

GENERATION AND MANAGEMENT OF MUNICIPAL SOLID WASTE How's Canada Doing?



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Executive Summary

Solid waste affects people's health and the environment surrounding them. Poorly managed solid waste accumulates in local bodies of water, oceans, and forests, degrading our ecosystems and negatively impacting human health. Therefore, appropriate management of solid waste is a particularly important public policy goal. This study examines the state and evolution of the generation and management of Municipal Solid Waste (MSW)—more commonly known as trash or garbage—in Canada over the past two decades, using official data and government reports.

Overall, as Canada's population and economy grew between 2002 and 2018, so did total waste generation. Canadians generated 35.5 million tonnes of MSW in 2018—16 percent more than in 2002 when 30.7 million tonnes were generated. However, when we account for population and economic activity, Canadians are generating less waste over time—2 percent less on a per-capita basis and 23 percent less per unit of GDP in 2018 compared to 2002. The fact that Canada's waste generation rate grew more slowly than its GDP from 2002 to 2018 suggests that Canada has partially decoupled waste generation from economic growth.

While per-capita waste generation is declining in Canada, data shows that solid waste generation from residential sources is on the rise and now makes up over 40 percent of total waste generated. On the other hand, waste generation from non-residential sources—which include industrial, commercial, and institutional sources—declined between 2002 and 2016.

Similarly, Canadians are disposing of less waste over time—10 percent less on a per-capita basis and 29 percent less per unit of GDP in 2018 compared to 2002.

In addition, waste diversion has steadily increased in Canada. In 2018, about 28 percent of MSW was diverted in Canada—chiefly comprised of paper fibres and organics—compared to almost 22 percent in 2002. In 2018, the remaining 72 percent of waste, which is largely comprised of food and plastics, was disposed of mostly in landfills. Overall, Canada's waste management still relies on landfills despite significant increases in diversion rates.

Furthermore, while most Canadian provinces have reduced waste generation and disposal over time (relative to economic activity and population), progress varies. New Brunswick saw the greatest increase in per-person waste generation and disposal (20 percent and 19 percent respectively), going from 726 kg of solid waste generated per person and 552 kg of solid waste disposed per person in 2002 to 872 kilograms of waste generated and 659 kg of waste disposed in 2018. On the other hand, British Columbia saw one of the highest declines in these metrics, with a 7 percent decrease in generation and a 17 percent decrease in disposal. Following British Columbia, Quebec and Ontario also made notable progress, reducing per-person waste generation by 3 percent and 5

percent, respectively, and by reducing their waste disposal per person figures by 16 percent and 12 percent, respectively.

Overall, Nova Scotia and British Columbia have the lowest disposal rates in the country, relative to both economic activity and population, while Manitoba has one of the highest.

Similarly, almost all provinces increased their diversion rates (i.e., the amount of MSW diverted as a proportion of waste generated) since 2002, with the exceptions of Manitoba and Alberta. Nova Scotia, which increased its diversion rate by 12 percent between 2002 and 2018, has the highest diversion rate in the country with almost half of its total amount of waste generated diverted from landfills. British Columbia is a close second with a diversion rate of almost 40 percent while Newfoundland and Labrador has the lowest diversion rate, at 10 percent. The largest provinces, Ontario and Quebec, have diversion rates of 25 percent and 33 percent, respectively.

Overall, the evidence illustrates that, when we account for population and economic activity, Canada has generated and disposed of less waste over the past two decades. On balance, the fact that Canada partially decoupled solid waste generation and disposal from economic growth is good news for the environment. Moreover, the country's progress in reducing per-capita solid waste disposal and waste disposal intensity, paired with increasing diversion rates, speaks volumes for Canada's stellar environmental performance and builds on its already impressive environmental track record.

1. Introduction

What is Solid Waste And How Do We Manage It?

Solid waste is one of those topics that impacts every one of us. We all generate waste in some form or another. But we don't usually stop and think about the details of how much waste we generate, where it goes, and the impact it has on the environment. Over the last few decades, however, there has been an increasing awareness campaign focusing on reducing, reusing, and recycling solid waste—commonly called the three Rs—in Canada and worldwide. Additionally, reducing solid waste became a key environmental performance metric after the adoption of the United Nation's Sustainable Development Goals.

Solid waste, in broad terms, refers to discarded materials generated from economic activity. It can be hazardous or non-hazardous in nature and is generated from many sources including industrial, residential, commercial, and institutional. Generally, solid waste can be characterized into two categories depending on the source and end-of-life generation stage. *Upstream waste* is generated when resources are processed into material and goods, while *downstream waste* is generated after goods or materials are consumed (Ecofiscal Commission, 2018). In this report we focus on downstream solid waste, which is commonly known as Municipal Solid Waste (MSW). [1]

MSW includes waste generated by residential and industrial, commercial and institutional (ICI) sources. It is primarily non-hazardous; however, it includes small quantities of hazardous materials (residential and non-residential) that require specialized collection, treatment, and disposal (Environment and Climate Change Canada, 2021). Examples of MSW include food scraps, electronics, used packaging, old computers, newspapers, and food waste generated by businesses and households.

Generally, municipalities have two main alternatives to manage MSW: disposal and diversion. [2] Waste disposal refers to how we get rid of the MSW that is generated, whether by transporting it to landfills (an open site or facility where waste is stored) or incinerating it in waste-to-energy facilities, municipal wastewater sludge incinerators, or biomedical incinerators. Solid waste diversion, on the other hand, refers to the preparation of MSW for recycling, composting, and re-using activities (Environment and Climate Change Canada, 2018a; Statistics Canada, 2018).

Overall, poorly managed solid waste can have a negative impact on public health and the environment. Waste management and recycling programs are costly but contribute to the public good by directly reducing litter and trash. In some cases, recycling

[1] In this report, the terms municipal solid waste, waste, and solid waste are used interchangeably.

[2] In the waste management hierarchy, waste prevention (which refers to any action to avoid waste generation) is the preferred option to manage MSW. However, measuring waste prevention is challenging as it represents waste that was never created. Currently, there is no available data on waste prevention.

programs may also generate processed waste products which can be resold. Note, however, that households tend to separate the most valuable among their discarded goods either for selling themselves or donating to thrift shops. The residuals which are placed in the trash or recycling stream tend therefore to be the least valuable materials.

It is important to also note that diverting systems also have environmental footprints. There are some cases where manufacturing products from recycled materials requires more energy and resources than does manufacturing the same products from primary raw materials (Brown et al., 2004). However, the environmental costs associated with diversion are typically smaller than disposal systems (EPA, 2021; Environment and Climate Change Canada, 2021). In other words, waste diversion is a more environmentally friendly method of waste management in comparison to waste disposal.

Nonetheless, it should be pointed out that the evidence is mixed regarding whether waste recycling is a cost-effective strategy to manage solid waste, especially when we account for both financial variables and environmental factors. While some studies have found recycling resulting in overall costs savings for waste management systems (Tonjes and Mallikarjun, 2013; Lavee, 2010), others have found that recycling costs tend to exceed the benefits (Tanskanen et al., 1998; Modak and Everett, 1996).

Who Is Involved?

In Canada, MSW management is a shared responsibility between federal, provincial, and municipal governments. However, the bulk of the operation lies on municipal governments as they manage the collection, disposal, and recycling of both residential and non-residential solid waste. Municipalities manage MSW either directly by using their own government staff or through private contracting firms.

On the other hand, provincial and territorial authorities regulate MSW management by establishing policies, strategies, targets, and programs and approving and monitoring waste management facilities and operations.

The federal government, besides regulating the international and interprovincial movements of hazardous waste and recyclable materials, sets standards and identifies the best practices for MSW management by publishing reports and recommendations. Additionally, it collects data, supports research and development, and provides fiscal incentives for recycling.

This complementary nature of MSW management is a key component of the Aspirational Canada-wide Waste Reduction Goal. On November 2018, the Canadian Council of Ministers of the Environment, composed of environment ministers from the federal, provincial, and territorial governments, set a non-binding aspirational goal of reducing per-capita solid waste disposal to 490 kg by 2030 and 350 kg by 2050 (Environment and Climate Change Canada, 2018b).

Objective and Main Findings

The purpose of this study is to track the state and progress of municipal solid waste generation and management in Canada over the last two decades. Section 2 breaks down Canada-wide data on solid waste generation, disposal, and diversion between 2002 and

2018. Section 3 analyzes and compares provincial data on MSW generation, disposal, and diversion between 2002 and 2018 while also describing some of the programs and objectives provinces have set for themselves.

Overall, the evidence shows that when we account for population and economic activity, Canada has generated and disposed of less waste over the past two decades. In particular, Canadians are generating less waste over time—2 percent less on a per-capita basis, and 23 percent less per unit of GDP in 2018 compared to 2002. In addition, per-capita waste disposal also declined by 10 percent during this period while disposal intensity, which measures MSW disposed of per unit of GDP, declined by 29 percent.

The fact that Canada's waste generation and disposal grew significantly more slowly than its GDP from 2002 to 2018 suggests that Canada has partially decoupled waste generation and disposal from economic growth.

Moreover, the data shows a shift in the sources of MSW generation. While non-residential sources continue to account for most of the solid waste generated in Canada (56 percent of total waste generated), its share has been declining since 2002 when it stood at 64 percent. Consequently, MSW generated by residential sources has increased from 11.2 million tonnes in 2002 to 15 million tonnes in 2016, making up 44 percent of total solid waste generated in Canada.

In addition, waste diversion has steadily increased in Canada. In 2018, about 28 percent of waste was diverted in Canada—chiefly comprised of paper fibres and organics—compared to almost 22 percent in 2002. In 2018, the remaining 72 percent of waste, which is largely comprised of food and plastics, was disposed of mostly in landfills. Overall, Canada's waste management still relies heavily on landfills despite significant increases in diversion rates.

Furthermore, while most Canadian provinces have reduced waste generation and disposal over time (relative to economic activity and population), progress varies. New Brunswick saw the greatest increase in per-person waste generation and disposal (20 percent and 19 percent increases, respectively), going from 726 kg of solid waste generated per person and 552 kg of solid waste disposed per person in 2002 to 872 kg of waste generated and 659 kg of waste disposed of in 2018. On the other hand, British Columbia saw one of the the highest declines in these metrics—a 7 percent decrease in generation and a 17 percent decrease in disposal. Following British Columbia, Quebec and Ontario also made notable progress by reducing per-person waste generation by 3 percent and 5 percent, respectively, and by reducing their per person waste disposal figures by 16 percent and 12 percent, respectively.

With respect to waste diversion, almost all provinces have increased their diversion rates since 2002, with the exceptions of Manitoba and Alberta. Nova Scotia, which increased its diversion rate by 12 percent between 2002 and 2018, has the highest diversion rate in the country with almost half of its total amount of waste generated diverted from landfills. British Columbia is a close second with a diversion rate of almost 40 percent while Newfoundland and Labrador has the lowest diversion rate, at 10 percent.

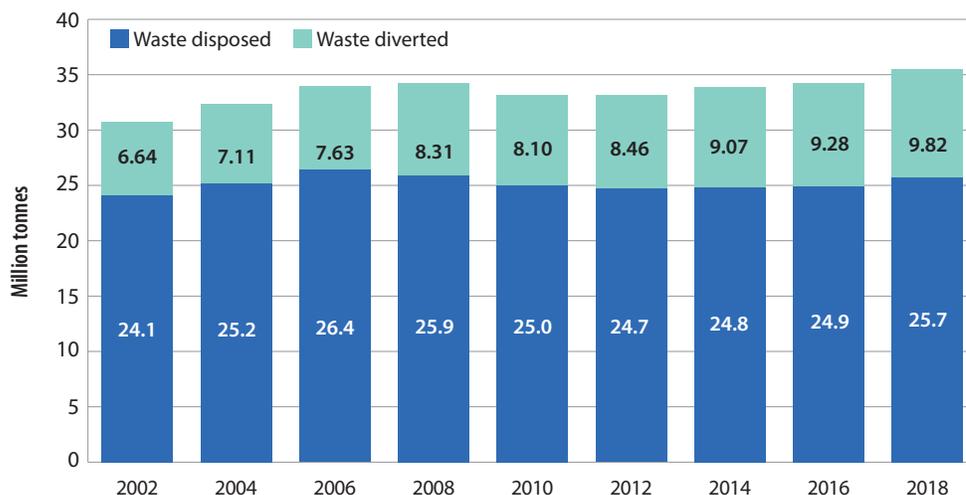
2. Waste Generation, Disposal, and Diversion in Canada

In most countries, the amount of waste generated tends to increase generally in line with population and economic growth. However, not all waste is treated equally. It is important to recognize the difference in treatment between waste disposed and waste diverted. The former is considered garbage and is sent to landfills or to an incineration plant, while the latter is treated as a commodity and sent to recycling and composting facilities for processing and re-use.

Figure 1 shows the evolution of total non-hazardous waste disposal and diversion in Canada over the period of 2002 to 2018 using published Statistics Canada information. Waste generation is the sum of total solid waste disposed and the total amount of solid waste diverted. Every two years, Statistics Canada carries out its Waste Management Industry Survey, collecting data from both the business and the government sectors and gathering information on solid waste collection, disposal, recycling, and other variables regarding MSW management. The latest available data for solid waste management in Canada is from 2018.

Overall, Canadians generated 35.5 million tonnes of solid waste, which is the sum of waste disposal and waste diversion, in 2018—16 percent more than in 2002 when 30.7 million tonnes were produced. By comparison, Canada's population and real GDP rose by

Figure 1: Total amount of waste generated, disposed, and diverted in Canada, 2002 to 2018



Sources: Statistics Canada, 2021a, 2021d.

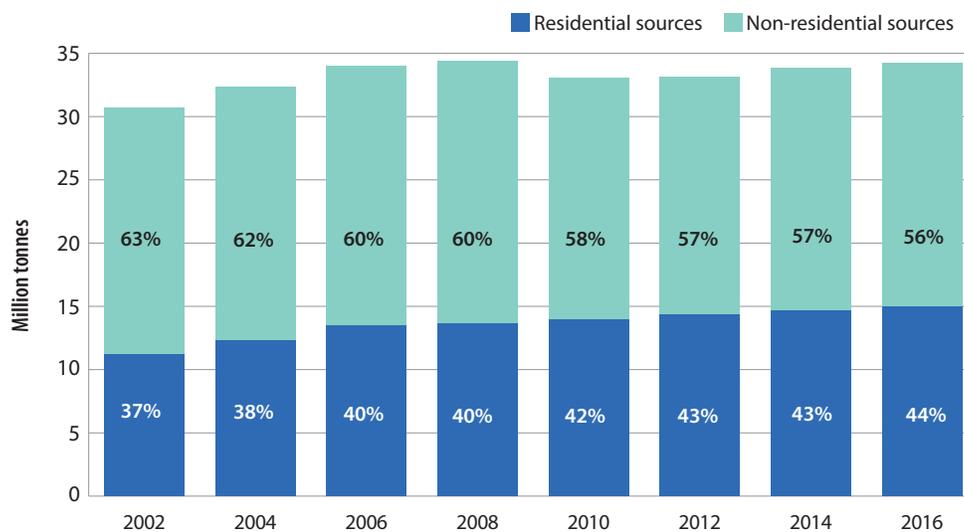
18 percent and almost 50 percent, respectively, over the same period (Statistics Canada, 2021a; Statistics Canada, 2021b). Of the total amount of solid waste generated in 2018, 72 percent was disposed of (landfills, incineration, or export) while 28 percent was diverted. In 2016 (the most recent data available), most of Canada's disposed solid waste went to landfill sites in Canada (82 percent), 15 percent was exported to the United States, while 3 percent was incinerated (Environment and Climate Change Canada, 2020).

Nationally, the amount of waste disposal reached 25.7 million tonnes in 2018—3 percent higher than 2016 levels and 7 percent above 2002 levels when waste disposal stood at 24.4 and 24.1 million tonnes, respectively.

Similarly, the total amount of waste diverted (reused, recycled, or composted) increased considerably over the same period. In 2002, Canadians diverted 6.6 million tonnes of solid waste. By 2018, the total amount of MSW diverted increased by 48 percent to reach 9.8 million tonnes.

Figure 2 shows waste generation by source in Canada from 2002 to 2016 (the latest year for which we have detailed available data). As shown, non-residential sources continue to account for most of the MSW generated in Canada. However, its share has declined since 2002. More specifically, solid waste produced by the industrial, commercial, and institutional sector went down from 19.5 million tonnes in 2002 (63 percent of total waste generated that year) to 19.2 million tonnes in 2016 (56 percent). [3] In contrast, household waste went from 11.2 million tonnes in 2002 to 15 million tonnes in 2016, a 34 percent increase. Residential sources made up 44 percent of all the waste produced in Canada in 2016.

Figure 2: Sources of waste generation, Canada, 2002 to 2016



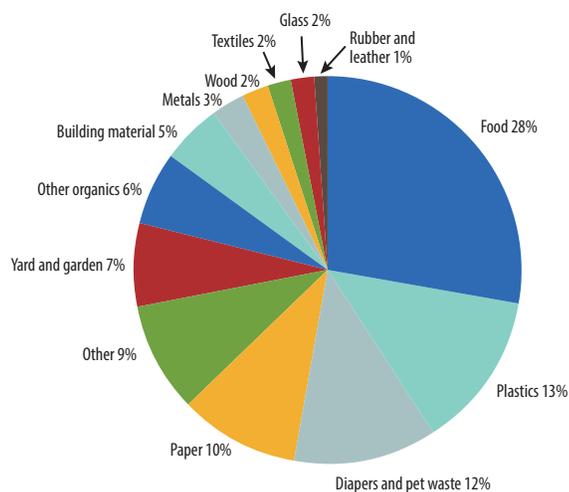
Source: Statistics Canada, 2021a.

[3] Shares of residential and non-residential sources for all sources were not available for 2018.

Similar to waste generation, most of the waste disposed of comes from the non-residential sector. More specifically, in 2018, 58 percent came from non-residential sources and the residential sector accounted for 42 percent. However, these proportions have changed over time. The share of non-residential solid waste decreased from 65 percent in 2002 to 58 percent in 2018 while the share of residential solid waste increased from 35 percent in 2002 to 42 percent in 2018.

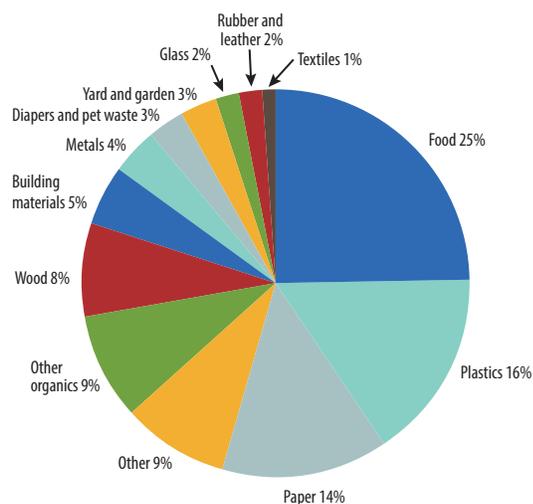
Figures 3 and 4 show the composition of residential and non-residential waste disposal in Canada in 2016, the year of latest available data (Environment and Climate Change Canada, 2020). Food and plastics, the two single largest categories, made up 41 percent of

Figure 3: Composition of residential MSW, Canada, 2016



Source: Environment and Climate Change Canada, 2020.

Figure 4: Composition of non-residential MSW, Canada, 2016



Source: Environment and Climate Change Canada, 2020.

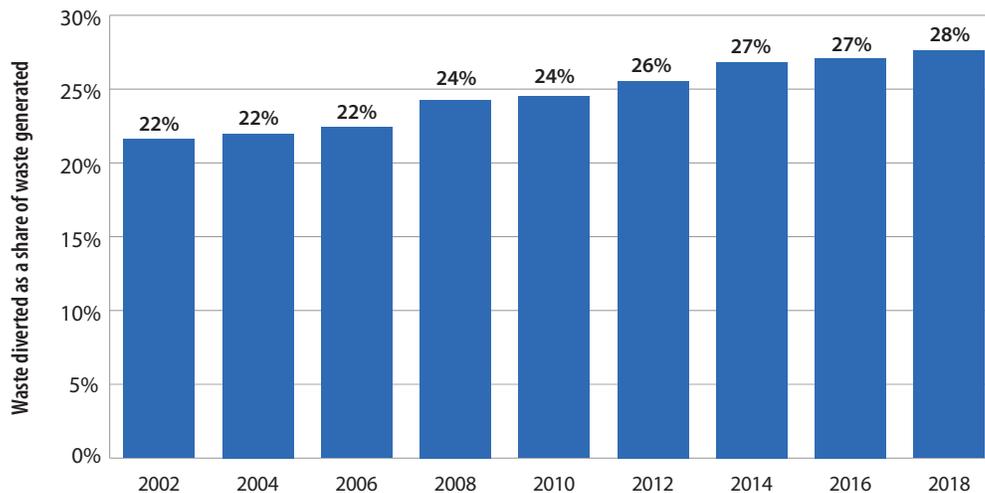
the total amount of waste disposed of in 2016 for both the residential and non-residential sectors. Approximately 5.8 million tonnes of food (161 kg per capita) and 3.3 million tonnes of plastic (93 kg per capita) were disposed of in 2016. Currently, Canada has a target of zero plastic waste disposal by 2030.

Evidently, diapers and pet waste accounted for 12 percent of all residential solid waste disposed in 2016—the third largest category for residential sources. Paper accounted for 10 percent and 14 percent of the total amount of waste from the residential and non-residential sectors, respectively.

It is worth noting that approximately 70 percent of residential waste and 74 percent of non-residential waste disposed in 2016 was considered degradable, i.e., methane-emitting materials.

Figure 5 depicts Canada's diversion rate, i.e., the amount of MSW diverted as proportion of waste generated, over the same period. As shown, the diversion rate has consistently increased in Canada over time. Specifically, it rose from 22 percent in 2002 to 28 percent in 2018, meaning that Canada currently diverts more than one quarter of the amount of waste generated. In terms of sources for waste diversion, in 2016, the residential sector was responsible for 52 percent of diverted waste while non-residential sector was responsible for 48 percent. [4] It is worth noting that the increase in Canada's diversion rate is largely driven by a sizeable uptick in recycling from residential sources. Between 2002 and 2016, recycling from residential sources increased by 71 percent while non-residential recycling rose by almost 17 percent.

Figure 5: Diversion rate, Canada, 2002 to 2018



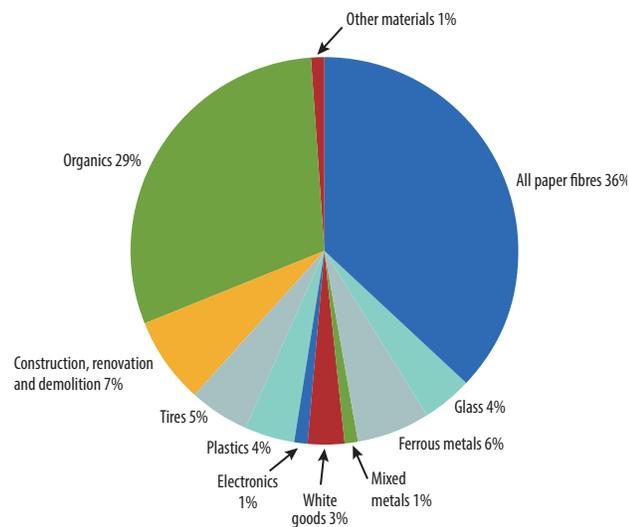
Sources: Statistics Canada, 2021a, 2021d; calculations by authors.

[4] Shares of residential and non-residential sources for materials diverted are not available for 2018 as electronic and tire source data are incomplete.

Figure 6 shows solid waste diversion by type of material in Canada in 2018. The vast majority of materials that were diverted in 2018 came from paper fibres and organics. Paper fibres, which include newsprint, cardboard, boxboard, and mixed paper, make up almost 36 percent of diverted material in Canada while the share of organics is 29 percent. This proportion has remained relatively stable since 2004.

The diversion of plastics, a debated issue in environmental policy, increased markedly during this time period. Canadians went from diverting 144,181 tonnes of plastics in 2002 to roughly 355,000 tonnes in 2018—a 146 percent increase.

Figure 6: Share of total waste diverted, by material, Canada, 2018



Source: Statistics Canada, 2021d.

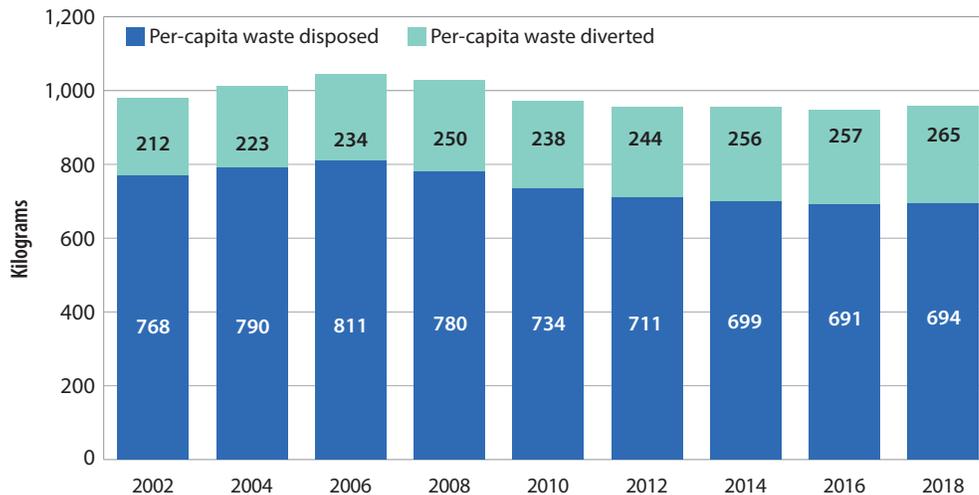
Figure 7 shows per-capita waste disposal and diversion in Canada between 2002 and 2018. Despite the fact that the total amount of MSW increased, per-capita solid waste disposal (both residential and non-residential) declined by 10 percent from 768 to 694 kg. As it stands, Canada has to reduce per-capita solid waste disposal by 30 percent if it wishes to achieve its goal of getting to 490 kg by 2030.

Similarly, diversion of waste per capita increased over the same period from 212 kg in 2002 to 265 kg in 2018, an increase of about 25 percent.

Adding the two streams together indicates that per-person generation of MSW decreased from 980 kg per person in 2002 to 959 kg in 2018—a 2 percent reduction.

Several factors can influence waste generation and disposal methods. As a country's wealth increases, solid waste generation is generally thought to increase. The main reason for this is rising incomes, which leads to rising material consumption. In other words, as people become more prosperous, they purchase and discard more newspapers, cars, clothes, etc., leading to more solid waste generation and disposal.

Figure 7: Per-capita solid waste disposal and diversion, Canada, 2002 to 2018



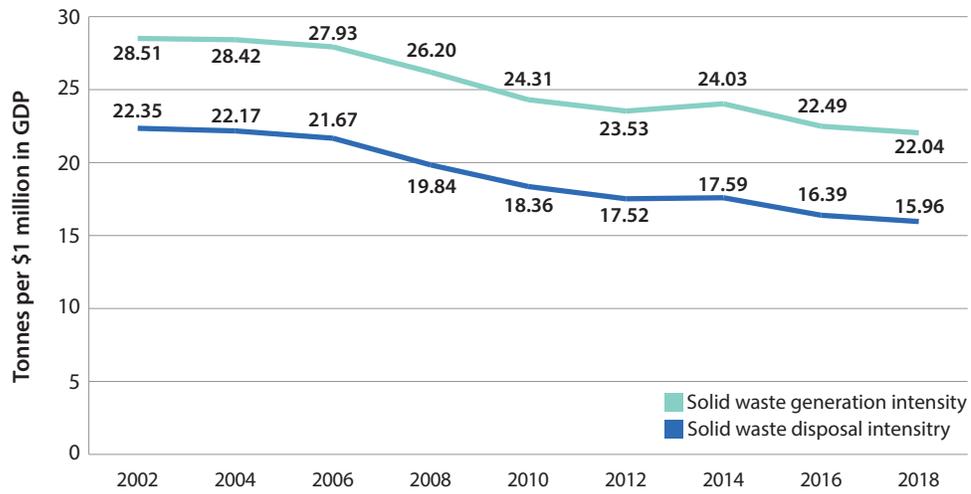
Sources: Statistics Canada, 2021a, 2021d, 2021e; calculations by authors.

Relative to economic activity, Canadians are also generating and disposing of less waste over time. **Figure 8** shows Canada's generation and disposal intensity, which measures the amount of waste generated and disposed of per unit of gross domestic product (GDP), between 2002 and 2018. Waste generation intensity fell considerably from 29 tonnes per \$1 million in GDP in 2002 to 22 tonnes per \$1 million in GDP in 2018—a 23 percent reduction. In addition, waste disposal intensity plummeted 29 percent during this period, going from 22 tonnes for every \$1 million in output in 2002 to 16 tonnes in 2018.

It is important to note that Canada's real GDP grew by almost 50 percent between 2002 and 2018 while its total waste generation and disposal increased by 16 percent and 7 percent, respectively, over the same period. The fact that Canada's waste generation and disposal grew significantly more slowly than its GDP suggests that Canada has, at least partially, decoupled waste generation and disposal from economic growth.

Overall, the data (and the trend) on solid waste generation and management in Canada tell three interrelated stories. First, despite absolute amounts increasing between 2002 and 2018, Canadians are generating and disposing of less waste on a per-capita basis. Second, Canadians are also reusing, recycling, and composting more solid waste than they used to in 2002, in both absolute and per-capita terms. And last, but not least, Canada has been partially decoupling its economic growth from waste generation and disposal.

Figure 8: Solid waste generation and disposal intensity, Canada, 2002 to 2018



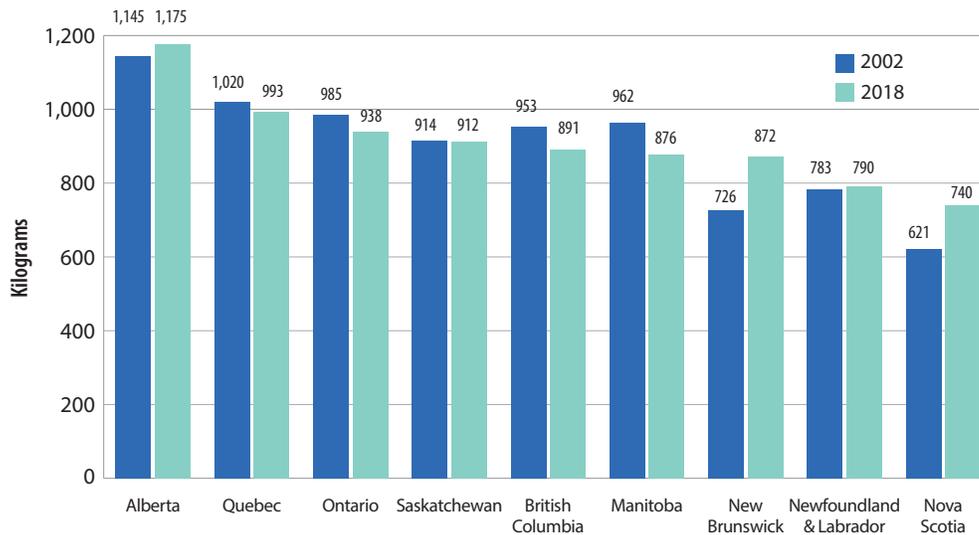
Sources: Statistics Canada, 2021a, 2021f; calculations by authors.

3. Waste Generation, Disposal, and Diversion in Canadian Provinces

In absolute numbers, all provinces in Canada generated more total waste in 2018 than in 2002. [5] This result is not surprising given that Canadian provinces have experienced higher economic growth and population levels over time. However, some provinces are generating less on a per-capita basis.

As shown in **figure 9**, five out of the nine provinces featured in this study reduced per-capita MSW generation during this period. Manitobans, for example, went from generating 962 kg of solid waste in 2002 to 891 kg in 2018—the largest per person reduction for any province (9 percent). The second largest reduction came from British Columbia, which reduced per-person MSW by 7 percent during this period by producing 891 kg in 2018. Similarly, Ontarians went from generating 985 kg per person in 2002 to 938 kg in 2018, a 5 percent reduction. In addition, Quebec continues to be one of the highest waste-generating provinces in Canada despite reducing per-capita waste generation by 3 percent during this period.

Figure 9: Per-capita waste generation, by province, 2002 and 2018



Sources: Statistics Canada, 2021a, 2021e; calculations by authors.

[5] Data for Prince Edward Island was not available.

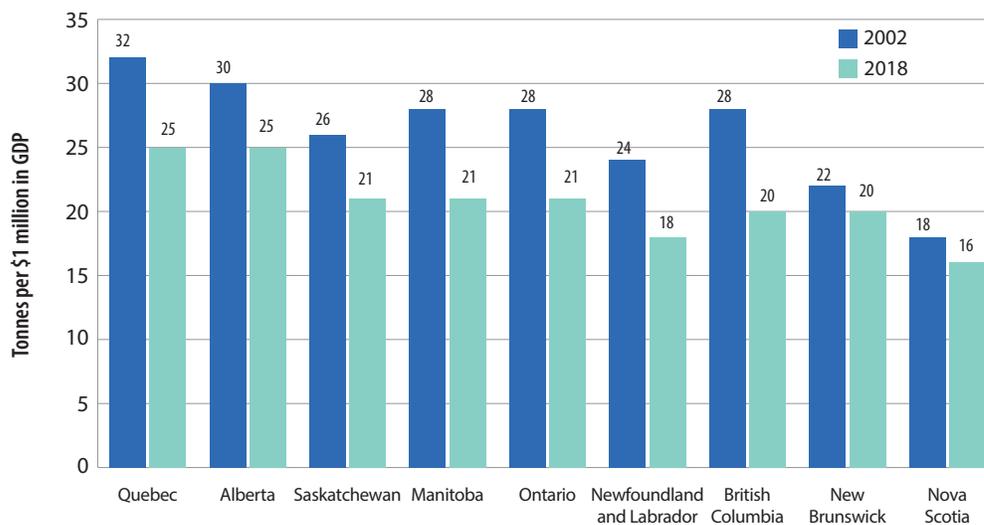
Overall, Alberta, Quebec, and Ontario are the provinces that generated the most MSW on a per-capita basis in 2018, possibly reflecting higher levels of economic activity compared to other provinces.

On the other hand, the three Atlantic provinces—Newfoundland and Labrador, Nova Scotia, and New Brunswick—generated the least amount of MSW in Canada, perhaps due to the small sizes of their economies. However, the three provinces increased per-capita waste generation during this time. Notable increases came from New Brunswick, which went from producing 726 kg of MSW per person in 2002 to 872 kg in 2018, and Nova Scotia, which increased its per-person MSW generation figures by 19 percent.

Figure 10 shows that, when we account for economic activity, all provinces reduced their solid waste generation intensity—which measures the tonnes of MSW generated for every \$1 million dollars of GDP produced. British Columbia went from producing 28 tonnes for every \$1 million dollar of output in 2002 to only 20 tonnes—a 28 percent reduction—despite having one of the largest economies in Canada. Other significant reductions came from Manitoba (27 percent), Newfoundland and Labrador (25 percent), and Ontario (24 percent).

Moreover, despite reducing their solid waste generation intensity by 22 percent and 19 percent, respectively, Quebec (25 tonnes/\$1 million GDP) and Alberta (25 tonnes/\$1 million GDP) continue to produce the most MSW relative to economic activity in Canada.

Figure 10: Waste generation intensity, by province, 2002 and 2018

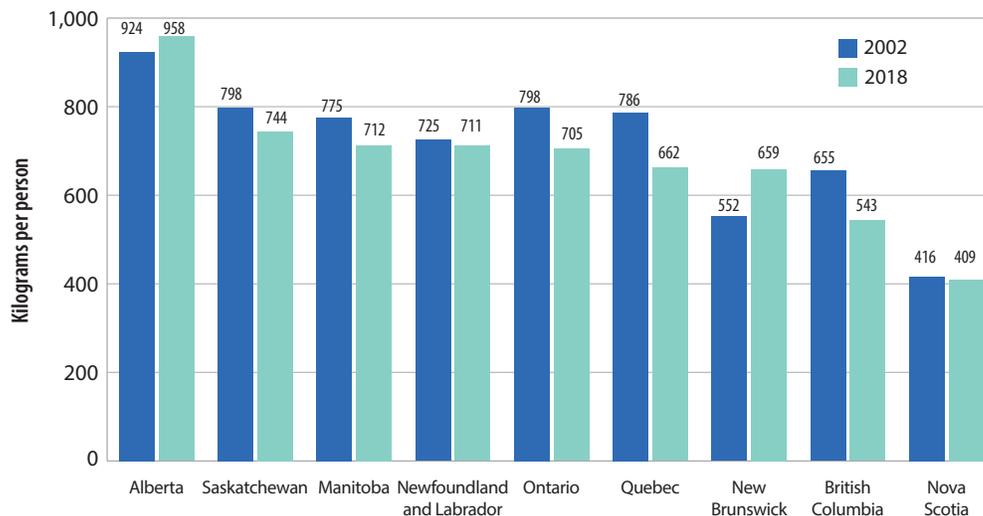


Sources: Statistics Canada, 2021a, 2021f; calculations by authors.

Figure 11 shows per-capita waste disposal across provinces, comparing 2002 and 2018. Alberta and New Brunswick are the only provinces that increased their waste disposal per person over this period. Specifically, Alberta is the province that disposes of the most MSW per-capita in the country, followed by Saskatchewan and Manitoba. Nova Scotia has the lowest disposal per person (409 kg per person) in Canada followed by British Columbia (543 kg per person) and New Brunswick (659 kg per person).

Albertans went from disposing of 924 kg of solid waste per-person in 2002 to 958 kg in 2018, a 4 percent increase. New Brunswick experienced the greatest increase in waste disposal per person (19 percent), going from 552 kg of solid waste disposed per person in 2002 to 659 kg in 2018. On the other hand, British Columbia saw the highest decline in this metric, a 17 percent decrease. Following British Columbia, Quebec and Ontario also made notable progress in reducing their waste disposal per person numbers, by 16 percent and 12 percent, respectively. As explained in the previous section, Canada has significantly increased its diversion rate in recent years (i.e., more recyclables and organics are being diverted from landfills). This increase in the diversion rate can explain (at least to some extent) the marked decline in waste disposal per person in most Canadian provinces

Figure 11: Per-capita waste disposal, by province, 2002 and 2018



Sources: Statistics Canada, 2021a, 2021e; calculations by authors.

Table 1 shows waste disposal per-person by source in 2002 and 2018 in Canadian provinces compared to the national average. Results vary across provinces. Quebec, for example, experienced a significant jump (53 percent) in per-capita waste disposal from residential sources between 2002 and 2018 while seeing a considerable (-48 percent) reduction from non-residential sources. Manitoba, on the other hand, increased

Table 1: Per-capita waste disposal by source, provinces and Canada, 2002 and 2018

	<i>Per-capita residential sources of waste for disposal (kg)</i>		<i>Per-capita non-residential sources of waste for disposal (kg)</i>	
	2002	2018	2002	2018
Newfoundland and Labrador	416	302	309	409
Nova Scotia	181	164	235	245
New Brunswick	272	288	280	371
Quebec	252	385	534	278
Ontario	284	278	513	427
Manitoba	357	247	418	465
Saskatchewan	280	328	518	416
Alberta	277	311	647	647
British Columbia	227	198	429	345
Canada	269	293	499	402

Sources: Statistics Canada, 2021a, 2021e; calculations by authors.

per-capita waste disposal from non-residential sources by 11 percent while experiencing a marked decrease (-31 percent) from residential sources.

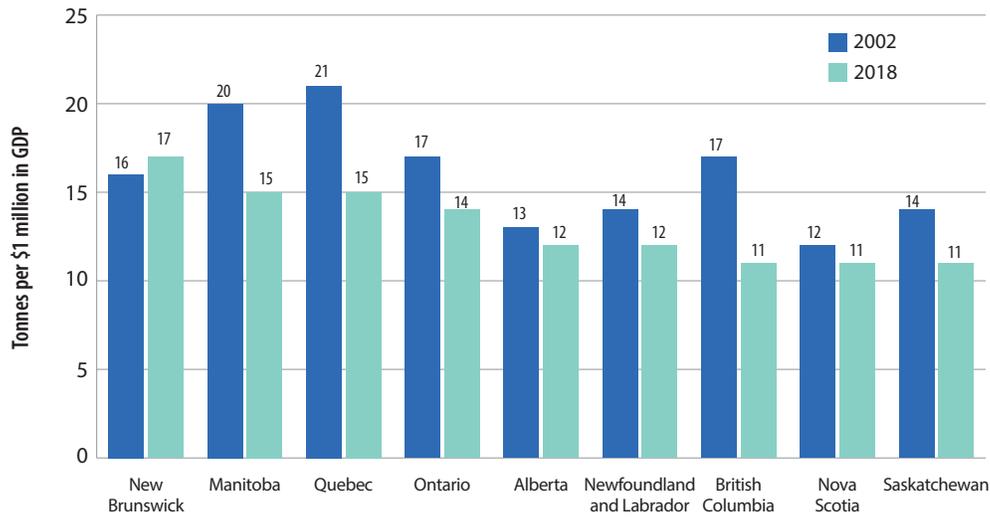
British Columbia and Ontario were the only two provinces that reduced per-capita waste disposal from both residential and non-residential sources. B.C., the best performer in this category, reduced per-capita waste disposal in the residential sector by 13 percent and in the non-residential sector by 20 percent. New Brunswick was the only province that increased per-capita waste disposal from both sources during this time period.

Only three provinces—Newfoundland and Labrador, Saskatchewan, and Alberta—disposed of more MSW than the Canadian averages for both residential (293 kg per person) and non-residential sources (402 kg per person).

However, despite per-capita waste disposal being a key metric to track the progress of solid waste management systems, it does not account for the difference in levels of economic activity across provinces. A relatively higher per-capita disposal number might be explained by differences in the relative sizes of provincial economies. Solid waste disposal intensity, which refers to the amount of solid waste disposed for every \$1 million of GDP produced, captures this difference in levels of economic activity and provides a more accurate comparison across provinces and time periods.

As shown in **figure 12**, all provinces (with the exception of New Brunswick) reduced their solid waste disposal intensity since 2002, though progress varies. In 2002, Quebec had the highest waste intensity, disposing of nearly 21 tonnes of waste per \$1 million of output produced. By 2018, Quebec's waste intensity decreased by 27 percent, but continued to be one of the highest waste intensity numbers in the country after New

Figure 12: Waste disposal intensity, by province, 2002 and 2018



Sources: Statistics Canada, 2021a, 2021f; calculations by authors.

Brunswick and Manitoba. Overall, the most notable reductions in waste disposal intensity came from British Columbia (33 percent decrease), Quebec (27 percent decrease), and Manitoba (25 percent decrease).

This is particularly important given that, as jurisdictions increase their wealth and prosperity, consumption patterns change, and waste disposal is expected to increase. However, in most provinces, waste disposal has risen at a slower rate compared to economic growth, which suggests that the vast majority of Canadian provinces have decoupled their waste disposal from economic growth.

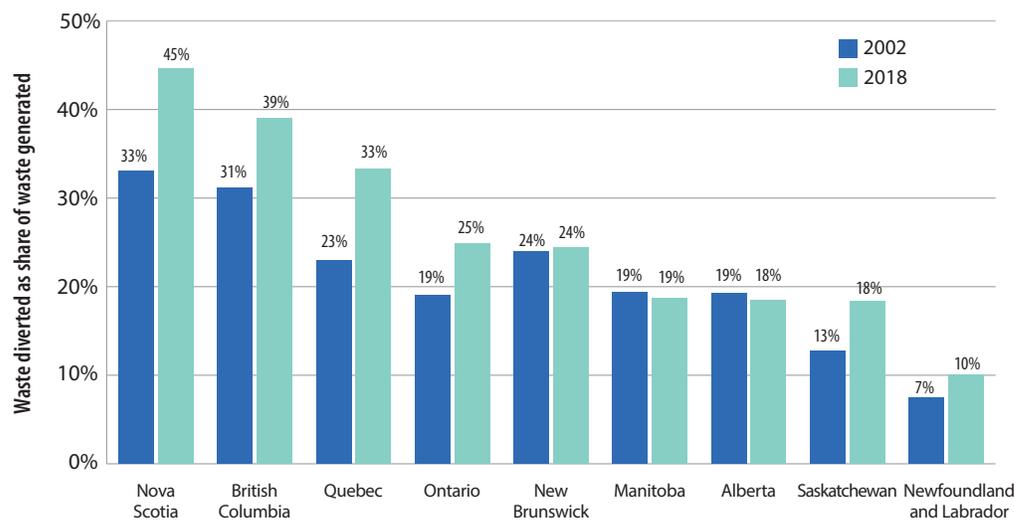
Saskatchewan, Nova Scotia, and British Columbia have the lowest disposal rates in the country, relative to economic activity, with roughly 11 tonnes of MSW disposed of per \$1 million of output produced. On the other hand, New Brunswick (16.7 tonnes), Manitoba (15.3 tonnes), and Quebec (15.1 tonnes) have the highest solid waste disposal rates in Canada when we account for the size of their economies. New Brunswick is the only Canadian province that increased its waste intensity between 2002 and 2018, by 8 percent.

It is worth noting that, despite Alberta and Saskatchewan having the highest per-capita disposal numbers in the country, the data paints a different picture when we factor in economic activity. In 2018, for every \$1 million of GDP, Alberta and Saskatchewan disposed 12 and 11 tonnes of solid waste, respectively. This was much lower than other provinces with far lower per-capita waste disposal numbers such as Ontario or Quebec.

Overall, when considering both measures—waste disposal per capita and waste disposal per unit of GDP—Nova Scotia and British Columbia are among the top performers while Manitoba is among the bottom performers.

Another key metric to gauge the state and progress of solid waste management systems is the diversion rate, which measures the total amount of waste generated that is prepared for reuse, recycling, and composting activities. As depicted in **figure 13**, provinces have made considerable improvements in their diversion efforts since 2002. Only two provinces, Manitoba and Alberta, reduced their diversion rates by 1 percent during this period. Nova Scotia, which increased its diversion rate by 12 percent between 2002 and 2018, has the highest diversion rate in the country with almost half of its total amount of waste generated diverted from landfills. British Columbia is a close second with a diversion rate of almost 40 percent. Other large provinces, like Ontario and Quebec, [6] have relatively higher diversion rates (25 percent and 33 percent, respectively). The provinces with the lowest diversion rates in Canada are Newfoundland and Labrador (10 percent), Saskatchewan (18 percent) and Alberta (18 percent).

Figure 13: Diversion rates, by province, 2002 and 2018



Sources: Statistics Canada, 2021a, 2021d; calculations by authors.

Table 2 gives a broad overview of the key indicators illustrating the state of solid waste management in Canada. British Columbia (348 kg), Quebec (331 kg), and Nova Scotia (330 kg) are the three provinces that diverted the most in Canada, on a per-capita basis, in 2018. This is not surprising given their higher-than-average diversion rates. Consequently, these three provinces are the only jurisdictions that divert more than the Canadian average of 265 kg per person. On the other hand, Newfoundland and Labrador (79 kg), Manitoba (164 kg), and Saskatchewan (168 kg) are the three provinces that diverted the least in 2018.

[6] Waste diversion data for Quebec are not derived from Statistics Canada's Biannual Waste Management Industry Survey but rather a survey administered by RECYC-QUÉBEC, Quebec's crown corporation in charge of MSW recovery and recycling. Given differences in methodology, comparability should be approached with caution.

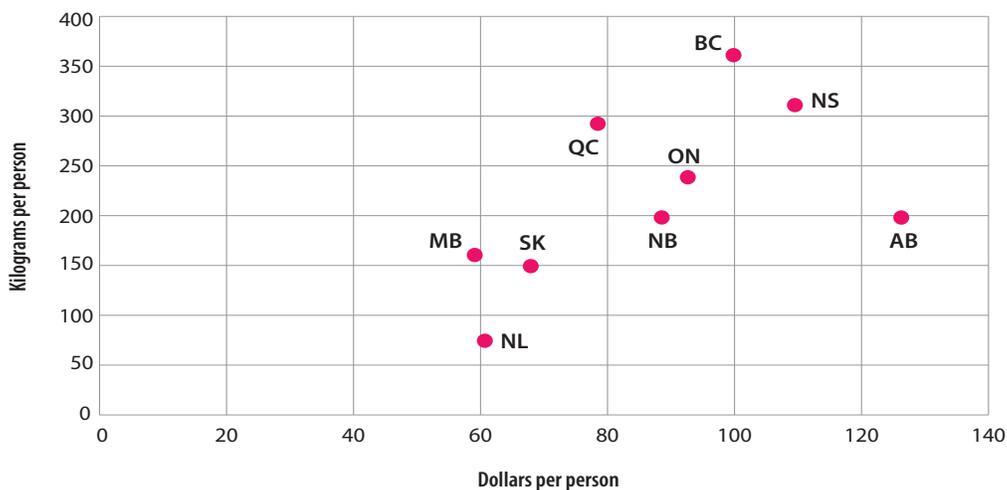
Table 2: Disposal, diversion, and generation per capita by province, all sources, 2018

	Disposal per capita (kg)	Diversion per capita (kg)	Generation per capita (kg)	Generation per unit of GDP (tonnes/\$1 million of GDP)
Newfoundland and Labrador	711	79	790	18
Nova Scotia	409	330	740	16
New Brunswick	659	213	872	20
Quebec	662	331	993	25
Ontario	705	234	938	21
Manitoba	712	164	876	21
Saskatchewan	744	168	912	21
Alberta	958	217	1,175	25
British Columbia	543	348	891	20
Canada	694	265	959	22

Sources: Statistics Canada, 2021a, 2021d, 2021e, 2021f; calculations by authors.

Figure 14 shows the relationship between local government expenditure and per-capita waste diversion. According to the latest available data (2016) for municipal expenditure, despite being the province that spends the most per capita on solid waste management, Alberta trails behind five other provinces in terms of per-capita MSW diversion. On the other hand, British Columbia, Nova Scotia, Ontario, and Quebec diverted more kilograms per person than Alberta while spending less money. Alberta spent \$126 per person in 2016 and diverted 198 kg of MSW per capita whereas a province like British Columbia spent \$26 less per person and diverted almost twice as much (361 kg per capita) as Alberta.

Figure 14: Per-capita waste diversion and per-capita municipal expenditure, by province, 2016



Sources: Statistics Canada, 2021a, 2021e, 2021g; calculations by authors.

Policies, Programs, and Targets

Most provinces have similar waste management programs that fall into three broad categories: extended producer responsibility programs (EPR), product stewardship programs, and blue box programs.

EPR programs are those in which the responsibility to manage products at their post-consumer end-of-life stage falls solely on producers (for example, manufacturers or importers). The funding for these programs is provided by these companies, which can pass down the cost to consumers or be internalized as part of their cost structure.

Product stewardship programs allocate the responsibility of MSW collection, disposal, and diversion to provincial/territorial or municipal governments. These programs are funded through either government-legislated environmental fees or through general revenue.

Finally, traditional blue box programs are those in which municipalities offer curbside collection of garbage, recycling, and organics. Depending on the province/territory and/or municipality, collection is provided by the jurisdiction or by private collection companies.

Over the last 20 years, most provinces have established waste reduction targets, whether they involve a reduction in the rate of per-capita solid waste disposal or an increase in diversion rates. For instance, Quebec has a target to reduce per-capita waste disposal to 525 kg by 2024 (Ministère de l'Environnement et de la Lutte contre les changements climatiques, 2019) whereas Ontario has a target of reaching a diversion rate of 50 percent by 2030 (Ministry of the Environment and Climate Change, 2017).

Other provinces decided not to impose a per-capita waste disposal goal similar to Canada's; in the case of Newfoundland and Labrador, for example, because it would need "considerable aggressive action" (Ministry of Municipal Affairs and Environment, 2019). Nova Scotia, one of the top performers, hasn't updated its targets of achieving a 50 percent diversion rate (established in 1995) and reaching 300 kg per capita of solid waste disposal (established in 2006).

British Columbia, another top performer, has a target of reducing MSW disposal rate to 350 kg per person through a decentralized approach in which all 27 regional districts have to submit a solid waste management plan to the provincial government.

It is worth noting that Canada's aspirational goal of reducing per-capita waste disposal to 490 kg by 2030 does not set specific targets for individual jurisdictions, which can become problematic as some provinces might end up doing the heavy-lifting while others might free-ride.

Finally, one of the ways in which communities could further reduce waste disposal is to implement user fees for waste collection. Specifically, implementing "pay-as-you-throw" (PAYT) schemes could, in fact, reduce the overall cost burden of municipal waste management systems and the amount of MSW that goes into landfills.

A recent report found that, after controlling for municipality and time fixed effects, municipalities in Massachusetts with PAYT programs experienced an 11 percent reduction in trash per household compared to municipalities without this program (Barry,

2017). Another study found that PAYT programs had a significant impact on waste reduction in municipalities in Southern Maine between 2007 and 2013 (Blackmer and Criner, 2014).

A PAYT model is considered an efficient market-based pricing mechanism for solid waste disposal in which users are charged a variable rate depending on the weight or volume of MSW they offer to municipal garbage collection services. For example, if an individual disposes 10 kg of MSW every week, and the pay-as-you-throw rate is \$1 per kilogram, said individual would have to pay a weekly fee of \$10. If the next week, the same individual disposes 5 kg of MSW then said individual would have to pay a weekly fee of only \$5. Therefore, a PAYT scheme creates a direct incentive to either generate less waste or to recycle or reuse more of the waste an individual generates.

However, implementing a PAYT program might create several unintended consequences. For instance, the “polluter pays” principle might create a potential incentive for households to reduce their PAYT liabilities through illegal dumping, littering, or other inappropriate waste disposal methods (Blackmer and Criner, 2014).

Generally, however, Canadian municipal waste management systems are funded through property taxes or via fixed fees, regardless of the amount and composition of waste that is collected and disposed.

4. Conclusion

Overall, as Canada's population and economy grew between 2002 and 2018 so did total waste generation and disposal. However, Canadians are generating 2 percent less waste on a per capita basis and 23 percent less per unit of GDP. The sources of waste are changing: residential sources now make up over 44 percent of all waste generated whereas MSW from non-residential sources, which include industrial, commercial and institutional sources, declined during this time.

On a provincial level, performance varies across jurisdictions. Some provinces, like Nova Scotia and British Columbia, are leading the way in generating and disposing of less waste, relative to population and economic activity, and diverting more. On the other hand, Manitoba consistently exhibits higher-than-average per-capita waste disposal rates, high waste disposal intensity figures, and low diversion rates. At the same time, Alberta generates and disposes the most MSW on a per-capita basis, but, interestingly enough, the province has lower waste disposal intensity with respect to GDP than other provinces with far lower per-capita waste disposal numbers such as Ontario and Quebec.

Altogether, since 2002, while most provinces reduced per-capita generation of MSW, the vast majority of the provinces reduced per-capita disposal of solid waste, with the exceptions of Alberta and New Brunswick. Similarly, almost all provinces increased their diversion rates during this time with the exceptions of Manitoba and Alberta.

On balance, the fact that Canada partially decoupled solid waste generation and disposal from economic growth is good news for the environment. Furthermore, the country's progress in reducing per-capita solid waste disposal and waste disposal intensity coupled with an increasing diversion rate speaks volumes for Canada's stellar environmental performance and builds on its already impressive environmental track record.

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