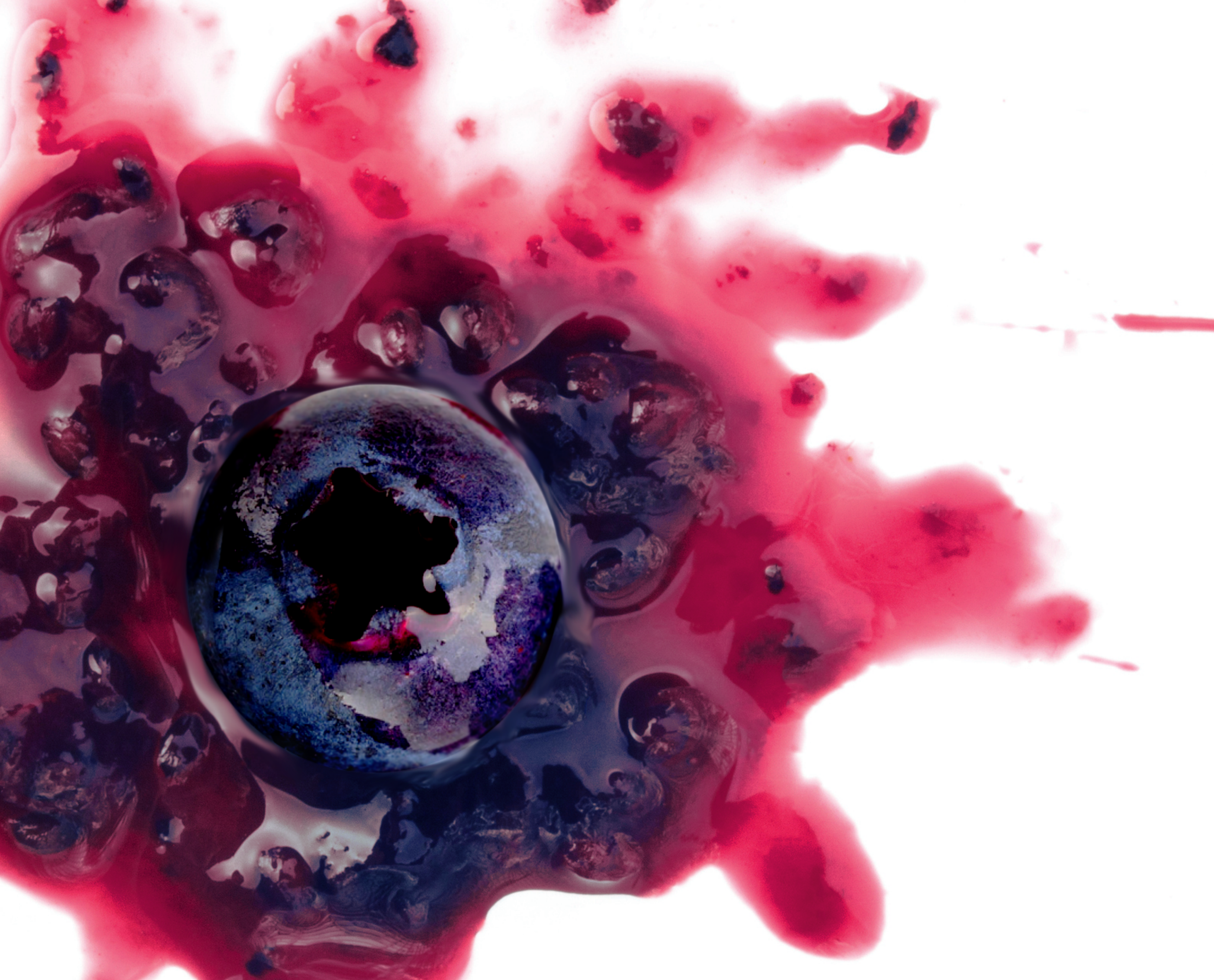

THE AVOIDABLE CRISIS OF FOOD WASTE: technical report

UPDATE

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Accessible from: **www.SecondHarvest.ca/Research**

We are proud to present this research, which was commissioned by Second Harvest and conducted by VCMI. Second Harvest defined the scope of this project, ensuring that it not only addressed the core objectives of updating the prior research, but also delved deeper into critical areas of food loss and waste, such as environmental impacts, food affordability and date codes (best before dates). While the data collection and evaluation were expertly handled by VCMI, Second Harvest played a pivotal role in connecting key sources and ensuring the report's clarity and accessibility. This research is a valuable resource for anyone interested in tackling food waste, and we are excited to share these important findings with you.

second harvest

Second Harvest is Canada's largest food rescue organization and a global thought leader on food waste and perishable food redistribution. It rescues unsold surplus food from thousands of food businesses from across the supply chain to redistribute it to non-profits in every province and territory. This prevents harmful greenhouse gases from entering the atmosphere while improving access to nutrition for millions of Canadians experiencing food insecurity.

Beyond food rescue and redistribution, Second Harvest is deeply involved in advocacy, research, training and education. Its groundbreaking reports, such as "The Avoidable Crisis of Food Waste," provide critical data and insights to inform public policy and educate the public on sustainable food systems.

Second Harvest is committed to driving systemic change, helping to shape policies and practices that reduce food waste and address its role in climate change while also supporting communities by providing them with the food they need.

VCM International

Value Chain Management International (VCMI) has authored/co-authored several publications on food waste and is a leading public and industry voice in bringing awareness to the opportunities and solutions surrounding food waste reduction, traceability and the environment. VCMI measures waste within the overall analysis of food systems to create pragmatic and sustainable solutions for businesses and industry organizations along the value chain. VCMI applies specialized value chain diagnostic tools to detect where waste occurs and to determine how to eliminate it. VCMI then participates in the implementation of new practices to solve the issues and ensure successful outcomes.

Executive Summary

When the Avoidable Crisis of Food Waste (ACFW) report was first published in 2019, it was the first research of its kind to quantify how much food was lost or wasted every year in Canada.

Five years later, Second Harvest identified the need for updated research to identify whether the volume and types of food waste (FW) that occur in Canada has changed given increased public awareness about FW and the better-known economic benefits of reducing it.

This renewed research aims to establish if there is a connection between FW in Canada and changing weather patterns and to better understand the effect of inflation on consumers' purchasing behaviours.

The update evaluates the environmental and economic effects of FW, its impact on the emissions of greenhouse gases (GHGs), and the role that best before dates (BBDs) play within the food industry.

The research found that the landscape surrounding FW has changed significantly. The 2024 research was conducted in a vastly different environment than that which existed in 2018 when the ACFW research (2019) was published. Many food businesses appear to be more conscious of FW than they were. All levels of government are much more aware of FW and the need to address it by supporting industry stakeholders and are actively working to better understand the widespread burdens associated with it. The Canadian government has revised how industry statistics are monitored and reported — present day and retroactively. These examples illustrate the extent to which industry and wider stakeholders' attitudes towards FW and its widespread effects have changed since the first report.

The research reported in 2019 relied on aggregated public and private data, the vast majority of which was not created to enable the detailed analysis of food systems generally, let alone FW. The data provided by industry was the best available, though was provided in an environment typified by limited awareness regarding FW and few purposeful measurements. Data provided by respondents often varied significantly across businesses operating in similar sectors. Multiple triangulated datasets, informed through the gathering of anecdotal insights captured during stakeholder interviews and interactive sessions, produced the defensible estimates published in 2019.

Since the 2019 report, considerably greater awareness of FW has led to businesses of all sizes and genres implementing FW measurement efforts. Most commercial operations, particularly those of larger scale, have appointed an ESG (environmental, social and governance) person or group possessing a detailed understanding and verified data on FW. With more emphasis on FW within businesses and industry generally, the 2024 research benefited from a higher number of industry respondents providing data via a national FW survey and targeted interviews than reported in 2019. In addition, there were fewer variations in the data provided by similar businesses than reported five years ago. These changes enabled the creation of more granular and refined estimates than was possible previously.

The 2024 research identified that, compared to 2019, total FW has decreased by 19.7 per cent, with avoidable FW having increased by 6.5 per cent and unavoidable FW having decreased by 31.8 per cent. The overall

Canadian food system is therefore more efficient than five years ago. The highest incidence and volume of avoidable FW is associated with field crops (incl. flour, bread and bakery), produce (fresh and processed fruit and vegetables) and dairy (incl. milk, yogurt and cheese).

Reasons for the changes that have occurred in the ratio of avoidable to unavoidable FW include consumer attitudes and behaviour, driven by food inflation and cost-of-living concerns, in particular, along with the increasing impact of climate change. A higher proportion of total and avoidable FW is occurring upstream versus in households than five years ago.

In addition, the research found that a direct causal relationship exists between industry's date coding practices and the creation of avoidable FW. An association was found to exist between BBDs and 23 per cent of avoidable FW that occurs from processing onwards — the earliest point at which consumer-facing BBDs are applied. Numerous respondents asked why items such as salt, which can lie in the ground (or in water) for millions of years, invariably carry a BBD when packaged. Consumers and the food industry have evolved massively since 1976, when Canadian date coding regulations were introduced, yet legislation and governance surrounding BBD determination and application practices have not. Consumers view BBDs as an indication of product value and safety, and as a means to reduce household FW and their overall cost of food. Retailers cited that it is not unusual to receive threats of litigation from overly concerned customers who purchased a product with a BBD that is close to passing or has just passed.

The total value of avoidable FW is $58 billion. Given that the cost of food purchased in hotels, restaurants and institutions (HRI) is typically higher than the cost of food purchased in retail, this figure is deemed conservative. The cost of avoidable FW on industry performance is notionally estimated to be $17.73 billion, which equates to 12 per cent of prices paid for food at retail in 2022.

The report concludes by presenting the environmental impact of avoidable and unavoidable FW in terms of GHG emissions and virtual water footprint. The three main GHGs associated with the food industry were quantified as carbon dioxide, methane and nitrous oxide. Reported in tonnes of carbon dioxide equivalents (CO_2e), the avoidable GHG emissions associated with FW that was edible at some point in its history or at the time of its disposal total 25.69 million metric tonnes of CO_2e annually. The GHG emissions associated with total Canadian FW is 77.65 million tonnes of CO_2e.

The virtual water footprint of avoidable FW was calculated at 13,314 million cubic metres. This is 35 per cent of the total water footprint of the 21.2 million metric tonnes of FW estimated to occur annually in Canada; that is, 37,541 million cubic metres. Unlike GHG emissions, which are universal, the movement of food translates into the shipping of enormous volumes of water from one part of the world to another, depleting water from the region of production to produce food that is subsequently wasted in Canada.

Glossary of Terms

As definitions adopted by FW researchers are often not uniform, this section defines key terms and positions taken by the project team.

Avoidable food waste	Edible and therefore fit for human consumption at a point in time including, potentially, at the time of its disposal. If operational or market-related factors are addressed, this waste could be reduced or eliminated. This FW includes unplanned and post-processing waste.
Best before date (BBD)	A date noting the point in time following a product's processing or manufacture (e.g., six months) at which a product's premium eating quality, appearance or nutritional content may begin deteriorating.
Commodities	Undifferentiated products grown by primary producers, such as grain and oilseed, to which value is added through processing or other means.
Consumer	An individual who purchases food and beverages in a retail store or prepared food and beverages from HRI for consumption on the premises or as takeout.
Customer	A commercial business to whom a farmer sells commodities, such as wheat (e.g., a flour mill) or to whom a distributor sells consumer-ready products, such as sausages (e.g., a retailer).
Data code	A date applied to a food or beverage product to communicate the point at which its optimum quality may begin to deteriorate (best before date) or after which it should not be consumed for food safety reasons (expiry date).
Not-for-profits (NFPs)	Charities, non-profits and Indigenous communities whose free, essential services help nourish people through initiatives such as school programs, community development, seniors' centres, shelters, food banks, regional food hubs and more.
Food waste (FW)	Discarding of avoidable (potentially edible) and unavoidable (associated inedible parts) of commodities and foods during the production, processing, manufacturing, distribution, retail, HRI, by households and during redistribution.
Food system inputs	Agricultural, horticultural, marine commodities and livestock that enter the food system immediately after having been farmed or caught in Canada, or after having been imported, as either raw commodities or as semi/fully processed foods and beverages.
Hotels, restaurants, institutions (HRI)	Encompasses any form of foodservice performed in hotels, fast- and full-service restaurants, cafés, conference centres, institutions from hospitals and long-term care or retirement homes, through to entertainment venues and penitentiaries, etc.
Manufacturing/further processed	Further processing of primary processed products into consumer foods that typically contain multiple ingredients. For example: animal carcasses into frozen entrees; flour, eggs and salt into bread; fruits, nuts and oats into granola.

Minimum life on receipt (MLOR)	The minimum remaining shelf life that a customer will accept on receipt of a product from the supplier. It is a key performance benchmark that customers (e.g. retailers) place on their suppliers.
Planned loss	These losses are inevitable. Examples of planned losses include husks, animal skins and bones.
Preharvest waste	Mature crops and livestock (incl. poultry) that are ready to harvest, though, for reasons such as prices being insufficient to warrant crops' harvest and weather having negatively impacted fruits' and vegetables' quality or appearance, result in them no longer meeting customer specifications.
Post-processing waste	These losses occur after processing and are typically due to market-related factors, such as products reaching best before dates, orders being cancelled, products being damaged or products being rejected/returned.
Processing	The primary processing of commodities into foods purchased by consumers or food ingredients used in the further manufacturing of consumer foods. Examples of practices within this category included the grading and packaging of fruits and vegetables, and the processing of wheat into flour.
Surplus edible foods (SEF)	Edible food that is surplus to market demand at any point along the value chain and could be rescued for redistribution to vulnerable populations.
Potentially edible foods	Food that is likely fit for human consumption or was fit for consumption at some point in its history.
Associated inedible foods	Inedible parts associated with the production of food for human consumption. Examples include peels, bones and by-products of processing or food preparation that are not consumable.
Unavoidable waste	Losses that are inevitable, including processing and cook shrink, moisture loss, removal of husks, peels and bones. Generally considered planned loss.
Unplanned loss	These losses are preventable. They typically result from operational factors occurring within individual businesses or along the supply chain that result in once edible products being lost due to quality issues or defective products.

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1 Introduction

Since the release of "The Avoidable Crisis of Food Waste" (ACFW) by Second Harvest in January 2019, acknowledgement regarding the impact avoidable food[1] waste (FW) has on society from economic, environmental and social perspectives has markedly increased within Canada and internationally. Second Harvest commissioned VCMI to partner with them on a follow-up study to:

1. Benchmark the volume and types of FW occurring in Canada against estimates published in 2019;
2. Quantify the GHG emissions of FW in more detail than has previously been calculated;
3. Provide greater granularity in the volumes and types of FW associated with distinct foods and the subsequent and environmental impacts of FW;
4. Determine the efficacy and validity of date coding practices employed by the food industry, and the degree to which current practices drive behaviours in relation to distinct types of foods;
5. Provide the subsequent economic impacts of FW; and
6. Provide granularity into on-farm FW and its causes, particularly the losses that occur in mature crops that remain unharvested and harvested crops that do not enter the food chain.

This report provides the evidence-based knowledge required to guide the development and execution of commercial decisions and public policies needed to significantly reduce FW in Canada. Less FW, achieved by management practices, such as reducing at source and increasing the volume of surplus edible foods (SEF) donated to vulnerable populations, will produce broad socio-economic benefits (by improving individuals' mental and physical health). Diverting surplus food in this way will also reduce the food industry's impact on the environment.

The research findings and conclusions can also inform and motivate increased alignment among different ministries and levels of government. The research highlights how cooperative and strategic partnerships between government and industry could help address FW, while also tackling environmental and socioeconomic challenges in Canada.

1.1 Why Reduce FW

Since the ACFW was published in 2019, an understanding of the enormity of FW from economic and environmental perspectives has increased. To society, FW represents the ineffective and unsustainable utilization of natural resources — resulting in environmental and ecological degradation. Reducing FW is a key element of achieving the United Nations Sustainable Development Goals (SDGs) and preventing global temperatures from rising more than 1.5°C above pre-industrial temperatures.[2]

From economic and financial perspectives, FW costs everyone. To industry, it represents lost revenue, increased costs and slim (potentially negative) margins. For consumers, the cost of FW is factored into the prices paid for food and beverages. The cost of managing and disposing of FW is factored into municipal taxes and haulage fees paid by consumers and industry. Reducing FW therefore represents enormous environmental, economic and financial opportunities for everyone.

[1] Throughout the report, the term "food" refers to both food and beverages.
[2] WRI; IPCC; Future Foods

2 Scope and Methodology

The jurisdictional scope of this project is FW occurring within Canada. This encompasses FW associated with food produced and consumed domestically; domestically produced and processed food that is subsequently exported prior to its exportation to another jurisdiction; and imported food that is subsequently consumed in Canada.

The methodology used to complete this research was built upon prior FW research completed by VCMI, including the ACFW (2019) and the Quantification Study of Food Loss and Waste in Quebec (2022). To estimate household FW types and volumes, prior household FW secondary data completed by a number of Canadian researchers was used, including VCMI's quantification of household FW and related GHG emissions in Halton Region (2020).[3]

As shown in Figure 2-1, the project followed an iterative four-phased approach, which began by reviewing lessons learned during the 2019 ACFW and 2022 Quebec studies. The methodologies established by other food systems and FW researchers (incl. WRAP, ReFED, Consumer Goods Forum [CGF], and Fight Food Waste Cooperative Research Centre [CRC]) were also reviewed to ensure that the chosen methodology and approach could produce the required insights and the drawing of evidence-based conclusions.

Figure 2 1: The Project's Four Phases

THE PROJECT'S FOUR PHASES

PHASE 1	PHASE 2			PHASE 3		PHASE 4
Design & Review	**Methodology**			**Validation Process**		**Reporting**
Approach	**Mass Balance**	**Survey**	**Analysis**	**Interviews**	**Focus Groups**	**Results/ Outcomes**
• Value chain analysis • Research Framework • Research Scope	Calculating the Baseline of the Food System	• Design • Rollout	Initial Analysis Final Analysis	• Insights • Data Validation	• Insights • Data Validation • Solution Testing	• Starting Hypothesis • Reserarch Findings • Solutions • Conclusions

[3] Quantifying the carbon footprint of household food waste and associated GHGs in Oakville, Ontario, and a municipality's role in reducing both food waste and GHGs - Canadian Geographies (2022)

2.1 Project Scope

As occurred in 2019, the project scope (see Figure 2-2) reflected a modified version of the Food Loss and Waste Accounting and Reporting Standard. In so doing, the boundary of the analysis was determined prior to destinations. Food rescue/redistribution is not included in destinations, because the redistribution of SEF prevents FW. Unlike studies completed by organizations including CGF and WRAP, the sending of unconsumed food and its inedible parts (avoidable and unavoidable FW) to animal feed is considered FW. Reasons for this include minute environmental and economic benefits that are achieved by sending uneaten edible food to animal feed versus having redirected uneaten edible food to vulnerable populations.

Figure 2 2: Project Scope

PROJECT SCOPE

TIMEFRAME

1 year (2022)

MATERIAL TYPE

Edible food and beverages (fresh, processed, manufactured)

Associated inedible parts

Planned/ unavoidable FW

Unplanned/ avoidable FW

Post-processing loss/avoidable FLW

BOUNDARY

Food Categories

- Dairy
- Eggs
- Field crops (e.g. grains & lentils)
- Meat/poultry
- Produce (e.g. field, covered, greenhouse)
- Sugars/syrups
- Marine

Lifecycle Stage

- Mature, not harvested
- Production to consumption
- Waste management

Geography

- Canada

Organizations

- Primary production
- Produce packer/ shippers
- Processing/ manufacturing
- Distribution
- Retail
- HRI
- Food redistribution
- Household

DESTINATION

Animal feed

Biomaterial processing

Anaerobic digestion

Compost/aerobic

Incineration

Land application

Landfill

Sewer

RELATED ISSUES

- Methodology of mass balance
- Measures in metric tonnes
- Value chain analysis
- Packaging not explicitly excluded
- Conservative loss factors used
- HH waste secondary data calculation

The weakness of the WRI Accounting and Reporting Standard is that it leaves individual users to determine the "material type" and "destination" included within their FW measuring and reporting practices, which leaves room for accidental misinterpretation. It also allows room for businesses to purposefully greenwash their performance. These factors limit the degree to which FW measurements and reports can be objectively compared and monitored. In recognition of this gap, the International Standards Organisation (ISO) is developing a "Management Systems Standard," which will provide a framework for food organizations throughout the food chain to work actively and effectively to measure and reduce FW across the whole value chain from producers to consumers.[4]

The initiative recently undertaken by the Canadian Standards Association (CSA) to develop common standardized terms and definitions for use in Canada will inform the global ISO effort.[5] On behalf of the Standards Council of Canada, the CSA Group serves as administrator for the Canadian Mirror Committee to the ISO's Technical Subcommittee 20 on food loss and waste, under the Technical Committee 34 on food products. This mirror committee's scope includes the "standardization of food loss and waste, providing a framework for food organizations throughout the food chain, to work actively and effectively with measuring and reduction of food loss and waste."

2.1.1 Research Methods

The primary methods employed to complete the research and analysis were in essence almost identical to those employed in 2018/2019; differences lay in how the research methods were designed and delivered. For example, the FW survey circulated to industries and not-for-profits (NFPs) operating across Canada incorporated changes made following the review of lessons learned from the 2019 and 2024 FW studies. These changes allowed for a better understanding of food loss at specific points along the food value chain.

2.2 Value Chain Analysis

Albeit in moderately less formal terms, given the extensive insights captured during the 2018/2019 study and conversations had with industry experts from along the food value chain in the intervening five years, the research methodology and methods reflected value chain analysis (VCA) techniques. VCA provides a rigorous assessment of the interactions and outcomes that together shape how a food system operates from enterprise and industry level perspectives. The three key elements of the VCA technique used to identify and assess the impact of causal factors in relation to FW are:

1. Governance
2. Product and technology
3. Information and communication

For a fuller description of the above VCA techniques, how they were employed to complete the research and analysis from whole of chain perspective and the unique insights that VCA provides from a system research perspective, see Section 2.2.1 and Appendix B contained in ACFW (2019).

4 International Standards Organization
5 Standards Council of Canada

2.3 Mass Balance

As occurred in 2018/19, a mass balance technique was employed to estimate food flow and FW volumes. Combined with the process employed in 2018/2019 to enable a direct connection to be established between commodities and the consumer goods derived from them, the mass balance approach enables the volume of products entering a food system (whether commodities produced domestically by Canadian farmers or foods imported in a fresh, semi-processed or further processed state) to be correlated to the volume of products exiting a food system.

With all commodities (foods and beverages transported by land, sea or air, and with the distributor of those items needing to know products' weight for commercial, safety and legal reasons), their weight in metric tonnes is readily available, and therefore total tonnage is easy to calculate once the total volume associated with a particular foodstuff has been established.

The analysis of food system input volumes began by analyzing primary production and import/export data sourced from Statistics Canada (StatCan) and Agriculture and Agri Food Canada (AAFC). The sources of data pertaining to distinct commodities and food products is included in Appendix A. The analytical process employed to calculate the volume of commodities and foodstuffs is as follows:

Food Production[6] *– (Exports + Imports) ± (Adjustment for Processed Food*[7]*) = Baseline*

This input baseline informed the development of a mass balance model. Appendix A describes how the data sourced from StatCan and AAFC in 2024 differed from that sourced in 2018. It further explains how the FW model was refined to enable the analysis of secondary and primary data from multiple sources to arrive at volumes of FW occurring along the value chain in greater detail than was possible in 2018.

2.3.1 Connecting Commodities to Foods and Beverages

To enable whole of chain analysis of foods and beverages, a link was established between products consumed and the commodities from which they are derived. The commodities and consumer products presented in Table 2-1 are almost identical to those published in 2019. The only change is that chocolate is now listed under "Sugars and Syrups."

Table 2 1: Connecting Commodities to Consumer Foods and Beverages

Category	Dairy & Eggs	Field Crops	Produce	Meat & Poultry	Marine	Sugars & Syrups
Consumer products (examples)	• Eggs • Liquid milk • Cream • Yogurt • Cheese • Butter	• Bread • Baked goods • Cereal • Beer • Spirits • Soymilk • Vegetable oils	• Fresh fruits and vegetables (F+V) • Processed F+V • Nuts[8] • Fruit juices • Cider • Wine • Coffee[9] • Tea[10]	• Fresh cuts • Primal cuts • Processed meats • Entrees	• Fresh fish • Processed fish • Fillets • Shellfish • Entrees	• Maple syrup • Sugar • Honey • Soft drinks • Confectionary[11]
Crops/inputs (examples)	• Milk: cows, goats, sheep • Eggs: broiler hens	• Wheat • Soybeans • Barley • Durum • Oats • Canola • Flaxseed • Beans	• Root crops • Tree fruits • Berries • Greenhouse • Leafy greens • Hardy greens • Nuts • Sweetcorn	• Livestock • Poultry	• Sea fish • Freshwater fish • Seafood	• Maple trees • Sugar beet • Apiaries • Corn • Chocolate

The categorization of commodities is deemed the most efficient and direct way to establish a mass balance for foods/beverages consumed fresh or after minimal processing. Knowing the comparative percentage of inputs used in the manufacture of processed foods also allows a direct link to be established between further processed products and the commodities from which they are derived. Thus, all consumer foods and beverages (and associated losses) can be linked to the appropriate commodities and their primary production.

[6] Terrestrial and marine
[7] Adjustment made after processing and manufacturing within the value chain model
[8] With the exception of peanuts, which are a legume, nuts are dry hard fruits: https://www.britannica.com/science/nut-plant-reproductive-body
[9] Coffee beans are seeds obtained from the harvesting of edible fruit: https://www.pastemagazine.com/articles/2015/06/coffee-fruit-natures-wasted-superfood.html
[10] Tea leaves are sourced from a tree that is pruned for ease of harvesting and produces fruit: http://factsanddetails.com/asian/cat62/sub408/item2610.html#chapter-2
[11] Originally listed under "produce" in 2019 due to cocoa pods being a fruit: https://www.chocolate.org/blogs/chocolate-blog/about-the-cacao-tree, the placement of chocolate in sugars and syrups reflects the increased granularity of 2024 vs. 2029 reporting.

3 Research Findings

The following section summarizes the research findings, including:

a. Volume, percentage and value of FW occurring along the Canadian food value chain;
b. Headline comparison of differences in published 2019 volumes versus 2024 estimates;
c. Incidence of reported measurement of FW;
d. Reported drivers of FW by key segment(s) of the food chain;
e. Relationship between BBDs and FW;
f. Environmental effects of FW; and
g. FW's economic impacts.

For further research findings, see Appendix A. For a fuller description of how the environmental effects of FW were calculated, see Appendix C.

3.1 Research Respondents

Data analyzed to produce the loss factors that were used to arrive at the FW estimates were sourced through three primary sources. The first and most important source for establishing baseline estimates was an online FW survey, distributed randomly across the Canadian food industry. The second source was targeted interviews with recognized experts from the commercial food industry, along with experts in food system analysis and the development of food policies/regulations. The third source was four validation workshops held across Canada. Attended by over 80 experts from across the food value chain, workshop participants provided feedback on FW estimates and conclusions being drawn from the analysis of survey and interview data.

Out of the approximate 1,000 responses to the online FW survey, 801 provided detailed data. Of these 801, 392 respondents were from industry and 409 were from NFPs. Presented in Table 3-1 are the food industry, survey respondents according to the sector in which they operate and how NFP respondents described their organization.[12]

[12] Throughout the reporting, due to rounding, percentages do not always total exactly 100 per cent

Table 3 1: Industry and NFP Survey Respondents by Sector/Type

Industry Respondents by Sector	# of responses	% of responses	NFP Respondents by Program Description	# of responses	% of responses
Field crop and livestock production	21	5%	Before/after school camp	7	2%
Livestock production	35	9%	Community development	67	16%
Dairy production	7	2%	Faith-based	31	8%
Eggs production	7	2%	Foodbank, pantry	219	53%
Marine production	8	2%	Public institution (e.g. school)	12	3%
Produce production	49	13%	Recovery, redistribution	24	6%
Produce packing/shipping	8	2%	Shelter/support residence	25	6%
Primary processing	19	5%	Other	24	6%
Further manufacturing	40	10%	**TOTAL**	**409**	
Distribution	21	5%			
Retail	74	19%			
Institutional foodservice	40	10%			
Restaurants, cafes, hotels	63	16%			
TOTAL	**392**				

Table 3-2 identifies the count and percentage of respondents by the province in which they are located. Many industry respondents and some NFP respondents represent businesses and organizations that operate in multiple provinces or nationally.

Table 3 2: Industry and NFP Survey Respondents by Location

Province	Industry Respondents		NFP Respondents	
	# of responses	% of responses	# of responses	% of responses
NFLD	7	2%	11	3%
NS	9	2%	28	7%
PEI	8	2%	5	1%
NB	7	2%	14	3%
QUE	44	11%	23	6%
ONT	174	44%	155	38%
MB	24	6%	37	9%
SK	25	6%	17	4%
AB	49	13%	50	12%
BC	45	12%	67	16%
Canadian Territories	-	-	2	<1
TOTAL	**392**		**409**	

Table 3-3 shows the breakdown of 83 interviewees in relation to their area of expertise. Food system/policy analysts included academic researchers and government employees, whose roles included the development of food-related policies and regulations. Each interview typically lasted between 30 and 60 minutes and followed a semi-structured format. This allowed the researcher to drill down into specific areas of interest that arose during the discussion while simultaneously ensuring the capture of standardized common data.

Table 3 3: Interviewees' Key Area of Expertise

Interviewee by Area of Expertise	Number	Percentage
Field crop and livestock production	2	2%
Produce production	3	4%
Produce packing/shipping	20	24%
Primary processing	6	7%
Further manufacturing	12	14%
Distribution	4	5%
Retail	14	17%
Restaurants, cafes & hotels	3	4%
Institutional foodservice	2	2%
Food rescue/redistribution	6	7%
Food system/policy analysis	11	13%
TOTAL	**83**	

During the analysis of survey data and the subsequent interviews, it became clear that the landscape in relation to awareness of FW and the measurement and reporting of FW by businesses situated along the value chain had changed markedly in five years. The data reported by survey respondents was more defined, and there was less variation in responses than occurred during the research published in 2019. During discussions with industry representatives, interviewees referred to loss factors that they had prepared ahead of time and had derived from measurement and reporting practices implemented within the last five years. They also knew FW trends associated with their business practices and had drawn correlations to the causes of FW evidenced from closely monitored measurement programs. A number of interviewees subsequently provided data reported by their businesses' FW measurement practices.

The primary reason for this improved measurement and reporting by industry ultimately relates to the need to improve operational performance to reduce costs and increase margins, along with pressure from the investment community, government agencies and society — there is now a general call for businesses to formalize sustainability practices and issue ESG reports.

Other insights that became clear during the interviews and validation workshops is the degree to which consumers' attitudes and purchasing behaviours have changed since prior to the COVID-19 pandemic. The primary reason for reported changes in consumers' attitudes and behaviours also ultimately relate to economics. Food inflation and cost-of-living concerns have led to consumers placing increased attention on food cost, value and quality. Hence, for example, the physical appearance of fresh fruits and vegetables has taken on increased importance as a perceived means of consumers extending the lifespan of purchased products — with the expectation that this will reduce household FW and the overall cost of food. Consumers have also placed an increased emphasis on BBDs as an indicator of food value, quality and food safety.

The knock-on effects of these changes in business practices and purchasing behaviours in relation to the volumes, types and location of FW are reported in the remainder of the report.

3.2 Total FW 2024

Table 3-4 presents an aggregated summary of the total avoidable and unavoidable FW — by volume and as a percentage of inputs — within the Canadian food system. Where the 21.18 million tonnes of total FW occurs along the value chain is subsequently presented as pie charts. See Section 3-5 for a comparative headline review of 2024 versus 2019 FW estimates.

Table 3 4: Canadian Food System: Inputs, Losses, Consumed (Volume and Percentage)

2024		Million Tonnes	% of Food Inputs	% of Total FW
Food system inputs		45.52		
Food consumed		24.34	53.5%	
TOTAL FW		**21.18**	**46.5%**	
	Avoidable FW	8.83	19.4%	41.7%
	Unavoidable FW	12.35	27.1%	58.3%

Figures 3-1 and 3-2 show, proportionally in volume and percentage terms, where in the value chain the 2024 research found total and avoidable FW to be occurring. As can be seen, the largest proportion (68 per cent) of FW occurs at preharvest (7 per cent), storage/grading (12 per cent) and processing/manufacturing (49 per cent) combined. With better data, preharvest FW has been separated from storage/grading FW. In the 2019 reporting, these were combined and termed "production."

As will be discussed in subsequent sections, a measurable proportion of this FW relates to customer and consumer demands. Hence, while household FW accounts for 15 per cent of total and 17 per cent (see Figure 3-2) of avoidable FW, consumer attitudes and behaviours, along with retailers' (and to a lesser degree HRI operators') response to changing consumer attitudes and purchasing behaviours, are driving FW along the entire value chain.

Figure 3 1: Tonnage (in Millions) and Percentage of Total FW

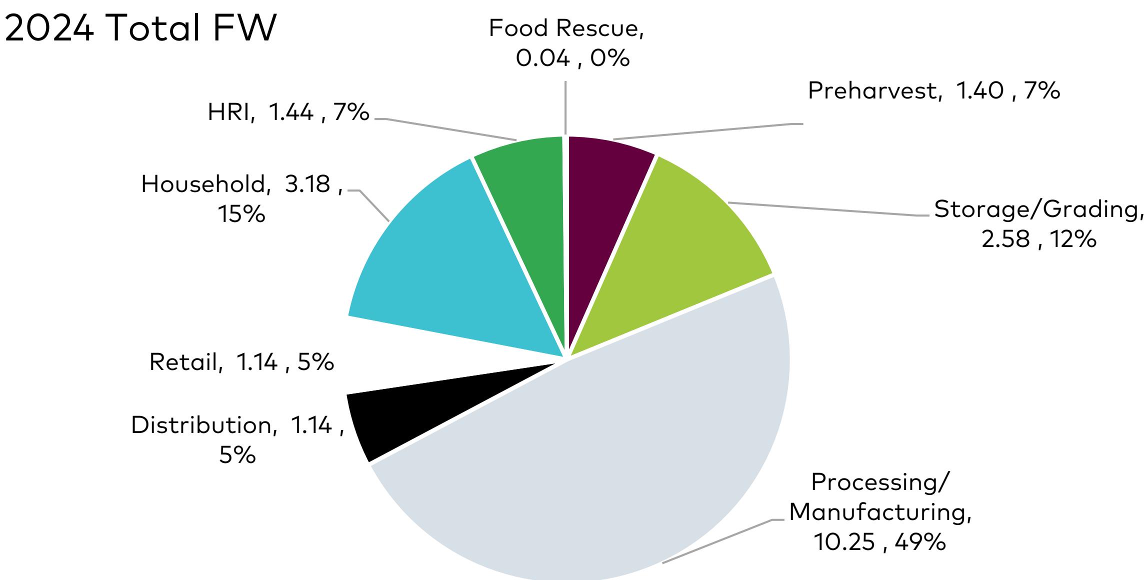
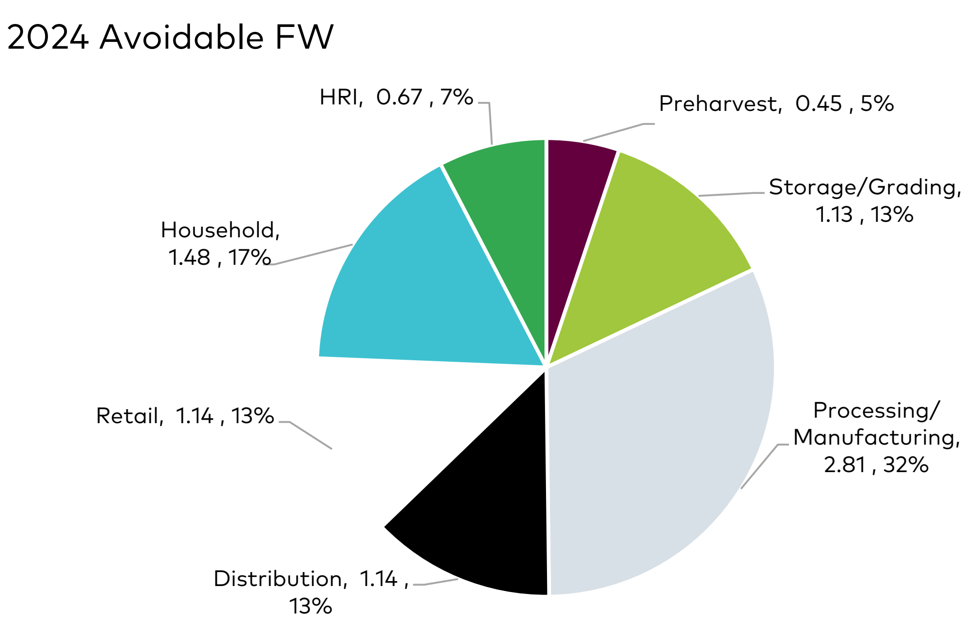


Figure 3-2 shows the breakdown of avoidable (potentially edible) FW found to be occurring along the value chain. Compared to the total FW shown in Figure 3-1, a larger proportion of avoidable FW is occurring in retail and in distribution (13 per cent avoidable vs. 5 per cent total for both retail and distribution), and a comparative smaller proportion of avoidable FW is occurring in processing and manufacturing (32 per cent avoidable vs. 49 per cent total). Other links of the value chain experience similar proportions of avoidable and total FW. NFPs did not report any avoidable (potentially edible) FW occurring in measurable quantities. This reflects a number of articles and reports citing that demand for food experienced by food banks and other charitable organizations outstrips supply, hence, there is no excess SEF.

Figure 3 2: Tonnage (in Millions) and Percentage of Avoidable (Potentially Edible) FW



3.2.1 Types of FW and Occurrence in Chain by Volume

The volume in metric tonnes of total, avoidable and unavoidable FW of each of the seven types of food studied is presented in Table 3-5.

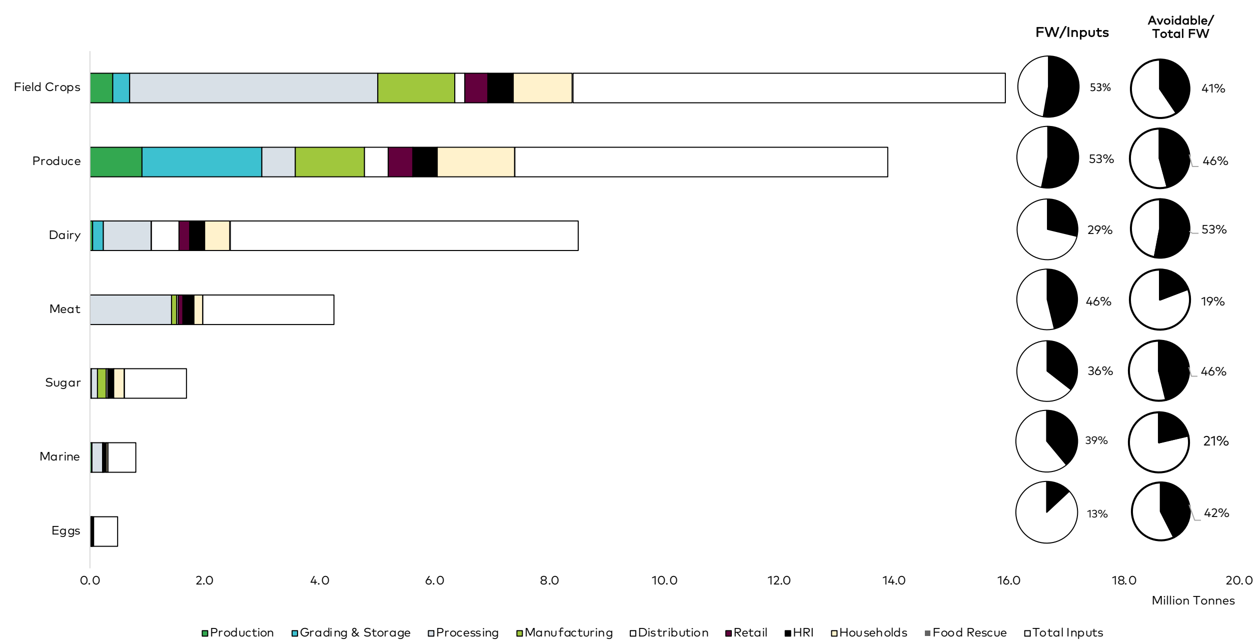
Table 3 5: Total Avoidable and Unavoidable FW by Food Type (Metric Tonnes)

Food Type	Total FW	Avoidable FW	Unavoidable FW
Field Crops	8,403,280	3,404,752	4,998,528
Produce	7,395,942	3,385,539	4,010,403
Dairy	2,440,688	1,292,680	1,148,008
Meat & Poultry	1,963,032	377,094	1,585,937
Marine	597,545	275,652	321,894
Sugars	311,986	66,624	245,361
Eggs	63,055	26,798	36,257
TOTAL	**21,175,527**	**8,829,139**	**12,346,388**

Figure 3-3 shows that where FW occurs along the value chain differs for each of the overarching seven types of food. The proportion of avoidable FW as a percentage of total FW occurring along the value chain also differs. The pie charts on the right-hand side titled "FW/Inputs" and "Avoidable/Total FW" represent total FW as a proportion of total inputs and avoidable FW as a proportion of total FW, respectively.

More granular research findings (e.g., tree fruits and root crops within the overall category of "produce") form Appendix B.

Figure 3 3: Proportion of FW in Distinct Foods by Weight and by Point in Value Chain



As shown in comparative terms within the bar chart, and quantified in Table 3-5, the highest volume by weight (metric tonnes) of total FW is associated with field crops (bread, bakery, soya, etc.), followed by produce (fresh and processed fruits and vegetables), then dairy (milk, yogurt, cheese, etc.).

For field crops, produce and dairy, avoidable FW accounts for 41 per cent, 46 per cent and 53 per cent, respectively, of total FW.

3.3 Value of Avoidable FW

A notional economic value was apportioned to avoidable FW using StatCan's Consumer Price Index[12] (CPI), which tracks prices paid by Canadian consumers for a fixed basket of goods and services. CPI data reported for individual items that lie within a given food category (e.g. apples and lettuce for produce; chicken breast and ground beef for meat and poultry) were analyzed to establish an average dollar value by unit of weight for each of the seven types of food (Table 3-6). Given that the cost of food purchased in HRI operations is typically higher than the cost of food purchased in retail, this $58 billion figure is considered conservative.

Table 3 6: Volume and Value of Avoidable, Potentially Edible FW

	Volume (Million Tonnes)	Value ($ Billion)
Field Crops	3.40	$27.62
Produce	3.39	$12.56
Dairy	1.29	$11.02
Meat & Poultry	0.38	$4.93
Marine	0.07	$1.39
Sugars	0.28	$0.36
Eggs	0.03	$0.19
TOTAL	**8.83**	**$58.07**

The estimate of $58 billion means that the value of avoidable FW has increased by 17 per cent compared to the $49.46 billion estimate published in 2019. This new estimate was triangulated against Core Consumer Price Index (CCPI),[13] [14] which was 134 in 2019, and at the time of writing this report the CCPI was 155.8, an increase of 16 per cent.

This $58 billion figure represents an enormous cost to society at a time when a significant proportion of the Canadian population are concerned about the rising cost of food. StatCan reported that, in 2023, 22.9 per cent of the population living in 10 Canadian provinces (8.7 million people) were food insecure.[15]

[12] Consumer price index portal (statcan.gc.ca)
[13] This measurement is widely used by economists because food and energy have highly volatile prices
[14] Canada Core Consumer Prices
[15] PROOF

3.4 Measurement and FW Trends

Survey respondents and interviewees were asked if they measured FW, and, if yes, the nature of those practices. As mentioned in Section 3.1, these respondents possessed noticeably superior FW data than the respondents and interviewees of five years ago. A close correlation exists between FW measurement and the volume of FW occurring at different points along the chain. As reported in 2019, generally speaking, higher proportions of FW occur where there is a lower likelihood of FW and overall operational performance being measured.

The following two figures present the proportion of respondents from each point along the value chain who stated that they formally measured FW as part of their management practices, and where in the chain the comparative proportion of total FW (Figure 3-4) and avoidable FW (Figure 3-5) is found to occur. Trend lines have been added to show the general correlation found to exist between stakeholders groups' likelihood to measure and the incidence of FW.

For the purpose of this example, production includes the packing/shipping of produce. As can be seen, the greatest likelihood of formal measurement systems existing is in retail. Compared to industry stakeholders overall, primary producers followed by HRI operators are less likely to formally measure FW.

Figure 3 4: Measurement and Incidence of Total FW Along the Value Chain

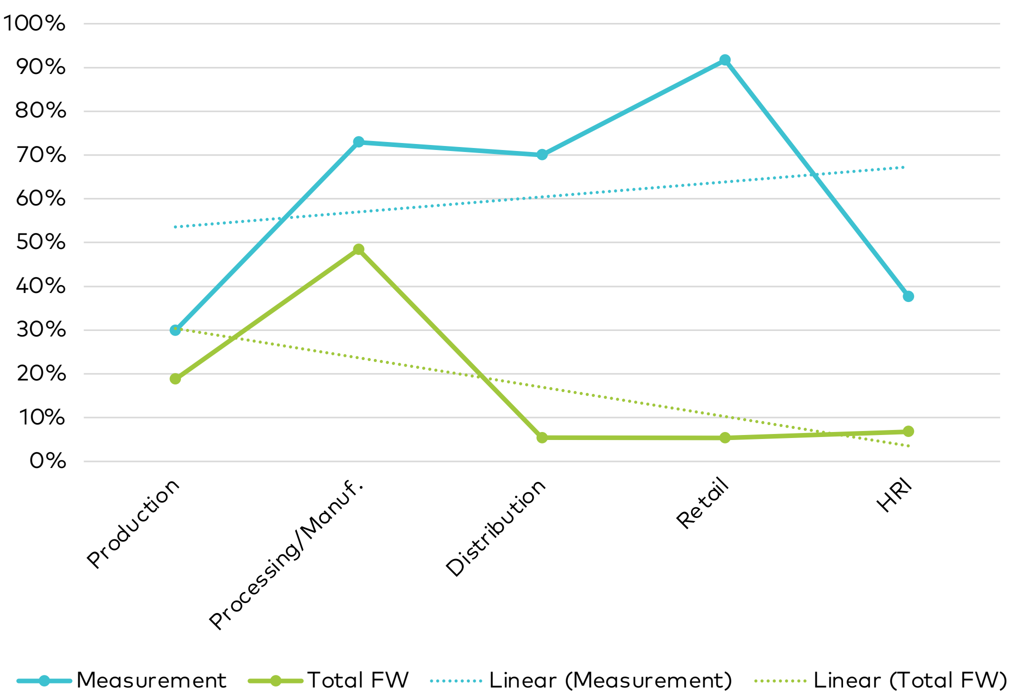
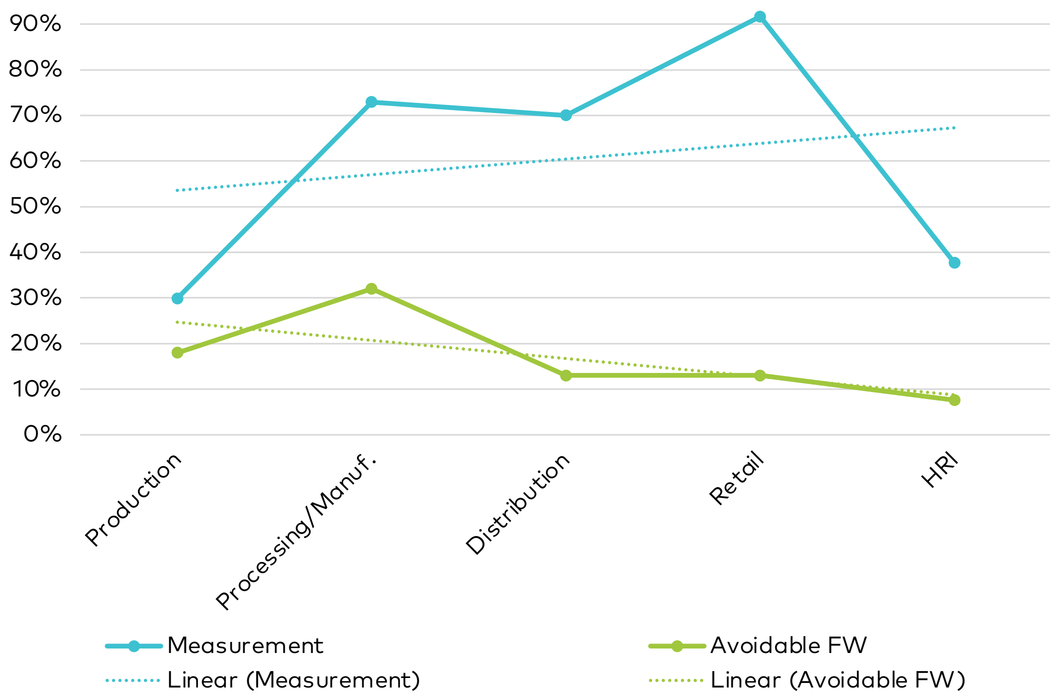


Figure 3 5: Measurement and Incidence of Avoidable FW Along the Value Chain



3.5 Comparisons to 2019

The following section compares and subsequently discusses differences in the overall FW figures published in 2019 to the estimates derived from the 2024 analysis. For additional information on 2019 versus 2024 comparisons, Appendix A describes how the comparative estimates were calculated, why the volume of food inputs, food consumed and FW differ to those published in 2019 and explores the differences in greater detail than presented below.

3.5.1 Proportion of Food Inputs Consumed vs. Wasted

In percentage terms, Table 3-7 presents the 2019 estimated proportion of food entering the Canadian food system that was not consumed. Estimated total FW is subsequently separated into avoidable and unavoidable FW.

Table 3 7: 2019 FW Overview

2019		Million Tonnes[16]	% of Food Inputs	% of TOTAL FW
Food system inputs		45.43		
Food consumed		19.04	41.9%	
TOTAL FW		**26.39**	**58.1%**	
	Avoidable FW	8.29	18.3%	31.4%
	Unavoidable FW	18.10	39.9%	68.6%

The following two tables show a side-by-side comparison (2019 vs. 2024) of the proportion of Canadian food system inputs (whether produced domestically or imported) that was consumed versus those which exited the food system as either avoidable or unavoidable FW.

Table 3-8 shows the proportions of food system inputs: food consumed and total FW, broken down into avoidable and unavoidable. The figures show that, in overall terms, the Canadian food system has become more efficient, with total FW as a proportion of food system inputs having reduced from 58.1 per cent to 46.5 per cent.

Table 3 8: Proportion of Food System Inputs (2019 vs. 2024)

	2019	2024
Food system inputs	100%	100%
Food consumed	41.9%	53.5%
TOTAL FW	**58.1%**	**46.5%**
Avoidable FW	18.3%	19.4%
Unavoidable FW	39.9%	27.1%

[16] See Appendix A for an explanation of why the volumes contained in this column differ to those published in 2019

Table 3-9 presents the volume (in million metric tonnes) of food system inputs: food consumed and total FW, broken down into avoidable and unavoidable. Total FW has decreased by 19.7 per cent:[17] avoidable FW has increased by 6.5 per cent; unavoidable FW has decreased by 31.8 per cent since 2019. Reasons for this are presented in the following sections.

Table 3 9: Comparative Food System Efficiency – Million Metric Tonnes (2019 vs. 2024)

	2019 Volume	2024 Volume
Food system inputs	45.43	45.52
Food consumed	19.04	24.34
TOTAL FW	**26.39**	**21.18**
Avoidable FW	8.29	8.83
Unavoidable FW	18.10	12.35

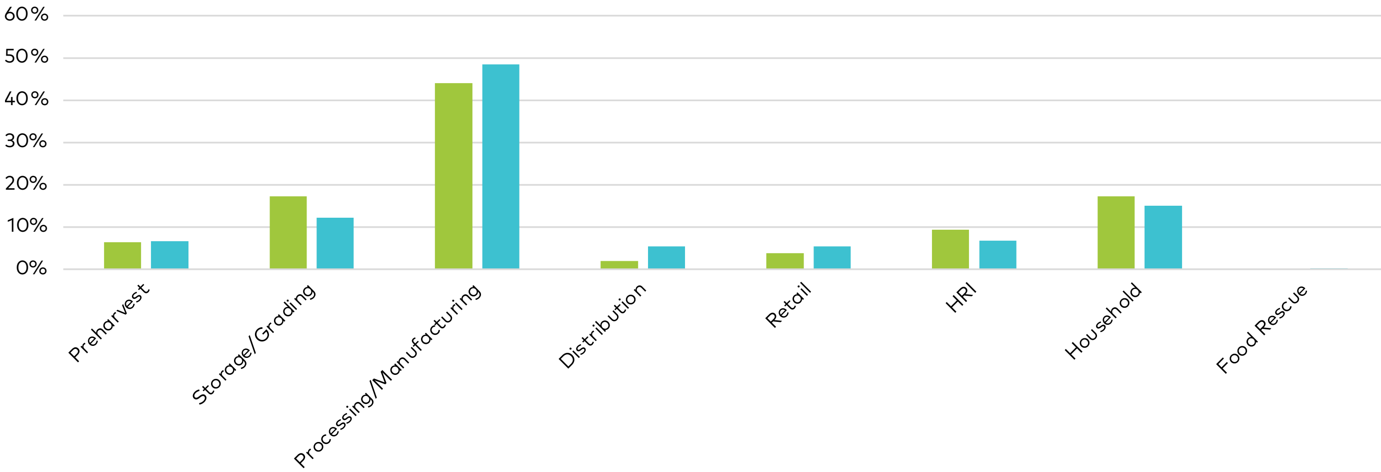
3.5.2 Changes in the Ratio of Avoidable to Unavoidable FW

As noted above, the ratio of avoidable versus unavoidable FW as a proportion of total FW has changed. An analysis of insights captured during discussions with industry interviewees (particularly those from the fresh produce, distribution and retail sectors of the food industry) identified that the reasons for this change in the ratio of avoidable versus unavoidable FW can be condensed into two main factors.

1. The estimates published in 2019 may have underreported the proportion of avoidable potentially edible FW occurring along the value chain, particularly in relation to produce grading, produce packing/shipping and food distribution.
    a. Compared to the research published in 2019, the depth of analysis into these sectors during the 2024 research was more granular.
    b. Respondents' awareness and subsequently the measurement of FW has markedly increased, leading to respondents more definitively classifying avoidable versus unavoidable losses. This resulted in the research capturing more accurate data.
2. Consumer behaviour has changed in response to food inflation and cost-of-living concerns. An increased focus on quality and value, in an effort to reduce the costs of food by reducing household FW, has increased avoidable FW along the chain (versus in the household). This appears to especially be the case in fresh produce, though respondents said that the proportion of avoidable FW occurring in the dairy and bakery sectors has also noticeably increased.
    c. Numerous respondents believe that the effect of these changes in consumer behaviour are exacerbated by retailers' (and HRI operators to a lesser degree) having adapted their business practices to help differentiate themselves and remain profitable in a hyper competitive marketplace.[18]
    d. Conversely, in an attempt to reduce FW by countering consumers' demand for pristine appearance, retailers have launched programs promoting misshapen fruits and vegetables at discounted prices.[19]

[17] Math calculation: (21.18-26.39)/26.39
[18] For example: Loblaw introduces Fresh Promise for produce: If it's not fresh, it's free | The Packer
[19] For example: Frozen; Fresh; Regulatory changes

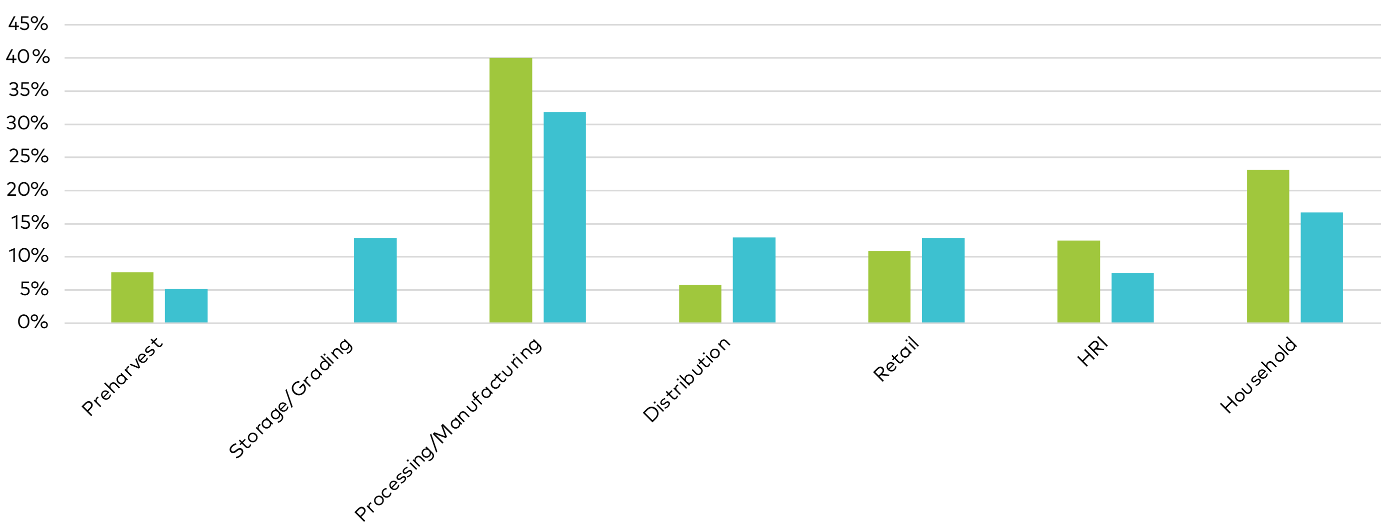
Figure 3 6: Proportion of Total FW Occurring Along the Value Chain



As described in the previous section, the research published in 2019 may have underestimated the avoidable potentially edible FW occurring during the initial grading of commodities grown in Canada and on the receipt of imported commodities. The latter particularly applies to fresh produce, where a higher proportion of imported produce is graded and packed than five years ago. This change has occurred as a direct response to customer and consumer demands.

As can be seen in the chart below, the proportion of avoidable potentially edible FW identified as occurring in distribution and retail has also increased. The proportion of avoidable potentially edible FW occurring in preharvested crops, processing/manufacturing, HRI and at the household level has decreased. This finding correlates and strengthens the insights provided by interviewees and workshop attendees that changes in consumers' purchasing behaviours are amongst the factors resulting in an increased proportion of total and avoidable FW occurring further up the value chain than published five years ago.

Figure 3 7: Proportion of Avoidable FW Occurring Along the Value Chain



Why the proportion of total and edible FW reduced in HRI but increased in retail largely appears to be due to two reasons. Firstly, increased food prices, combined with cost-of-living concerns, have caused a shift in consumer behaviour. The volume of food purchased in HRI in relation to retail has decreased. Secondly, driven by economic and financial challenges, the HRI sector is purchasing differently than it was five years ago. The volume and range of products kept on hand in HRI operators' inventory is less than five years ago.

An example of how this dynamic has played out relates to fresh produce. An interviewee told us that HRI distributors need to keep a full array of fresh produce on hand so that they do not miss a sale. HRI operators are, however, purchasing more selectively and sporadically. Examples of this are heritage tomatoes or specialized mixed salad mixes, both of which are ordered sporadically and in limited volumes by a small segment of the overall HRI market. This has led to HRI distributors experiencing higher volumes of FW than previously.

3.6 Causes of FW Along the Value Chain

The following section builds upon the research findings presented previously. It explores the comparative impact of distinct drivers of FW as reported by survey respondents, interviewees and validation workshop participants.

Respondents were asked to identify and rank the primary causes of FW occurring in their business or organization. This data was analyzed in relation to five distinct points in the value chain: 1) primary production (pre and postharvest); 2) processing, manufacturing, distribution; 3) retail; 4) HRI; and 5) food rescue/redistribution. In each case, the reported likelihood of each cause of FW to occur and its impact on the creation of FW when it does occur are mapped on a four-quadrant matrix.

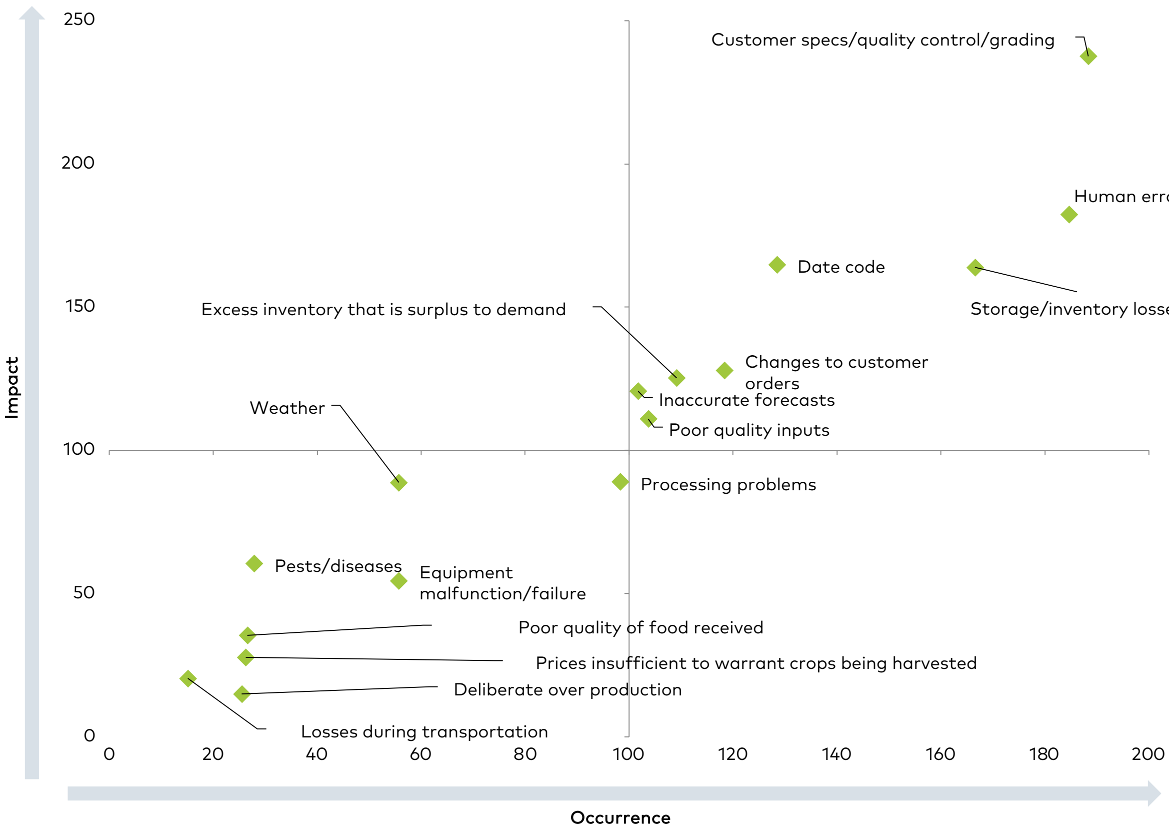
Two distinctly different drivers of FW, whose impact has markedly increased over the last five years and whose influence extends along the entire value chain to some degree, are subsequently discussed in greater detail. These are: 1) best before dates (BBDs) and 2) changing weather patterns/climate.

In the following seven charts (Figures 3-8 to 3-14), the causes contained in the top right-hand quadrant are those which were reported as most likely to occur and have comparatively greater impact on the creation of FW should they occur. On the flipside, the causes contained in the bottom-left quadrant were reported as least likely to occur and have comparatively less impact on the creation of FW. The point of equilibrium (n=100) on each axis of the quadrant (likelihood and impact) was established by determining the median response for all reported causes by the stakeholders being referenced.

3.6.1 Comparative Whole of Chain Causes of FW

Presented in Figure 3-8 below is the comparative impact and likelihood to occur of causes of FW as reported by food industry survey respondents. Each are subsequently described in more detail in relation to specific points along the value chain.

Figure 3 8: Whole of Chain Causes of FW



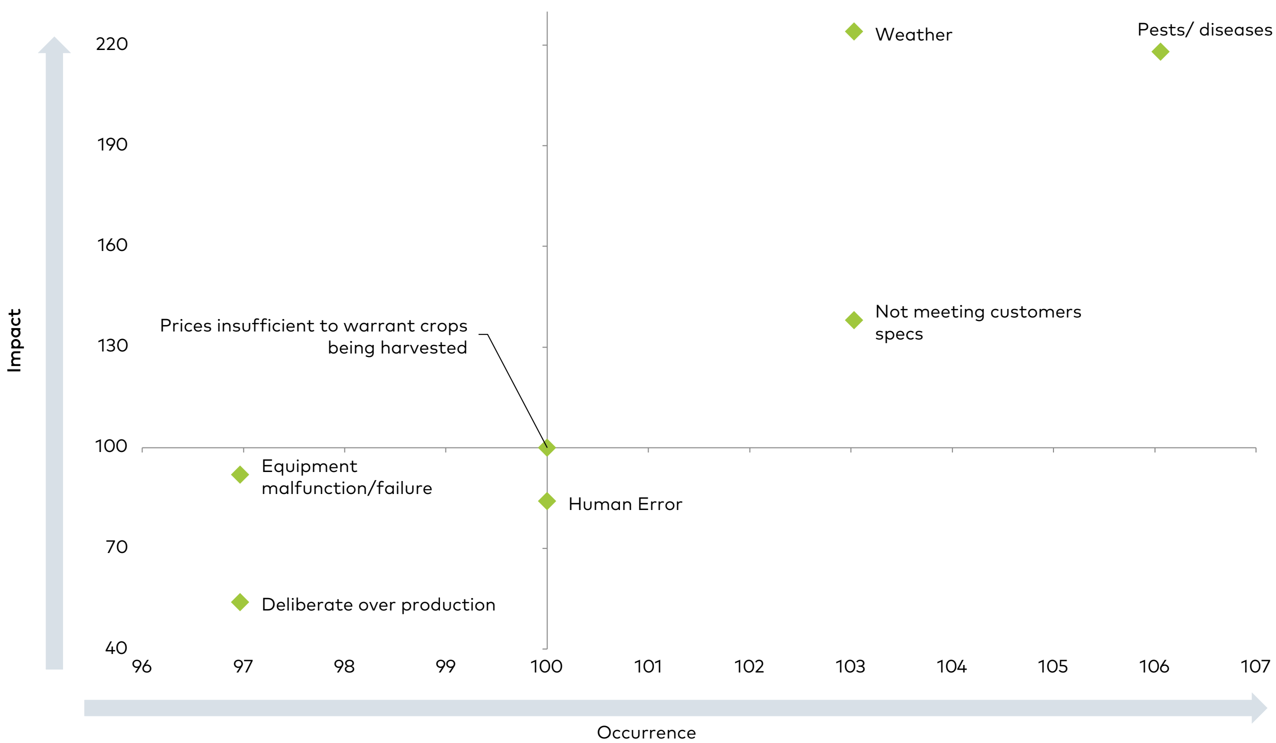
As can be seen, the four most impactful and likely to occur drivers of FW are 1) customer specifications and quality control/grading, 2) human error, 3) storage/inventory and 4) date code. A number of the comparatively less impactful and likely to occur drivers, such as weather and processing problems, relate to these overarching factors. Weather and climate change is impacting the quality, predictability and shelf life of perishable food in particular. This results in commodities and foods that do not meet customers' expectations. Processing problems can be caused by human error and exacerbated by inconsistencies in the quality and supply of inputs. Drivers, such as changes to customer orders and inaccurate forecasts, are also likely to be closely linked. Inaccurate forecasts can be purchasing or supply related, the latter impacting customers' ability to depend on the timely delivery of quality products that are of the required specification.

3.6.2 Causes of FW in Primary Production

As the concerted analysis of FW in meat and poultry focused on carcasses immediately after harvest, the following causes relate primarily to field crop and fruits/vegetable production. Preharvest causes of FW are in relation to mature crops that were not harvested, the most common reasons for such reported to be quality, price and demand related. Agricultural and horticultural crops are not harvested when the anticipated price received is insufficient to cover harvest and postharvest handling costs, or an expected market does not eventuate. This, said a number of respondents, becomes an increasingly important decision for farmers, due to input, equipment, labour, utility, packaging and transport costs having increased (sometimes markedly) in recent years.

The most likely to occur and impactful causes of crops not being harvested relate to weather and climate change, including the fact that this is leading to pest and disease related issues, which further impact primary producers' ability to grow crops that meet exacting customer specifications.

Figure 3 9: Preharvest Causes of FW (Crops, Fruit, Vegetables)

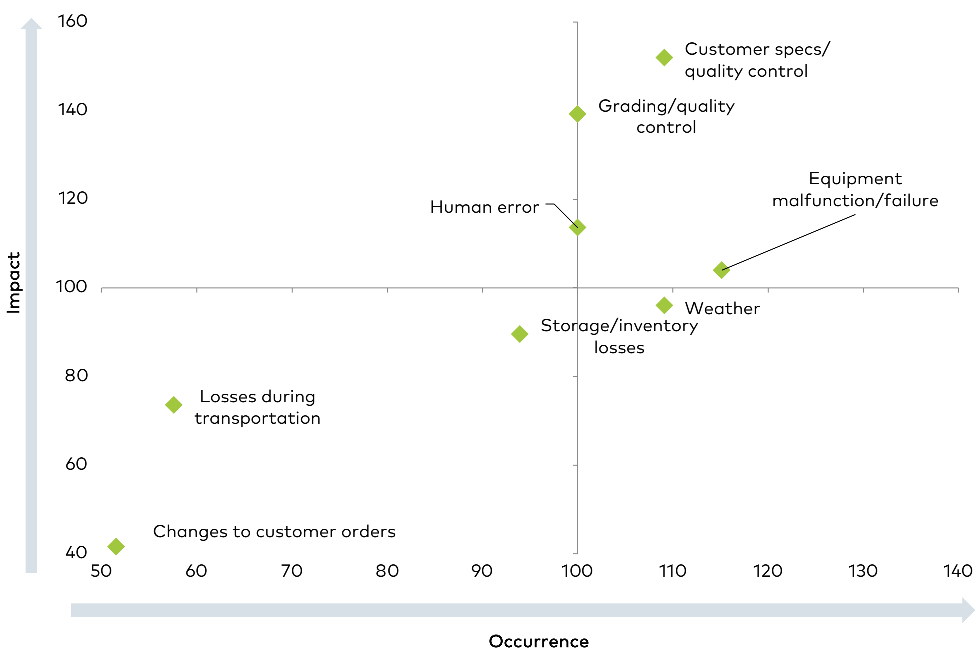


Changing weather patterns do not only relate to incidences such as heat domes;[20] weather variability is increasing the challenges associated with the planting, growing and harvesting of crops.[21] This is decreasing primary producers' ability to consistently and predictably grow crops, particularly tender crops such as peaches and grapes that are sensitive to temperature change or weather events during the growing cycle — thereby leading to an increase in the incidence of crops whose quality does not meet consumer expectations.

An example of weather patterns leading to avoidable loss due to a crop not meeting customer specifications was recounted by an interviewee. Weather events, including high temperatures and the smoke from forest fires, negatively impacted the growth of cantaloupe and honey dew melon crops – causing the products to be one quarter inch smaller than the size specified by the retail customer. This led to 85,000 lbs of cantaloupe and honeydew melons being rejected and going unsold, even though the crops were fine other than in size.

As reported in 2019, another reason for crops not being harvested was that doing so could contravene crop insurance claim requirements. In certain circumstances and crops, such as vegetables grown for processing, the ability to claim crop insurance was reported as reducing the motivation to harvest. However, in 2024, neither of these preharvest causes of FW were consistently cited by respondents. As can be seen below, failing to meet customers' specifications, which can be a direct function of the production environment, was cited as the most impactful and second most common cause of postharvest FW.

Figure 3 10: Postharvest Causes of FW (Crops, Fruit, Vegetables)



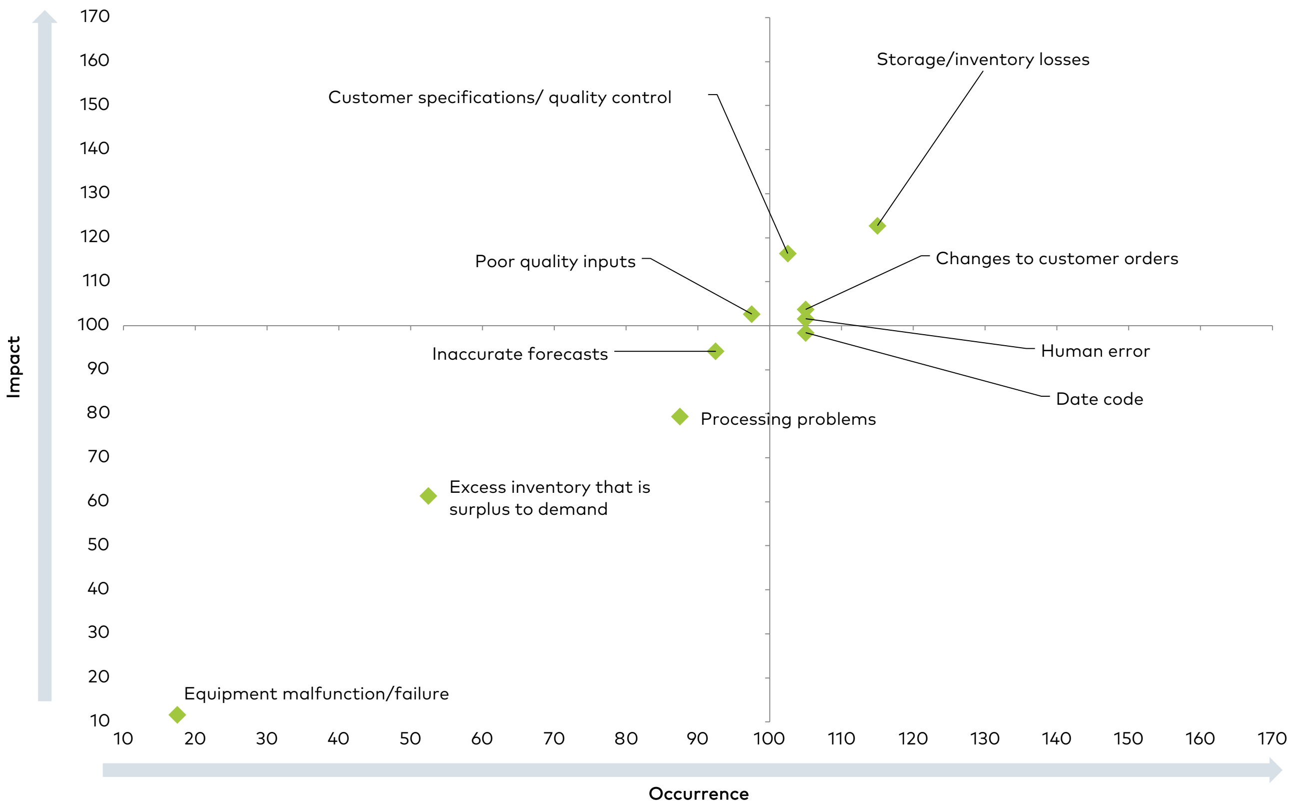
[20] CBC First Person (2024); Ontario Strawberry Crop (2024); Grain Central (2021);
[21] Climate change impacts on agriculture - agriculture.canada.ca

Another difference compared to the 2019 findings is the impact and likelihood of deliberate overproduction driving FW having noticeably reduced. This is because input costs (incl. fuel, fertilizer, seed) and labour have increased to the point where farmers cannot afford to grow on speculation.

3.6.3 Causes of FW in Processing, Manufacturing and Distribution

The analysis of food processor, manufacturer and distributor responses found that FW in this area of the food value chain is most likely caused by product storage and inventory issues, followed by customer specifications/ quality control. The three next most impactful causes of FW are tightly grouped together: changes in customer orders, human error and date coding.

Figure 3 11: Causes of FW in Processing, Manufacturing and Distribution



Discussions with interviewees identified that date codes (BBDs and expiry dates) are a common feature of customer specifications, in the form of stipulated minimal life on receipt (MLOR).[22] Interviewees confirmed findings from prior research which identified that the retailers' MLOR can significantly differ from one another, and that the inability to dispatch a product prior to it falling foul of customers' MLOR requirements can render it unsellable. This often leads to inventory loss. That said, a few respondents cited that retailers have begun accepting fresh/chilled products (e.g. processed meats) that do not meet their usual MLOR if they are frozen prior to the MLOR criteria having been compromised.

[22] On the impact of adjusting the minimum life on receipt (MLOR) criterion in food supply chains - ScienceDirect

Another cited cause of storage/inventory losses, particularly of perishable products, is an inability to move products in a timely manner. Challenges associated with the availability, dependability and predictability of international freight and domestic haulage were cited by numerous interviewees as an issue affecting their operations, and which consequently result in FW. The impact of transport on the food industry and other sectors was also commonly cited by industry and other stakeholders.[23]

An interviewee whose manufacturing facility produces frozen further processed meat products stated that the impact of weather extends beyond it interfering with the physical transportation of products. It is placing greater strain on cold chain infrastructure, with the losses caused by cold chain failures that occur during transportation now annually accounting for the equivalent of one day's production.

The next most impactful cause of FW in processing/manufacturing/distribution was reported as poor quality inputs. A number of interviewees expressed that this often stems from weather/environmental challenges having affected sourced products' quality and consistency. Transport delays due to weather also interfere with processing and manufacturing operations. Transportation delays also lead to losses during the distribution of consumer-ready products.

3.6.4 Causes of FW in Retail

The two most impactful causes of the FW are excess inventory, followed by date coding. Numerous respondents cited that it is common practice for retailers to purposely order excess inventory as a means of ensuring that they do not miss a sale, and that this practice is more common for national branded items than for private label. Retailers may return unsold products such as bread and soft drinks to vendors, potentially increasing the losses reported by distributors or processors/manufacturers. Retailers have been cited as being reluctant to donate private label[24] products, which could lead to a higher proportion of these items being wasted than national branded products.

The second most impactful cause of FW at retail is BBDs. A discussion on the relationship between BBDs and FW is presented in Section 3-7. Given that interviewees cited that a relationship commonly exists between BBDs and other cited causes (incl. excess inventory, storage/inventory losses and customer specifications/expectations), the effect of BBDs on FW is potentially even greater that it would first appear.

[23] World Economic Forum (weforum.org); Impact of Climate Change on Canada's Food Supply Chains

[24] Private label is the term used to denote brands that are owned by the retailers and often sold at a lower price point than national branded items, the objective being to increase consumer loyalty and repeat purchases. Private label is an increasingly important feature of retailers' merchandizing practices. Examples of private label brands are "Only Goodness" owned by the Pattison Food Group, "No Name" owned by Loblaw, and "Compliments" owned by Sobeys.

Figure 3 12: Causes of FW in Retail

Discussions with retailers and vendors identified that FW caused by poor quality inputs primarily relates to fresh and perishable foods, such as fruits and vegetables — the shelf life of which can be negatively impacted by multiple factors, including the environment within which they are grown, then distributed. Delays in products' transportation increases the likelihood that fresh foods will deteriorate faster than anticipated and fail to meet consumers' expectations, resulting in unsold products and waste. In the words of a fresh produce vendor supplying retail: "Fickle North American consumers buy primarily on appearance, even though produce which does not appear perfect can have better internal qualities." Examples of produce where this can often be the case include limes, mangoes and papayas.

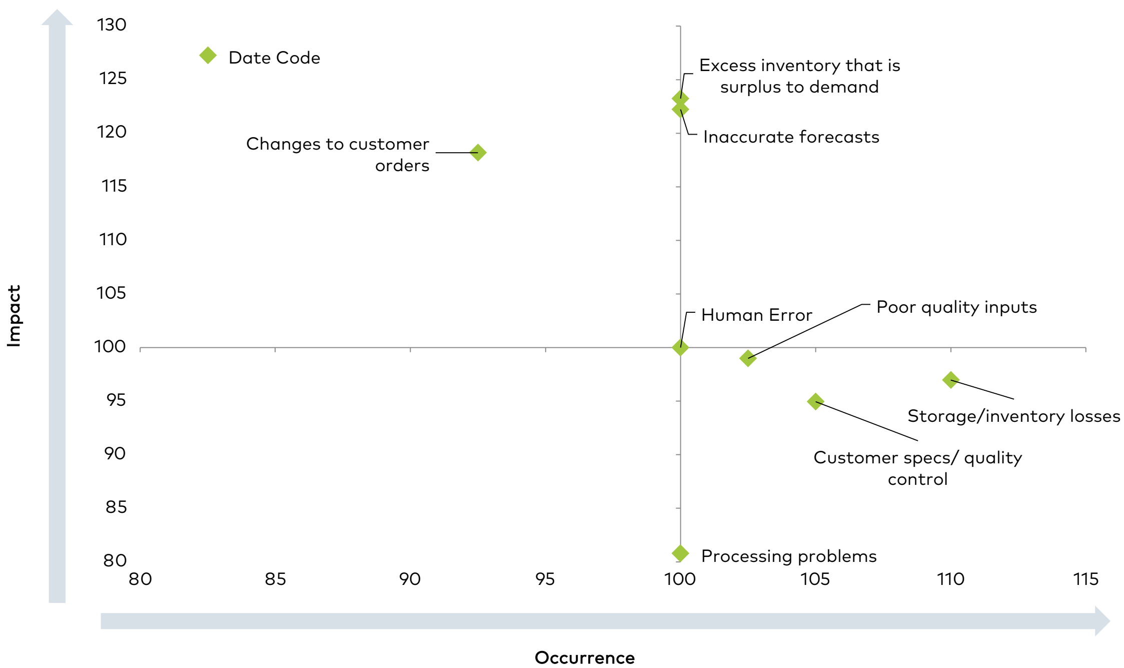
Human error, potentially due to store staff not receiving the necessary training, is often referred to by industry experts and commentators as a driver of inefficient operations and FW.

3.6.5 Causes of FW in Hotels, Restaurants, Institutions (HRI)

The HRI sector encompasses a wide array of operations. HRI ranges from cafés and quick-service restaurants operated by independents and corporations, through to institutional buffet-style foodservice operated by contracted operators. Discussions with interviewees and validation workshop attendees illustrated the degree to which, while corporate HRI operations are typically polished and highly efficient with low to moderate FW at the operational level (particularly in terms of preparation [vs. plate] waste), independent operations can experience much higher levels of FW in comparison to their respective size.

Although date code was reported as having a significant effect on FW in HRI when it occurs, compared to retail, its occurrence is significantly less common. This suggests that there is good management of products carrying short date codes.

Figure 3 13: Causes of FW in HRI



As can be seen in Figure 3-13, the most impactful causes of FW in HRI relate to inventory management, including forecasting. This can be linked to the analysis of survey responses identifying that HRI is the second least likely (after primary production) to have implemented formal FW measurement and reporting practices. Improving the measurement of FW therefore represents an important opportunity for many HRI operators to improve their financial performance.

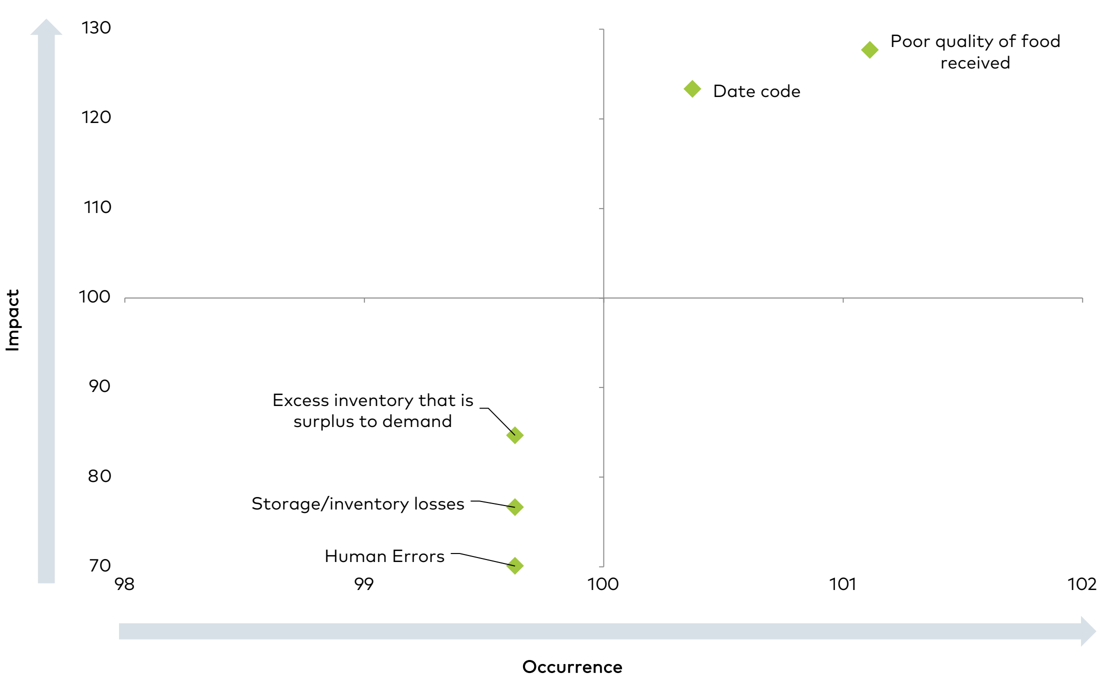
Interestingly, HRI operations who have implemented formal FW measurement systems have focused in the area of food preparation, not plate waste. Reasons for this could include that it is more difficult to categorize plate waste by food type. As well, plate waste relates to food which has been purchased. Operators may arguably, therefore, be less motivated to work towards its reduction.

3.6.6 Causes of FW in Food Rescue and Redistribution

In volume terms, the FW that was estimated to occur during the rescue and redistribution is much less than that which occurs at other levels of the value chain. However, its existence still reduces the volume of foods and beverage that could be directed to vulnerable populations.

The two primary causes of the FW experienced by NFPs are 1) the poor quality of food received, and 2) date codes, in particular BBDs. Both causes relate to SEF donors often being reluctant to donate edible food until the last moment, for financial reasons. Other studies have identified that the existence of a financial incentive, such as tax rebate for donated foods, could help motivate businesses to donate food sooner — thereby alleviating the FW experienced by NFPs.

Figure 3 14: Causes of FW in Food Rescue and Redistribution



3.7 Date Coding

During the researching of the ACFW (2019), a retail executive described BBDs as a "monster." In the intervening five years since that research was published, the ferocity and scale of the BBD monster has grown exponentially. In a world that is unrecognizable[25] compared to when BBDs were first introduced by Marks and Spencer as a means to manage store inventories in the 1950s before being introduced to retail shelves in 1972, the premise on which BBDs have been based since their inception has not keep up with reality.

In 1976, Canada became one of the first countries to introduce regulations pertaining to which foods should carry a date code and why. Regulators' intent was never to encourage the widespread use of BBDs. Neither was their intent to use BBDs as a means to communicate food safety. Their intended scope was short shelf-life foods — those with a durable shelf life of 90 days or less. The Canadian Inspection Agency defines durable shelf life as the period during which a food or beverage product "will remain wholesome, palatable and nutritional."[26]

Durable shelf life is affected by intrinsic factors associated with the product itself and the materials/gases in which it is packaged, and extrinsic factors that relate to the external environment.

Fast forward almost 50 years since the introduction of Canada's BBD regulations, and BBDs have been applied extensively across the food industry, with potentially little regard given by businesses about whether BBD reflects a food's actual shelf life — particularly given that BBDs have no direct correlation to food safety. Why, asked a number of interviewees and workshop participants, do products such as table salt carry a BBD? An interviewee possessing extensive experience in food processing said that he had consumed pasta that was over 20 years old, adding that there was absolutely nothing wrong with it.

The challenge, cited by interviewees and validation workshop participants, is that BBDs have created a culture where consumers do not make decisions based on their own knowledge and common sense. Instead, they defer to dates determined by risk-averse food processors and manufacturers whose primary concern is the profitability of their businesses. If a consumer disposes of a safe-to-consume product unnecessarily, and subsequently purchases a replacement, the food industry involved in the production and distribution of that product benefits financially. The losers are consumers (who unwittingly purchase foods unnecessarily) and the environment. Similar sentiments have been voiced by numerous organizations, including Approved Food, a UK wholesaler/retailer selling clearance food at discount prices; National Resources Defense Council, Smithsonian Magazine; and Agri-Food Analytics Lab.

In the words of a retail interviewee: "Businesses definitely use best before dates to drive sales." Interviewees provided numerous examples regarding the extent to which the determination of BBDs is an arbitrary decision that needs not have any correlation to science. A producer of mixed leafy greens told us that they wanted to apply a date code that was considerably longer than their retail customer would accept. A retailer told us about a meat processor who had transitioned to new packaging that extended the shelf life of poultry considerably. They did not adjust the BBD, however, out of concern for how consumers would interpret the change. Other examples given related to soup, canned milk and more.

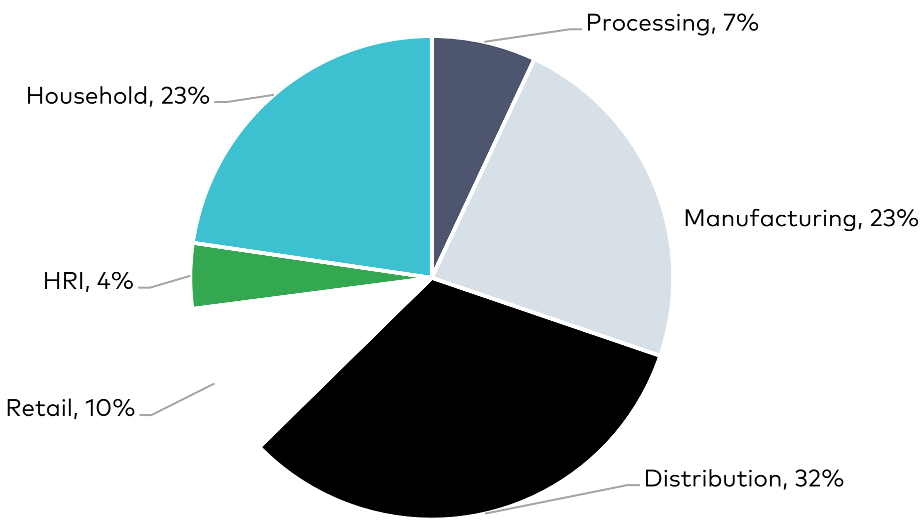
[25] Advancements in packaging technology and food processing capabilities, longer, more complex supply chains, along with tremendous changes in consumers' expectations and demands during the intervening 70 years, strongly suggest that the assumptions on which BBDs are based is outdated. NRDC; Consumer Reports; Approved Food; Agri-Food Analytics Lab
[26] Shelf life studies - inspection.canada.ca

While multiple Canadian studies have identified that BBDs are a common cause of household FW,[27] these studies have not established the proportion of household FW linked to BBDs. The analysis of this survey data enabled direct correlations to be established between BBDs and FW along the value chain.

The estimated volume of total avoidable FW associated with BBDs is 1.6 million metric tonnes. This equates to 18 per cent of total avoidable FW (8.83 million tonnes), and 23 per cent of the 7.24 million tonnes of avoidable FW that occurs from food processing (the earliest point at which BBDs are applied) through to the point of purchase by consumers. This includes fresh produce that has been value-added; for example, in the form of bagged salads and baby carrots. This estimate is quite similar to WRAP's estimate that 17 per cent of household FW is caused by people having incorrectly interpreted BBDs.[28] A European Union study estimated that 10 per cent of total FW can be linked to BBDs.[29] Consumers most wary of BBDs are mothers with young children and the elderly.[30]

The analysis of survey responses and subsequent interviews with industry experts identified that BBD-related FW is not merely a household matter; it is also an industry matter. As identified in Figure 3-15, a higher proportion by weight of BBD-related FW occurs during distribution than among households. One reason is that items such as bread are returned to manufacturers/distributors by retailers if unsold within a certain timeframe.

Figure 3 15: Proportion of Avoidable FW Associated With Best Before Dates

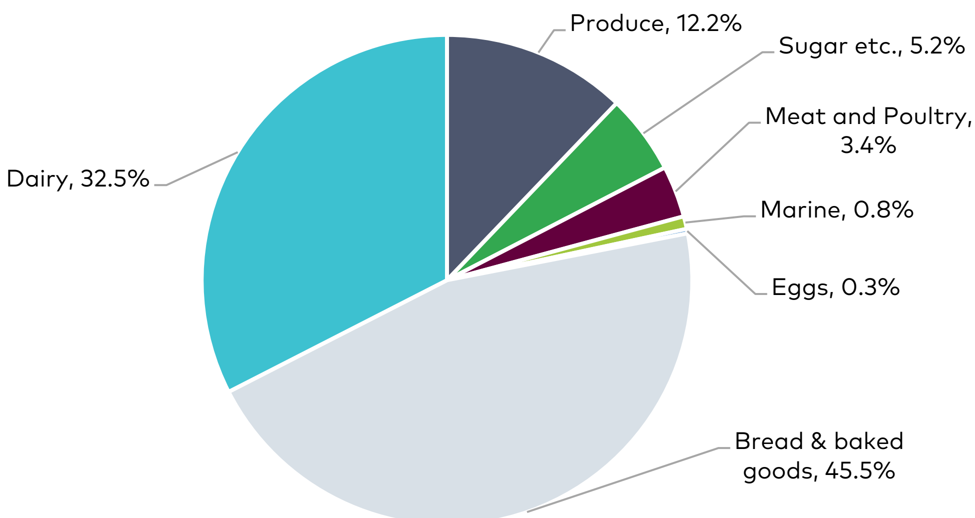


[27] For example: VCMI; Western; NZWC; University of Guelph
[28] Citizens' disposal decisions report (wrap.ngo)
[29] Date marking and food waste prevention - European Commission (europa.eu)
[30] VCMI Halton Region Household Study; Household Food Waste Practices; Australian Fresh Produce Alliance

Other examples of FW during distribution were cited by an importer of processed consumer-ready foods and a food manufacturer. The importer said that the BBDs placed on the foods imported had been shortened for market competition, resulting in a greater likelihood of the foods being wasted prior to reaching the end market, or being lost because they did not fall within the MLOR stipulated customers.

Presented in Figure 3-16 are the foods most likely to be wasted due to issues related to BBDs. The greatest FW by weight is associated with bread and bakery, followed by dairy, then fresh and processed produce.

Figure 3 16: Best Before Date Related FW by Food Type



Retail interviewees cited the degree to which consumers have become obsessed by BBDs, largely because they have become a default mechanism that consumers use to define quality and value. The perception is that the longer the remaining BBD period, the higher value the purchase and the less likelihood there is of the food or beverage becoming household FW. An example of this mentality, cited by a retailer, includes observing a consumer who emptied an entire milk display to find the container carrying the longest date code. The retailer said that, while the "leapfrogging" of products in easy reach to find an item carrying a longer date code has been common practice for years, the new level of fixation that they are witnessing is unprecedented.

Another retail interviewee stated: "I cannot tell you how many times customers have threatened to sue me after having bought foods/beverages that are close to or slightly past BBD."

Evidence captured by the research clearly shows, therefore, that BBDs are a key reason behind why avoidable FW has increased over the last five years.

3.8 The Relationship Between Climate Change and FW

In addition to the survey data presented previously in relation to the effect of weather on crop production and the proportion of harvest commodities that meet market specifications, workshop attendees and interviewees cited how changing weather patterns are leading to increased FW along the food chain. Climate affects the quality, consistency and predictability of crops and livestock produced outdoors. It can also affect indoor crops and livestock. Changing weather patterns affect the harvest, distribution and shelf life of foods and beverages. The effect of erratic weather on soil health is also driving increased FW.

Climate change drives increased FW along the food value chain in multiple ways.[31] Examples cited by interviewees and workshop participants regarding how changing climate is affecting crops include an increase in the proportion of fruits and vegetables that do not meet customers' exacting specifications.[32] A food upcycling organization in Eastern Canada cited how they regularly hear of large proportions[33] (40+ per cent) of crops such as cauliflower being wasted, because they are either under or oversized, or are blemished. The occurrence of such incidences has increased in recent years. They expressed regret at having neither the demand nor the processing and storage capacity required to enable them to accept more crops of this type, which are perfectly edible.

Increased variability in crop quality, size and appearance leads to increased FW during grading and packing, particularly given the previously mentioned increase in consumers' demand and expectations for pristine high quality fresh fruits and vegetables. Interviewees mentioned that shelf life is affected by crops' growing conditions, leading to increased FW during distribution and in the retail store. Increased variability in fruits and vegetables grown for processing, such as potatoes for French fries and chips, also leads to increased FW — both prior to and during their processing.

While no quantifiable evidence was provided, several expert interviewees mentioned that they have heard anecdotally of higher incidences of full or part carcasses being condemned due to disease and parasitic pressure caused by climate change. It is illegal for condemned meat to enter the food system.[34]

An example given by research respondents of how deterioration in soil health due to changing weather patterns leads to increased FW was in relation to carrots. Erratic rain fall, followed by periods of high temperatures that quickly dry the soil, can cause light loam soils, suited to the growing and harvesting of carrots, to be turned into panned crusted soil. This can cause a large proportion of carrots to break during their harvesting, which, even though they are perfectly edible, usually renders them unsalable.

As mentioned previously in "Causes of FW" (Section 3-6), the impact of climate change on equipment and infrastructure is also driving increased FW among fresh and frozen foods in particular. Though massive food supply chain crises, such as those caused by environmental disasters, are typically rare in Canada, climate-induced weather events are predicted to increase in coming years.[35] Unless the Canadian food system is prepared, this could well lead to avoidable FW continuing to grow.

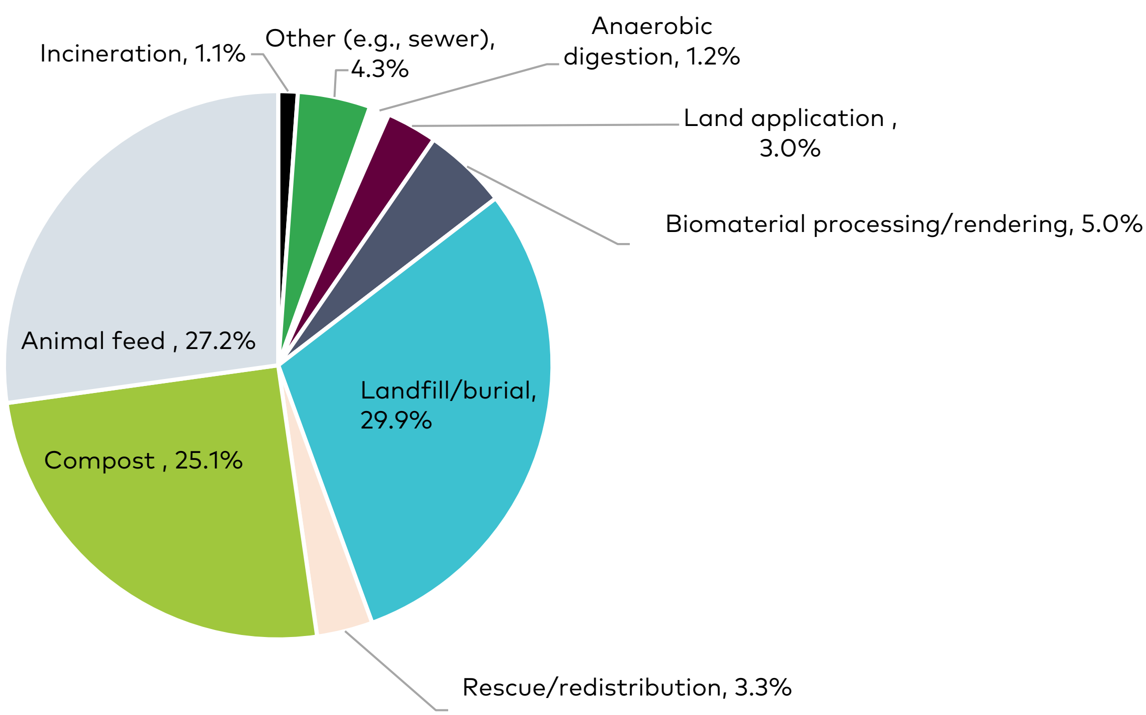
[31] Identifying FW causing factors along the food chain; Climate change impacts on Canada's cold chain
[32] How oddly shaped produce is leading to global food waste problem
[33] Canadian On Farm Losses; Taking Stock, Canada; Northern California; Global on farm losses
[34] Climate impacts on livestock value chains; Climate change impacts on microbial foodborne diseases in Canada
[35] B.C. floods reveal fragile food supply chains

3.9 Destination of Avoidable (incl. SEF) and Unavoidable FW

Survey respondents were asked to identify their primary method of disposing of FW. The analysis and inference of responses, as a whole and in relation to distinct sectors and food types, enabled an estimation of the destination of total, avoidable and unavoidable FW. Conclusions resulting from this analysis were subsequently used to arrive at total GHG emissions associated with FW. Results of the GHG analysis form Section 3-11.

Shown below in Figure 3-17 is the estimated volume of avoidable potentially edible FW directed by respondents to distinct destinations. Given that interviewees commonly cited that, largely for economic reasons, they are sending a smaller proportion of SEF to redistribution than five years ago, this estimation of 3.3 per cent by volume being directed to rescue and redistribution aligns with conclusions reached in prior VCMI research completed for Second Harvest.[36]

Figure 3 17: Comparative Volume of FW by Destination



Compared to five years ago, many interviewees stated that they are sending a higher proportion of both avoidable and unavoidable to animal feed and composting, and a smaller overall volume of FW to landfill. Reasons commonly cited for this change include organic landfill bans[37] and that the sending of SEF to animal feed or compost is less costly and complex than directing it to redistribution, which requires that they follow food safety practices.

[36] Wasted Opportunity (secondharvest.ca)
[37] For example: Nova Scotia; British Columbia

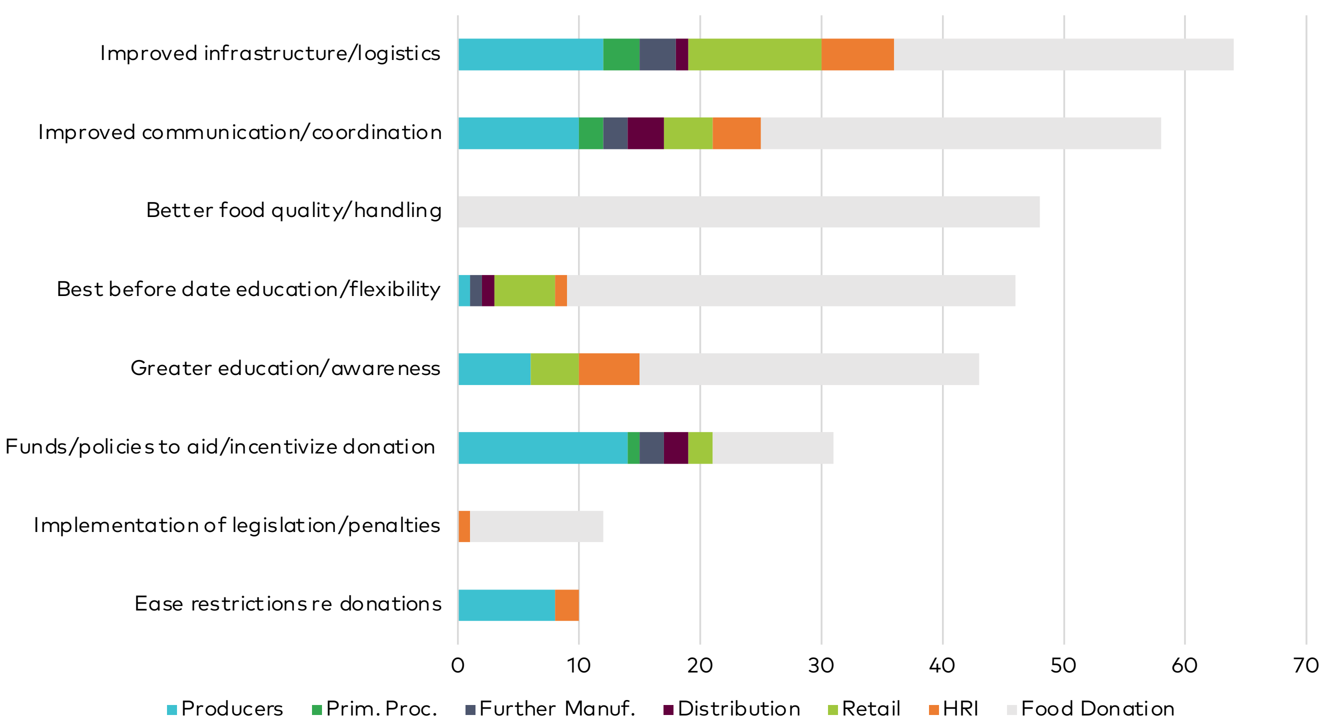
Redistribution can also take up cold storage space and can be a drain on financial resources at a time when margins are already thin. Conversely, businesses can derive a financial benefit from directing unsold or unsaleable food to animal feed or compost. This benefit comes in the form of revenue generation, as is typically the case with animal feed, along with the cost of handling/haulage being covered by a third party. In addition, from ESG perspectives, the sending of avoidable (incl. SEF) and unavoidable FW to animal feed or compost is viewed as FW reduction.

3.10 Increasing the Proportion of Avoidable FW Rescued and Redistributed

Survey respondents from industry and NFPs were asked to suggest how the proportion of SEF directed to rescue and redistribution could be increased. Three hundred and twelve respondents provided detailed suggestions for increasing the volume of donated SEF. Those responses are presented below in Figure 3-18. The bottom axis in the figure shows how many of the 312 respondents suggested each of the means to increase the volume of SEF rescued and redistributed.

As can be seen, the first and second most cited suggestions relate to improved infrastructure and logistics, as well as better communication and coordination. The dominant suggestion from organizations that receive food donations was the need for better food quality and better handling of food. The other less commonly cited suggestions, such as BBD-related initiatives and increasing funds and policies targeted at encouraging/enabling food donation (incl. tax incentives), would also help increase the donation and redistribution of SEF.

Figure 3 18: Increasing Donation of Surplus Edible Food (SEF)



3.11 Quantifying the Environmental Impact of FW

Since the 2019 ACFW report's release (motivated by factors including countries' and industries' commitment to the SDGs), the estimation and investors' demands for businesses to implement sustainability initiatives and the estimation and reporting of environmental performance have progressed considerably.

All of the calculations presented below are based on peer-reviewed data. A detailed description of methodology employed to calculate the impacts described below form Appendix C.

3.11.1 GHG Emissions

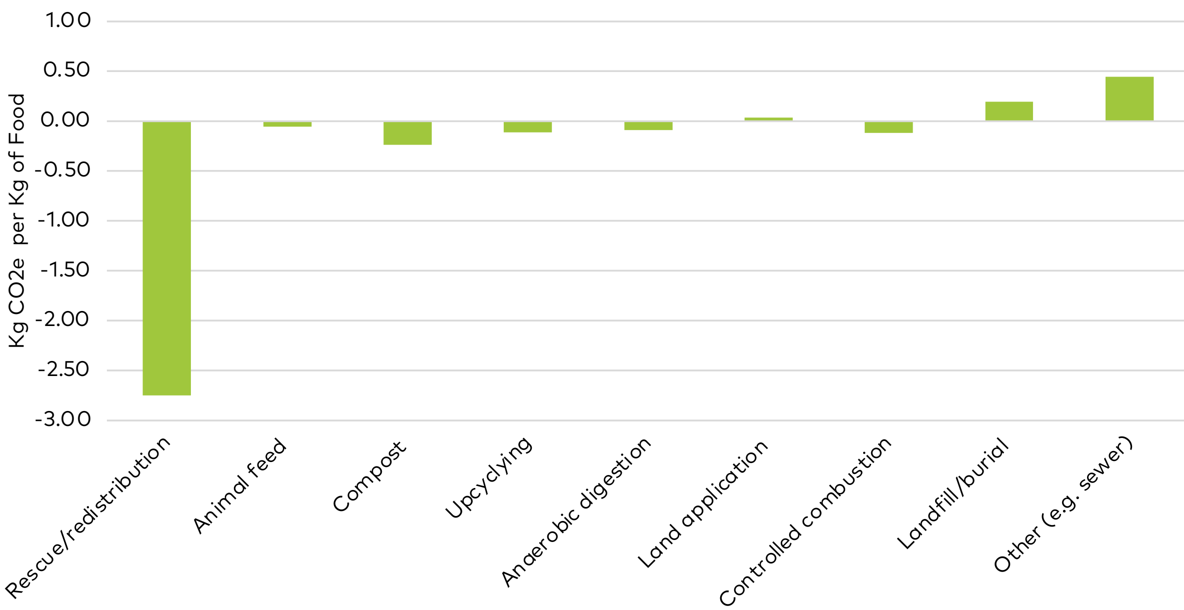
Forty-nine of the goals within the UN's 17 SDGs relate directly or indirectly to reducing greenhouse gas (GHG) emissions. The food system represents over one-third of anthropogenic GHG emissions (UN, 2021; Crippa et al., 2021).[38] The environmental effects of FW represent approximately 8 per cent of total GHG emissions and 26 per cent of global food system related GHG emissions. Three key GHGs (carbon, methane and nitrous oxide) are accounted for in the calculations, which have been standardized to tonnes of CO_2e (carbon dioxide equivalents).

GHGs are added and accumulated as food moves along the value chain from production through to consumption. The final destination of food system bio-products, along with food and beverages that are not consumed, also affects total food and beverage related GHG emissions. One of the most impactful means to reduce food system related GHGs is to distribute excess edible food to vulnerable populations. According to the United States Environmental Protection Agency, this could reduce avoidable food related GHGs by over 12 times that achievable by composting FW, and 30 times that achievable by upcycling into new foods.

Presented in Figure 3-19, using data from ReFED, are the comparative environmental benefits/penalties associated with directing food that would otherwise have been wasted to different destinations. On average, for each tonne of food, the redistribution of SEF represents a reduction of approximately 2.6 tonnes of GHGs having been emitted unnecessarily. By contrast, the sending of FW to landfill leads to an additional ~0.5 tonnes of GHGs being produced due to the methane created during the decomposition of organic matter. Commonly used destinations of edible and inedible parts that exit the food system, such as to animal feed, represent noticeably less environmental benefits than options such as composting.

[38] Food systems responsible for a third of anthropogenic GHG; Food system global GHG emissions

Figure 3 19: GHC Effect by Destination



Source: ReFED (2021)

The calculation of GHG intensities associated with Canadian FW was developed using publicly available peer-reviewed data, specifically data related to the Canadian market. This began by consulting StatCan data to identify key primary production regions, food availability and importation. The calculation is for the seven food types presented in the FW model (dairy, eggs, field crops, produce, meat/poultry, marine and sugar/syrups) and 25 food subcategories residing within each of the seven overarching food types investigated.

Production GHG intensities were gathered for the dominant production regions: domestic and/or international. Based on the proportion of imports for each food subcategory, established by having consulted StatCan data and industry experts, a representative intensity was then calculated for each food subcategory. The GHG intensity of the seven food types are based on the weighted average of the subcategories. The weighting of the subcategories within each category was developed using StatCan food availability data.

As shown in Table 3-10, the GHG emissions associated with the 21.2 million metric tonnes of FW equate to 77.7 million tonnes of CO_2e. Avoidable FW accounts for 25.7 million tonnes (33 per cent) and unavoidable accounts for 52 million tonnes (67 per cent).

Table 3 10: GHG Emissions Associated With Total, Avoidable and Unavoidable FW

	CO_2 equivalent (million tonnes)	% of FW
Total FW	77.7	
Avoidable	25.7	33%
Unavoidable	52.0	67%

Based on Our World in Data triangulated against US-EPA data, the 77.7 million tonnes of GHG associated with total FW along the chain is equivalent to the GHG emissions from 765,386 one-way flights from Toronto to Vancouver. For avoidable FW this equivalency is 253,223 such flights.[39]

The GHG emissions associated with each of the seven types of food that comprise the Canadian food system and the six distinct levels of the value chain (production and postharvest, processing and manufacturing, distribution and retail, households, HRI and food rescue/redistribution) are detailed in Appendix C. The GHG emissions resulting from the avoidable and unavoidable FW associated with each of the seven food types is also presented.

3.11.2 Water Footprint of FW

The concept of a virtual water footprint is used to measure the water resources required to yield a product. The water footprint was established to help understand our water usage within our global economy. Like energy, water can neither be created nor destroyed but transitions through our global economy and is used in the production of the food we grow, consume and waste.

The international movement of food causes the movement of water (particularly blue water) from the place of production to the place of consumption/wastage. The water footprint has three types of water: green, blue and grey. As described in more detail in Appendix C, green water is associated with precipitation; blue water is that which is sourced from surface or groundwater, such as for irrigation; grey water is the amount of fresh water required to assimilate pollutants to meet specific water quality standards.

The vast majority of water associated with the food industry is used in the primary production of commodities that are subsequently consumed or wasted. As shown in Table 3-11, the water footprint associated with the 21.2 million metric tonnes of FW equates to 37,541 million cubic metres of water. Avoidable FW accounts for 13,314 million cubic metres (35 per cent) and unavoidable accounts for 24,226 million cubic metres (65 per cent).

[39] Our World in Data

Table 3 11: Water Footprint Associated With FW Throughout the Food System

	Million m³ water	% of FW
Total FW	37,541	
Avoidable	13,314	35%
Unavoidable	24,226	65%

The volume of water associated with total FW is equivalent to 151.1 days of water flowing over Niagara Falls.[40] For avoidable FW this equivalency is 53.6 days.

By reducing food waste, we are reducing the burden on our and other jurisdictions' water resources. Canada has enormous water resources; however, we import significant amounts of foods, such as produce — including that ground in arid jurisdictions facing climate change challenges and water shortages.[40] In foods that we are unable to produce domestically, such as fresh produce, we are shipping the equivalent of enormous volumes of water from one part of the world to another, depleting the water from the region of production to produce food that is subsequently wasted.

Appendix C shows the comparative green, blue and grey water intensities of each of the seven types of foods examined and subsets of this categorization (e.g. fruit vs. vegetables within produce; beef vs. poultry with meat).

3.12 The Economic Impact of Food Waste on Industry and Consumers

The following section explores the true economic opportunity that reducing FW offers the Canadian industry and consumers. It commences with a contextual background taken from the UK's experience in valuing and addressing FW to achieve widespread economic benefits to industry and consumers alike.

3.12.1 Background

The economic cost of FW to industry and consumers is enormous. The first concerted effort to establish a value for the financial impact that FW and associated costs (energy, labour, transport, disposal, etc.) was undertaken by the UK's Red Meat Industry Forum (RMIF) in 2002.[41] Conducted by the Lean Enterprise Research Centre (LERC) on behalf of RMIF, the "Cutting Costs – Adding Value in Red Meat" initiative determined that avoidable FW which occurs along the red meat value chain equates to 10 per cent of the prices paid by consumers.

A fundamental goal of the Courtauld Commitment,[42] a voluntary pre-competitive agreement formed in 2005 by UK retailers and food manufacturers to reduce food and packaging waste and overseen by WRAP, was to deliver £3 billion in cost savings within 10 years. By 2012, the involved businesses had bettered that target —

[40] 2,875.6 cubic meters of water flows over Niagara Falls every second
[41] Red Meat Industry Forum
[42] History of the Courtauld Commitment

achieving almost £5 billion in cost savings. In 2013, WRAP estimated that the average cost incurred by food manufacturers (the midpoint in the value chain) for every tonne of FW was £950. Accounting for 11 years' UK inflation (2013-2024) and the pound sterling to Canadian dollar exchange rate[43] at the time of writing the report, WRAP's estimate equates to $2,412 per tonne of FW.

The pre-competitive commitment by major UK retailers and food manufacturers to collaborate on FW reduction continues, with them having voiced their support for the UK government to introduce legislation that will mandate all businesses over a certain size to report their annual FW.[44] The purpose of the move is to motivate all business to improve the efficiency of their operations and reuse or donate SEF whenever physically possible.

3.12.2 Impact of Avoidable FW on Canadian Industry and Consumers

Interviewees provided examples of the degree to which Canadian businesses are financially impacted by avoidable FW. Retailers recounted how they could construct and fit-out multiple stores each year with the money lost through instore FW. The cantaloupe and honeydew melon incident described in section 3.6.2 saw a farmer loose a valuable revenue source due to environmental circumstances and a customer's procurement decision, both of which were beyond his control. Another respondent described how transportation delays had caused avoidable FW on a scale for which its value exceeded the importer's net worth.

Many other examples exist of the opportunities for individual businesses operating in multiple sectors and the wider Canadian food industry to benefit financially from reducing avoidable FW.[45] They illustrate why, in reducing FW by 1 per cent, businesses can capture financial benefits that equate to a 4 per cent increase in revenue. This improvement largely stems from how, in addressing the 20 or more costs that are associated with FW and are in addition to the face value of the food or beverage item itself, businesses can reduce their operating costs by 15 to 20 per cent. All savings go to the bottom line, leading to increased margins and profits.

In the absence of an average per tonne dollar value for each tonne of FW in food manufacturing having been established for Canada, the adjusted WRAP value of $2,412 per tonne was applied to avoidable FW volumes to arrive at a notional figure of the economic value that FW could contribute to the price of food paid by consumers.

Presented below in Table 3-12 is the proportion of food system inputs accounted for by avoidable FW for each of the seven types of food, and the volume of avoidable FW this constitutes — by food type and overall — which the 2024 FW model identified as occurring along the food value chain through to retail and HRI. They do not include household FW. The results of that analysis are presented below.

[43] UK Inflation Calculator; Monthly exchange rates - Bank of Canada
[44] Retail Gazette; Grocery Gazette
[45] Campbell Soup; Food in Canada; Italian Bakery; EarthFresh; Mainline distribution; $27 Billion Revisited

Table 3 12: Volume and Value of Avoidable FW in Industry by Food Type

Food type	Avoidable FW as % of Inputs	Volume of Avoidable FW (Million Tonnes)	Adjusted WRAP value (Million Tonnes)
Field Crops	16%	2.68	$6.47
Produce	23%	3.06	$7.38
Dairy	11%	1.08	$2.60
Meat & Poultry	5%	0.29	$0.70
Marine	7%	0.05	$0.12
Sugars	12%	0.17	$0.41
Eggs	4%	0.02	$0.05
Total volume and $ value		**7.35**	**$17.73**

As shown above, 7.35 million tonnes of avoidable FW occurred from production or importation through to the point of retail and HRI. Notionally based on the WRAP estimate of £950 per tonne adjusted for 2013-2024 UK inflation and the sterling/CAD exchange rate, which is $2,412, the value of avoidable FW occurring within the food industry equates to $17.73 billion. This figure equates to 12 per cent of the $147.44 billion that consumers spent on foods and beverages from retail in 2022, and closely aligns with the LERC estimate that avoidable FW accounts for 10 per cent of food prices paid by consumers.

4 Conclusions and Recommendations/Feedback

This final section summarizes the research conclusions. It also highlights the recommendations and feedback received by survey respondents, interviewees and workshop participants.

4.1 Conclusions

The purpose of the research completed in 2024 was to document Canada's progress in reducing FW since the release of the ACFW report in 2019, and the extensive recommendations for change contained therein. The research also sought to quantify the environmental impact of FW, particularly in relation to GHG emissions and virtual water footprint, to determine the relationship that exists between BBDs and avoidable FW, and subsequent economic impact.

Evidence presented in the research findings show that Canada's food system has become more efficient compared to the findings published in 2019. This achievement is however countered by the proportion of avoidable FW having increased in relation to total FW. Why this change has occurred can be condensed into three reasons, which together negatively impact food system economics and increase the price of food paid by consumers. These reasons are:

1. In reaction to food inflation and cost-of-living challenges, consumers seek increased value from the foods that they choose to purchase. This has led to greater focus being placed on foods purchased being pristine in quality and appearance, and more attention being placed on BBDs.
2. In an increasingly competitive marketplace typified by slender margins, retailers (and to a lesser extent HRI operators) have introduced more stringent purchasing practices, such as tighter quality specifications, for their suppliers.
3. Climate change is causing pre and postharvest production losses to increase and lead to variability in the appearance and quality of perishable foods in particular. Variability in the predictability of commodities' quality and supply is also negatively impacting processor and manufacturers' yields and margins.

Together, these and other factors described in the report are leading to avoidable FW representing a higher proportion of total food system inputs and total FW than five years ago.

Food waste equates to unnecessary GHG emissions. The environmental intensity of the three main GHGs associated with the food industry (carbon dioxide, methane and nitrous oxide) were standardized and reported as carbon dioxide equivalents (CO_2e). The GHG emissions associated with total Canadian FW is 77.65 million tonnes of CO_2e. The GHG emissions associated with avoidable FW total 25.69 million metric tonnes of CO_2e.

The domestic and international movement of food equates to the depletion of water from the region of production to produce food that is subsequently wasted. The virtual water footprint of avoidable FW is 13,314 million cubic metres. This is 35 per cent of the total water footprint of FW occurring annually in Canada, which is 37,541 million cubic metres.

The economic impacts of FW are enormous. Based on the Consumer Price Index published monthly by StatCan, the total value of avoidable FW is $58 billion. Given that the cost of food purchased in HRI operations is typically higher than the cost of food purchased in retail, this figure is conservative. The impact of avoidable FW on business performance and prices paid by consumers were also explored. Using a notional value per tonne estimate of $2,412 derived from UK estimates adjusted for inflation, the analysis found that the avoidable FW that occurs from production through to retail and HRI could account for 12 per cent of prices paid for food. These estimates represent an enormous cost to society when a significant proportion of the Canadian population are concerned about the rising cost of food.

Canada is on the road towards improving the efficiency and effectiveness of its food system, though there remains much room for improvement. As identified in 2019, FW truly is a societal issue, it is not just an industry issue. Too many businesses and members of the public are accepting of FW without contemplating the economic, environmental and societal costs that it represents. In addition, interviewees stated that, primarily for economic reasons, the proportion of SEF being donated at the grocery store level and subsequently redistributed to vulnerable populations has decreased since 2019.

A clear opportunity to further improve the effectiveness and efficiency of the Canadian food system is:

1. Setting a Canadian data benchmark and the introduction of a national FW target with progress measured against Canadian data;
2. The introduction of a federal policy on monitoring, measuring and reporting of FW by food-based businesses; and
3. Government to act on a recommendation by the Standing Committee on Agriculture and Agri-Food to "investigate how the elimination of 'best before' dates on foods would impact Canadians."

4.2 Recommendations/Feedback

The ACFW released in 2019 presented a series of detailed recommendations. As presented in Table 4-1, those recommendations for reducing FW were presented in relation to:

- Whether a business was seeking to reduce waste on its or in conjunction with other businesses;
- Specific topics regarding the measurement and reporting of FW data, and subsequently acting upon that data;
- Industry stakeholders' role in the food system and in reducing FW; and
- Timelines for implementing each recommendation.

Table 4 1: Summary of Recommendations Published in ACFW 2019 Report

Thematic Type of Recommendation	Target Action and Outcomes
Business optimization	Measure, value and report FW
	Set reduction targets
	Engage employees
	Improve forecasting
	Reduce HRI specific FW
	Improve date coding information and practices
	Ensure available, affordable temporary and seasonal labour
Marketing and merchandizing	Streamline product ranging
	Streamline product availability
	Reformulate products and packaging
Social and environmental responsibility	Raise public awareness of responsible food behaviour
	Increase donation of surplus edible food
	Improve FW management
	Incorporate the full cost of food production, management and waste into decision making
Target stakeholder	Business
	NFPs
	Industry body
	Government
Timelines	Do now
	Do soon
	Build a plan
Commercial considerations that will shape businesses' contextualization of each solution	Single business acting alone
	When business collaboration is low or developing
	When business collaboration is well established

The focus of the 2024 study was not to replicate or seek to better the recommendations published in 2019, which, as evidenced by the research findings, remain as applicable today as they did then. Instead, it sought to evidence the degree to which these recommendations have been acted upon.

4.2.1 Measurement, Reporting and Execution

In terms of FW measurement and reporting, clear headway has been made. The incidence of businesses who have implemented FW measurement and reporting programs in conjunction with the development and implementation of FW reduction has significantly improved since 2019. Research respondents stated three initiatives that would assist industry to measurably improve FW reduction initiatives, particularly among small- and medium-sized enterprises. These are:

1. Making consistent easily applicable tools available to measure, monitor and report FW. The tools must be easy to embed in businesses' overall management systems, versus being a standalone feature.
2. Increasing businesses' awareness of the importance of reducing FW from economic and wider stakeholder perspectives, and increasing the capacity of employees (particularly middle management through to senior executives) to implement sustainable FW reduction initiatives.
3. Standardizing FW terms and definitions to improve the effectiveness of enterprise and sector/industry level benchmarking efforts. For example, although WRI's Food Loss and Waste Accounting and Reporting Standard recommends specific ways to measure and report FW, it does not, however, provide specific terms and definitions for what constitutes avoidable (edible parts) and unavoidable (associated inedible parts) parts.

The financial benefit to businesses measuring FW is demonstrated by the fact that reducing FW by 1 per cent can result in the equivalent of a 4 per cent increase in revenue. This stems from having reduced costs by 15 to 20 per cent and improving overall operations by having addressed the root causes of FW.[46]

4.2.2 Increased Donation and Redistribution of Surplus Edible Food (SEF)

Numerous respondents from industry and NFPs stated that many stakeholders are donating a smaller proportion of SEF for redistribution than five years ago. Evidence captured during the research found that the primary reason for this change is economics. Apps designed to help businesses capture revenue from the sale of late dated and unsold food have increased in popularity since 2019 — resulting in less SEF.[47] As well, it is easier and less challenging/costly from labour and operational perspectives for businesses to send edible and inedible FW to animal feed or composting. Businesses also derive revenue directly from the selling of FW for animal feed, or indirectly from not paying haulage and disposal fees. In addition, businesses are more cautious about the potential for food safety related legal/financial or reputational risks arising from a food safety incident occurring in donated food. Respondents therefore recommended:

[46] $27 Billion Revisited; Table potato production and grading; Mainline distribution
[47] Canadian Grocer

1. The establishment of tax incentives, as offered in the United States, which they say clearly provides a financial incentive that motivates business to donate SEF.
2. Standardizing SEF donation and collection practices as much as possible.
3. Upcycling foods not suited to redistribution in their current form or pack size. These would be processed into foods that can be redistributed to NFPs.
4. Addressing BBD practices and reducing the misunderstandings that exist regarding their interpretation (see below).

4.2.3 Best Before Dates

A direct correlation exists between BBDs and avoidable FW;[48] however, establishing later BBD periods to communicate longer shelf life may not in itself guarantee[49] significantly less avoidable FW. The challenge is more nuanced. In light of this, respondents had four recommendations:

1. Modify and enforce date coding regulations. This could include limiting the products which can carry a date code.
2. Regulate a common standardized BBD format for all foods and beverages.
3. Incorporate the application of two dates: #1 refers to quality, #2 refers to food safety, with the second date featuring more predominantly than the first.
4. Improve the effectiveness of consumer-targeted BBD education and information initiatives.

4.2.4 Fruits and Vegetables Specifications

The need to increase consumers' willingness to purchase imperfect fruits and vegetables was commonly mentioned by respondents, due to the unrealistic expectations of many Canadian consumers for year-round access to "unblemished picture book" quality food inevitably driving avoidable FW. A number of respondents also mentioned that if retailers adopted specifications suited to strategically expanding the market for imperfect produce targeted at defined segments of the population, this too would result in less avoidable FW. Respondents made a number of recommendations in this regard:

1. Review government policies and regulations to identify those regulations that prevent or discourage the sale of fresh produce which cannot presently be sold in Canadian retail stores, resulting in avoidable FW. These efforts must acknowledge that one role of grading standards is to limit the importation of fruits and vegetables that could negatively impact the domestic produce industry.
2. Fresh fruit and vegetable suppliers and their customers (retailers and HRI) collaborate on the development of specifications suited to the sourcing and merchandizing of currently out-of-spec products (e.g. different sizing and colour variations) for select markets. This is to support the increased sale of imperfect produce where it will not undermine retailers and HRI operators' value proposition in the marketplace.
3. Communicate and promote to consumers the economic and environmental benefits of purchasing imperfect fruits and vegetables, including how seemingly imperfect fresh produce can possess better internal qualities and provide a better eating experience.

[48] E.g. van der Werf (2024); WRAP (2022); VCMI (2020); Bacenetti et al (2018); Broad et al (2013)
[49] Amani & Gaddi (2015)

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6 Appendix A:

The scope of the research document in this report is commodities/food produced and consumed domestically; food produced and exported, prior to its exportation to another jurisdiction; and imported foods that are subsequently consumed in Canada. The summary contained in this appendix describes how the estimates detailed in this report were calculated. It begins by describing the objectives and purpose that guided the design of a more granular FW model than that which was used to estimate the FW published in 2019. It then discusses changes in FW occurring along the value chain.

This is followed by a summary of the data used to establish the volume and types of commodities, and subsequently foods and beverages, flowing through the Canadian food system. It also describes how publicly available production and import/export data had been changed since the initial research was completed in 2018, prior to its publication in January 2019, and the process that the researchers used to allow direct five-year (2019 vs. 2024) food flow and FW comparisons to be made.

The appendix ends by describing known factors and limitations associated with the model and conclusions that can subsequently be drawn, and sources of data analyzed during the research.

Model Purpose and Objectives

The purpose of the model's development was to report Canada's progress in addressing FW and its environmental and economic impacts, and present findings in greater detail than those contained in the 2019 report. This includes attaining greater clarity on commercial and operational factors associated with BBDs applied to foods and beverages. The objective of developing the 2024 calculator model was to update the whole of chain FW research and analysis published in 2019, thereby providing the evidence-based knowledge required to guide the development and execution of commercial decisions and public policies needed to significantly reduce FW in Canada.

Less FW, achieved by management practices such as reducing at source and increasing the volume of surplus edible foods (SEF) donated to vulnerable populations, will produce broad socioeconomic benefits (by improving individuals' mental and physical health). Diverting surplus food in this way will also reduce the food industry's impact on the environment.

The research findings and conclusions will also inform and motivate increased alignment among different ministries and levels of government. The research highlights how cooperative and strategic partnerships between government and industry could help address FW, while also tackling environmental and socioeconomic challenges in Canada.

Model Assumptions

The key assumptions that drove the model's design and development are:

1. The volume of food entering the Canadian food system should increase in line with the population increase.
2. Although 2022 food system input data was used, those surveyed and interviewed were using their most current data (2023/24). Therefore, 2022 and 2024 data was analyzed to arrive at an estimate of FW that has occurred recently over a twelve-month period of time.
3. The volume and types of food consumed may have changed due to factors including food price inflation and higher interest rates, which affected business practices and consumers' purchasing behaviour.
4. There is increased awareness and measurement of FW along the chain leading to reduced FW.

Comparative Headline Findings

Total FW is the proportion of commodities and foods/beverages that enter the food system, though not consumed. For this report, total FW is classified as either avoidable or unavoidable. The term "avoidable FW" is used to describe foods that were edible at some point in their history, including at the time of their disposal. "Unavoidable FW" is inedible parts associated with the production of food for human consumption. Precisely what is defined as avoidable versus unavoidable differs by culture and country.

As presented in Section 3-5, the 2024 research identified that, compared to 2019, total FW has decreased by 19.7 per cent: avoidable FW has increased by 6.5 per cent; unavoidable FW has decreased by 31.8 per cent. The Canadian food system is therefore more efficient than five years ago. As reported in 2019, the highest incidence and volume of avoidable FW in 2024 is associated with the same three types of foods: field crops (including flour, bread and bakery), produce (fresh and processed fruit and vegetables), and dairy (including milk, yogurt, cheese).

How this played out in terms of total FW reported in 2019 compared to estimates derived from the 2024 study in relation to distinct points along the Canadian food value chain is presented below in Table 1. The increase in total FW occurring in processing/manufacturing, distribution and retail reflects the findings described within the body of the report, which shows a higher proportion of total FW occurring further up the value chain versus estimates published in 2019.

Table 1: Comparative Changes in Total FW Occurring Along the Value Chain (2019 vs. 2024)

Total FW Comparison	2019	2024	Percentage Point Change
Preharvest	6.4%	6.6%	0.2
Storage/Grading	17.3%	12.2%	-5.1
Processing/Manufacturing	44.0%	48.4%	4.4
Distribution	2.0%	5.4%	3.4
Retail	3.8%	5.4%	1.6
HRI	9.3%	6.8%	-2.5
Household	17.3%	15.0%	-2.3
Food Rescue	-	0.2%	N/A

Table 2: Comparative Changes in Avoidable FW Occurring Along the Value Chain (2019 vs. 2024)

Total FW Comparison	2019	2024	Percentage Point Change
Preharvest	7.7%	5.1%	-2.6
Storage/Grading	0.0%	12.8%	12.8
Processing/Manufacturing	40.0%	31.9%	-8.2
Distribution	5.8%	13.0%	7.1
Retail	10.9%	12.9%	2.0
HRI	12.5%	7.6%	-4.9
Household	23.1%	16.7%	-6.4

The analysis of research responses identified that, compared to five years ago, the ratio of avoidable to unavoidable FW has noticeably changed. Avoidable FW as a proportion of total FW has increased by 1.1 percentage points (from 18.3 per cent in 2019, to 19.4 per cent in 2024). Unavoidable FW as a proportion of total FW has decreased by 12.8 percentage points (from 39.9 per cent to 27.1 per cent).

A number of factors appear to have led to a shift in where FW occurs along the value chain and the ratio of avoidable versus unavoidable FW reported herein compared to that reported in 2019. These include a marked increase in the businesses measuring FW and those measurement practices having become more accurate. This change appears to have influenced how stakeholders define avoidable FW versus unavoidable FW.

Differences in the ratio of avoidable and unavoidable FW also relate to how food inflation and the higher cost of living has led to consumers (and subsequently retailers and HRI) having adopted more rigorous purchasing practices. Furthermore, climate change has impacted the appearance, quality and shelf life of fresh fruits and vegetables, while consumers' expectations and demands for perfect produce have increased. Further evidence of how changes in consumer behaviour have resulted in increased avoidable FW, as stated by interviewees, is the extent to which BBDs are viewed as a key indicator of product quality and value, and subsequently have greater impact on consumers' purchasing decisions than five years ago. These are among the factors that have also driven an increase in the proportion of avoidable FW further up the value chain than the estimates in 2019, while the proportion of total and avoidable FW in households has decreased.

In 2019, estimating the volume of donated surplus edible food (SEF) handled by NFPs was beyond the scope of the study. In 2024, the estimated volume of food handled by Canadian NFPs equated to approximately 1 per cent of food available for sale/consumption in retail and HRI. This figure was arrived from having analyzed survey and interview data, consulting major NFPs' annual reports, corporate retail annual sustainability reports, and speaking with NFP experts. This estimate closely matches the 4 per cent of SEF estimate reported in the Wasted Opportunity[50] (2022) report, a figure derived from the analysis of operations data provided by 943 organizations serving vulnerable populations across Canada and the analysis of data published by research bodies such as PROOF[51] and major NFPs. It is therefore considered robust. The FW associated with donated and redistributed SEF equates to 0.2 per cent of total FW.

Model Data

As mentioned previously, the scope of the study is FW occurring in Canada. As described below, since the previous research and analysis, Agriculture and Agri Food Canada (AAFC) and Statistics Canada (StatCan) are among the industry stakeholders who have revised and improved the reported data. This is especially the case for data pertaining to field crops and food imported and exported. The food flow research and analysis published in 2019 (researched in 2018) used 2016 food supply and population data. The 2024 food flow research and analysis used 2022 food supply and population data. This is because the administrative data of food production data lags by two years.[52]

Described in greater detail below are the specific datasets from which data was sourced and that had been retroactively changed between the time the ACFW study was published in 2019 and the undertaking of this 2024 study. These include:

- Domestic commodity production data for crops and livestock
- Starting and ending crop storage inventories
- Food and beverage imports/exports
- Crops produced for animal feed and biofuel production
- Crops produced for beer production

The following sections also describe changes that were made to the model used to analyze secondary and primary data from multiple sources to arrive at volumes of FW occurring along the value chain in greater detail than was possible in 2019.

[50] Wasted Opportunity: Technical Report (2022)
[51] Located at the University of Toronto, PROOF is an interdisciplinary research program studying effective policy approaches to reduce household food insecurity in Canada.
[52] In the case of marine data, it is three years behind.

Data Updates

Food production and availability data used to complete the 2019 ACFW have been retroactively updated by AAFC and StatCan. This includes the 2016 production data used to arrive at the volumes of food consumed and types/volumes of FW occurring along the Canadian food value chain. In addition, the Canadian International Merchandise Trade (CIMT) database was significantly improved in 2021, allowing improved accessibility and the use of Canadian import and export data to refine commodity flow estimates.

Given that these retroactive data revisions cannot be reverse-engineered to directly reflect the format in which 2016 data was originally presented, the following section details which specific data updates were used to revise the 2016 baseline data reported in 2019, to enable a concise comparison to the 2024 research findings.

Dairy and Eggs

In the 2024 model, eggs have been separated from dairy and now form a distinct category.

Field Crops

- A more robust calculation of grain use in animal feed was provided by the Animal Nutrition Association of Canada (ANAC). In 2019, assumptions based on industry estimates and developed with the assistance of AAFC were applied to arrive at the volume of grains and oilseed directed to animal feed. These assumptions were that 80 per cent of barley, 60 per cent of corn and 30 per cent of wheat was used to feed animals (livestock and poultry). ANAC has since published a document with 2022 data on animal feed usage based on the number of animal and nutrition requirements. These proportions have been used in the derivation of the 2022 field crop baseline data.
- Availability of an estimate for the volume of grains used in biofuel production (ethanol and biodiesel).
- Availability of an estimate for the volume of grains used in beer production.
- The adjustment of milled products, along with the destination of associated products, was made after processing.

Produce

AAFC/StatCan production data was categorized more effectively than that which existed in 2019, through the standardizing and clarifying of definitions. As with other commodities and foods, this process included using concordances to group sets of data according to HS Codes.[53]

Meat/Poultry

The increased granularity/complexity of the model, required to arrive at the level of detail that was not possible in 2019 reporting, prompted changes to the meat/poultry categories analysis and reporting.

The model has been improved to start with warm carcass weight and account for the importing/exporting of carcasses before butchering and the importing and exporting of cut meats along the chain. The previous model began with harvested meat from a carcass. Imports/exports of meat were included in the baseline data rather than as a mid-model adjustment. This revision more accurately reflects where semi and further processed meat imports enter the food system.

In addition, slaughtered animal data and average carcass weight has been updated by AAFC. There are differences in data reported at the provincial level versus the federal level. Average carcass weights would be expected to differ by province/jurisdiction versus the federal average. In addition, variances also exist between the number of animals reported as slaughtered by aggregated AAFC data and regionally reported data. To address these differences, the 2024 model used aggregated AAFC slaughter data and AAFC average warm carcass weight data.

[53] Explanation of Harmonized System (HS) Codes

Marine

Marine data lags an additional year behind all the other input data, and therefore the data is for 2015 and 2021, respectively.

Sugars/Syrups

Updated data was gathered from the Canadian Sugar Institute and Statistics Canada.

Mid-Model Adjustments

Compared to the 2019 model, mid-model adjustments reflecting food entering (imports) or leaving (exports) the Canadian food chain are significantly different, due to improved data and revisions made to achieve the desired increase in granularity of reporting.

For example, the data shows there has been a 20 per cent increase in the number of cattle slaughtered, 15 per cent increase in the number of sheep, and an 11 per cent increase in the number of poultry slaughtered. Consequently, there has been a 19 per cent increase in the amount of exported butchered meat, which is now accounted for mid-model rather than at the input stage. There has also been a significant increase in the exportation of processed dairy products.

In the previous model, there was a subcategory for "miscellaneous prepared foods." Rather than being a separate category, the items that were included in this category in the original publication have been allocated to appropriate food categories. The majority of this previous subcategory was included in produce, as its components were generally sauces. To enable the direct comparison of the 2019 and 2024 models, this has been done for both the 2016 data and 2022 datasets.

Proportion of Foods Further Manufactured

Compared to the 2019 model, mid-model adjustments reflecting food entering (imports) or leaving (exports) the Canadian food chain are significantly different, due to improved data and revisions made to achieve the desired increase in granularity of reporting.

Improvements in the visibility and proportioning of foods further manufactured (post primary processing) contained in the 2024 model compared to the 2019 model is as follows:

Dairy: The 2024 model provides more granularity by separating out liquid milk, semi solid (e.g. yogurt) and solid (cheese, powdered milk, etc.) The allocation of milk usage based on these subcategories was conducted using statistics sourced from the Dairy Board of Canada. One per cent of dairy products was assumed to go on to further food manufacturing (e.g. the production of ready-made meals, bakeries, etc.).

Eggs: Previously included with dairy, these are now a separate category, incorporating the subcategories of fresh and processed eggs. One per cent of processed eggs was allocated to further manufacturing (the production of ready to eat meals, bakeries, etc.).

Field crops: The proportions of crops and FW are similar to those published in 2019, though allocated losses are more reflective of where they occur along the chain.

Fruit and vegetables: The 2019 model and subsequent analysis assumed all produce passed through further manufacturing, with loss factors reduced accordingly to take account of this not providing a full representation of industry's structure. In the 2024 model, the proportion of fruits and vegetables assumed to pass through processing and/or manufacturing (versus sold fresh) was determined by subcategories, whose creation was guided by industry expert insights.

Meat and poultry: No definitive Canadian data exists on the proportion of meat that is further processed in Canada. To address this void, UK data sourced from the Agriculture and Horticulture Development Board (AHDB) was triangulated against information provided by Canadian industry interviewees to arrive at proxies for the proportion of beef, pork and lamb further processed. The proportion of poultry apportioned to further processing was guided by insights provided by Canadian meat industry experts. It is estimated that approximately 20 per cent of poultry is further manufactured.

Determination of Percentage of FW Along the Chain

- An online survey circulated between April and June 2024 captured 789 detailed responses. Of these, 382 responses were from businesses operating in at least one of the seven food types investigated. Median loss factors arrived at by analyzing the responses statistically were subsequently applied to the model.
- Following the initial analysis of survey data, 83 interviews were conducted with industry experts from along the chain for the seven food types encompassed by the research. Those interviewed were in a position to provide insight into the awareness of FW in their sector/organization as well as provide actual data. Where appropriate, survey data and/or conclusions drawn from the analysis of survey data were subsequently adjusted to reflect input captured during the interviews.
- Four workshops were conducted to gain on-the-ground and regional insights into volumes of food handled along the food chain, proportions processed and further manufactured, along with planned versus unplanned FW and edible FW versus inedible parts.
- In 2019, household FW was primarily based on American data from research conducted by the USDA's Economics Research Services. Since then, multiple Canadian researchers have conducted household (HH) FW research, enabling triangulated Canadian HH FW to be included in the 2024 model. Canadian HH FW data was also triangulated against the results of more extensive US studies than existed in 2019. The loss factors included in the 2024 model are lower than those reported in 2019.

Accounting for Retroactive Data Updates

To allow a comparison to be made between what happened five years ago with the current situation, updated 2016 administrative data was revisited. The comparing of 2019 versus 2024 FW estimates required the researchers to account for AAFC and Statistics Canada food system data having been retroactively updated since the ACFW was published in 2019.

The food consumption and FW volumes reported in 2019 were based on the available data for 2016, which showed that the amount of food entering the Canadian food system was ~61 million tonnes (Table 3). The more precise retroactive production and availability data analyzed for the 2024 FW update study has been significantly improved compared to that which had been analyzed in 2019, particularly in relation to field crops. Greater clarity and precision also provided improved visibility into the starting and ending storage inventories and export volumes of field crops. The analysis of this more precise and more effectively classified data found that the actual volume of commodities and foods/beverages entering the Canadian food system in 2016 was ~45.5 million tonnes.

While these changes in the quality and granularity of food system data enabled the researchers to achieve more definitive estimates in relation to distinct types of food (e.g. tree fruit and root crops as subsets of fresh produce) than possible in 2019, achieving this outcome required the FW calculator to be modified. In addition to increased granularity and complexity, the 2024 model also recognizes that a lag exists between harvest data and export reporting data.

Table 3 shows a comparison of three sets of data: the original 2019 report data, the updated 2016 food system data (used for the 2019 report) and the 2022 baseline data used in the 2024 model.

Table 3: Comparison of Model Baseline Data

Food Types	**Million Tonnes**			**% Δ** (difference between 2016-updated and 2022 data)
	2016 data used in the 2019 report	Updated 2016 data	2022 data used in the 2024 report	
Dairy & Eggs	9.3	9.2	10.3	11%
Field Crops	33.8	16.6	17.1	3%
Produce	13.3	12.5	13.3	6%
Meat/Poultry	2.5	5.0	5.6	12%
Marine	0.8	0.8	0.7	-9%
Sugar/Syrups	1.2	1.3	1.4	12%
Mid Model Adjustment(s)	0.22	0.1	-2.9	
Food System Supply	61.12	45.43	45.5	0%
Population 2016 vs 2022		36,257,421	39,276,140	8%

Derived from the analysis of updated 2016 data retroactively revised by StatCan and AAFC, presented below in Table 4 are the percentage changes in the volume (million metric tonnes) of total FW occurring at distinct points in the value chain in 2019 versus 2024.

Table 4: Total FW (Million Metric Tonnes) 2019 vs. 2024

Stage in Chain	2019	2024	Percentage Change
Production/Preharvest	1.68	1.4	-17%
Storage/Grading	4.55	2.58	-43%
Processing/Manufacturing	11.6	10.25	-12%
Distribution	0.53	1.14	115%
Retail	0.99	1.14	15%
HRI	2.45	1.44	-41%
Household	4.55	3.18	-30%
Food rescue	-	0.04	N/A

As can be seen and described in the body of the report, by volume, FW has increased in two links of the value chain: distribution and retail. Both reflect the findings described in Section 3-5 regarding how consumers' increasingly discretionary purchasing decisions are driving a higher proportion of FW up the chain, versus in households. The comparatively large increase in FW occurring in distribution, driven by more FW during storage and transportation, is likely due to more stringent purchasing practices from retailers and HRI operators in response to changes in consumers' purchasing behaviour. This includes consumers' unwillingness to buy anything that is imperfect, which in turn impairs products' flow along the chain. It may also be a function of the original distribution estimates being based on limited respondent data (both in the number of respondents and their ineffective measurement techniques), thus distribution FW may have been underreported in 2019.

Model Limitations and Differences between 2019 and 2024 Models

Derived from survey respondents, interviewees and validation workshop participants, the following are purported reasons for key changes that led to the FW model update and enabled improvements in the reporting of FW. Also noted is a limitation that impacted the estimation of food flows and FW volumes, which the research sought to address.

1. There is a greater awareness of FW, its cost and societal impact along the chain. This is reflected in the survey responses (Do you measure FW?), along with enterprises, such as retailers and distributors, including FW measurement and reporting in their ESG functions.
2. The responses to the research published in 2019 (namely survey responses and interviewees) were comparatively few in their detail, with significant variation across the responses provided. Conservative defendable estimates of FW were arrived at by removing erroneous data through statistical analysis. With increased FW awareness, 2024 saw an increase in the number and depth of survey responses. It can

therefore be concluded that estimated FW figures reported as occurring along the chain in 2024 are more robust and granular than those reported in 2019.

3. Due to the time lag between model input data (2022) and the FW factors reported by survey respondents and interviewees, there is potential for some misalignment between the FW factors gleaned from the primary research and the food flow estimates gleaned from the analysis of secondary data.
4. Canada does not produce any robust estimates of the comparative volumes and types of food sold/consumed in retail versus HRI. Based on industry experts consulted at the time, the research published in 2019 assumed that 65 per cent of all food was sold via retail and 35 per cent was sold or consumed via HRI. Guided by insights provided by industry experts in relation to specific types of food, the 2024 model is considered to represent a more robust estimate of food types and volumes sold or consumed in retail versus HRI.
   - The proportions of each of the seven types of food supplied to retail versus HRI and contained in the 2024 model are:

Food type	Retail	HRI
Field Crops	73%	27%
Produce	71%	29%
Dairy	73%	27%
Meat/Poultry	54%	46%
Sugar	65%	35%
Marine	52%	48%
Eggs	76%	24%

Data Sources

Presented below in Tables 5 and 6 are the sources of production and trade data from which domestic food flow types and volumes, and subsequently FW volumes, were derived.

Primary Production Data

The mass balance inputs were populated using production data gathered from StatCan (referred to as "STC" in source table below), AAFC and Fisheries and Ocean Canada (FOC), along with data provided by industry for sugar. Table 5 provides details regarding all the sources of production data that formed the basis of the model used to calculate Canadian FW.

Table 5: Production Data Sources

Food Type	Data Source
Dairy	Canadian Dairy Information Centre (2022) hectolitres converted to tonnes based on the density of 1.03kg/litre
Eggs	Number of eggs sold for consumption from STC Table 32-10-0119-01 converted to tonnes based on an egg size of 56g
Field Crops	Grain Supply • STC Table 32-10-0359-01 Estimated production of principal field crops (tonnes). • Table 32-10-0013-01 Supply and disposition of grains in Canada Est of use in animal feed Animal Nutrition Association of Canada (2024) 2022 Estimates of animal feed consumption Estimate of use in beer • STC food availability data (2022) Estimate of use in biofuel • USDA-GAIN (2023) Biofuels Annual- Canada
Meat & Poultry	Monthly red meat slaughter (AAFC); beef, pork and lamb/goats Average warm carcass weights (AAFC) beef, pork and lamb/goats Poultry – STC Table 32-10-0117-01: Production and disposition of poultry meat. Number of animals slaughtered by species were converted to carcass weight based on the Federal Average Carcass weight.
Produce	• Greenhouse production – Table: 32-10-0456-01 • Mushroom production – Table: 32-10-0356-01 • Fresh and processed fruit production – Table: 32-10-0364-01 • Potatoes – Table: 32-10-0358-01 (weight converted from hundredweight to metric tonnes (*.0508023) • Vegetables (non-greenhouse) – Table: 32-10-0365-01
Sugars and Syrups	• Maple sugar production – Table: 32-10-0354-01 (maple products expressed as syrup (gallons) converted to metric tonnes based on 1 gallon of syrup = 13.246 pounds and 1lbs = 0.453592kg) • Honey production – Table: 32-10-0353-01 (lbs converted to tonnes) • Tonnes of refined sugar from sugar beets – Canadian Sugar Industry Statistics
Marine	Fisheries and Oceans Canada (2022) Canada Fisheries Fast Fact 2022 (this data lags other statistics, most recent data and that which was used in analysis is from 2021)

Imports and Exports Data

All import and export data was gathered from the Canadian International Merchandise Trade Web Application. Using the harmonized system (HS) code exports and imports, the data was categorized into the seven categories and 25 subcategories of foods and beverages were established.

Table 6: Import/Export Data Categorization

	HS Chapter	Included	Excluded
Dairy	4	Milk, cheese, butter, yoghurt, fermented milk products, powdered milk and eggs (fresh and processed)	
Eggs	4	All eggs	Hatching eggs, birds' eggs fertilized for incubation, edible products of animal origin, not elsewhere specified
Field Crops	7 10 12	All grains Lentils, peas, beans, and leguminous vegetables Oilseeds-soya beans, mustards seed, sunflower seed, rape or colza seed, linseed (flaxseed)	Seeds for sowing Animal feeds
	11 15 23	Grain Products and Oilseed Products (AAFC Concordance file to allocate)	
Meat & Poultry	2	Fresh and frozen cuts, offal, fat and processed, beef, pork, lamb/mutton and poultry.	
	16	Prepared/preserved meat and poultry products	
Produce	7 8 9	Vegetables Fruit and nuts Coffee, tea, spices	Peas, beans, lentils and leguminous vegetables excluded from here and included in field crops.
	20	Prepared/preserved produce, including fruit and veg. juices (1 litre = 1 kg)	
Sugars, Syrups and Confectionary	4 17	Honey (HS040900) Raw sugar (beet and cane) Maple sugar and syrup	
	17 18	Sugar confectionary, chewing gum-containing sugar, chocolate etc.	
Marine	3	Fish and crustaceans, molluscs and other aquatic invertebrates	
	16	Prepared/preserved fish and crustaceans, molluscs and other aquatic invertebrates	

By adding imports and subtracting exports, this adjusted the baseline to establish the raw food product available to flow into the food system. It is acknowledged that the imports and exports of prepared or minimally processed foods would occur further through the chain, and thus two adjustment points were made within the model: one after processing for minimally processed products, and one after manufacturing for prepared foods. Prepared foods were allocated to the food category of their dominant ingredient.

7 Appendix B: Analysis of FW for 7 Categories and 25 subcategories

The following section presents the research findings in relation to 25 subcategories of food. Each category and subcategory encompasses fresh and processed foods. For example, in produce, 65 per cent[54] of total domestic Canadian potato production is processed into products such as French fries, chips and other food products. Potatoes are also used in the manufacture of fresh and frozen entrees. During any calendar year, a significant volume of potatoes in fresh and processed form are also exported and imported. The results presented include FW associated with exported fresh and processed foods prior to their export and imported foods following their importation.

The production segment of the bars shown in the figures include FW that occurs pre- and during harvest,[55] during storage, and during the grading/packing process. This includes the FW that occurs during the grading/packing of imported fruits and vegetables. The processing and manufacturing segments of the bars encompasses the FW associated with the proportion of commodities that are processed (e.g. pork carcasses into primal cuts; melons into fruit trays) and manufactured (e.g. pork into pulled pork; potatoes into French fries). This includes FW which occurs prior to that product's export or post product's import. The distribution, retail, HRI, household and food rescue segments of the bars pertain solely to FW associated with food that remains in Canada.

The "FW/Inputs" and "Avoidable/Total FW" pie charts represent total FW as a proportion of total inputs and avoidable FW as a proportion of total FW, respectively.

The table below shows the seven food types, and the 25 subcategories of fresh and frozen foods contained within, in the order in which they are presented in the following pages. As mentioned, their order reflects the total volume of weight that each food represents.

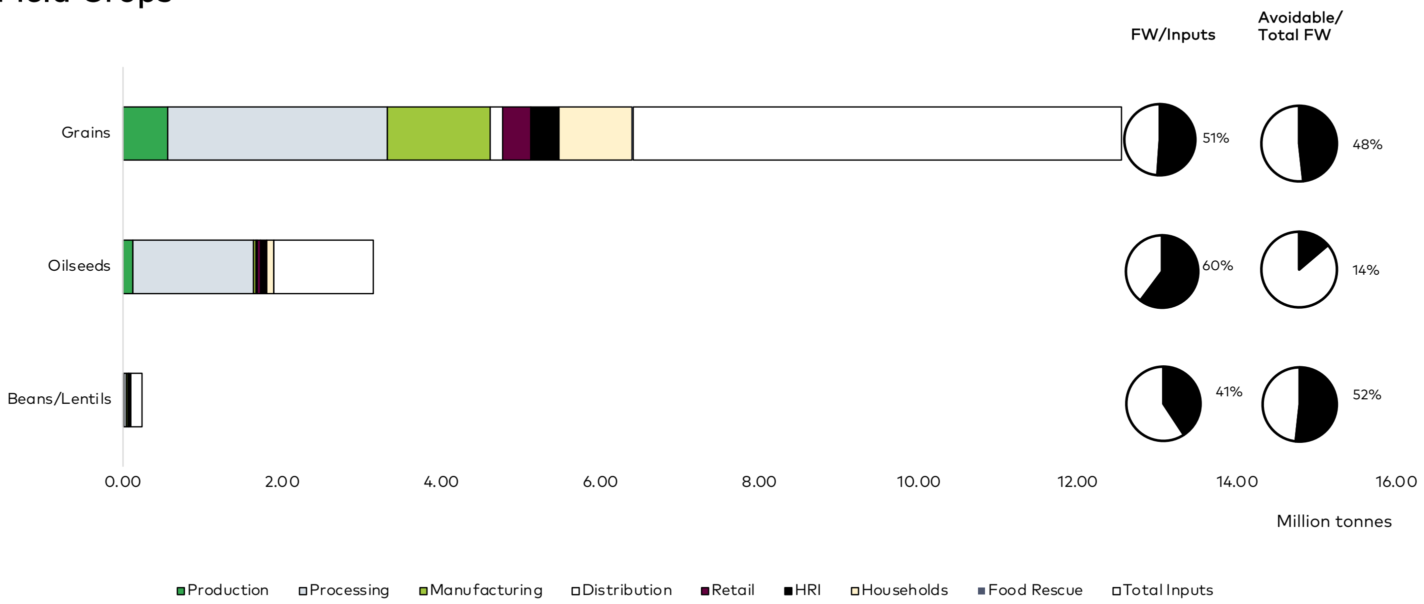
Categories and Subcategories of Food

Field crops	Produce	Dairy	Meat	Sugar	Marine	Eggs
Grains	Root vegetables	Solid	Poultry	Sugar	Seawater	Fresh
Oilseeds	Other perishable	Semi-solid	Pork		Aquaculture	Processed
Beans/lentils	Exotic fruit	Liquid milk	Beef/red meat		Freshwater	
	Other storable		Lamb			
	Tree fruit					
	Brassicas					
	Greenhouse veg					
	Berries					
	Leafy greens/ salads					

[54] Potato Market Information Review 2022-2023

[55] During the mechanical and hand harvesting of crops, a proportion of total yield is invariably lost. Reasons for this include soil type and condition, crop characteristics (e.g., canola is susceptible to pod drop and shattering as it dries in the field or is harvested), equipment set-up and operation, and weather conditions at the time of harvest.

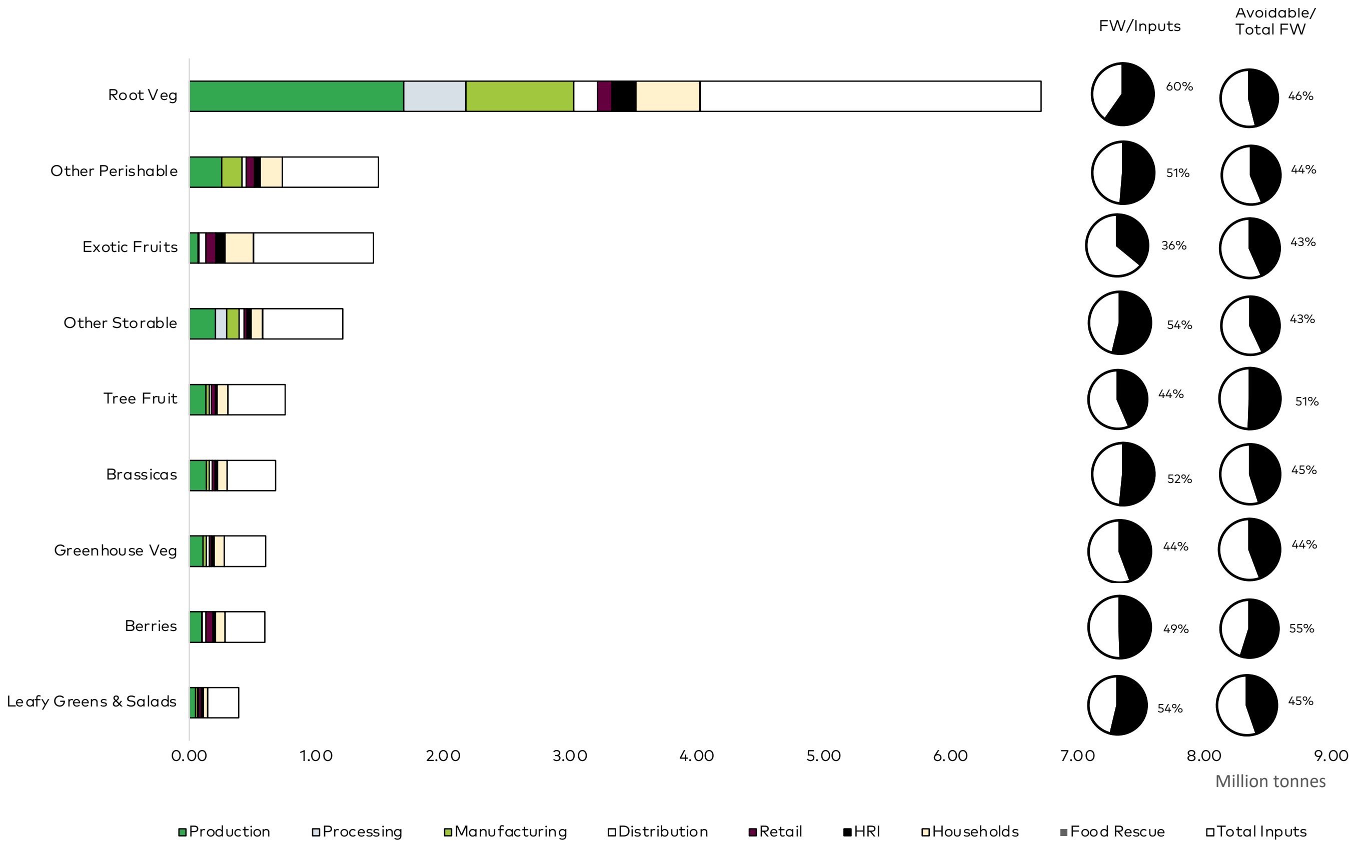
Field Crops



Consumer products in the above field crops chart include:

- **Grains**: flour, bread, cakes, crackers, pastries
- **Oilseeds**: vegetable oil, margarine, tofu
- **Beans/lentils**: chickpeas

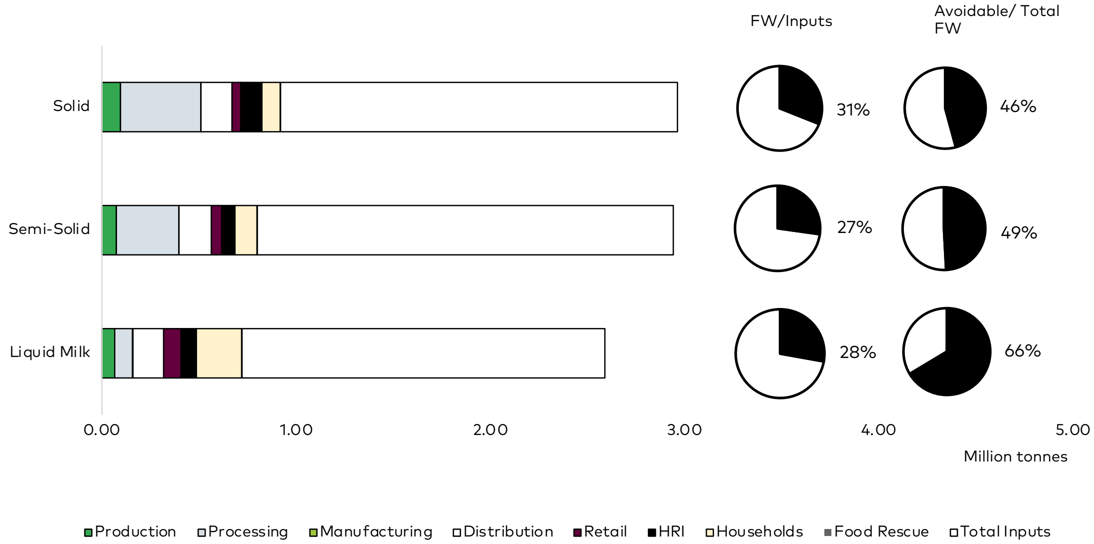
Produce



Consumer products in the above produce chart include:

- **Root vegetables**: table potatoes, carrots, baby carrots, parsnips, French fries, crisps, hash browns, soups, ingredients in entrees
- **Other perishables**: fresh sweet corn, field grown tomatoes/peppers/cucumbers, mushroom, wax beans, melons, green onions, asparagus, pasta sauce, salsa, guacamole, tinned tomatoes, ketchup, ingredients in entrees
- **Exotic fruits**: bananas, oranges, mangoes, fruit trays, smoothies
- **Other storables**: onions, garlic, pumpkins, squash, onion rings, ingredients in entrees
- **Tree fruits**: apples, pears, nectarines, peaches, juices, canned fruit
- **Brassicas**: cabbage, cauliflower, broccoli, coleslaw
- **Greenhouse vegetables**: greenhouse grown tomatoes, cucumbers, capsicums, mixed salads
- **Berries**: strawberries, raspberries, blueberries, cranberries, smoothies
- **Leafy greens and salads**: iceberg, romaine, spinach, arugula, bagged salads

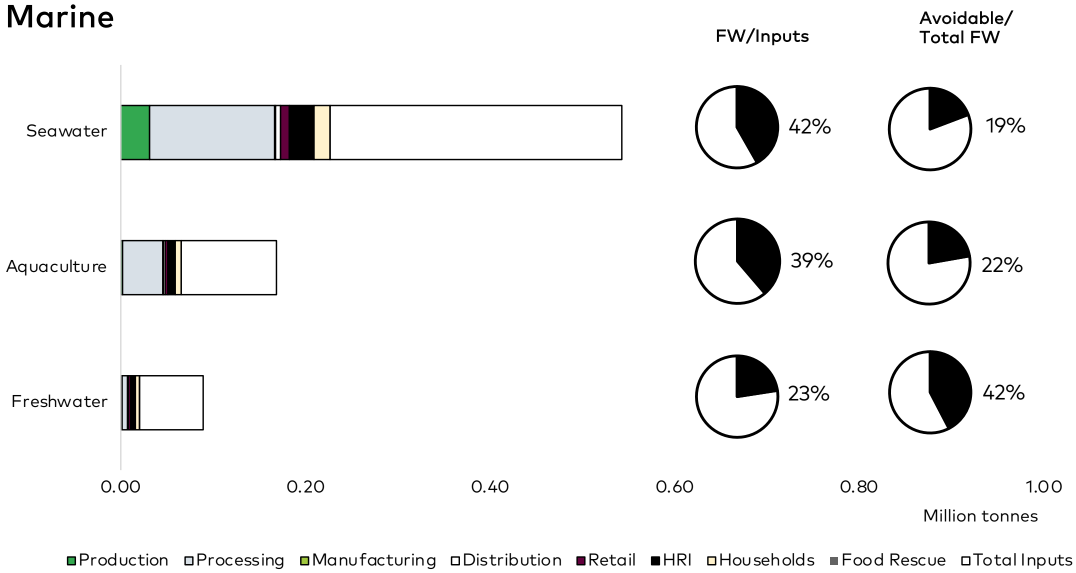
Dairy



Consumer products in the above dairy chart include:

- **Solid**: cheese, butter, ice cream
- **Semi-solid**: yogurt, cottage cheese, sour cream
- **Liquid milk**: plain and flavoured milk, long life milk

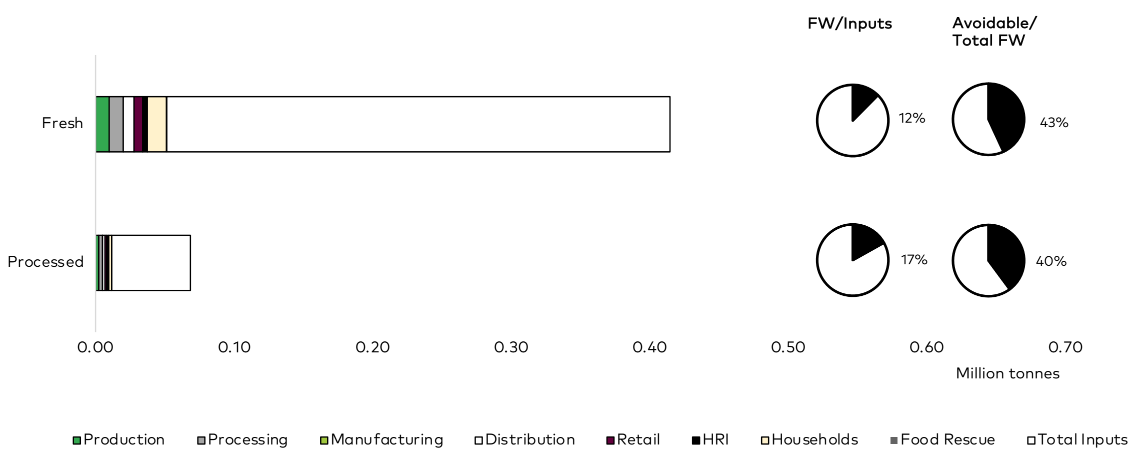
Marine



Consumer products in the above marine chart include:

- **Seawater**: salmon, cod, haddock, tuna, shrimp, scallops, lobster
- **Aquaculture**: salmon, mussels, oysters, shrimp
- **Freshwater**: salmon, trout, walleye

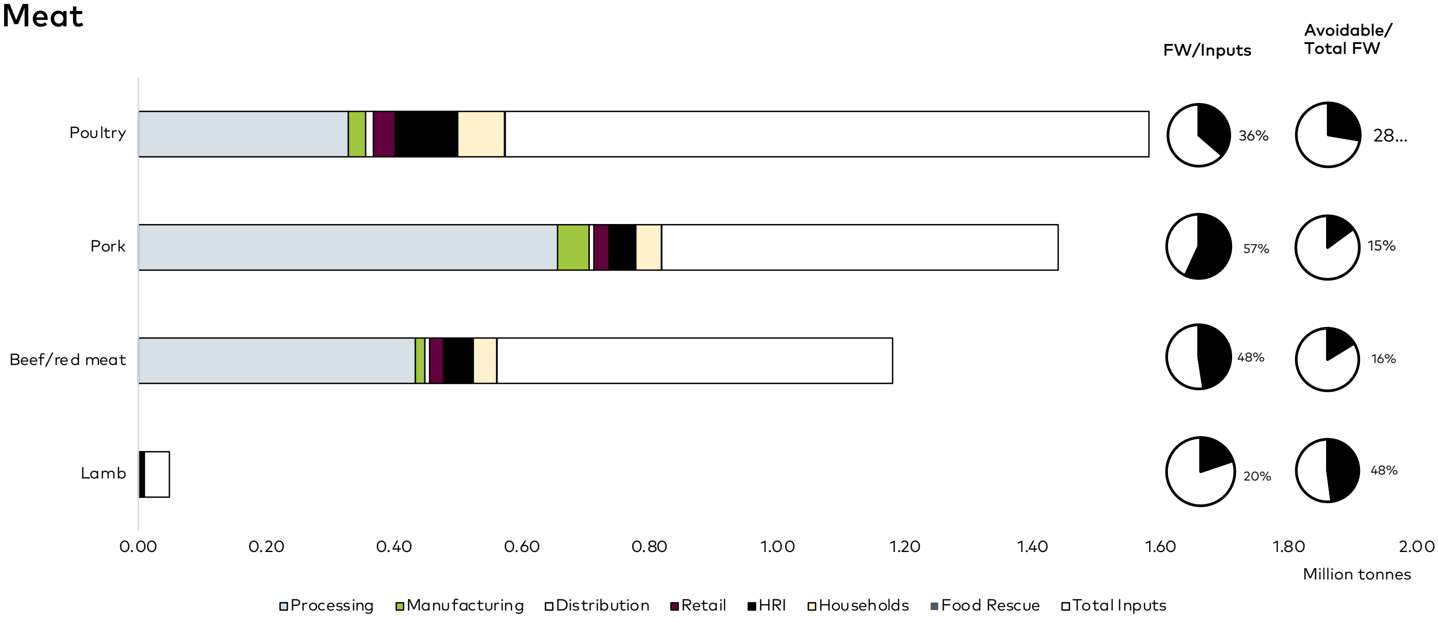
Eggs



Consumer products in the above eggs chart include:

- **Fresh**: unshelled chicken and duck eggs
- **Processed**: liquid eggs, boiled eggs, omelets, dried yolk

Meat



Consumer products in the above meat chart include:

- **Poultry**: chicken, turkey, duck, goose, offal (e.g. liver, kidneys, ingredients used in food manufacturing)
- **Pork**: pork cuts, bacon, sausages, offal (e.g. liver, kidneys, ingredients used in food manufacturing)
- **Beef and red meat**: beef, veal, venison, bison, offal (e.g. liver, kidneys, ingredients used in food manufacturing)
- **Lamb**: lamb, mutton, offal (e.g. liver, kidneys, ingredients used in food manufacturing)

Sugar

Consumer products in the above sugar chart include:

- **Sugar**: granulated sugar, soft drinks, confectionary

8 Appendix C: Calculating the Environmental Impact of FW

Following is a description of the methodologies employed to estimate the GHG emissions and water footprint of total, avoidable and unavoidable Canadian FW along the value chain in relation to distinct foods and beverages. The calculation process drew on the work previously completed by VCMI for Second Harvest, RECYC-Quebec and other businesses/organizations.[55]

GHG Intensities and Emissions Associated with FW

The calculation of GHG intensities and emissions associated with Canadian FW was developed using publicly available peer-reviewed data, specifically data related to the Canadian market. This began by consulting Statistics Canada (StatCan) data to identify key primary production regions, food availability and importation. The calculation is for the seven food types presented in the FW model: dairy, eggs, field crops, produce, meat/poultry, marine and sugar/syrups and 25 food subcategories residing within each of the seven overarching food types investigated. The calculations encompass three key GHGs (carbon, methane and nitrous oxide) accounted for by standardizing each to tonnes of CO_2e (carbon dioxide equivalents).

Production GHG intensities were gathered for the dominant production regions: domestic and international. Based on the proportion of imports for each of the seven food types, established by having consulted StatCan data and industry experts, a representative intensity was then calculated for each of the 25 subcategories. The GHG intensity of the seven food types are based on the weighted average of the subcategories. The weighting of the subcategories within each category was developed using StatCan food availability data.

In limited circumstances, a proxy intensity of a similar product was used to calculate subcategory GHG emissions. Intensities for prepared foods were calculated based on the proportion of ingredients within them. Processing GHG intensities was sourced from Canadian data. Where Canadian data was not available, a proxy processing intensity from the US or similar economy was used.

All foods were classified as either ambient or chilled/frozen and the GHG intensities for retail presented by Poore & Nemecek (2019) were used. This accounts for GHG associated with the energy used in retail to keep food fresh and ready for sale.

Greater Toronto Area was used as the proxy for transportation distances. The mode of transport from domestic and international production to Toronto was collated for each food subcategory. The transport intensities reported by Poore & Nemecek (2019) were used to estimate emissions for the various modes of transport: road, rail and sea (ambient and refrigerated). All transport-related emission estimates were standardized to 1 kg of food per km.

[56] Examples include the creation of Second Harvest's GHG and water calculators, and the FW and associated GHGs in the Province of Quebec.

Table 1 presents the GHG (CO_2e) intensities used to calculate the GHG associated with FW that occurs along the chain.

Table 1: GHG Intensities by Food Type

Representative GHG (kg CO_2e/kg product)	Production	Processing	Retail	Transportation
Meat/Poultry	18.916	1.385	0.259	0.564
Dairy	8.693	0.557	0.247	0.214
Field Crops	0.716	0.310	0.043	0.183
Marine	7.054	2.628	0.190	0.403
Produce	0.245	0.041	0.084	0.872
Sugar/Syrups	1.138	0.595	0.040	0.188
Eggs	1.858	0.000	0.270	0.228

The total volume of FW estimated by the 2024 FW model at each point in the chain was multiplied by the appropriate intensities. Table 2 shows where those intensities were applied. Transportation was only applied to retail and distribution, as this constitutes the bulk of the transportation from point of primary production and/or processing/manufacturing to the point of consumption. Applying transport intensities to households, HRI and food rescue risks double counting the GHG associated with transportation. Thus, the reported estimate of GHG emissions is considered conservative.

Table 2: GHG Intensities Applied at Each Stage of the Chain

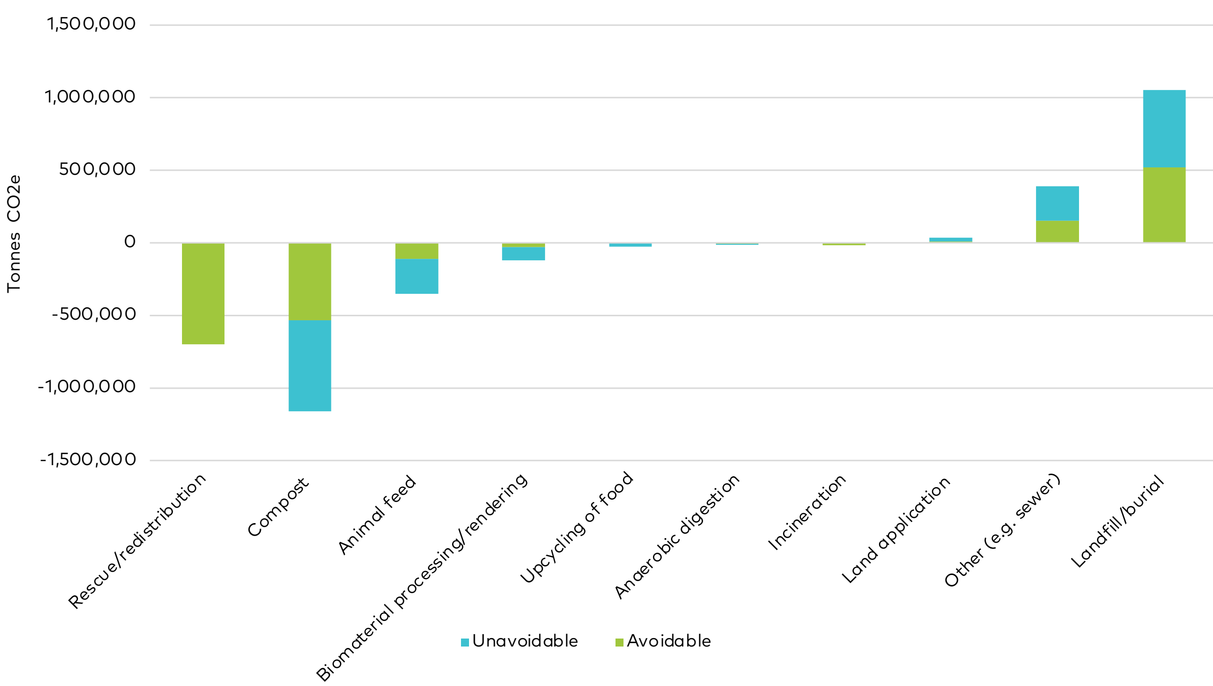
Primary Production	Processing and Manufacturing	Retail & Distribution	Households	HRI	Food Rescue
Production	Production + Processing	Production+ Processing+ Retail+ Transportation	Production+ Processing+ Retail	Production+ Processing+ Retail	Production+ Processing+ Retail

Destinations Intensities

Survey respondents were asked to provide their dominant form of FW disposal.[57] These responses informed the destination analysis that allocated avoidable and unavoidable FW along the chain to various destinations. Emissions factors applicable to these various destinations and points in the chain were applied to the estimated tonnage of FW disposed of via these destinations. These destination emissions factors are from work conducted by ReFED (2021) in the United States. ReFED shares an extensive database of GHG emission intensities and the methodology employed to calculate them.

To account for GHG being emitted or sequestered depending on the destination, a destination adjustment was made to the overall calculation of GHG associated with FW from along the chain. Overall, this adjustment reduces the GHG emissions from FW by 1.2 per cent. Figure 1 presents the overall effect of destination on GHG by disposal method. The "0" baseline represents the unconsumed food or beverage items' CO_2e prior to its rescue, or direction to an alternative destination. Anything below the baseline shows the volume of CO_2e that was prevented from having been emitted unnecessarily by having directed SEF or FW to a particular destination. Anything above the baseline shows the volume of CO_2e related to a particular destination, such as methane released during the decomposition of organic matter in landfill.

Figure 1: Net GHG Emissions From Disposal Destinations



[57] Household destinations are based on data from Quebec.

As presented in Figure 3-19 of Section 3-11, on average, for each tonne of food, the redistribution of SEF represents a reduction of approximately 2.6 tonnes of GHG having been emitted unnecessarily. By contrast, the sending of FW to landfill leads to an additional ~0.5 tonnes of GHG being produced due to the methane created during the decomposition of organic matter.

As can be seen, though the volume of SEF rescued and redistributed to vulnerable populations is significantly less than the volume of avoidable and unavoidable FW directed to compost and animal feed, per tonne, its comparative effect on preventing the unnecessary emissions of CO_2e is considerable.

GHG Analysis Results

The total FW tonnage calculated by the 2024 FW model at each stage of the chain by food type is presented in Table 3.

Table 3: Tonnage of FW Calculated by 2024 FW Model

Total FW Tonnes (avoidable + unavoidable)	Primary Production	Processing & Manufacturing	Retail and Distribution	Households	HRI	Food Rescue
Meat/Poultry	0	1,511,114	107,950	151,679	189,654	2,628
Dairy	234,534	831,998	671,958	437,303	258,122	6,756
Field Crops	691,838	5,656,777	576,929	1,022,503	438,761	16,430
Marine	34,003	186,962	23,666	27,509	39,568	278
Produce	2,989,133	1,790,331	837,627	1,341,731	427,755	9,341
Sugar/Syrups	21,571	264,337	45,686	179,896	84,342	1,709
Eggs	12,399	12,606	17,210	15,885	4,645	309
TOTAL	**21,175,432**					

Total GHG emissions bound up in the FW occurring along the food chain are presented in Table 4, and Figure 2 illustrates where in the chain the FW is occurring. The small pie charts in Figure 2 show the proportion of these GHG emissions associated with avoidable FW.

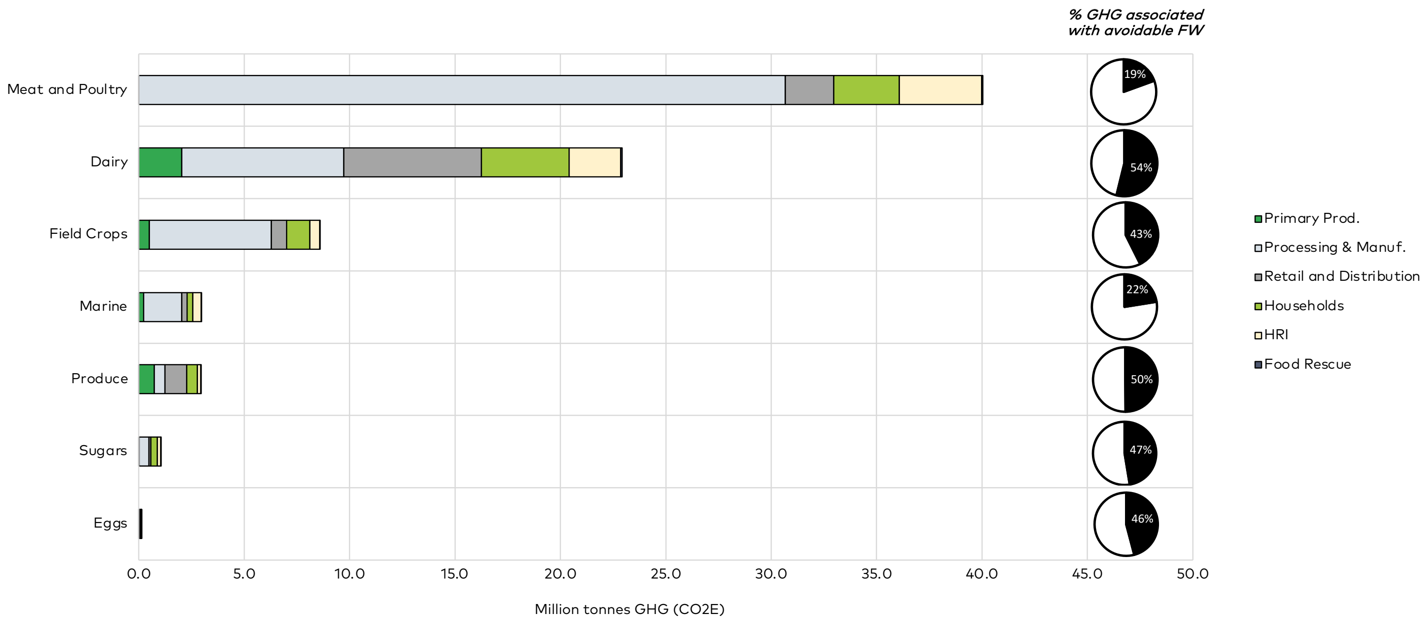
Table 4: GHG Emissions Associated with Avoidable and Unavoidable FW

Million Tonnes GHG (CO_2e)	Avoidable FW	Unavoidable FW	Total FW
Meat and Poultry	7.79	32.24	40.03
Dairy	12.34	10.59	22.93
Field Crops	3.67	4.93	8.60
Marine	0.67	2.29	2.96
Produce	1.47	1.47	2.94
Sugar, Syrups/ Confectionary	0.49	0.55	1.04
Eggs	0.06	0.07	0.13
TOTAL	**26.48**	**52.15**	**78.63**
Destination Adjustment	-0.80	-0.19	-0.98
TOTAL GHG with Destination Adj.	**25.69**	**51.96**	**77.65**

For meat and poultry, the FW calculator does not report FW at production, because the model's starting point is carcass on a hook. The high production GHG intensities of meat production is therefore seen in the processing/manufacturing, where significant unavoidable waste occurs as the animals are butchered and further processed.

The most recent Canadian inventory of GHG emissions (2024) reports that agriculture is responsible for 70 million tonnes of CO_2e. VCMI calculated that the FW occurring at primary production equates to ~3.6 million tonnes of CO_2e. Thus, FW contributes to ~5 per cent of the total GHG emissions associated with Canada's agricultural industry.

Figure 2: GHG (CO_2e) Associated With Total FW Along the Chain



Water Footprint

The concept of a virtual water footprint is used to measure the water resources required to produce a product. The water footprint was established to help understand water usage within our global economy. Like energy, water can neither be created nor destroyed. It transitions through our global economy and is used in the production of the food we grow, consume and waste. The international movement of foods and beverages represents the movement of water (particularly blue water) from the place of production to the place of consumption/wastage. The water footprint has three types of water: green, blue and grey.

Green water is "from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products." (Water Footprint Network).

Blue water is "sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time." (Water Footprint Network) e.g. irrigated agriculture.

Grey water is "the amount of fresh water required to assimilate pollutants to meet specific water quality standards." (Water Footprint Network).

The work conducted by Mekonnen & Hoekstra (2010) for UNESCO provides a comprehensive water footprint dataset for the world and the food/beverage products we derive from our planet. Similar to the methodology used for GHG intensities, the peer-reviewed dataset of water footprint intensities was used to gather intensities relevant to the Canadian food system. These intensities were then proportioned, based on the ratio of imported vs domestically produced product and dominate production location.

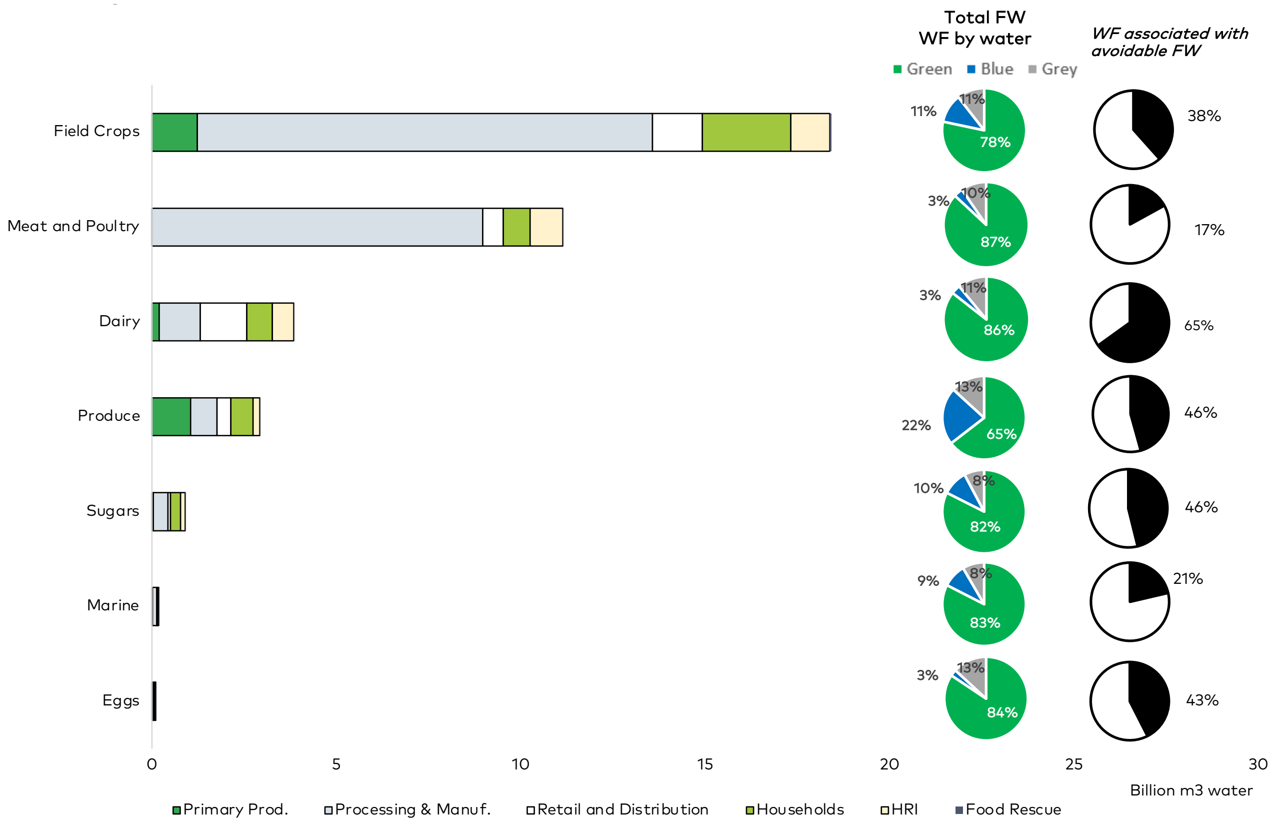
Table 5 shows the representative water footprint intensities resulted from the analysis. These intensities were multiplied by the tonnes of FW resulting from the 2024 FW calculator. Figure 3 shows the water footprint of representative foods residing within each of the seven types of food.

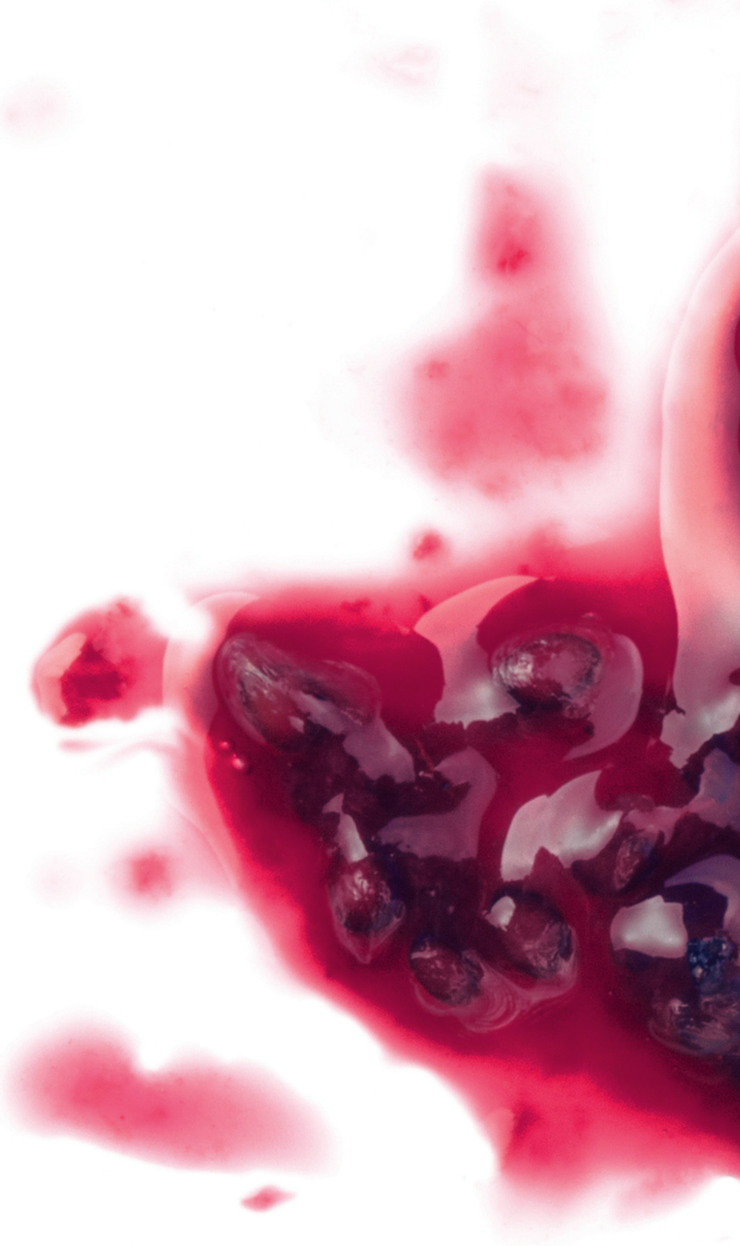
Table 5: Representative Water Intensities Used in the Water Footprint Calculation

Water Footprint	WF Intensities m³/Tonne of Food			
	Green	Blue	Grey	Total WF
Dairy				
Milk	716	26	92	834
Semi-solid	1,063	40	136	1,239
Solid	3,296	137	422	3,855
Eggs				
Eggs	1449	42	226	1718
Field crops				
Grains	1,181	5	177	1,362
Oilseeds	2,743	513	309	3,565
Beans/Lentils	1,636	7	1,603	3,246
Produce				
Fruit	427	237	67	732
Vegetables	191	59	58	308
Salad	36	39	45	120
Processed Produce	1,071	125	150	1,345
Meat/Poultry				
Beef	8,915	198	794	9,907
Lamb	6,833	336	11	7,180
Pork	4,402	370	727	5,498
Poultry	1,513	31	234	1,777
Marine				
Marine	489	54	50	592
Sugar/Syrups				
Sugar/Syrups	1,247	148	117	1,513

In Figure 3 below, the left-hand series of pie charts presents the proportion of green, blue and grey water utilized in the production of foods within these categories. The right-hand series of pie charts presents the proportion of water associated with avoidable FW. By reducing food waste, we are reducing the burden on our domestic and global water resources. This consideration is critical, given how changing weather patterns are leading to water scarcity in Canada and many regions of the world from where we source food.

Figure 3: Total water footprint of FW by food type along the chain, ratio of water type and amount of water footprint associated with avoidable FW





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