



The Future of Circular Food Hubs in Nova Scotia

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The National Zero Waste Council is a collaborative, leadership initiative of Metro Vancouver that brings together businesses, governments and communities to advance waste prevention and the circular economy in Canada.

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Circular Food Hubs: Mainland Nova Scotia tested the application of a 5-step food hub development process, designed by Guelph-Wellington's **COIL**, that integrated circularity and food loss and waste (FLW) prevention. Circular food hubs in Nova Scotia aim to create an anchor of activity in the Canadian landscape and contribute to the evolution of a Canada-wide circular food system.

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Towards a circular food system in Nova Scotia

Nova Scotia has long been a place of innovation and enterprise, with a strong community spirit and a willingness to take risks. The conception of a regional food hub in Nova Scotia by the Halifax Regional Municipality (HRM) has brought together a cornucopia of innovative companies and start-ups, exceptional academic institutions such as Dalhousie University, and governmental support over the past few years. By supporting circular economy food hubs, Nova Scotians have demonstrated their capacity to come together and create meaningful change.

Looking forward, the principles of a circular economy hold enormous potential to transform food systems into a model that is regenerative, resilient, and equitable, producing new opportunities for innovation and collaboration. In Nova Scotia, a circular food system would be built upon connected and thriving networks of food system actors and citizens, from farm to fork. This system would encompass both individual circular solutions, which address specific challenges, and place-based circular food hubs, which are geographically clustered solutions that respond to local contexts and drive down greenhouse gas (GHG) emissions by reducing transportation requirements.

Such a system in Nova Scotia would be supported by a strong financial, physical, and logistical infrastructure that ensures food loss and waste is prevented and communities across the province have access to affordable, accessible, and good-quality food. By fostering these place-based food hubs, we can transform parts of Nova Scotia into anchors of activity within a Canadian circular economy. This approach moves beyond siloed efforts, promoting a comprehensive system change that supports both individual solutions and clusters, ultimately driving forward a full Canadian system change.



Current state of the linear food system in Nova Scotia

Nova Scotia's food system is diverse and unique, comprising some of Canada's richest fishing and farming traditions. Nova Scotia is deeply intertwined with its coastal heritage and agricultural landscapes: fisheries play a vital role in the economy, representing over \$2.5 billion in exports, which has more than doubled over the past decade.¹ Agricultural exports have also doubled over the past decade, reaching nearly \$500 million in 2022. While food exports are rising, total GHG emissions from agriculture across the Atlantic provinces are declining, from about 1.8 million tonnes per year of carbon dioxide equivalent (CO₂e) in the 1990s to about 1.5 million tonnes in recent years.² The main causes of this decline are reductions in cattle and from the use of heating oil.

There is still ample room for Nova Scotia to develop toward a more circular food system.

While these trends indicate a clear positive direction, it is estimated that Nova Scotia wastes approximately 600,000 tonnes of food annually.³ Nearly half (48%) of food waste and loss occurs in just three areas of the value chain: production, manufacturing, and households.⁴ Field crops represent the largest quantity of food products lost or wasted. Dairy and eggs represent the second highest, followed by marine products and meat and poultry, respectively. Food waste doesn't only represent a loss in value, but also contributes to GHG emissions released from the aerobic breakdown of organic matter. The vast majority of emissions associated with food loss and waste result from field crops in the food processing step of the value chain. Although meat and poultry represent a relatively small volume of

total food produced and wasted in Nova Scotia, this category produces the second-highest GHGs due to the level of inputs required across the supply chain relative to crops, for example.

It has also been documented that agricultural soils in Nova Scotia and across the Atlantic provinces have been losing carbon content in recent years due to the increased reliance on chemical inputs to agricultural fields, making those soils a carbon source rather than a sink.⁵ Implementing regenerative and circular agricultural practices where nutrients and carbon from agricultural residues and by-products are returned to the soil can mitigate the negative impacts of conventional farming, while creating opportunities for multiple revenue streams for farmers. Such an approach can contribute to restoring soil's carbon sequestration ability, improving water retention and sustaining long-term agricultural productivity.

1 OneNS. (n.d.). *Goal 15: Fisheries and agriculture exports - Deep dive.*

2 National Farmers Union. (2020). *Agricultural GHG emissions in Atlantic Canada.*

3 Dillon Consulting. (2023). *Circular food system assessment for the Province of Nova Scotia. National Zero Waste Council (NZWC).*

4 Dillon Consulting. (2023). *Circular food system assessment for the Province of Nova Scotia.*

5 National Farmers Union. (2020). *Agricultural GHG emissions in Atlantic Canada.*

Vision for a circular food system and its potential benefits

Transitioning toward more sustainable food systems will be paramount in the coming decades as climate change, food security, and resource scarcity become increasingly pressing issues across Canada. Climate change is already impacting Canadian agriculture through increased frequency and severity of extreme weather events, such as droughts, floods, and wildfires, which are major disruptors to crop yields and livestock productivity.^{6 7 8} Nova Scotia has recently seen such events, with the wildfires around HRM in 2023, and flooding in 2024. The combination of soil degradation and loss of arable land with overfishing and changing ocean temperatures pose a uniquely devastating risk to Nova Scotia's food production system and the livelihoods of those working in these industries.^{9 10} Many rural and coastal communities in the Atlantic provinces experience higher levels of food insecurity due to limited access to diverse food options, dependency on long supply chains, and vulnerability to global food commodity price shocks.^{11 12} These factors collectively highlight the critical need for sustainable practices to build a resilient and secure food system in Canada.

To effectively address these future challenges, an overarching vision for Circular Food Hubs in Nova Scotia has been grounded in six key elements. Firstly, a circular food system must promote **food security** by ensuring equitable and inclusive access to food for all citizens, and maintaining secure food supplies to withstand emergencies and climate change impacts. **Waste prevention** will ensure that waste and loss throughout the food supply chain are minimized and by-products and unused products can be optimally utilized. **Community awareness and support** should enable communities to act on food waste while promoting the skills to implement circular approaches and policies. This is further supported by **partnerships** among food system actors, **innovative** ways of organizing food flows and processing by-products and scaling up new ideas and businesses. Lastly, **institutional and financial investment** stresses the necessity of dedicated time, policy tools, and finances from provincial and federal institutions to support circular practices and help businesses thrive.

6 Zimonjic, P. (2023, July 28). *Next disruptions on the horizon*. CBC News

7 Agriculture and Agri-Food Canada. (n.d.). *Climate change impacts and adaptation*.

8 Government of Canada. (2021). *Canada in a changing climate: Sector perspectives on impacts and adaptation*.

9 Government of Canada. (n.d.). *Adapting to change in the Atlantic fisheries*.

10 Burton, D. (2017). *Presentation on agricultural issues*. Senate of Canada.

11 Government of Nova Scotia. 2024. *Improving Food Security for Nova Scotians*.

12 Canadian Agri-Food Trade Alliance. (n.d.). *Importance of trade to Canadian agri-food*.



Fig. 1 Six key elements of a circular food system, as defined by participants in the Circular Food Hubs: Mainland Nova Scotia project.

Implementing the vision for Circular Food Hubs can lead to a number of important benefits for Nova Scotia. Circular economy solutions are already being applied across different pillars of the food system today. We focus on three pillars for the sake of simplicity: shifting to more local and regenerative food production models; recovering and redirecting food loss and waste; and establishing new uses for agricultural residues and fishery by-products. Many of these solutions have been shown to produce a variety of economic, social and environmental benefits. Some of these benefits have been demonstrated on a Canadian level and are summarized below:

1. **Shifting toward more local and regenerative food production models** such as silvopasture, productive food forests in peri-urban areas, and diversified small-scale agriculture can not only enhance food security and biodiversity but also offer farmers more diverse streams of income. This is especially important for Nova Scotia as 75% of its land is forested, and soil carbon is currently declining. One study in Ontario showed that the use of cover crops, reduced tillage, and organic amendments increased soil organic matter by up to 20% over five years, while similar research from Quebec found that regenerative practices improved soil water retention by 15 to 20%.^{13 14} Similarly, there are long-standing holistic approaches to fisheries management that integrate Marine Protected Areas (MPAs), Territorial Use Rights for Fishing (TURFs), Sustainable Fishery labels, and ensuring the enforcement of monitoring and control of catches and landings. These practices have not been associated with circular economy per se but work to ensure that marine ecosystems retain the capacity to regenerate populations and maintain biodiversity.

13 Ontario. (n.d.). *Soil health in Ontario*.

14 Dillon Consulting. (2023). *Circular food system assessment for the Province of Nova Scotia*.

2. **Recovering and redirecting food loss and waste.** In Canada, about 58% of all food produced is lost or wasted annually, representing an economic loss of \$49.5 billion.¹⁵ Recovering just 15% of this wasted food could feed over 3.5 million Canadians annually. Efficient distribution channels and recovery programmes like food banks can play a crucial role in redistributing surplus food, assisting over 1.1 million individuals monthly, supporting vulnerable communities.^{16 17} While these efforts address food for people, other approaches that divert inedible food scraps offer additional benefits. For example, inedible food scraps can be used as animal feed, reducing reliance on traditional feed. According to Statistics Canada, in 2020, Canada produced over 27 million tonnes of organic waste, including food scraps which could potentially be repurposed as animal feed.¹⁸ By systematically minimizing food waste and loss, Canada could make significant short-term contributions to closing the 44 million tonne emissions gap that exists between current GHG projections and the 2030 reduction targets.¹⁹ Nova Scotia could save nearly 70,000 tonnes of GHG emissions if it were to recover and redirect lost food along the production, processing, and manufacturing chain.²⁰

3. **Diverting inedible food waste and establishing new uses for agricultural residues and fishery by-products** is a material innovation strategy that can support adjacent industries. Annually, Canada produces over 35 million tonnes of agricultural residues and millions of tonnes of fishery by-products, which offers opportunities for the creation of bio-based materials in packaging, insulation, cosmetics and biofuels.²¹ These resources offer opportunities for waste transformation.

15 Second Harvest and Value Chain Management International. *The Avoidable Crisis of Food Waste: Technical Report. 2019,*

16 Food Banks Canada. *HungerCount 2020.*

17 Second Harvest. *Food Rescue.*

18 Loop Resource. *Organic Waste Diversion Solutions.*

19 NZWC. (2023). *Food loss and waste strategy.*

20 Dillon Consulting. (2023). *Circular food system assessment for the Province of Nova Scotia. NZWC.*

21 Alberta Biomaterials Development Centre. *Bio-plastics from agricultural residues. ABDC Bio-plastics, University of Victoria.*



Exploring future possibilities for Nova Scotia's vision

This section delves into the future potential of Circular Food Hubs in Nova Scotia, anchored in the three pillars of circular food system solutions described previously. Within each pillar, we outline current trends and ongoing innovations, and showcase inspiring examples of pioneering solutions. Additionally, we explore promising future trajectories aimed at strengthening Nova Scotia's Circular Food Hubs. This vision aims to unite stakeholders and provide a rallying point for systemic change, collective action, and progress.

Shifting toward more local and regenerative food production models

A number of policy and technological advancements are already driving the adoption of more regenerative food production models across Canada. The *Canadian Food Policy* and *Canadian Agricultural Partnership*, along with provincial climate action plans, the establishment of carbon markets and certification programs like the Carbon Offset Systems and Regenerative Organic Certification, incentivize regenerative practices.^{22 23} They offer financial rewards for carbon sequestration and soil health improvements while providing standards for environmentally friendly food production.^{24 25} In parallel, rapidly developing technological innovations in precision agriculture are empowering farmers with data-driven insights and sustainable solutions to optimize resource use and enhance soil fertility. In 2018, one survey indicated that 80% of Ontario farms were already using at least one form of precision agriculture technology, such as

GPS guidance systems or soil mapping to improve farm management and resource use efficiency.²⁶ These efforts underscore a growing commitment to regenerative food production approaches in Canada, aimed at promoting soil health, biodiversity, and climate resilience across the agricultural sector.

In Nova Scotia, the emphasis on sustainable agriculture is particularly crucial due to the province's diverse landscapes and coastal ecosystems. The Annapolis Valley in particular is a vital food production region due to its fertile soil, favorable climate, and diverse agriculture, supported by a strong historical legacy and sustainable farming practices.²⁷ This area's significant economic and cultural impact make it an important geography for clusters of initiatives and emerging sustainable practices. Local initiatives, such as the *Nova Scotia Environmental Farm Plan* and support for small-scale, diversified farming operations, further support the transition towards regenerative practices. With many home-grown assets like Dalhousie's Precision Agriculture Research Program and innovative businesses like TruLeaf, Nova Scotians have a strong footing to expand precision agricultural practices in the future.²⁸

Recent amendments to Canada's *Fisheries Act* in 2019 emphasize the conservation and protection of fish habitats, supporting sustainable fisheries and aquaculture practices by enhancing habitat protection, requiring habitat restoration, and rebuilding fish stocks. The Ocean Supercluster offers an enormous opportunity for Nova Scotia.

22 Agriculture and Agri-Food Canada. (n.d.). *Sustainable Canadian agricultural partnership*. Government of Canada.

23 Agriculture and Agri-Food Canada. (n.d.). *Food policy for Canada*. Government of Canada.

24 Agriculture and Agri-Food Canada. (n.d.). *Sustainable Canadian agricultural partnership*. Government of Canada.

25 Government of Canada. (n.d.). *Canada's climate plan: Overview*.

26 Kumar, S., & Chinnasamy, S. (2018). Bio-based plastics from agricultural residues. *Canadian Journal of Plant Science*, 98(1), 56-63. doi:10.1139/cjps-2017-0342

27 Nova Scotia Environmental Farm Plan. (n.d.). *Nova Scotia environmental farm plan*.

28 Dalhousie University. (n.d.). *Technologies. Precision Agriculture*.

Launched with a \$300 million investment, it aims to generate over \$14 billion in GDP growth and create more than 3,000 jobs over the next ten years, focusing on innovative technologies for sustainable fisheries and aquaculture.²⁹ Additionally, the adoption of ecosystem-based management (EBM) approaches, such as those in the Pacific Integrated Commercial Fisheries Initiative, and certification schemes like the Marine Stewardship Council (MSC) certification, which includes 33 Canadian fisheries, promote sustainable practices.³⁰ Nova Scotia is well-positioned to capitalize on this movement: the Bedford Institute of Oceanography is Canada's largest centre for ocean research and innovative companies like Innosea will be crucial players in providing analysis for accurate stock assessments, and enhancing fisheries management and the resilience of coastal ecosystems.³¹

Innovative examples in practice

TruLeaf Sustainable Agriculture: TruLeaf is a Nova Scotia-based company that utilizes vertical farming technology, known as GoodLeaf Farms, which can grow leafy greens and herbs year-round with 90% less water than traditional farming methods. Their vertical farming systems are capable of producing up to ten times the yield per square foot compared to conventional outdoor farming.³²

Resson: New Brunswick-based Resson has developed a technology platform to help growers manage their crops by generating production metrics, and detecting pests and disease at the individual plant level. The system enables a targeted spraying approach by identifying and targeting pests and disease in real time as a tractor is moving through a field, reducing the amount of crop protection materials used—benefiting both the environment and grower profitability.

Semios: Semios is a Vancouver-based precision agriculture company that provides a real-time crop management platform, integrating pest management, disease control, and water management. Semios helps farmers optimize resource use and improve sustainability, supporting regenerative agriculture.

29 *Ocean Supercluster*. (n.d., August 2, 2024).

30 Fisheries and Oceans Canada. (n.d.). *Pacific integrated commercial fisheries initiative (PICFI)*.

31 Innovasea. (2023, August 22). *Innovasea purchases facility in Bedford, Nova Scotia*.

32 Goodleaf Farms. (n.d.). *GoodLeaf Farms*



Exploring possible future directions

With the increasing impacts of climate change and depleting soil quality, there is a growing recognition of the need for resilient, adaptive agricultural systems. In Nova Scotia, several innovative approaches could be further developed to realize a more resilient, regenerative, and adaptive food system.

Hydroponics, aquaponics, and vertical farming use significantly fewer resources, including water and land, and are less susceptible to extreme environmental events. These systems can capitalize on urban or peri-urban facilities, utilizing unused or underused spaces to produce food. Coupled with predictive information systems and on-demand logistics, these approaches ensure that consumers have access to locally grown, nutritious fresh food via local farmers' markets, community-supported agriculture (CSA), and online platforms that connect farmers directly with consumers. To realize such a system, collaboration among tech companies for data and monitoring, precision growing system providers, and logistics companies are essential. This integrated approach not only reduces the carbon footprint associated with long-distance food transportation but also enhances food security by providing a reliable supply of fresh produce year-round.

Silvopasture and regenerative farming practices. Considering that 75% of Nova Scotia is forested land, tailored regenerative approaches like silvopasture offer a means of intensifying production, preventing forest fires through managed grazing in brushland, sequestering carbon in soils, and producing multiple income streams for farmers. Silvopasture integrates trees, forage, and livestock, creating a synergistic system that enhances biodiversity, improves soil health, and increases farm resilience. For instance, managed grazing can reduce the risk of wildfires by controlling underbrush and improving forest health. Implementing silvopasture would require collaboration between livestock farmers,

the forestry industry, and governmental support to provide necessary resources and incentives. Advanced tools enable farmers to assess tree growth, monitor forage production, and track livestock movement, facilitating data-driven decision-making and system optimization. This approach not only diversifies income for farmers but also contributes to climate change mitigation by sequestering carbon.

Precision farming practices that leverage tools such as remote sensing, GPS tracking, a variety of imagery, and machine learning can significantly boost resource efficiency in agriculture. These technologies allow for precise application of inputs like water, fertilizers, and pesticides, reducing waste and environmental impact while optimizing crop yields. For example, drones and satellite imagery can monitor crop health and soil conditions in real-time, enabling farmers to make informed decisions about irrigation and nutrient management. Additionally, machine-learning algorithms can predict pest outbreaks and disease spread, allowing for timely interventions that minimize crop losses. By adopting precision farming techniques, Nova Scotia's agricultural sector can enhance productivity, reduce costs, and improve sustainability.

Sustainable and regenerative fisheries practices represent a holistic approach to preserving our marine ecosystems while ensuring economic viability for future generations. A cornerstone of this approach would be Integrated Multi-Trophic Aquaculture (IMTA) that combines different species, such as fish, shellfish, and seaweed, creating a balanced ecosystem that reduces waste and pollution. Such an approach can be implemented by using a combination of species-specific enclosures, monitoring systems, and nutrient recycling techniques to create a balanced ecosystem where the waste from one species serves as food for another.³³ Enforcing quotas, monitoring catch and seasonal restrictions to prevent overfishing, could leverage advances in digital technology to minimize bycatch and

33 Bai, Z., & Wang, Z. (2009). Assessing the impact of land use changes on food security. *Science of the Total Environment*, 408(21), 4186-4196. doi:10.1016/j.scitotenv.2009.07.028

preserve fish populations. Waste valorization further enhances this system by converting fish waste into valuable products like fishmeal, fish oil, or biofertilizers, thereby reducing waste and generating additional revenue streams.

To fully realize these innovative agricultural systems, strong **community awareness** and **policy support** will be crucial. Policies that provide **financial incentives, technical assistance**, and **infrastructure** development can accelerate the adoption of these practices. Focused **awareness raising** through **education** and **training** programs can equip farmers with the skills needed to implement and manage these technologies effectively. Furthermore, fostering trust through **partnerships** between research institutions, government agencies, and the private sector can drive continuous innovation and improvement in agricultural practices. While novel initiatives can be risky and sometimes fail, it can be a valuable learning experience that builds more resilient business models over time.³⁴ By embracing hydroponics, aquaponics, vertical farming, silvopasture, and precision farming, Nova Scotia can develop a more resilient, regenerative, and adaptive food system. These approaches not only address the challenges posed by climate change and soil degradation but also create sustainable economic opportunities for farmers, enhance food security, and contribute to environmental conservation.

Redirecting edible food loss and waste throughout the food value chain

Policies, business solutions, and enabling technologies aimed at preventing food loss and waste are expanding significantly across many countries including Canada. Goal 12.3 of the United Nations Sustainable Development Goals specifically aims to halve per capita global food waste by 2030, underscoring the widespread recognition of the issue and the international commitments to address it on a global scale. In Canada, it is a significant trend that will undoubtedly expand in the future considering that around 58% of food produced is lost or wasted annually, with approximately 32% of this being edible food, amounting to an economic impact of \$49.5 billion.³⁵ The Canadian *Food Policy* aims to halve food waste at retail and consumer levels while reducing losses in supply chains.

Nova Scotia has been a front-runner on this topic, placing a full ban on food waste from entering landfills since 1996. The Halifax Food Policy Alliance's *Just Food Action Plan* is a comprehensive strategy that enhances food security and addresses food justice.³⁶ They achieve this by supporting local food production, advocating for equitable policies, and fostering collaboration among stakeholders across the sector. Similarly, Ontario's *Food and Organic Waste Framework* and Québec *Residual Materials Management Policy* further incentivize the reduction of food waste by offering grants and support for innovative waste reduction solutions, both novel and proven.^{37 38} These policies promote the adoption of practices such as improved inventory management, redistribution of surplus food, and enhanced composting

34 Chase, C. (2024, August 1). *Sustainable Blue minority owners submit CAD 30 million stalking horse as part of restructuring efforts*. Seafood Source

35 Second Harvest. (2022). *The avoidable crisis of food waste: Technical report*. Second Harvest

36 Just Food Halifax. (n.d.). *Just Food Halifax*

37 Ontario Ministry of the Environment, Conservation and Parks. (2020). *Food and organic waste framework*.

38 Government of Québec. (2023). *Residual materials management policy (Regulation Q-2, r. 35.1)*.



infrastructure, while also reinforcing partnerships and connections across the value chain to ensure that these innovations can be sustained through effective collaboration. In Nova Scotia, initiatives like the Ecology Action Centre's Harvest Handlers program and Valley Gleaners redirect surplus produce from local farms to food banks and community kitchens, significantly contributing to food security. Commissary kitchens such as Common Roots Urban Farm and Hope Blooms provide shared spaces for local food entrepreneurs and community groups, reducing food waste and supporting small-scale food production.

Concurrently, business and technological innovations have rapidly expanded across many countries, playing a pivotal role in addressing food waste in Nova Scotia and across the nation. For instance, the integration of artificial intelligence and machine learning into inventory and supply chain management enables retailers and producers to predict demand accurately, thus reducing overproduction. Optimizing inventory management and supply chain processes not only minimizes losses associated with overproduction but also results in substantial cost savings for businesses, enhancing their competitiveness and profitability in the market. The recent Grocery Code of Conduct paves the way for many of these initiatives to be harmonized across retail businesses and supply chains.³⁹ Beyond economic gains, these efforts also carry significant social responsibility implications, as wasted food represents lost opportunities to alleviate hunger and food insecurity. By preventing food waste, societies can ensure more equitable access to food resources, address social justice issues related to food distribution, and promote healthier eating habits, contributing to improved public health and overall well-being.

Innovative examples in practice

Shivani's Kitchen is a Nova Scotia-based company specializing in Indian spices, ready-to-use sauces, frozen meals, and paneer (co-packed by Holmstead cheese) that is made from whey by-products. It has successfully piloted the upcycling of waste whey into its recipes.

Still Good is leveraging technology and innovative solutions to connect surplus food with community organizations, ensuring that excess food is upcycled or donated instead of going to waste.⁴⁰ Based in Montreal, Still Good plays a crucial role as a lynchpin in a circular economy hub, working with partners like TriCycle to maximize the use of food resources. By upcycling food that would otherwise go to waste, Still Good not only helps reduce landfill contributions but also supports local communities.

Dartmouth's College is developing protein powder from imperfect vegetables and juice processing by-products, using fermentation to enhance nutritional quality and digestibility. Dartmouth's project, currently in advanced research stages, collaborates with local farmers and food industry partners to scale up production and optimize the supply chain.

TriCycle is an edible insect farm that uses 80 tonnes of organic and food waste annually to feed its insects. Located in Montreal, TriCycle exemplifies sustainable agriculture by repurposing waste into valuable protein sources. Through innovative practices, TriCycle contributes to a resilient and environmentally friendly food system, addressing global food security challenges.

39 Harris, C. (2024, August 1). *The new grocery code of conduct should benefit both Canadians and the food industry.* The Conversation

40 Still Good Foods. (n.d.). *Still Good Foods*

Exploring possible future directions

Amidst the pressing challenge of excessive food loss and waste, there is a growing recognition of the need for robust solutions to foster a more sustainable food system. In Nova Scotia, various innovative approaches could be further developed to prevent edible food loss and waste, thereby realizing a more efficient, resource-conscious, and sustainable food system.

Efficient disposal prevention practices

throughout the food processing, distribution and retail industries are a crucial first step in the waste prevention hierarchy. Inventory management practices such as the First-In-First-Out (FIFO) practice can significantly reduce waste due to spoilage. Staff training on use and trimming strategies, coupled with predictive planning and forecasting systems, can enhance manufacturers' ability to manage demand while providing crucial information to collaboration partners. Furthermore, advancements in production processes, such as the implementation of AI-driven tools in processing, can enable the maximization of saleable products removed from carcasses, bolstering profitability while curbing waste.⁴¹ On a community level, food rescue platforms, such as the province's newly developed food resource map, can be used to identify excess products from animal processing facilities, minimizing waste. Additionally, maintaining strict cold chain standards and improving packaging to better protect and insulate food products not only extend shelf life but also reduce waste. For instance, strategic packaging changes, like shrink-wrapping cucumbers, can triple shelf life, while discouraging convenience plastics like free plastic bags at supermarkets diminishes plastic waste. Incentives and targets across retail and restaurants to reduce waste from bruising and falling produce can be supported by collaborations with data companies and research institutes.

Expanding the prevention of edible food loss and waste

is paramount for building a more sustainable and efficient food system. Organizations like The Station Food Hub are leading the way by repurposing produce that doesn't reach the market due to procurement or economic reasons, offering rental production space to other businesses. However, to strengthen these efforts in the future, several key strategies must be implemented. Firstly, changes to retail procurement policies, such as standardized date labelling and incentives for retailers to source imperfect produce, can significantly enhance the effectiveness of these initiatives. Secondly, investment in data solution providers and logistics, including the establishment of cold storage facilities, is essential for better inventory management and distribution of surplus food. Additionally, supporting restaurants or community kitchens that base their menus on seasonal or real-time surplus can further reduce food waste while providing affordable and nutritious meals to communities. Exploring different food products or target demographics that can expand market share without undermining existing ones, helps to foster a more resilient and sustainable food system. Examples of successful collaborations between existing businesses and newcomers can showcase the scalability and sustainability of these solutions.

Growing recovery opportunities for animal feed

will also be crucial, as inedible food scraps can provide enormous value as feed supplementation. Insect farming, for example, championed by companies like Midgard Insect Farm Inc. and Oberland Agriscience, underscores Nova Scotia's innovative approach to waste reduction. Leveraging fallen produce for companion animal treats and establishing partnerships between local farms, rescue centres and local processors for feed can further alleviate waste and foster specific collaborations. If Nova Scotia implements supportive policies for insect farming and feed supplementation using food scraps, such as providing incentives

41 Miller, S., & Garcia, C. (2023). Sustainability assessment of food waste reduction strategies: A case study. *Sustainability*, 15(13), 10482. doi:10.3390/su151310482



or subsidies for food loss and waste diversion to local businesses, the industry could scale up significantly. Collaborative partnerships between various stakeholders—including farms, zoos, rescue centres, local processors, research institutions, and technology companies—will be essential for maximizing the impact of waste reduction efforts and driving innovation in sustainable practices. These partnerships can facilitate the development of supportive policies, create economic opportunities, and stimulate market growth, ultimately promoting a more sustainable food system in Nova Scotia.

Establish new uses for agricultural residues and fishery by-products

The global market for bio-based materials is expanding rapidly, with the bioplastics market projected to reach \$44 billion by 2025, growing at an annual rate of over 20%.^{42,43} Canada's *Bioeconomy Strategy* focuses on diversifying feedstocks, investing in research and innovation, implementing supportive policies and regulations, and fostering stakeholder collaboration.⁴⁴ With such diverse and unique ecosystems across the Province of Nova Scotia, there is a unique opportunity to leverage its research institutions, entrepreneurs and businesses, and farming and fishing communities to invest in and become a leader in the bioeconomy.

Specifically regarding packaging, Canada's *National Zero Plastic Waste Strategy* and *Plastic Innovation Challenge* tackle plastic pollution and promote sustainable materials.^{45,46} Through regulations and recycling initiatives, the strategy aims to reduce plastic waste and support the transition to a circular economy. Complemented by the Plastic Innovation Challenge, which

supports research and collaboration in alternative materials and recycling technologies, these initiatives drive innovation and environmental stewardship in the materials sector. Marine and fishery by-products, to which Nova Scotia has primary access, are becoming increasingly significant in bioplastic development globally. Innovative materials like chitosan, fish gelatin, and fish oil derivatives may become prized local resources for Nova Scotia's marine sector to play a principal role in advancing Canada's *National Zero Plastic Waste Strategy*.

Investment in bio-based industries is also on the rise. In 2020, global venture capital investment in sustainable products, including bio-based materials, amounted to approximately \$10 billion. The bioplastics market alone is expected to grow from 2 million tons in 2020 to 6 million tons by 2027, with significant market penetration in the packaging, textiles, and automotive sectors.⁴⁷ In 2020, Canada's bioeconomy sector saw investments of approximately \$4.27 billion from transforming over 21 million tonnes of agricultural and forestry biomass into various bioproducts.⁴⁸ Furthermore, the Green Municipal Fund is focusing its support towards net-zero and circular economy solutions in the food system, and Technology Adoption Programs support the adoption of advanced technologies and matchmaking between international technology providers. These trends point to significantly greater support for technologies such as the integration of advanced biorefinery systems that can enhance efficiency and cost savings in biobased material production, further contributing to a more sustainable and resilient bioeconomy.

42 MarketsandMarkets. (2024). *Biopolymers and bioplastics market by type, application, and region - Global forecast to 2027*.

43 GlobalData. (2023). *Bioplastics market analysis*.

44 Biotech Canada. (2022). *National bioeconomy strategy*.

45 Canadian Council of Ministers of the Environment (CCME). (n.d.). *Waste*.

46 Environment and Climate Change Canada. (2024, April 18). *Canadian plastics innovation challenges: Phase 1 recipients*.

47 GlobalData. (2023). *Bioplastics market analysis*.

48 Bioenergy International. (2023, November 1). *Canada's first bioeconomy strategy launched*.

Innovative examples in practice

Moc Biotechnologies Inc. is a multi-award winning bioprinting company specializing in 3D bioprinting technology, focusing on the production of hard bioinks (filaments) for various bioprinting applications, including scaffolds and bone-like implants.

Agritherm is a fast pyrolysis technology used in the bioenergy sector. Fast pyrolysis involves rapidly heating biomass (such as agricultural residues, forestry waste, or dedicated energy crops) in the absence of oxygen to produce bio-oil, biochar, and syngas. Agritherm aims to efficiently convert biomass into valuable bio-based products while minimizing energy consumption and environmental impacts.⁴⁹

Ivey Circular Economy Program is an initiative that identifies, examines and facilitates food waste repurposing exchanges between businesses through research. Thanks to the programme, many industrial symbiosis initiatives are emerging and being mapped throughout the city of London and the province of Ontario.⁵⁰

Exploring possible future directions

Amidst the pressing challenge of excessive food loss and waste, there is a growing recognition of the need for robust solutions to foster a more sustainable food system. In Nova Scotia, various innovative approaches could be further developed to prevent edible food loss and waste, such as the following.

Bio-based construction and packaging materials. In Nova Scotia, the utilization of agricultural by-products for sustainable packaging and materials is gaining momentum, propelled by the province's significant cereal crop production. With ample stems and chaff and seafood by-products being generated annually, there is a strong opportunity to create sustainable and biodegradable packaging materials like chitosan, which aligns with the surging demand for eco-friendly alternatives.⁵¹ Additionally, surplus straw from cereal crops can be utilized to manufacture medium-density fiberboard (MDF) or straw/fibre-concrete, meeting the increasing demand for sustainable building materials. To make these innovations a reality, key stakeholders such as agricultural producers, research institutions, government agencies, and industry partners need to collaborate closely. Agricultural producers play a crucial role in supplying the raw materials, while research institutions contribute expertise in material science and process optimization. Government agencies can support innovation through funding programs, policy incentives, and regulatory frameworks that promote the development and adoption of sustainable technologies. Industry partners, including packaging manufacturers and construction firms, are essential for scaling up production and commercializing the new materials.

49 Cancarb. (n.d.). *Agri-Therm: The agri-based carbon black solution.*

50 Gualandris, J., Jain, S., & Lynch, M. (2022). *Scaling the climate-smart circular economy. Ivey Business School.*

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Industrial enzymes, pharmaceuticals, and nutraceuticals.

Nova Scotia's thriving seafood sector presents opportunities for collagen extraction from fish processing waste, meeting the rising demand for collagen supplements. Rendering slaughterhouse excesses into fats, oil, and tallow for industrial applications further optimizes resource utilization. Agricultural residues like corn stover and rice husks are enzymatically hydrolyzed to produce fermentable sugars, while fruit and vegetable waste provide enzymes for industrial processes. Fish processing waste contains proteolytic enzymes used in detergents and waste treatment. Plant-based extracts from grape pomace and citrus peels, as well as marine-derived compounds from fishery waste like omega-3 fatty acids and collagen peptides, serve as sources of bioactive compounds for pharmaceutical formulations. Microbial fermentation of agricultural substrates produces pharmaceutical intermediates and active ingredients. Fruit and vegetable waste, such as citrus peels and berry pomace, contain bioactive compounds like polyphenols and antioxidants used in nutraceutical products. Marine-derived nutraceuticals from fishery waste, including fish oil and collagen peptides, are popular ingredients in dietary supplements. Cereal processing by-products like bran and germ fractions are rich sources of dietary fibre and nutrients for functional foods.

Fertilizers, soil amendments and biofuels.

Nova Scotia has 22 abattoirs, which can potentially provide ample by-products for fertilizer production. Extracting phosphorus from bone by-products contributes to resource circularity, providing a valuable fertilizer for farming. Repurposing fish processing by-products into fishmeal, insect feed, or fertilizer taps into revenue streams while addressing waste. Additionally, advancements in technology, such as integrating advanced anaerobic digestion systems or exploring novel biogas utilization methods, could lead to even greater efficiency and cost savings in on-farm biogas generation, further contributing to a more sustainable and resilient food system in Nova Scotia.



Conclusion

We need systemic change to shift towards a more circular food system, and every actor—from the provincial government to community members, grocery chains to farmers markets, research institutions to entrepreneurs—has a crucial role to play in this transformation. But systemic change need not rely on large technological investments or lengthy policy reforms; the emphasis should be on small but meaningful actions that foster a collaborative environment for change. By focusing on local and actionable steps, we can collectively build a healthier, more resilient food system that benefits both Nova Scotians and the planet. Through concerted effort on a few key actions, we will gradually assemble the building blocks of change, creating a resilient and equitable food system we can all take pride in.

Municipalities, such as the HRM, play a crucial role in facilitating change. Among the key actions that could yield significant results, municipal governments can **leverage public procurement** through institutions like schools and hospitals to drive demand for local, organic, and upcycled products. They can **stimulate local initiatives** by replicating best practices, such as Toronto’s Market Cities plan, which supports farmers markets and local food vendors through strategic urban planning. **Providing platforms** where collaborators can share expertise can help grow trust among local stakeholders and **building community awareness** and support for residents in preventing food waste at home will also be crucial. This can be done by, for

example, creating community gardens and urban agriculture projects—such as the HRM Urban Farm Network—that boost local food production and strengthen community ties. **Implementing small grants** for pilot projects, increasing food processing infrastructure, and providing financial and zoning support for commissary kitchens can foster innovation. Securing a food recovery broker to coordinate surplus food recovery agencies and mandating data collection, along with supporting institutional food waste recovery collaborations to distribute edible surplus food, are also crucial steps. These are meaningful actions to enable a more sustainable and resilient food system across the province.

The provincial government holds a powerful role in shaping the rules of the game across the province and establishing a long-term strategic plan for its food system. Establishing **supportive policies** that incentivize local production and consumption and protects valuable agricultural land from development is crucial. Examples like British Columbia’s Buy BC program and Ontario’s Greenbelt Fund shows how **marketing and funding support** can boost local agriculture. Practical **investments in infrastructure** and **training programs** can help ensure that the right facilities are in place and workers have the right knowledge and skills to recover food loss and waste. These are simple but meaningful steps that can go a long way in creating a more sustainable and resilient food system.



Farmers and producers are at the centre of creating a sustainable and resilient food system. By **collaborating with local food hubs**, they can improve processing and marketing efforts, reducing waste and increasing profitability. The Vermont Food Venture Center serves as a valuable model, providing farmers with essential support in these areas. Similarly, the Ontario Agri-Food Venture Centre helps farmers with processing and product development, enhancing their market reach. Additionally, **forming cooperatives** can help farmers pool resources and market their products collectively, as demonstrated by the successful cooperative models in Quebec's agriculture sector and the Organic Valley cooperative in the United States. These collaborative efforts are essential steps toward a more efficient and sustainable agricultural system.

Community initiatives and non-profits are crucial in **raising awareness** and building trust among stakeholders. Hosting in-person gatherings and events can educate and connect stakeholders to initiate solutions across the region. **Replicating the successes of others** such as FoodShare Toronto and others can help scale solutions for supporting food security. **Establishing partnerships** with agencies like Food Mesh or Second Harvest, both of which rescue surplus food from retailers and redistribute it to organizations serving those in need, show how non-profits can reduce food waste while supporting vulnerable populations. Inspired by the Toronto Food Policy Council's success and the Halifax Food Policy Alliance's experience, these efforts are essential for creating a more inclusive and sustainable food system.

Educational and research institutions are key to **providing knowledge and training** for new entrants into farming, similar to the University of British Columbia's FarmWORKS programme which partners with local farms to offer hands-on training and support for new farmers. They can also **conduct research and development** on innovative farming practices and food waste

reduction methods. An example is the University of Guelph's Arrell Food Institute, which integrates research and practical applications to support sustainable food systems and technologies to minimize food waste.

Entrepreneurs and businesses represent the wheels of innovation that bring viable solutions to market. **Exploring new product-market fit** for biobased materials from agricultural residues, fishery by-products, and processing by-products is crucial for introducing new circular products into the market. Entrepreneurs can **form partnerships** with research institutions and non-profits, **participate in accelerator programmes** like the Halifax Innovation District, and engage in **consumer education** to raise awareness about sustainability. Additionally, improving supply chain efficiency through circular economy principles, influencing policy through advocacy, and designing products with end-of-life considerations are all essential roles for businesses. These actions are key to driving progress toward a more sustainable and innovative food system.

Transitioning to a circular food system in Nova Scotia requires all stakeholders to work together. By fostering collaboration, supporting local initiatives, and investing in sustainable practices, we can build a resilient and secure food system. Let's ensure Nova Scotia's food system is ready to meet future challenges, providing a prosperous and sustainable future for generations to come. Together, we will achieve a thriving, circular food system that benefits us all.

