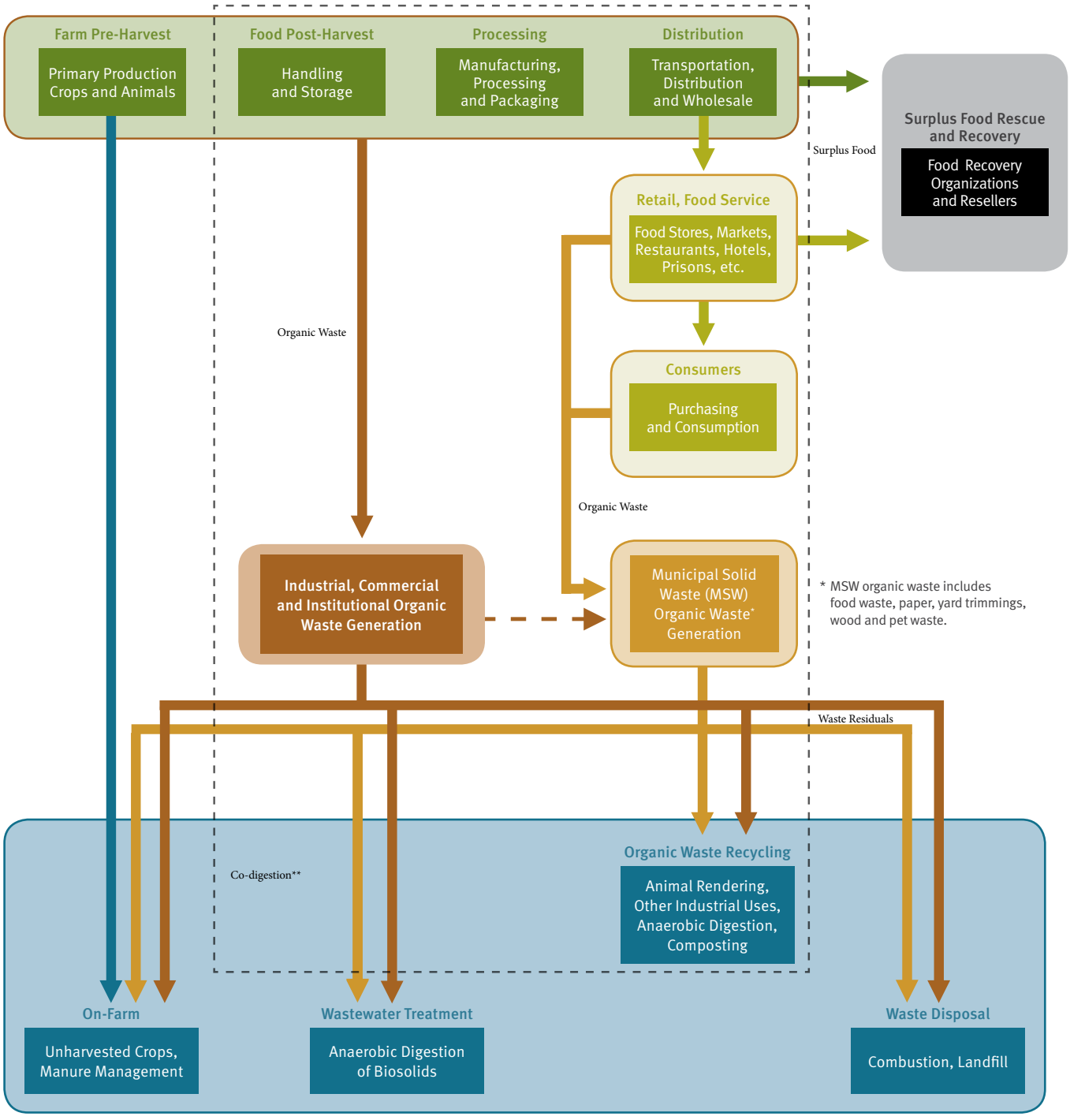
Definition of "Organic Waste," and Project Scope

The specifications for what constitutes organic waste are not consistent across Canada, Mexico or the United States. To guide the scope and content of the foundational report, "organic waste," as used herein, is defined as any material originating from a plant or animal that can be decomposed by microorganisms or consists of the remains, residues or waste products of any organism.

This paper focuses on specific types of organic waste, such as food waste (i.e., discarded food, any inedible parts of food), yard and garden debris (e.g., leaves, grass clippings), paperboard and other paper products, wood (except construction and demolition–related debris), and pet waste. Organic waste, of course, does not include metals or glass. For the purposes of this paper, organic waste does not include textiles, leather, or petroleum-based plastic. It also excludes livestock manure and wastewater treatment biosolids, except when an organic waste type as specified above is co-digested with livestock manure or biosolids—and except when referring to Mexico, where the analysis specifically included these types of waste.

Figure 1 shows how these sources of organic waste interact and are, ultimately, treated and disposed of. It also shows which elements are included in the scope of this paper.

FIGURE 1. **Overview of organic waste generation, diversion and processing**



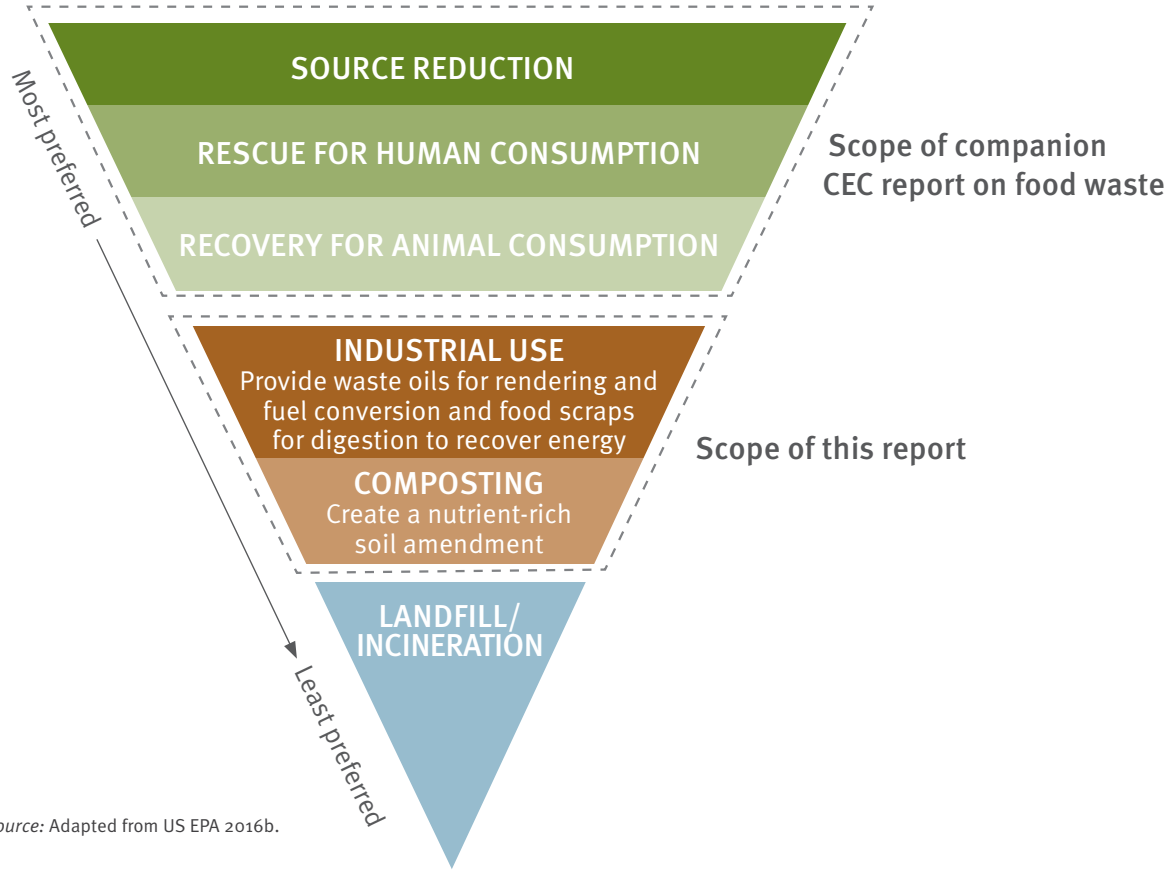
** On-farm manure management and wastewater treatment are outside the scope of this project. An exception is the case of co-digestion of Municipal Solid Waste in waste water treatment anaerobic digesters.

- Production, Storage, Processing and Distribution
- Consumer-facing Business and Households
- Industrial, Commercial and Institutional (ICI) Sources
- Surplus Food Rescue and Recovery
- Municipal Solid Waste (MSW) Sources
- Organic Waste Processing
- Project Scope

This paper highlights downstream practices and programs that encourage organic waste diversion and processing. It is organized in descending order from the most to least preferred processing method, focusing on industrial uses—i.e., rendering animal byproducts for animal feed or products such as cosmetics, paints and varnishes; anaerobically digesting organic waste to generate biogas and digestate; and composting organic materials to produce soil amendments and fertilizer.

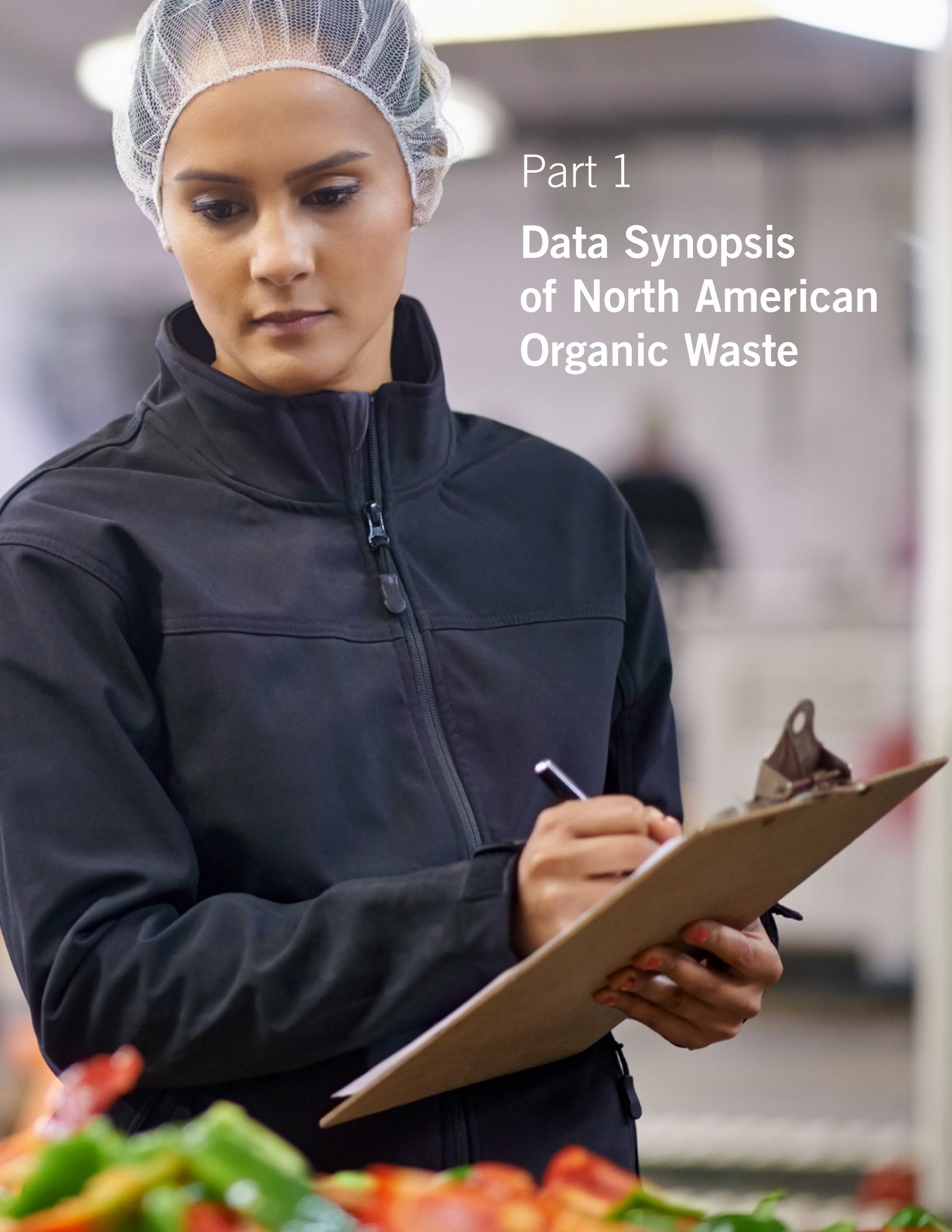
Surplus food recovered to feed people and animals, and organic waste managed through combustion or landfilling are not considered in this paper. A companion CEC report entitled *Characterization and Management of Food Loss and Waste in North America* (CEC 2017a) describes opportunities for reduction of food waste sources in the ICI sector (e.g., food producers, grocers and restaurants, hospitals, schools, universities), as well as recovery of wasted or surplus food for human consumption, or of food scraps for animal feed from the ICI sector (Figure 2).[2]

FIGURE 2. **Food recovery hierarchy**



Source: Adapted from US EPA 2016b.

2. Differences in measurement methodologies, data years, and organic materials analyzed hinder the comparison of estimates of food waste shown in the companion report and the organic waste shown in this paper. Although the estimates in this paper relied on the best available national data for each country, data gaps existed for each (most notably in ICI data), resulting in lowered generation estimates.



Part 1

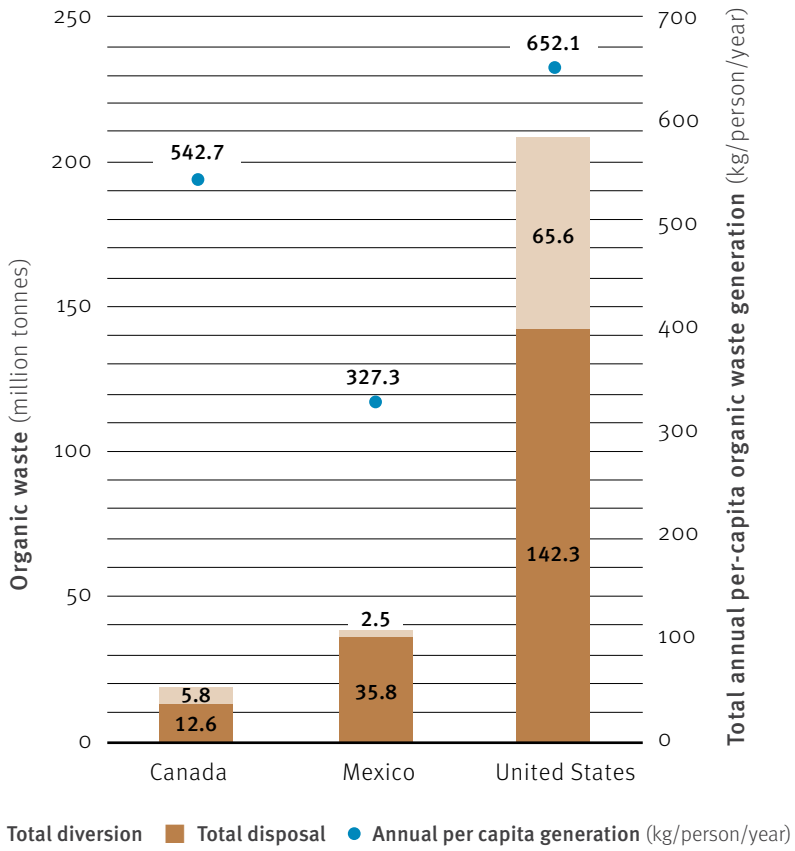
Data Synopsis of North American Organic Waste

Generation, Diversion and Disposal of Organic Waste in North America

While Canada, Mexico, and the United States define organic waste differently, estimates of residential organic waste in North America are the most comparable, since all three countries track the residential stream of solid waste. ICI sector comparisons are more difficult due to differing data collection programs and large data gaps.

Despite these difficulties, this research found enough consistency in the country data to estimate information on organic waste generation, diversion and disposal in North America. Figure 3 provides an estimate of the amount of annual organic waste diversion and disposal (in million tonnes per year) and the amount generated (in kilograms/person/year) in Canada, Mexico, and the United States.[3] In all, the three countries generate nearly 265 million tonnes of organic waste annually (CEC 2017b). Of this amount, residents and businesses divert approximately 75 million tonnes of organic waste, through activities such as industrial anaerobic digestion and composting, and dispose of approximately 190 million tonnes of organic waste (CEC 2017b). Canada and the United States each have an organic waste diversion rate of 32 percent, while Mexico's rate is 7 percent (CEC 2017b).

FIGURE 3. **Estimated organic waste generation, diversion and disposal, and annual per-capita generation, by country**



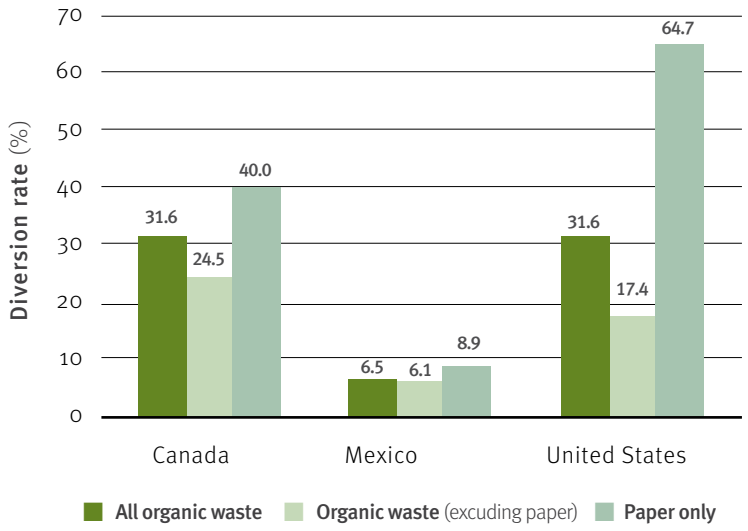
Note: Weights are in million tonnes unless otherwise noted. Mexican values include residential and food waste from harvest to commercialization, but not ICI generation, diversion or disposal estimates from any other sources.
Source: CEC 2017b, Table 24.

3. Available data sets for each country were analyzed and used to estimate annual generation, diversion and disposal rates, but the data sets are incomplete and the quantities shown should therefore be considered informed estimates.

Figure 4 shows the diversion rates for organic waste—with and without paper (i.e., food, yard and wood), and paper only. Excluding paper, Canada has the highest diversion rate of food, yard and wood waste, at about 25 percent; Mexico's diversion rate is 6 percent and the US diversion rate is a little over 17 percent. Nevertheless, diversion through existing management options (i.e., industrial uses, AD and composting) is still eclipsed by combustion and landfilling, which are still used to dispose of the largest share of organic waste.

Established infrastructure, higher market value, and market stability of paper compared to other organic materials are reflected in the higher diversion of that organic material. Because of this higher value, paper remaining in the disposal stream may be targeted for additional diversion through the fiber market instead of through composting or AD.

FIGURE 4. **Estimated diversion rates for all organic waste, paper organic waste, and non-paper** (i.e., food, yard and wood) **organic waste**



Note: Mexican values include residential and food waste from harvest to commercialization, but not ICI generation, diversion or disposal estimates from any other sources.
Source: CEC 2017b.

Environmental Impacts of Organic Waste in North America

When organic matter decomposes in landfills, it releases the greenhouse gases carbon dioxide (CO_2) and methane (CH_4), which contribute to global climate change. In addition, these emissions also impair air quality and are associated with public health concerns, such as asthma. Diverting the organic waste component of the solid-waste stream to AD (including co-digestion) and composting not only conserves valuable—and diminishing—landfill space, but also provides economic and environmental benefits such as renewable energy, reduced GHG emissions, and improved water and soil conditions.

AD is a process by which micro-organisms break down organic matter in the absence of oxygen, releasing a gas called biogas and leaving an organic residue called digestate. Farm-scale manure AD is well established in North America, and organic waste AD is steadily increasing in Canada and the United States. Co-digestion is a promising subset of AD, in which energy-rich organic waste materials such as fats, oils, grease, energy crops, crop residues, and/or restaurant food wastes are added to manure- or wastewater-digesters that have excess capacity. The main benefit of co-digestion projects is that they can use existing assets and infrastructure, making more efficient use of

process equipment while also sharing costs. Other benefits of co-digestion include greater decomposition of volatile solids, and higher biogas production rates (Canadian Biogas Association 2015). Co-digestion is an emerging practice that has not yet been widely adopted in Canada, Mexico and the United States, but preliminary initiatives are underway in the United States.

Composting is the decomposition of organic materials (e.g., yard trimmings, food waste, paper) by aerobic (and anaerobic) micro-organisms into humus—a usable, soil-like by-product. There are many markets and end-uses for compost, depending on its quantity and quality. Canada and the United States have well-established composting programs, many of which accept food waste. While Mexico lags behind in implementation, the potential for robust composting of organic waste is clear.

GHG Benefits of Organic Waste Diversion

As part of their commitment to the United Nations Framework Convention on Climate Change (UNFCCC), Canada, Mexico and the United States have all developed estimates of GHG emissions from landfills, using methodologies approved by the Intergovernmental Panel on Climate Change. Based on documents submitted to UNFCCC, Table 1 summarizes estimated GHG emissions from organic waste in each North American country.

Much of the estimated emissions described in Table 1 could be eliminated if all organic waste were diverted from landfilling to AD or composting; however, this scenario is not currently realistic for any of the three North American countries. As shown in Table 2, this research found that increasing organic waste diversion to AD and composting could result in a reduction of 3 million metric tonnes of carbon dioxide equivalent ($MTCO_2e$) in Canada, between 2 and 38 million $MTCO_2e$ in Mexico, and 60 million $MTCO_2e$ in the United States

TABLE 1. **Estimated annual GHG emissions from solid waste disposal**

Canada	Mexico*	United States
26 million $MTCO_2e$[a] (0.73 $MTCO_2e$ per capita)	18–25 million $MTCO_2e$[b] (0.15 to 0.21 $MTCO_2e$ per capita)	148 million $MTCO_2e$[c] (0.46 $MTCO_2e$ per capita)

* Emissions from organic waste management in Mexico are likely much higher than Table 1 shows. Obtaining reliable estimates of emissions, however, is complicated by the lack of consistent and reliable data and the higher number of uncontrolled landfills and open dumps in Mexico.

Sources:

a. CEC 2017b, Table 63.
b. CEC 2017b, Table 64 (Gg methane converted to MTCO2e, using a global warming potential of 25).
c. CEC 2017b, Table 68.

TABLE 2. **Estimated annual potential GHG emissions reduction**

Canada	Mexico	United States
3.4 million $MTCO_2e$[a] (0.09 $MTCO_2e$ per capita)	2–38 million $MTCO_2e$[b] (0.02 to 0.32 $MTCO_2e$ per capita)	60 million $MTCO_2e$[c] (0.19 $MTCO_2e$ per capita)

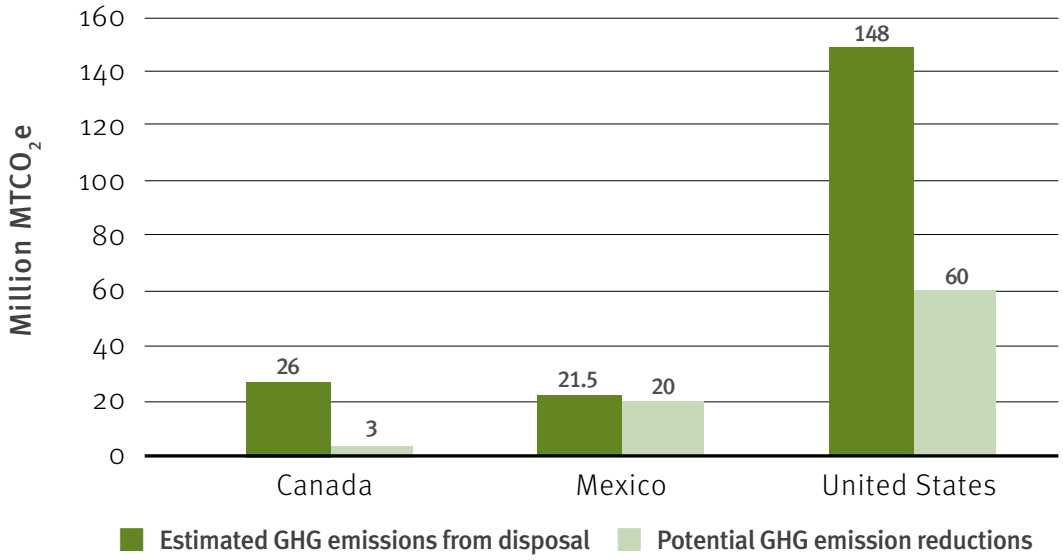
Note: Differences in measurement methodologies, data years and organic materials analyzed hinder the comparison of estimates of food waste shown in the companion CEC report, *Characterization and Management of Food Loss and Waste in North America*, with those of organic waste shown in this paper.

Sources:

a. CEC 2017b, Section 5.2.2. (Based on current organic waste generation and disposal rates.)
b. CEC 2017b, Table 65. Note that 38 million MTCO2e is the estimated potential emission reduction in 2030.
c. CEC 2017b, Table 69. (Based on current organic waste generation and disposal rates.)

Figure 5 shows the potential GHG benefits of organic waste diversion, by juxtaposing the North American countries' GHG emission reduction potentials from organic waste diversion with their GHG emissions from disposal. The figure uses a conservative, middle-ground value from Table 2 for Mexico's emissions reduction potential. While the basis for these emission reduction estimates varies by country, there is potential for a total annual reduction of up to approximately 80 million $MTCO_2e$, from organic waste diversion in all three countries combined—nearly half of the current total annual emissions from solid waste disposal.

FIGURE 5. **GHG benefits of organic waste diversion**



Note: Differences in measurement methodologies, data years, and organic materials analyzed hinder comparing the estimates of food waste shown in the companion CEC report *Characterization and Management of Food Loss and Waste in North America* and the organic waste shown in this paper.
Source: CEC 2017b.

Other Environmental and Socioeconomic Benefits of Organic Waste Diversion

Diverting organic waste from landfills has many benefits in addition to reducing short-lived climate pollutants like methane:

- ICI byproducts (e.g., rendering scraps, citrus rinds) help conserve virgin materials by using organic waste as feedstock in new products (e.g., animal feed, essential oils in cleaners).
- Biogas is used to produce electricity, heat or renewable natural gas, thereby offsetting use of fossil fuels and providing a local source of renewable energy.
- Digestate is used as soil amendment, animal bedding, or fertilizer.
- Use of compost decreases the need for synthetic fertilizers (as well as intense energy/emissions associated with their manufacture), increases erosion control, prevents topsoil loss and further protects the climate by capturing carbon (e.g., sequestration).
- Diversion helps avoid groundwater and drinking water contamination, and reduces other airborne pollutants that contribute to smog and create human health impacts (e.g., asthma).

Part 2

Overview of North American Organic Waste Policies, Programs, Regulations and Best Practices

As North America embarks on new or expanded initiatives to increase organic waste diversion and processing, it is important to review and examine the effective policies, programs, regulations and best practices already in place. Some of these initiatives are outgrowths of national policy, such as national laws that regulate waste management (including organics) or may entail state authorities issuing regulations, as is the case in Mexico. In the absence of federal policy, as in Canada and the United States, other initiatives have been developed and implemented at the provincial, territorial, state or municipal level. For example, in the United States, organics (mainly yard waste) are banned from landfills in 24 states (Gardner 2016). Moreover, cities such as San Francisco enacted a zero waste goal by 2020 that, in part, requires residents and businesses to separate organic waste into colored bins (SF Environment 2016). Presently, these individual efforts occur independently, but there might be opportunities to better share or leverage expertise and experiences to increase organic waste diversion and processing across the continent. The following sections describe some of the policies, programs, regulations and best practices in Canada, Mexico, and the United States, including incentives created to encourage participation and compliance.

Canada

In the absence of a federal organics waste management framework, Canadian municipalities, provinces and territories set the policies, regulations and guidelines for managing solid waste. Similarly to in the United States, most Canadian provinces and territories began organic waste diversion by focusing on leaf and yard waste diversion and composting, and then on source-separated organics processing (through composting or AD). The blue box recycling programs in Canada typically receive some level of funding through stewardship programs and/or extended producer responsibility programs. The municipal tax base usually funds organics programs, with limited provincial or federal funding available to support them.

Several jurisdictions in Canada have imposed a ban on disposal of organic waste in landfills. Prince Edward Island and Nova Scotia banned organic waste disposal in landfills in 1998, followed by municipalities in British Columbia. For example, in 2005 the Regional District of Nanaimo banned from its landfills organic waste generated from commercial and institutional sources, and in 2015 the Metro Vancouver Regional District banned residents and businesses from disposing of organic waste in landfills (Gorrie 2012). More recently, the provinces of Quebec and Ontario are considering implementing similar bans by 2020 and 2022, respectively.

Canada established a National Zero Waste Council in 2013 to bring together governments, businesses and nongovernmental organizations to advance waste prevention in Canada. In March 2017, the Council put forth the National Food Waste Reduction Strategy, which aims to cut the amount of food waste disposed of in landfills by suggesting a national target of 50 percent food-waste reduction by 2030, aligning with the US target (National Zero Waste Council 2017).

Many Canadian initiatives promote increased diversion in the ICI sector, but the vast majority of them are voluntary, and publicly available information is limited. However, there are several initiatives aimed at increasing ICI organic waste diversion and processing. In 2012, the Canadian Council of Ministers of the Environment completed work with major retailers, the restaurant and food sector, brand owners, and the packaging industry, that has led to an industry-driven approach to reduce packaging in Canada (Loblaw Companies Limited 2012; Walmart Canada 2012).

In June 2016, the province of Ontario passed the Waste-Free Ontario Act, to encourage greater recycling innovation while helping to lower costs for recycling and provide consumers and businesses access to more recycling options. The City of Calgary put forth an Industrial, Commercial, and Institutional Organics Waste Diversion Strategy in 2015. The strategy includes mandatory organics diversion, differential tipping fees and a ban on the disposal of organic waste in landfills. Another part of Calgary's strategy is to work with the private sector to develop a separate strategy for managing, monitoring and reporting ICI waste (Seidel-Wassenaar 2015).

Ontario's feed-in-tariff programs provide a preferential revenue stream for electricity generation from renewable sources such as the biogas created through the AD of organic wastes. In addition, Ontario Regulation 452/09, "Greenhouse Gas Emissions Reporting" (from 1990), requires companies to report on their annual GHG generation, under the cap-and-trade-program. This gives industries an economic incentive to reduce their emissions so as to meet the overall environmental goal. Alternatively, companies can purchase "carbon offsets": projects that reduce GHGs, such as building composting and AD facilities.

Mexico

At the federal, state and municipal levels, integrated solid waste management is regulated under the General Law on the Prevention and Comprehensive Management of Waste (*Ley General para la Prevención y Gestión Integral de los Residuos*—LGPGIR), effective January 2004. This law was issued after Mexico's accession to the Organization for Economic Co-operation and Development (OECD), following the OECD's recommended strategies for waste prevention and minimization (DOF 2004; OECD 2000). To achieve the law's objectives, federal, state and municipal authorities are responsible for determining the volume and composition of such wastes and the infrastructure and capacities available for their processing. They must also identify needs, and design and implement programs to create the conditions at national, state and municipal levels to satisfy such needs.

Examples of other initiatives in Mexico include the following:

- The Strategic Project for Food Security (*Proyecto Estratégico de Seguridad Alimentaria*), launched in 2005 in collaboration with the UN Food and Agriculture Organization. Aimed at marginalized communities in Mexico, this project seeks to increase food security and generate income. It has been an important driver for the use of technologies such as biodigesters (primarily on farms), providing technical support and training. The program currently operates in 23 Mexican states (IRRI México and Tetra Tech 2015).
- The Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación*—Sagarpa) also supports AD and biogas use, through the Shared Risk Trust Fund (*Fideicomiso de Riesgo Compartido*—Firco). This fund supports agribusiness projects that use animal manure for electricity generation, via the Added Value to Agribusiness Support Project (*Proyecto de Apoyo al Valor Agregado de Agronegocios*—Provar). Provar provides 50 percent of the biodigester cost (up to P$1 million) and 50 percent of the generator's procurement and installation cost (up to P$250,000) (Semarnat 2013). (Mexico reported 2,167 biodigesters as of September 2014; 317 of these were financed through Firco.) There was no information about acceptance of organic waste in the operational digesters; efforts should be considered that would promote the adoption of organic waste to improve operational and economic performance (e.g., increase biogas yield).
- As a pilot project, the National Autonomous University of Mexico (*Universidad Nacional Autónoma de México*—UNAM) built a small (600 kg/day) residential organic waste anaerobic digester, with waste conditioning and electricity generation facilities. It was funded by the National Council of Science and Technology (*Consejo Nacional de Ciencia y Tecnología*—Conacyt) and the Mexico City Secretariat of Science, Technology and Innovation (*Secretaría de Ciencia, Tecnología e Innovación de la Ciudad de México*—Seciti), with a total budget of roughly P$36 million. The pilot project could serve as a testing facility for various operational and technological options, to establish a working model for Mexico (Durán Moreno n.d).
- The experiences of Mexico City and states such as Jalisco—which are leaders in developing and enforcing standards for the separation of organic waste (yard and municipal green waste) for composting, and in managing slaughterhouse waste—offer lessons to be learned. While other states, provinces, and municipalities have similar plans, most are not strictly followed or enforced.
- The Economy Secretariat is developing a voluntary standard for aerobic treatment of organic waste and for product quality that may offer opportunities to revive Mexico's composting operations.

United States

The Resource Conservation and Recovery Act (RCRA) establishes a national framework for the proper management and disposal of non-hazardous and hazardous solid waste in the United States (US EPA 1976). While RCRA does not specifically address the management of organic waste, its Subtitle D, Section 4001, encourages disposal of solid waste in environmentally sound ways that maximize the utilization of valuable resources. It also states that the federal government will provide technical and financial resources to states; the US EPA developed its solid waste program, including the waste management hierarchy, in response to this directive. While the US EPA and the US Department of Agriculture (USDA) announced the nation's first-ever food waste reduction goal—50 percent by 2030—in September 2015 (US EPA 2015), the United States has no federal or nationwide organic waste diversion or processing laws or policies. Instead, states, counties and/or municipalities have been leading the way by implementing organic waste diversion or disposal bans on yard and/or food waste, or by enacting requirements (policies, incentives) to encourage organic waste diversion and processing.

States have their own differing policies and regulations for organic waste; there is no comprehensive state-by-state listing of such regulations. About half of all states have enacted yard and/or food waste disposal bans and a handful of states—California, Connecticut, Delaware, Florida, Massachusetts, Michigan and New York—have also set landfill diversion targets, and organics exclusion will likely help achieve those goals. But current policies in some states impede greater composting and/or use of AD to handle these diverted organics, so it is unknown how much impact these bans and targets might truly have. Composting operations and digesters, in particular, are subject to solid waste and air and water quality permitting that varies from state to state, thereby requiring project developers that work in multiple states to know how each permit or local ordinance might affect specific projects (finances, technology selection, end-products).

Counties and municipalities in the United States are leading the charge for increased organic waste diversion and processing, yet there remains tremendous untapped potential to implement and expand programs across the country. Most counties or municipalities with organic waste diversion support composting of source-separated organics, due to a variety of advantages. For example, Alameda County (California) has a composting program that serves 420,000 single-family households by collecting food scraps, food soiled paper and plant debris (StopWaste 2016); in New York City, 100,000 households and over 150 apartments receive food scraps collection services (New York Department of Sanitation 2016). In the ICI sector, Weis Markets in Pennsylvania achieved its GHG reduction goal five years ahead of schedule, in part due to an extensive food-waste composting program (end-product is then made available to customers for purchase) (Goldstein 2013). At Purdue University (Indiana), food waste is collected from the campus and sent to a WWTP for co-digestion, which helps power the treatment facility (Purdue University 2013).

Examples of US policies include the following:

- Many federal incentive programs support organic waste diversion and processing. Among these are the following:
    - There are more than 523 biomass-related regulatory policies and/or financial incentives—of which 227 relate specifically to AD technologies (NC Clean Energy Technology Center 2016).
    - The federal Renewable Fuel Standard includes biogas as a cellulosic and advanced fuel to meet renewable volume obligations (US EPA 2017). (Qualifying biogas used in transportation generates renewable identification numbers that help facilitate markets for biogas sales from AD.)
    - The US Department of Energy's Qualified Energy Conservation Bonds offer AD funding (US DOE 2017).
    - The USDA's Advanced Biofuel Payment Program offers AD funding (USDA 2017a).
    - The USDA's Rural Energy for America Program can help agricultural producers and rural small businesses install renewable energy systems, including AD (USDA 2017b).
- The US EPA created the "Waste to Biogas Mapping Tool," an interactive map created to connect organic waste producers (e.g., grease rendering facilities, food processing facilities) and potential users for co-digestion with biogas recovery (US EPA 2016c). EPA also developed the Co-Digestion Economic Analysis Tool to assess the initial economic feasibility of food waste co-digestion at WWTPs/WRRFs for biogas production (US EPA 2016a).
- States also offer certain incentives to promote organic waste diversion. For example, CalRecycle provides funding for public and private solid-waste management projects, such as composting and AD, through its organics grants program (CalRecycle 2017). The goal of this competitive grant program is to lower overall GHG emissions by expanding existing capacity or establishing new organics processing facilities around the state to reduce the amount of organic materials or alternative daily cover sent to landfills.

- Several states have established GHG reduction goals that include organic waste diversion. For example, California passed a bill (SB 1383) in September 2016 requiring a reduction in methane emissions from dairy and livestock, organic waste, and landfills. The law is intended to support the adoption of policies that improve organics recycling and innovative, environmentally beneficial uses of biomethane derived from solid-waste facilities. The legislation also specifies steep reduction targets for organic waste disposal in state landfills: a 50-percent reduction from the 2014 level by year 2020 and a 75-percent reduction by 2025 (Government of California 2016).
- Nongovernmental organizations are also filling important information gaps to advance organic waste diversion, processing, end-products and markets:
    - The American Biogas Council rolled out a new voluntary Digestate Standard Testing and Certification Program that will allow biogas plants to more effectively market their digestate by providing information about the digestion process and digestate feedstocks and composition. The program also provides composters that accept digestate with data that will allow them to determine the optimal blend for composting (Leib et al. 2016).
    - The US Composting Council created its Seal of Testing Assurance (STA) Program for testing, labeling and disclosing information about compost products (USCC 2016) to: address the lack of federal regulations or quality standards, and to help producers and purchasers determine a compost's suitability for intended use(s) and/or compare compost products; STA Program manufacturers or marketers regularly sample and test their compost in accordance with STA protocols and pay an annual application fee per certified product to display the STA Program logo.
    - The federal government (e.g., the US EPA) and states have also developed procurement requirements for compost and fertilizers made from organic waste (e.g., used in landscaping around federal and state buildings and parks). Thirteen states mandate the use of Certified Compost (STA-approved), a requirement that promotes compost markets (Miller and Germain 2016).

Part 3

Key Challenges, Gaps and Recommendations

Drawing on a review of published organic waste research, government and industry statistics, and case study data and interviews with stakeholders, this study identified persistent challenges to and gaps in greater organic waste diversion and processing across North America. This section highlights these cross-cutting challenges and gaps across North America, as well as country-specific challenges, and makes recommendations for policy or decision makers.

Cross-cutting Challenges, Best Practices and Recommendations

This section describes a series of challenges, best practices, and recommendations that apply to multiple stakeholder groups across all three North American countries.

Providing Data Clarity: Recommendations for Policy Makers

Up-to-date, accurate data are critical for developing baselines, metrics, policies, programs, incentives, markets and regulations. Because the requirements and standards for measuring, monitoring and reporting organic waste vary among the countries (as well as across states, provinces and municipalities), data availability and consistency also vary. This represents a challenge in designing national, state/provincial or local actions to expand organic waste diversion and processing, and makes it more difficult to assess progress. Recommendations for government policy makers are described below.

Create a North American Organic Waste Database

While the definition of organic waste differs between the countries, combining or linking national databases and/or establishing a comprehensive database for Canada, Mexico and the United States would allow for the recording, tracking and maintenance of organic waste data and other statistics for the public (e.g., allow benchmarking, data comparison, policy analysis). For example, estimates of residential organic waste in North America are the most reliable, since this waste stream is tracked. However, ICI sector comparisons are more difficult, due to differing definitions and data collection efforts. Large data gaps exist in both Canada and Mexico for ICI-sector organic waste generation and diversion, while the United States has limited data on the industrial sector. Furthermore, the US and Canadian ICI estimates do not include organic waste from sewage treatment plants, animal excrement and manure, and animal carcasses, yet these sources contribute to increased opportunities for diversion and processing. A North American organic waste database could be hosted by an industry trade group (as one example) and promoted to stakeholders in Canada, Mexico, the United States and other countries worldwide.

Create a Knowledge Portal

This project highlighted a demonstrated need to collect, track and maintain centralized information about North American and international programs, policies, incentives, case studies, best practices, and other technical materials and tools. Creating a centralized organic waste knowledge portal (i.e., website) of available information would facilitate the exchange of information across North America and other countries. A knowledge portal could also host or link to a North American organic waste database.

Improve Data Tracking at the Municipal, State, and Provincial Levels

Better data tracking and reporting at the state, provincial and municipal levels would enhance development of a North American organic waste database. For example, Canadian national waste composition data are not available to generate national solid-waste data. Waste composition data are still gathered at the local level through characterization studies and not easily obtained for extrapolation to the national level.

Engage the ICI Sector

Data about the use of organic waste in the production of end-products were quite limited and represent a large gap in understanding the types of products or how these products are produced or sold. The North American ICI sector has much greater diversion potential (e.g., grocery stores, restaurants), but data are lacking, and Mexico's organic waste diversion programs from the ICI sector are just emerging. To fill this engagement gap, targeting the ICI sector is viewed as a potential opportunity for a number of jurisdictions. Policy makers have limited data, which contributes to limited or no policies or programs focusing on ICI. Governments face challenges designing effective and transparent policies or programs without reliable data.

Coordinate with Sustainable Business Organizations to Gather Data

Efforts to coordinate with sustainable business organizations (e.g., the World Business Council for Sustainable Development) and the ICI sector should be encouraged, to gather data that can be made available to the public, inform policy, and ensure transparency.

Focusing on Economic Considerations: Recommendations for Local, State and Provincial Government

Organic waste infrastructure typically has higher capital and operational costs than other solid waste management practices such as landfilling and combustion, and the cost difference between organic waste diversion and processing and disposal inhibits the growth of the organics industry, particularly in the ICI sector. Recommendations for local, state and provincial government policy makers are described below.

Level the Playing Field

Governing bodies must evaluate how much priority will be placed on organic waste diversion and processing. Supporting more organic waste diversion may require higher landfill or waste-to-energy tipping fees. It may be necessary to levy landfill taxes or other taxes that organic waste processors can use to help level the playing field. In the United States, at least 20 states have implemented landfill taxes that support grants, infrastructure or education (ReFED 2016).

In addition, economic incentives such as grants, low-interest loans, feed-in tariffs, renewable portfolio standards (such as those in Canada and the United States) or carbon credit opportunities to allow trading or purchasing offsets (by reducing or avoiding methane) from organic waste processing could be expanded across North America.

Consider Implementing Unit-based Pricing Programs

Provincial/state and municipal governments throughout North America have successfully implemented unit-pricing programs (e.g., pay-as-you-throw [PAYT]) that help waste generators reduce disposal costs by diverting a portion of their waste—thereby reducing the overall volume of waste they pay to dispose of—or other financial incentives aimed at encouraging voluntary diversion (e.g., lowering tipping fees for organics at drop-off facilities).

Consider Banning Organics from Landfills

Mandatory recycling laws, or bans on organic waste in landfill require generators to divert organic waste to composting or AD. In Canada, for example, some provinces (e.g., Prince Edward Island, Nova Scotia) and municipalities (e.g., the Regional District of Nanaimo and the City of Vancouver in British Columbia) have banned organics from landfills. Similar bans exist at the state level in the US (e.g., Massachusetts, California) and at the municipal level (e.g., Seattle). Despite those initiatives, complete bans on organic waste in landfills are challenging to implement. Successful enforcement, penalties, and transition strategies must be in place, and individual jurisdictions often must take the initiative to introduce bylaws, larger penalties, and tipping fees, to discourage disposal of recyclable materials.

Focus on Regions with Existing Support for Organic Waste

Waste diversion projects continue to be viewed as high-risk/low-reward. Focusing efforts in states, provinces or cities with landfill disposal bans, higher waste tipping fees, and existing infrastructure can minimize investor concerns (e.g., established infrastructure, markets, knowledge and support for organic waste diversion).

Consider Job Creation Benefits

Consider other economic benefits due to job creation from organic waste diversion and processing. The Rethink Food Waste through Economics and Data (ReFED) Roadmap (ReFED 2016), which focused on food waste, found that processing jobs are created at the project level, as well as regionally and nationally (i.e., ancillary service jobs). A similar job creation analysis could be done to consider the entire organic waste life-cycle (from collection services to educational initiatives to selling end-products).

Overcoming Operational Issues: Recommendations for Project Developers and Municipal Program Managers

Operational factors, including the consistency of organic feedstock, the capabilities of municipal collection fleets, organic waste characteristics, implementation strategies (e.g., use of color-coded bags), and community acceptance, influence the success of organic waste diversion and processing efforts. Recommendations for project developers and municipal program managers are described below.

Have a Financial Plan

Before initiating a project, rigorously analyze all potential sources of revenue or cost savings. Consider questions such as whether to consume power or heat onsite or to sell them to the grid or natural gas pipeline or end-user(s). Identify and secure markets for end-products (through agreements) before developing organic waste processing facilities.

Other revenue-generating considerations include economies of scale (larger facilities with higher throughput) and revenue maximization (energy, tipping fees, secondary products and incentives). Lease models for AD may also offer opportunities for a third-party owner or operator to maintain several regional digesters, especially for medium-size facilities (ReFED 2016).

Failing to secure sustainable sources of revenue or cost savings will harm the project's bottom line. Contracts and off-take agreements for end-products must be identified (markets), negotiated (adding cost) and secured (preferably long-term, to lock in pricing). Since some market participants might be reluctant to enter a long-term contract, consider including variable pricing. For example, a contract that adjusts for the prices of energy over a 10-year power purchase agreement or gas sale agreement could significantly affect project finances, considering factors like low energy prices, a rebound in natural gas prices, or availability of renewable identification numbers.

Accurately Assess Feedstock Consistency

Accurately determining the feedstock content and quantity of the incoming waste stream is crucial to the success of any organic waste diversion and processing program. The quality (e.g., waste composition), quantity (e.g., anticipated population growth), packaging and source of the waste material play important roles in the collection, treatment, capital and operational costs, and operations of an organic waste processing facility and its future performance. In addition, securing long-term agreements and reliable feedstock with fewer contaminants is critical for addressing investor or lender concerns about long-term project viability.

Depending on the source, organic waste can contain high levels of contaminants such as glass, plastics, metals and sand; if so, it must be pre-treated before processing. Pre-treatment may also be needed to remove plastic bags or grind organic waste into a pulp for further processing, to ensure process efficiency, maximize yield and reduce operational costs.

Evaluate Collection Fleet Capabilities

Analyze the current collection fleet to determine if the vehicles are adequate to collect and transport organic waste or whether specialized vehicles are needed. Collection vehicles for organic waste require less compaction, may use augers instead of compaction blades, and have specialized containment for liquids. Newer vehicles may also have multiple compartments to allow for the collection of multiple waste streams, such as source-separated organics or municipal solid waste (MSW); this can reduce the number of vehicles and routes needed for waste collection. However, a cost-benefit analysis for procuring specialized collection vehicles should be determined.

Pilot Test Projects Prior to Implementation

Start out with a pilot project before investing in large-scale infrastructure projects. Pilot projects allow managers to identify issues that could occur at full scale (e.g., feedstock composition, contamination, collection routes, participation rate) and allow project leaders to make necessary adjustments while the investment is still relatively small. Toronto, Ontario, for example, pilot-tested using AD technology for processing organics, before going full-scale. The Dufferin Organics Processing Facility was constructed as a 25,000-tonne pilot facility in 2002 and subsequently expanded over time to full-scale operation. In another example, Sunnyvale, California, embarked on a nine-month food-scrap recovery pilot program from March to December 2015. Roughly 500 households were provided with 64-gallon carts, with 32-gallon capacity on each side. Results of the pilot indicated that 90 percent of the residents participated and 75 percent of food scraps were placed on the proper side of the cart.

Expand Yard Waste Collection Programs

In many cases, municipalities fund organics programs, with limited provincial, state or federal funding available to support them. Expanding existing yard waste collection programs to gradually include food waste may reduce the need for separate collection and use existing infrastructure to keep costs manageable without increasing taxes on residents or business.

Consider Opportunities to Improve Source Separation of Organic Waste

Opportunities to improve source separation of organic waste include providing more bins or bags, preferably color-coded to help distinguish them from other recyclables that might be collected, and providing compostable bags for co-mingled organics. In San Francisco, California, for example, the use of a color-coded bin system, policies (including financial incentives) and extensive public outreach have helped the city divert about 80 percent of its waste from landfills—the highest diversion rate of any major North American city (SF Environment 2016). Municipalities in Nova Scotia (including Cumberland and Oxford) use clear plastic bags for organics, which allows for easier inspection by collection crews. Allowing residences and businesses to use compostable bags for organic waste co-collection with yard waste or MSW could eliminate the need for separate collection vehicles and allow more frequent collection (since a regular hauling vehicle could co-collect the material without increasing collection frequency).

Ease Siting and Community Concerns

The public, especially in larger municipalities, can be resistant to certain technologies and programs in their neighborhoods (e.g., the "not-in-my-backyard" [NIMBY] phenomenon). With composting facilities, for example, procuring a site can pose difficulties, as odor and increased vehicle traffic can be concerns for nearby residents (Hay 2013). Modifying existing waste infrastructure, such as by adding composting or AD to a landfill or waste-to-energy

facility, is less likely to cause as many concerns as siting on a greenfield site. Moreover, adding or modifying existing centrally located drop-off sites gives residents another way to divert organics, especially in more-rural areas. Many Canadian and US cities offer drop-off sites that accept food waste for processing.

In addition, municipalities should consider flexibility and support for expanded or new collection and processing infrastructure (creative solutions may be needed that might fall outside current policies or regulations). For example, consider adding new or upgraded infrastructure like transfer stations or materials recovery facilities as centralized collection points that can also pre-treat organic waste.

Improving ICI Data: Recommendations for Government and ICI Collaboration

The North American Initiative on Organic Waste Diversion and Processing found that most local governments do not mandate diversion of organic waste from the ICI sector. Instead, most rely on voluntary efforts. One major hurdle identified in the foundational report is a lack of data on ICI activities and successes. A recommendation for improving ICI data is described below.

Encourage Waste Reduction Activities and Reporting

Through outreach efforts or voluntary partnership programs, municipalities or states/provinces could encourage the ICI sector to implement waste-prevention activities, such as bulk purchasing, paper use reduction, initiatives to limit purchases of single-use or disposable products (e.g., plastic bags, disposable cutlery), and re-use programs. Jurisdictions could encourage the ICI sector to recycle materials that already have diversion programs (e.g., printed paper and packaging, electronics, organics).

In addition, companies are increasingly establishing sustainability policies or zero-waste goals and/or landfill diversion targets that likely include—or could be achieved with greater—organic waste diversion. It would be useful to have communication among governments and the stakeholders in the ICI sector, and documentation of the achieving of these policies, goals or initiatives through organic waste diversion.

Waste policy frameworks need to have more direct engagement with and requirements for the ICI sector—possibly legislated (e.g., landfill bans) or through negotiated agreements. Waste policy frameworks could also require that ICI waste disposal data be reported to municipal or state/provincial authorities.

Improving data collection and transparency could help inform and design future programs, thereby securing processing capacity and ensuring markets for end-products (e.g., biofuels, biogas, compost).

Establishing ICI Best Practices: Recommendations for ICI Managers

Some of the lessons learned from municipal collection (e.g., use of color-coded bags) apply to the ICI sector; however, other issues are not applicable, since ICI leaders are collecting materials from fewer individual locations than municipalities. Recommendations for ICI managers are described below.

Explore Collaborative Procurement

For small and medium-size businesses, access to collection services can be problematic. For example, haulers face difficulties making a sound business case for investment if they cannot demonstrate a secure level of feedstock, and they cannot wait for infrastructure to be built to appease investors. Businesses could pull their collective resources and work through collaborative procurement: combine food waste volumes to leverage buying power, and then purchase collection services from a single supplier.

Demonstrate Organics Diversion through Events or Initiatives

Concert and other event venues, such as stadiums, and special events represent an opportunity to introduce the community and businesses to organic waste diversion and processing. An example of this in practice is the provision of separate containers for food waste and compostable plates, cups, utensils and napkins go into a single container (May n.d.). Municipalities or haulers could encourage the use of compostable plates, cups and cutlery, to introduce the materials to the public. They could also offer separate bins or compostable bags to residents and businesses (free of charge or with coupons offering discounts).

In addition, events offer opportunities for expanding the use of compostable packaging. For example, in a case study developed by the Sustainable Packaging Coalition, a single evening concert with 6,000 attendees can divert over one tonne of organic waste, including approximately 350 kg of food-soiled packaging (Sustainable Packaging Coalition 2017).

Sustainability efforts—including organic waste diversion initiatives like the Green Sports Alliance, which represents members from teams, venues and leagues in Canada and the United States—could be further expanded in North America. Large venues are ideal locations to get the word out about a team's support for sustainability efforts, while encouraging fans to recycle organic waste.

Supply Marked or Color-Coded Bins for Food Waste Collection

Specially marked or color-coded bins for food waste collection in commercial or institutional environments (e.g., restaurants, college cafeterias) can significantly encourage employees or customers to properly discard food waste in the appropriate bins as well as re-enforce outreach messaging and reduce contamination (McKiernan 2015).

Encourage Use of Compostable Packing and Materials

Compostable packaging presents a potentially valuable opportunity to mitigate contamination issues with source-separated organics while also increasing the amount of organic material that can be diverted and reducing the need for petroleum-based plastic packaging products.

Expand Onsite Processing Capabilities

Businesses are increasingly interested in onsite processing to save money or demonstrate sustainability initiatives or both. Small-scale, onsite, organic-waste processing technologies are beginning to appear in restaurants, hotels, shopping malls, sports and entertainment venues, and government facilities. Onsite AD technologies can process from several kilograms up to several thousand kilograms of food waste per day. Commercial greywater systems use AD in combination with nutrients or enzymes and bacteria to reduce organic waste so it can be introduced into the sewerage system (ReFED 2016).

However, these technologies come at a high price, require added staff training and oversight, and—in the case of greywater—may not be acceptable to wastewater treatment plants (WWTPs) and water resource recovery facilities (WRRFs) (i.e., they may require more processing or added capacity to accept the material) (ReFED 2016).

Enhancing Markets for End-Use Products: Recommendations for Government Policy Makers

A primary benefit of organic waste diversion and processing activities is the resulting end-products that can be used in other applications (e.g., manufacturing, energy generation, soil enhancement). To maximize the potential of these end-products, the North American countries are cultivating markets for both public and private uses—particularly for compost, which appeals to users ranging from state transportation agencies to commercial landscapers and homeowners. In addition, rendering organic waste materials from the ICI sector results in commercial

products, which include soaps, paints and varnishes, cosmetics, explosives, toothpaste, pharmaceuticals, leather, textiles and lubricants. Organic waste end-products from Canada, Mexico and the United States mainly find markets in North America, though some are sent overseas. Furthermore, market drivers are primarily steered by project economics—proximity to markets affects revenues and expenses (e.g., fuel to transport product).

One recommendation for government policy makers is described below.

Promote Buy-Local Efforts

Because markets may be limited or distant from organic waste processing, organic waste end-products are usually less expensive if the markets to sell their products exist locally (i.e., "buy local"). States, provinces and municipalities should encourage the use of local organic waste end-products through the procurement process (e.g., procurement of compost for public landscaping) and promote the products to consumers via media campaigns.

To maximize the potential of end-products, markets for both public and private uses should be cultivated. This is particularly applicable for compost, which appeals to a broad range of users, including state transportation agencies, commercial landscapers, and homeowners.

Promoting Greater Outreach and Education: Recommendations for Government Policy Makers

There is a need for ongoing and consistent outreach and education to inform residents and businesses of pending plans to develop an organic waste processing site, addressing their potential concerns (e.g., concerns about odor or other nuisances, such as flies), explaining how to properly separate organics to minimize contamination, and advertising the benefits of composting and AD. In addition, there is a need to address perceptions that some residents have—e.g., that organics collection should be free because recycling is free or that landfill disposal is still typically the least expensive waste management option. States, provinces and municipalities must better convey the realities of organic waste diversion. Developing infrastructure and markets will require community investment and acceptance. Communication will go a long way to address several other issues and concerns that might arise. Recommendations for government policy makers include the following:

- Develop a well-conceived educational initiative that focuses on reducing contamination and encouraging high levels of participation. This should be done as an initial step prior to moving ahead with an organic waste program.
- Support concerted, long-term educational campaigns and events to promote local benefits from organic waste diversion and end-products. After an educational initiative has been established, municipalities and private-sector companies can shift their focus to long-term strategies intended to instruct the public. Educating participants and/or reminding them that collection of source-separated organics merely isolates a portion of solid waste
  they already generate and manage might help alleviate some concerns.
- Host public forums and outreach at public events; provide handouts and other communications explaining the community's critical role in making the program a success. For example, if taxes will rise for residents or businesses because of the program, be sure to emphasize the program's benefits (e.g., chance to increase jobs in the community, potential cost savings). Involving the community early in the program may increase interest.
- Consider combining outreach with penalties for nonparticipation, to achieve behavior change (ReFED 2016).
- Monitor and evaluate educational initiatives routinely to determine what is working, what is not, and what can be done about it; adjust programs as needed.

Country-specific Challenges and Recommendations

The three North American countries approach organic waste management quite differently. While each country has similar policies, each faces persistent challenges to greater organic waste diversion. For example, low landfill tipping fees in areas of Canada compete with organic waste diversion and processing initiatives; lack of compliance and enforcement in Mexico limits markets for organic waste, due to end-product quality concerns; and lack of federal regulations in the United States causes a patchwork of state and local policies, programs, initiatives and regulations. One of the most common themes is a lack of consistent or sufficient generation and collection of data—particularly in the ICI sector—that could help inform and design future programs and thereby secure processing capacity and ensure markets for end-products (e.g., biofuels, biogas, compost).

This section describes a series of challenges and recommendations for each of the three North American countries.

Canada

The North American Initiative on Organic Waste Diversion and Processing identified the following challenges and recommendations for increasing organics waste diversion and processing in Canada.

Conduct More Research on Co-digestion

While many municipalities in Canada are encouraging co-digestion of organic waste at WWTPs/WRRFs, the practice is not common; thus far it has not been widely adopted. Co-digestion of organic waste with agricultural waste and manure is much more common. More guidance and research on successful co-digestion facilities, practices, policies and incentives should be developed. Lessons can be learned from other countries that are promoting opportunities for co-digestion, such as the United States. For example, the US EPA published a report that discusses opportunities for enhancing biogas generation in WRRFs through the addition of food waste and fat, oils and grease (US EPA 2014).

Assess Additional Sources of Organic Waste

There is no separate data collection to inventory organic waste from septage, sewage, biosolids, animal excrement and manure, and animal carcasses, in Canada. Opportunities may exist to expand Statistics Canada's national survey to track this information.

Investigate Opportunities to More Fully Use Available Processing Capacity for Organic Waste

Canada's composting facilities have about 4.2 million tonnes of available approved processing capacity and currently accept 2.6 million tonnes of organic waste annually, leaving 38 percent of existing capacity unused. Canada should investigate opportunities to expand organic waste acceptance using existing composting infrastructure.

Improve ICI Organic Waste Diversion and Processing

In 2012, the Canadian Council of Ministers of the Environment completed work with major retailers, the restaurant and food sector, brand owners, and the packaging industry that led to an industry-driven approach to reduce waste in Canada (CCME 2014). Resulting recommendations for the ICI sector are summarized as follows:

- Jurisdictions could encourage the ICI sector to implement waste prevention policies such as bulk purchasing, paper-use reduction, initiatives to limit purchases of single-use or disposable products (e.g., plastic bags, disposable cutlery), and re-use programs.

- Waste policy frameworks need to have more direct engagement with and requirements for the ICI sector—possibly legislated or through negotiated agreements. For example, jurisdictions could require the ICI sector to participate in extended producer responsibility (EPR) programs. Alternatively, jurisdictions could encourage the ICI sector to recycle materials that already have diversion programs (e.g., printed paper and packaging, electronics, organics).
- Waste policy frameworks should require ICI waste disposal data to be reported to provincial/territorial authorities to ensure monitoring capabilities.
- Jurisdictions could facilitate ICI organic waste diversion by implementing landfill bans, education and outreach, and infrastructure support.

The *Rethink Organic Waste: A Circular Strategy for Organics* report made a series of recommendations on how to drive organic waste management forward in Ontario (OWMA et al. 2015). Although these recommendations were written for Ontario, they could serve as a template of what would be useful to advance organic waste diversion and processing across Canada.

National Recommendations Based on Ontario's Experience

- Develop a long-term comprehensive strategy for reducing food waste and capturing and processing organic waste, based on the waste hierarchy's prioritizing reduction and re-use, recovery, and recycling. The strategy should include economic, social and environmental elements; policies based on the strategy should incorporate these longer-term objectives.
- Support broader public and business understanding of the need to reduce food waste and of diversion and processing of organic waste, by creating a public awareness campaign.
- Provide tax incentives and develop government procurement policies to reduce food waste, through mechanisms like food donation programs.
- Identify incentives to increase organic residual management programs at all government agencies and institutions and establish preferred purchasing programs for organic residual products (i.e., feedstocks for new products) to encourage procurement.
- Provide incentives to encourage markets for renewable energy generated from organic waste.
- Establish disposal bans, disposal levies, and/or extended producer responsibility (EPR) programs, to encourage organic waste reduction and diversion.
- Restructure the approvals and service-delivery processes, to reduce complexity and strengthen enforcement while ensuring environmental protection.
- Establish a system to better capture and publish data on organic-waste generation, type, collection, processing and end-markets, by working with the organic waste sector.
- Establish ongoing investment and funding for research and development, to keep standards up to date.
- Require businesses and organizations to collect and manage organic materials in a manner that reduces contamination and ensures high-quality outputs.

Mexico

Like Canada and the United States, Mexico has organic waste policies, laws and projects. However, this research found that compliance and enforcement related to these laws and policies are often inconsistent or lacking. While many state and municipal authorities acknowledge the relevance of diversion programs, maximizing potential requires political will and coordination among different entities (i.e., agencies, service providers, processors). Further, when local regulations are passed that include provisions for waste diversion and processing, they often lack enforcement, understanding and promotional markets, policies and incentives, and public education initiatives. While facing a multitude of challenges, Mexico shows tremendous opportunity for significant expansion of organic waste diversion and processing. The market is in essence untapped: adopting effective strategies and recommendations should enable Mexico to achieve organic waste diversion and processing growth and success. Recommendations for Mexico are described below.

Increase Support for National and Local Initiatives

Mexico could establish more national, state and municipal programs to develop specific standards and guidance; promulgate technical information; and offer outreach, education, training and technical assistance. The 2013–2018 National Program for the Prevention and Comprehensive Management of Waste (*Programa Nacional para la Prevención y Gestión Integral de los Residuos*) has not yet been issued (Semarnat 2017). Upon its launch, it will support a framework for formulating or updating state and municipal programs, but a robust enforcement, compliance and education initiative is needed for the program to succeed.

Partner with Trade Associations to Promote ICI Diversion and Processing

To accelerate the involvement of large generators of organic waste in diversion and processing, Semarnat (in coordination with state and municipal authorities) could promote a program for implementing waste management plans in food generation, production and distribution, slaughterhouses, hotels, restaurants, markets, supermarkets, and other sources, through the relevant trade associations.

Support End-Product, Market, and Investment Opportunities

To increase support for scientific and technological research to improve organic waste end-product, market and investment opportunities, Semarnat could explore implementing a strategy and convene a working group consisting of Conacyt; other secretariats, such as Sagarpa; and key universities and research centers across the country.

Develop a Public Registry of Composting and AD Service Providers

A growing number of companies that specialize in composting and vermicomposting offer technical assistance, compost products, and machinery to produce compost. In some cases they develop projects for the creation, operation and supervision of composting and vermicomposting plants. Currently, there is no survey or directory of such companies. Companies that offer proven composting and AD services related to organic waste processing for industry, educational institutions and households—in urban and rural areas—should be identified and listed in a public registry, and involved in activities to strengthen Mexico's capacity to process organic waste.

Develop Standards and Guidance to Promote Beneficial Re-use

Projects that use organic waste to produce biofuels or compost for crop fields will rely on support from the Secretariat of Energy (*Secretaría de Energía*), as well as the Secretariat of Health (*Secretaría de Salud*), Sagarpa and Semarnat, to develop standards and guidance to promote beneficial uses for organic waste.

Form Partnerships across Government Agencies

In its *2030 Agenda for Sustainable Development for Mexico*, Mexico could establish programs or policies that are consistent with the United Nation's 17 Sustainable Development Goals (UN 2015) in supporting organic waste diversion and processing. These programs or policies could be supported and promoted by different secretariats, such as the Secretariat of Health (healthy communities), Sagarpa (rural sustainable development), and Semarnat (self-sustaining housing), as well as civic and educational organizations involved in sustainability initiatives. The secretariats of Treasury and Economy could also be involved, to ensure that there are economic incentives in place along with other incentives for the sustainable production and consumption of biofuels, compost or other products from organic waste processing.

Tap into University Expertise

Clusters of universities involved in related education and research—as well as networks of experts and associations working to strengthen Mexico's capacity to reduce, re-use and recycle wastes—are a source of experience and social will that could be useful in designing and implementing strategies for organic waste diversion and processing.

Create a Centralized Database of Waste Statistics and Information and a Directory of Stakeholders

Mexico could consider developing the National Information System for Integrated Waste Management (*Sistema de Información Nacional para la Gestión Integral de los Residuos*—SINGIR) to create a centralized database of key waste statistics and information sharing. These data could become part of a comprehensive North American organic waste database. Mexico could also consider creating an electronic directory of institutions, groups, businesses and government agencies involved in organic waste diversion and processing.

Provide More Information on End-Use Products

An important consideration for compost market potential is fertilizer use. Many food producers continue to use chemical fertilizers (with their large operations and customer base, synthetic fertilizer manufacturers benefit from economies of scale); 30 percent use organic fertilizer. This 30 percent could represent a market opportunity for compost containing organic waste. However, more information is needed on organic compost products (e.g., nutritional content, collateral effects) before their wider adoption as fertilizer.

Document and Share Information

Mexico could increase efforts to document and share information on composting activities (e.g., type/amount of organic waste generated and processed, type of equipment, processing costs per tonne, quantity and quality of the final product).

United States

While there are many examples of successful policies, programs, incentives and best practices from all levels of government, communities and businesses, challenges persist that limit opportunities for greater organic waste diversion and processing in the United States. States have their own differing policies and regulations for organic waste. About half of all states have enacted yard and/or food waste disposal bans, and a handful of states have also set landfill diversion targets. Current policies in some states impede greater composting and/or use of AD to handle these diverted organics, though, so it is unknown how much impact these bans and/or targets might truly have. Composting operations and digesters, in particular, are subject to solid-waste and air- and water-quality permitting that varies from state to state, thereby requiring project developers that work in multiple states to know how each permit or local ordinance might affect specific projects (finances, technology selection, end-products).

States have a patchwork of definitions for organic waste and renewables, and how AD or other types of organic waste conversion technologies are defined affects whether a project qualifies for any incentive. Achieving agreement on common definitions will facilitate growth of the biogas industry. Many federal and state incentives are available to support the adoption of cleaner technologies, but their applicability to organic waste can be uncertain. For example, the United States has more than 523 biomass-related regulatory policies and/or financial incentives. Of these, 227 relate specifically to AD technologies—but it is unclear how many (if any) of these initiatives are specific to organics and/or include composting efforts. In addition, more than three-quarters of the states have renewable portfolio standards or renewable energy portfolio policies that they could meet if there were more emphasis on organic waste diversion and processing. As with incentives, there is little information specifically on the use of biogas from AD.

Initiate a National Organic Waste Working Group

To tackle the challenges stated above, state and federal government representatives, along with representatives from the organic waste industry and nongovernmental organizations, including trade associations and academia, should establish a working group to evaluate these disparities and develop a set of norms to streamline the expansion of organic waste diversion and processing. The working group would identify and analyze the key challenges and opportunities at the federal, state and local levels and provide a set of recommendations. The recommendations would form the basis for a series of solutions that could be considered for agreement by government or industry.

4. San Francisco hosted a United Nations World Environment Day in 2005, during which mayors from around the world were invited to sign the Urban Environmental Accords based on existing best practices in areas such as "energy, waste reduction, urban nature, transportation, and water" (SF Environment 2017). To date, more than 100 mayors have signed and begun applying the Accords within their own cities.

Increase Federal Cooperation on Organic Waste

Federal agencies and departments, including the US EPA, US Department of Energy and USDA, are involved in organic waste diversion and processing at various levels (i.e., creating policies, programs, incentives, regulations). Opportunities for greater cooperation between and within these agencies and departments should be considered. Another option includes involving other agencies and departments such as the Department of Labor to evaluate and recommend improvements for markets for end-products or for providing technical and outreach support to the ICI sector (e.g., encourage greater data transparency, developing national ICI metrics). Federal agencies and departments should consider establishing an inter-agency task force to coordinate organic waste efforts. Federal experts could analyze many of the challenges described in this paper or foundational report to provide recommendations for harmonizing efforts to expand organic waste diversion and processing in the United States. For example, the AgSTAR program has historically focused on farm-based digesters. Given the volume of non-farm organic waste, the US EPA or USDA or both should consider expanding the program to include more resources on co-digestion and facilitate partnerships between food processors and farms and/or wastewater treatment plants to increase co-digestion.

Promote Lessons Learned from State and Local Government

Opportunities exist for local governments to enter into partnerships with other cities or organizations to help further environmental goals. More than 100 local governments participate in the US EPA's WasteWise program. Others could look to state programs or offices such as RecyclingWorks or CalRecycle for guidance or lessons learned.

In 2005, the city of Austin, Texas, signed onto the San Francisco Environment's Urban Environmental Accords, which comprise a set of objectives "for an urban future that would be ecologically sustainable, economically dynamic, and socially equitable" (SF Environment 2017).[4] In doing so, Austin committed to achieving zero waste to landfills by 2040 (City of Austin 2005). In 2009, the city established Texas' first local Zero Waste Strategic Plan (City of Austin 2009); to help implement that plan, it adopted the Resource Recovery Master Plan in December 2011 (City of Austin 2011).

Opportunities for Trilateral Collaboration

Collaboration among North American countries as well as information-sharing by organic-waste-related organizations could go a long way toward advancing organic waste markets and practices. Lessons learned from existing programs and best practices in each North American country could also be shared with communities in the other countries, especially if they are similar in population and infrastructure (e.g., "sister cities"), to give those governments advance knowledge of what issues they might encounter and how they might address those issues. Opportunities for trilateral collaboration are described below.

Examine Cross-Border Market Opportunities

There may be opportunities for cross-border cooperation, especially along the Canada–US and Mexico–US borders. For example, establishing a composting or AD plant in these border regions could draw on a larger waste shed (feedstock) to supply the plant. Border requirements would need to be examined to determine how national and state/provincial laws would affect such cross-border exchange (e.g., sending waste collection vehicles across the border). The North American Initiative on Organic Waste Diversion and Processing identified minimal information about cross-border markets for organic waste, and recommends additional research to evaluate the challenges and opportunities.

Expand Collaborative Efforts to Establish Sustainability Goals

A growing number of communities and businesses are establishing sustainability goals that include zero waste initiatives, but there are considerable opportunities for expansion. Federal, state, provincial and municipal governments and businesses should work together to support continued expansion of sustainability goals, including organic waste diversion and processing. Examples of potential collaboration include promoting and rewarding achievements, sharing best practices, and educating the public/customers.

To help establish or achieve zero-waste goals, localities should consider legislative approaches—as well as working with generators—to develop programs and incentives to encourage expansion of organic waste diversion and processing as part of corporate or municipal sustainability plans.

Collaborate to Identify End-Markets for Products Derived from Organic Waste Processing

The organic waste industry, including trade associations (American Biogas Council, US and Canadian compost councils), could collaborate with government to invest and develop joint initiatives to research and document markets for end-products (benefits, cost) and conduct outreach to potential end-user business or manufacturing trade associations to make this information available (several trade associations have already developed some materials to promote their end-products and markets, but there is no unified effort).

Improve Data Collection and Transparency

Improving data collection and transparency—particularly in the ICI sector—could help inform and design future programs, thereby securing processing capacity and ensuring markets for end-products (e.g., biofuels, biogas, compost).

Conduct Capacity Building Efforts and Training in Mexico

Mexican authorities (national, state, municipal) could work with Canadian, US and international industry and public leaders to pursue capacity-building and training. Many of Mexico's challenges are technical and involve limited organic waste expertise in the commercial sector. Most of Mexico's efforts focus on composting, and there have been repeated problems—ranging from operations and maintenance to collection and separation. Regional training workshops would facilitate an exchange of knowledge from North American experts, including field operations expertise. In addition, several training workshops could be hosted in Canadian and US processing facilities. Attendees would have a chance to learn about all aspects of the process, including designing and maintaining an effective diversion program, establishing policies (e.g., PAYT), and exchanging best practices (e.g., hands-on experience in pre-treatment and processing). The training workshops would align attendees with similarly sized municipalities. Lessons learned from programs and best practices in other cities—especially cities similar in population and infrastructure (e.g., "sister cities")—would help the Mexican government (federal, state, local) understand potential problems and generate ideas about how to overcome them.

Mexico could explore convening international experts to help identify the elements, strategies and actions to include in a proposed new national program on organic waste diversion and processing. This could involve a planning workshop to which Canadian and US experts would be invited to share their experiences and best practices and discuss lessons from the foundational report. The experience of the experts could facilitate dialogue to help Mexico advance organic waste diversion and processing initiatives. Using digital technology (e.g., social media) to inform interested parties about the purpose of the program and desired outcomes could be an effective, inexpensive and immediate way to catalyze the process and attract attention.

Limitations

The greatest limitation of this paper is the lack of organic quantity and composition data that are consistent in their coverage and availability across countries, provinces, states and municipalities. Without sound data, it is difficult to develop strategies, policies or programs, or metrics around the management of organic wastes across North America. Gaps in data about industrial, commercial and institutional organic waste generation and post-generation handling or treatment were frequently found during the research phase, as well as about industrial uses that should be considered for further evaluation. Some of the gaps could be filled through agreed-upon terms and definitions, and parameters needed in data collection, monitoring, reporting and verification. See Part 3 for a more detailed discussion of the recommendations for improving data quality and quantity.

Additional limitations included differing methodologies used to estimate GHG emissions from organic waste disposal and potential emission reductions to be gained from diverting organic waste to beneficial uses. There is no single methodology or model to estimate landfill GHG emissions versus life-cycle GHG emissions for the three countries and a robust country-specific or regional (or both) tool to estimate lifecycle GHG emissions would be useful.

The CEC companion report, *Characterization and Management of Food Loss and Waste in North America*, found similar limitations in identifying country-specific data on environmental and socio-economic impacts from food loss and waste for the three countries. Given that, an approach that could be considered would be to build on existing environmental and socio-economic impact quantification models using proxy data to customize by country.

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