THE AVOIDABLE CRISIS OF FOOD WASTE:

technical report

ACKNOWLEDGEMENTS

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The Food Loss and Waste Stakeholder Advisory Committee played a critical role in ensuring this project delivered primary data on food loss and waste in the Canadian supply chain and that the strategic direction of this project accurately represented the current food waste landscape. We want to thank the following organizations for their contribution:

Dalhousie University
Gordon Food Service
Loblaw Companies Limited
Maple Leaf Foods
Metro Inc.
Provision Coalition
Sodexo Canada
University of Guelph
Walmart Canada
Bette Jean Crews, Independent

This project was made possible by a generous donation from the ***Walmart Foundation.***

Walmart Foundation

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Suggested citation: Gooch, M., Bucknell, D., LaPlain, D., Dent, B., Whitehead, P., Felfel, A., Nikkel, L., Maguire, M. (2019). The Avoidable Crisis of Food Waste: Technical Report; Value Chain Management International and Second Harvest; Ontario, Canada.

Accessible from: www.SecondHarvest.ca/Research

Second Harvest is Canada's largest food rescue organization and an expert in perishable food recovery. Every year we are expanding our network to include more farms, manufacturers, distributors and retailers. We work with hundreds of businesses across the food supply chain, reducing the amount of edible food going to waste, which in turn stops millions of pounds of greenhouse gases from damaging our environment. The food Second Harvest recovers is redirected to social service organizations and schools, ensuring people have access to the good food they need to be healthy and strong. Second Harvest is a global thought leader and continually innovates processes and shares methods, to create a better future for everyone.

www.SecondHarvest.ca
www.FoodRescue.ca

Value Chain Management International (VCMI) has authored/co-authored several publications on food loss and 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.

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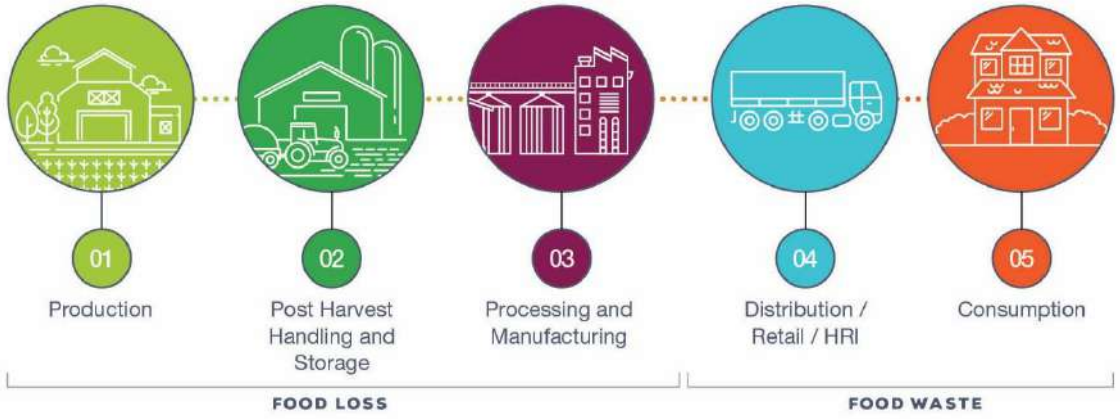
Executive Summary

Stated in simple terms, food loss and waste (FLW) is 1) the discarding of resources along the value chain utilized in the production and distribution of consumer foods and beverages, and 2) foods purchased by consumers though not eaten. As shown in the diagram below, the term "food loss" is typically used to describe the discarding of food that occurs from production through to processing, while the term "food waste" describes the discarding of food during its distribution to consumers through retail or foodservice and subsequently in the home. Food waste also applies to food and beverages that are donated to food rescue organizations but end up being discarded.

Commonly Accepted Distinction between Food Loss and Food Waste



A year-long study, undertaken by Value Chain Management International in partnership with Second Harvest, has led to the development of this technical report, which is a guide to reducing FLW in Canada through prevention and redistribution, and reducing FLW going to landfill by reuse and recycling.

The report reflects the Food Recovery Hierarchy produced by the United States Environmental Protection Agency.[1] The Food Recovery Hierarchy states that the most preferred FLW management approach is to reduce at source, followed by redistribution to address hunger, reuse (e.g. feeding to animals), and recycle (e.g. turning FLW into bio-fuel). The least preferred FLW management option is landfill.

This is a world-first project; the following factors that differentiate our project from prior FLW research are summarized below.

- It is a whole of chain analysis, from primary production through to end of life (incl. consumed, lost or wasted).

[1] https://www.epa.gov/sustainable-management-food/reduce-wasted-food-feeding-hungry-people

- The whole of chain analysis includes the rescue of all food types from along the value chain and the effectiveness of efforts involved in redistributing food to community food groups.
- It establishes a replicable whole of chain FLW analytical framework, comprising standardized metrics that can be utilized at enterprise and industry level.
- The project encompasses all food types, sourced/processed from terrestrial and marine commodities.
- It identifies then validates loss factors based on primary data provided by industry.
- It calculates mass balance: total available commodities produced for food, minus exports, plus imports (from a whole chain perspective).
- It establishes a means to connect commodities to finished products (foods and beverages), to enable extrapolations to be established between consumer products and primary source.
- It identifies the root causes of FLW, where they occur along the value chain, and the extent to which they differ by food type.
- It assesses the destination of FLW occurring along the value chain.
- It estimates household FLW by having Canadianized loss factors produced by USDA/ERS.[2]

Two forms of FLW occur along the food chain: **1) planned (unavoidable) FLW** – such as animal bones; and **2) unplanned / post-processing (avoidable) FLW** – such as apples that reach the retail store, though are not purchased by consumers due to having been bruised in transit. Because it is preventable, avoidable FLW represents the greatest opportunity to reduce FLW. This can be achieved by improving the processes involved in producing/catching, manufacturing and distributing foods and beverages to consumers.

The research identifies that all types of FLW are avoidable to a degree, because reducing avoidable FLW has a direct and positive effect on the occurrence of unavoidable FLW. An example is bread: less avoidable waste in foodservice, retail stores and in the home (due to better forecasting, handling and storage) would result in less production waste further up the chain. This would be because less grain would be milled in the production of the flour, and in turn less flour used in the manufacturing of the bread.

The research estimates that the total avoidable and unavoidable FLW occurring annually along the Canadian food value chain equates to 35.5 million metric tonnes,[3] of which 11.2 million metric tonnes (32%) is avoidable FLW (the equivalent of the weight of almost 95 CN Towers). Based on the consumer (retail and HRI[4]) value of food, **the value of avoidable FLW equates to $49.5 billion,** representing 51.8 percent of the money Canadians spent on food purchased from

[2] https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation/

[3] Total FLW estimated to represent 58 percent of commodities entering the Canadian food system

[4] HRI = hotels, restaurants and institutions

retail stores in Canada in 2016. **($49.5 billion equates to 3% of Canada's 2016 GDP and would feed every person living in Canada for almost 5 months.)**

Based on an assessment produced for Second Harvest by VCMI, the GHG footprint of FLW occurring in Canada is 56.5 million tonnes of CO_2 equivalent, Based on environmental assessments of FLW produced by the Food and Agriculture Organization of the United Nations (FAO), the blue water (surface and ground water) footprint of avoidable FLW occurring in Canada is 1.4 billion tonnes. Total FLW accounts for almost 60 percent of the food industry's blue water footprint.

The root causes of the FLW that occurs in Canada include a culture of accepting waste. A direct correlation can be drawn between some business and governmental decisions and the creation of avoidable FLW. Other root causes of FLW include the true cost of FLW not being internalized by industry and consumers. In addition, there is no common template for redistributing food that would otherwise go to landfill or non-food use. Prior FLW estimations have commonly not considered foods and by-products going to animal feed as loss and waste, and that masks enormous inefficiencies.

These and other factors have negatively impacted the motivation and ability to implement the fundamental changes in behaviour within businesses, across value chains, and among consumers that are required to manifestly and sustainably reduce FLW.

Why this enormous inefficiency and the causal factors identified by the research exist are not the fault of one organization, business, sector, or government department. FLW is a systemic issue that results from how the food system presently operates. Systemic issues can only be fully addressed by tackling the underlying assumptions, values and practices that determine how the present system operates.

Addressing the systemic issues identified during the study would provide enormous economic, environmental and social benefits. **Four million Canadians have insufficient access to food. Nevertheless, of the avoidable and edible FLW that occurs along the value chain, an estimated 86 percent is currently not rescued and redistributed.**

The research findings and FLW solutions presented in this report were produced by employing value chain analysis and mass balance methodologies to:

1. Create a standardized framework for estimating, benchmarking and monitoring FLW at the business, sector, national, and international level;
2. Estimate unavoidable (planned) and avoidable (unplanned / post processing) FLW occurring along the food value chain, from the primary production or capture of terrestrial and marine commodities through to consumer foods and beverages;
3. Identify the root causes of Canadian FLW occurring in different foods and at explicit points along the value chain; and
4. Develop sustainable solutions for reducing FLW in Canada.

The above is described in greater detail in Appendix A.

The proposed actions for change that will result in reduced FLW and assist in achieving ten[5] of the targets contained in the United Nations Sustainable Developments Goal 12, to which Canada is a signatory, are summarized below in matrices contained in the following three tables. The timelines for implementing these actions are presented as "Do now (2019)," "Do soon (2020-2021)" and "Build a plan (2022 onwards)." The proposed solutions and actions are detailed at the conclusion of this report.

The three matrices together form the roadmap for reducing FLW in Canada. Many of the same actions could be applied worldwide in developed and developing nations to reduce FLW on a global scale.

[5] https://sustainabledevelopment.un.org/sdg12 - SDG goals that the project directly and indirectly connects with include: 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.A and 12.B

Do Now (2019)

	Prevent at source	Redistribution	Waste Management
Industry	• Start measuring FLW • Set FLW reduction targets • Value benefits of meeting FLW targets • Understand FLW root causes and work to improve • Deliver lean-thinking awareness training to staff • Communicate date labelling meaning to consumers • Cease using best before dates where it does not constitute a food safety issue • Review menu design to ensure unnecessary plate waste	• Identify solutions to increase redistribution of excess food from along value chain • Engage employees in redistribution initiatives • Review date code policies relating to food donation, to ensure that they do not prevent the donation of safe food • Food rescue and community food programs deliver lean thinking awareness training to staff and volunteers • Improve strategic and operational collaboration between food rescue and community food programs at all levels (federal down to local)	• Identify reuse and recycle solutions to reduce non-rescuable edible and inedible FLW from along food value chain going to landfill • Engage employees in reuse and recycle solutions • Identify opportunities to expand and improve upon current solutions to transform inedible FLW into edible foods and ingredients
Industry organizations	• Establish collaborative FLW agreement with members in conjunction with voluntary FLW reduction agreement with government • Produce common FLW reporting framework • Publish guidance on collaboratively addressing FLW • Set FLW reduction targets • Publish best practice date coding policies • Develop a lean food enterprise methodology with training and implementation support • Communicate the importance of menu design to HRI	• Establish standardized communication system and processes for donors and redistributors • Publish guidance on collaborative means to expand distribution options • Review Good Samaritan Act legislation to identify potential weaknesses and recommend standardized framework to government • Encourage public participation in volunteer gleaner programs • Improve strategic oversight of food rescue and community food programs at all levels (federal down to local)	• Publish guidance on collaborative means to increase industry's use of reuse and recycling options • Publish case studies on exemplary/leading edge reuse and recycling initiatives • Encourage and support the development of new business models by waste management haulers • Promote proven solutions for transforming inedible FLW into edible foods and ingredients

Government	• Map where FLW reduction by category can contribute to specific government objectives • Invest in strategic voluntary FLW agreement with industry • Review landfill policies, regulations, legislation and fees • Increase fees for dumping organics in landfill • Communicate responsible purchasing and food handling behaviours to consumers • Address prescriptive nature of seasonal and temporary worker programs • Provide funding for current and future lean, continual improvement training and implementation initiatives	• Produce a standardized framework for the Good Samaritan Act and produce a national awareness campaign. • Identify best practice redistribution processes and publicly funded means to enable improved redistribution • Identify infrastructure gaps preventing redistribution and potential means to address • Establish clear, robust rules surrounding the management of potentially donatable food by public health institutions, to address the current "when in doubt, throw it out" philosophy • Provide the resources required to implement the above rules	• Launch review of reuse and recycling infrastructure needs in conjunction with cost benefit analysis • Identify best practice redistribution processes • Identify infrastructure gaps preventing reuse and recycling • Fund national study of actual household FLW • Increase funding available for the development and commercialization of innovative solutions for transforming inedible FLW into edible foods and ingredients

Do Soon (2020-2021)

	Prevent at source	Redistribution	Waste Management
Industry	• Implement systems that enable increases in minimum date code life of products on receipt • Establish collaborative planning, forecasting and replenishment programs • Reduce consumer FLW through pack size optimization, packaging design and labelling • In conjunction with employee training and mentorship, implement lean enterprise to reduce FLW and associated costs • Adopt new date code formats, e.g. Julian codes	• Establish industry standard on date code protocols regarding food donations • Review and revise vendor agreements to enable donation of edible food • In conjunction with the training of food rescue and community food programs staff and volunteers, implement lean enterprise training and mentorship to utilize current infrastructure and systems more effectively • Remove any clauses in crop insurance policies that prevent the donation of edible crops	• Invest savings and revenues from FLW reduction initiatives into individual or shared reuse and recycling infrastructure

Industry organizations	• Assist members to quantify true cost of FLW • Provide CFO and executive mentorship in total cost accounting, FLW reduction best practices • Publish case studies on industry collaboration to reduce FLW • Commence publishing FLW reduction figures • Promote optimized packaging to consumers • Provide food packaging optimization advice • Standardize what a portion should be to reduce plate waste • Create official protocols for serving systems (e.g. buffet process) to encourage donation of excess food	• Support implementation of foundational redistribution system, with guidance on modifying to suit local conditions • Establish and communicate best practice standardized guidelines on date code policies regarding donated food • Work with industry and government to eliminate date codes from being abused for competitive advantage • Publish food rescue, redistribution figures • Standardize language around the descriptions used to determine whether unsold food is donated or destroyed • Identify and publish best practice models for implementation by food rescue and community food programs	• Support implementation of foundational reuse and recycling systems, with guidance on modifying to suit local conditions • Identify best practice reuse and recycling practices for packaged foods • Publish improvements in reuse and recycling, including amount diverted from landfill
Government	• Tie food procurement by public institutions to the reporting of FLW • Commence investment in infrastructure required to enable room service meal preparation and delivery in publicly funded HRI • Review impact of business relationships on FLW levels and destinations • Legislate mandatory reporting of FLW • When issuing RFPs, include need for respondents to measure and reduce the amount of food going to waste • Establish clear national enforceable date coding regulations and legislation • Establish standardized emissions polices, regulations and legislation	• Invest in the development of innovative redistribution infrastructure and initiatives, including the implementation of lean by food banks and other hunger relief agencies • Collaborate with industry, food rescue and community food programs on redistribution initiatives to ensure best practices wherever possible • Publish best practice food rescue, redistribution and community food program models • Establish clear guidelines and legal framework for allowing mislabelled food products that do not represent a food safety hazard to be donated • Ensure removal of any clauses in crop insurance policies that prevent the donation of edible crops	• Invest revenue from increased landfill and emissions taxes in the development of innovative reuse and recycling infrastructure and initiatives • Establish standardized reuse and recycling polices, regulations and legislation • Establish national ban to prevent FLW going to landfill with firm timelines for its implementation • Establish national ban to prevent FLW being dumped at sea with firm timelines for its implementation

Build a Plan (2022 onwards)

	Prevent at source	Redistribution	Waste Management
Industry	• Invest savings from FLW reduction initiatives into infrastructure and technology upgrades required to enable further reductions in FLW	• Expand scope and scale of collaborative rescue, redistribution and community food initiatives • Establish formal collaborative agreements between multi-regional food redistribution and community food programs	• Expand scope and scale of collaborative reuse and recycling initiatives
Industry organizations	• Assist businesses to individually and jointly evaluate long-term investment options to reduce FLW through prevention • Benchmark FLW reductions by industry through prevention	• Assist businesses to individually and jointly evaluate long-term investment options to reduce FLW through redistribution • Benchmark FLW reductions by industry through redistribution	• Assist businesses to individually and jointly evaluate long-term investment options to reduce FLW through reuse and recycling • Benchmark FLW reductions by industry through reuse and recycling
Government	• Minimize incongruences in policies, regulations and legislation relating to food packaging design, materials and recycling • Invest in infrastructure required to enable room service meal preparation and delivery in publicly owned HRI • Tie implementation of pragmatic lean process improvement courses to public owned of tertiary business, management and commerce related courses • Reintroduce food handing and preparation studies into schools	• Collaborative investment in and operation of redistribution infrastructure and community food programs initiatives • Tie support for expansion of collaborative and innovative food rescue, redistribution and community food models to performance	• Collaborative investment in and operation of reuse and recycling infrastructure and initiatives • Establish mandatory reuse and recycling polices, regulations and legislation (differentiated by rural, urban and semi-urban)

Following this roadmap will result in significant and sustainable reductions in FLW, and overall societal benefits, by:

1. Increasing chain wide awareness to measure, set and then meet FLW reduction targets;
2. Implementing strategies at retail, in HRI, and within households to prevent over purchasing and excessive portion sizing;
3. Increasing rescue and redistribution of edible excess food and beverages; and
4. Encouraging inedible foods and beverages to be reused and recycled rather than go to landfill.

Glossary of Terms

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

Collaborative Planning, Forecasting & Replenishment	Collaboration between multiple business partners for the purpose of driving continual improvements in marketing, production, and replenishment activities; resulting in increased value for consumers, while simultaneously producing sustainable competitive advantages for the involved businesses.
Food loss	Discarding of edible and inedible commodities and foods during the production, processing and manufacturing of food or beverages for human consumption prior to their distribution and sale in retail or foodservice. Includes commodities used in the production of beverages. Examples include barley used in the production of beer and spirits, grapes used in the production of wine, carrots used in the production of fruit juice.
Food waste	Discarding of edible foods and beverages (and inedible parts of) during distribution retail, foodservice, households and during redistribution. Includes beverages, unless explicitly stated otherwise.
Full cost accounting[6]	The measurement and valuation in monetary terms of the externality costs associated with the environmental and societal impacts of food loss and waste.
Internalize	Environmental and social costs resulting from how products are produced, manufactured, consumed and managed throughout their life cycles are incorporated into cost and pricing structures, and stakeholders' decisions.
Macroeconomic	Analysis of the interrelationships that occur within and between different sectors in order to understand how and why the overall economy functions.
Manufacturing	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, oats into granola.
Planned loss	These losses are inevitable. Examples of planned losses include husks, animal skins and bones.
Post-processing loss	These loses occur after processing and are typically due to market related factors, such as products reaching expiry 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.
Theoretically edible foods	Food that is fit for human consumption.
Theoretically inedible foods	Peels, bones, by-product of processing or food preparation that is not fit for human consumption.

[6] FAO Full Cost Accounting Methodology (2014)

Theoretically unavoidable loss/waste	Losses that are inevitable, including processing and cook shrink, moisture loss, removal of husks, peels, and bones. Generally considered planned loss.
Theoretically avoidable loss/waste	Waste that, if operational or market related factors are addressed, the loss/waste could be reduced or eliminated. Generally, this is unplanned and post-processing 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.

1 Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimated that, worldwide, one third of food produced for human consumption is lost or wasted.[7] The analysis used to produce this estimate primarily utilized administrative data[8] and theoretical percentages of losses and waste. FAO's estimates were not based on primary data obtained for the purposes of calculating food loss and waste[9] (FLW). Studies that used theoretical percentages of loss and waste to estimate regional FLW include ReFED's analysis of FLW occurring in the United States.[10]

The purpose of the evidence-based research undertaken by Value Chain Management International (VCMI), in partnership with Second Harvest, was to create then populate a whole of chain framework for estimating FLW and identifying its root causes by sourcing primary data from industry, then use the findings to:

1) Produce materials for enabling industry to implement sustainable solutions to reduce FLW through prevention and redistribution, and
2) Reduce FLW going to landfill through improved reuse and recycling.

To enable the comparative effectiveness of FLW reduction efforts to be directly compared and benchmarked – resulting in the ability to continually improve on best practice – the framework described in Section 2 utilizes one standardized metric that is internationally recognized: **metric tonnes**.

With minimal modification, the same framework could be used to estimate and benchmark the environmental impacts of FLW, for example, tonnes of GHG or tonnes/litres of water.

1.1 Why Reduce FLW?

FLW represents enormous economic costs to businesses and society. It also represents enormous environmental impacts and costs. FLW impacts productivity and stifles investment and innovation. The costs of FLW extend to unnecessary transportation, energy, water, fertilizer, machinery and equipment, packaging, labour, and capital invested – just to name a few.

Although there is currently enough food to adequately feed the world's population, we have regions that have severe malnutrition, while other regions have public health issues, such as obesity. Four million Canadians (including 1.4 million children) have insufficient access to food, despite the enormity of avoidable FLW that occurs along the chain and in the home.

[7] http://www.fao.org/save-food/resources/keyfindings/en/
[8] Administrative FAO data: production volumes from FAO Statistical Yearbook 2009, national and regional Food Balance Sheets from the year 2007
[9] The term "food loss and waste" encompasses food and beverages.
[10] ReFED (2016). A Roadmap to Reduce US Food Waste by 20%: Technical Appendix

Economically FLW represents the lost value of the food that is waste, the cost of disposal and negative externalities of the disposal, and the opportunity cost of the farmland.[11] FLW is therefore an indication of inefficiency that drives up costs and lowers productivity, leading to higher prices. Costs of disposal and over production to accommodate the factored-in losses drive up the costs of business. If combated, this could lead to lower prices and increase food accessibility, and/or lead to consumers trading up to higher value products that are more profitable for businesses.

Reducing FLW therefore represents an opportunity for businesses along the entire food chain to improve their financial performance and competitiveness. These opportunities arise from cost reduction, competitive positioning and resource efficiency; thus, providing businesses an opportunity to improve performance in all three pillars of sustainability – environment, economy and society.

2 Scope and Methodology

In a concerted effort to address the factors described above, VCMI and Second Harvest undertook a whole of chain evidence-based FLW analysis of the Canadian food industry. A detailed description of the project's research methodology is presented in Appendix B.

In 2016 Canada's agri-food industry generated $111.9 billion GDP and 6.6 percent of Canada's total GDP.[12]

The research encompassed and expanded upon approaches employed in prior FLW research. This included incorporating the Food Loss and Waste Accounting and Reporting Standard[13] (FLWARS) throughout the analysis and reporting.

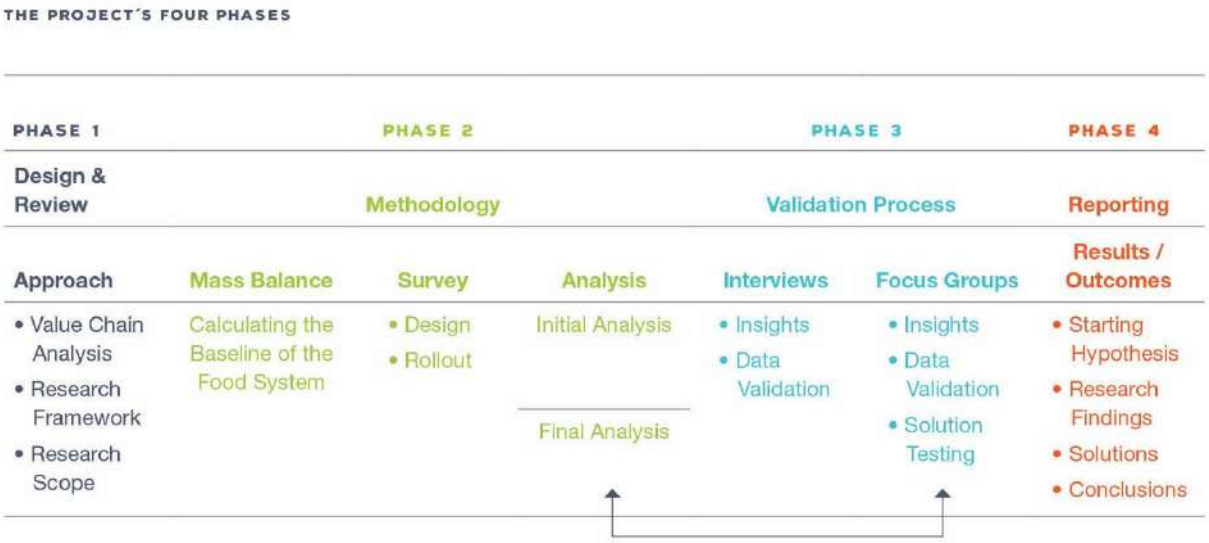
As shown in the project pathway presented below (Figure 2-1) the project was completed in four phases, with a reiterating validation process occurring during phases 2 and 3.

[11] Buchner, Barbara, Claude Fischler, Ellen Gustafson, John Reilly, Gabriele Riccardi, Camillo Ricordi, Umberto Veronesi, and Barilla Center for Food & Nutrition (BCFN). 2012. "Food Waste: Causes, Impacts and Proposals." *Barilla Center for Food & Nutrition*, 53–61. doi:45854585

[12] http://www.agr.gc.ca/eng/about-us/publications/economic-publications/an-overview-of-the-canadian-agriculture-and-agri-food-system-2017/?id=1510326669269

[13] Food Loss and Waste Accounting and Reporting Standard

Figure 2-1: The Project's Four Phases



Factors that differentiated the project from prior FLW research and guided the design of the final research scope and methodology include:

- A whole of chain analysis, from primary production through to end of life (incl. consumed, lost or wasted);
- Establishing a replicable whole of chain FLW analytical framework, comprising standardized metrics that can be utilized at enterprise and industry level;
- Encompassing all food types, sourced/processed from terrestrial and marine commodities;
- Identifying then validating loss factors based on primary data provided by industry;
- Calculating mass balance: total available commodities produced for food, minus exports, plus imports;
- Establishing a means to connect commodities to finished products (foods and beverages), to enable extrapolations to be established between consumer products and primary source;
- Identifying the root causes of FLW, where they occur along the value chain, and the extent to which they differ by food type*;*
- Assessing the destination of FLW occurring along the value chain; and
- Estimating household FLW by having Canadianized loss factors produced by USDA/ERS.[14]

[14] https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation/

2.1 Project Scope

The scope of the project is presented below (Figure 2-2), using a modified version of the FLWARS template. So that the template reflects the research methods and results described in subsequent sections of this document, working left to right, the column "boundary" has been placed ahead of "destination."

Figure 2-2: Project Scope

2.2 Research Methods

The research methodology utilized and expanded upon methodologies employed in prior FLW research. Of particular note regarding the research methods is the application of value chain analysis (2.1.1) and mass balance (2.1.2) techniques, and directly connecting commodities (2.1.3) to consumer foods and beverages. The research was also guided and enabled by:

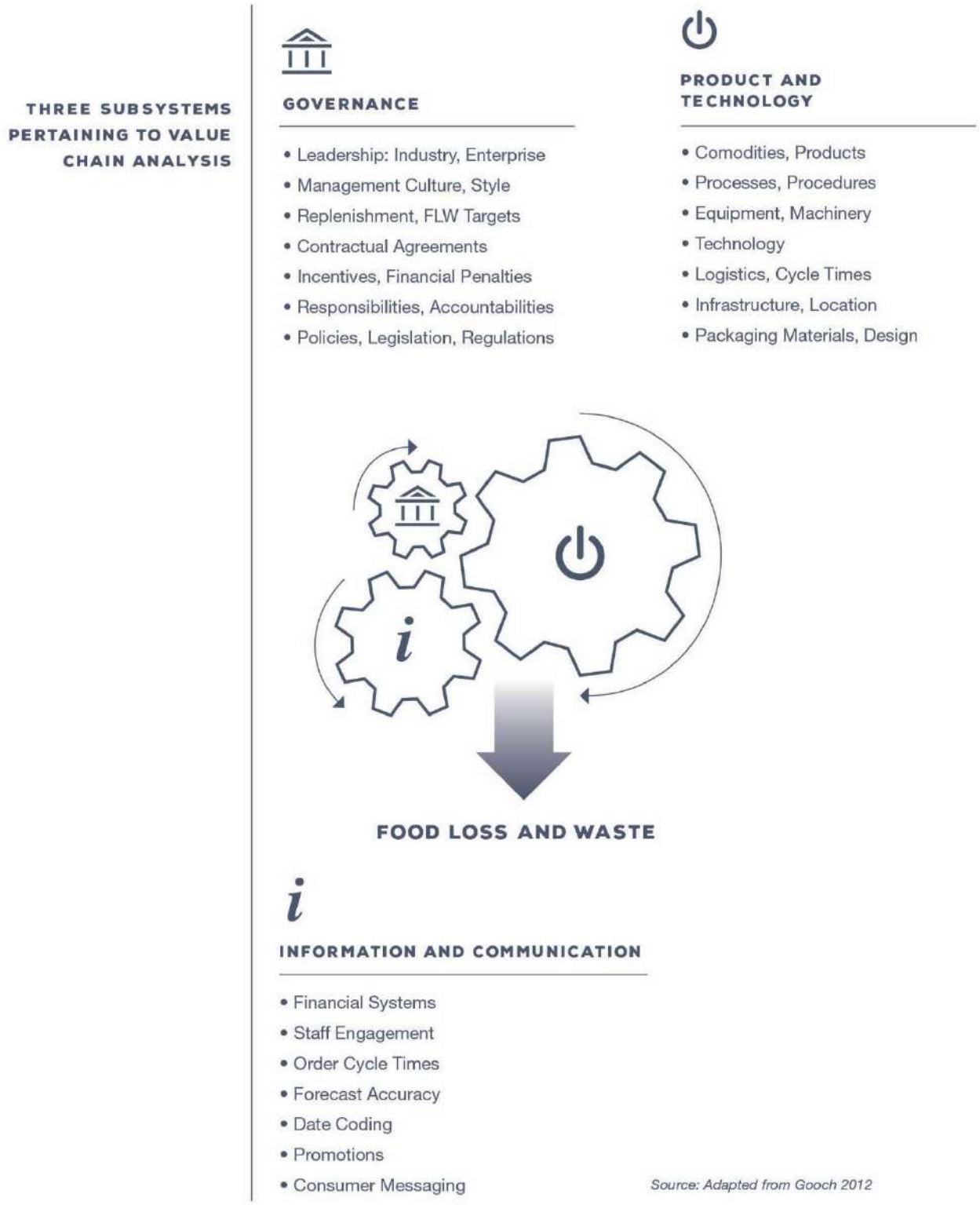
- The intellectual property and international experience possessed by the VCMI team, a number of whom possess two decades of experience extracting waste from businesses and value chains operating in multiple industries in developed and developing nations; and
- A stakeholder advisory group – comprising expert industry stakeholders from farming, processing, distribution, foodservice, retail, academia, and industry organizations – to help engage industry, validate research methods and research findings, and ensure no important considerations were omitted.

2.2.1 Value Chain Analysis

Value chain analysis (VCA) provides a rigorous assessment of the interactions and outcomes that together shape how a food system operates. VCA can be applied at the enterprise and industry level. This enables researchers to determine factors impacting the creation of FLW, by having investigated interrelationships between the three subsystems that together determine how individual businesses within the food industry – and ultimately the food industry itself – operate. As presented in Figure 2-3, the three subsystems are:

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

Figure 2-3: Three Subsystems Pertaining to Value Chain Analysis



The VCA process recognizes that FLW is impacted by weaknesses in intra- and inter-firm relationships – with ineffective operations and communication resulting from a lack of strategic alignment, operational understanding, trust, commitment, benefit sharing, and collaboration. For these reasons, the level of collaboration that exists within and between businesses will influence the amount of FLW occurring along the value chain in which they operate. The same reasons impact businesses' motivation and ability to reduce FLW. That these disconnects can be addressed and the resulting opportunities achieved with little if any capital investment makes FLW solutions an easy win for businesses, consumers and wider industry stakeholders.

Another important reason for utilizing VCA in FLW research is that individuals' experiences and personal beliefs need to be understood, as these influence how they view themselves in context to the world around them and how they will respond to potential recommendations.

2.2.2 Mass Balance

Mass balance techniques are widely used for the purpose of analysing the volume of materials flowing through a physical system. This is achieved by accounting for materials that enter and exit a system. With all commodities, foods and beverages being transported by land, sea and/or air, their weight in metric tonnes can be readily calculated.

The research established a baseline of food availability at primary production in metric tonnes. This is total volume of food that is grown, caught and harvested, and enters the Canadian food system. The process followed to achieve the food availability baseline was:

$$Food\ Production^{15} - (Exports + Imports) \pm \left(Adjustment\ for\ Processed\ Food^{16}\right) = Baseline$$

This baseline informed the development of a mass balance model that, through applying loss factors identified from primary data provided by industry, calculated the waste occurring at each point in the chain of the food types presented below from production to distribution, then subsequently retail and/or HRI.[17] Household FLW was estimated through the analysis of Statistics Canada data using modified USDA/ERS loss factors.

2.2.3 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. Following an analysis of commodity and product categories developed by organizations including FAO, WRAP, ReFED and Canadian commodity data sheets, the six categories presented below in Table 2-1 were established.

[15] Terrestrial and marine
[16] Adjustment made after processing and manufacturing within the value chain model
[17] Hotels, Restaurants and Institutions (foodservice)

Table 2-1: Connecting Commodities to Consumer Foods and Beverages

Category	Dairy and Eggs	Field Crops	Produce	Meat and Poultry	Marine	Sugars and Syrups
Consumer products incl. *(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[18] • Chocolate[19] • Fruit juices • Cider • Wine • Coffee[20] • Tea[21]	• Fresh cuts • Primal cuts • Processed meats • Entrees	• Fresh fish • Processed fish • Fillets • Shell fish • Entrees	• Maple syrup • Sugar • Honey • Soft drinks
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

The categorization of commodities and establishing the mass balance for foods/beverages presented above is most convenient for products consumed fresh or after minimal processing. It also, however, enables a direct link to be established between further processed products and the commodities from which they are derived (e.g. in bread, ingredients include multiple types of grains and seeds, sugar, margarine or butter, eggs, salt, water, etc.). Knowing the comparative percentage of inputs used in the manufacture of processed foods, it is possible to measure and monitor loss and waste of inputs. Thus, all consumer foods and beverages can be extrapolated – at minimum in reasonably accurate terms – back to the appropriate commodities and their primary production.

[18] With the exception of peanuts, which are a legume, nuts are dry hard fruits: https://www.britannica.com/science/nut-plant-reproductive-body

[19] Cocoa pods are fruits: https://www.chocolate.org/blogs/chocolate-blog/about-the-cacao-tree

[20] Coffee beans are seeds obtained from the harvesting of edible fruit: https://www.pastemagazine.com/articles/2015/06/coffee-fruit-natures-wasted-superfood.html

[21] 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

This process of categorizing products and commodities guided the gathering and analysis of secondary data required to populate the mass balance model. The categorization of products and commodities also guided the:

a. Design of two online surveys used to source primary data from industry,
    i. Agricultural production and downstream operations for all foods
    ii. Marine production (wild capture and farmed) and processing
b. Analysis of primary data and validation processes,
c. Reconciling of secondary and primary to estimate the volume and value of FLW, and
d. Identification of root causes at key points along the value chain by food type.

3 Research Findings

Section 3 summarizes the following research findings (detailed in Appendix A): the volume and value of FLW estimated to occur along the food value chain (3.1); respondents' likelihood to measure FLW versus the comparative occurrence of FLW along the food and beverage value chain (3.2); the categories into which respondents were grouped (3.3); the primary reasons given for why FLW occurs (3.4); and suggested ways to improve food rescue and redistribution (3.5). This section ends by proposing a means to address the limitations of the current binary process of differentiating avoidable versus unavoidable and edible versus inedible FLW (3.6), and discusses the environmental impact of FLW (3.7).

Data analyzed to produce loss factors and FLW estimates was primarily sourced through two online surveys distributed widely to industry. The two surveys were viewed on a total of 782 occasions, with 618 valid responses being received. As shown below in Table 3-1, these responses provided a reasonable representation from across the food chain.

Table 3-1: Percentage of Survey Responses by Business Type

Business Type	% of Survey Responses
Primary production (incl. marine)	38%
Packing, processing and manufacturing	15%
Distribution/wholesalers	3%
Retail	33%
HRI (hotels, restaurants, institutions)	11%

Of the 618 valid responses, 251 provided either a) detailed FLW data from formal measurement programs, or b) estimates based on experience and informal tracking of FLW. Initial findings and conclusions were verified and refined through a process of triangulation. This included contrasting and extrapolating survey data against that gathered during in-depth interviews with 49 industry stakeholders, numerous informal discussions with a wide array of industry stakeholders, six focus

groups conducted across Canada, and consulting throughout the project with the stakeholder group referenced in Section 2.2.

3.1 FLW Estimate: Annual Tonnage and Value

Presented below in Table 3-2 is the overall FLW estimated to occur along the Canadian food value chain from tertiary and marine production through to consumers. Each row shows, in metric tonnes (millions), the estimated loss and waste occurring at each level of the chain for a specific type of food. Losses occurring during the grading and packaging of fruits and vegetables are listed under processing.

The far right-hand column shows the percentage of each food type that respondents from food rescue, foodbanks and other food programs stated as typically being lost during its redistribution. Due to insufficient responses being received to produce a robust estimate, Table 3-2 does not include loss percentages for marine and sugars/syrups during redistribution. The latter includes soft drinks.

Table 3-2: Estimated FLW along the Chain (in Metric Tonnes - Millions)

	Grow/Produce			Processing		Manufacturing		Distribution	Retail	Consumer (HH)		HRI		Total FLW occurring along the food value chain	Losses (%) occurring during Rescue and Redistribution
Food Type	Unplanned Loss	Planned Loss	Storage / Pack loss	Planned Loss	Unplanned and post processing Loss	Planned Loss	Unplanned and post processing Loss	Loss	Waste	Prep waste	Plate Waste	Prep waste	Plate Waste		
Dairy and Eggs	0.00	0.00	0.14	0.00	0.00	0.46	0.52	0.08	0.16	0.53	0.48	0.35	0.31	3.03	7%
Field Crops	0.00	1.69	2.65	8.84	1.24	0.97	1.84	0.17	0.78	1.05	0.94	0.93	0.78	21.89	5%
Produce	0.66*	0.66	2.77	0.74	0.82	0.41	0.00	0.23	0.28	0.85	0.69	0.28	0.25	7.97	5%
Meat/ Poultry	0.00	0.00	0.00	0.25	0.14	0.22	0.19	0.04	0.05	0.11	0.10	0.10	0.08	1.28	7.50%
Marine	0.00	0.04	0.00	0.05	0.04	0.00	0.00	0.03	0.04	0.07	0.06	0.01	0.01	0.34	N/A
Sugar/ Syrups	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.15	0.12	0.00	0.00	0.36	N/A
Total	0.66	2.41	5.57	9.89	2.25	2.07	2.57	0.55	1.31	2.76	2.38	1.68	1.44	34.88	

**5% edible product left unharvested = avoidable/potentially edible FLW*

In Table 3-2 above, avoidable FLW is identified by the orange cells.

The loss factors and subsequent calculation of estimated total FLW occurring along the food chain are purposely conservative. Reasons for this include that the model views all foods and beverages flowing through both processing and manufacturing. This is not the case particularly for fresh foods, such as unprocessed fruits and vegetables, eggs and liquid milk. Despite this, as shown below in Table 3-3, the total annual unavoidable (planned) and avoidable (unplanned/post-processing) FLW estimated to occur along the Canadian food value chain is 35.54 million metric tonnes. This equates to 58.1 percent of commodities entering the food system. Of total FLW, 11.17 million metric tonnes is avoidable (unplanned/post-processing) and likely edible.

A summary of the total, unavoidable and avoidable FLW – by volume and as a percentage of inputs that enter the Canadian food system, and across the six type of foods – is summarized in the following table and pie charts. Table 3-3 presents an aggregated view of the entire system. The study identified that, of the 61.12 million tonnes of commodities entering the Canadian food system, 25.58 million tonnes (41.9%) is consumed. The remainder is lost or wasted, much of it unnecessarily.

Table 3-3: Canadian Food System Overview: Inputs, Losses, Consumed (Volume and Percent)

		Million Tonnes	Percent of Food Inputs	Percent of total FLW
Food System Inputs		61.12		
Food Consumed		25.58	41.9	
Total FLW		**35.54**	**58.1**	
	Avoidable FLW[22]	*11.17*	*18.3*	*31.4*
	Unavoidable FLW	*24.37*	*39.9*	*68.6*

Figures 3-1 and 3-2 below illustrate the considerable amount of loss estimated to occur during primary production, processing and manufacturing. An estimated 71 percent of total FLW and 49 percent of avoidable, potentially edible FLW occurs at these stages of the food chain. While all of loss occurring in primary production was considered to be unavoidable, an adjustment was made in the calculation of avoidable/potentially edible FLW in fruits and vegetables. This correction was made to account for produce left in the field, unharvested. The research identified that this is where a considerable amount of potentially edible FLW occurs.

That the analysis estimates household FLW to be considerably less than that estimated to occur in other countries (e.g. 43% of total FLW in the US[23] and 47% of total FLW in the UK[24]) speaks to the conservative nature of the estimates produced by our study.

[22] Likely edible
[23] ReFED (2018). 27 Solutions to Food Waste
[24] WRAP (2015) Estimates of Food and Packaging Waste in the UK Grocery Retail and Hospitality Supply Chains

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

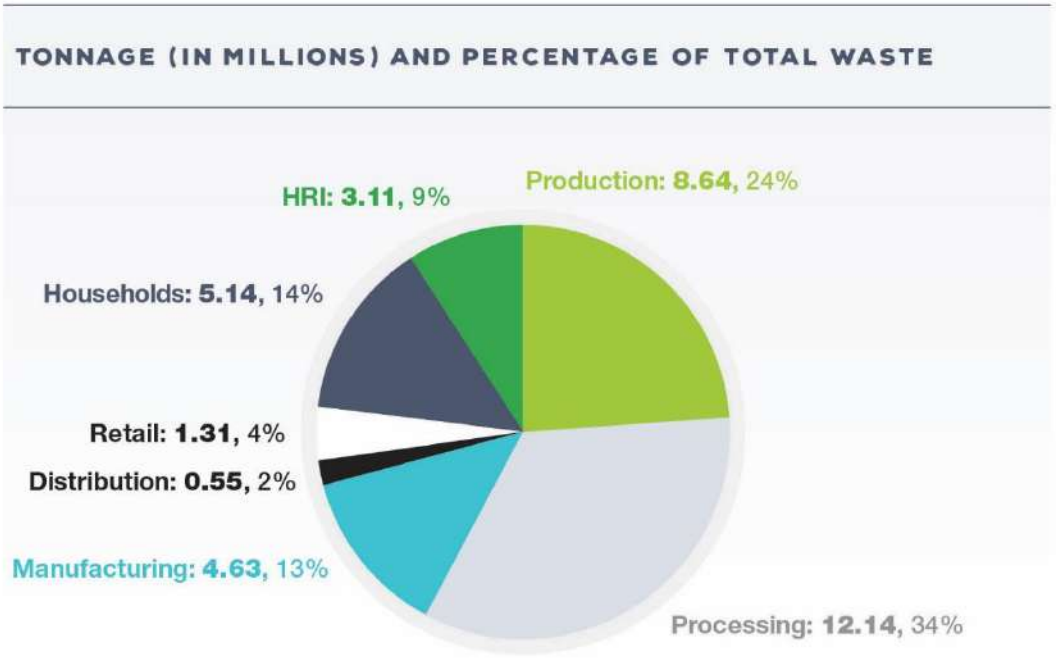
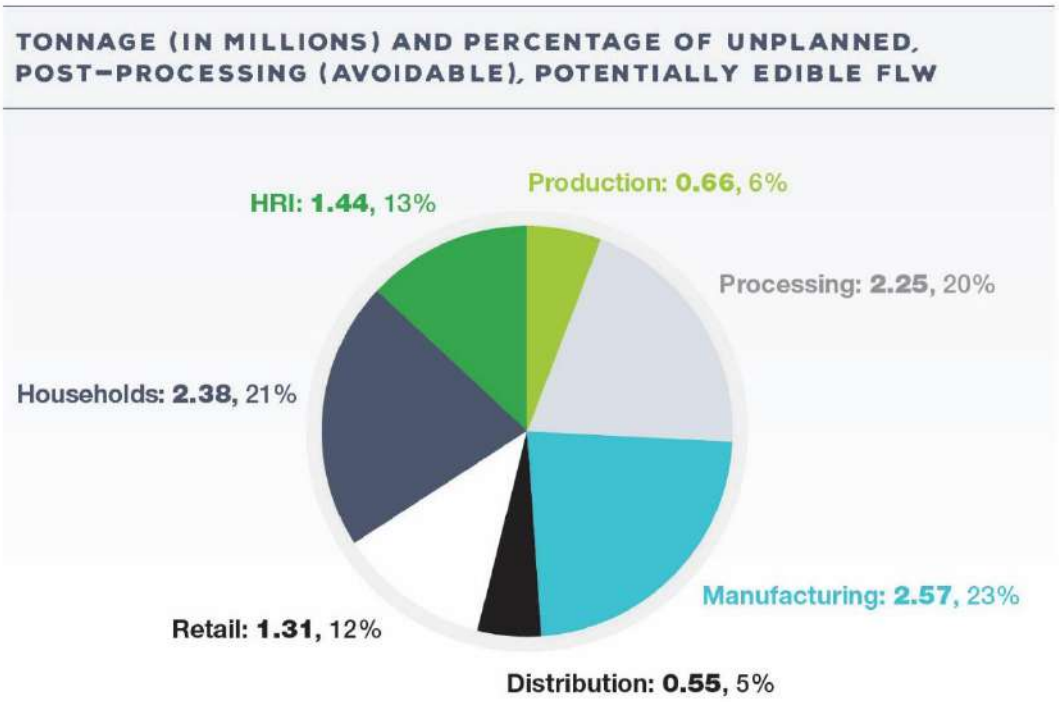


Figure 3-2 Tonnage (in Millions) and Percentage of Unplanned, Post-Processing (Avoidable), Potentially Edible FLW



Apportioning value to FLW was achieved using Statistics Canada data, which reported that retail food sales for 2016 was $95.5 billion[25] and food service receipts were $62.2 billion.[26] The volume of food at the point of purchase by consumers is estimated at 34.49 million tonnes. The analysis of Statistics Canada and other sources of data established that approximately 65 percent of food is sold through retail and 35 percent through HRI. Accounting for losses identified in the model, this equates to 22 million tonnes sold through retail and 12.5 million tonnes purchased at HRI. Thus, we calculated the average price per tonne of food at retail to be $4,351 and at HRI to be $4,967. Underlining the conservative nature of estimates produced by our study, other research (e.g. WRAP[27]) indicates that the differences in the value of food sold at retail versus that sold at HRI, and therefore FLW, is considerably greater than that proposed above.

Presented below in Table 3-4 is the volume of avoidable FLW occurring at each level of the value chain, to which values have been attributed based on aforementioned prices per tonne of food. The highest point of avoidable FLW by volume and value occurs in manufacturing, followed by households, and then in processing. As discussed in the following sections and expanded upon in the appendices, the root causes of avoidable (and unavoidable) FLW often lie at different points along the value chain to which it occurs.

Table 3-4: Volume and Value of Avoidable, Potentially Edible Waste

Chain Location	Volume (million tonnes)	Value ($ billion)
Production (Produce)	0.66	2.88
Processing	2.25	9.78
Manufacturing	2.57	11.17
Distribution	0.55	2.41
Retail	1.31	5.70
Household	2.38	10.37
HRI	1.44	7.14
TOTAL	**11.17***	**49.46****

***11.2 million metric tonnes = the weight of almost 95 CN Towers.**
****$49.5 billion = 3% of Canada's 2016 GDP. It would feed every person living in Canada for almost 5 months.**

The estimated value of avoidable FLW is over half (51.8 percent) of the money that Canadians spent on food purchased from retail stores in Canada in 2016. This figure represents an enormous cost to society and individual businesses, and does not account for the environmental costs incurred in the

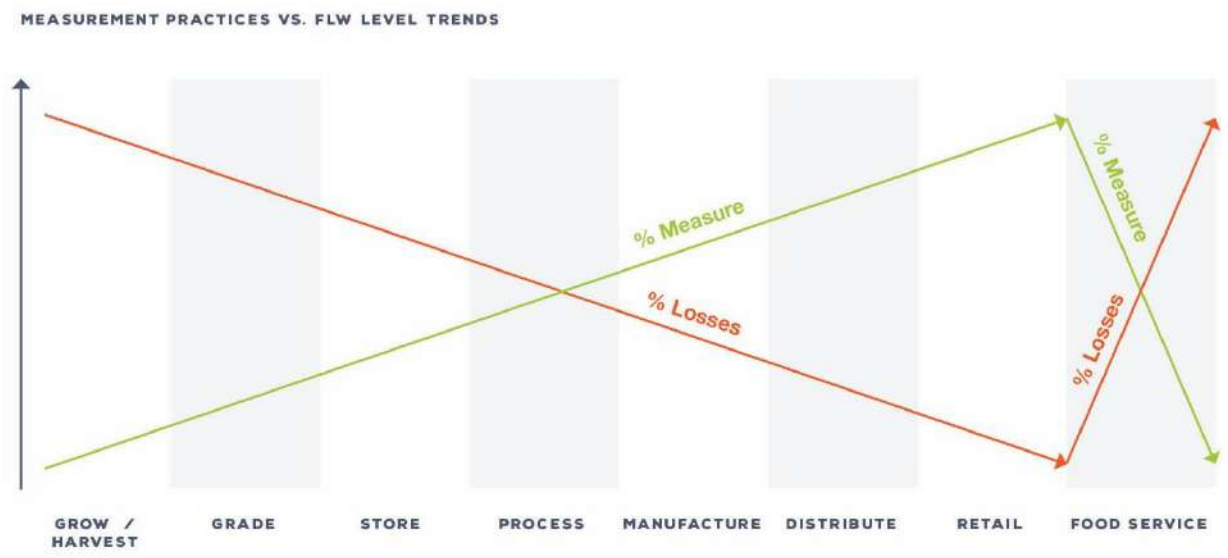
[25] Statistics Canada. Table 20-10-0008-01 Retail trade sales by province and territory (x 1,000). Sales from Grocery stores and specialty food stores, seasonally adjusted.
[26] Statistics Canada. Table 21-10-0019-01 Monthly survey of food services and drinking places (x 1,000). Receipts from food services excluding drinking places, seasonally adjusted.
[27] WRAP (2015) Estimates of Food and Packaging Waste in the UK Grocery Retail and Hospitality Supply Chains

production of food that is loss and wasted, the disposal of the FLW, and greenhouse gas (GHG) emissions produced by the FLW.

3.2 Measurement and FLW Trends

While a direct correlation cannot be proven between the two opposing trends presented below in Figure 3-3, the analysis identified that, generally speaking, the highest percentage of FLW occurs at the same points along the value chain where FLW is least likely to be measured. The potential for a correlation to exist between FLW and measurement practices is strengthened by the fact that waste is higher and there is less likelihood to measure FLW in foodservice versus retail.

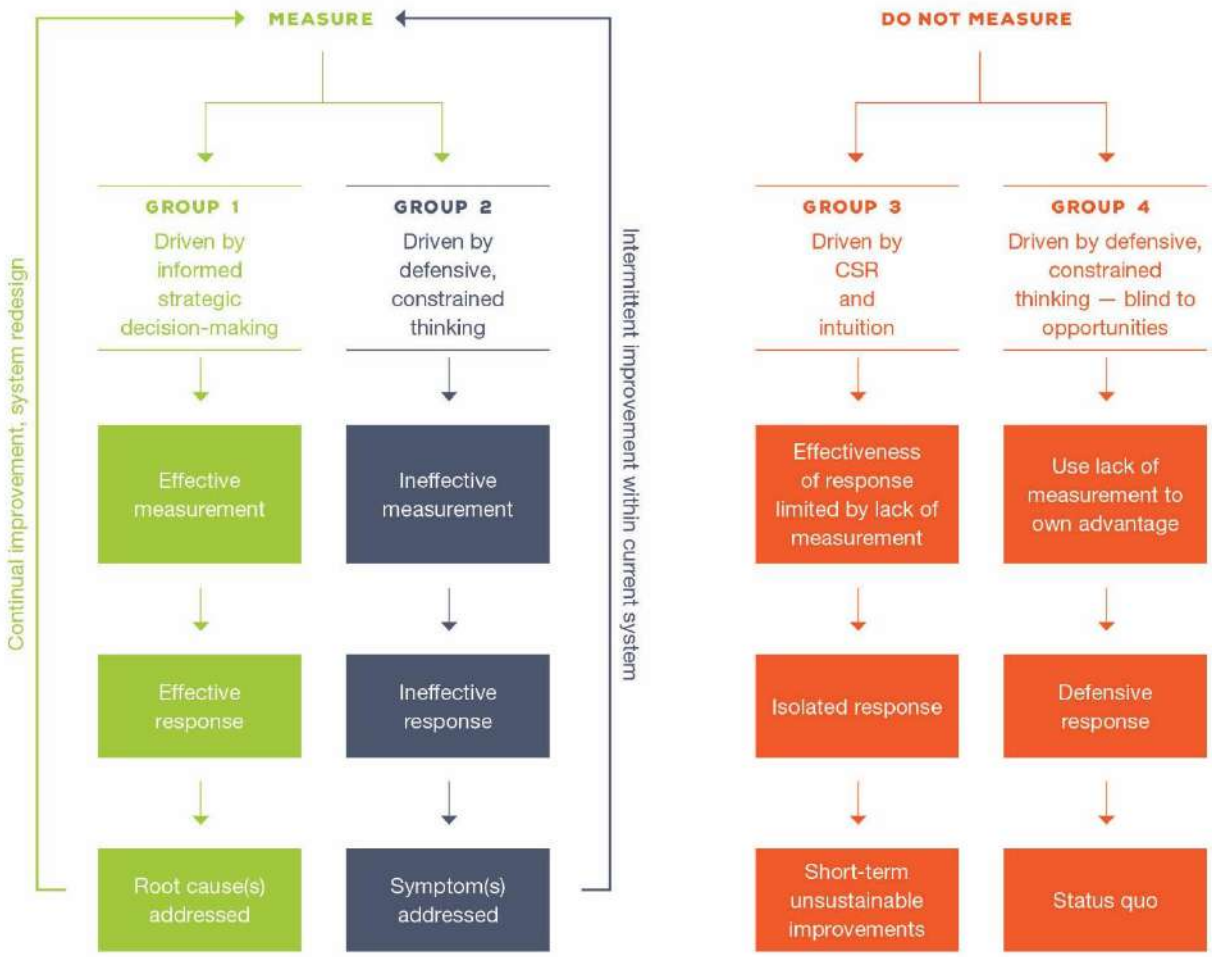
Figure 3-3: Measurement Practices vs. FLW Level Trends



3.3 Categorizing Respondents

It was clear from online survey responses and in-depth interviews that the respondents could be categorized into four groups (see Figure 3-4 below). This thereby gave an indication as to the reasons lying behind the level of FLW occurring along the chain and current measurement practices. Feedback captured during the focus groups validated the existence of the same four groups across the wider food industry.

Figure 3-4: Four Respondent Groups



The differences found to exist between the four groups reflect how a combination of three factors that determine individuals' behaviour (culture, personal ideas, and values and beliefs) impact respondents' approach to FLW. The same factors impact organizations' approach to FLW, including how they view inefficiencies associated with FLW. An example of this is the bakery sector, where executives view sending enormous volumes of unsold bread to animal feed as a revenue source, rather than an indication of the scale of opportunities that exist to improve performance.[28]

The most effective FLW reduction efforts and resulting benefits will be achieved by individuals belonging to Group 1; the least effective FLW will be achieved by individuals belonging to Group 4. Individuals from each of the four groups can work within the same organization. As cited by interviewees and focus group attendees, the ability of Group 1 respondents to implement programs

[28] Respondents estimated that considering the sale of excess food and beverages to animal feed as a revenue source could be masking approximately $800 million in inefficiencies within the Canadian bakery sector alone.

that result in improved performance by reducing waste will typically be determined by their seniority.

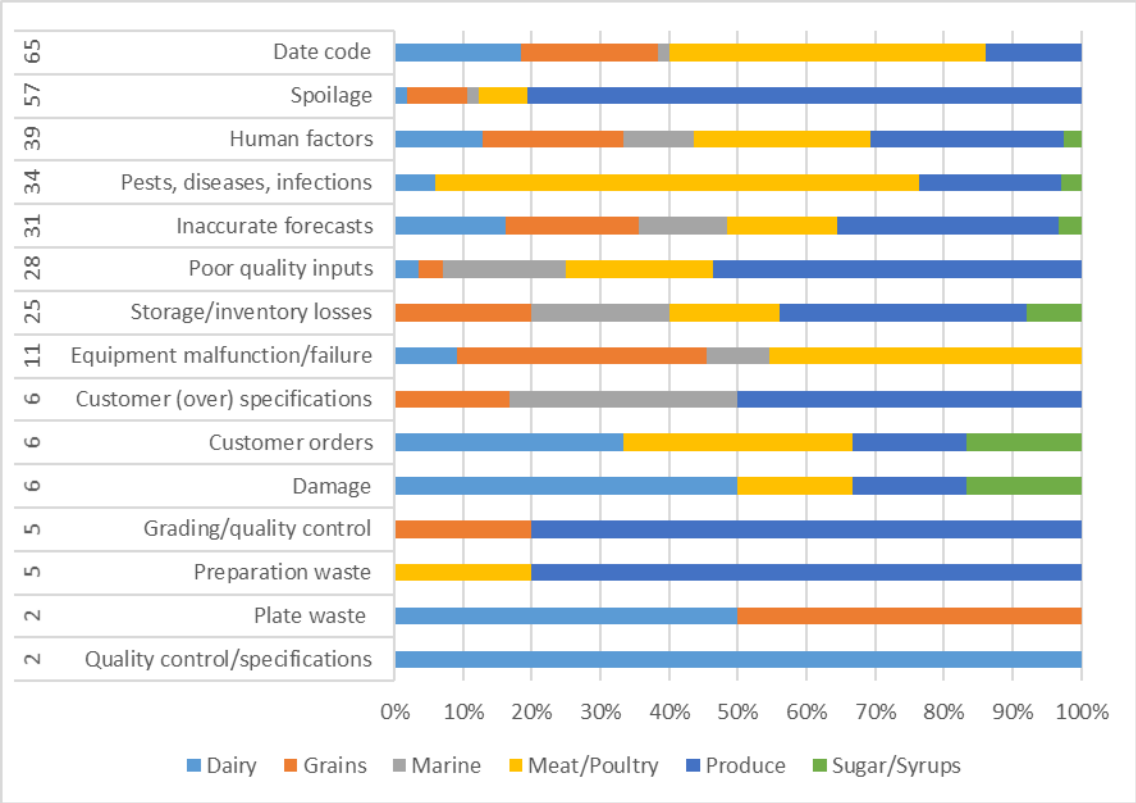
Numerous examples were given of senior executives belonging to Groups 2 or 4 who have purposely prevented effective FLW programs from being implemented, by not making the necessary changes to business operations to support FLW reduction efforts. In short, businesses' approach to combating FLW and realizing the potential benefits starts (or falters) at the top.

3.4 Causes of FLW along the Value Chain

Respondents were asked to identify the primary cause of FLW occurring in their business. The responses show that: 1) FLW that occurs in industry is commonly a symptom of inefficiency, and 2) common causes for why FLW occurs in industry are identical to those that drive food waste in the home. This is particularly so for avoidable (unplanned/post-processing) FLW.

Shown below in Figure 3-5 is an overview of responses from the entire value chain. The immediate causes of FLW are listed in order of the frequency reported by respondents. All reasons are listed despite some not pertaining to all parts of the chain (e.g. pest, disease and infection pertains only to primary production; plate waste pertains only to HRI).

Figure 3-5 Immediate Causes of FLW in Industry

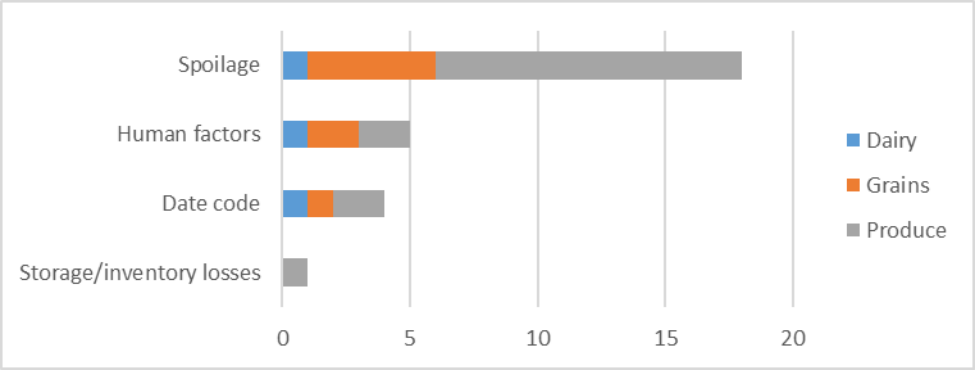


The most frequently cited immediate cause of FLW is date codes, followed by spoilage. These two causes impacted all food types to some extent, except for sugar/syrups. Date code was reported the most for meat/poultry; this category accounts for 46 percent of responses. Spoilage was reported the most for produce; this category accounts for 80 percent of responses. That FLW in produce is due to the widest variety of causes points to this being a food category where considerable opportunities exist to reduce losses and waste. Pests, diseases and infections are prominent causes of FLW: in meat and poultry due to mortality rates, and in produce by impacting appearance/size/etc. These farm-level losses for meat are not included in the FLW model and estimates presented earlier in Section 3.1. The starting point for meat and poultry entering the chain is post slaughter. The starting point for marine foods entering the chain is post evisceration.

3.5 Improving Food Rescue and Redistribution

The research estimated that 86 percent of edible foods lost and wasted along the value chain are not presently rescued for redistribution. The research also found that of the foods that are rescued, between 5 and 7.5 percent is lost during redistribution for various reasons. Actual loss differs by food type. As shown below in Figure 3-6 the most common cause of this loss is spoilage. Produce, followed by grains (predominantly bread and bakery) are the foods most commonly lost during redistribution.

Figure 3-6: Causes of Loss during Food Redistribution

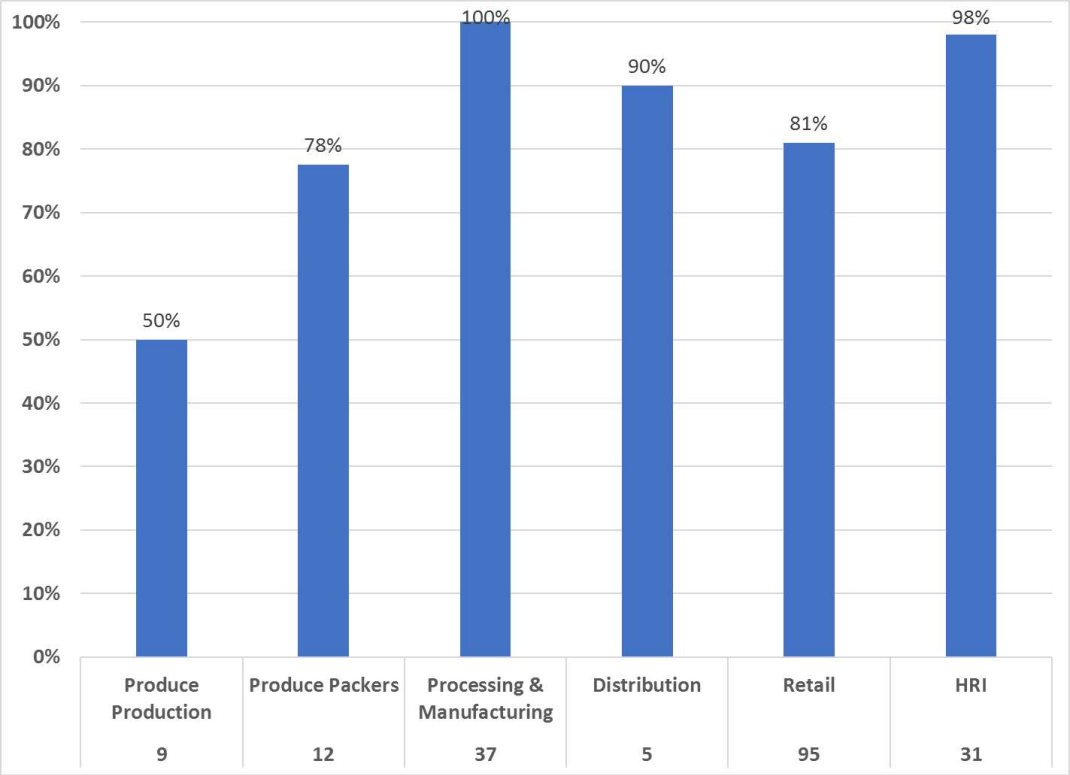


There is considerable potential to increase the amount of food that is rescued throughout the chain, particularly in processing and manufacturing where the median response to the question "What percentage of overall edible food or beverages not sold for human consumption was rescued for redistribution?" was zero percent. This was because, while two of the 37 respondents from processing and manufacturing said that they donate 100 percent of edible foods, the vast majority of remaining respondents stated that they do not donate. Similarly, in produce production, where the donation of unsold edible foods is highest, only 50 percent of available food is currently rescued.

Figure 3-7 below shows the extent to which significantly more edible foods could be rescued from along the food chain. The median scale of opportunity to rescue more edible food is 50 percent from produce producers, 78 percent from produce packers, 100 percent from processors and

manufacturers, 90 percent from distributors, 81 percent from retailers, and 98 percent from HRIs. The number of respondents who provided data at each link in the chain, on which the above estimates are based, is also shown.

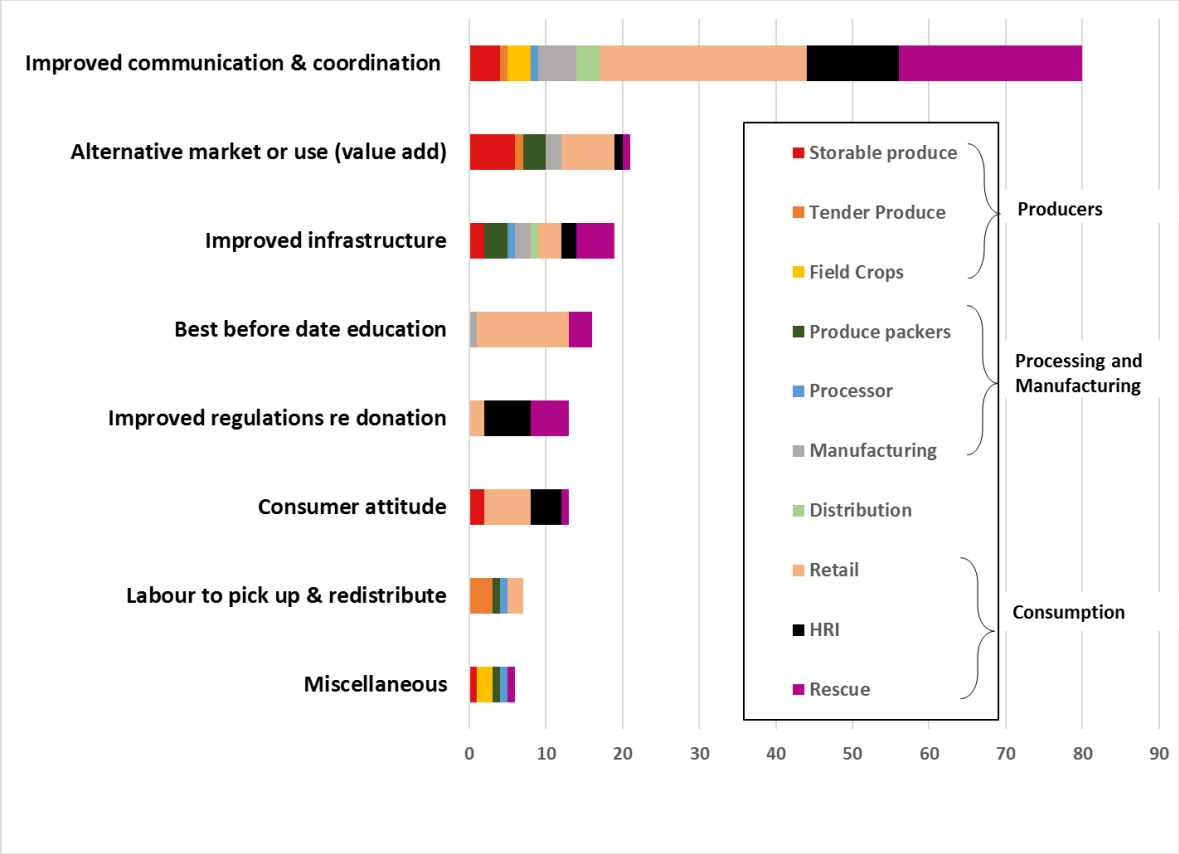
Figure 3-7: Median Percentage of Unsold Edible Food and Beverages Not Rescued



Respondents cited that meat and protein constitute some of the greatest opportunities to rescue a higher percentage of edible food from being lost and wasted. Why perishable products, such as produce and bread, are not rescued is partly a result of volume and the ineffectiveness of redistribution systems. In the words of respondents from community food programs: “We do not have the ability to share the abundance of produce that occurs here with other areas,” and “We don’t need any more bread.”

All respondents (those from industry, along with those involved in food rescue and community food programs) were asked to identify ways to improve the rescue and distribution of foods and beverages. The results produced from having analyzed the 175 responses on this topic are presented below in Figure 3-8.

Figure 3-8: Ways to Improve Food Rescue and Redistribution

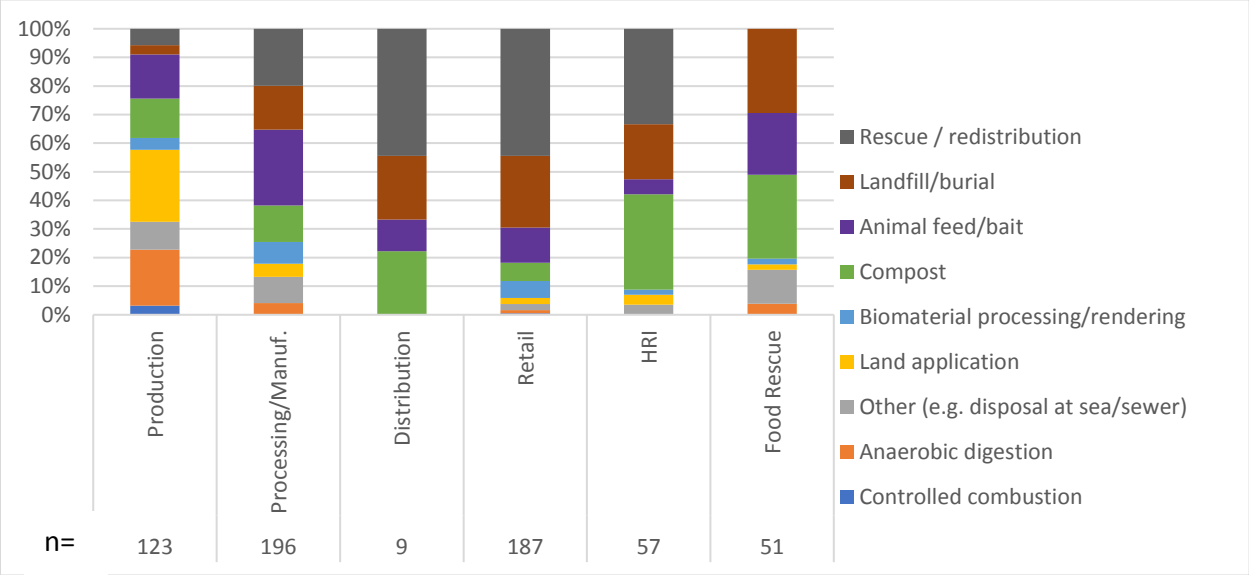


As seen in the above bar chart, respondents believe that the greatest opportunities lie in improving value chain communication and coordination. This includes, for example, retailers providing greater clarity to stores about forecasted deliveries that stores could, in turn, use to improve their rescue and donation practices. Respondents also cited that considerable opportunity exists to improve the communication and coordination of redistribution systems, resulting in improved performance and more effective use of existing infrastructure.

3.6 FLW Destinations

Reflecting the FLWARS framework presented in Section 2.1, respondents were asked to indicate where (in addition to food rescue) their operations directed edible food and inedible FLW. Respondents were able to indicate more than one destination. Shown below in Figure 3-9 are the destinations cited by respondents. Each bar shows how often (out of 100%) a destination was cited by respondents located at each link in the value chain, and the number of responses contained within each bar. For example, the number of responses received from retail and HRI was 187 and 57, respectively.

Figure 3-9: Utilization of FLW Destinations by Value Chain Members



Building on from Section 3.5, all levels of the chain utilize food rescue to some degree. That this is most likely to occur in retail means that there is significant potential to rescue more food:1) prior to it arriving in the retail store, and 2) from HRI.

The analysis identified correlations between destination, size of operation (number of employees) and location (region of the country). Those processors/manufacturers,[29] HRI and food rescue respondents located in Eastern Canada are more likely to send FLW to landfill than respondents from the same sectors operating in Western Canada. Although food rescue was a key destination for retailers across the country, approximately 30 percent of retail respondents in all regions also utilize landfill.

Along the entire chain, larger operations more typically cited food rescue as a destination than smaller operations. In HRI, larger operations are equally likely to compost edible (and inedible) food as they are to rescue edible food. Among food rescue organizations, larger operations are more likely to direct FLW to animal feed or compost versus landfill.

A different picture emerged in primary production, where smaller (versus larger) operations more commonly cited food rescue as a destination: supplying family and friends with food rather than working with a formal food rescue organization.

[29] Includes Produce Packers

3.7 Differentiating Avoidable and Unavoidable/Edible and Inedible

The analysis identified shortcomings and limitations with the present binary categorization of FLW as 1) avoidable versus unavoidable, and 2) edible versus inedible. A binary approach does not allow for the nuances that exist in today's complex food industry or the cultural differences that determine food choice. For example, some consumers and entire cultures will eat broccoli stalks, shrimp shells and fish/animal skin.

The recommendation presented below in Table 3-5 includes examples to illustrate how limitations associated with the current binary system can be addressed in future research through the utilization of a 3 by 3 matrix.

Table 3-5: Three by Three Matrix for Categorizing FLW

	Prime condition	**Useable**	**Inedible**
Avoidable	• Unharvested fruit and vegetables • Food not donated due to vendor agreement	• Vegetable stalks (e.g. broccoli) • Products thrown away early due to conservative best before date • Product falling onto floor from conveyors or bags splitting that could be made edible through processing into new product	• Fruit left to spoil • Crops incorrectly stored
Theoretically avoidable	• Undersized crop left in field • Edible fish species caught in by-catch, though not kept, as currently not marketed	• Lobster shells disposed of at sea or buried instead of processed into food ingredient • Foods served though not eaten due to portion serving size • Regulatory impact on amount of carcass condemned due to, for example, abscess or other isolated issue	• Inventory that spoils due to poor FIFO[30]
Unavoidable	• Husks, bran and germ lost during milling process	• Orange peel	• Animal bones disposed of during HRI and at-home preparation of food

The matrix proposed above reflects that food which is inedible in its present form can be made edible through manufacturing into a new product. New processes for transforming inedible food into edible foods or ingredients are rapidly emerging. The importance of the new approach is underlined by the research having identified that, while some FLW is clearly unavoidable, categorizing FLW as unavoidable when it could theoretically be avoidable negatively impacts the motivation for individuals to change their behaviour.

[30] FIFO is "**first in first out**" and simply means food needs to be labeled with the dates they are stored, and older foods need to be put in front or on top so that they are selected first.

3.8 Environmental Impact

To indicate the environmental impact of FLW detailed in Section 3.1, a whole of chain CO_2 equivalent model produced for Second Harvest by VCMI and life cycle[31] assessments produced by FAO[32] were used to calculate the carbon footprint (GHG emissions measured in CO_2 equivalent) and the blue water footprint (consumption of surface and ground water resources).

3.8.1 Carbon CO_2

Using published estimates and publicly available data, we established an entire chain estimate of CO_2e. Production, processing and manufacturing estimates came from published LCA[33] literature. Emissions from transportation between chain links were determined based on published truck emissions and estimated distances of transportation for each food category. As described in Appendix C, energy consumption at retail, HRI DCs, HRI, and households was extrapolated from company reports and Canadian statistics. A calculator model was constructed for each food type, therefore we could estimate the CO_2e associated with FLW occurring in that chain. The total CO_2e for all six food types provided the overall FLW CO_2e footprint. Using the loss factors of potentially avoidable FLW from the FLW model, an estimate of potentially avoidable CO_2e was derived.

Table 3-6: CO_2 Equivalent of Total, Avoidable and Unavoidable FLW (Million Tonnes)

		CO_2 equivalent (Million tonnes)	**Percentage of total CO_2 equivalent footprint**
Food System Inputs		99.7	100
Food Consumed		43.2	43.3
Total FLW		**56.5**	**56.6**
	Potentially avoidable FLW[34]	*22.2*	*22.3*
	Likely unavoidable FLW	*34.3*	*34.4*

As shown in the above table, FLW accounts for close to 60 percent of the food industry's CO_2 equivalent footprint. Just over one fifth of this enormous footprint is entirely unnecessary.

[31] "Including agricultural production, post-harvest handling and storage, food processing, distribution, consumption and end-of-life (i.e. disposal)." (FAO 2013:10)
[32] FAO (2013). Food Wastage Footprint; Impacts on Natural Resources
[33] Life Cycle Assessment: Majority of LCAs only consider the GHG emissions from the production phase of the food supply chain (FSC), as this is where majority of emissions are accumulated in a product (Porter et al. 2016).
[34] Likely edible

3.8.2 Surface and Ground Water

Similarly, FAO estimated that FLW in the NAO region consumes 16.26km^3 of surface and ground water resources. This means that every tonne of FLW occurring in Canada equates to 128 tonnes of wasted surface and ground water. The majority (92%) of the food industry's water footprint occurs on farm during primary production.[35]

Based on FAO's estimate, Table 3-7 below shows that the blue water footprint of total FLW, avoidable FLW and unavoidable FLW equates to 4.5, 1.4, and 3.1 billion tonnes, respectively. Also shown are the blue water footprints of total food entering the food system and food consumed.

Table 3-7: Blue Water Footprint of Total, Avoidable and Unavoidable FLW (Billion Tonnes)

		Million tonnes	Water footprint (Billion tonnes)	Percentage of total water footprint
Food System Inputs		61.12	7.8	100
Food Consumed		25.58	3.3	42.3
Total FLW		**35.54**	**4.5**	**57.7**
	Avoidable FLW[36]	*11.17*	*1.4*	*17.9*
	Unavoidable FLW	*24.37*	*3.1*	*39.7*

As shown in the above table, similar to the food industry's CO_2 equivalent, FLW accounts for close to 60 percent of the food industry's blue water footprint; and a large part of this enormous footprint is entirely unnecessary.

Most telling, therefore, is that the environmental footprint of food consumed – measured in terms of CO_2 equivalent and blue water – is smaller than the environmental footprint of loss and waste that occurs along the food chain. This raises the question of whether the current food industry is environmentally sustainable.

[35] Hoekstra & Mekonnen (2012). The Water Footprint of Humanity

[36] Likely edible

4 Root Causes

The systemic inefficiencies described in the previous section result from misalignments occurring between the three subsystems that determine how individual businesses and the wider food industry operate: 1) Product and Technology, 2) Information and Communication, and 3) Governance.

The detailed analysis of data gathered from the online surveys, in-depth interviews, focus groups, as well as multiple informal discussions with industry stakeholders and process team meetings, enabled the root causes of these systemic misalignments to be quantified. The root causes of these systemic misalignments are presented from the perspectives of:

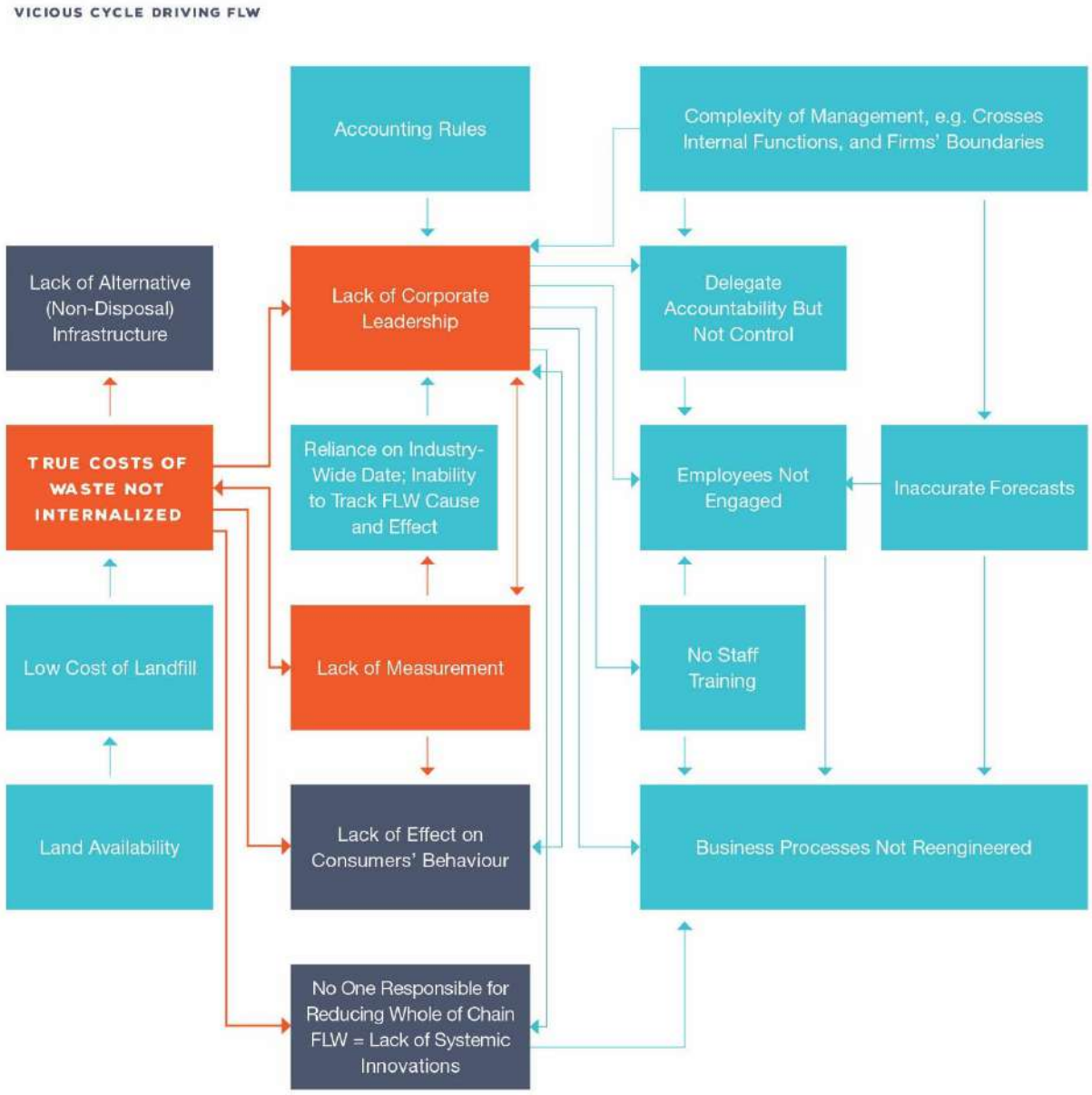
1. Whole of chain
2. Primary production
3. Processing and manufacturing
4. Retail
5. Hotel, restaurant and institutions (HRI)
6. Redistribution

Each of the root causes and their implication for driving unnecessary levels of avoidable (unplanned/post-processing) and unavoidable (planned) FLW at each link of the chain are discussed in greater detail in Appendix A.

4.1 Culture of Accepting FLW

Presented below in Figure 4-1 is a graphical representation of how the interactions that occur between the three subsystems analyzed during the study (1. Product and Technology, 2. Information and Communication, and 3. Governance) influence the levels of avoidable and unavoidable FLW occurring throughout the Canadian food system. The same interactions influence individuals' motivation to change. Unless a sufficient number of individuals – particularly those in authority – are willing to purposely change their behaviour and motivate others to do so also, industry wide change will not occur.

Figure 4-1: Vicious Cycle Driving FLW



The cycle reflects the fact that the overarching driver of FLW in Canada is a cultural acceptance of waste. This culture ultimately emanates from the true costs of waste not being internalized by industry. This, in turn, affects consumers' attitudes and behaviour.

Industry's culture of accepting FLW (particularly that which occurs in the home) extends to some businesses and organizations viewing FLW as a benefit to industry, because it drives increased sales. Evidence was found of some government representatives possessing similar sentiments.

4.2 Industry

The six root causes of what has become a general culture of accepting FLW are listed and described below. These root causes lead to unnecessary waste by preventing FLW being addressed at source, or by preventing the redistribution of excess foods and beverages that are edible.

1. Business owners'/employees' acceptance of waste
2. Adversarial, distrusting relationships
3. Purposely conservative date codes
4. Ineffective FLW measurement, reporting and mitigation
5. Maximizing production capacity and throughput
6. Perceived risk associated with food donation

Each of the six causes are described in sections 4.2.1 to 4.2.6. While respondents cited and applauded some industry leaders on multiple occasions for best practice, the extent to which these leaders are able to implement practices that further reduce current levels of FLW is hampered by the macroeconomic environment within which the Canadian food industry and its international stakeholders operate.

4.2.1 Business Owners'/Employees' Acceptance of Waste

Respondents provided numerous examples of where a "so long as the numbers are met, we do not need to change" attitude exists in businesses operating along the entire value chain. This attitude exists in situations where the potential financial benefits run to tens of millions of dollars annually, and investment amortization can be counted in weeks. The practice of senior management setting "numbers" that include current levels of FLW lessens the motivation to change.

4.2.2 Adversarial, Distrusting Relationships

Multiple respondents stated that ineffective forecasting, planning and replenishment can be more prevalent among businesses serving the retail sector versus foodservice. The causes of this partly lie in the adversarial relationships and distrust that typify the general grocery industry. This leads to an unwillingness to share data, plan and execute collaboratively. This dynamic occurs within and between businesses, leading to many root causes of avoidable FLW occurring at the interface between different functions (e.g. procurement and operations) and business partners.

The extent to which the food industry uses promotions to drive sales can exacerbate the negative impacts of ineffective forecasting and replenishment. It also exacerbates household FLW.

Linked to ineffective forecasts are overproduction and excess inventory. A fear of being penalized by their customer(s) if demand exceeds forecasts, or if 100 percent on-shelf availability is not met, drives suppliers to ensure product availability at short notice. Financial penalties are viewed by some as a source of revenue, which perpetuates this cycle of overproduction and excess inventory.

4.2.3 Purposely Conservative Date Codes

In the words of an interviewed retail executive: “In date coding we have created a monster.” Multiple examples were provided of businesses purposely setting overly conservative best before dates as a means to drive sales. This results in unnecessary FLW, not least because the same businesses may not be prepared to donate food that is close to or slightly past its best before date for redistribution.

Respondents also cited that some foods and beverages carry a best before date unnecessarily. This was in reference to 1) products that do not need to carry a best before date, because they have more than two years’ shelf-life; and 2) products where only minor eating quality or nutrient value, not safety, would be affected.

4.2.4 Ineffective FLW Measurement, Reporting and Mitigation

Reasons pertaining to the ineffective measurement, reporting and mitigation of FLW often revolve around businesses not internalizing the true cost of FLW. It is undervalued: accounting practices do not recognize hidden costs (e.g., labour, energy, transport, invested capital, etc.). The cost of FLW is typically recorded as disposal cost. Other costs are not factored into the analysis, resulting in neither the culture of accepting FLW nor the impact of misaligned incentives being challenged corporately.

Reasons why the true cost of FLW is not factored into financial analysis include the fact that food waste is not segregated from other wastes, or identified by stock keeping unit (SKU). Instead, the tracking of food waste occurs in the form of aggregated tonnes, typically provided by a third-party contractor. Businesses’ strategic and operational decisions are based on more granular reports regarding SKUs and category value. Connecting the two metrics takes determination and investment, particularly when the bespoke software required to achieve this on a mass scale may not exist.

In addition, few businesses have senior executives tasked with reducing FLW across their entire operations. This results in the continuation of misaligned business functions and incentives (within and between businesses), and helps perpetuate the existence of the aforementioned adversarial distrusting relationships, all of which are key drivers of avoidable FLW.

4.2.5 Maximizing Production Capacity and Throughput

Much of the food system operates from a produce, batch and queue standpoint. Businesses operate at (or close to) maximum capacity in order to 1) minimize per unit fixed costs, 2) respond to inaccurate forecasts and dysfunctional replenishment systems, and 3) maximize return on capital employed (ROCE). This invariably creates avoidable waste and unnecessary costs. It also ties up enormous amounts of capital.

The alternative approach is known as “lean.” The basis of lean is matching capacity to customer and consumer demand, and reducing cycle time. As occurs in the automotive or other industries, collaboration does not mean an end to competitive supplier/buyer relationships; it means channeling resources into constructive dialogue and continual improvement programs.

4.2.6 Reluctance and/or Resistance to Donate Safe Edible Food

The research estimated that 86 percent of excess edible food is not donated and redistributed. By definition, some foods are easier to donate and flow through redistribution systems than others. Regardless of food type, there is a reluctance – even resistance – among some businesses to donate edible foods to redistribution agencies.

The research found that reluctance is typically due to a handful of causes:

1) The comparative (real or opportunity) cost of donation versus alternative management options;
2) The complexity (real or perceived) of donation versus alternative management options;
3) Lack of infrastructure and/or ineffective communication between potential donors and recipient agencies, or logistical capacity – including transport, storage and cool chain;
4) Concern that donation will cause customers to react negatively, questioning the vendor as to why the product was not offered to them first at a discount;
5) Concern that brand value is undermined, potentially even destroyed – these concerns are heightened when best before dates come into the mix; and
6) Legal liability. Each province and territory has a Good Samaritan Act, though there is no standardization between the acts. There is also a general lack of awareness that these acts exist and the protection that they provide.

Resistance to donate also stems from the above reasons, plus an important caveat:

1) Vendor supply agreements. Vendor agreements can include a clause stating that excess products must be destroyed, and therefore cannot be donated.

4.3 Redistribution by Community Food Programs

Food rescuers and community food programs play a crucial role in society. The root causes of inefficiencies that result in avoidable FLW identified as existing in food rescue, redistribution, and within the community food programs that they supply, are identical to a number of those found to occur in the food industry and the markets that they serve.

These root causes, along with the necessity to rely on volunteers and the organizational cultures that can stem from this, can impact the degree to which innovative leaders in the food industry and community food programs are able to motivate and enable the adoption of sustainable best practices.

4.3.1 Strategic

While there is advocacy for food rescuers and community food programs operating within and across regions, there is little strategic oversight. This, combined with siloed and sometimes polarized relationships between organizations and stakeholders at the national, provincial/territorial and municipal level, leads to ineffective communication and ineffective execution. This in turn results in existing infrastructure and capabilities not being used to their full potential.

Limited strategic oversight and coordination acts as a barrier to securing the financial investment required to address gaps in current infrastructure (e.g. lack of refrigerated storage and transport capacity). Respondents from industry and community food programs indicated that this gap is the largest single barrier to increasing the rescuing and redistribution of food. While infrastructure gaps are particularly acute in rural and semi-urban areas, they can occur anywhere, hence the need for increased collaboration and strategic oversight.

4.3.2 Operational

The strategic weaknesses described above factor into the lack of standardized communication and processes implemented by food rescuers and community food programs. Respondents said this constituted the greatest overall cause negatively impacting the performance of the current system.

It manifests itself as poor communication with donors, ineffective forecasting and distribution, lack of trained, knowledgeable, professional standard staff/volunteers, and consequently the sub-optimized operation of existing infrastructure. The opportunity for improvement is illustrated by numerous food industry respondents making statements similar to: “If more foodbanks operated like *(name withheld for reasons of confidentiality)*, we could and would donate more.”

Operational performance is also negatively impacted by some rescuers and community food programs exhibiting a culture of primarily viewing themselves as providers of societal good versus part of an interconnected system for redistributing food to address hunger relief. This impacts the staff that they recruit, as well as how staff and volunteers are trained and incentivized. In the words of respondents from local community food programs that rely on regional community food programs to meet clients’ demands: “It’s unlikely that someone with a degree in psychology knows much about food logistics, though that’s the type of person that they tend to hire,” and “We don’t know what we are going to receive, so [we] source what we can locally, then have excess that goes to waste, due to doubling up.”

Standardized, well communicated processes would aid rescuers and community food programs to address the issue of donors expecting them to accept everything, regardless of its suitability for redistribution.

4.4 Consumers

Primary consumer research was beyond the scope of this study. Therefore, any reference to the root causes of consumer FLW is limited to that provided by respondents in the online surveys, during the in-depth interviews, or during the focus groups.

The research estimated that 21 percent of avoidable FLW occurs amongst consumers. Consumer driven waste also occurs in HRI. Evidence provided by respondents, along with research conducted previously and simultaneous to this project, suggest that, like industry, consumers exhibit a culture of accepting waste.

Respondents identified five consumer reactions that cause increases in the FLW occurring in industry, in HRI and within the home. The same reactions occur amongst the clients of community food programs. These are:

1. Part-filled shelves
2. Best before dates
3. Product aesthetics (looks)
4. Packaging of products
5. Menu design

That the first four factors are said to have less impact on consumer behaviours when purchasing online versus in a retail store could explain why, anecdotally, respondents identified that they had experienced markedly less FLW occurring a) in the households of those that have transitioned to E-tailing, and b) along value chains supplying (and within) E-tailing operations versus retailers and the value chains through which they source goods.

4.4.1 Part-filled Shelves

Multiple respondents provided evidence that consumers' purchasing of a product typically slows when shelves are only part-filled or nearing empty. Keeping shelves full to prevent a slowdown in consumer purchases and/or dissatisfaction being voiced by consumers leads to overproduction. It also leads to increased waste at the retail store. In community food programs, how shelves are stocked drives changes in client behaviour and has the potential to create avoidable FLW.

4.4.2 Best before Dates

Considerable evidence was presented on the impact that products reaching or close to their best before dates have on consumers' purchasing decisions. Consumers typically interpret "best before" to mean "bad after." As the research identified, this can lead processors and manufacturers to use overly conservative best before dates as a mechanism to drive increased sales. Clients of community food programs will shun foods that are close to or have reached their best before dates, even when offered at no cost.

4.4.3 Product Aesthetics (Appearance)

According to respondents, consumers do not buy imperfect looking products, specifically imperfect fruits and vegetables. An Ontario community food program was amongst those who described how some of their clients will not accept misshapen vegetables, such as carrots, even when offered at no cost. In hunger relief agencies, commonly the only means of ensuring imperfect fruits and vegetables are not wasted is by using them in the preparation of cooked foods.

4.4.4 Packaging of Products

Product shelf life can be extended – often significantly – by packaging it, or changing the design of the materials in which products are packaged. However, numerous respondents stated that Canadian consumers have proven to be adverse to products, particularly fresh products, being packaged. This has negatively impacted the Canadian food industry's willingness to utilize packaging to its full potential, resulting in Canada being approximately a decade behind Europe in utilizing packaging as a means to reducing FLW by extending shelf life.

4.4.5 Menu Design

Respondents identified a direct correlation between menu design and plate waste in HRI. In some circumstances, the level of FLW caused by menu design, such as the inclusion of items often not eaten by their customers, is greater than that attributed to portion size.

The packing of standardized boxes by community food programs, regardless of clients' personal preferences and dislikes, and their circumstances – including access to refrigerators, freezers and cooking equipment/utensils – drives avoidable waste.

4.5 Waste Management Practices and Options

Businesses' waste management decisions for both excess edible food and beverages, as well as inedible FLW, is predicated on a number of factors. The research identified a handful of root causes that lie behind businesses' waste decisions.

1) **Sending to landfill is easy.** Sending to reuse or recycling requires food to be separated from other waste and a change in business practices. This requires the investment of resources in processes, procedures, and potentially the modification of infrastructure, including buildings.
2) **Landfill/tipping fees.** Low landfill/tipping fees can make any other management option for edible and inedible food financially unviable. This is particularly the case where the population density is low and thus the economies of scale required to establish and operate the traditional infrastructure to produce bioenergy, for example, are unviable. In such cases, excess food and beverages invariably continue to be sent to landfill.
3) **Resistance from established waste management companies.** Waste management is big business and profitable, partly because organic waste is heavy and therefore expensive to

transport. Examples were given of waste management companies using the comparative expense of reuse or recycling versus sending to landfill as a reason why businesses should not change their waste management practices.

4) **Green bin/composting programs.** Respondents involved in produce packing, food processing, food and beverage manufacturing, distribution, retail, and foodservice stated that a lack of access to green bin and composting programs prevents them from more responsibly managing waste streams. While many of these respondents were located in Western Canada, the same situation exists in much of the country. Population density does not appear to be the determining factor of whether green bin and composting programs exist in a particular municipality.
5) **Current macroeconomics** that drive capital investment and business management decisions do not support investing in the processes and infrastructure required to cost-effectively divert more FLW from landfill. The same macroeconomic factors limit the funding provided to those seeking to develop innovative reuse or recycling solutions. This perpetuates the current situation.

4.6 Government Policies, Regulations and Legislation

An audit of federal, provincial, territorial, and municipal policies regarding their impact on the creation of avoidable and unavoidable waste was not the purpose of the project. That said, multiple respondents provided evidence of the influence that policies, legislation and regulation enacted by all three levels of government[37] can have upon driving avoidable FLW.

Evidence provided by respondents strengthened VCMI's previous (2016) assessment of the present situation: "No ministry or level of government has ultimate responsibility or is accountable for food loss and waste. This leaves industry in the unenviable position of having to grapple with an environment shaped by misaligned policies, legislation/regulations and systems."

The study categorized the root causes related to the impact of policies, legislation and regulations on driving decisions that lead to unnecessarily high levels of avoidable and unavoidable FLW into three groups:

1. Policies that lead to industry and consumers not internalizing the true cost of FLW;
2. Unintended consequences of policies, regulations and legislation; and
3. A belief that reducing FLW will negatively impact farmers' and businesses' viability.

[37] The British North America Act (BNAA) Sections 92, 93 and 95 determined the structure of Canadian governmental processes (federal, provincial/territorial, municipal), and, in turn, led to the creation of overlaps and conflicts being built into the Canadian food policy and regulatory system. This leads to the creation of incongruences that impact commercial decisions and lead to the creation of unnecessary FLW.

4.6.1 Policies that lead to industry and consumers not internalizing the true cost of FLW

The combined effect of the root causes listed above includes that the true costs of FLW are not internalized by businesses and consumers. Not internalizing the true costs of FLW can lead, for example, to businesses choosing to send FLW to landfill rather than recycling. It can also lead to consumers apportioning less value and care to the foods and beverages that they choose to purchase.

Why the true costs of food production and management are not internalized by businesses and consumers include:

1) No national policies, regulations and legislation regarding landfill regulations and tipping fees. An example of a lack of consistency, just at the municipal level, includes that the organic tipping fees of neighbouring municipalities can differ by hundreds of dollars per tonne. That provincial/territorial jurisdictions jointly govern landfill regulations and waste management infrastructure means that achieving change can take years and rests on the lowest common denominator.
2) No standardized policies, regulations and legislation pertaining to emissions created during the production, processing and disposal of food. For example, reducing emissions below targets agreed with a ministry can create challenges that are similar to those if businesses exceed targets. The existence of differing legislation across provinces, along with inspectors differing in how they interpret legislation, directly and negatively impacts businesses' motivation and ability to reduce emissions through investment in continual improvement programs.
3) No link existing between landfill regulations and tipping fees to investment of public funds in the knowledge, skills and infrastructure required to reduce FLW through prevention, redistribution, recycling and reuse. Reasons why revenues produced by landfill fees are not reinvested in innovation, infrastructure and training include that it would require collaboration between different levels of government and different government departments.

4.6.2 Unintended consequences of policies, regulations and legislation

While the unintended consequences of policies, regulations and legislation on the creation of FLW might not be understood, and therefore not factored into their design and implementation, below are the most common examples cited by respondents.

Marine catch licenses and quotas

Wild catch fishing is the final bastion of hunter gathering in the mainstream food industry. Fishers do not know how many, what type, and what quality/value of fish or marine creature they will catch until it is in the net or on the line. These and other considerations are often not factored into

the development, implementation and enforcement of quotas or other marine legislation, resulting in significant unnecessary FLW. Examples of such situations include:

1) Legislation can prevent fishers from landing some species unless they have a minimum of catch, or landing some species at all. Stocking programs lead to artificial imbalances in species, and fishers purposefully discarding a sizeable percentage of their catch because it is not their target fish. In all such cases, discarded fish are typically dead or injured.
2) Limiting the timing of when marine species can be caught in a given area, though not the volume that can be landed, and explicitly linking neither to market demand, health or quality can create enormous fluctuations in volume and losses. This is most impactful where seafood is transported live.

Temporary and seasonal workers

The farming and food processing sector has been negatively impacted by changes to the seasonal and temporary worker regulations. In agriculture and horticulture, too few workers lead to on-farm losses, due to the inability to harvest crops at peak quality – if at all. Examples provided include:

1) In the wine industry, workforce shortages lead to the inability to correctly manage the vine, resulting in a heightened risk of pests and diseases. Consequently, the quality of the grapes is potentially reduced, and subsequently the wine.
2) In the grains industry, workforce shortages lead to harvesting equipment not being fully utilized. Delay in harvesting leads to crops being downgraded in quality and price, resulting in crops grown for food being downgraded to animal feed or another non-food use. It also leads to some crops not being harvested at all.
3) In the fruit industry, workforce shortages lead to crops being harvest past their prime, resulting in higher percentage of culls and higher than usual losses in storage. It also leads to crops being left unharvested.

Labelling

Two of the examples provided by respondents regarding the impact of labelling regulations on driving unnecessary FLW are:

1) Foods imported into Canada can run into issues if the label does not meet Canada's legal requirements. Not meeting these requirements results in foods not being able to be sold or donated, even if the issue does not pertain to food safety. With no other option available, the foods are sent to landfill.
2) Best before. For food safety reasons – for example, the prevention of Listeria monocytogenes in ready to eat (RTE) products – clear guidelines exist for the use of best before dates on some products. If not scientifically tested, the best before dates on many low acid RTE foods only allow a maximum of five days' shelf life. This can lead to edible

products being disposed of prematurely, particularly those supplied by smaller suppliers who do not have the financial resources required to complete scientific shelf life studies. The guidelines for determining industry's use of best before dates across other food types are, however, less defined. This leaves the potential for the best before date system to be abused.

Food Rescue in Public Health Institutions

Public health institutions commonly follow a "when in doubt, throw it out" philosophy towards food that could potentially be donated. The lack of clear and robust guidance surrounding the management of excess safe-to-eat foods leads to current rules mandated by provincial and municipal governments being interpreted and acted upon differently, and potentially edible foods going to landfill. There are no consistent public health regulations across Canada. Regulations differ even within the same province, as it is up to municipalities to execute them, resulting in confusion amongst provincial or national food businesses on when and how they can donate excess product. Similarly, the system is confusing for food rescue organizations to navigate and to assure food donors of the correct process.

Crop Insurance

Providers of crop insurance are typically Crown corporations. Weather or other growing factors can create quality and size issues that prevent a farmer from selling their crops to the commercial market. To protect themselves financially in the event of such an occurrence, farmers insure their crops. Many crop insurance claims do not relate to a food safety hazard. Hail-damaged apples, for instance, look less appealing visually though are still edible and their interior quality likely unaffected. The claiming of crop insurance can prevent a farmer donating a crop to hunger relief efforts, resulting in nutritious foods unnecessarily going to waste.

Crop and Livestock Protection

An effective crop and livestock protection regulatory system is critical to maximizing on-farm productivity and minimizing incidences of meat being condemned. A relationship exists between the regulation of pesticides and fungicides used in crop production and livestock production pharmaceuticals and avoidable FLW on the farm and along the value chain. Throughout the research numerous respondents from all sectors of the food industry cited examples of how the current Canadian regulatory system can lead to unnecessary losses and waste. For example, not having access to pharmaceuticals, which are widely used during animal production in other countries, leads to preventable parasitic infestations and the condemnation of meat during processing; and not having access to fungicides used in fruit production leads to unsaleable apples, due to this negatively impacting crops' quality, storability, shelf life, and appearance. In addition to avoidable production-related losses, having limited control over known situations can lead farmers to overproduce for fear of shorting customers.

4.6.3 A belief that reducing FLW will negatively impact farmers' and businesses' viability

Some government representatives (and industry organizations) believe that reducing FLW would negatively impact the economic viability of the Canadian food industry, particularly farmers. This can lead to the reduction in FLW not being supported by government/industry individuals and potentially departments/agencies.

This line of thinking stems from a belief that a) reducing FLW will impact the equilibrium between supply and demand, leading to a reduction in commodity prices; and b) reducing FLW will automatically lead to reductions in what farmers can produce. Therefore, reducing FLW will impact farmers' margins and profitability and, by definition, the sales and profitability of those production inputs.

The argument presented above reflects the concept of scarcity, not the concept of abundance.[38] The concept of scarcity reflects a belief that a) the market will pay producers for mediocre quality products that subsequently go to waste further along the chain; b) reducing costs and improving resource utilization will not positively impact the food system; c) any unused capacity cannot be used by farmers and other businesses to access latent demand in markets not currently supplied; and d) the mechanisms that determine Canadian commodity prices are entirely domestically driven.

5 Solutions and Actions

Waste can arise at any point in the value chain, and it is often the case that the actions of one part of the chain can give rise to waste in another. Without proper measurement and a whole chain focus on food waste prevention, FLW costs are cumulative, leading to higher prices for businesses and consumers alike. This also results in lower margins and profits. That the full costs of waste ultimately fall on society points to the need for a comprehensive approach that encompasses all parts of the food system.

Our research did not find any examples of waste being measured and managed systematically across a whole value chain from farm to fork. However, we know that businesses collaborating as a team can produce commercial and societal benefits that are not possible when working in isolation. We also encourage the promotion of teamwork across the industry and its regulators. Partnerships between businesses and redistribution agencies result in more edible foods and beverages being rescued. Purposeful management of waste streams enable more inedible foods and beverages to be reused and recycled instead of going to landfill.

[38] **Concept of scarcity**: only so much available in the market, so the only way for me to negotiate and succeed is to take something away from you (win/lose). **Concept of abundance**: plenty out there and available in the market, so the only way that we can negotiate and succeed is to improve performance by collaborating to access new markets and improve the utilization of available resources (win/win).

5.1 Three to Succeed

The matrices presented at the beginning of this report – "Do now (2019)," "Do soon (2020-2021)" and "Build a plan (2022 onwards)" – are based on the three overarching approaches listed below for driving reductions in FLW. The final concluding section of this report sets out recommended actions for implementing these approaches.

The first two approaches (Measure and Lead) are proven means of reducing FLW in industry and the home. We believe that they also have a role in reducing FLW by encouraging the rescue of edible food, and improving the performance of community food programs. The third approach (Enable) is about creating an enabling environment for a) motivating and supporting industry, consumers and community food programs to reduce avoidable FLW wherever possible; and b) reducing FLW going to landfill through reuse and recycling. The three approaches are:

1. **Measure**
    - Standardized FLW measurement, valuation and reporting
    - Improve forecasting, communication and collaboration
    - Drive innovation in packaging and products that reduce waste
2. **Lead**
    - Mentorship and capacity building
    - Drive changes in business practices
    - Engage employees in constructive reasoning and response
3. **Enable**
    - Address policies, legislation and regulations that are incongruent to reducing FLW
    - Government and industry commit to constructive, outcome-driven collaboration

The proposed solutions and actions that underpin these approaches can lead to significant and measurable reductions in FLW, by influencing macro and micro change within industry and among consumers. Figure 5-1 below presents the envisaged process of how this will occur.

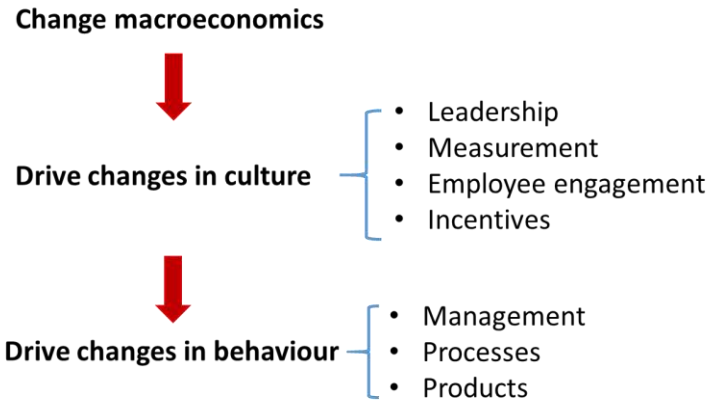
Changing the macroeconomics that influence how industry and community food programs operate leads to changes in business culture. This includes the accurate measurement and valuation of FLW, along with the emergence of the leadership required to incentivize and engage industry (along with consumers and community food programs) in the change process.

Sustained changes in culture and, subsequently, sustained changes in behaviour (including the management of processes followed by industry, food rescuers and community food programs, and how products are produced, handled and distributed) are ultimately key to sustainably reducing FLW. This can only be achieved through:

1. Changes in how FLW is measured and reported;
2. Senior leaders from industry and government proactively and collaboratively championing the need for change; and
3. Establishing the incentives required to engage employees in implementing practices that lead to reductions in FLW.

As illustrated in Figure 5-1, this process begins with changing the macroeconomics that influence how the overall food system operates.

Figure 5-1: Change Processes to Reduce FLW



5.2 Making Change Happen

The following tables identify 14 solutions and actions to reduce FLW through prevention and redistribution, and responsibly manage FLW that does occur through reuse and recycling.

Collaboration can deliver considerably greater and sustainable benefits than businesses can attain on their own. It is however a difficult option, because it involves setting exacting targets and driving continuous improvement together. (At the end of this Section we explain the different value chains that exist and how businesses respond and benefit from each type of chain.)

To take into consideration the specific group scenarios that exist, we have categorized the recommended actions for each of the 14 solutions by:

- A single business acting alone
- Value chain partners working together where
  - Collaboration is low or developing
  - Collaboration is well established
- Food rescue organizations
- Industry bodies providing advocacy, leadership and guidance
- Different tiers of government

The actions are based on a belief that industry bodies and governments alike should direct the development and promotion of FLW prevention strategies implemented by businesses operating along food value chains. Bodies advocating for food rescuers and community food programs also have a crucial role to play in the implementation of FLW prevention strategies. This would guide how businesses work independently, or preferably in partnership, to take greater steps to prevent FLW, by implementing improved measurement and actions particular to the value chains in which they operate. It will also guide the implementation of improved measurement and actions throughout rescue and redistribution systems.

Categorized as “Business Optimization,” “Marketing and Merchandizing” and “Social and Environmental Responsibility,” the 14 solutions and associated actions are described below.

Business Optimization

Solution #1: Measure, value and report FLW at business level ***Applicable to all levels of industry, food rescue/redistribution; all types of food***
Implementations by Businesses
As a single business acting alone • Measure, value, report and act upon FLW at business level Where collaboration is low or developing • Monitor and communicate extent of FLW linked to business dealings; for example, by benchmarking supplier performance Where collaboration is well established • Share and act on FLW data in conjunction with continual improvement program, sharing benefits to motivate continued mutually-beneficial commitment
Implementations by Food Rescue Organizations
In conjunction with those businesses from whom community food programs source foods and beverages, • Implement monitoring systems to address inefficiencies, particularly foods and beverages that go to waste due to disconnects between supply and demand.
Implementations by Industry Body
In conjunction with stakeholder initiatives, such as the Grocery Manufacturers Collaborative, produce a strategy and common framework for individual members to report FLW, set targets and KPIs • Incorporate into a voluntary agreement and FLW reduction targets established with government Define foods and beverages diverted to animal feed as FLW • Viewing the diverting of excess food to animal feed as a revenue source masks potentially enormous inefficiencies • Incorporate standardized measurement, valuation and reporting practices into CFO training and executive mentorship Assist individual members to quantify the true value of FLW and scale of financial opportunities achievable by reducing FLW • Ensure effective narrative is used in communications to industry (e.g. emphasize the scale of labour-related costs that can be reduced by addressing FLW at source) • Incorporate into CFO training and executive mentorship
Implementations by Government
Legislate making FLW reporting compulsory • Incorporate into investment in voluntary agreement

Solution #2: Set reduction targets
Applicable to all levels of industry, food rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Set business targets
- Incorporate FLW targets and reduction strategies into employee incentive systems

Where collaboration is low or developing

- Understand the impact of achieving the FLW reduction target up and down the chain
- Review product specifications (including seasonal variations) to determine their impact on driving avoidable FLW, and identify appropriate remedial actions
- Incorporate into vendor scorecards/benchmarking

Where collaboration is well established

- Set chain FLW reduction targets and conduct root cause analysis
- Establish and commit to mutually advantageous cross-chain action plan
- Motivate improvements by equitably sharing benefits
- Incorporate into vendor scorecards/benchmarking

Implementations by Food Rescue Organizations

Individually and in conjunction with those from whom they source and supply food

- Food rescue organizations establish targets and monitor performance in order to determine best practices that are shared to encourage continual improvement and increased widespread impact

Implementations by Industry Body

Assist individual members to quantify the true value of FLW and reduce FLW

- Incorporate into a) voluntary agreement between industry and government, and b) CFO and executive mentoring

Explore better practices utilized in other industries (e.g. automotive) to drive continual improvements in resource utilization and innovation

- Examples include constructive pre-agreed sharing of gains achieved by improving efficiencies over a set timeframe

Implementations by Government

Map how FLW reduction by category contributes to specific government objectives (food security, GHG reductions, etc.), then set local, provincial and national targets

- Use resulting insights to guide policy, regulatory and legislative development, implementation and evaluation

Review impact of business relationships on FLW to propose possible interventions

- Incorporate into investment in voluntary agreement

Solution #3: Engage employees
Applicable to all levels of industry, food rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Assign responsibility at senior executive level for reducing FLW
- Identify an individual from senior management or an executive who is responsible for waste prevention and who can direct remedial action
- Provide staff training and mentorship to support implementation of lean enterprise practices
- Delegate control as well as accountability for FLW and associated waste reduction
- Introduce individual/team/store targets and incentives

Where collaboration is low or developing

- Assign responsibility among senior executives and management to reduce FLW
- Incorporate employee accountability for reducing FLW in business agreements and dealings

Where collaboration is well established

- Provide inter-firm training and forums to support the implementation of collaborative lean enterprise practices across the multiple businesses and business functions
- Leverage collaboration to drive continual reductions in FLW and associated wastes

Implementations by Food Rescue Organizations

Engage staff and volunteers in designing then implementing improved processes, protocols and systems, then to share results and best practices, through:

- Networking, training and mentorship to create capacity to implement lean thinking throughout the food rescue network
- Proactively hiring staff and engaging volunteers who possess logistics training and experience
- Engage staff and volunteers in the optimized management of inventory and stocking

Implementations by Industry Body

Invest in voluntary agreement

- Commit to a structured process for engaging employees from all levels of industry in enabling and motivating continual improvement in FLW reduction

Develop lean enterprise process improvement training modules for members

- Communicate best practices and achievements
- Linked to CFO training, executive mentorship, and wider industry communications

Partner with universities and colleges to ensure delivery of effective and pragmatic lean process improvement courses

- Communicate best practice
- Encourage industry to support action learning by students through secondment or other means

Implementations by Government
Invest in voluntary agreement • Commit to a structured process for engaging industry leaders from across the food value chain in enabling and motivating continual improvement in FLW reduction Couple university and college funding with delivery of at least one lean enterprise continual process improvement unit • Apply to all students studying business, management, commerce and food preparation/handling related disciplines

Solution #4: Improve forecasting ***Applicable to all levels of industry, food rescue/redistribution; all types of food***
Implementations by Businesses
As a single business acting alone • Review internal forecasting processes and protocols to identify root cause of forecast deficiencies and address Where collaboration is low or developing • Provide meaningful forecasts in appropriate metrics/information Where collaboration is well established • Introduce Collaborative Planning, Forecasting and Replenishment processes • Manage promotions to minimize creation of unnecessary FLW • Implement vendor managed inventory where appropriate • Motivate continued commitment by sharing benefits achieved
Implementations by Food Rescue Organizations
In conjunction with peers and community food programs, establish the strategic oversight required to ensure implementation of effective and efficient forecasting and replenishment processes, protocols and practices at local, regional and provincial/territorial levels of hunger relief efforts. • Resulting in the improved utilization of current infrastructure and aiding long-term capital investment decisions
Implementations by Industry Body
Identify better practice forecast creation, communication and execution • Incorporate insights into executive mentorship, CFO training and wider industry communications Publish guidance and case studies on collaborative forecasting and replenishment • Incorporate into the establishment of FLW reduction targets and the monitoring/reporting on industry performance

Implementations by Government
Monitor industry relationships and practices to determine whether market power is abused in ways that result in excessive FLW within a specific value chain(s) or the wider industry • Incorporate into investment in voluntary agreement

Solution #5: Reduce HRI specific FLW ***Applicable to HRI; all types of food***
Implementations by Businesses
As a single business acting alone • Measure then manage preparation, plate/tray and dry waste • Discourage excessive serving/portion sizing by HRI and consumers in self-serve facilities. *Incorporate into Solution #11: Raise public awareness of responsible food behaviour* • Implement room service model to hospitals, care homes and healthcare facilities • Incorporate lean thinking into ordering, preparation and serving decisions/ management Where collaboration is low or developing • Ensure procurement process and vendor evaluations reflect lean enterprise approaches Where collaboration is well established • Collaborative planning, forecasting and replenishment
Implementations by Food Rescue Organizations
Aid donation of food by HRI sector through establishing straightforward and auditable Standard Operating Procedures (SOPs) that are readily implementable, and common language for ensuring the effective implementation of these SOPs by HRI staff/management and food rescue organizations • Food redistributors provide support and capacity required to enable implementation of effective and efficient food rescue solutions across HRI
Implementations by Industry Body
Collaborate with culinary arts colleges to deliver pragmatic hands-on modules on lean enterprise and FLW reduction • Ensure best known practices incorporated into students' learning and development
Implementations by Government
Connect the procurement of food and beverages by broader public foodservice with the accurate reporting and valuing of FLW • In conjunction with the implementation of continual improvement programs and the training of public employees, both executive and staff Support food redistributors to develop (or gain access to) the resources, skills and capacities required to implement effective and efficient solutions for rescuing safe edible food from HRI • Ensure sufficient attention given to enabling implementation of food rescue SOPs in healthcare institutions across regions and provinces/territories

Solution #6: Improve date coding information and practices
Most applicable to processing, manufacturing, retail and HRI; all types of food

Implementations by Businesses

As a single business acting alone

- Review corporate policies and corporate practices to ensure socially and economically responsible date coding practices

Where collaboration is low or developing

- Incorporate corporate policies into supplier scorecards, vendor benchmarking, and contractual agreements

Where collaboration is well established

- Eliminate best before, use by, and sell by date practices that lead to avoidable FLW
- For best before dates where there are no food safety implications, use a format that enables effective stock management though is not obvious to consumers (e.g. Julian codes[39])
- Increase minimum life on receipt, and monitor practices between suppliers

Implementations by Food Rescue Organizations

Establish standardized, clearly defined language for communicating acceptable timeframes for receiving and redistributing products that are close to, or have reached, their best before date to:

- Businesses where rescued food is sourced
- Community food program staff and volunteers
- Community food program clients

Implementations by Industry Body

Establish industry standard for corporate date code policies and processes

- Establish best practice policies for businesses to evaluate their policies, procedures and protocols

Communicate the purposes and meaning of each date code type to consumers and industry

- Ensure responsible behaviour by having established basis of common understanding

Implementations by Government

Establish clear, practical and enforceable policy and regulations on date coding

- Includes establishing clear differentiation between use by industry, and legislation by government, of “best before,” “use by” and “sell by” date coding practices

[39] For further information, as example, see: https://www.thereadystore.com/food-storage/1221/julian-date/

Solution #7: Ensure available, affordable temporary and seasonal labour
Most applicable to agriculture, processing and manufacturing sectors; all types of food

Implementations by Businesses

As a single business acting alone

- Be aware of program requirements, plan ahead, and implement processes to ensure compliance with temporary and seasonable worker regulations

Where collaboration is low or developing

- As with a single business acting alone, be aware of program requirements, plan ahead, and implement processes to ensure compliance with temporary and seasonable worker regulations

Where collaboration is well established

- As with a single business acting alone, be aware of program requirements, plan ahead, and implement processes to ensure compliance with temporary and seasonable worker regulations
- Explore the possibility of collaboratively sharing workforce to ensure its effective and efficient utilization, such as between farming operations or between farming / marine and processors

Implementations by Food Rescue Organizations

N/A

Implementations by Industry Body

Foster objective results-driven collaboration between industry and government

- Establish clearly defined guidelines setting out businesses' accountabilities when engaging temporary and seasonal labour, including compliance requirements

Implementations by Government

Reintroduce proven programs for temporary and seasonal workers, especially in agriculture

- Separate temporary worker and seasonal worker program requirements and monitoring practices
- Establish standard operating procedures for inspectors to follow when evaluating applications

Address the prescriptive nature of current programs

- Place accountability for the responsible management of the temporary worker and seasonal worker programs on individual businesses
- Monitor program implementation through the establishment of standard operating procedures, along with clearly defined rules for inspectors and industry to follow

Marketing and Merchandizing

Solution #8: Streamline product ranging (retail, HRI, redistribution)
Primarily applicable to retail, HRI, food rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Ensure SKU range matches stores' local demographics, deleting any underperforming SKUs
- Ensure effective shrink management policies and reporting procedures

Where collaboration is low or developing

- Review product ranging (products and pack size) to align more specifically with local demand and FLW reduction targets

Where collaboration is well established

- Incorporate monitoring of store ranging into collaborative planning, forecasting and replenishment processes

Implementations by Food Rescue Organizations

Ensure food redistribution processes and protocols allow staff and volunteers to respond effectively and efficiently to clients' needs and preferences

- For example, within the bounds of what is practical, be flexible in the size and contents of food boxes / hampers that community food programs provide to their clients

Implementations by Industry Body

Identify and communicate best practice for optimizing stores' SKU ranging decisions

- Communicate to industry pre-competitive examples of success and how achieved

Implementations by Government

N/A

Solution #9: Streamline product availability in retail, HRI and redistribution
Primarily applicable manufacturing, retail, HRI, rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Retailers: use on-shelf messages to explain why availability of particular SKUs is limited and therefore shelves are not fully stocked
- HRI: use menu, or other means if more appropriate, to explain why availability of particular items is limited
- Vendors: minimize the occurrence of supply outages by implementing lean enterprise practices

Where collaboration is low or developing

- Determine if positive correlation between forecast accuracy and product availability is proven to exist. If it does exist, conduct root causes analysis and remediation

- Vendors: proactively communicate to suppliers and customers if possible forthcoming limitations in supply arise

Where collaboration is well established

- Optimize availability through collaborative planning, forecasting and replenishment programs

Implementations by Food Rescue Organizations

Redistributors collaborate with their peers and the community food programs that they supply, locally, regionally and inter-provincially to:

- Improve the strategic and operational transparency required to react effectively and efficiently to the needs of individual community food programs

Implementations by Industry Body

Research impact of empty and part-filled shelves on consumer behaviour

- Pre-competitive analysis to identify in which products and consumer segments negative reaction is most acute, and avenues/means to successfully address

Implementations by Government

Ensure activities pertaining to voluntary agreement encompass the analysis of penalizing practices imposed by customers on suppliers on the creation of unnecessary FLW

- Incorporate into funding of voluntary agreement

Solution #10: Reformulate products and packaging
Applicable to processing, manufacturing, retail, HRI; all types of food

Implementations by Businesses

As a single business acting alone

- Identify optimized packaging and communicate these changes to consumers. A slight increase in one type of packaging, whether tertiary (for transportation purposes), secondary (boxes/trays such as that often seen on retail shelves), or primary (packaging that consumers take home) can reduce overall packaging requirements and also, in turn, produce significant reductions in food waste

Where collaboration is low or developing

- Establish and communicate standard operating procedures for evaluating and determining packaging and product innovations to vendors and packaging material manufacturers

Where collaboration is well established

- Optimize tertiary, secondary and primary packaging design to minimize whole of chain food, beverage and packaging wastes
- Determine most appropriate pack size(s) and design(s) for target market(s), implement appropriate supply chain processes, then monitor overall performance

Implementations by Food Rescue Organizations

N/A – unless food and beverages specially packaged for purchase by or donation to agencies, in which case a balance must be attained between pack size and target clients

Implementations by Industry Body
Establish guidance for businesses to follow when seeking to design optimized packaging solutions, and communicating the benefits of optimized packaging to consumers • Identify and communicate the benefits achieved through best practice
Implementations by Government
Legislation than enables improved development and use of optimized packaging • Minimize incongruences between packaging design, materials and recycling policies, legislation and regulations Introduce and standardize (nationally) producer responsibility in packaging • Establish national standard for producer responsibility Collaborative investment by municipalities in infrastructure for reuse and recycling of packaging • Linked to discouraging the disposal of packaging in landfill by industry and consumers

Social and Environmental Responsibility

Solution #11: Raise public awareness of responsible food behaviour ***Applicable to processing, manufacturing, retail, HRI, food rescue/redistribution; all types of food***
Implementations by Businesses
As a single business acting alone • Point-of-sale messaging where consumers can source information on reducing at-home FLW • Optimize pack sizing decisions in product ranging • Partner with the Love Food Hate Waste campaign: https://lovefoodhatewaste.ca/ Where collaboration is low or developing • Pack size optimization, labels providing storage and freezing guidance, portioning and help with using leftovers • Best practice in date labelling and open life guidance Where collaboration is well established • Pack size optimization, labels providing storage and freezing guidance, portioning and help with using leftovers • Best practice in date labelling and open life guidance
Implementations by Food Rescue Organizations
Identify best practices and standardized common language for ensuring responsible behaviour amongst community food program clients and reducing FLW during redistribution
Implementations by Industry Body
Identify best practices for ensuring responsible purchasing and food handling behaviours amongst consumers • Encourage standardized merchandizing and consumer messaging across industry

Expand involvement in Canada's Love Food Hate Waste campaign

- Champion industry's involvement in program

Implementations by Government

Expand involvement in Canada's Love Food Hate Waste campaign across all jurisdictions

- Invest in enabling its communication via a range of media channels

Reintroduce home economics (food handing and preparation) into high schools nationally

- Invest in the required infrastructure and human resources

Solution #12: Increase donation of edible food

Applicable to all levels of industry, food rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Contribute food to local redistribution schemes and community food programs
- Contribute services, such as transportation (e.g. reverse logistics), to local redistribution schemes
- Engage employees in design, implementation and continual improvement of food donation programs

Where collaboration is low or developing

- Review vendor agreements to ensure they do not obstruct redistribution

Where collaboration is well established

- Introduce collaborative programs to enable excess food to be donated with the most shelf life, by linking donation process to business forecasting, replenishment and demand processes

Implementations by Food Rescue Organizations

Aid donation of food by any business operating along the value chains supplying retail and HRI, through establishing straightforward and auditable SOPs that are readily implementable and share a common language.

- Establish the strategic oversight required to ensure improved communication and coordination between donors, redistributors and community food programs.
- Redistributors, through strategic engagement with industry and government, improve the availability of effective and efficient food rescue solutions

Implementations by Industry Body

Investigate extent and causes of resistance to donating edible food

- Use findings to counter resistance to donation through constructive information and communication

With NGOs, standardize collection and communication systems between donors and redistributors (system may need to vary between rural and urban settings)

- Facilitating positive change by enabling more effective communication and interactions between industry and redistribution agencies

Publish advice and case studies on donation liability and vendor agreements

- Encourage redistribution through providing industry with constructive advice and providing support network

Implementations by Government

Standardize and communicate Good Samaritan Acts

- Ensure consistency between all provinces' and territories' Good Samaritan Acts

Collaborative investment in re-distribution infrastructure

- Minimizing occurrence of rescued/rescuable food that is wasted due to lack of infrastructure or effective processes

Introduce incentives for businesses to donate excess edible food

- Ensure policies, regulations and legislation reflect food waste hierarchy
- Coordinate capacity building for food recovery

Solution #13: Improve FLW management

Most applicable to processing, manufacturing, retail, HRI, food rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Segregate FLW from general waste streams, to enable more effective and efficient reuse and recycling of inedible food

Where collaboration is low or developing

- Audit current FLW management practices to identify effectiveness of improvement mechanisms, and design/implement remediation actions

Where collaboration is well established

- Incorporate monitoring and benchmarking of FLW management performance into collaborative continual improvement program including Joint Business Plans

Implementations by Food Rescue Organizations

Identify where FLW occurs and current management practices, to identify root causes and support continual improvement efforts.

Implementations by Industry Body

Research and report best practice from innovators

- Driving innovation through piloting, communication and networking

Explore new waste management business models

- Potential examples include full or part ownership in centrifuges to reduce water content in organic waste at source, enabling opportunities to create new products and markets while reducing transport and handling costs

Implementations by Government

Incorporate food waste hierarchy into policies, regulations and legislation

- Ensure policies, regulations and legislation aligned to ensuring minimal FLW sent landfill

Ban organic waste from landfill

- Federal, provincial/territorial and municipal governments collaborate to implement economically and environmentally optimal FLW management systems

Invest in alternative infrastructure to enable recycling

- Create economics of scale required to reduce comparative cost of reuse and recycling, particularly in rural and semi-urban regions

Audit municipal, provincial and federal regulations/policies at system level to identify incongruences

- Insights guide development of standardized process of policy, regulatory and legislative development, implementation and evaluation, resulting in increased alignment of policies, legislation, regulations and their implementation nationally across provinces/territories and municipalities

Solution #14: Incorporate the full cost of food production, management and waste into decision making

Applicable to all levels of industry, food rescue/redistribution; all types of food

Implementations by Businesses

As a single business acting alone

- Identify true cost of FLW by applying full cost accounting methods
- Include all costs of FLW (incl. wasted labour, energy, transport, processing costs), not just costs of disposal into decision making processes and contractual arrangements

Where collaboration is low or developing

- Factor true costs of FLW into contractual agreements and vendor scorecards

Where collaboration is well established

- Identify scale of opportunities by quantifying volume and value of FLW within individual businesses and along overall value chain. Use insights to drive collaborative continual improvement program.

Implementations by Food Rescue Organizations

Include full cost accounting methods when community food programs are evaluating the effectiveness of contractual purchasing arrangements established with industry.

Implementations by Industry Body
Publish true cost of FLW using total cost accounting methods • Establish standardized model for FLW cost accounting • Incorporate into voluntary agreement Provide CFO training and mentorship • Ensure members are able to identify true costs of FLW, along with supporting and championing the use of total cost accounting in financial reporting
Implementations by Government
Introduce means to ensure that the true costs of FLW are internalized by industry and public • Commencing with international review of best practice policies, regulations and legislation for driving internalization of true FLW costs • Ban FLW produced by the food and beverage industry and households from landfill • Ban FLW produced by the food and beverage industry and households from being dumped at sea or into landfill

5.3 Comments on Proposed Solutions and Actions

5.3.1 Suitability and Limitations by Food Type and Location

When taking into consideration the above 14 solutions, the three key priorities are to 1) find the means to prevent avoidable FLW, 2) increase the availability of food to those individuals who rely on food rescue services, and 3) increase the effectiveness of food redistribution systems. However, this is not straightforward. For example, some solutions have greater potential to reduce FLW of perishable products, like fresh produce. These include changes to date coding protocols and improving forecasting or using food that does not meet retailer specifications.

The donation of food by manufacturers, distributors, retailers, restaurants and institutions is likely to be more cost effective in urban and semi-urban locations, where both collection and re-distribution take place in relatively close proximity. Few of the solutions for improved food rescue and redistribution require investment in infrastructure and capital expenditure, rather using the existing infrastructure and systems more effectively. This will lead to greater efficiencies than can otherwise be attained, thereby reducing the costs and complexities that many businesses currently associate with food rescue.

5.3.2 Differentiating Actions by Chains' Collaborative Capacity

The Value Chain Management Centre (the precursor to Value Chain Management International) developed a classification for value chains[40] according to their collaborative capacity. This is set out in Table 5-1 below. Anecdotally, the research found evidence on similar differences existing in the relationships that occur amongst and between food rescue organizations and partner community

[40] Value Chain Management Centre (2012) *Characterizing the Determinants of Successful Value Chains*

food programs, and the comparative performance that consequently results from these relationships.

Table 5-1: Classification of Value Chains

Fragmented	Companies primarily compete on a traditional trade footing. The majority of business is conducted as a series of short-term, one-off transactions. Price, volume and quality are commonly paramount to business dealings. The primary onus of strategic decisions is on self-preservation and sharing the bare minimum of transactional information, for fear a company's insights are used against it. Typically, the result is a fragmented chain comprising businesses that share adversarial and distrusting relationships. These types of businesses often look to past experiences for solutions to current challenges, and have little opportunity to utilize the resources of other members of the value chain. As a result, they are limited in their ability to effectively and efficiently adapt to changing market demands.
Cooperative	Companies possess a mutual understanding of how and why they can benefit from cooperating with one another over the medium term at an operational level, rather than undertaking specific short-term or one-off business deals. The attitudes and culture of the businesses involved will determine whether a chain's structure can develop into a more strategically aligned approach, where the partners can utilize one another's capabilities for commercial advantage. Whether such an approach is feasible may also be determined by the environment in which the chain operates and in which it competes against other chains and businesses.
Coordinated	Companies with complementary attitudes, cultures and leadership styles choose to coordinate their business arrangements over a short to medium timeframe. A more strategically aligned structure than the one exemplified above causes at least part of the chain to think and act from a strategic – not only operational or tactical – perspective. A strategic perspective arises from operating in an external environment that allows this type of approach to occur. Over time, the participants come to steadily acknowledge the benefits of conducting medium-term business deals with chosen suppliers and buyers, leading to increased levels of commitment and the development of more sophisticated value chain management capabilities.
Collaborative	Companies engage in longer-term strategic arrangements that involve collaboratively sharing resources and/or investing in the capabilities required to achieve mutually beneficial outcomes. Successfully adopting this type of model requires the involved businesses to possess compatible cultures, vision and leadership. It also requires an external environment that is conducive to supporting and enabling such an approach. While the model can undoubtedly produce greater rewards than the three alternative models, it also generates increased risks, particularly for businesses that are still developing (as opposed to refining) their value chain management skills.

Businesses can use indicators described in the above table to categorize the type of chain(s) in which they operate and identify which of the proposed solutions and actions are most suited to their current situation – and those to which they aspire. Where chains can point to examples of positive systems and behaviours that already exist, they can then more confidently implement the actions requiring a high level of chain collaboration. Where only some systems or behaviours can be found, chains should start with those actions requiring little collaboration, and then progress to the more challenging ones. Where few positive indicators are present, firms should initially focus on those actions they can do unilaterally.

We maintain that big and small companies can work together to their joint advantage, because collaboration offers, for example, 1) more opportunities to increase margins through reducing costs or capturing price premiums; 2) better access to market information and 3) help to identify new business opportunities.

Farmers and other small producers can be sceptical about the feasibility of collaboration, often because of unequal size differences with retailers, for example. This, they believe, inevitably creates an unequal partnership. The research also found evidence regarding how a lack of collaboration leads to FLW occurring among large businesses. In the UK, such concerns led to the introduction of a voluntary code of practice, and subsequently to the introduction of a Groceries Code Adjudicator. A similar process occurred in Australia.

Irrespective of chain relationships and industry level initiatives, we accept that not all the proposed solutions and corresponding actions can be achieved overnight. It is, however, clear from our research where businesses should begin, which is to implement the three simple steps set out below.

1) Measure, value and report FLW in a consistent way in accordance with the international Food Loss and Waste Accounting and Reporting Standard;
2) Set a FLW reduction target that contributes to SDG 12.3, and integrate this into all corporate documents, as well as reporting said target publicly and engaging with your suppliers/customers to take similar action; and
3) Engage employees in taking actions to reduce your own FLW, and, in partnership, help suppliers, customers and consumers reduce theirs.

6 Future Research

Based upon the findings and lessons learned during the research described in this technical report, we propose eight opportunities for future research. Their priority will likely differ according to the needs and challenges faced by industry and community food organizations in specific jurisdictions.

Future Research Opportunity #1

Opportunity	**Refine whole of chain FLW methodology to enable and ensure its effective application in developed and developing countries**
Purpose	Jurisdictions' state of development is not binary, it's a continuum. Applying the current whole of chain FLW methodology in chosen countries from domestic and export/import perspectives would ensure the methodology's widespread replicability, regardless of countries' states of development. The process would see lessons learned by the research team (during this past study and from prior experience reducing FLW in multiple international jurisdictions) being incorporated into a final methodology. This would include sampling (as opposed to surveying) consumer behaviour and household food waste.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Standardized FLW methodology and reporting mechanisms proven to produce accurate FLW measurement, monitoring and benchmarking within and between developed and developing nations. • Quantification of the nature and comparative impact of root causes that drive FLW at all levels of the value chain – including commonalities / differences between the root causes of FLW occurring in developed versus developing jurisdictions. • Sustainable, affordable and contextually suitable solutions for motivating and enabling significant reductions in FLW that are designed and monitored to enable continual improvements in effectiveness.

Future Research Opportunity #2

Opportunity	**Create innovative best practice food rescue and redistribution processes**
Purpose	Utilize research findings to guide the design, implementation and testing of sustainable best practice food rescue solutions
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Templates created for rescue and redistribution solutions that are suited to the characteristics of partners' relationships. • Flexible templates tailored to the level of collaboration required for their implementation by businesses and stakeholders, including rescuers and community food organizations, along with the sector and food type they most lend themselves towards. • Address issues stemming from some donors who expect that food programs take everything – regardless of whether it can be redistributed or the environment in which the system operates (e.g. rural vs. urban and population density) – by creating symbiotic relationships between rescue, reuse and recycling systems.

Future Research Opportunity #3

Opportunity	**Test whole of chain FLW methodology at enterprise level**
Purpose	Prove applicability and value of applying the research methodology in individual businesses along the value chain. Including product life in the analysis would provide actionable insights into how product life is set, how much product life is given to retail/HRI/households, and how to extend product life in households by flowing products faster along the value chain. The analysis of household behaviours should be achieved by sampling, as opposed to surveys.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Standardized FLW measurement and reporting mechanisms proven to enable the implementation of operational improvements that lead to reduced FLW and commercial benefits for businesses operating along the value chain. • Methodology tailored to enable its flexible application by businesses possessing different capabilities, varying levels of collaboration, and operating in differing circumstances. • Ability to extrapolate findings produced by enterprise and industry level analysis of FLW aids implementation of sustainable FLW solutions.

Future Research Opportunity #4

Opportunity	**Lean enterprise implementation programs tailored to food rescue and redistribution**
Purpose	Enable the more effective and efficient use of current food redistribution and community food infrastructure by having produced proven, easily implementable lean enterprise materials tailored to food rescue. This would ideally extend to identifying lean enterprise approaches that are effective for reducing FLW among community food program clients.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Robust, easily implementable tools and techniques that food redistributors, community food organizations and their donors can follow to attain, then continually improve upon, their current best practice. • Standardized methodology, enabling lessons learned by organizations and donors possessing different capabilities and operating in differing circumstances to be shared and acted upon to aid widespread continual improvements. • Greater percentage of excess edible food rescued and successfully redistributed, resulting in long-term societal benefits and reduced FLW.

Future Research Opportunity #5

Opportunity	**Modify whole of chain FLW methodology to enable whole of chain environmental monitoring**
Purpose	Modify the FLW measurement and reporting methodology to encompass life cycle analysis for enabling the accurate monitoring and benchmarking of the environmental impacts of FLW from a whole of chain perspective. Applied at a product level, potentially in conjunction with selected value chains (e.g. meat/dairy/produce), this would provide detailed and actionable findings.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Ability to accurately evaluate and monitor the environmental footprint of different sectors of the food industry, and the food industry overall, from a whole of chain life cycle analysis perspective. • Ability to optimize FLW solutions according to their economic sustainability, societal benefit and environment footprint. • Continual reduction in the environmental footprint of food systems.

Future Research Opportunity #6

Opportunity	**Evaluating longitudinal trends in Canadian FLW at industry and enterprise level from whole of chain perspective**
Purpose	Regularly monitor consequences of changes in business practice, and government policies and practice, on FLW in Canada from the perspectives of individual anonymous value chains and overall industry. To ensure the research identifies the consequences of changes occurring in the wider macro environment and in business practices, and why those changes occur, the "tracker chains" would represent different types of food, states of collaboration and jurisdictions. Suggestion is that "tracker chain" assessments would occur every two years, while industry assessments would occur every four years. Ideally, the research would include the sampling of household behaviours and household food waste.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Ability to quantify the performance, and factors determining the performance, of anonymous "tracker value chains" and the monitoring of such over time. • Robust assessment and explanation of FLW trends, thereby aiding the design and implementation of effective policies, legislations and regulations. • Continual improvement of best practice solutions tailored to the needs of individual businesses, food rescue organizations, community food programs, reuse and recycling initiatives.

Future Research Opportunity #7

Opportunity	**Apply whole of chain FLW methodology to aid the design and implementation of optimized packaging**
Purpose	Create ability to simultaneously measure, report and benchmark the effectiveness of packaging materials and the design of food packaging from whole of chain, life cycle analysis and environmental perspectives. The addition of sampling household behaviours and household food waste would best quantify how to optimize packaging to reduce FLW among consumers.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Proven whole of chain methodology for simultaneously analyzing 1) FLW, 2) packaging waste, and 3) relationships between the environmental footprints of food and packaging. • Support the development and utilization of innovative tertiary, secondary and primary packaging, and responsible management of packaging waste. • Continual reduction of FLW and packaging waste.

Future Research Opportunity #8

Opportunity	**Expand application of proven whole of chain FLW methodology into non-food industries**
Purpose	Use lessons learned to modify, test and refine the whole of chain methodology to enable non-food industries (e.g. forestry, apparel, and mining) to: 1) accurately measure, monitor and benchmark waste; 2) identify root causes; and 3) ascertain environmental impacts associated with waste and root causes.
Expected: • **Outputs** • **Outcomes** • **Benefits**	• Standardized whole of chain methodology and reporting mechanisms for accurately measuring and benchmarking waste, and its environmental footprint across multiple industries. • Quantification of nature and comparative impact of root causes of waste at all levels of the value chain, thereby enabling commonalities and differences existing between industries and jurisdictions to be quantified. • Continual improvements in the effectiveness of solutions for significantly reducing waste by enabling lessons learned to be shared across industries.

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APPENDIX A: Gathering and Analysis of Data

This appendix describes how the mass balance analysis was conducted. It also provides more granular insights into the research findings than are contained in the body of this report. The results provide a robust and reliable indication of FLW levels occurring across the Canadian food system, and immediate causes of FLW as reported by respondents. The findings did not lend themselves to the level of statistical analysis required to produce defensible granular insights for individual crops at specific levels of the value chain.

1 Primary Production Data

The mass balance inputs were populated using production data gathered from Statistics Canada (STC), Agriculture and Agri-food Canada (AAFC) and Fisheries and Ocean Canada (FOC), along with data provided by industry for sugar. Table A provides details regarding all the sources of production data that formed the basis of the model used to calculate Canadian FLW.

Table A: Production Data Sources

Food Type	Data Source
Dairy and Eggs	Canadian Dairy Information Centre (2016) hectolitres converted to tonnes based on density of 1.03kg/litre 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	STC Table 32-10-0359-01 provides the most comprehensive data for farm production of the major field crops produced across Canada. As this is a farm level estimation, the data likely includes significant animal feed production. Crops included in this data are barley, canola, oats, peas-dry, rye, soybeans, lentils, wheat, flaxseed, mixed grains, mustard seed, buckwheat, sunflower seed, triticale, beans-all dry (white and coloured), chick peas, fava beans, and corn for grain. **Adjustment for animal feed –** exports of wheat, barley and corn were subtracted from production, and then the percentages as reported by ANACAN were applied (80% barley, 60% corn and 30% wheat go to animal feed) to calculate the net availability. NB: because the exports of these grains have been tallied here, they have been excluded from the total export number. https://www.anacan.org/about-our-industry/canadian-feed-industry-statistics.html
Meat & Poultry	Slaughter numbers and average carcass weights for beef, pork and lamb were gathered from AAFC red meat section data; poultry meat data is from *STC Table 32-10-0117-01: Production and disposition of poultry meat*. Goat and other specialty meats have not been included. Meat yields were used to estimate the total amount of meat produced, i.e. harvested product. The meat yields used were: Cattle – 66% Sheep – 54.4% Hogs – 69%

Production data for produce and sugars and syrups is gathered from 2016 Statistics Canada tables as follows:	
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	A summation of aquaculture production and Ocean and Freshwater landings statistics provided by Fisheries and Oceans Canada. Data from 2015 (Ocean and Freshwater landings) and 2016 (Aquaculture) are the most recent available.

1.1 Imports and Exports Data

All import and export data was gathered from the Canadian International Merchandise Trade Database. Using the harmonized system (HS) code exports and imports, the data was categorized into the food types established by VCMI. 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 foods would occur further through the chain, and thus an adjustment was made within the model prior to distribution to account for processed foods entering and exiting the Canadian food system. The balance of exports and imports of prepared foods was added to the total food available to enter into the retail and food service. Where possible, within the model, these prepared foods were allocated to the appropriate food type. A miscellaneous prepared food type was added at the point of distribution to account for a small amount of prepared food that could not be attributed to one specific food category. The scope of the import/export data is summarized in Table B below.

Table B: Import/Export Data Categorization

	HS Chapter	**Included**	**Excluded**
Dairy and Eggs	4	Milk, cheese, butter, yoghurt, fermented milk products, powdered milk and eggs (fresh and processed)	Fertilized eggs for incubation, edible products of animal origin, not elsewhere specified
Field Crops	10 7 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

Meat & Poultry	2	Fresh and frozen cuts, offal, fat and processed, beef, pork, lamb and mutton. Poultry HS codes 0207xx and poultry fat HS02990	
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.
Sugars and Syrups	040900 170220 170112 170114 170113 170191 170199	Honey Maple sugar and syrup Raw sugar (beet and cane)	
Marine	3	Fish and crustaceans, molluscs and other aquatic invertebrates	
Processed Foods Adjustment			
Dairy & Eggs		No data available but nominal amount added to the model	
Meat and Poultry	16	Prepared/preserved meat and poultry products	
Produce	20	Prepared/preserved produce, including fruit and veg. juices (1 litre = 1 kg)	
Sugars and Syrups	17 18	Sugar confectionary, chewing gum-containing sugar, chocolate etc.	Does not include codes: 170220 170113 170112 170191 170114 170199
Marine	16	Prepared/preserved fish and crustaceans, molluscs and other aquatic invertebrates	

2 Statistical Composition of the Chain

To guide the primary research and analysis, the number of operations that together comprise the Canadian food and beverage industry, and their location by province, was quantified through a combination of secondary and primary research.

The collection of statistics/information regarding the number of business along the chain provide a distribution of size and types of food businesses that occur across the country and by province. This distribution informed the primary research survey. The following section outlines the data used to create a picture of Canada's food system businesses.

2.1 Production

The total number of farms by commodity category was obtained from STC's 2016 Census of Agriculture data. The STC table 32-10-0403-01 classifies farms by NAICS code. This was used in all cases except for the number of sugar beet farms and a measurement of marine production enterprises. Canada classifies sugar beet farming under the NAICS code 11199 – All other crop farming. To obtain a specific number of sugar beet farms, Table: 32-10-0154-01 was used. The Department of Fisheries and Oceans 2015 statistics (the most recent available) were consulted to acquire the total number of registered vessels and total number of licenses.

Table C: Farms (NAICS codes) Categorized by Food Type

	NAICS Codes
Dairy and Eggs	112120 – Dairy Cattle and Milk Production 112310 – Chicken Egg Production
Field Crops	1111 – Oilseed and Grain Farming which includes: • Soybean Farming • Dry Pea And Bean Farming • Wheat Farming • Corn Farming • Other Grain Farming • Oilseed (except Soybean) Farming
Meat & Poultry	11210 – Beef Cattle Ranching and Farming, including Feedlots 1122 – Hog and Pig Farming 1124 – Sheep and Goat Farming 112320 – Broiler and Other Meat-Type Chicken Production 112330 – Turkey Production
Fruits & Veg	11121 – Vegetable and Melon Farming 1113 – Fruit and Tree Nut Farming 111411 – Mushroom Farming 111419 – Other Food Crops Grown Undercover 111993 – Fruit and Vegetable Combination
Sugars and Syrups	111994 – Maple Syrup and Products Production 112910 – Apiculture (Honey Production) Sugar beet farm numbers from Table: 32-10-0154-01 – Census of Agriculture, selected crop data, Canada and provinces
Marine	Licence and registered vessels are for commercial ocean fisheries, acquired from the Department of Fisheries and Oceans. Data for freshwater licences/registered vessels were not available.

2.2 Processors

The number of processors was gathered from the Canadian Industry Statistics. These statistics classify businesses by NAICS code. Classification at the four-digit level was used to allocate food manufacturing/processing businesses by food category. Table D below outlines the codes used within each category.

Table D: Processing and Manufacturing Categorization by Food Type

	Includes	Comments
Dairy and Eggs	3115 – Dairy Product Manufacturing	There is no food manufacturing for eggs.
Field Crops	3112 – Grain and Oilseed Milling 3118 – Bakeries and Tortilla Manufacturing	
Meat & Poultry	3116 – Meat Product Manufacturing	Includes secondary processing
Fruits & Veg	3114 – Fruit and Veg. Preserving and Specialty Food Manufacturing 31141 – Frozen Food Manufacturing 31142 – Fruit and Veg Canning, Pickling and Drying	
Sugars and Syrups		Although there is a NAICS code 3113 for Sugar and Confectionary Product Manufacturing, we did not include this category, as sugar and syrups go into many streams/food products.
Marine	3117 – Seafood Product Preparation and Packaging	

2.3 Distribution Centres/Wholesalers

Major retail and foodservice distribution centres were researched by VCMI contacting corporations individually. This information is confidential and therefore not presented. Food wholesalers' numbers were sourced from Canadian Industry Statistics. This provided an indication of the location and number of wholesalers and distribution centres across the country.

The Canadian Industry Statistics categorize wholesalers by food category; VCMI allocated them by food types as per Table E below.

Table E: Wholesalers Categorized by Food Type

Food Category	Included (NAICS)	Comments/Notes
Dairy and Eggs	Dairy 41312 & Eggs and Poultry 41313	This includes poultry wholesalers as eggs and poultry are combined in NAICS 41313
Field Crops	No specific wholesale NAICS code	Bakery and pasta wholesalers are included in the description of 41319 "Other Specialty – Line Food Merchant Wholesalers"
Meat & Poultry	Red Meat and Meat Product Merchant Wholesalers– 41316	
Fruits & Veg	Fresh Fruit and Veg – 41315	
Sugars and Syrups	No specific wholesale NAICS code	Candy, syrups wholesalers are included in the description of 41319 "Other Specialty – Line Food Merchant Wholesalers"
Marine	Fish and Seafood – 41314	
Canada Total (no specific food type)	• General-Line Food Merchant Wholesalers – 41311 • Other Specialty-Line Food Merchant Wholesalers – 41319	

2.4 Food Retailers

The Canadian Industry Statistics also provided the data of numbers of food retailers across the country. These include Grocery Stores, Convenience Stores, Specialty Food Stores, Beer, Wine and Liquor Stores. As the majority of food retailers are generalists, they were not allocated to specific food types.

2.5 Food Service

Canadian Industry Statistics' NAICS codes listed in Table F were used to gather data on the foodservice industry.

Table F: Foodservice NAICS Codes

VCMI Food Service Categories	NAICS Code and Label
Hotels	7211 – Traveller Accommodation
Food Service Contractors	72231 – Food Service Contractors
Restaurants/QSR	7225 – Full Service Restaurants
Catering/Event Services	72232 – Caterers
Beverage	7224 – Drinking Establishments

2.6 Food Rescue

The number of organizations involved in food rescue was researched and provided to VCMI by Second Harvest staff.

3 Data Analysis

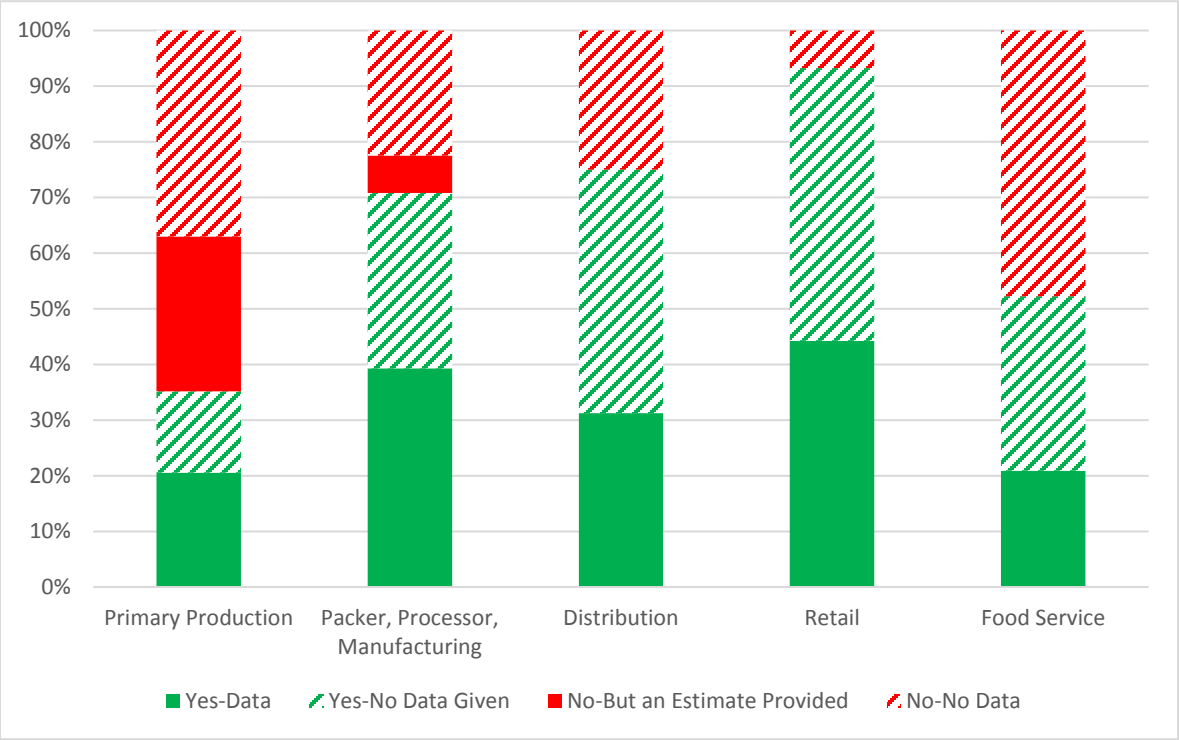
3.1 FLW Measurement through the Chain

The research team expected that measurement of FLW would increase through the chain as the value of food increases. This was generally true, the clear exception being foodservice (Figure A). The responses from the survey were divided into those who responded yes or no to the question: “Do you measure FLW?” They were then further subdivided into those that gave data on their FLW. Lack of response in FLW values did not correlate with continued lack of response to other questions throughout the survey.

Respondents were given the option to give FLW data in any of the following ways: head (for livestock), tonnes, litres, percentage, value, and other (please specify). Of those that did provide FLW data, the majority responded with a percentage. Value was the next most prevalent metric provided. Some respondents provided the measure in more than one metric: volume, percentage and value.

In primary production, those respondents producing storable produce and poultry were the most likely to measure FLW. Fifty-nine percent of storable produce producers measure FLW; 54 percent of poultry producers measure FLW. Approximately 30 percent of producers in the other primary production categories measure FLW.

Figure A: Measurement of FLW through the Chain: Do you measure FLW?[1]



3.2 Model Development

Losses reported from the survey were applied to the baseline data to provide a roll throughput yield of the food system. Where possible, percentage loss was calculated from the data given, or used directly if a percentage was provided. Estimates of FLW are based on conservative losses, unless validated during interviews. The loss factors were applied at each stage through the chain to give a tonnage loss. At the point of distribution, food was divided into two streams: retail and HRI. Based on information provided by interviewees, it was determined that 65 percent of food is sold through retail and 35 percent is sold through HRI. Loss factors were applied to the consumer-facing sectors and household consumption, culminating in a total loss throughout the chain.

3.2.1 Household Waste Calculation

Household waste audits were outside the scope of this project. Therefore, secondary data was used to provide an indication of the food waste that occurs at the household level.

Statistics Canada (STC) provides data on Food Available in Canada (per person). This statistic is calculated by dividing the domestic disappearance by the Canadian population as of July 1 of the reference year. However, the domestic disappearance by the Canadian population does not allow for

[1] This question was not directly asked of Food Rescuers.

losses at the retail level, in households, restaurants or institutions during storage and preparation, or for unconsumed food.

Therefore, STC introduced the food available adjusted for losses. These are losses that occur in the storage, preparation and cooking of the food, as well as the food that makes it to the plate but not consumed, or plate loss. *These losses can occur in the retail store, home, restaurants or institutions*. *The objective is to provide a proxy of fork-level consumption based on food supply data.*

However, STC provides the losses happening from the retail weights (the domestic disappearance) to the fork-level consumption as one number. For this project, we needed to have an estimate of the waste happening at the household level only. We found the Economics Research Services (ERS) of the United States Department of Agriculture (USDA) provides estimates for the food waste happening at the two levels.

Assuming that there are significant similarities between the Canadian food retail industry and the US food retail industry, as well as between the Canadian consumer behavior towards food wastage and the US consumer, we decided to use the ERS's estimated food waste distribution between the two levels in order to breakdown STC's food waste estimation, which combines the two levels together. We thus applied ERS's estimated food waste distribution to the STC's estimated losses that occur in the supply chain downstream. As a result, we were able to estimate the household level of food waste, and this is the data that was used in the model for household waste. The losses that occur in retail and food service (HRI[2]) were gathered from the survey data.

3.3 Calculation of FLW

Table G below provides the loss factors used at each stage of the chain, and shows the volume of loss at each point in the chain, classifying FLW as planned or unplanned. As shown, the analysis of secondary production data estimated 60.9 million metric tonnes enters the food chain.

As per Table H, the application of these loss factors in the mass balance model calculated the total tonnage of waste deriving from the whole food chain to be 35.5 million. As mentioned previously from the loss factors indicated via survey responses, we erred on the conservative side, in part to recognize that not all products go through both processing and further manufacturing.

[2] Hotels, Restaurants and Institutions

Table G: Summary of Loss Factors Applied in Mass Balance FLW Model – Production to Distribution

	Baseline Volume	**Grow/Produce**		**Processing**		**Manufacturing**		**Distribution**	**Retail**	**HH**	**HRI**	**Food Rescue**
Food Type	Million Tonnes	Production Loss	Storage/ Pack loss	Planned Loss	Unplanned and post processing Loss	Planned Loss	Unplanned and post processing Loss	Loss	Waste	Waste	Waste	Waste
Dairy and Eggs	9.3	0%[3]	2%	N/A	N/A	5%	6%	1%	3.0%	21%	25%	7%
Field Crops	33.8	5%	8%	30%	6%	5%	10%	1%	7.3%	21%	32%	5%
Produce	13.3	5%	22%	8%	9%	5%	N/A	3%	5.8%	38%	22%	5%
Meat/ Poultry	2.5	N/A[4]	N/A	10%	6%	10%	10%	2%	4.0%	20%	33%	7.5%
Marine	0.8	5%	N/A	6%	6%	N/A	N/A	4%	9.0%	32%	8%	N/A
Sugar/ Syrups[5]	1.2	1%	1%	1%	1%	1%	1%	1%	1.0%	33%	1%	N/A
Total	**60.9**											

N/A = Not Available/Not Applicable

[3] Dairy and egg producers reported a minimal loss of 0.08%. This was reported in the model as 0% waste. The minimal loss at production was largely attributed to the fact that the industry is supply managed, and therefore all that is produced is sold. There were, however, reports of the fact that what loss does occur is due to disease/ illness, quality control, human factors, and equipment malfunction.

[4] Mortality rates for livestock production were obtained but not used in the model, because the baseline was carcass weights of livestock.

[5] There was limited response for the sugar/syrups category of food, and thus a nominal amount of loss was attributed to this category. The category itself only represents just under 2% of the model.

Table H: FLW throughout the Chain by Food Category (Million Tonnes)[6]

	Grow/Produce			Processing		Manufacturing		Distribution	Retail	Consumer (HH)		HRI		Total FLW occurring along the food value chain	Losses (%) occurring during Rescue and Redistribution
Food Type	Unplanned Loss	Planned Loss	Storage / Pack loss	Planned Loss	Unplanned and post processing Loss	Planned Loss	Unplanned and post processing Loss	Loss	Waste	Prep waste	Plate Waste	Prep waste	Plate Waste		
Dairy and Eggs	0.00	0.00	0.14	0.00	0.00	0.46	0.52	0.08	0.16	0.53	0.48	0.35	0.31	3.03	7%
Field Crops	0.00	1.69	2.65	8.84	1.24	0.97	1.84	0.17	0.78	1.05	0.94	0.93	0.78	21.89	5%
Produce	0.66	0.66	2.77	0.74	0.82	0.41	0.00	0.23	0.28	0.85	0.69	0.28	0.25	8.63	5%
Meat/ Poultry	0.00	0.00	0.00	0.25	0.14	0.22	0.19	0.04	0.05	0.11	0.10	0.10	0.08	1.28	7.50%
Marine	0.00	0.04	0.00	0.05	0.04	0.00	0.00	0.03	0.04	0.07	0.06	0.01	0.01	0.34	N/A
Sugar/ Syrups	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.15	0.12	0.00	0.00	0.36	N/A
Total	0.66	2.41	5.57	9.89	2.25	2.07	2.57	0.55	1.31	2.76	2.38	1.68	1.44	35.54	

We used the reports of unplanned and post-processing loss waste as a proxy for avoidable and therefore potentially edible waste, as this waste, had it not occurred, would have resulted in edible products. Production, storage and pack loss were classified as unavoidable losses, as much of production loss is due to weather, pest and disease. However, when calculating the edible FLW we did make an adjustment to the produce sector, as we heard, during the research, of edible crops being left in the field unharvested, due to market reasons as opposed to the crop not being viable. We allocated 5 percent loss in production of produce that is avoidable/potentially edible loss.

[6] Totals may not add up due to rounding.

A considerable amount of loss occurs in production, processing and manufacturing. A total of 69 percent of FLW occurs in the production, processing and manufacturing sectors. All of the loss occurring in primary production was considered to be unavoidable; however, an adjustment was made in the calculation of avoidable/potentially edible FLW in order to account for produce crops that are left in the field unharvested, as this was highlighted through the research as an area of potentially edible FLW.

3.4 Valuing FLW

Statistics Canada reported that retail food sales for 2016 were $95.5 billion[7] and food service receipts were $62.2 billion.[8] We estimated, via the model, that 21.9 million tonnes are sold through retail[9] and 12.5 million tonnes sold through HRI. Thus, we calculated the average price per tonne of food at retail to be $4,351, and at HRI to be $4,967. The retail value is applied to loss and waste occurring at all levels of the chain except HRI.

As reported above, the model calculated that Canada produces a total of 35.5 million tonnes of FLW per year; an estimated 11.17 million tonnes of which is unplanned/avoidable and therefore potentially edible waste. Based on our value of food per tonne, the value of avoidable, potentially edible waste is $49.46 billion. Of this waste, $10.37 billion is wasted at the household level, while $39.1 billion is a cost to businesses within the value chain (Table I).

Table I: Volume and Value of Avoidable, Potentially Edible Waste

Chain Location	Volume (million tonnes)	Value ($ billion)
Production (Produce)	0.66	2.88
Processing	2.25	9.78
Manufacturing	2.57	11.17
Distribution	0.55	2.41
Retail	1.31	5.70
Household	2.38	10.37
HRI	1.44	7.14
TOTAL	**11.17**	**49.46**

[7] Statistics Canada. Table 20-10-0008-01 Retail trade sales by province and territory (x 1,000). Sales from grocery stores and specialty food stores, seasonally adjusted.
[8] Statistics Canada. Table 21-10-0019-01 Monthly survey of food services and drinking places (x 1,000). Receipts from food services excluding drinking places, seasonally adjusted.
[9] After retail losses.

3.5 Losses in Redistribution

The research also asked food rescue and redistribution organizations how much FLW they experienced in the products that they most commonly saw coming through their establishments. The results of this are presented in Table J below. There is between 5 to 7.5 percent of loss that happens within the rescue/redistribution sector. This occurs for various reasons, the most common of which is spoilage.

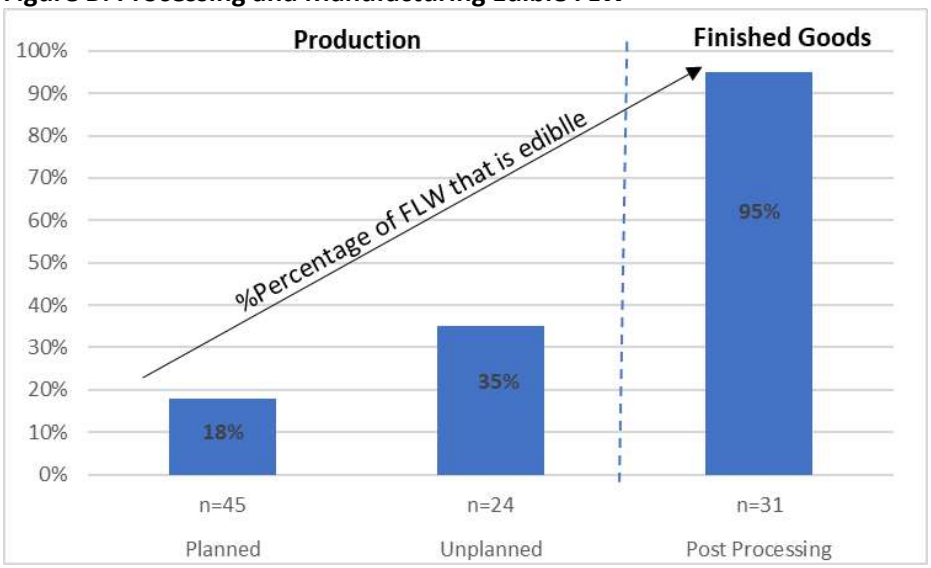
Table J: Loss Occurring in Rescue and Redistribution by Food Category

Food Type	Rescue %
Dairy and Eggs	7%
Field Crops	5%
Produce	5%
Meat/Poultry	7.5%
Marine	N/A
Sugar/Syrups	N/A

3.6 Potential for Redistributing Edible Food Not Currently Rescued

Processing and manufacturing respondents were asked: "As a percentage, approximately how much of your processing losses would be edible – either in their present form or after processing?" This was asked with regard to planned, unplanned and post-processing loss. Figure A below illustrates that, as we move through the food processing and manufacturing line, the amount of FLW that is edible increases. As Figure B illustrates, there is also potential for some planned waste to be rescued and utilized more effectively.

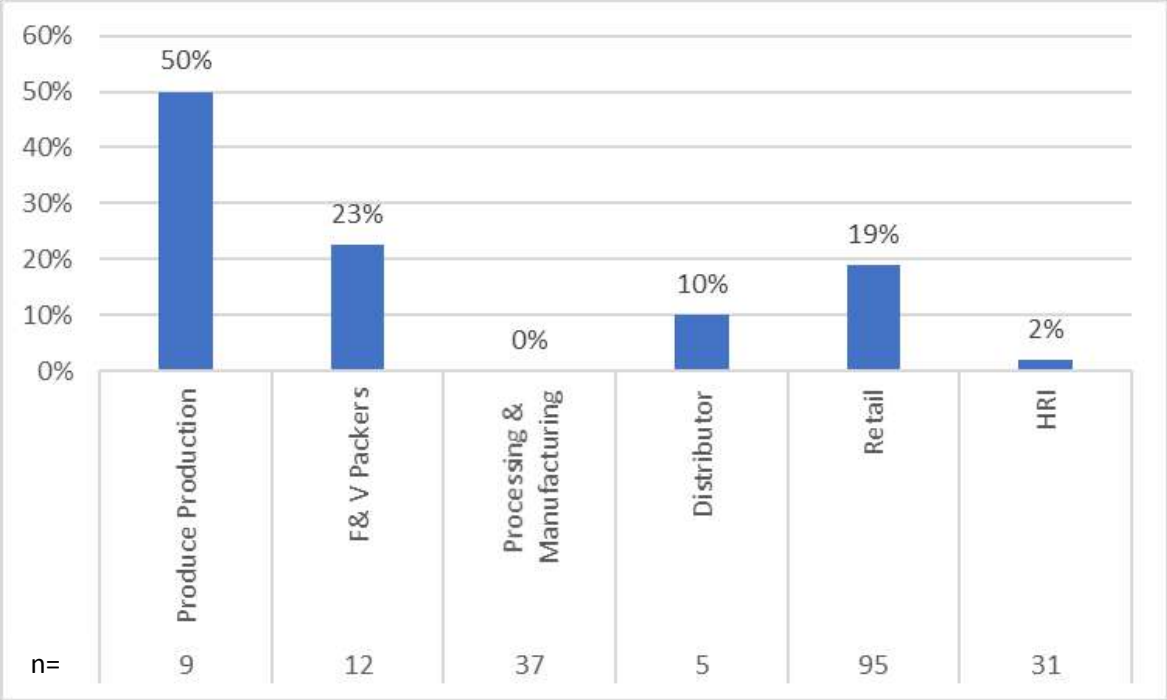
Figure B: Processing and Manufacturing Edible FLW



An average of 86 percent of edible food is not rescued throughout the chain. This equates to 9.6 million tonnes of edible food (based on 11.17mt of potentially edible food waste).

In addition, most members of the chain[10] were asked: "What percentage of overall edible food or beverages not sold for human consumption was rescued for redistribution?" Figure C illustrates that there is considerable potential to increase the amount of food that is rescued throughout the chain, particularly in processing and manufacturing where the median response to this question was zero percent. Yet there are reportedly significant losses within this sector that are edible, as pointed out above.

Figure C: Percentage of Overall Edible Food or Beverages Not Sold for Human Consumption Rescued for Redistribution



[10] This was not asked of livestock, poultry, dairy, or egg producers. It was asked of field crop producers, but only two respondents indicated that any of their crop was rescued or donated, and none provided a % of that which was rescued/donated.

4 Validation Process

4.1 Interviews

To validate and test the findings from the survey and the model, the research team conducted 49 formal and a considerable number of informal interviews. To ensure full and accurate capture of information, each of the formal interviews involved at least two research team members. These interviews lasted between 22 and 90 minutes. Information was also sought from industry experts informally during general conversation, including discourse that occurred during industry conferences and FLW initiatives.

The research team developed a structured guide for the formal interviews, which was peer reviewed and revised prior to the interviews commencing. We started by providing the interviewee with our research approach and initial findings and then we sort information and specific data regarding FLW amounts and causes within their chain element. Interviewees were then asked about potential solutions and the relative impact that they could have on addressing the root causes of FLW upstream and downstream within their chain.

Following the interviews, several respondents provided detailed FLW data, handling arrangements, and costs at specific facilities. All responses were collated into an excel table for review and analysis by the entire research team.

4.2 Focus Groups

Throughout the course of the research, six focus groups were conducted across the country. The first two focus groups were conducted in Vancouver and Portage la Prairie during July 2018. The outcome of these two focus groups was validation of the research methodology, initial estimates, and causes of FLW throughout the food type chains.

A further four focus groups were conducted in Calgary, Moncton, Mississauga and Ottawa during September 2018. The first three focus groups presented a complete analysis, along with straw-model solutions. The fourth focus group did the same, though focused solely on the produce industry. All sessions had two purposes:

1. To validate the final estimates of FLW and conclusions of the research, and
2. Refine and/or add to the solutions developed by the team.

Feedback captured during and subsequent to all six focus groups, via emails and a post-event survey circulated amongst participants, was incorporated into the findings and recommendations.

4.3 Case Studies

A number of respondents participated in the development of case studies designed to demonstrate how the measurement process can work at the level of individual value chains. Working with individual respondents became part of the data validation process.

The first of the case studies is presented below. Other case studies, which include an illustration of using the reporting process to convey what can be achieved when action is taken to reduce FLW, will be made available as separate documents. A blank template for completion by businesses and FLW researchers will also be available as a download.

4.3.1 Onion Chain

We were able to gather information from one respondent that spanned the value chain from production to distribution. We then adjusted the retail loss factor at retail to be more representative of a storable produce product, and applied the household loss calculated for onions and shallots within our HH waste calculation and applied the produce HRI FLW factor. Below is a comparison of the FLW calculated through the model and that which was calculated using the onion case study.

In the onion case study the various losses were:

- 10% loss at production was attributed to agricultural issues, such as weather and disease;
- 10% was attributed to crop left in the field due to size and some mechanical damage;
- 10% in store loss was due to shrink from drying/curing;
- 10% during grading packing to meet customer specifications;
- Post grading/pack loss was “insignificant,” so we allocated 1% to cover the likelihood that some losses would occur; and
- Distribution loss was also indicated as “rare” so we allocated 0.5%.

At retail, as onions are a relatively resilient storable product, we allocated a loss factor of approximately half the overall produce loss factor. As mentioned above, household waste was taken from our calculation from Statistics Canada data, and HRI loss was the same as produce as we had no specific onion data to substitute into the case study.

Table K: Losses through the Chain Onion Case Study Compared with Produce Calculation

		Grow/Produce			Processing		Manufacturing		Distribution	Retail	Consumer (HH)		HRI		Total FLW occurring along the food value chain	Losses (%) occurring at Rescue
Food Type	Baseline	Unplanned Loss	Planned Loss	Storage/ Pack loss	Planned Loss	Unplanned and post processing Loss	Planned Loss	Unplanned and post processing Loss	Loss	Waste	Prep waste	Plate Waste	Prep waste	Plate Waste		
Loss Factor		5%	5%	22%	8%	9%	5%	N/A	3%	5.80%	19%	19%	11%	11%	65%	5%
Produce (MMT)	13.3	0.66	0.66	2.77	0.74	0.82	0.41	0.00	0.23	0.28	0.85	0.69	0.28	0.25	8.63	5%
Onions Case Study																
		On-Farm	Storage/Curing/Grading / packing				Processing/Manuf.		Distribution	Retail	Consumer (HH)		HRI		Total FLW occurring along the food value chain	Losses (%) occurring at Rescue
		Harvest loss	Unplanned loss	Storage/ Curing Loss	Grading Loss	Post Grading/ Packing Loss	Planned Loss	Post processing	Loss	Store losses	Prep waste	Plate Waste	Prep waste	Plate Waste		
Loss Factor		10%	10%	10%	10%	1%	N/A	N/A	0.5%	3%	22.5%	22.5%	11%	11%	58%	5%
Tonnes	8181	818	736	663	596	54	0	0	27	103	750	581	204	181	4713	
Root Cause		Most impactful root causes of FLW, listed in order of impact														
#1		Not meeting size of required product	Lot sizes	Drying/ Curing/ Moving	Grading for Size	Too many days on hand	NA		Too Many Days in DC	Moisture loss			Food Prep	Serving Size		Too many days in on hand
#2		Mechanical Damage	Bacterial Rot						Damaged in Transit	Damage from handling						Damage from handling
#3		Rot	Growth Defects													
Waste Destinations									Exact destination will differ according to location.							
Rescue / gleaning				N/A mostly moisture loss	20%		NA									
Animal feed																
Biomaterial processing																
Compost / anaerobic									20%	80%	50%		50%			80%
Controlled combustion																
Land application		100%	100%		80%	100%										
Landfill									80%	20%	50%		50%			20%
Sewer																

Being a more storable and robust product (highlighted in the table above), the overall loss through the chain for onions is less than that of the collective produce chain. There is a 7 percent difference between the total FLW identified in the industry analysis versus the case study – 65 percent versus 58 percent, respectively.

In addition to loss factor information, we acquired information regarding the causes of the losses and the percentage of those losses that go to various destinations.

4.4 Model Validation and Comparisons

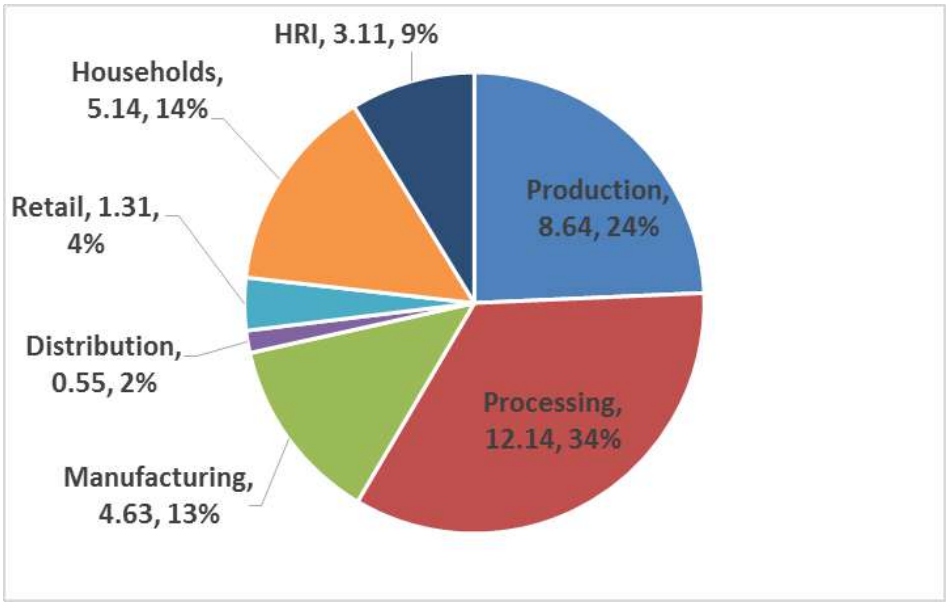
In addition to validating the model inputs of loss factors through the interview and focus group process, the research team looked at previous research and sources – such as Canadian and US businesses, NGOs and government representatives – to provide insights and ensure that our numbers were accurate.

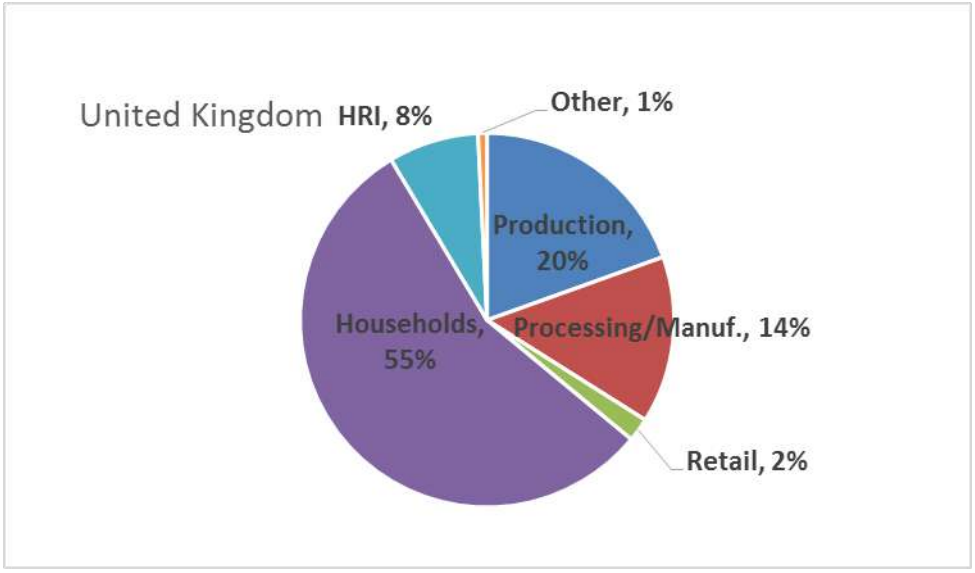
The output of the model estimated that the total food consumed in Canada after preparation waste was 2.02kg/pp/day. National Geographic reports that in Mexico daily food utilization is 1.8kg, while in the US it is 2.7kg (National Geographic, 2018). Our estimation of 2.02kg for Canada is within this range

We compared the percentages of overall waste calculated from our model with those found in the UK. It is evident from Figure D that a key difference is the household and processing/manufacturing waste. The fact that the household waste calculated in the UK was collected from household waste audits suggests that our household waste based on secondary data may be highly conservative.

Figure D: Total Waste by Sector – Canada and the UK

Canada





A comparison between the data calculated by Buzby et al (2014) for the US and the equivalent calculated by VCMI is presented below. The difference between the two is only 130 and 140 grams/person/day. These results are very close, and the difference could be attributed to a number of factors. They include our conservative loss factors through the chain, the allocation of food to retail and HRI after distribution, or simply a difference in consumption over time or in a different country.

Drawing on the data presented in Buzby, Wells, and Hyman 2014, we compared the amount of food supplied at retail and consumed in the household. The difference in both cases is just over 100 grams. This model validation and comparisons suggest that it is a reasonable estimation of the FLW that occurs through the Canadian food system and can be refined and improved with increased measurement, resulting in more accurate loss and waste factors. It follows that if we know how much is being produced and consumed, then the difference remaining is FLW.

Table L: Model Output Comparison

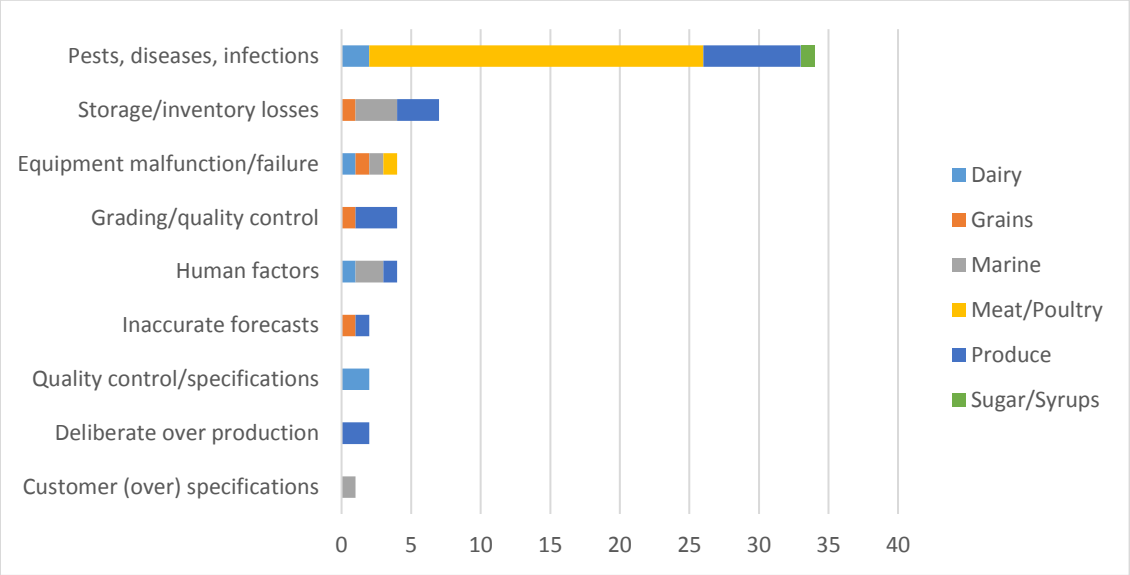
Food: (person/day)	**Food Supply at Retail (kg)**	**Household Consumption (kg)**	**Foodservice Consumption (kg)**
Buzby et al (2014)	1.73	1.20	N/A
VCMI (2018)	1.86	1.34	0.77
Difference	**0.13**	**0.14**	

5 Reported Causes of FLW

5.1 Production

The primary cause of loss (as per Figure E) reported in production is from pest, disease and infections. This cause was a particularly prominent amongst respondent livestock producers, followed by respondents from the produce sector. The produce sector also accounted for the widest array of causes, the second and third most impactful causes after pest and disease being grading, followed by storage/inventory.

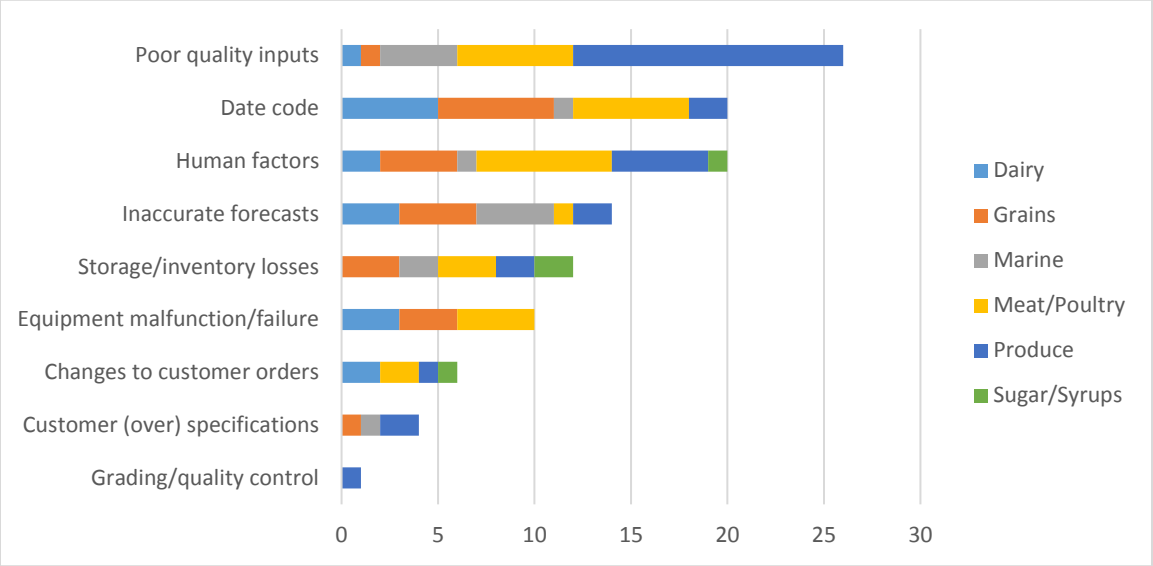
Figure E: Causes of Waste in Production by food type



5.2 Processing and Manufacturing

Poor quality inputs were the most commonly cited issue for FLW in the processing and manufacturing sector (see Figure F). This was reported for all food types except for sugars/syrups. Date code and human factors were the next most equally common cited causes. Human factors being reported by all food types and date code by all except sugar/syrups.

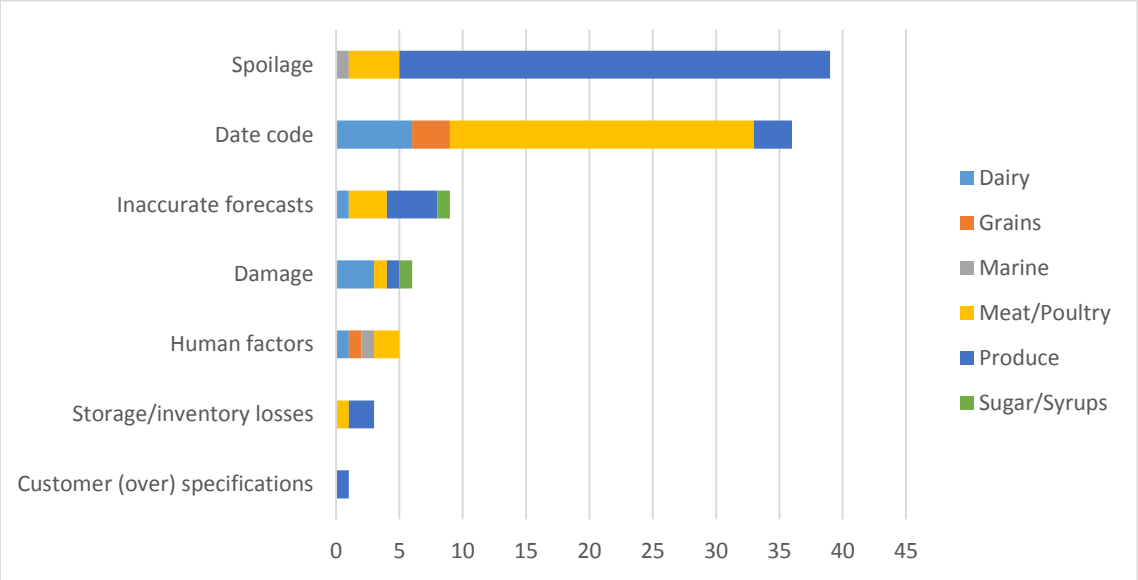
Figure F: Causes of Waste in Processing and Manufacturing by Food Type



5.3 Retail

In retail, spoilage was the most common cited cause of FLW and most prominent in produce (see Figure G). Date code was the second most commonly cited cause and the most significant cause of FLW for meat/poultry. A considerable gap exists between those and the third most commonly cited cause of FLW at retail, which is inaccurate forecasts.

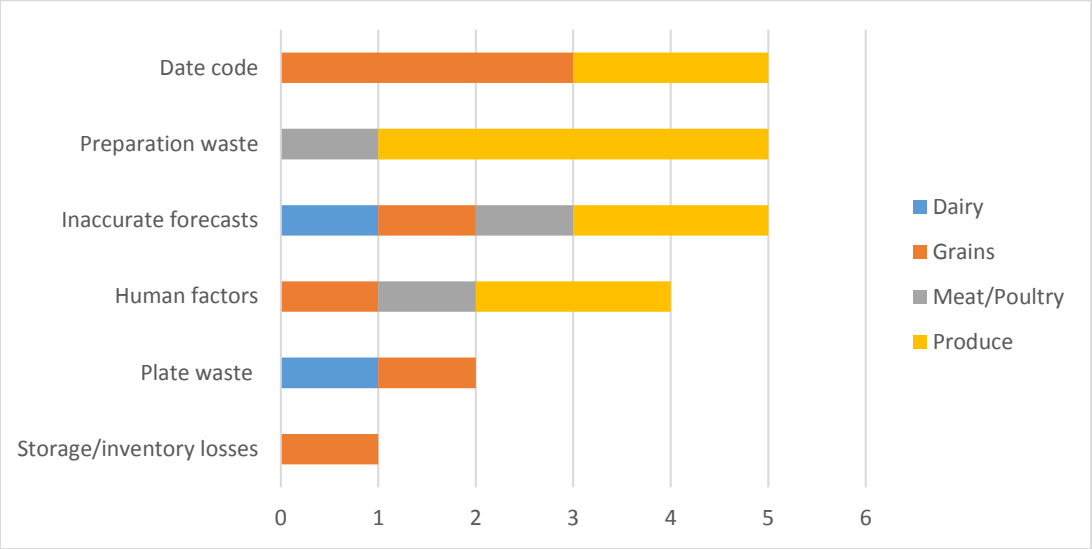
Figure G: Causes of Waste in Retail by Food Type



5.4 HRI

Date code, preparation waste, and inaccurate forecasts were all equally reported as contributing to FLW in the HRI sector (see Figure H). Date code was most common for grains. Preparation waste was most common in produce. As per responses received, inaccurate forecasts affect all four food types; the food type most commonly affected by inaccurate forecasts being produce.

Figure H: Causes of Waste in HRI by Food Type



APPENDIX B – Methodology

1 The Methodological Approach

The overall methodology followed in this project was designed to analyze food loss and waste (FLW) from the perspective of industry stakeholders, by gathering first-hand experiences of those that participated in the research – the respondents. This is known as social constructivism. Such methodologies enable researchers to interpret findings from the key perspectives and experiences of individuals involved in the industry. It provides a means to quantifying FLW from an industry/food system perspective, and produces practical and sustainable recommendations to which stakeholders respond constructively.

The whole chain approach to waste minimization adopted in this study was tested in the UK by the Food Chain Centre (FCC), which operated at IGD (Institute of Grocery Distribution) between 2002 and 2007. The aims of the FCC included the development of food chain analysis from farm to point of sale, in order to identify how efficiency savings can be made to the benefit of all players. This resulted in reported savings of £14.4 million amongst those that participated in the programs offered by the FCC over its years of operation. Approximately 100 business participated. The reported savings do not consider the ongoing savings that have potentially been realized by the continued implementation and improvement of lean processes established by the FCC team in conjunction with the involved business. FCC's work was grounded in tried and tested business improvement methods that were little known or applied in the food industry at the time. This has, in effect, provided us with a "proof of concept" that we expanded upon in this approach.

This research estimated FLW across the Canadian Food System and assessed the root causes of FLW in order to provide solutions to the issue of FLW. This was done using value chain analysis (VCA) and a mass balance model, detailed in Section 2 and 2.3, respectively. VCA provides a clear method for understanding complex commercial systems. In combination with mass balance, it provides a means of effectively outlining where and why FLW occurs throughout the food system. The research required to complete the VCA and mass balance was conducted between January and September 2018.

The following sections begin by comparing the methodological approach adopted for this study versus prior FLW research conducted in Canada and elsewhere. This is followed by a discussion of the VCA process and its value for addressing FLW, the analytical framework, the project's scope, and the establishment of the mass balance baseline.

1.1 FLW Methodological Comparison

The following section describes how the methodology built upon prior research methods employed by Canadian and international organizations, and resulting materials. Previously released FLW reduction strategies, such as the National Zero Waste Council's "A Food Loss and Waste Strategy for Canada," Provision Coalition's "Developing an Industry Led Approach to Addressing Food Waste in Canada," and

ReFED's "A Roadmap to Reduce U.S. Food Waste by 20 Percent," were also reviewed during the research methodology's design and implementation.

Several reports have attempted to quantify and address the issue of FLW in Canada and in other comparable jurisdictions; however, none have combined a national mass balance from the whole of chain perspective, as this research has done. The estimation of FLW that has arisen from this project is considerably larger than previous estimates for Canada, which have ranged from 6 to 13 million tonnes.

The fact that we have taken a whole of chain approach and established a more complete set of data and insights along the food value chain than previous studies have undertaken in estimating FLW, has naturally resulted in our producing larger estimates of FLW than those produced by prior studies. There are still limitations to the methodology followed to establish this new estimate. These limitations include that the loss factors are largely reliant on estimates and assumptions of stakeholders within the sector, as there is limited measurement of FLW and even less standardized measurement. However, the research team believes it provides a more complete picture of the extent of FLW across the entire food life cycle.

Table A provides an overview of methods used to estimate FLW, particularly in Canada, with further discussion/comparison of these key reports and work on FLW presented below. Reports by Agriculture and Agri-food Canada (AAFC), National Zero Waste Council (NZWC), ReFED (US), and the Commission for Environmental Cooperation (CEC) have all been reviewed and considered by the research team.

Table A: FLW Estimates for Canada (except FAO) and Methodological Comparison

Report/ Authority	FLW/Year Estimate	Food Products Included	Value Chain								Method
			Pre-harvest	Post-harvest	Processing/ Manufacturing	Distribution	Retail	Food Service	Food Rescue	Consumer	
FAO	1.3 billion tons (Global)	All (Implied)	✓	✓	✓	✓	✓	✓		✓	FAO production data used in mass flow model. Loss factors from literature review and authors assumptions.
AAFC	6 million tonnes	215 products	✓	✓	✓	✓	✓	✓[1]		✓	Applied USDA retail, household, cooking and plate loss to Canadian food availability data to generate a Canadian loss-adjusted food availability.
NZWC	5.6 million tonnes	All (Implied)			✓	✓	✓	✓		✓	Used waste-composition/weight data from key municipalities to extrapolate FLW entering solid waste management systems.
CEC	13 million tonnes	All (Implied)	✓	✓	✓	✓	✓	✓		✓	Used FAO data; global food production data with conversion/loss factors applied.
ReFed	5.7 million tonnes[2]	All (Implied)	✓		✓	✓	✓	✓		✓	Literature review – FLW per employee from ICI through chain. Census, secondary sources for waste generation rates. Farm level "ugly food" estimate.
VCMI/SH (2019)	**35.5 million tonnes**	**All (Implied)**	✓	✓	✓	✓	✓	✓	✓	✓	Mass balance of the value chain with stakeholder acquired loss factors. Root causes and solutions developed from stakeholder engagement.

[1] This only includes post-consumer waste; food prep waste is not included in this data.

[2] Estimated equivalent based on Canada having 1/10th of the population of the US. ReFED calculated 56.7 million metric tonnes; with a 10th of the population, Canada would be approximately 5.7 million tonnes.

1.1.1 Agriculture and Agri-Food Canada (AAFC) and United States Department of Agriculture (USDA)

The 2015 overview of the Canadian Agriculture and Agri-food sector published by AAFC had a special feature on FLW. This was the first time the government had attempted to quantify the issue across Canada. By applying FLW estimates developed by the USDA (Buzby et al., 2014), AAFC and Statistics Canada (STC) provided a loss-adjusted food availability statistic product, which is monitored by STC. The primary purpose of the loss-adjusted food availability statistic is to "more closely estimate actual per capita intake" (Buzby et al., 2014). The intention of this data was not to estimate FLW; therefore, there are key gaps within this analysis regarding FLW. For example, foodservice only includes post-consumer FLW and does not include preparation waste. There is no consideration of food waste prior to retail. Distribution, processing, production (pre or post-harvest) are also not incorporated into this data.

1.1.2 Commission for Environmental Cooperation (CEC) and United Nations-Food and Agriculture Organisation (FAO)

The 2017 report from the Commission for Environmental Cooperation (CEC) provides an overview of FLW across North America (Canada, US and Mexico). Although some measurements of FLW have been conducted within each of the countries, CEC sought to have a standard measure, against which the three countries would be compared. The FAO data and methodology were deemed the most appropriate under the parameters of the CEC report; however, the FAO estimates used in this report "should be interpreted with a high degree of uncertainty" (CEC, 2017).

Although the FAO study took a similar approach of mass flow (balance) through the food system, the FAO data had significant limitations regarding availability of data, particularly on a global scale. The loss and waste through the chain was estimated from FAO's food balance sheets for the year 2007 and from a literature review.

The FAO food balance sheet data for Canada omits key commodities that are significant contributors to the agri-food system. Some of the commodities that have no loss data within the FAO dataset include bovine meat, poultry meat, milk, and marine. Where data was missing, Gustavsson et al (2011) made assumptions and estimations based on FLW in comparable regions, commodity groups or steps within the value chain. This VCMI/SH research provides an update and a more refined analysis of FLW within the Canadian context, due to the fact that the production data is from 2016 and loss factors have been collected from the industry directly.

The CEC report provides solutions (labelled as approaches) for addressing FLW. However, they are often siloed in nature, and do not address the fact that the food value chain is a complex system with interacting stakeholders.

1.1.3 National Zero Waste Council

The NZWC report[3] extrapolated weight and composition data from representative municipalities to assess how much food waste was entering waste management systems across the country (National Zero Waste Council 2017). This did not explore losses occurring pre-harvest, or during production and processing. Consequently, NZWC did not account for food waste being fed to animals, which is a key disposal method, particularly at the production and processing end of the value chain.

1.1.4 WRAP (UK)

WRAP has pioneered the measurement and prevention of food waste in the UK since it was established in 2000.

Government funding has enabled WRAP to measure food waste in households, retail, manufacturing, food service, and most recently in agriculture, using comprehensive survey techniques. These studies have provided policy relevant data on the amounts and make up of food waste, often for the first time. The work on household food waste led WRAP to introduce the consumer campaign “Love Food Hate Waste” in 2007. This work aims to raise awareness of food waste and offer practical advice and solutions to help the public reduce their food waste.

In 2005 WRAP also pioneered a ground-breaking voluntary agreement with the food industry, known as the Courtauld Commitment, which ran through three phases until 2015. In its third phase, WRAP reported that over £100 million in business savings was delivered by reducing food waste.

WRAP also ensured that a baseline on waste data was established, and that progress towards the targets in each phase of the agreement was rigorously monitored to demonstrate progress to stakeholders. It also provides technical guidelines for businesses to help consumers reduce their food waste by commissioning independent research on, for instance, household waste and its causes.

In 2016 WRAP launched a 10-year producer to consumer voluntary agreement known as the Courtauld Commitment 2025. This was to make food and drink production and consumption more sustainable. Meeting the Courtauld 2025 targets will help the UK achieve UN Sustainable Development Goal 12.3 by 2030.

A scan of the work emanating from the UK on FLW found there to be some whole of chain projects that looked at specific commodities or products. However, WRAP has always looked at commodities and products separately. Therefore, there has never been a link established between the commodity production and product production. In turn, this has prevented the completion of standardized whole of chain analysis. To combat this break in the chain and allow for measurement of FLW throughout the chain, VCMI/SH developed a food classification where the food is classified by the commodity that is the primary ingredient of that food (Section 2.3.1).

[3] Produced by Tetra Tech to establish a benchmark for the Love Food Hate Waste (Canada) campaign.

1.1.5 ReFED (US)

ReFED (2016) looked at FLW in the US across the value chain. The outcome of ReFED's analysis was a list of solutions, with their associated cost-benefit, for industry to consider. To measure the cost-benefit, their solutions were contextualized by volume and value, founded on the baseline FLW estimation developed by the ReFED team. The baseline is grounded in FLW per employee of key industrial, commercial and institutional (ICI) entities throughout the chain and on a per capita basis for households. Data to populate ReFED's model was acquired through a literature review, supplemented with stakeholder interviews and verification.

ReFEDs methodology contrasts with the mass balance approach taken by this project (section 2.3), which established baseline food input into the system, and then sort loss factors through the chain from primary research. There is a significant difference in the focus of the ReFED report and VCMI/SH: ReFED is focused on solutions, whilst VCMI/SH is focussed on the root causes and measurement to assess ongoing improvement. Although the ReFED work provides some insightful solutions, the VCMI/SH research provides a standardized metric that enables the measurement of FLW. Through measurement, benchmarking and monitoring, the effectiveness of various solution implementation can be tested. The VCMI/SH research builds on ReFED and other prior FLW research by providing a means to acquire meaningful data upon which to base future policy and solution implementation. This is something that, to date, has been lacking in all FLW research.

1.1.6 Inclusion of Food Rescue

No report on FLW has ever looked at the amount of FLW that occurs in the food rescue sector, or included this sector in the research and analysis of FLW issue. This sector is specifically excluded from the FLWARS, as it states that food rescue and distribution is a secondary food system. FLWARS does suggest that the methods they present can be used to measure FLW within the food rescue/ redistribution sector; however, it is not considered by the FLWARS to be a component of the primary food system. It is therefore outside the boundary/scope of the standard. This project has included food rescue/redistribution as a destination, and has investigated the potential of increasing food diversion to rescue/redistribution.

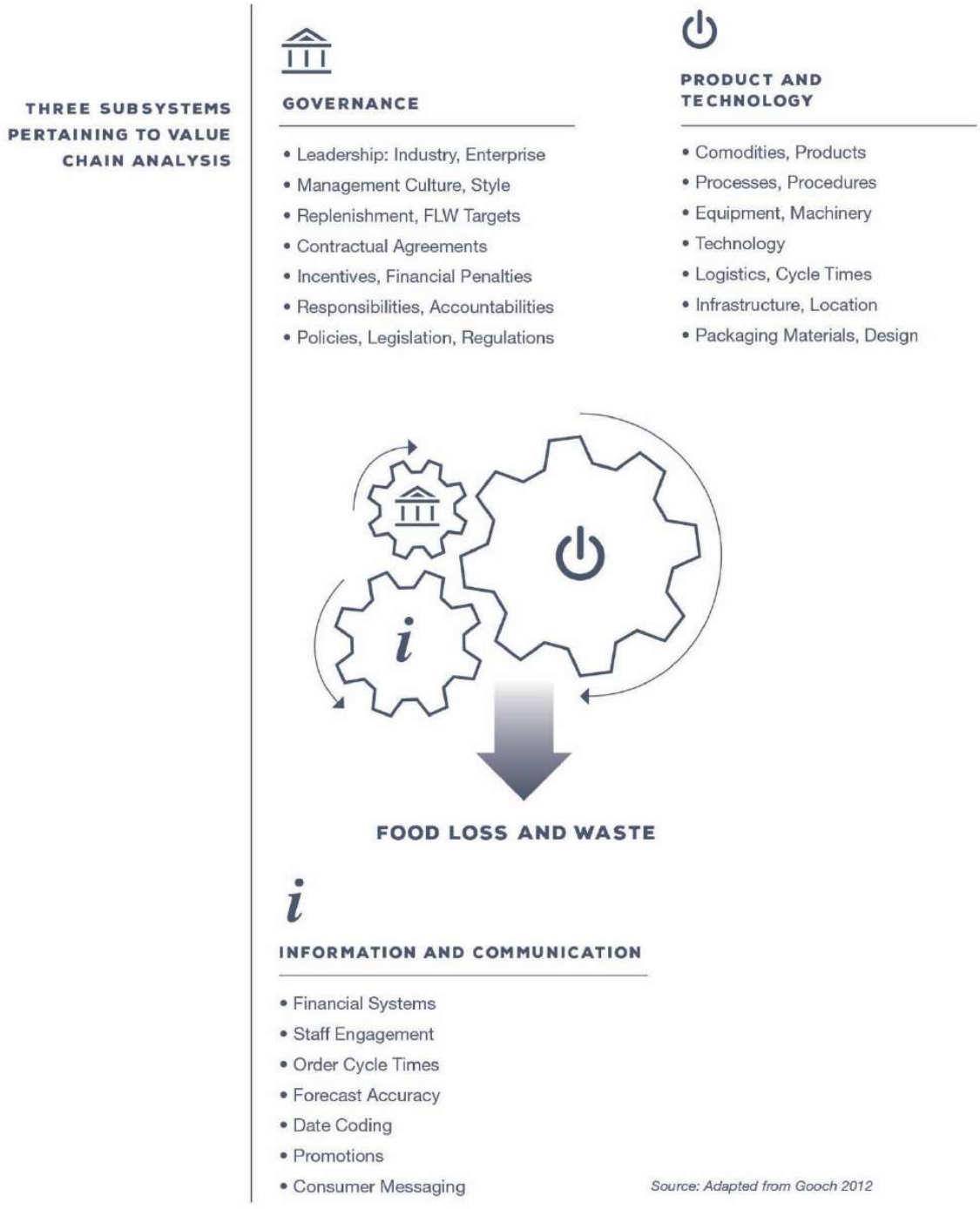
2 Value Chain Analysis

The modern food industry is a complex multi-faceted system. The root causes of FLW can lie at a different point in the food chain to which the resultant losses and waste and occur. When industry seeks to address FLW at one point of the chain without due consideration to the wider food system, overall FLW may not be reduced, but simply moved to another part of the chain.

All systems are composed of subsystems, whose interaction results in what is termed "emergent properties." The food system has many participants and moving parts; however, there are three subsystems that impact how individual value chains and the overall food system function. FLW is an emergent property of the food system; it results from interactions occurring between the three subsystems described below. As illustrated in Figure A, these three subsystems are:

1. **Governance:** Who and what determines how businesses operate unilaterally and from a value chain perspective; along with the degree to which the macroeconomics factors – including regulations and legislation – impact management decisions.
2. **Product and technology:** How commodities and products flow along the value chain to their final destination; along with the utilization of technology to improve productivity, and operational effectiveness and efficiency.
3. **Information and Communication:** How, what and when information flows within and between businesses versus retained for competitive or other reasons; along with what information is acted upon (or not), by whom, when and why.

Figure A: Three Subsystems Pertaining to Value Chain Analysis



The process of VCA examines the food system from a horizontal perspective, allowing a rigorous assessment of the interactions and outcomes that together shape how the overall food system operates. This enables researchers to determine factors impacting the creation of FLW, by having

investigated interrelationships between the three subsystems (listed above) that together determine how individual businesses within the food industry – and ultimately the food industry itself – operates.

Triangulating quantitative and qualitative data gathered from different sources enables researchers to develop a robust and objective picture of FLW and its root causes from a whole of chain perspective. The VCA process recognizes that FLW is not just affected by lack of investment, operational costs or deficient technologies.

FLW is also impacted by weaknesses in intra- and inter-firm relationships, with ineffective operations and communication resulting from a lack of strategic alignment, operational understanding, trust, commitment, benefit sharing, and collaboration. For these reasons, the level of collaboration that exists within and between businesses will influence the amount of FLW occurring along the value chain in which they operate. The same reasons will also impact businesses' motivation and ability to reduce FLW.

The results produced by VCA aid the development of effective sustainable solutions. This is because individuals' experiences and personal beliefs need to be understood, as these influence how individuals view themselves, in context of the world around them and how they will respond to potential recommendations.

2.1 Analytical Framework

The food system starts with production of terrestrial and marine foods, and the wild capture of marine foods. Food is then transported and transformed through the food system to the consumer. At each step in the chain there is FLW to varying degrees, and the disposal of this waste has various destinations. In light of the fact that food is transported throughout the system, and that the use of that transportation system requires the weight of the load to be known, the common metric for the weight of FLW is metric tonnes. No matter the type of commodity/food, the weight is known or can be calculated; therefore, mass balance is a logical method for measuring FLW.

A graphic of the research framework is presented in Figure B. The team first established the amount of production that occurs in Canada. The total amount of food that would typically enter into the food system was then established, accounting for imports, exports and grains that are used for animal feed. The losses at each stage were gathered from the industry survey. Information about the destinations of FLW and the causes of this FLW were requested from the industry, and finally solutions were developed and verified with stakeholders. As already mentioned, the key measurement of food produced, distributed sold and consumed as well as FLW should be metric tonnes. The logic behind this is that most food is likely weighed during production, and formulas exist for translating common measures (e.g. bushels or apples and bushels of wheat) into metric tonnes. In addition, all food and liquids (e.g. milk) must be transported by road, air and/or sea at various stages of the production system – so therefore its weight is known (as mentioned above).

Figure B Analytical Framework

Farms / Marine	**Primary Processing**		**Manufacturing**		**Distribution**	**Retail**	**Food-service**	**Consumers**	**Redistribution**
Production	Planned loss	Unplanned loss*	Planned loss	Unplanned loss*					
Production / sales									
Losses / waste; edible / inedible									
Destination									
Root causes									
Solutions									

*includes Post-Processing losses

2.1.1 Stakeholder Advisory Group

To assist in ensuring the robustness and rigour of the research and conclusions drawn, an advisory group comprising expert industry stakeholders was established. Representing farming, processing, distribution, foodservice, retail, academia, and associated industry stakeholders, the group's primary purpose was to help ensure that the project achieved its intended outcomes of:

- Producing and populating FLW metrics that reflect the Food Loss and Waste Accounting and Report Standard; and
- Creating data, materials and solutions that are conveyed in a Canadian context, though can be extrapolated across jurisdictions to enable international comparisons.

Advice and feedback provided by the stakeholder group helped ensure that no important considerations were omitted during the research, analysis and subsequent development of proposed solutions. The members also assisted in engaging industry throughout the design and implementation of the research. This included directing the researchers to important sources of secondary data, commenting on the draft online survey, circulating the survey across the Canadian food industry, recommending experts and organizations to consult during the data validation process, and participating in the focus groups.

The research commenced by establishing a baseline of food: the total volume of food that is grown, caught and harvested and enters into the Canadian food system. A comprehensive survey, supplemented with interviews, provided information regarding FLW throughout the food system. All this information informed the development of a mass balance model that provided an estimation of FLW or leakage from the food system. This model calculation was conducted on the six food categories from production to distribution. After distribution, food flows into retail and/or HRI.[4] The model was built to accommodate this differentiated flow, and the different losses estimated for FLW in food service, retail and household were applied to a portion of the total food flowing through the model. Results from the model are described in the body of this report and expanded upon in Appendix A.

In addition to acquiring loss factors, the primary research identified key causes of FLW and the destinations of FLW. The prevalence of, and barriers to, food rescue and redistribution were also of key concern within the research. Targeted interviews and focus groups across the country were used to verify research findings and triangulate them for validation. Focus groups were also used to inform and guide the development of sustainable solutions, conceptually testing these solutions with industry experts across Canada. Appendix A provides details regarding the calculation of the food system baseline, the survey, data analysis, interviews, and the focus groups.

[4] Hotels, Restaurants and Institutions (Food service)

2.2 Research Scope (FLWARS)

The development of this project used the Food Loss and Waste Accounting and Reporting Standard (FLWARS) as a guide. Figure C below illustrates the scope of this project with reference to the FLWARS terminology. The template shown below is a modified version of that contained in the FLWARS. To better reflect the research methodology, working left to right, the template was modified by placing the column "boundary" ahead of "destination."

Figure C: Scope of the Research

The research distinguished between planned and unplanned FLW, which were defined as waste that was unavoidable (planned) and avoidable (unplanned). This acknowledges that there is some shrinkage of food within the food system during processing and due to moisture loss etc. The definitions of these

were provided to our survey participants and can be found in the glossary of terms. The project also enquired into the amount of edible FLW that was occurring along the chain.

All destination types were part of the inquiry, and the boundary included the entire food system across Canada with food classified into six categories.

The research addressed FLW through the whole of chain: food production from farm (terrestrial/ marine) and wild capture of sea and fresh water commodities to fork (human consumption). It has been conducted using a systems approach at the commodity and food type level. Therefore, granularity on specific food and beverage SKUs is not included.

The project does not include a specific assessment/measurement of energy and environmental costs associated with FLW. This is an area of research that has been completed for other regions of the world and should be considered as further research regarding FLW within the Canadian context. Food that was produced for animal feed and its associated waste was also outside the scope of this project.

2.3 Mass Balance Baseline

We used mass balance to quantify the amount of FLW occurring throughout the food system. The FLWARS presents this as one of the potential methods to be used for estimating FLW, and the research team felt that this was the best way to estimate FLW for the entire food system within Canada.

Shown below in Table B is the baseline of net available food (for 2016). The formula used to calculate the baseline is also shown. The baseline consisted of:

$$Food\ Production^{5} - (Exports + Imports) \pm \left(Adjustment\ for\ Processed\ Food^{6}\right) = Baseline$$

Table B Baseline Volume

Food Type	Million Tonnes
Dairy	9.3
Field Crops	33.8
Produce	13.3
Meat/ Poultry	2.5
Marine	0.8
Sugar/ Syrups	1.2
Total Tonnes	**60.9**
Prepared Food Adjustment	0.22
Food System Supply	61.12

[5] Terrestrial and marine

[6] Adjustment made after processing and manufacturing within the value chain model

Data for food production came from AAFC, STC, and Fisheries and Oceans Canada. Trade data (imports and exports) came from Canadian International Merchandise Trade Database (CIMT). At the time of the research, 2017 data was being continually updated; therefore, the research project used 2016 data, as this was the most recent *stable* data set. The only exception was some statistics for marine registered vessels and production, which is from 2015. This was the most recent data available for this sector at the time of the research.

All data that was collated was measured or converted into metric tonnes. For example, milk and eggs needed to be converted. Hectolitres were converted to tonnes based on the density of 1.03kg/litre. Dozens of eggs were converted to tonnes based on the average egg size of 56g. Production statistics for meat was collected based on carcass weight. An adjustment was made to key feed grain production data to account for the large amount of grain that is grown for animal feed.

All the production data was categorized into the six food categories used for this research, the rational for which is discussed below. All data was collected at the provincial level to enable some geographic analysis. The trade data was attributed to the province of importation or exportation; however, it was noted that the port of entry was not necessarily the final destination.

A total of 60.9 million tonnes was calculated as the baseline of Canadian food production (Table B). Further detail on the baseline data sources can be found in Appendix A.

2.3.1 Categorizing Food and Beverages from Whole of Chain Perspective

A key issue of addressing FLW has been disconnects between measurement of production loss and consumer waste. Previous FLW research measured food loss and food waste separately, and did not establish a direct connection between the commodities that enter the food system and the consumer products that are formulated from them. This research has bridged that gap and Table C outlines the categorization this project adopted: all food is based on the major commodity that it consists of.

Using the mass balance approach, and knowing the comparative percentage of inputs used in the manufacture of processed foods, it is possible to measure and monitor loss and waste of inputs. Thus, waste can be portioned to appropriate commodities back to primary production. Within the survey, processing and manufacturing respondents were asked to provide percentages of the particular food types that were processed at their facility, and to provide the percentage of planned and unplanned FLW that occurred in these various food types.

Table C: Categorization of Food by Product

Category	Dairy and Eggs	Field Crops	Produce	Meat and Poultry	Marine	Sugars and syrups
Consumer products incl. *(examples)*	• Eggs • Liquid milk • Cream • Yogurt • Cheese • Butter	• Bread • Baked goods • Cereal • Beer • Spirits • Soymilk • Vegetable oils	• Fresh F+V • Processed F+V • Nuts • Chocolate • Fruit juices • Cider • Wine • Coffee • Tea	• Fresh cuts • Primal cuts • Processed meats • Entrees	• Fresh fish • Processed fish • Fillets • Shell fish • Entrees	• Maple syrup • Sugar • Honey • Soft drinks
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

3 Survey

We used an online survey to capture data and information regarding FLW from across the country and throughout the value chain. The survey design was informed by the FLWARS, our expert team, and a review of background information regarding the "hots spots" of FLW that have been found in Canada, the US and the UK. The survey ultimately provided the loss factors that went into the model used to estimate losses along the chain. It also provided initial insights into where and why FLW is occurring.

3.1 Survey Design

We designed the survey to be disseminated throughout the value chain and across the country. It was designed to capture data for the six different food types, and was directed to different segments of the value chain. There were common questions throughout the survey; however, once the respondent identified their position in the chain, skip logic allowed for questions only pertaining to them to be answered – thus customizing the survey for specific industries and value chains

There were 14 different positions within the chain for a respondent to select from (as referenced in Table D), eight of which were various types of primary production. The online platform of Survey Monkey was used to disseminate the survey.

Table D: Value Chain Segments Surveyed

Primary Production	Processing & Manufacturing	Distribution	Retail	Food Service	Food Rescue
• Livestock • Poultry • Egg • Dairy • Storable Produce • Perishable Produce • Marine • Sugar/Syrup	• Produce Packers • Primary Processing • Further Manufacturing			• Hotel • Restaurant • Institution	

Based on FLWARS, the survey was designed to inquire about edible and inedible FLW, and we also asked about planned and unplanned (i.e. avoidable and unavoidable FLW). A literature review of FLW hot spots and prior analysis informed the survey design, particularly with regard to the list of potential causes of FLW that were presented to survey respondents. In addition to the list developed, there was an option to indicate a different cause and explain it.

Overall the questions within the survey were designed to:

1. Establish which part of the chain the responded was situated
    a. Size of business
    b. Physical location of the business (rural, semi-urban, urban)
2. Establish which food type the respondent was primarily reporting on

3. Establish if measurement of FLW is currently occurring
4. Establish the amount of FLW that is occurring within the business, i.e. loss factors (where measurement was not formally conducted, estimates were requested)
5. Establish the type of FLW that is occurring
    a. Edible, inedible/planned or unplanned
    b. Processing and manufacturing were additionally asked about any post-processing losses
6. What were the causes of FLW
7. Where is this FLW going, i.e. what are the disposal methods
    a. Is it being rescued/redistributed?
    b. What would increase the amount of food rescue/redistribution?

Respondents were also given the opportunity to provide additional comments and feedback throughout and at the end of the survey.

3.2 Survey Roll Out

The survey was tested in mid-May 2018, by distributing the draft among fifty individuals with whom Second Harvest or VMCI had strong relationships and who represented businesses that stretched along the value chain. These businesses included various farming operations, produce packer/shippers, processors, manufacturers, retailers, foodservice, and food redistributors. Each potential respondent received a personal invitation, requesting that they complete the survey online and provide feedback regarding the usability and/or wording of the survey.

Written feedback was provided via the 43 survey responses received, or separately by email. Five respondents provided further detailed feedback verbally. Based on this feedback, the survey was revised prior to its dissemination across Canada in early June 2018. The stakeholder advisory group assisted in distributing the survey to businesses and industry organizations. Provincial and national organizations – representing farmers, processors, manufacturers, retailers, foodservice and food redistributors (incl. food rescue and foodbanks) – distributed the survey link and information via email blasts and newsletters. The survey was viewed on 732 occasions, with 579 responses received.

Following a request by a representative from the seafood harvesting sector in early July 2018, a separate complementary survey was designed and distributed amongst individuals involved in the wild catch and aquaculture sectors. The survey was viewed on 50 occasions, with 41 responses received.

The online surveys closed in late July, with regular downloads and cleaning of data occurring throughout the six-week period that information on the project was disseminated to industry.

3.3 Survey Data Distribution

The survey had a response rate of 79 percent from 782 visits to the online survey. A total of 618 valid responses[7] were received from all along the value chain. Two hundred and fifty-one respondents gave specific information regarding FLW in their operation. Those that did not give specific information on FLW were still considered respondents, because they gave information/feedback regarding the issue of FLW. The distribution of the responses in comparison to the make-up of the industry indicates that statistically the responses were overrepresented in the processing and retail sectors and under represented in the primary production and HRI sectors. However, reasonable representation was received from across the chain.

Business Type	**% of Industry**[8]	**% of Survey Responses**
Primary Production (incl. marine)	54%	38%
Packing, Processing and Manufacturing	1%	15%
Distribution/Wholesalers	2%	3%
Retail	9%	33%
HRI (Hotels, Restaurants, Institutions	33%	11%

Responses were received from across the country. As can be seen from the table below, responses were over represented in Ontario, British Columbia, Manitoba and PEI. Every effort was made to ensure each region of the country was engaged through follow-up interviews and focus groups.

Provinces	**% of Industry**	**% responses by Prov.**
Newfoundland and Labrador	2%	1%
Prince Edward Island	2%	**8%**
Nova Scotia	4%	1%
New Brunswick	3%	1%
Quebec	18%	1%
Ontario	28%	**46%**
Manitoba	6%	**15%**
Saskatchewan	12%	3%
Alberta	15%	8%
British Columbia	12%	**16%**
Territories	0%	1%

The above figures show that the researchers' target of acquiring 250 survey responses, representing respondents from across the country and throughout the various food type chains, was exceeded.

[7] Valid responses were those that had answers to questions, not simply a visit to the survey.
[8] Calculated from Industry Canada Statistics

APPENDIX C: GHG Associated with FLW

This appendix describes the methodology followed in a project that was related though separate to the Avoidable Crisis of Food Waste research to produce high level whole of chain estimates of the CO_2 equivalent (CO_2e) footprint of FLW presented in Section 3.8.1 of the Technical Report.

Using published estimates and publicly available data, we established an entire chain estimate of CO_2e. Production, processing and manufacturing estimates came from published LCA[1] literature. Emissions from transportation between chain links were determined based on published truck emissions and estimated distances of transportation for each food category. Energy consumption at retail, HRI DCs, HRI, and households was extrapolated from company reports and Canadian statistics. A calculator model was constructed for each food type; therefore, we could estimate the CO2e associated with FLW occurring in that chain. The total CO_2e for all six food types reported in "The Avoidable Crisis of Food Waste (2019)" provided the overall FLW CO_2e footprint. Using the loss factors of potentially avoidable FLW from the FLW model an estimate of potentially avoidable CO_2e was derived.

In scope data:

- Growing and production, primary processing and manufacturing data with source attribution for the food consumed within Canada, (78mm tonnes produced domestically plus 10mm tonnes imported), **but not that** which is exported (27mm tonnes)
- Retail and distribution as a standard carbon foot print for a typical operation
- Emissions associated with truck rolls to and for each element of the value chain
- Estimates for HRI and HH food preparation, cook and serve

Out of scope data:

- Emissions associated with fishing vessels and aquaculture (unless included in the LCA literature)
- Production fertilizer NO_2 effect (unless included in the LCA literature)
- Animal medication and healthcare (unless included in the LCA literature)
- The construction of warehouses, stores and HRI properties
- Employee and consumer commute
- HRI eatery footprint
- Water and wastewater pumping and treatment
- Carbon sequestration of fruit trees and grazing/pasture lands.

Production, Processing and Manufacturing:

Majority of LCAs only consider the GHG emissions from the production phase of the food supply chain (FSC), as this is where majority of emissions are accumulated in a product (Porter et al. 2016). Where possible, emissions factors for processing and manufacturing were acquired to apply to our model. All production emissions factors (except Sugar/Syrups) were drawn from Porter et al. (2016), the North America and Oceania regional data set. Generally, this is the average of products within the food types;

[1] Life Cycle Assessment

however, the field crops category was adjusted downwards based on the predominate crops in Canada being wheat, maize and oilseeds.

Emission factors for processing and manufacturing are added to production to give total emissions for that food type at that stage. The one exception to this is in the dairy and eggs category, in which the processing emissions factor is an average of production and processing all dairy products in Canada (Vergé et al. 2013) and includes fluid milk as well the higher emission-producing processes, such as cheese and powdered milk.

Table A: Emission Factors (tonnes of CO_2 Equivalent Emissions per tonne of food)

Food Type	Production	Processing	Manufacturing	Retail	HRI DCs	HRI	Households
Dairy and Eggs	2.395	3.445	3.445	A total CO_2e tonnage for each of these chain elements was calculated by the methods described below and allocated to food type based on % of FLW from that food type at each stage. Transportation was added where applicable.[2]			
Field Crops	0.500	0.541[3]	0.760[4]				
Produce	0.462	0.462	0.462				
Meat/ Poultry	11.528	11.698[5]	11.868[6]				
Marine	4.420	4.420	4.420				
Sugar/ Syrups[7]	0.440	0.629	0.629				

Transportation

Food is transported by ship, air, rail, and truck. We have no visibility as to what volumes of food is transported by which mode, so we have defaulted to all food being shipped by truck. This will allocate a defendable conservative CO_2e foot print. We have addressed the trucking of 60 mm tonnes of food, minus the FLW that occurs, along the chain as far as the retail store or HRI. While the legal maximum for a tractor trailer load is 36 tonnes, we have assumed a truck load is 25 tonnes one way. This loading will account for lighter loads, such as potato chips, leafy greens etc., as well as the use of smaller rigid body trucks. We have no insight as to the number of return empty truck rolls, so our CO_2e for trucking is conservative.

Using information available from www.transportenvironment.com and Volvo (trucks), indications are that trucks currently emit between 0.8 and 0.9 kg CO_2e per km (Ambel 2015; Volvo Truck Corporation 2018). The actual emission will vary according to the age and condition of the truck, how, where and when it is driven. However, our calculations will serve as a conservative estimate. The estimated number of loads, distances traveled and CO_2e emissions were estimated based on average distances

[2] Transportation was not added to retail, as this was included in Loblaw's CSR report (mentioned below) for fleet operations and extrapolated across all retail.
[3] Wheat Milling (Espinoza-Orias, Stichnothe, and Azapagic 2011)
[4] Bread Manufacturing (Espinoza-Orias, Stichnothe, and Azapagic 2011)
[5] Slaughtering and Rendering of Pigs, Chickens and Cattle (Aan Den Toorn, Van Den Broek, and Worrell 2017)
[6] Added the same again for manufacturing based on cooking energy etc. required for further processing of meat products.
[7] Emissions factors for sugar/syrups sourced from García et al. (2016), which is the best available estimate that could be found.

particular food types would need to travel for processing/manufacturing and marketing. The transportation estimate does not include the transportation associated with secondary uses such as animal feed, rendered product and/or disposal of food waste.

Retail Stores

In their 2017 Corporate Social Responsibility (CSR) report,[8] Loblaw Companies Limited indicated that the corporate carbon footprint for food retail stores and DCs (but not Shoppers Drug Mart for 2016) was close to 1mm tonnes (Loblaw Companies Limited 2017). This comprised:

- Natural gas
- Electricity
- Fleet fuel consumption
- Refrigerant releases
- Waste
- Corporate travel

Loblaw Companies Limited revenues for 2016 were $46.4B, of which Shoppers Drug Mart accounted for ~$10.6B. Of the remaining ~$36B, Statistica indicated Loblaw Companies Limited food sales were $31.18B, with the remainder being non-food sales and financial services.

If Canadian food sales for 2016 were $95B, and if we extrapolate Loblaw Companies Limited carbon foot print for $31.18B food sales, then the Canadian food retail foot print is: 1mm tonnes x $95B/$31.18B or 3mm tonnes CO_2e.

HRI DCs

HRI sales for 2016 were ~$60B. Using the retail calculation above, HRI DCs' CO_2e foot print would be 2mm tonnes for 2016. However, HRI DCs do not operate retail stores, thus natural gas, electricity and refrigerant releases would be much lower. Scaling off Loblaw Companies Limited 1mm tonnes, we estimate these to be around 550k tonnes. We have reduced this by 75% to account for the difference in operation – thus we have 137.5k tonnes plus the balance of 450k tonnes,[9] for a total of 587.5k tonnes x 2[10] ($60B) for a total of 1.175k tonnes CO2e assigned to HRI DCs.

HRI Operations

This will vary considerably by type and size of operation, and sources of information are limited. We estimated that the typical HRI operation has 28.8 tonnes[11] of CO_2e associated with the storage, preparation and cooking of food. In 2016 there were approximately 87,000 HRI establishments (2016) in Canada. Therefore the estimated total of CO_2e is 87k x 28.8 = 5,220k tonnes.

[8] Metro's CSR report does not report emissions in a manner that would allow the calculation of its unique CO_2e. Sobeys' website has a sustainability section, but it does not appear to address CO_2e of its operations.
[9] Portion of the carbon footprint not associated with natural gas, electricity and refrigerant releases.
[10] Based on HRI sales being approximately double that of retail.
[11] Assuming the kitchen consumes 80% of the energy and based on information from Fastcasual.com (2016).

Canadian Households

The most recent data we were able to find indicating household emissions from energy consumed within the home (excludes automotive fuel) was ~1.3 tonnes per person – or 3.2 tonnes per household (Clark-Milito and Gagnon 2008). We estimate that 12.5% of this energy is used to store, prepare and cook food; thus we have a national household food related carbon footprint of (3.2 tonnes x 14.5mm households) x 12.5% = 5,800,000 tonnes CO_2e.

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