Circular Food System Assessment for the Province of Nova Scotia

October 2023

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NATIONAL ZERO WASTE COUNCIL
An Initiative of Metro Vancouver

ACKNOWLEDGEMENT

This report was prepared for the National Zero Waste Council in support of its *Circular Food Hubs: Mainland Nova Scotia* initiative. This report was made possible with funding provided by Environment and Climate Change Canada and Divert Nova Scotia, and additional support provided by COIL and Halifax Regional Municipality.

Environment and Climate Change Canada
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COIL Circular Opportunity Innovation Launchpad

HALIFAX

1. Food Waste Flow Analysis for Nova Scotia

1.1. Introduction

Dillon Consulting Limited (Dillon) was retained by the National Zero Waste Council to map the flow of food loss and waste (FLW) in Nova Scotia; and then to identify strategic opportunities for circular soluti°ns that could be applied as waste prevention methods. This two-part effort is intended to be a preliminary step in supporting the development of food hubs in mainland Nova Scotia. These food hubs will integrate circularity and FLW prevention, creating an Atlantic coast anchor of activity in the Canadian landscape, and contribute to the evolution of a Canada-wide circular food system away from the current linear model (**Figure 1**).

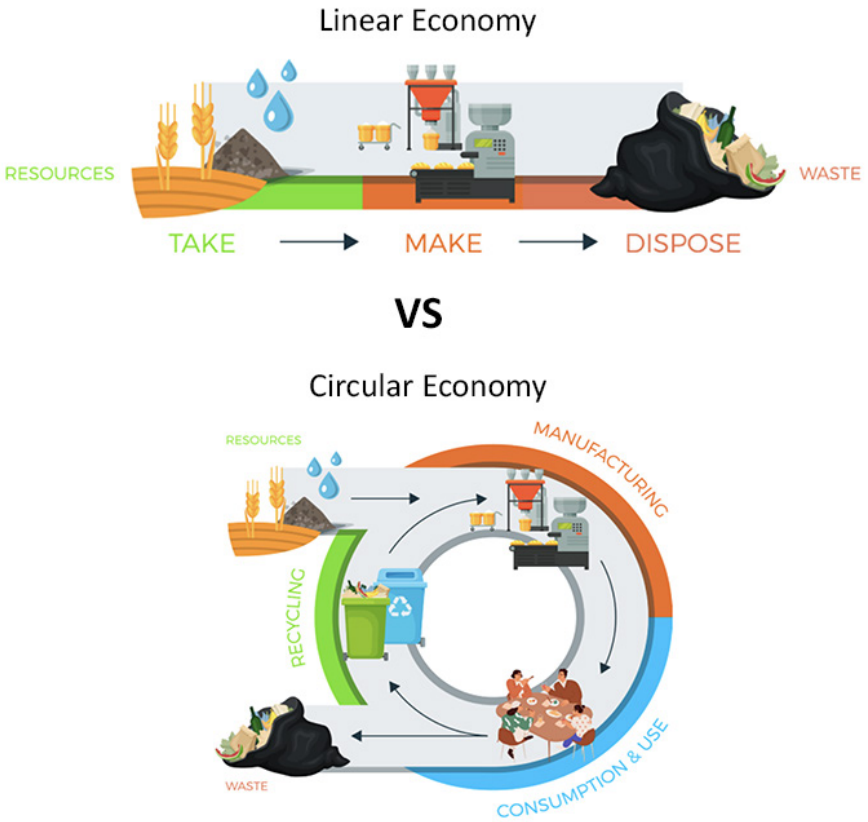

Figure 1: Visual comparison of a traditional, linear economic model and a circular economic model.

In addition to understanding the flow of food waste across the province, hotspots or points in the supply chain where FLW and greenhouse gas (GHG) emissions were the highest were identified. Options to help redirect this product back into the supply chain are presented in this summary report. These options are designed to spur discussion and further idea generation by members of the local food supply chain who may be able to incorporate food currently lost or wasted by one organization into another organization's operations.

A visual representation of the data collected for this work deepens an understanding of the flow of food that is consumed and lost along the supply chain in Nova Scotia. This visual representation was generated as a component of this work and is shared in **Section 4.0**.

1.2. Food Waste Flow Analysis Methodology

The process to complete this work followed seven steps. Data collection required access to Statistics Canada data as well as information from supply chain participants and past research. The steps and process to analyze and interpret Statistics Canada and supply chain participants' data were as follows:

1. Collect and process Statistics Canada food production data.

   Data from Statistics Canada was used to develop an understanding of food available for consumption in Nova Scotia. The data was not organized in the format or categories required for this research; data cleaning and organization was required.

2. Summarize the imports and exports of interest and add or subtract, as required.

   Import and export data were collected from Statistics Canada. Although imports and exports can occur at any point in the supply chain, the sum values for imports and exports were added to the total food availability data at the beginning of the supply chain. Both calculations were completed at a single point in the supply chain and not distributed across multiple points. Identifying where and what proportions of products are imported or exported at any given point presents a challenge, due to the lack of data transparency amongst supply chain participants. It is unlikely that this approach significantly impacts the findings or end recommendations compared to having import and export data broken down and added or subtracted at each level of the supply chain.

3. Collect waste and loss data from members of the Nova Scotia food supply chain.

   Supply chain participants were contacted to provide input on the amounts of food lost or wasted at each step in the supply chain. Provincial groups such as Divert Nova Scotia provided some waste data and connections to data sources to aid this work.

4. Refine FLW proxies.

   Where data was not available from supply chain participants on how much product is lost during a particular step in the supply chain, a review of the literature was undertaken to identify FLW figures that have been previously recorded. The primary source of this data was the foundational work completed on FLW across Canada in 2019.[1]

5. Create a material flow diagram (Sankey).

   *The data collected and the FLW proxies identified were used to create a visual depiction of the flow of food through the Nova Scotia supply chain in the form of a Sankey diagram (***Figure 4***).*

6. Identify GHG hotspots.

   An analysis of the areas where FLW is occurring was undertaken. This examination identified which areas of the supply chain were associated with the highest amount of GHG emissions for the wasted food. These GHGs, produced along the supply chain as the food item moves and then produced when the wasted food is disposed of by composting, become superfluous when the food fails to be consumed. These GHGs were flagged as a part of this analysis.

7. Develop circular solutions that could be used as interventions to reduce FLW and GHG emissions.

   Based on the GHG analysis, areas of the supply chain that are associated with particularly high amounts of unnecessary GHGs were identified, and interventions to reduce the amount of product lost in these areas were proposed for discussion and further development.

1 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. *www.SecondHarvest.ca/Research*

1.3. Food Waste Flow Considerations

This report is framed around the US Environmental Protection Agency (EPA) Food Recovery Hierarchy (**Figure 2**). The hierarchy focuses on actions that can be taken to lessen the impact of food that is lost or wasted along the supply chain.

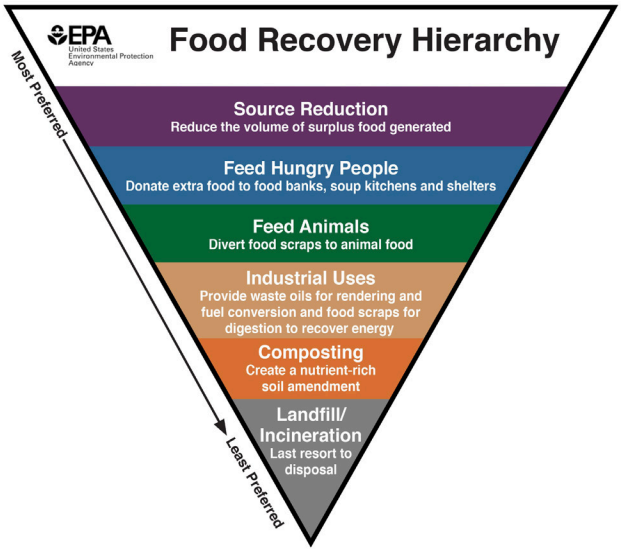

Figure 2: EPA Food Recovery Hierarchy

This work recognizes there is a common and recognized ambiguity around how products are categorized as FLW. For example, an apple eaten to the core may not be considered food waste by some, but others, who are accustomed to eating the apple core, may consider an apple core as food waste (**Figure 3**).

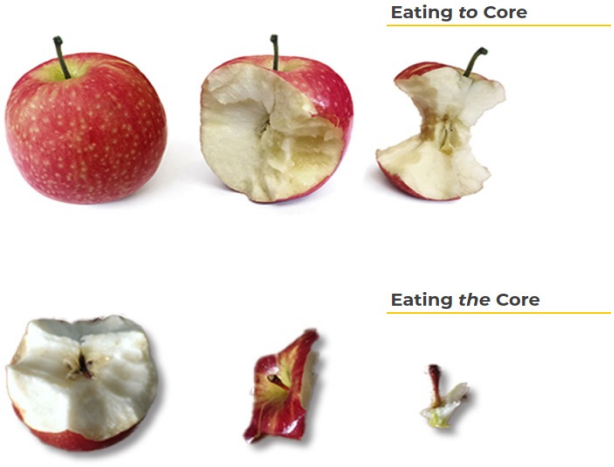

Figure 3: Consuming an apple down to its core versus eating a whole apple, including the core.

The definitions of FLW are contentious and varied, but this work favours the definition presented by the Food and Agriculture Organization (FAO) of the United Nations. This definition describes food loss as something that typically occurs during production, post-harvest and processing stages of the food chain, while food waste refers to the discard of edible foods at the retail and consumer levels.[2] The FAO definition puts an emphasis on food loss occurring primarily in developing nations, while food waste occurs more commonly in developed nations. This work recognizes that both FLW occur in Nova Scotia's food supply chain, and a circular approach to food supply chains requires that we consider how to redirect production, post-harvest, processing, retail and household FLW.

In general, nuanced data that reveals the level of detail regarding what is potentially edible and inedible has limited availability, specifically in Canada. However, this consideration is important to establish when developing recommendations on how to redirect FLW back into the supply chain. Food supply chain data in Canada is available through Statistics Canada; however, collecting any nuance in understanding the level of FLW occurring is difficult. This requires connecting with supply chain participants who are often reluctant to share their data or do not collect data in sufficiently robust manners to apply to a detailed investigation. This was an obstacle for this work and other work completed across the country.[3,4] In the case of this research, best estimates were made based on available quantitative data, typically from Statistics Canada, and recommendations for waste redirection were generated using a combination of quantitative Statistics Canada data and qualitative feedback as a result of interviews with supply chain participants.

2. Food and Agriculture Organization of the United Nations (2023). Sustainability Pathways. *https://www.fao.org/nr/sustainability/food-loss-and-waste/en/#:~:text=Food%20Wastage%20Footprint&text=Food%20loss%20refers%20to%20the,levels%2C%20mostly%20in%20developed%20countries*.

3. Our Food Future. (2021). Food and Food Waste Flow Study. *https://guelph.ca/wp-content/uploads/Food-and-Food-Waste-Flow-Study-Report-WP1.pdf*

4. Second Harvest. (2019). The unavoidable crisis of food waste technical report. *https://www.secondharvest.ca/getmedia/58c2527f-928a-4b6f-843a-c0a6b4d09692/The-Avoidable-Crisis-of-Food-Waste-Technical-Report.pdf*

1.4. Categories of Data

The categories of chosen data are based on the foundational, Canadian research commissioned by Second Harvest — *The Avoidable Crisis of Food Waste*.[5] This allows the study to be consistent with research and data categorization that considers the Canadian context. Categories are presented in **Table 1**.

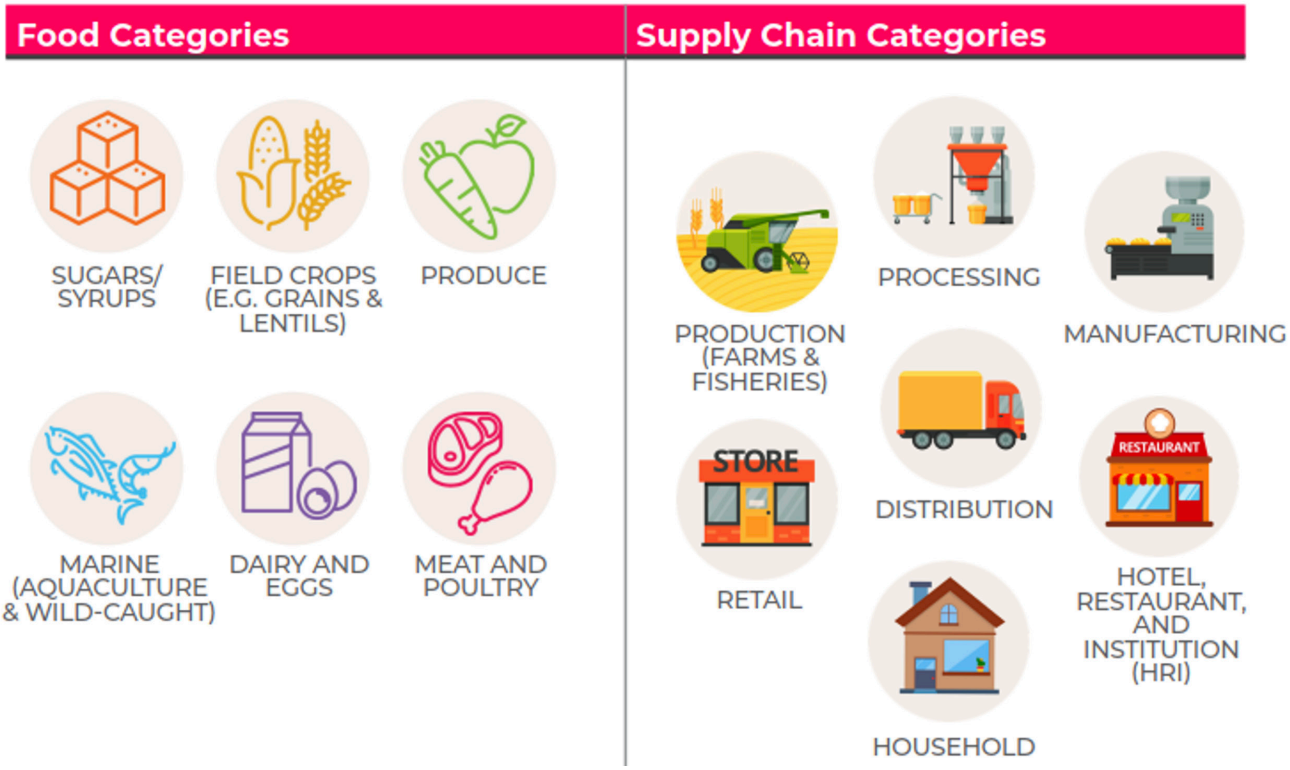

Table 1: Categories used to organize the food supply chain data

5. Second Harvest. (2019). The unavoidable crisis of food waste technical report. *https://www.secondharvest.ca/getmedia/58c2527f-928a-4b6f-843a-c0a6b4d09692/The-Avoidable-Crisis-of-Food-Waste-Technical-Report.pdf*

1.5. Results

The following sub-sections highlight the results of the study.

1.5.1. Sankey

Sankey diagrams offer a comprehensive and useful way of viewing large, process-flow data sets. A Sankey can show visually complex processes that would require many paragraphs of text to describe verbally. They allow the viewer to focus on specific data that interest them at any point in the flow or to view the whole flow as a larger system, including how any one area fits within that larger system.

The flow of food products across Nova Scotia is shown in a Sankey diagram (**Figure 4**). This Sankey diagram depicts the flow of any quantity using arrows with different thicknesses to indicate the flow rate. For this Sankey, the categories of food investigated are shown along the vertical axis of the figure, with the total lost or wasted food shown at the bottom, lower horizontal axis. The steps of the supply chain considered are shown along the upper horizontal axis of the figure and end with the total amount of food consumed.

The results show that field crops represent the largest quantity of food products in the province. Dairy and eggs represent the second highest, and marine products follow. Meat and poultry, and produce follow, respectively. Although meat and poultry represent a relatively small volume of products moving through the supply chain, this category produces significant GHGs due to the level of inputs required across the supply chain, relative to crops or produce, for example. The GHG emissions associated with specific areas of loss are evaluated in **Section 1.5.3**.

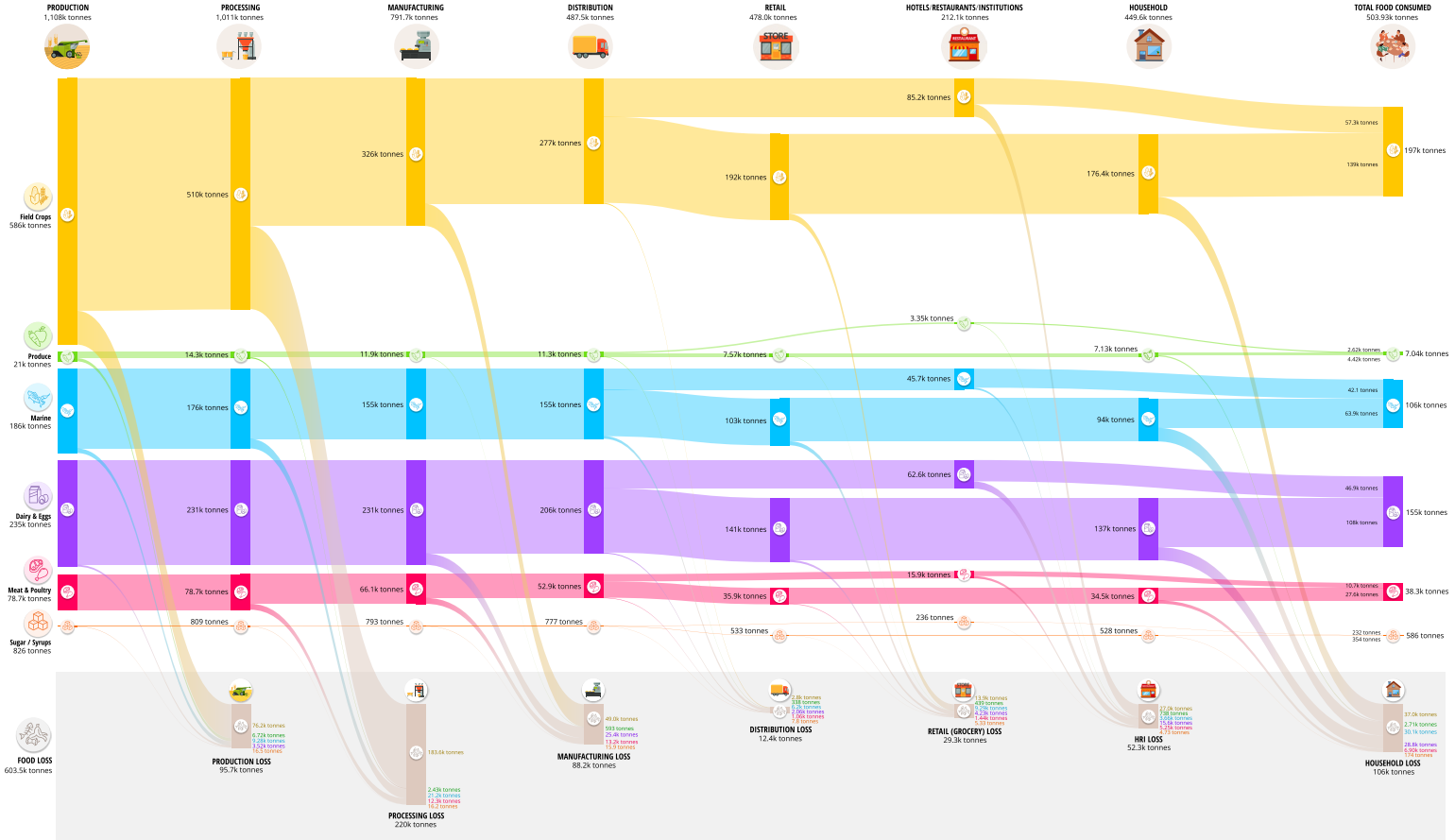

Figure 4: Sankey Diagram depicting the flow of FLW in the province of Nova Scotia

1.5.2. Loss Across the Supply Chain

An alternate presentation of part of the data shown in the Sankey (**Figure 4**) is offered (**Figure 5**). This figure focuses on the amount of food lost or wasted for each category of food considered in this study, at each point of the supply chain. This data is shown on the lower horizontal, or x-axis, of the Sankey diagram. The bar graph presented in **Figure 5** can be a useful tool to focus on FLW only and shows that field crop waste is significantly higher in volume than other types of food.

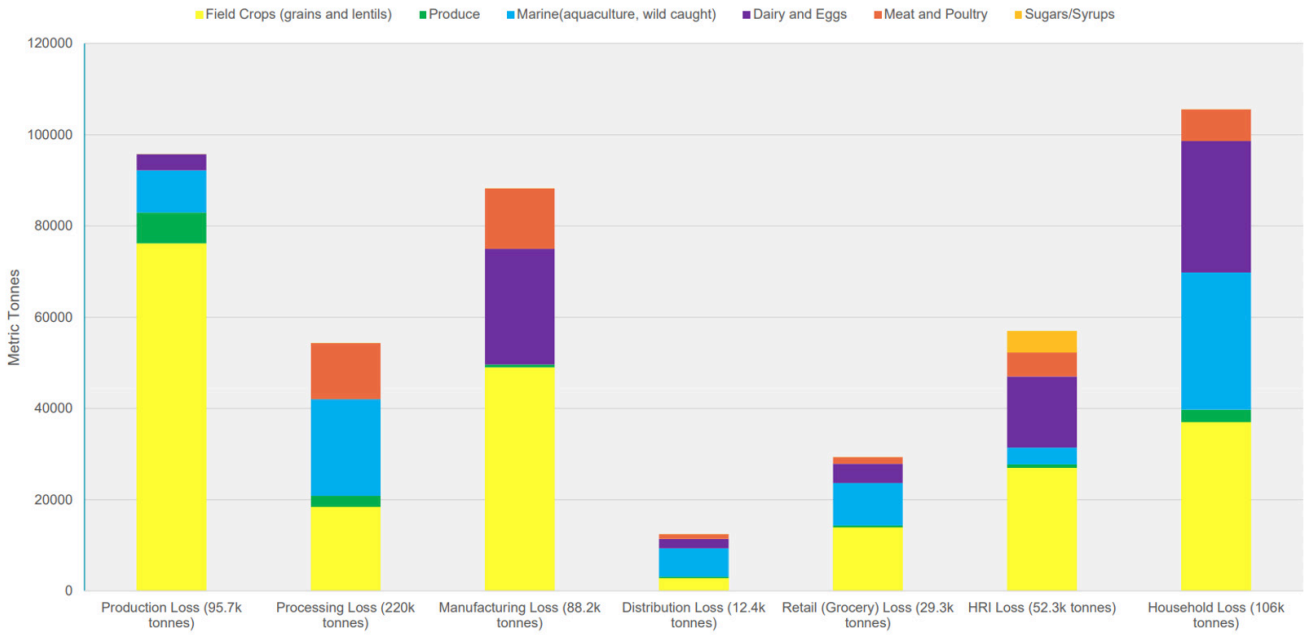

Figure 5: Amounts of food lost or wasted, by category, at each step in the supply chain

1.5.3. GHG Emissions

GHG emissions are produced as a result of many aspects of the food supply chain. The production of energy required to plant, harvest, process and move food products results in the generation of GHGs. These GHGs are necessary to produce the food needed for human survival; however, when the food products are wasted, the input GHGs have been unnecessarily generated. Further, the waste food products will decompose and release GHGs. If the food products were to be disposed of in an anaerobic environment such as a landfill, their decomposition would result in methane, a potent GHG that, over a 20-year period, has 80x the warming potential of carbon dioxide.[6] To avoid this, Nova Scotia banned organics from entering landfills in 1996, and instead, organics must be processed by composting or other aerobic methods. This significantly improves the GHG potential of the decomposing food; however, carbon dioxide is still released from the aerobic breakdown of food waste. The summary results of GHGs generated in key areas of the Nova Scotia food supply chain are provided (**Figure 6**).

6. Government of Canada. (2023).Review of Canada's methane regulations for the upstream oil and gas sector. *https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/review-methane-regulations-upstream-oil-gas-sector.html*

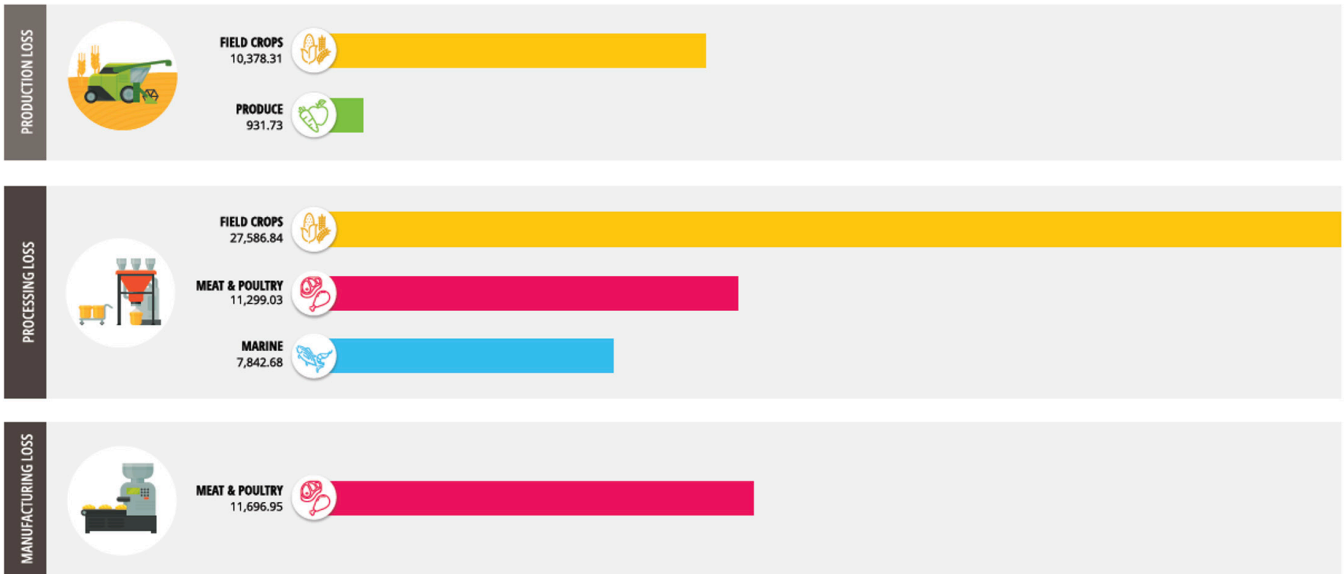

Figure 6: GHG production associated with key areas of loss in the food supply chain.

2. Strategic Circular Solution Interventions

A variety of interventions are proposed in this section. The intent of these interventions is to encourage additional discussions among supply chain participants and stakeholders. Identifying areas of lost food products and potential options to reduce these amounts is the first step in moving towards a more circular food system. Collaboration and communication among supply chain members are required to do the most important work of implementation.

These interventions have either worked in other regions similar to Nova Scotia or are currently happening at a smaller scale in Nova Scotia. The Food Recovery Hierarchy (**Figure 2**) is important to consider when thinking about interventions to reduce food waste: considering strategies that tackle source reduction first, then redirecting to hungry people and then animals before moving products to industrial uses, and then composting. The interventions in each area of the supply chain described are listed according to their place on the Food Recovery Hierarchy. More research is needed to identify the impacts of a specific intervention on GHG production, but taking the Food Recovery Hierarchy approach will help maximize the GHG reduction.

Hotspot: Production Loss for Field Crops and Produce

SOURCE REDUCTION	**Regenerative agriculture approaches (e.g., silvopasture).** Nova Scotia has the benefit of being approximately 75% covered in trees. Due to this, there are opportunities for silvopasture, the intentional integration of managed forest and grazing systems. This agricultural tactic can improve overall soil quality, sequester carbon, and provide diversified revenue streams for farmers. Silvopasture can integrate the harvesting of building wood, fruit from fruit trees, and crops that are integrated into the system, as well as grazing livestock, all providing revenue streams.
	Reduce lost food due to labour shortages through labourer recruitment and incentives. As a province with the most aged farming population and few of these farmers having succession plans in place[7], there may be opportunities to recruit new workers by providing pathways to partial farm ownership or eventual purchase. This will help reduce product loss due to worker shortages as well as help more farms continue on as productive farmland.
	Using residues to grow mushrooms (e.g., straw). This is a diversification of income streams for farmers. Mushroom farming has the advantage of being possible at a small or large scale and could be an avenue for both small and large farms in the province. The volume of straw and other stems produced as a byproduct of crop production makes it significant. It is readily available and can be used as a growth substrate instead of generating or importing something new. Using local straw and other stems is a more circular approach.
FEED HUNGRY PEOPLE	**Donate to food security organizations for meals.** Locating a food security organization in Nova Scotia that can accept overages may not be challenging. This web map lists many resources that can accept donations for distribution. *https://gis.dillon.ca/maps/apps/webappviewer/index.html?id=15f8671e72944e3eb70bd6d00f4270b3*
	Use "ugly" produce in other products/markets/businesses (e.g., soup, sauce, jam, juice, etc.) or change procurement guidelines for aesthetics. Tapping into existing food distribution terminals to glean seconds provides an opportunity to gather these items and repurpose them. The Station Food Hub uses this model and provides rental production space to other businesses.
	Dehydrated potato mash. Although the number of potato farms in the province has decreased, there is still a large volume of potatoes grown and consumed in Nova Scotia. This provides an opportunity to gather overages for dehydrated mash that can be sold.
FEED ANIMALS	**Insect feed.** Edible insects for human and other animal consumption is a growing market. Midgard Insect Farm Inc. and Oberland Agriscience, are Nova Scotia-based insect farms that are pushing new boundaries with their farming and potentially offering new avenues for waste food streams.
	Grounder/fallen produce can be used to create companion animal treats and animal feed. Apples and other fruit that fall from the tree and end up on the ground are typically left on the ground due to contamination concerns. Apple farms are one of the leading types of fruit farms in the province. This provides an opportunity to harvest inexpensive grounders for business opportunities. When treated properly (heat), these apples can be used to make treats and add to feed and can help the orchard remove apples that can contribute to pests.
	Send produce waste to farms, zoos or rescue animal feed (or require pick-up and alert with food rescue digital platform). The opportunity for farms, zoos and animal rescues to contact local farms and processors to ask for their seconds and waste products already exists; however, this is time-consuming. Using and building on the existing map of food assets in the province[8] can streamline this process and divert more waste.

7. Senate of Canada. (2023). Shrinking Nova Scotia, farmland threatens food security. Retrieved from: *https://sencanada.ca/en/sencaplus/opinion/shrinking-nova-scotia-farmland-threatens-food-security-senator-cordy/#:~:text=Indications%20are%20that%20these%20trends,them%20reported%20a%20succession%20plan*.

8. *https://gis.dillon.ca/maps/apps/webappviewer/index.html?id=15f8671e72944e3eb70bd6d00f4270b3*

Hotspot: Production Loss for Field Crops and Produce – continued

INDUSTRIAL USES	**On-farm biogas generation.** This technology can turn manure or food waste into energy; anything that produces methane when decomposing can be used. Nova Scotia farmers have been using this technology to power their farms for over a decade and is an opportunity for energy cost savings for farmers that implement the system.
	Fertilizer production (when mixed with viscera/offal and other ingredients). Nova Scotia has 22 abattoirs in the province.[9] Connecting with these companies to determine the availability of by-products and waste products can allow for relationship building and the opportunity to share waste products for fertilizer production
	Biodegradable packaging and materials from stems and chaff. Nova Scotia is a major producer of cereal crops, which means lots of stems and chaff are being produced. Biodegradable packing is becoming increasingly popular, which provides a market opportunity for biodegradable packaging material creation.
	Medium-density fiberboard (MDF) from straw or straw/fiber-concrete. Lots of cereal crops being grown in the province means lots of straw to augment building materials. The interest in these more sustainable building materials is growing and can be leveraged to generate new, more sustainable materials.

Hotspot: Processing Loss for Field Crops, Meat and Poultry, and Marine

SOURCE REDUCTION	**Optimization of production processes to reduce the amount of edible products being discarded.** Using new artificial intelligence-driven tools, processors can maximize the amount of saleable meat that is removed from the carcass. This improves the bottom line and decreases waste.
FEED HUNGRY PEOPLE	**Explore opportunities for new products; products traditionally consumed by other cultures may provide a market opportunity in Nova Scotia (e.g., pigtails or chicken feet).** The immigrant community in Nova Scotia is growing. This provides new and emerging markets for products not traditionally sold in the province. For example, East Asian cultures have many uses for chicken feet and tripe. Ham hocks, beef tongues and pigtails are more commonly consumed by Eastern Europeans. Fish heads are used more commonly in Asia and Europe.
	Production of fish sauces or pastes for the retail market. Increasing immigration and new markets also provide the opportunity to produce fish sauces for local sale or export.
	Collagen extraction (skin and viscera/offal). Nova Scotia has an active seafood sector. Gleaning the skin and offal from fish processing facilities presents an opportunity for new business, particularly as the demand for collagen supplements continues to grow. Collagen can be extracted from these waste products using acid or enzymatic processes.
FEED ANIMALS	**Produce "fish meal," insect feed or fertilizer from fish processing by-products for the agricultural livestock sector or aquaculture.** This is another opportunity for the use of fish processing by-products or abattoir waste products. Collecting these items and processing them into fishmeal for the growing farmed fish, feeding the growing number of farmed insects or creating crop fertilizer provides potential revenue streams from wasted food products.
INDUSTRIAL USES	**Send slaughterhouse excesses to rendering plants for conversion into fats, oil and tallow.** The by-products from abattoirs can have tallow extracted or rendered, and it can be used in many industrial applications such as for lubrication, bio-diesel and cosmetics.
	Phosphorus extraction from bone. Phosphorus is a key fertilizer used in farming; it can be extracted from bone by-products from fish processing or abattoirs and sold as fertilizer.

9. Nova Scotia. (ND). Abattoirs Under Provincial Inspection. Retrieved from: *https://novascotia.ca/agri/documents/food-safety/abbattoir-listing.pdf*

Hotspot: Manufacturing Loss of Meat and Poultry	
SOURCE REDUCTION	**Inventory management practices; adhering to First-In-First-Out (FIFO).** FIFO practices reduce the amount of waste due to spoilage. Implementing this practice is advisable for any manufacturing facility in the province.
	Staff training on use and trimming strategies to minimize wasted products. Staff training at individual manufacturing facilities can help decrease the amount of lost product through ineffective practices. Teaching better techniques will reduce the amount of lost product and reduce waste.
	Production planning and forecasting improvements through training and system updates. Updating software to include better predictive models and tools such as artificial intelligence can improve how accurately manufacturers are able to forecast and meet demand.
FEED HUNGRY PEOPLE	**Develop or tap into a food rescue platform to share the availability of excess products.** The province has a newly developed a food resource map that can be used to identify sources that can use excess products from animal processing facilities.[10]
FEED ANIMALS	**Add to feed for livestock or companion animals.** Similar to processing loss, these products from local fish processors or abattoirs can be gleaned and turned into feed for other livestock or companion animals. Certain by-product meals, when properly treated, can be safely used to increase the protein content of livestock or companion animal feed.

10. *https://gis.dillon.ca/maps/apps/webappviewer/index.html?id=15f8671e72944e3eb70bd6d00f4270b3*

General Interventions

SOURCE REDUCTION	**In homes and the hotel, restaurant, and institution (HRI) sector, it may be useful to regrow food from the stems, tops or root ends of certain produce items such as beets, green onions, lettuce and garlic.** • This practice can offset the impacts of the limited growing season in Nova Scotia and can help households save money on their grocery bill.
	Strict cold chain maintenance to reduce spoilage loss. • Augmenting existing supply chains with things such as reusable cooling gel packs or eutectic plates can help maintain cool when crates and boxes are moving from one area of the supply chain to another; an area where the cold chain often breaks down. These also represent smaller investments compared to investing in new reefer trucks or cold storage spaces in buildings; however, both these larger investments can reduce waste through temperature maintenance and humidity control.
	Improved packaging standards to better protect and insulate food products that also consider the life span of the packaging. • Strategic packaging changes to increase the shelf life of a product can be useful strategies to reduce food waste and increase the revenue generated. For example, shrink wrapping on cucumbers can extend the shelf life by up to three times.[11] Conversely, convenience plastic such as free plastic bags at the supermarket does not appear to markedly increase shelf life, and customers bringing their own bags should be encouraged instead to decrease plastic waste.
	Retail display strategies that suggest to 'stack em high, watch em fly' should be avoided as it increases bruising to stacked produce near the bottom of the pile as well as increases the risk of damage due to falling produce. • This is a practice common across Canada, including within retail grocery stores in Nova Scotia. The trope is well ingrained but should be challenged to reduce waste associated with bruising from drops and stacking weight.
	Avoid the practice of 'auto-ketchuping' in restaurants. Placing condiments in small ramekins leads to waste as often customers fail to consume all the condiments in the ramekin; however, that condiment cannot be given to other customers and must be disposed. • Replacing the ramekin system with dispensing bottles can reduce restaurant-associated food waste as well as save restaurants money as less product is going to waste, which means they will need to purchase ingredients less frequently.
FEED HUNGRY PEOPLE	**Use scraps from vegetable prep to make novel food items such as cauliflower crust pizzas or potato peel chips.** • Of the Atlantic provinces, Nova Scotia is a prolific producer of field and greenhouse fruits and vegetables.[12] Using some of the peels or scraps associated with the prep of these items to create new items for market provides a business opportunity. Alternatively, teaching how they can be used in home or restaurant kitchens can save costs for homes and businesses.
INDUSTRIAL USES	**Compost scraps close to the sites of production to reduce transport GHGs and apply to local gardens such as home gardens, restaurant kitchen gardens or community gardens.** • While Nova Scotia does have a ban on organics and food waste going to landfill, GHGs are still required to transport food waste to municipal compost sites. Processing food waste as close to the site of generation as possible reduces the GHG burden. Backyard and community gardens with compost sites provide alternatives to municipal pick-up. Some cities, such as HRM, publish resources to help local access to community gardens.[13]

11. Shrivastava, C., Crenna, E., Schudel, S., Shoji, K., Onwude, D., Hischier, R., & Defraeye, T. (2022). To wrap or to not wrap cucumbers?. Frontiers in Sustainable Food Systems, 6, 750199.

12. *https://publications.gc.ca/collections/collection_2020/aac-aafc/A71-37-2019-eng.pdf*

13. *https://www.halifax.ca/parks-recreation/parks-trails-gardens/gardens/community-gardens*

3. Next Steps

In order to move this work forward, local engagement and the involvement of stakeholders in the system are needed. When considering the changes that are required to produce a more circular, sustainable food supply chain in Nova Scotia, it is useful to consider an old adage — you cannot push a chain. A supply chain does not easily move or change due to pushing from the top-down. Instead, pulling the chain from the end allows for better and easier movement. In this way, this work seeks to motivate the actors at the end of the system that can cause change by pulling the chain. All citizens of Nova Scotia are end users of the food supply chain. By considering the implications of the lost product and working together on solutions, change can happen.