Sustainable Management of Bioplastics: Lessons from a social innovation lab for Simon Fraser University and British Columbia

by

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Abstract

Bioplastic food packaging is gaining traction as an alternative to petroleum-based plastics and is being considered within university sustainability strategies. However, bioplastics present their own complex challenges and limitations to sustainability across their lifecycle. Using a social innovation lab approach, this research explored the challenges and opportunities of bioplastic packaging and foodservice ware from a systems perspective. This study draws upon the findings from key informant interviews and three workshops with stakeholders from across the bioplastics system, as well as a current practice scan of Canadian universities. The findings from this research informed recommendations for improving the use and management of bioplastics with respect to bioplastic feedstocks; standards and regulations; waste management; and sustainability and single-use item reduction more broadly. Furthermore, the findings were applied to the context of Simon Fraser University (SFU), and the study provides recommendations on bioplastic use and sustainability at SFU.

Keywords: bioplastics; circular economy; waste management; social innovation; plastic waste; food packaging

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List of Acronyms

EPR	Extended Producer Responsibility
LCA	Life cycle assessment
OttawaU	University of Ottawa
SFU	Simon Fraser University
UBC	University of British Columbia
UdeM	Université de Montreal
UofA	University of Alberta
UofT	University of Toronto
YVR	Vancouver International Airport

Chapter 1.

Introduction

Disposable food packaging and foodservice ware are pervasive across the food supply chain, with plastics playing a central role. Plastics are a durable, lightweight, and versatile material that facilitates the transportation, consumption, and preservation of food. However, the use of disposable plastic in the food system comes at a price. Plastic, while an immensely useful material, is a major contributor to environmental and social issues such as fossil fuel use, pollution, and biodiversity loss (Dauvergne, 2018; EMF, 2017; UNEP, 2018). Plastic made from petroleum first entered the market less than 100 years ago, and since then over 9 billion tons of plastic have been produced on Earth (Dauvergne, 2018; Ferraro & Failler, 2020). Over 400 million tonnes of plastic are now produced globally each year, accounting for approximately 6% of annual global fossil fuel consumption. Plastic packaging makes up a significant portion of this, representing 26% of plastics used (EMF, 2017, p. 12). At the same time, it is estimated that only 9% of plastic waste is recycled, leaving the rest to landfills, incineration, and the natural environment (EMF, 2017). In response to growing awareness of the negative consequences of disposable plastics, people are seeking more sustainable options for food packaging and takeout items. One of the alternatives rising to prominence is bioplastics, also referred to as bio-based plastics or compostable plastics.

Policy responses to stem the tide of plastics proliferation have emerged globally and locally. At the international level, the Global Partnership on Marine Litter was launched in 2012, the G7 has introduced an Ocean Plastics Charter, and the United Nations Environment Assembly recently endorsed a resolution to develop a legally binding agreement to address plastic pollution (UNEP, 2017; Government of Canada, 2018; UNEP, 2022). Domestically, Canada has established a zero-waste plastics initiative, recently classified fossil-fuel based plastics as toxic, and is pursuing single-use item product bans (Government of Canada, 2020, 2021a, 2021b). Single-use plastic bans and reduction strategies are also being implemented at the municipal level across Canada (B.C. Ministry of Environment and Climate Change Strategy, 2021). Along with these initiatives, there are calls for greater emphasis on reducing, reusing, and recycling, and for substituting single-use plastic items with alternative products and materials.

Compostable, biodegradable, or plant-based plastics have been proposed as solutions to combat the harms of plastics. Grouped as ‘bioplastics’, these products are being more frequently used as a replacement for fossil-fuel based plastic items such as single-use foodservice ware and packaging. As of 2020, the global bioplastics market size was estimated at $7 billion USD (Fortune Business Insights, 2021). Bioplastics are now being discussed within various sustainability and circular economy strategies (EMF, 2017; European Commission, 2020; OECD, 2013), and some stakeholders view bioplastics as a way to transition away from fossil fuels and reduce plastic waste (Asgher et al., 2020; European Bioplastics, 2018; Smart Prosperity Institute, 2019). However, bioplastics present their own complex challenges to sustainability across their lifecycle. Some of the main issues include concerns over the biodegradability performance of compostable bioplastics; inadequate end-of-life options; and challenges relating to product standards and certifications (Bhagwat et al., 2020; Compost Council of Canada, 2020; Lambert & Wagner, 2017; National Zero Waste Council, 2018). In Canada the legislative and policy framework for bioplastics also remains limited.

This study focuses on bioplastic food packaging and foodservice ware, such as takeout containers and cutlery, at the systems level. Issues relating to bioplastics take place across the product lifecycle and involve many different stakeholders. However, there is a research gap with respect to the opportunities, challenges, and solutions for bioplastics from a systems perspective. This study seeks to fill this gap, specifically within the regional context of Greater Vancouver. This study also applies these findings about bioplastics to the specific context of university campuses, many of which are currently seeking to reduce their plastic waste and enhance sustainability.

This study applies social innovation methodology (Westley & Laban, 2015), drawing on three collaborative stakeholder workshops, called ‘social innovation labs.’ The social innovation labs for this project brought together stakeholders that work with and are impacted by bioplastic foodservice products across the supply chain, and their perspectives contributed to determining key challenges, opportunities, and solutions. After completing the social innovation labs, this project also collected information about how university dining departments are currently approaching the issues of single-use plastic reduction and bioplastics. Findings were used to inform recommendations about the bioplastics system broadly, as well as bioplastic packaging and foodservice ware procurement, waste reduction and sustainability at Simon Fraser University (SFU). The latter contributed to the final outcomes of a Living Lab project at SFU. The SFU Living Lab program funds student-led climate solutions research to advance sustainability targets on SFU campuses, and this specific research project was used to inform SFU's actions towards Target 4 of their current Sustainability Plan.

This project addresses the following research objectives:

1. To explore the social and environmental challenges and opportunities of bioplastic packaging and foodservice ware from the perspectives of stakeholders across the supply chain.

2. To identify how Canadian universities are addressing single-use plastic waste, bioplastics, and sustainable foodservice ware and packaging.

3. To develop recommendations for the use and management of bioplastics, and to apply findings and recommendations to the specific context of university campuses.

The following chapter (Chapter 2) of this paper consists of a literature review covering the topics of the circular economy; bioplastics and sustainable packaging; and planning for waste management. Chapter 3 describes the research context and methodology that was undertaken for this study. Chapter 4 then presents the study's research findings. Chapter 5 offers a discussion of the results, and Chapter 6 presents recommendations and concludes the paper. This study will contribute to a better understanding of the bioplastics system and its associated infrastructure, including the key barriers facing the sustainable use and management of bioplastics, and potential solutions. This study will also provide key considerations for sustainability initiatives in university dining. Finally, this study will offer insights into the role of bioplastics in the transition away from fossil-fuel based plastics.

Chapter 2.

Literature Review

2.1. Circular Economy

In the last few years, the circular economy has gained prominence as a strategy for material sustainability. One of the most widely used definitions for the circular economy is a system that is based on design and the principles of "[eliminating] waste and pollution, [circulating] products and materials (at their highest value), and [regenerating] nature" (EMF, n.d., Definition section, Circular Economy). In other words, the circular economy stands in contrast to the dominant "take-make-waste" linear system of production and consumption, opting instead to "turn supply chains into supply loops" and mimic nature's circular flows (Maier et al., 2020, p. 194). The circular economy aims to address the issue of resource depletion as well as waste generation and pollution. Thus, circular economy strategies target both inputs and outputs of production and consumption, and can include reducing, reusing, recycling, and remanufacturing (Lazarevic & Brandão, 2020; Mah, 2021). In the case of plastics, the circular economy seeks to reduce plastic waste, use renewable materials as inputs, keep materials in circulation and recapture product value without leakage into the environment (Smart Prosperity Institute, 2019; Payne et al., 2019; EMF, 2017).

While the circular economy serves as a rallying cry for more sustainable production and consumption, there is still considerable ambiguity and contradiction in the concept. Lazarevic and Brandão (2020) note that the circular economy is a politically and policy driven concept that has been attached to a range of agendas. Some proponents of the circular economy describe the movement as a way to decouple growth and production from resource constraints, framing the concept as a win-win for the economy and environment (Lazarevic & Brandão, 2020; Mah, 2021). This discourse is exemplified by the Smart Prosperity Institute (2019), which states that a plastics circular economy "will result from market evolution, not revolution" (p. 3) and "would be a growth economy recirculating plastics in a manner that harnesses their extraordinary material properties but without waste" (p. 4). This messaging is also observed by Mah (2021) who argues that the petrochemical industry is working to contain and reframe the circular economy agenda in efforts to future proof the plastics industry.

On the other hand, some criticize this win-win agenda, arguing that the circular economy must challenge the paradigm of economic growth and advocate for a system-wide transition towards more sustainable models of manufacturing, consumption, and waste management systems (Reike et al., 2018). For example, Lazarevic & Brandão (2020) disagree with assertions that the circular economy can decouple resource use and environmental impact from economic growth. Instead, they offer the definition for the circular economy as "the set of practices that aim at the minimization, in view of total elimination, of resource extraction and waste generation" (Lazarevic & Brandão, 2020, p. 15). Some environmental advocates have also attached the circular economy to the zero waste agenda, calling for waste prevention as opposed to waste diversion (Mah, 2021).

Practically, circular economy interventions occur across product lifecycles and the economic system. One area of focus is material inputs and primary resources, which places priority on feedstocks that are either renewable or derived from "waste" materials recaptured from previous uses (Maier et al., 2020). A second area of intervention is product and system design, with the aim of designing out waste. Andrews (2020) argues that design is an increasingly important tool for achieving circular economy change, as "changes in design and business models are needed to change behaviour and increase circularity" (p. 44). Consumer behaviour and consumption habits is also a point of focus in the circular economy agenda, exhibited by calls for individuals to reduce the amount they buy and opt for more "sustainable" products (Camacho-Otero et al., 2020). Finally, waste management and product end-of-life interventions is key for realizing the circular economy objectives of recapturing materials and regenerating natural systems (Aid & Lazarevic, 2020).

The principles of the circular economy are increasingly being applied within solutions to address plastic waste and fossil-fuel use, and bioplastics feature heavily in these propositions. For example, the circular economy features heavily in the Ellen MacArthur Foundation's *New Plastics Economy* report (EMF, 2017), and the Smart Prosperity Institute's report *A Vision for a Circular Economy in Plastics in Canada* advocates for bioplastics as a way to align plastics to the circular economy (Smart Prosperity Institute, 2019). Payne et al. (2019) argues that the plastics industry must seize the opportunity of moving towards a circular plastics economy, such as through using renewable (bio-based) feedstocks, in order to reduce the environmental impacts of plastics while also realizing socioeconomic benefits.

2.2. Sustainable Packaging and Bioplastics

2.2.1. Sustainability and Packaging

The rise of both disposable plastics and sustainability have played out, in part, within the realm of food packaging. The ubiquity of disposable plastic packaging in the food system represents an intentional industry shift towards disposables in the mid-20th century which aimed to expand the market share of plastics. By establishing that "the future of plastics [was] in the trash can", the plastics industry facilitated an increase in single-use items and successfully out-competed other packaging material types (Stouffer, 1963, p. 1). Today, the success of this agenda is exhibited by the fact that disposable petroleum-based plastics occupy a central role in our food system (Mendes & Pedersen, 2021). Packaging is currently the largest application for plastics, and as of 2015 plastic packaging accounted for 25% of global packaging (EMF, 2017). However, these high volumes of disposable plastics have brought significant environmental consequences. Most plastics are made from petroleum, rely on fossil-fuel use during production, and are non-biodegradable, thus contributing to fossil fuel use, greenhouse gas emissions and the waste crisis (EMF, 2017; UNEP, 2018).

In response to the negative impacts of single-use plastics, the new vision for the packaging industry is sustainability-focused. Product characteristics such as biobased, compostable, recycled content, and recyclable (which represent both sustainable materials and waste reduction concerns) are being used to gauge the sustainability of packaging (Oregon DEQ, 2018). Pressures for environmentally friendly packaging options are coming from consumer preferences as well as government policies, and industry is pursuing new packaging options and ways to make plastics more sustainable (Mendes & Pedersen, 2021).

2.2.2. Bioplastics

Bioplastic packaging and foodservice ware are being promoted as one "sustainable" alternative to fossil fuel-based plastics in the food industry, and many organizations are now considering bioplastics in their strategies for circularity and sustainability (EMF, 2017; European Commission, 2017; National Zero Waste Council, 2018; OECD, 2013). However, while some people view bioplastics as a promising sustainable solution that should be promoted (Karan et al., 2019; OECD, 2013), others question if bioplastics create more problems than benefits (Lambert & Wagner, 2017; Pierce, 2018).

The term 'bioplastics' covers a range of products categorized based on their composition (bio-based vs fossil-fuel based) and decomposition (biodegradability), as presented in Figure 1. Bio-based plastics are made using part or all renewable biomass resources, such as corn, sugarcane, and algae. Biodegradable plastics can be broken down by microorganisms in the environment and converted into natural substances such as water, carbon dioxide, and compost (European Bioplastics, 2018). Within the category of biodegradable plastics there are also compostable plastics, which need to be processed under specific conditions, typically found at industrial composting facilities (Lambert & Wagner). It is important to note that bio-based plastics are not necessarily biodegradable or compostable (Lambert & Wagner, 2017; Recycle BC, 2019). The wide variation in bioplastic products lends itself to consumer confusion and improper disposal of bioplastics (National Zero Waste Council, 2018; Pierce, 2018; Recycle BC, 2019).

The literature holds both favourable and unfavourable views of bioplastics. Advocates of bioplastics view them as a promising pathway for transitioning away from fossil fuels and towards a bioeconomy (Moshood et al., 2021; OECD, 2013). Due to their potential biodegradability and compostability, bioplastics are also framed as a potential solution to the plastic waste crisis. Authors such as Asgher et al. (2020) discuss some of the ongoing technological and chemical advancements in bioplastic development and biodegradability, arguing that bioplastics demonstrate the potential to replace petroleum-based plastics. Samer et al. (2021) also note the opportunity for using materials that would otherwise be wasted, such as agricultural residues, as feedstocks for bioplastics. Finally, Karan et al. (2019) discuss the potential role of nondegradable bioplastics as a carbon sink.

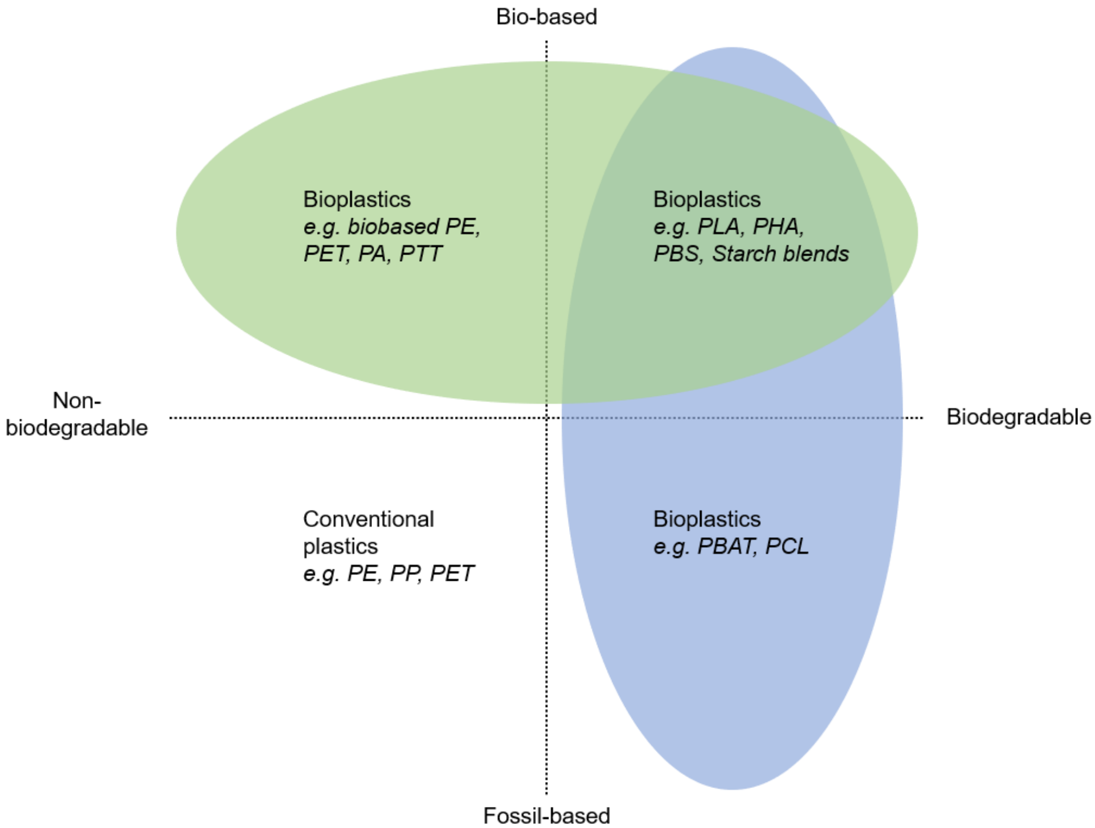

Figure 1 Classification of plastics based on material type and biodegradability
Adapted from European Bioplastics, 2018.

The literature is inconclusive about the environmental impacts of bioplastics. When determining the how bioplastics affect the environment, there are upstream (feedstock, production, transportation) and downstream (disposal and degradation) impacts to consider (Gerassimidou et al., 2021). Additional consideration can be placed on the role of bioplastic food packaging in preventing food loss and waste. Lifecycle Assessments (LCAs) are a common tool used to research and quantify the impact of bioplastics on the environment. However, LCA findings are the product of the inputs and assumptions used and can have varying results.

Recent LCA studies comparing bioplastics to other packaging types have had mixed results. A review of existing LCAs by Spierling et al. (2018) calculated that if bio-based plastics were to replace 65.8% of all plastics globally, they would emit between 241 and 316 less tonnes CO2-eq annually. However, the inputs that would be required to meet this level of bioplastic production come with other environmental costs. Samer et al. (2021) argue that greenhouse gas (GHG) emissions can be further reduced if agricultural residues, rather than primary feedstocks, are used to produce bioplastics. Another LCA review study conducted by Brizga et al. (2020) found that the GHG emissions required to produce petrochemical and bioplastic packaging actually overlap across LCA studies, with emission estimates for petrochemical plastics ranging from 41.5 and 90.1 Mt of CO2 and emissions estimates for bioplastic substitution between negative 17.5 and 80.1 Mt of CO2. (Brizga et al. 2020). When considering the global warming impacts of bioplastics, Hottle et al. (2017) noted that the impacts were heavily dependent on the end-of-life scenarios for bioplastics. With respect to feedstocks, Brigza et al. (2020) found that to substitute all global plastic packaging with bioplastics would require 54% of current global corn production, 12 times the current global production of castor beans, and 0.8% of global roundwood production. Sixty-one million hectares of land and 388.8 billion kilolitres of water would be required to accommodate this level of production (Brizga et al., 2020).

Bioplastics end-of-life is a point of concern throughout the literature, especially with respect to the performance of bioplastic biodegradation and the shortcomings of current biodegradability standards. Lambert and Wagner (2017) note that bio-based plastics that are biodegradable, compostable, or neither all have different end-of-life degradation pathways, meaning they “(bio)degrade to different degrees under various conditions” (p. 6856). Thus, biodegradable plastics will break down to different extents in the soil versus the ocean, and compostable plastics will break down much more successfully in commercial composting facilities than in the natural environment. The environment and conditions in question, as well as the chemical structure and additives in bioplastics, all impact the ability for bioplastics to break down (Haider et al., 2019; Lambert & Wagner, 2017; Viera et al., 2021). As such, Bhagwat et al. (2020), Lambert and Wagner (2017), and Viera et al. (2021) argue that standards for bioplastic biodegradation are crucial for successfully managing bioplastic waste and preventing environmental leakage. Additionally, these authors raise the issue of disconnect between lab testing conditions for biodegradability and the actual conditions that bioplastics will need to degrade within both composting facilities and the natural environment.

The literature demonstrates that there is considerable complexity associated with bioplastics at each stage of the bioplastic lifecycle, from the feedstocks used to the product end-of-life. There are environmental impacts, which are not straightforward or agreed upon, and social implications related to consumption habits and consumer experiences with bioplastics and waste. However, much of the literature evaluates the sustainability of bioplastics primarily from an environmental standpoint, or through focus on specific segments of the product lifecycle (Gerassimidou et al., 2021). Addressing this gap, Gerassimidou et al. (2021) takes on a systems-level approach by reviewing existing literature for information about the environmental, social, economic, and technical elements of bioplastics across their lifecycle. This analysis highlights the value in looking at bioplastics from a systems perspective and considering multiple aspects of sustainability when assessing sustainability and trade-offs.

The bioplastics system can also be analyzed in relation to its role in the circular economy system and narratives. One key question in this respect is whether bioplastics work within the current system or challenge the paradigm at the root of the plastics and climate crises. As discussed in the earlier review of Circular Economy literature, there are authors that view bioplastics as a natural progression for the plastics industry and as a substitute for petroleum products (Payne et al., 2019; Smart Prosperity Institute, 2019). Befort et al. (2021) argue that these objectives make bioplastics a “drop-in innovation reproducing the economy of waste” (p. 7). With this view, bioplastics do not challenge the existing paradigm of single-use items, reflecting the win-win narrative of certain circular economy proponents, like the Smart Prosperity Institute (2019), rather than the more revolutionary vision for the circular economy (Lazarevic & Brandão, 2020).

2.3. Planning for Waste Management

Waste management consists of the collection, sorting, transportation, handling, processing and final disposal of discarded items and materials. Waste management typically occurs on the local scale, and responsibility for planning, coordinating and/or carrying out waste management activities often falls to municipal governments (Silva et al., 2016). The dominant approaches to waste management focus on “end-of-life” solutions for discarded materials. Once disposed, materials become waste and are dealt with through means such as landfilling, incineration, recycling, or composting (Silva et al., 2017).

With initiatives such as the 3Rs “reduce, reuse, recycle” waste policy, environmental sustainability has been incorporated into the waste management sector and agenda. However, end-of-life solutions, such as recycling, continue to dominate sustainability efforts to date. Recycling is the focal point of the 3Rs and has been promoted through legislative and institutional channels across governments; in contrast, waste reduction and reuse have received less attention and concrete policy support (Sicotte & Seamon, 2021). As consumption continues to grow in urban areas, end-of-life responses such as recycling are inadequate for handling the volume of waste being created (Silva et al., 2016). Furthermore, low plastic recycling rates indicate that there has been limited circularity achieved through recycling up to this point (EMF, 2017).

As the limits of current approaches to waste are recognized and the sustainability agenda advances, waste management discourse is incorporating more holistic views of sustainability. A key part of this transition is the move towards system-level approaches to waste management that account for the full product lifecycle. This includes integrating front end strategies such as product design and reduced consumption (Silva et al., 2016; Tencati et al., 2016). It also consists of the need to better integrate and connect product supply chains, largely through promoting collaboration and communication between stakeholders across the supply chain (Salmenperä et al., 2021). Finally, it entails a willingness to change waste policy and ideologies, such as through embracing the circular economy concept, shifting towards sustainable production and consumption models, and viewing waste as a resource to be recovered and sustainable managed (Arena et al., 2021; Salmenperä et al., 2021; Silva et al., 2017).

While earlier iterations of sustainability in waste management featured waste diversion, meaning diverting waste away from landfill to other streams such as recycling, waste prevention, including through municipal waste management planning, is central to the proposed sustainability transition discussed above. The rise of urban waste, specifically packaging waste, has created a crisis in urban governance as municipal budgets and waste infrastructure are put under pressure (Hawkins, 2012) and end-of-life waste solutions fall short (Silva et al., 2016). Approaches to relieving these pressures and reducing waste entails preventing waste by reducing consumption (Sicotte & Seamon, 2021; Zaman & Lehmann, 2011) and through material recovery and circularity. The latter concerns the prevention of waste by viewing waste as a valuable material to be recovered and recirculated through waste management processes (Anshassi et al., 2019; Arena et al., 2021; Salmenperä et al., 2021; Silva et al., 2017).

To accomplish this transition in waste management there are several elements that emerge in the literature. The first is institutional support for and investment in waste management, including planning, policies and regulation that are harmonized across jurisdictions and set the stage for success in a new approach to waste management (Salmenperä et al., 2021). In this respect, Silva et al. (2017) states that the "transition in managing waste requires governments to lead the space with policy and potential infrastructure development in order to drive materials recovery and behaviour change" (p. 555). Suggested policies to support this shift include government mandates, extended producer responsibility, fees and taxes, ecolabeling, and public information (Sicotte & Seamon, 2021). Additionally, investments in effective waste management infrastructure are needed so that waste managers are equipped to operate in a different and potentially expanded capacity. Finally, public awareness and education about waste management systems and policies is important for achieving the desired outcomes related to waste prevention (Tencati et al., 2016).

Part of the value proposition of compostable bioplastics is that they can fit into a circular material flow, decomposing and then serving as inputs to future biological or production processes. This is consistent with the circular economy approach of preventing waste by recovering and circulating materials. However, the literature indicates that these outcomes are heavily dependent on the available waste infrastructure and systems. In theory, a range of end-of-life processing options for bioplastics are possible, including composting, mechanical recycling, and energy recovery through incineration. In practice, not all these options are possible. Bioplastics do not always properly degrade in organics facilities, and recycling options are not commonly available for bioplastics. In order to achieve environmental benefits, material recovery, and/or biodegradation of bioplastics, having the appropriate waste management infrastructure, collection and sorting systems is critical (Gerassimidou et al., 2021; Wojnowska-Baryła et al., 2020). Having these systems in place would enable bioplastics to contribute to the circular economy and reduce negative environmental impacts such as plastic leakage into the environment (Cucina et al., 2021).

Chapter 3.

Methodology

3.1. Research Context

This research is centred within the policy contexts of Canada, British Columbia (BC), and Greater Vancouver, which consists of the regional districts of both Metro Vancouver and the Fraser Valley. While various levels of government are taking steps to address plastic pollution and reduce single-use items, the legislative and policy framework for bioplastics remains limited. Canada's Zero Plastic Waste Strategy includes a ban on six single-use plastic items in 2022, and "plastic manufactured items" are to be listed as a toxic substance Schedule 1 of the *Canadian Environmental Protection Act, 1999* (Government of Canada, 2021a, 2020). It has not yet been determined whether bio-based and compostable plastics will be exempt from the government's ban. The BC government is also working on plastics reduction strategies through the Clean BC initiative and is actively supporting the phasing out of single-use plastics as spearheaded by several BC municipalities through product bans (CleanBC, n.d.; BC Premier, 2020). Single-use bioplastics are commonly included in these bans. Specific to bioplastics, the BC Organic Matter Recycling Regulation (OMRR), which regulates compost facilities, is under review to consider adding compostable plastics, which currently are not an accepted feedstock (OMRI, 2019).

This research is also taking place within the context of SFU. The SFU Sustainability Plan 2020-2025 is seeking to advance sustainability at SFU through both operational and research activities. Target 4 of the Plan aims to "reduce operational waste by 10% despite growth, expansion, and construction", and one of the stated strategies for meeting this target is to "eliminate single-use plastics and products from all three campuses by May 2021" (SFU, n.d.-b, p. 20). Contributing to this work is the SFU Re-Use for Good project, which is seeking to reduce single-use plastics and disposable products on the SFU campus and advance reusable alternatives in food services (SFU, n.d.-a). However, the COVID-19 pandemic and restrictions on in-person dining have delayed these efforts and triggered the expansion of single-use foodservice ware use on campus.

Another component of the SFU Sustainability Plan is to fund living lab research whereby students work with SFU staff and faculty to research climate solutions that can be applied on SFU campuses. This research was undertaken as part of a Living Lab project to address Target 4 in the Plan. The aim of the project was to make recommendations to advance SFU's progress towards this target, and to contribute to SFU's sustainability efforts by applying systems-level findings about bioplastics to SFU's procurement within its dining services.

This research has secured ethics approval from the SFU Research Ethics Board as part of the Social Innovation Management for Bioplastics (SIMBIO) research project. It uses qualitative research methods to collect data about the social and environmental aspects of bioplastics and university practices relating to bioplastics and sustainable foodservice ware. There are two components to this research. First, a social innovation approach was used to understand bioplastics from a systems and stakeholder perspective. Second, a current practice scan was conducted to determine how Canadian universities are currently approaching bioplastics and sustainable dining. The social innovation lab part of the research took place in Greater Vancouver, BC, and the findings are thus tailored to this specific regional context. The findings from both the social innovation lab and best practice scan are applied to the context of SFU. This research took place during the COVID-19 pandemic, and all research activities were therefore carried out virtually.

3.2. Social Innovation Lab

This project applies a social innovation methodology to the topic of bioplastics. Social innovation aims to solve problems by effecting systems-level change and altering a system across scales (Westley & Laban, 2015). The process of social innovation can be used to address complex problems because it recognizes that problems exist within complicated and multidimensional systems. This methodology is suited to the topic of bioplastics because bioplastics represent a "wicked problem", meaning a problem that contains tensions and lacks a clear answer (Westley & Laban, 2015). Within the realm of bioplastics, there are many trade-offs and tensions, and the environmental and social costs of these products are unclear. Additionally, the problems associated with bioplastics span the bioplastics lifecycle and numerous systems and stakeholders.

Bioplastics have yet to be addressed comprehensively on a system-level and would thus benefit from a social innovation process.

Social innovation labs are a process that strategically bring together a cross-section of stakeholders to form a common understanding of a problem and create innovations to address the problem. According to Westley and Laban (2015), social innovation labs “[emphasize] not only imagining high potential interventions but also gaining system sight, redefining problems, and identifying opportunities in the broader context with the potential to tip systems in positive directions.” Social innovation labs take the form of multi-stakeholder workshops, following a three-workshop format as set out by Westley and Laban (2015). Workshop one, entitled Seeing the System, brings participants to develop a common understanding of the problem. The aim of workshop two – Designing Innovation – is to explore and develop solutions to the problem. Lastly, in workshop three – Prototyping Strategies – lab participants test and prototype potential solutions identified in the workshop two. Prior to conducting the social innovation lab workshops, researchers gather initial information about the problem and local context through key informant interviews (Westley & Laban, 2015).

Using a social innovation lab model, this research project addresses the entire lifecycle of bioplastics by engaging stakeholders involved in bioplastics production, use and end-of-life management, and stakeholders with knowledge or experiences of the social and environmental impacts of bioplastics. The project scope was centered on food-related bioplastics and included single-use and reusable compostable and recyclable products. Interviewees and workshop participants were recruited through purposive sampling (Campbell et al., 2020) using the contacts of the research team and participants. Participants consisted of bioplastic manufacturers, distributors, and certifiers; food industry stakeholders; officials from multiple levels of government; university employees; and representatives from non-governmental organizations (see Figure 2). Most stakeholders were situated in Greater Vancouver, with a small portion joining from other locations in Canada. Through the course of the three workshops, stakeholders shared their knowledge and experiences related to bioplastics to inform an understanding of the bioplastics system and innovate potential solutions. The three workshops took place in October – November 2020, February 2021, and April 2021, respectively (see Table 1) over Zoom.

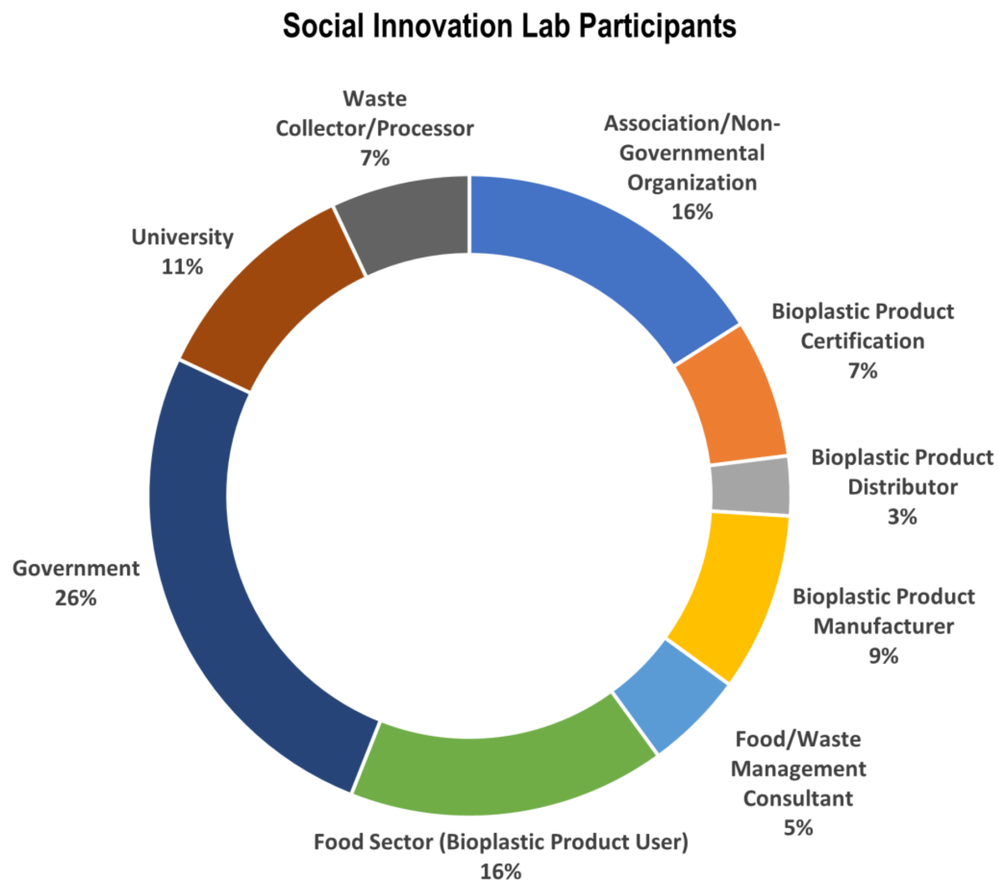

Figure 2 **Social Innovation Lab Participants**
Summary of stakeholder that participated in the social innovation lab interviews and workshops.

Table 1 **Summary of Social Innovation Research Activities**

Research Activity	Session	Dates	Participants
Key Informant Interviews	n/a	February - July 2020	23
Workshop 1	Session A	October 21, 2020	22
	Session B	October 28, 2020	18
	Session C	November 4, 2020	18
Workshop 2	Session A	February 4, 2021	16
	Session B	February 11, 2021	18
Workshop 3	Session A	April 21, 2021	16
	Session B	April 28, 2021	15

3.2.1. Key Informant Interviews

The key informant interviews took place prior to the social innovation lab workshops and served the purpose of gathering background information on the production, use and end-of-life management of bioplastics. Interviews were conducted between February and July 2020, and followed a semi-structured interview format. A total of 23 interviews were carried out.

3.2.2. Workshop 1

The first workshop, “Seeing the System”, took place over three sessions and brought together between 18 and 22 participants across the sessions. The aim of this workshop was to consider key issues at each stage of the bioplastic lifecycle, build a systems level view of the problem, and identify leverage points for potential interventions. The workshop activities included a group timeline exercise where participants considered both personal and societal experiences with bioplastic packaging, and a system mapping exercise to map the journeys of single-use bioplastic products across their lifecycle.

3.2.3. Workshop 2

The second workshop, “Designing Potential Solutions”, took place over two sessions and brought together 16 and 18 participants, respectively. In this workshop, participants and the research team explored solutions to some of the complex problems in the bioplastics system, including existing innovations. This included identifying potential areas for intervention in the system. The first session consisted of two “design jams”, which are focused brainstorming sessions, to flesh out potential solution areas. The second session consisted of exercises to identify system traps and opportunities and to pitch different solutions to the group.

3.2.4. Workshop 3

The third and final workshop, “Prototyping Potential Solutions”, took place over two sessions and involved 16 and 15 participants. The goal of this workshop was to assess the feasibility and potential impacts of the proposed solutions. This workshop employed a serious games approach (Gómez, 2017) to test potential solutions identified in the previous two workshops. The first exercise had participants develop and test labels for different bioplastic products, and in the second exercise participants fleshed out responses to scenarios where single-use plastics were banned. Due to the focus of this paper, the findings will focus only on the first exercise

3.3. Current Practice Scan

To better inform SFU's procurement policies, this study conducted a current practice scan. It is common for policy reports to identify best practices and examples of current practices from different jurisdictions, organizations, or companies in order to support evidence-based interventions. This approach is exhibited by Canadian Council of Minister of the Environment (2021), Seas At Risk (2021), and Smart Prosperity Institute (2021). The goal of the current practice scan was to collect university specific information about the use and management of foodservice ware, including bioplastics, and to apply these findings to inform sustainability at SFU.

For the current practice scan, the following universities were contacted by email: University of Toronto (UofT), Université de Montreal (UdeM), York University, University of British Columbia (UBC), Concordia University, University of Alberta (UofA), University of Ottawa (OttawaU), and University of Waterloo. These universities were selected because they are some of the largest universities, by number of students, in Canada, and they also represent a range of regions across the country. The Vancouver International Airport (YVR) was also contacted as a corporate example. Each recipient was asked to share any procurement, sustainability, and/or single-use reduction policies that cover single-use items for their food and beverage providers, and they were also asked what types of foodservice ware items their food vendors use and what disposal options are available for those items. Additionally, a total of 26 documents and 43 web pages from the contacted institutions were reviewed.

3.4. Limitations

There are several limitations to this research. The social innovation lab was intended to take place in person over the course of three full day workshops. Due to COVID-19 the workshops were instead held remotely using Zoom. This resulted in some constraints. The planned activities were scaled back and adapted due to the additional time and efforts required to conduct workshops on the online environment, and the limitations of the available online tools. Additionally, participants experienced online meeting fatigue, which may have affected workshop attendance and engagement.

Another limitation was that some stakeholder groups were under-represented in the social innovation lab workshops. There was limited representation from stakeholders in the waste management industry. Further, the workshops were not able to include stakeholders from marginalized groups that may be impacted by plastic and bioplastic pollution and waste, and this may have been due to hosting the workshops online. In terms of university stakeholders, there were SFU staff members that attended Workshop 3; however, university students were not represented.

Finally, the current practice scan was intended to inform recommendations to SFU related to single-use reduction and bioplastic management. This research activity was exploratory in nature and resulted in an overview of what other universities are doing in these areas. However, information was not available about the performance of the measures described by the respondents. Nor was there guarantee that the findings could inform best practices to be adopted by SFU.

Chapter 4.

Findings

This chapter summarizes the key findings from the key informant interviews, the social innovation lab and the current practice scan. The key informant interview and social innovation lab findings, presented for each workshop, fulfill the study's first objective to explore the social and environmental challenges and opportunities of bioplastics from the perspectives of stakeholders. The current practice scan results respond to the second research objective to identify how Canadian universities are currently addressing foodservice ware and packaging. Together, these findings inform the recommendations in Chapter 6.

4.1. Workshop 1 – Seeing the System

This section will cover workshop 1 and will also integrate the findings from the key informant interviews. Through workshop one, the lab group developed a system level view of the bioplastics problem, identified key issues at each stage of the bioplastics lifecycle, and discussed conditions that would be necessary to address these challenges. Over three sessions, the following themes emerged: bioplastics feedstocks; regulation, standards, and labelling; bioplastics end-of-life; and consumers perceptions of and interactions with bioplastics. These themes, supported by the rich discussion and perspectives contributed during the workshop, provide a more robust understanding of the current state of the bioplastics 'system' and shed light on current barriers and potential solutions. Additionally, across the themes, stakeholders grappled with questions related to the appropriate use of bioplastic products, the role of bioplastics as single-use items, and their relationship to the waste hierarchy. Each of these themes are discussed in turn below.

4.1.1. Bioplastic Feedstock

Biobased plastics integrate renewable biomass, such as plants instead of petroleum, to make plastics and could support a transition towards a low-carbon economy. Yet not all renewable material sources are equal when considering sustainability and ethics. Participants discussed the topic of bioplastic feedstocks with a variety of considerations in mind. One of the issues raised was food security, as there is a potential trade-off between using land for food production versus materials for bioplastics. Bioplastics currently rely on a nominal global agricultural area for feedstocks (European Bioplastics), but this should be monitored as the industry grows. Another social issue discussed was labour practices in feedstock industries, such as farming. Some stakeholders emphasized that labour practices, including concerning migrant workers, should be factored in when evaluating bioplastic feedstock sources.

Results from the key informant interviews confirmed these types of concerns, specifically regarding food production. For example, one government official noted that:

> "The starches need to come from somewhere. So, you have now growers that they grow for starches that is not going into food production, that's going now into production of plastics. And those plastics don't have any…food value or so basically so it's kind of diverging land from producing food into producing other stuff." (Government Employee 1)

Stakeholders also discussed the distinction between edible and inedible biomass. Innovators are seeking to integrate industrial by-products from agriculture, aquaculture, and forestry into bioplastic feedstocks. This presents an opportunity for using materials that would otherwise be wasted, and for circumventing concerns about food security; it could also provide an additional revenue stream for farmers and lower cost feedstocks for manufacturers. However, while mitigating pre-consumer waste is beneficial and can reduce the virgin feedstocks displacing food production, risk needs to be managed around perpetuating extractive practices and inefficient material use. This includes accounting for the broader ecological impacts and biological boundaries of these resources, as well as their production processes (e.g., fossil-fuel use in industries producing feedstocks).

Multiple stakeholders interviewed also spoke to the use of waste materials as bioplastic feedstocks. One bioplastics distributor expressed that "…the long-term goal for bioplastics is to increasingly source from waste materials" (Bioplastics Distributor 1). A stakeholder from an Association/NGO echoed this sentiment when discussing the potential environmental impacts of bioplastics:

> "It would have to meet the true definition of circularity and not be contributing to any environmental negative consequences. I think,

essentially, it would have to come, like the bioplastic itself, would have to come from 100% post-consumer source." (Association/NGO 1)

Workshop participants concluded that for bioplastics to offer a sustainable and ethical alternative to petroleum-based plastics, sustainability and ethics must be at the core of bioplastic material sources. This includes considerations of food security, ecological impacts, and labour practices. Figure 3 exhibits some of these elements as recorded during the systems mapping exercise from the workshop.

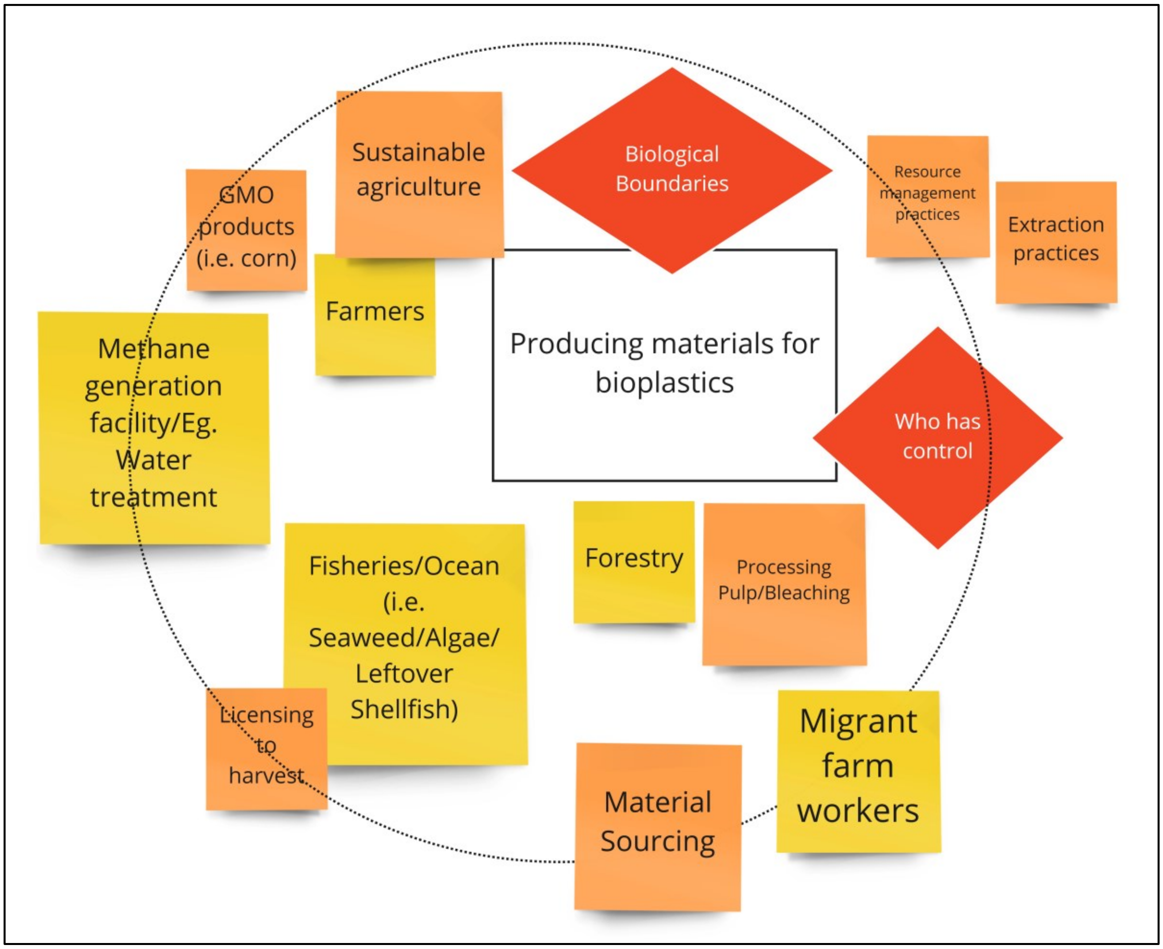

Figure 3 Stakeholder notes on bioplastic feedstocks, as captured in the Workshop 1 Session B systems mapping exercise

The yellow squares represent stakeholders involved in producing materials for bioplastics; the orange squares represent experiences that create challenges or problems; and the red diamonds represent gaps or conflicts

4.1.2. Standards, Regulation and Labels

There are significant gaps and challenges relating to the standards, regulation and labelling for bioplastics in BC; in the workshop, this was emphasized as one of the biggest barriers to effective and sustainable bioplastic use. Challenges largely revolve around the terms and labels used to market bioplastic products, as well as the claims made about how products break down once they are disposed. Firstly, while there are compostability standards and certifications available for bioplastic products, Canada does not have a defined standard that it follows, and product certification is currently voluntary. Canada also lacks regulation for how bioplastic products can be labelled. One consequence of these regulatory gaps is that product labels and compostability certifications are not well aligned to the conditions in local composting facilities. Additionally, brands can label their products as “compostable”, “biodegradable” and “bio-based” and use green branding without meeting any specific criteria. According to stakeholders, this creates problems for certified bioplastic manufacturers who must compete with industry greenwashing, and who have certified products that are rejected from composting facilities. It also contributes to consumer confusion about what bioplastics are and how to dispose of them.

During the key informant interviews, a researcher also highlighted problems associated with the currently sparse regulatory framework:

> “[Create] a proper regulatory framework which weeds out the bad actors and amplifies the good ones, because right now there is no difference [between certified and uncertified products]. Like you could have the best product in the market but someone doing a terrible thing with the same green brand with its lower price point will beat out the good players.” (Researcher 1)

Stakeholders also noted the challenges of multiple jurisdictions in bioplastic regulation. Product regulation can occur across levels of government, and waste management systems may vary significantly between different municipalities and regions. This can lead to overlap and conflicts between jurisdictions. At the same time, it also creates conditions for regulatory gaps. For example, stakeholders discussed that there is no clearly defined entity responsible for post-consumer bioplastic waste in BC. There are no extended producer responsibility programs for bioplastics in BC, and instructions related to composting bioplastics are fragmented.

In the final session, stakeholders concluded that accepted, clear and consistent standards is an important condition for a successful and positive bioplastics system. This entails having standardized and regulated definitions for products, as well as product labels that are effective and recognizable by both users and processing facilities. It also means compostability requirements that are reflective of real-world waste management processing conditions, and potentially a common framework for product acceptance in waste facilities. These findings were reinforced in the key informant interviews, with one government official saying that "a clear regulatory standpoint on the acceptability and definition of compostable plastics is probably the key piece, right? Either they are accepted, or they aren't. And what's the definition of what is compostable versus not" (Government Employee 2). Figure 4 summarizes some of the key notes relating to standards, regulation and labelling for bioplastics during the workshop.

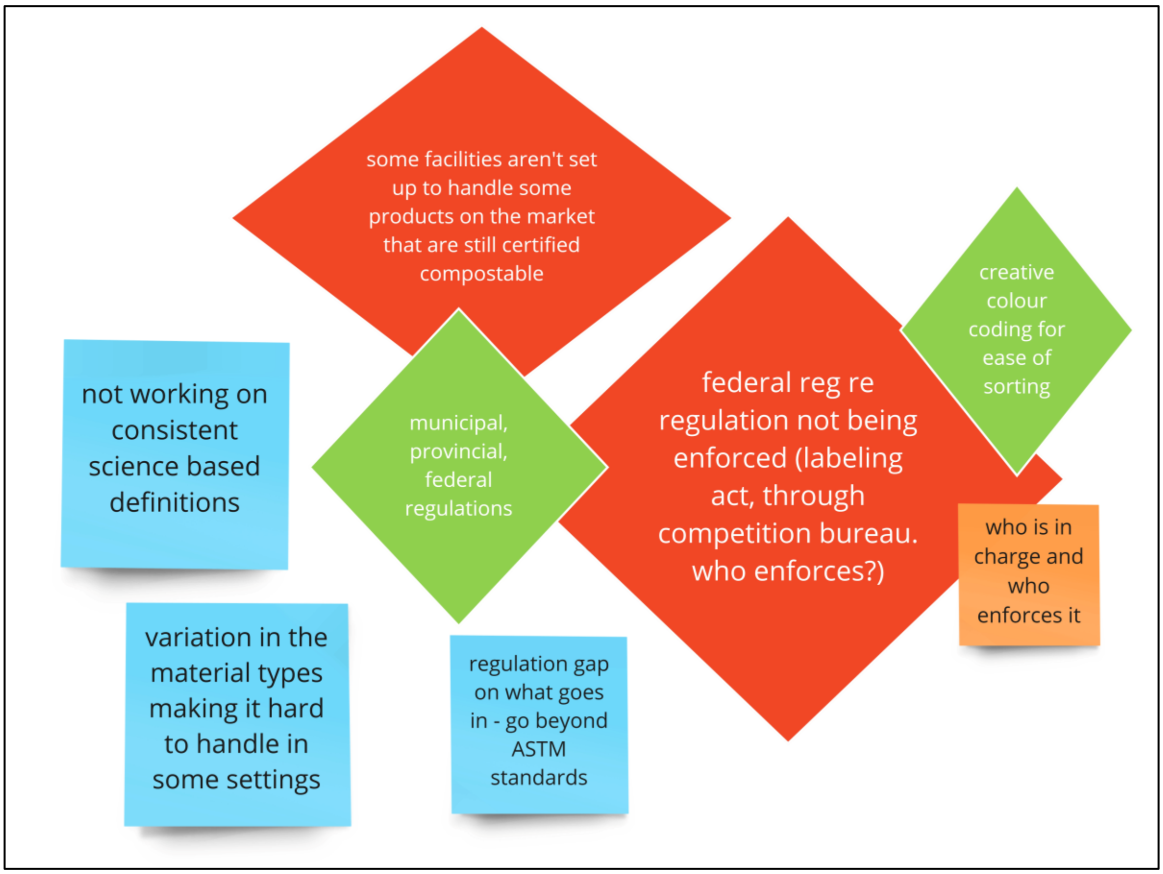

Figure 4 **Stakeholder notes on bioplastic standards, regulation and labels, as captured in the Workshop 1 Session B systems mapping exercise**

The orange squares represent experiences that create challenges or problems; the blue squares represent circumstances that trigger challenges or problems; the red diamonds represent gaps or conflicts; and the green diamonds represent opportunities.

4.1.3. Bioplastic End-of-Life and Management

The current state of end-of-life options for bioplastics is a significant challenge for stakeholders across the supply chain. One primary concern in this area is that bioplastics lack a clear end-of-life pathway and are not accepted for composting by most composting facilities in Greater Vancouver. This is despite many bioplastics being marketed as biodegradable or certified compostable. According to stakeholders in the workshop, this is in part because facilities do not have the correct infrastructure or conditions to process bioplastics. For example, while the ASTM compostability standard requires bioplastic products to break down within 180 days, stakeholders involved in waste management confirmed that the active composting phase for many compost facilities is about three weeks. There is also variation in infrastructure and processing capacities across facilities in the region. However, building new infrastructure and retrofitting existing facilities is costly, and clear direction on infrastructure requirements is lacking. For facilities that can process compostable bioplastics, another issue is that it is difficult to distinguish compostable bioplastics from other plastic and bioplastic contamination. As a result, all bioplastics are often screened out at compost facilities before composting.

A researcher that was interviewed echoed these findings:

> "I know that municipalities such as [redacted] had tremendous problems with it [bioplastics] dangling on equipment and not breaking down in colder spots... [they] actually banned the use of biodegradable plastics in their compost facility." (Researcher 2)

Concerns over compost quality was another point of discussion in the workshop. Due to incompatibilities between bioplastics and composting facilities, bioplastics do not always fully break down in the compost. This creates the risk of smaller bioplastic fragments and chemicals contaminating the final compost product. This risk is exacerbated by the challenges in differentiating between various types of bioplastics and plastics. Stakeholders stressed that the compost produced by industrial facilities is a commercial product and must meet certain soil quality standards; stakeholders also contemplated the possibility of bioplastics adding value to the composting process.

A waste management professional also commented on concerns over soil quality during the key informant interviews:

"They [composting facilities] don't seem to want them. Some of the ones that do accept them they're usually either bleeding it into their products and it's creating a lower quality product than what they would have if they didn't have those bioplastics in their mix, or they're just not accepting them all together." (Waste Management Professional 1)

In session three of workshop one, stakeholders emphasized that compatibility between bioplastic products and end-of-life processing options is a necessary condition in order to achieve a positive bioplastics system. This would entail designing products for end-of-life options, having clear end-of-life pathways, and waste management infrastructure with the capacity and willingness to process bioplastics. Figure 5 represents these findings as recorded in the workshop.

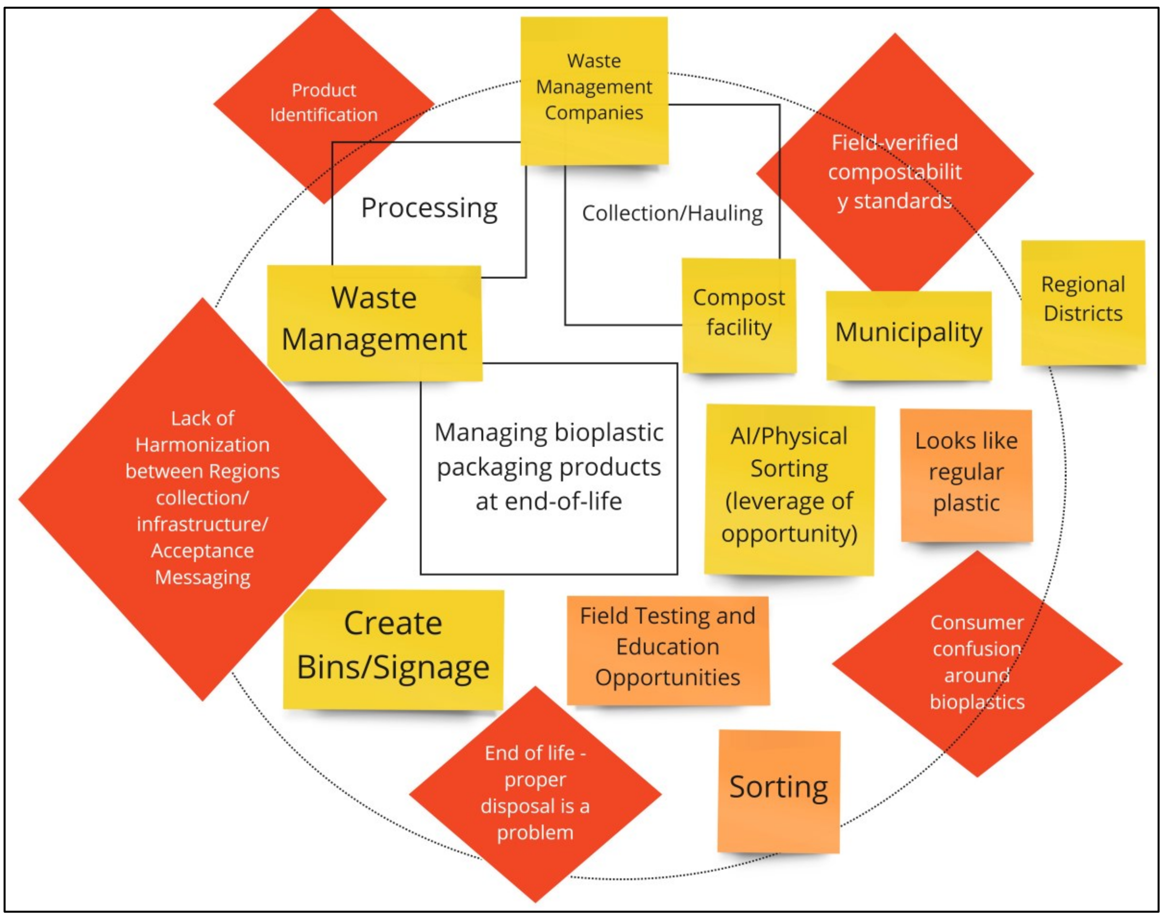

Figure 5 Stakeholder notes on bioplastics end-of-life and management, as captured in the Workshop 1 Session B systems mapping exercise.
The yellow squares represent stakeholders involved in producing materials for bioplastics; the orange squares represent experiences that create challenges or problems; and the red diamonds represent gaps or conflicts.

4.1.4. Consumers and Consumption

Stakeholders noted that there is significant confusion about bioplastics among both food/beverage businesses and the general public. For businesses, the confusion arises when seeking to procure "sustainable" single-use items; for consumers, it is often difficult to determine what bioplastics are, how to recognize them, and how to dispose of them. Stakeholders also described instances of both businesses and consumers expecting that bioplastics are an environmentally friendly and compostable option and being surprised and disappointed to find out that is not necessarily the case. These issues are exacerbated by limited and fragmented end-of-life options for these products and the lack of clear and consistent guidelines and product labelling. Opportunities to improve these issues relate back to required changes in regulation and standards, as well as compatibility with waste management systems. Figure 6 shows these elements as captured during the workshop.

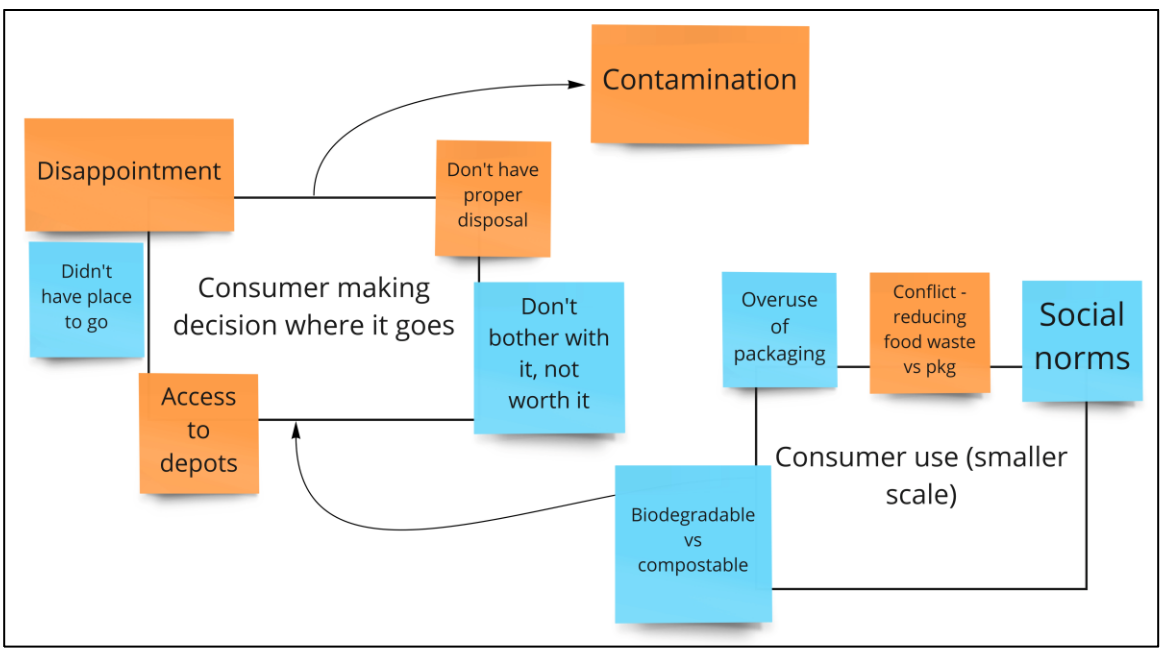

Figure 6 Stakeholder notes on consumer experiences of bioplastics, as captured in the Workshop 1 Session B systems mapping exercise
The orange squares represent experiences that create challenges or problems; and the blue squares represent circumstances that trigger challenges or problems

Certain stakeholders also discussed the role of bioplastics as they relate to consumption and sustainability. In the workshops, stakeholders expressed concerns about how bioplastics may perpetuate the culture of single-use, continue contributing to waste creation, and potentially undermine efforts towards reusable items and waste reduction. Within these discussions, some stakeholders emphasized the need to be thoughtful about when and how bioplastics are used. Similarly, in the key informant interviews a government official stated that “[they] think one of the unintended consequences of that is it continues to foster a reliance on the single use items as opposed to investing in cyclical reuse systems” (Government Employee 3).

4.2. Workshop 2 – Developing Potential Solutions

In workshop two, the lab focused on exploring solutions to the barriers and problems identified in the first workshop. In this workshop, stakeholders went in depth into three solution scenarios: an extended producer responsibility program for bioplastics; a reusable sharing bioplastic food packaging program; and a single-use bioplastic ban.

4.2.1. Extended Producer Responsibility

The aim of an EPR program for bioplastics (Figure 7) is to improve the end-of-life management for bioplastics, to raise funding for bioplastics management, and to support stakeholder connections across the supply chain. In the hypothetical EPR program developed in the workshop, bioplastic producers would be responsible for ensuring that after use, bioplastics are collected and processed in an appropriate waste stream. Producers would fund the program and could raise revenue through mechanisms such as deposit fees. Funding would be used in part for bioplastics research, encourage innovation and product designs that align with local waste management contexts; it would also be used to improve end-of-life management processes and infrastructure, for example through composting facility upgrades. This type of EPR program would facilitate more direct lines of communication between producers and waste managers, enabling feedback that would serve to improve product design and management. It could also effect improvements to bioplastic labelling and performance standards.

The potential role of an EPR program was also raised by a government official in the key informant interviews:

> “And so then that’s where the EPR piece comes in when we’re trying to advocate with the province around a holistic approach that they ensure that if these items are allowed on the market that at the back end they can be processed and that at the front end that there’s a collection system and that producers are paying to invest in this infrastructure.” (Government Employee 3)

Something that was emphasized by stakeholders was the importance of setting up the program to be democratic and transparent and avoid conflicts of interest. This would be done by including all relevant stakeholders and structuring the program so that companies paying into the EPR program do not monopolize the program’s direction and policies.

An EPR program for bioplastics offers a potential solution to some of the barriers discussed in the first workshop, such as the absence of end-of-life options and disconnects between bioplastic manufacturers and composting facility operators. It is an intervention that would improve upon the current system and seek to eliminate the problem of bioplastic waste by effectively managing it. By connecting producers with their products after use, EPR would also move bioplastics towards the circular economy and facilitate a system-wide approach to waste management in this area.

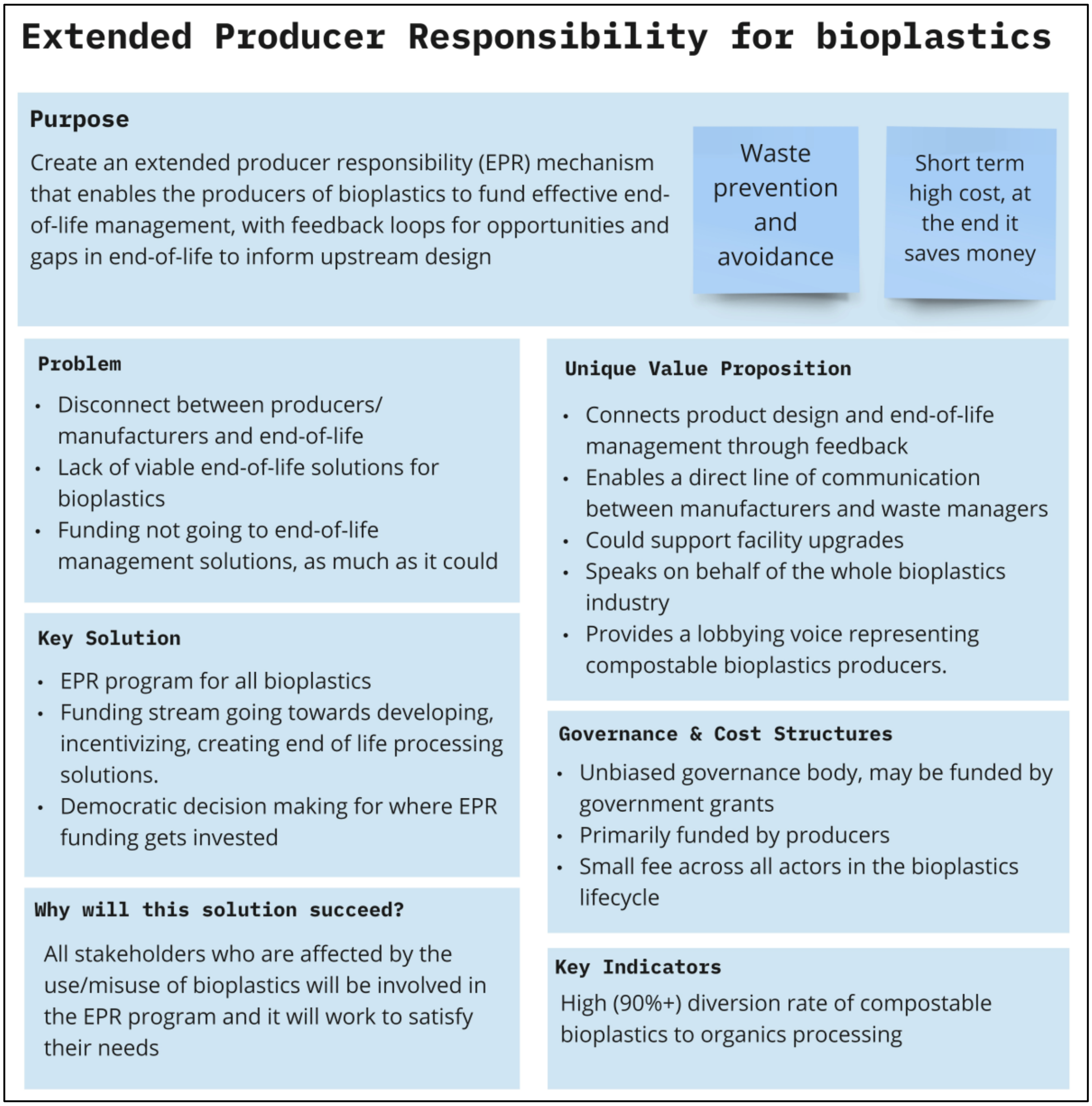

Figure 7 Excerpt from EPR solution notes, captured in Workshop 2 Session B

4.2.2. Shareables and Single-use Ban

The shareables solution (Figure 8) was developed to be a universal sharing system for durable, reusable bioplastic takeout containers across restaurants. The goals of this program were to reduce environmental waste by replacing single-use items, and provide restaurants with an easy, consistent, and less costly solution to participate in. One concern that arose was the risk of large companies succeeding at the expense of small and medium-sized businesses, as well as escalating competition within the industry. In response, stakeholders identified the opportunity to build in supports for smaller businesses, such as exceptions for companies with lower annual service rates. Participants also emphasized the benefit of universality; shared infrastructure, common industry standards, and collaboration would present opportunities for broadening the reach, success, and accessibility of this program. To combat potential problems with inventory (e.g., dishes not being returned) and responses (e.g., resistance and low participation), education for both restaurants and consumers would be necessary. Communications about what the program was, how to participate, and the social and environmental benefits would be key to the program's success.

The single-use item ban (Figure 9) was intended to be a plastics ban that includes bioplastics in its scope. The program would classify plastics and bioplastics as either essential or nonessential, and reduce plastics by first banning the nonessential items, such as single-use takeout items. By enacting the ban, the program would aim to equalize the playing field for small businesses because all would be subject to the same clearly defined rules. The group recognized that there would be risks and challenges associated with the ban, including negative responses from and impacts on stakeholders, as well as risks to food longevity and the environment. However, by properly framing the ban, harmonizing standards and regulations, and shifting the bioplastics focus to durable and reusable uses, the group hoped it could harness the benefits of this policy and minimize the risks. This policy would complement and potentially increase demand for shareables programs as described above, and it could create new opportunities for the bioplastics sector in durable and reusable products.

These two scenarios represent a shift away from the current system of single-use item consumption. Rather than making changes to improve upon single-use bioplastic management, such is the case with EPR, these solutions aim to eliminate waste by no longer using single-use items, including bioplastics, and moving instead to alternative systems. This goal also arose during the key informant interviews:

> "…business models that actually prioritize reduction by shifting to reusables, whether that's bring your own or like whole new business models that offer professional sanitation of the items between customers, that's I think where the biggest paradigm shifts will come from." (Government Employee 3)

These solutions would also facilitate a transition to the circular economy by reducing consumption, but beyond the scope of bioplastics. They also fall into the waste reduction aims of waste management. As one bioplastics distributor interviewed stated, “the future is refillable and reusable” (Bioplastics Distributor 1).

Reusable Sharing Food Packaging Program

Purpose

- Minimize waste and environmental footprint while maximize sharing
- Target takeout and restaurant/cafe food packaging

Problem

- Bioplastics still ending up in landfill
- Confusion about what is actually good for the environment
- Consumer and business guilt about disposables

Key Solution

Universal sharing system for a suite of container types

Why will this solution succeed?

- Solution will create jobs
- Cheaper for restaurants, less waste
- Attractive looking containers

Key Indicators

Local and regional waste audits

Unique Value Proposition

- Universality eliminates the consumer thinking about waste streams
- Minimizing the burden on individual businesses
- Not a single-use system

Partners, Channels, Outreach

- Political will and regulation
- Incentives and buy-in to participate
- Education for restaurants
- Public health sector
- Container designers and manufacturers

Cost Structure

- Restaurants paying into system
- Consumers pay a deposit fee

Figure 8 **Excerpt from reusable program solution notes, captured in Workshop 2 Session B**

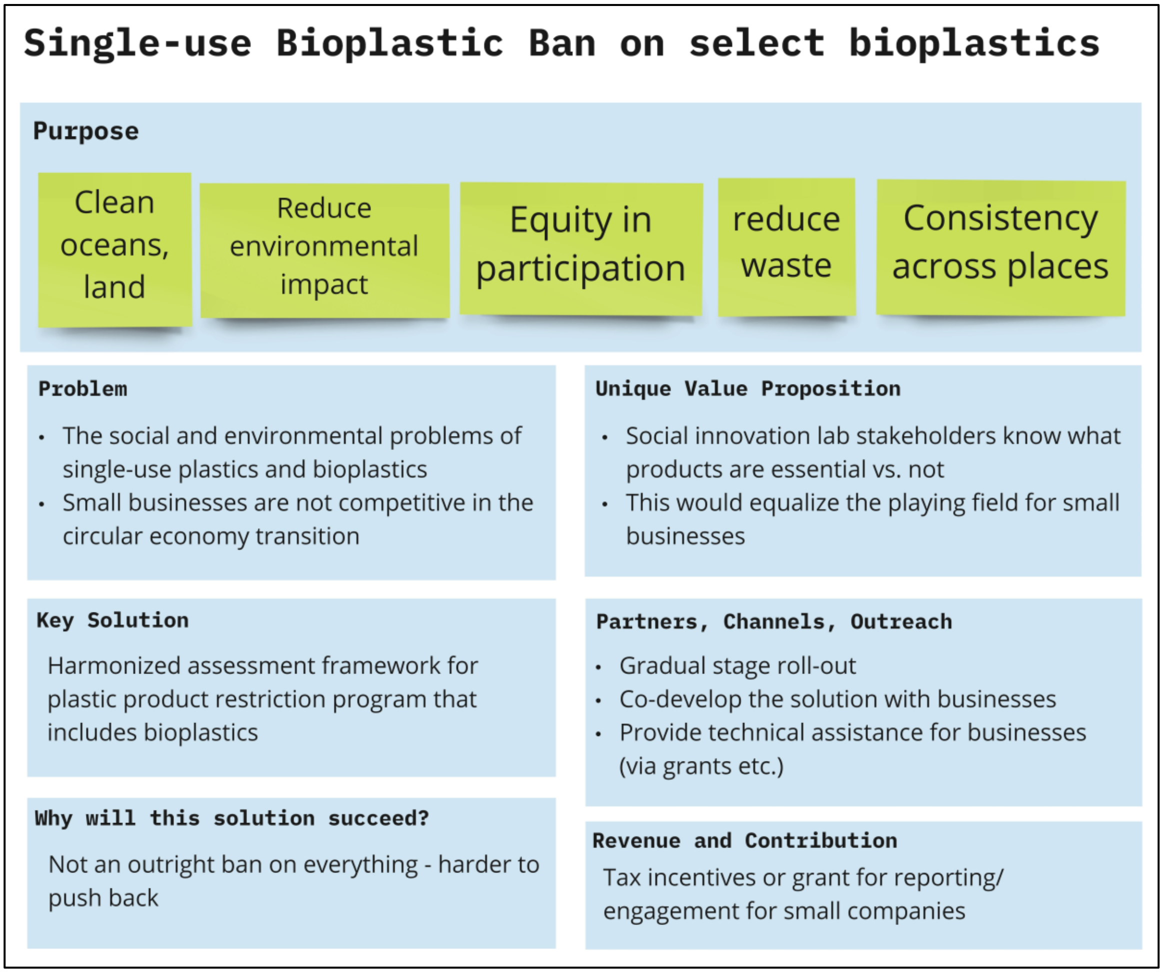

Figure 9 Excerpt from bioplastic ban solution notes, captured in Workshop 2 Session B

4.3. Workshop 3 – Prototyping Potential Solutions

Workshop three was geared towards prototyping potential solutions in the social innovation lab setting. This entailed developing activities to imitate real-world scenarios that could provide lessons about how solutions may perform, using a serious games approach. One of the activities in this workshop was a game called “Can You Sort It?” The purpose of this game was to test out labels to differentiate between biodegradable, compostable, recyclable, and other (non-biodegradable, non-compostable, and non-recyclable) plastics, and determine the effectiveness of visual identifiers for sorting products. In Session A, participants developed ideas to visually differentiate the types of plastic using symbols, colours and other distinguishing features that could be applied to single-use packaging and items. Figure 10 shows the final labels developed by each group.

In Session B, workshop participants (n=15) played the Can You Sort It? game using the Kahoot platform (Figure 11). In three breakout groups, participants were tasked with sorting plastic packaging using the labels designed by a different group. The game gave players 5 seconds to answer each question, and there were 18 questions total. The final scores for each group were 65%, 54% and 72% correct answers.

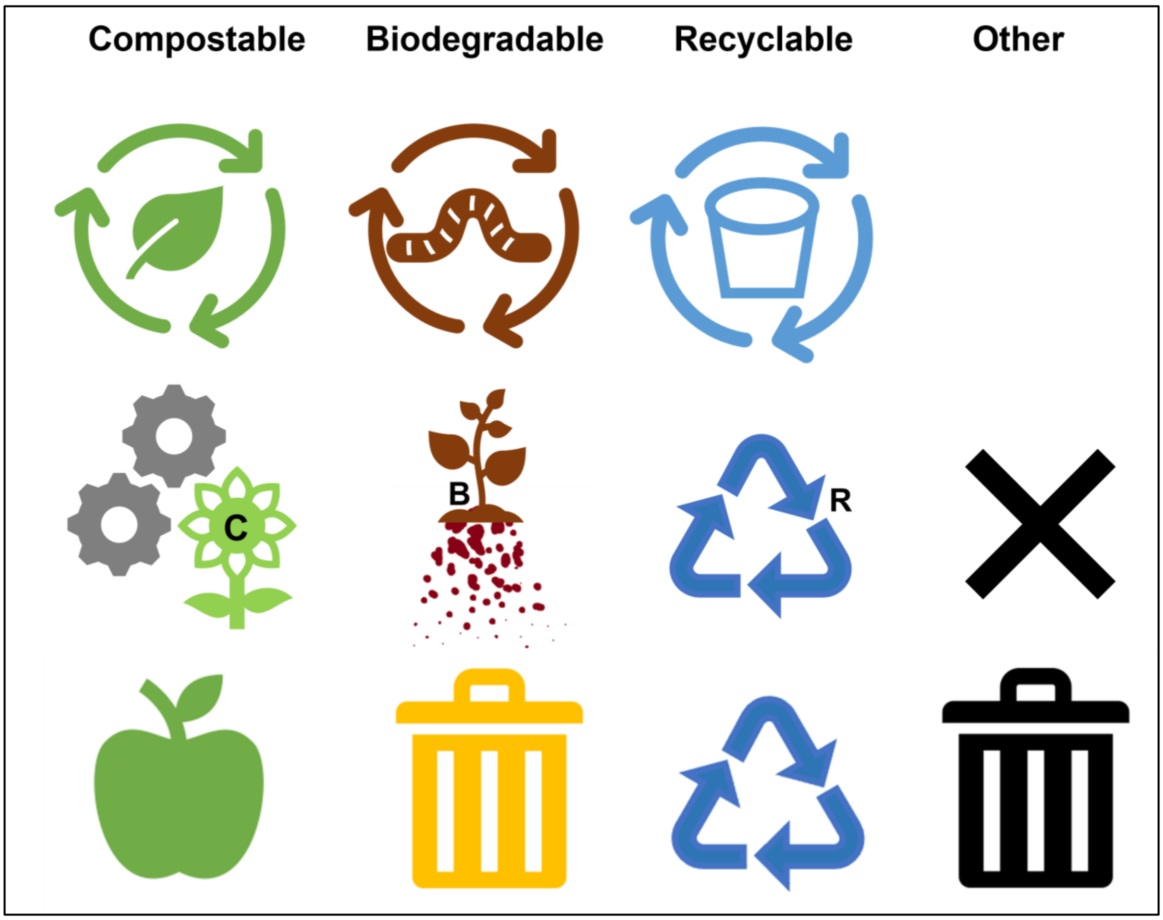

Figure 10 Labels developed in Workshop 3 for Can You Sort It?
Each row consists of the labels developed by one of the three groups of stakeholders for the categories of compostable, biodegradable, recyclable, and other (garbage).

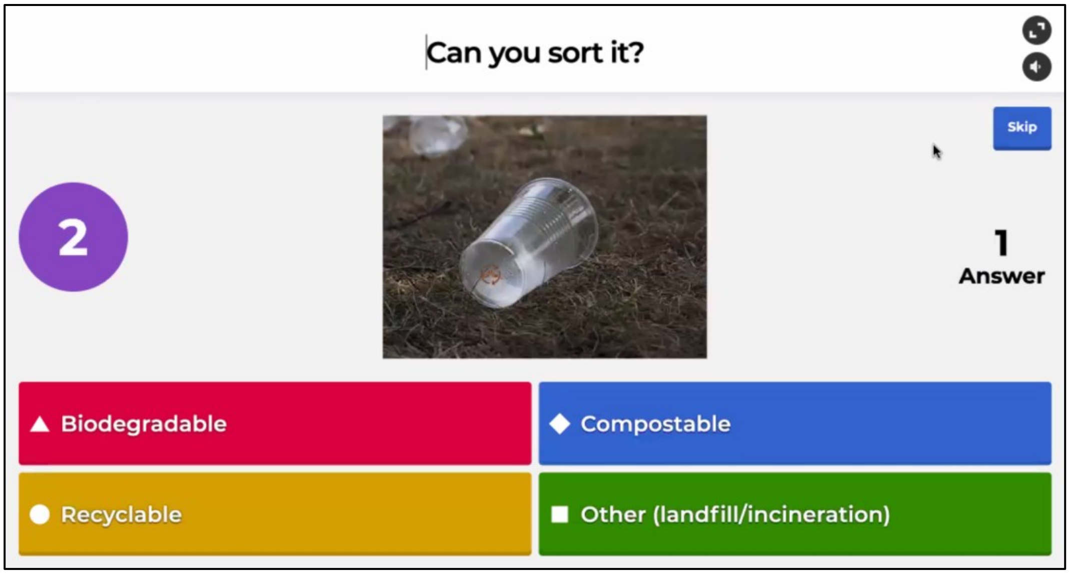

Figure 11 Screen capture from Can You Sort It? on the Kahoot platform
Participants had to sort the item in the image into one of the four categories, based on its label.

After the game, the groups discussed their experiences in playing Can You Sort It?. Participants generally felt that the game was easier as time went on. There were also different approaches to the game. Some players sorted the items based on their prior knowledge of the products, rather than the new symbols, while others focused only on the symbols. Challenges identified included difficulty seeing the symbols and colours; paying attention to only the symbol, rather than the colour; and prior association with the colours and symbols which conflicted with their meanings in the game.

Reflections and discussions in the workshop raised considerations and suggestions that can be applied to the broader issue of labelling bioplastics. Firstly, stakeholders discussed problems with the category of biodegradable plastics; currently, there is no waste stream for biodegradable products, and the term 'biodegradable' does not have a single meaning. Additionally, participants found that the biodegradable labels could easily be mistaken for the compostable plastic category. Accessibility concerns were also raised in relation to different types of visual identifiers. For example, participants discussed the need for symbols in addition to colours, to account for colour blind individuals. The idea to include textures for visually impaired individuals was also introduced. Symbols also have different meanings and degrees of familiarity across cultures. Some participants emphasized the need to consider cultural context and geographic scale (e.g. regional, national, international) when selecting symbols for labelling plastics. Finally, stakeholders stressed the importance of avoiding complexity in symbol designs, and certain participants reflected on the challenges of educating the public on new symbols and scaling up labels for bioplastics at the global level.

4.4. Current Practice Scan

The current practices scan showed that there is a range of approaches to plastic waste reduction on Canadian university campuses, but that across-the-board universities are committed to moving forward with sustainability initiatives. Responses to the email requests for information were received from UofT, UdeM, UBC, UofA, OttawaU, and YVR during the period of July to August 2021. York University replied as well but indicated that they are currently developing their strategy in this area and could not share further information at this time. The responses received are summarized in Table 2.

Table 2 Summary of Responses from Current Practice Scan

INSTITUTION	KEY POLICIES	FOODSERVICE ITEMS AND DISPOSAL
University of Toronto	Food and beverage providers soon to be mandated to participate in University sustainability driven policies	**ITEMS:** Compostable and recyclable foodservice items. Did not confirm if bioplastics are used.
		DISPOSAL: Currently no organics/compost collection.
Université de Montreal	n/a	**ITEMS:** Compostable bioplastic items (containers, cups, lids, utensils) and some recyclable plastics.
		DISPOSAL: Limited compost collection, restricted to food facilities.
University of British Columbia	Zero Waste Food Ware Strategy prohibits most single-use plastics and bioplastics.	**ITEMS**: Compostable paper, wood and fibre-based items (either untreated or certified compostable), and recyclable plastic cups and lids.
		DISPOSAL: Compost collection and a composting facility on site.
University of Alberta	Food and beverage vendors must participate in University sustainability initiatives. Polystyrene products are prohibited. Single-use foodservice ware must be recyclable or compostable.	**ITEMS:** Compostable bioplastic or fibre containers and cups, compostable bioplastic cup lids, compostable stir sticks and straws, recyclable utensils.
		DISPOSAL: Compost collection that accepts bioplastics.

University of Ottawa	Disposable cutlery must be compostable	**ITEMS:** Recyclable plastics, some compostable packaging, compostable coffee cups, compostable bioplastic cutlery. Stated that they try to avoid bioplastics.
		DISPOSAL: Compost collection that accepts bioplastics.
Vancouver International Airport (YVR)	Single-Use Plastic Reduction Plan to prohibit most single-use plastics and bioplastics starting January 2022. By 2023, coffee and drink cups will need to be compostable. Food and beverage vendors must use untreated or BPI certified fibre-based products only	**ITEMS**: BPI certified/untreated fibre-based products, plastic coffee cup lids (plastic numbers 1, 2, 5, 6).
		DISPOSAL: Compost collection, and staff are available to sort waste.
Simon Fraser University	Food and beverage vendors must participate and follow the terms of the Re-Use for Good initiative.	**ITEMS**: A mix of plastics, bioplastics (e.g. cutlery), paper and fibre-based items (straws and containers).
		DISPOSAL: Compost collection across campus, but bioplastic cutlery not accepted.

These responses demonstrate a range of approaches to sustainable foodservice ware. Overall, compostable products were featured in all six responses, though some institutions favoured either bioplastics or plant fibre-based items in different instances. UofT and UdeM use at least some compostables, including bioplastics, but did not have adequate disposal systems to compost these products. UofA uses compostables, including bioplastics, which are accepted in the compost stream. OttawaU uses some compostables, including some bioplastics; bioplastics are accepted in the compost stream, but OttawaU tries to avoid bioplastics to reduce consumer confusion and waste stream contamination. UBC and YVR have banned many single-use plastics and bioplastics, and now favour plant fibre-based compostable items and recyclable items.

In addition, the respondents indicated that there are a variety of single-use reduction policies, tools and initiatives taking places across their institutions/businesses. These include: policies requiring food vendors to participate in the university's sustainability initiatives and follow certain foodservice procurement requirements (UofT, UofA); banning certain single-use items, including plastic bottles and disposable coffee cups (UofT, UdeM, UBC, UofA, YVR); providing visual procurement and zero waste guidelines to food and beverage vendors (UBC, UofA); reusable initiatives, including reusable container programs and programs providing reusable dishes to students in university residences (UofT, UdeM, OttawaU); catering and conference services fee structure that charges for single-use items and offers reusable dishes for free (in consideration by UofT); only providing certain single-use items upon request (YVR); and communicating targeted dates for reducing and eliminating single-use items (UofT, UBC, YVR).

Chapter 5.

Discussion

This study builds on conclusions and debates in the literature and provides lessons for bioplastics use and management based in the specific contexts of Greater Vancouver and university campus dining. Moreover, these findings integrate the themes of the circular economy, sustainable packaging and bioplastics, and waste management planning. The following discussion frames our research findings within the recent literature, covering bioplastic feedstocks; standards, regulation, and labelling; end-of-life management; and bioplastic use and role in the circular economy.

5.1. Feedstocks

While using renewable inputs in production processes is a key tenet of the circular economy (Essity et al., 2018; Smart Prosperity Institute, 2019), this study's findings exposed the complexity in the application of this. The circular economy literature consists of goals such as decoupling resource use from economic growth, and of minimizing resource extraction (Lazarevic & Brandão, 2020). In the case of bioplastics, renewable inputs are used; however, their use is accompanied by social and environmental impacts and trade-offs. Furthermore, the types and sources of feedstocks will affect the social and environmental outcomes of bioplastic production, particularly if bioplastic use is scaled up. Stakeholders in this study raised concerns about how bioplastics feedstock production may put pressure on food production and security, as well as the natural environment. These risks are supported by bioplastics LCA studies, which show that substituting bioplastics for fossil-fuel based plastics will require substantial amounts of land and crops (Brizga et al., 2020). The use of waste materials, such as agricultural and forestry residues, is one way to reduce these pressures (Samer et al., 2021) and reduce competition for edible crops. Participants in our study discussed current innovations in this area and expressed support for prioritizing inedible waste materials as bioplastic feedstocks. This would move bioplastics closer to the goal of minimizing resource use. However, care must be exercised in sourcing inputs for bioplastics; just because bioplastics rely on renewable resources does not mean that they avoid the trade-offs and potential negative impacts involved with resource extraction.

5.2. Standards, Regulation, and Labels

The study's findings on bioplastic standards build upon conclusions in the literature. The bioplastics literature asserts the importance of biodegradability standards for reducing bioplastic waste and minimizing environmental impacts (Bhagwat et al., 2020; Lambert & Wagner, 2017; Viera et al., 2020). Our study reaffirmed this conclusion and expanded on it by examining bioplastic standards within the Canadian context. Canada does not follow a specific standard, and product certification is voluntary. Moreover, many available standards are not aligned to the real-world waste management contexts and capacities in BC. In addition to a notable regulatory gap in Canada, this is in part due to discrepancies between the conditions in biodegradability lab tests and real-world compost facilities, which is also documented in the literature (Lambert & Wagner, 2017). Standards are also important for combatting greenwashing and reducing instances of bioplastics not successfully biodegrading in real world conditions (Bhagwat et al., 2020; Viera et al., 2020). Stakeholders from our study exposed the practical consequences of not having enforced and applicable standards, namely that composting facilities must contend with contamination, reduced soil quality and resulting risks to their businesses.

Findings on the importance of bioplastic labelling standards was another outcome from our study. Labels are a mechanism for communicating product characteristics such as what a product is made of, where it should be disposed, how it will break down, and whether it has met biodegradability standards. The types and consistency of labels applied to bioplastics impact their end-of-life management due to consumer understanding of the products (Gerassimidou et al., 2021; Viera et al., 2020) and waste sorting abilities (Wojnowska-Baryła et al., 2020). Through the labelling activity in Workshop 3, this study found that label design affects consumers' likelihood of disposing single-use items in the correct waste stream. However, Canada lacks standards on labelling for bioplastic products. This contributes to consumer confusion about bioplastics and disposal, as within Canada there are a range of labels and terms applied to bioplastic products. It also means that products may be labelled with terms, such as "biodegradable", that do not have corresponding waste stream options in BC.

Clear regulations, labelling, and harmonized standards are also important for successfully procuring sustainable products and reducing waste at universities. Confusion about bioplastics, both on the parts of food vendors and consumers, was raised in multiple cases in the current practice scan. At the same time, universities rely on biodegradability certifications when determining which products to use. Without designated standards and labelling that align with waste management contexts, universities risk procuring bioplastic items that will not break down as promised, and customers risk contributing to waste stream contamination through improper disposal of bioplastics.

5.3. Bioplastics End-of-Life and Management

Reducing waste and recirculating materials are fundamental parts of the circular economy, but these goals are not being achieved in the case of bioplastics. From a technical standpoint, there are several ways to process bioplastic waste at end-of-life. However, the literature does recognize the challenges of managing bioplastic waste in practice, and emphasizes the importance of harmonized legislative frameworks, standards, labelling, and waste management systems (Bhagwat et al., 2020; Gerassimidou et al., 2021; Lambert & Wagner, 2017; Wojnowska-Baryła et al., 2020). Our findings indicate that the necessary bioplastic systems and waste management options do not consistently exist in BC, and as a result, bioplastics are contributing to further waste problems. This was revealed by stakeholders in our workshop through discussions of regulatory gaps, consumer confusion, and current end-of-life management options and concerns. These findings are consistent with observations in other Canadian reports (Compost Council of Canada, 2020; National Zero Waste Council, 2018; Recycle BC, 2019).

These findings also support conclusions in the literature that current end-of-life focused approaches to waste cannot effectively deal with single-use packaging waste (Hawkins, 2012; Silva et al., 2016). In line with calls to incorporate front-end approaches and stakeholder connections within waste management (Silva et al., 2016; Tencati et al., 2016), our study explored EPR, single-use item bans, and product labelling as ways to address the end-of-life challenges of bioplastics through system-level and front-end solutions. Additionally, the process of social innovation reaffirmed the value in communication and collaboration among stakeholders across the supply chain, which can enhance compatibility between product design and waste management.

For universities seeking to reduce their plastic waste, the current status of bioplastic waste management in many places is a barrier to achieving waste reduction through bioplastics. A lack of compost, or compost acceptability, in some cases reviewed in the current practice scan meant that the use of bioplastics was resulting in them being disposed in the garbage. This undermined university efforts to switch to sustainable products. In the cases of UBC and YVR, this issue contributed to a ban on many bioplastic products and a preference for plant fibre-based compostable items, along with pursuit of single-use item reduction in their strategies.

5.4. Bioplastics Use and Circular Economy

Through the course of this study, stakeholders grappled with questions about the role of bioplastics in the circular economy and single-use reduction more broadly. The circular economy aims to divert from the linear take-make-waste model of production and consumption and to minimize waste, albeit according to a variety of visions (EMF, 2017; Lazarevic & Brandão, 2020; Reike et al., 2018; Smart Prosperity Institute, 2019). Our findings suggest that bioplastics are not currently achieving this goal and should not presently be adopted as a circular economy solution to plastic waste. However, beyond the current state, our study reflected a larger ongoing debate about the role of bioplastics in sustainability as they relate to single-use consumption patterns. The circular economy literature exhibits a tension between “win-win” technical solutions, on one hand, and calls to overhaul existing production and consumption patterns, on the other (Lazarevic & Brandão, 2020). Waste management literature also emphasizes the need for waste reduction, which can be achieved through either material recovery or preventing waste generation in the first place (Anshassi et al., 2019; Sicotte & Seamon, 2021; Zaman & Lehmann, 2011). These tensions played out in our workshop discussions, as we explored ways to not only improve the bioplastics system, but also to address single-use culture through single-use product bans and reusable dishes programs. The current practice scan results also demonstrated a growing commitment to single-use item reduction and reusables programs at Canadian universities. Overall, study participants expressed concerns about how using bioplastics as a direct substitute for single-use plastics may undermine efforts to shift societal values in the direction of reducing and reusing.

Chapter 6.

Recommendations and Conclusion

6.1. Recommendations

While bioplastics are produced using renewable feedstocks and have the potential to be compostable, the barriers identified through this project are currently preventing bioplastics from being a sustainable and beneficial way of reducing single-use plastic waste. In addition to the problems with the current bioplastics system and regulatory context, single-use bioplastics also risk replicating the harms and negative patterns of single-use plastics. The following recommendations offer suggestions for prioritizing the circular economy in approaches to bioplastics and addressing the barriers and issues associated with bioplastics, both in the contexts of BC and SFU.

6.1.1. Exercise precaution prior to expanding single-use bioplastic usage, and prioritize reducing and reusing

First, this study recommends that all stakeholders in the bioplastics system exercise precaution prior to expanding single-use bioplastic usage. This is firstly because bioplastic use must be supported by the applicable systems, including standards and waste management, to achieve the desired results and minimize negative impacts. Additionally, disposable bioplastic-use risks undermining efforts to reduce and reuse in accordance with the waste hierarchy. As such, this study also recommends that reducing and reusing be prioritized above single-use bioplastic use. Bioplastics should be integrated in the context of sustainable resource use and reduce initiatives, such as single-use item bans and reusable dishes programs. Prior to adopting single-use bioplastics, stakeholders should explore whether more sustainable alternatives and opportunities for reusable goods are available. Where bioplastics may be an appropriate option, product designs and applications should be critically examined for alignment with sustainability goals. Factors to consider in this respect include the characteristics and technical feasibility of the product, social acceptance, end-of-life options, and available alternatives.

6.1.2. Prioritize non-edible feedstocks

Second, this study recommends that non-edible feedstocks (i.e., residues and waste) be prioritized over edible feedstocks in bioplastic production. As the bioplastics industry grows, it is critical that the ecologically and socially harmful production model underlining fossil-fuel based plastic production is not repeated. It is projected that bioplastic feedstocks will account for 0.020% of global agricultural land in 2025 (European Bioplastics, 2016), and this should continue to be monitored so that food production can be prioritized within agricultural land-use. When both primary crops and residues are used as bioplastic feedstock, it is important to respect biological boundaries, prevent additional ecological stresses, and prioritize ethical labour practices.

6.1.3. Implement standards for bioplastic biodegradability and labelling

Third, this study recommends that the provincial and/or federal governments implement standards for bioplastic biodegradability and labelling. For biodegradability, mandatory standards should be established for bioplastic products to direct the time and conditions required for products to break down, as well as testing methods. These standards must align with available waste management options and real-world conditions in composting facilities. For labelling, standards should be introduced for the terms (i.e., “compostable, “biodegradable”, and “bio-based”), images and logos used to label bioplastic products. This recommendation is imperative in order to reduce consumer confusion about bioplastics, combat greenwashing in the industry, and address bioplastic-related environmental impacts.

6.1.4. Provide direction on bioplastic end-of-life waste stream(s) and responsibility for management

Fourth, this study recommends that the provincial government and/or municipal and regional governments take action to determine which waste stream(s) will accept bioplastics, and who will be responsible for the costs and logistics of managing them; it is also recommended that the option of EPR be explored. These decisions should be informed by collaboration between stakeholders in the research and production stages and waste management professionals who will be managing the waste downstream. The application of an EPR approach is one option for end-of-life bioplastic management. An EPR program for bioplastics would connect upstream and downstream stakeholders and could create accountability for producers and brand owners so that the full life cycle of products, including waste management costs, are factored in at the onset of product development. Furthermore, EPR could encourage innovative product design, high performance standards and continuous learning and improvement for producers and waste management professionals.

6.1.5. Procure foodservice ware and packaging with the goals of reducing waste, consumer confusion, and waste stream contamination at universities

The recommendations outlined in the previous section are key in order for bioplastics to be included in single-use plastic reduction strategies on university campuses. Necessary conditions external to universities include waste streams that accept bioplastics for composting or recycling, compatible standards and labelling, and policies and regulation that enable effective management of bioplastic products. It is imperative that university procurement of foodservice ware items aligns with available waste management options. Internally, university campuses need to ensure that they procure items that meet approved standards and are clearly labelled. Universities must also take responsibility for educating students and other customers about the single-use products they use and providing clear directions for disposal. Concurrently, universities should reduce offerings of all single-use items and promote reusable alternatives where possible. If the above-noted conditions are not present, especially alignment with waste management options, bioplastics are not an appropriate foodservice ware option for universities.

Based on this project's research findings, this study recommends that SFU select foodservice ware items with the goals of reducing waste, consumer confusion, and waste stream contamination. Unless SFU's waste hauler and processors explicitly accept compostable bioplastics for composting, it is recommended that SFU no longer use compostable bioplastic items; continued use of compostable bioplastics would lead to waste stream contamination and plastic waste accumulation. With the goal of waste reduction in mind, SFU should also avoid using bioplastics that are simply bio-based or labelled as 'biodegradable'. If certain compostable bioplastic products are accepted for composting by SFU's waste service providers, SFU should prioritize clear labelling and messaging about disposal for compostable bioplastic items. SFU should also continue to build upon the work of Re-use For Good in its efforts to reduce operational waste and eliminate single-use items.

This study provides the following specific recommendations (Table 3) for SFU in the areas of procurement, communications, and single-use reduction.

Table 3 Recommendations to SFU

Procurement
1. Align SFU foodservice ware packaging and products with what is accepted by SFU's waste haulers and compost processors. Do not use any compostable products, including bioplastics, that are not accepted for composting by waste haulers and processors.
2. When procuring compostable items, select products that meet or exceed compostability certifications.
3. Select compostable items that minimize confusion about disposal, and prioritize items that have clear labelling and direction for where they belong (e.g. labelled 'compostable' instead of bio-based, plant-based, or biodegradable).
4. Update SFU Dining Service's procurement policy to reflect SFU's commitment to procuring compostable products that are accepted by waste haulers and processers; more specific and current guidance on acceptable and unacceptable items; the changing context of single-use packaging, given single-use item bans and the latest findings about compostable plastics.
Communication
5. Provide clear and consistent guiding information about foodservice ware items and packaging to SFU food vendors, and ensure guidance is aligned with updates to SFU's procurement policy and what is accepted by SFU's waste haulers and processors.
6. Continue providing clear communications to students about how to dispose of different products.
Single-use item reduction
7. Develop SFU Dining Services targets for single-use item reduction and elimination, which can be communicated to the SFU community.
8. Reduce offerings of single-use items at SFU by introducing a "by request" policy for certain single-use items, such as disposable cutlery, and by encouraging customers to bring their own reusable dishes.
9. Continue moving forward with reusable programs, such as reusable container and mug-share programs, at SFU.

6.2. Conclusion

Plastic waste from single-use packaging and foodservice ware is an environmental problem of growing significance, yet alternatives must be closely considered so that issues of resource extraction and waste creation are not repeated. Bioplastics, which consist of bio-based and biodegradable plastics, have the potential to replace some single-use plastic items in the food system, including on university campuses, and are being considered as one path away from petroleum-based plastics. However, bioplastics have social and environmental challenges of their own. This study used a social innovation approach to assess bioplastic food packaging and takeout items from a systems perspective, as well as a current practice scan to identify how Canadian universities are approaching bioplastics within sustainability and waste reduction dining strategies. The results from this study included a system-wide understanding of the barriers to sustainable bioplastic use, evaluations of potential solutions, and lessons for waste reduction in university dining contexts. Based on the findings, this study emphasizes the importance of systems, such as legislation, waste infrastructure, and stakeholder communications, for minimizing the negative effects of bioplastics and reaching circular economy goals. This study recommends that bioplastic feedstocks account for food and resource concerns, that harmonized and mandatory standards for bioplastics be implemented, and that responsibilities for bioplastic waste management be established. Furthermore, this study recommends that SFU aligns their dining services procurement with existing waste systems, and that communications and single-use item reduction be prioritized within sustainability initiatives. Finally, this study recommends that reducing and reusing be adopted as the primary responses to the plastic waste crisis. With the proper systems in place, and in cases where re-use and reduction are not possible, bioplastics may be an appropriate single-use alternative to fossil-fuel based plastics. However, bioplastics must not be treated as a reason to replicate the model of taking, making and wasting at unsustainable levels.

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