Exploring Barriers in Promoting Circular Economy Practices: Insights on Consumer Durable Goods in Remote and Indigenous Communities In Newfoundland and Labrador

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Abstract

Consumer durable goods (CDGs), including appliances and electronics, are a major driver of global waste and create challenges for remote and rural communities—both Indigenous and non-Indigenous—due to limited waste management infrastructure. While urban areas have well-established recycling and disposal systems, rural and Indigenous communities lack these resources, accumulating waste that could otherwise be repurposed or recycled. This issue is exacerbated by restricted access to repair services, high transportation costs, and the widespread impact of planned obsolescence.

This research examines opportunities and limitations to the adoption of circular economy (CE) principles for CDGs in two Newfoundland and Labrador (NL) communities: Harbour Main, a remote non-Indigenous community, and Conne River, a Mi'kmaq First Nations community. Using a qualitative research approach, semi-structured interviews were conducted with community members, garbage collectors, and band council members to understand their waste disposal behaviors, repair and reuse practices, and the economic and cultural factors influencing product lifespan decisions.

Using grounded theory, themes were developed through the analysis of primary research data using ATLAS.Ti software. The findings revealed three major categories of barriers: logistical, attitudinal, and cultural, resulting in seven key themes. These include the inaccessibility of repair services, the high costs associated with transportation and repairs, the impact of planned obsolescence, the affordability of new goods compared to repairs, and the decline of TEK in

managing waste. Participants also highlighted the need for community-driven initiatives and policy support to improve waste management practices in these regions.

By analyzing broader consumption trends at the community-level impacts, this research identifies if there is an opportunity to integrate Traditional Ecological Knowledge (TEK) with CE strategies, adapting resource efficiency, waste reduction, and environmental sustainability. The findings emphasize the need for targeted infrastructure investments and inclusive policies supporting remote and Indigenous communities adopting CE practices. Addressing these challenges is essential for promoting equitable participation in sustainability efforts and enhancing environmental and economic resilience in rural and remote regions.

General Summary

Indigenous communities have a longstanding tradition of living in harmony with the land, sustainably managing resources through practices deeply rooted in Traditional Ecological Knowledge (TEK). Their approach to environmental stewardship is through conservation, reuse, and minimal waste that respects and conserves natural resources for future generations. However, the growing dependence on Consumer Durable Goods (CDGs), such as household appliances and electronics, has posed significant challenges to sustaining these traditional practices. Unlike traditional tools made from locally available, biodegradable materials, modern CDGs are made from complex technological components, including plastics, metals, and hazardous materials. These elements pose significant challenges for repair, recycling, and sustainable disposal.

This thesis explores whether integrating TEK with CE strategies can support sustainable CDG waste management in Newfoundland and Labrador. Using a qualitative, community-based participatory approach, interviews in Harbour Main and Conne River revealed systemic barriers, logistical and financial limitations, and a lack of repair services. Many participants found repairs costly and impractical, leading to increased waste. Addressing these challenges requires infrastructure investments and community-led initiatives.

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Preface

This thesis has been structured as a series of manuscripts presented in Chapter 2 and Chapter 3. Due to the manuscript-based format, some repetition of material is unavoidable.

Chapter 2 Atabakifardtehrani, Y., Sarkar, A., & Shetranjiwalla, S. Integrating Traditional Ecological Knowledge into a Circular Economy Framework using the example of Consumer Durable Goods for Northern Rural Communities
This manuscript was accepted by the Royal Society of Chemistry (RSC) sustainability journal and is currently in the press.

Chapter 3 Atabakifardtehrani, Y., Sarkar, A., Shetranjiwalla, S., John, A., Pujari, A., & Fairbridge, N.
Exploring Barriers in Promoting Circular Economy of Consumer Durable Goods in Remote and Indigenous Communities in Newfoundland and Labrador

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List of Abbreviations

CDG – Consumer Durable Goods

CE – Circular Economy

DIY – Do It Yourself

EPA – US Environmental Protection Agency

EPR- Extended Producer Responsibility

ISO- The International Standards Organization

LCA – Life Cycle Assessment

MSW – Municipal Solid Waste

NCC – Nature Conservancy of Canada

NL – Newfoundland and Labrador

NRRCs- Northern, Rural and Remote Communities

OECD – Organization of Economic Cooperation and Development

POPs- Persistent Organic Pollutants

RL- logistics systems

SGS – Sustainable Development Goals

SMEs – Small and Medium-sized Enterprises

TEK – Traditional Ecological Knowledge

UN – United Nations

Chapter 1: Introduction

1.1 Background and Rationale

Consumer Durable Goods (CDGs), including household appliances, electronics, furniture, etc., are essential in modern economies but pose significant environmental and economic challenges. Products over three years of lifespan are classified as CDGs by the US Environmental Protection Agency (EPA) definition and contribute significantly to municipal solid waste (MSW), leading to pollution, resource depletion, and environmental degradation (US EPA, 2017a).

As planned obsolescence has increased, new technology has become less durable, favoring short product lifespans, leading to increased waste generation, reduced repairability, and a heightened dependency on virgin materials (Nes & Cramer, 2006). Moreover, many of these products contain toxic substances, such as heavy metals and flame retardants ("Electronics," n.d.). For instance, due to the ineffective management of e-waste, valuable resources are lost; toxic and hazardous substances are released into the local environment, contaminating the global climate by releasing Persistent Organic Pollutants (POPs) and mercury and posing health risks to the informal workers and communities nearby toxic waste dumps ("Electronics," n.d.).

In 2018, in the US and Canada, 57 and 36 million tons of MSW were generated, where waste from CDGs contributed 20% and 36% of the overall MSW, respectively (Jairo Yunis & Elmira Aliakbari, 2021; US EPA, 2017c). In Canada, particularly in NL, waste management challenges are exacerbated by geographic isolation and limited infrastructure (MMSB, 2022).

The Canadian government's solid waste diversion report measures the generation, recycling, composting, combustion, energy recovery, and landfilling of these materials from the CDGs in

MSW. In 2022, Canada's national solid waste diversion rate stood at 27.1%, meaning that just over a quarter of all municipal solid waste was kept out of landfills through recycling, composting, and other recovery processes. However, NL had the lowest diversion rate in the country at just 11.4%, falling well below the national average (Environment and Climate Change Canada, 2024).

A key factor contributing to NL low waste diversion rate is the structural and logistical challenges that hinder effective waste management and recycling efforts. Unlike urban areas with advanced recycling infrastructure and CE initiatives, geographic dispersion, economic factors, logistics and distance of communities from recycling and repair facilities, and limited access, contribute to waste being buried in landfills in NL (Waste Management In Remote Rural Communities Across The Canadian North: Challenges And Opportunities, 2018). In this context, systemic obstacles to a more sustainable development path call for localized, community-based solutions that apply CE concepts but consider the province's specific socio-economic and environmental barriers. This underscores the importance of exploring CE strategies tailored to rural and Indigenous communities, where traditional resource management practices and community resilience could serve as a foundation for a more sustainable approach to waste management.

The CE is a global paradigm shift that presents a viable alternative to the predominant linear "take-make-waste" model by promoting sustainable practices that emphasize resource efficiency, waste reduction, and the longevity of resources (Bakker et al., 2014). Although CE strategies have become a growing area of interest, their practical application is lacking, particularly in rural and Indigenous communities, where geographic isolation, poor infrastructure, and socio-economic limitations impede sustainable waste management. The low diversion rates mentioned above stem

from limited access to repair services, recycling facilities, and sustainable disposal options, making the adoption of CE principles particularly difficult.

1.2 Circular Economy and Sustainable Solutions

The International Standards Organization (ISO) defines the CE as an economic system that is embedded within the social and environmental systems, and that maintains a circular flow of resources by recovering, retaining, or adding to their value while contributing to sustainable development (ISO 59004:2024 (En), Circular Economy — Vocabulary, Principles and Guidance for Implementation, n.d.).

CE advocates the modularity of the product, as well as the design for disassembly, as critical to the diminution of electronic and durable goods waste (Mallick et al., 2024). For example, in home appliances such as refrigerators and washing machines, modular components enhance the ease of repair, replacement of parts, and recycling, reducing the amount of waste generated. Reverse logistics systems (RL) are foundational to operationalizing this approach, keeping CDGs in circulation rather than prematurely disposed of (Mallick et al., 2024). A real-world application of RL can be observed in the European Union's Extended Producer Responsibility (EPR) framework, encouraging furniture and appliance manufacturers to take back used products for refurbishment and resale (Planned Obsolescence, n.d.).

Despite increasing concerns about sustainability, CE principles remain primarily absent in CDG manufacturing and disposal, intensifying environmental degradation and resource depletion. (Milios, 2018) One of the challenges of implementing CE is ensuring that marginalized communities, particularly remote and Indigenous populations, have equitable access to sustainable infrastructure and policy support. These populations often lack specialized repair facilities, recycling programs, or sustainable means of disposal, resulting in limited options and a tendency

to landfill CDGs.((13) (Pdf) Waste Management In Remote Rural Communities Across The Canadian North: Challenges And Opportunities, 2018) These Challenges conflict with Traditional Ecological Knowledge (TEK), which emphasizes environmental stewardship and sustainable resource use (Whyte, 2013).

Although CE frameworks have been developed to encourage waste minimization, resource efficiency, and product longevity, limited research has been conducted specifically regarding public perception, consumer behaviors, and socio-economic barriers in remote and Indigenous communities (Cooper, 2016).

1.3 Traditional Ecological Knowledge

Traditional ecological knowledge (TEK) is the accumulated knowledge and practices of local communities that are rich in culture, customs, and environmental sensitivity, which are passed from generation to generation and evolve with the changes in the community (Houde, N., 2007). TEK emphasizes the interconnectedness of all living beings and the importance of living in harmony with nature (Whyte, 2013).

In Canada, TEK is being increasingly recognized and incorporated as part of the Canadian environmental management and conservation effort. The Indigenous communities collaborate with scientists and policymakers to integrate their time-honored practices and observations into climate change solutions and sustainable resource management. Nature Conservancy of Canada (NCC) has forged partnerships with Indigenous Peoples, combining Western scientific approaches with traditional knowledge in conservation projects.

Studies show that Indigenous knowledge can inform sustainable land and resource management, fostering community-driven ecological balance (Jiraphanumes & Sansompron, 2024). Moreover,

Indigenous worldviews encourage regenerative perspectives regarding optimal resource use, which complements CE strategies (Rocasolano, 2024). However, TEK has been largely absent from mainstream CE policy discussions, highlighting a critical need for Indigenous perspectives to be included in CE frameworks.

1.3 Study Objectives

This study aims to identify the barriers and challenges in promoting a CE for CDGs in remote and Indigenous communities of NL. To contribute to a sustainable and inclusive CE model, the study will integrate Traditional Ecological Knowledge (TEK) and community voices to develop a comprehensive framework. The following objectives of the study are shown in the table below:

Table 1. Research Objectives

Objective Number	Objective Description
1	To identify the barriers and challenges in the current 'take-make-waste' linear economy that hinders recovery, reuse, and regeneration in CDGs.
2	To determine the current/dominant product design's negative impacts on the community in the current linear economy.
3	To explore how TEK can contribute to understanding the impacts of waste from CDGs.
4	To develop an inclusive CE framework based on insights from remote and Indigenous communities to guide the waste management of CDGs.

1.4 Outline of Thesis

Chapter 2 provides a thorough literature review on CDGs and CE. It reviews the nature of the contribution of CDGs to households' municipal solid waste (MSW) management in NL and highlights the low waste diversion rates in rural and Indigenous populations. The review identifies barriers to CE adoption, including limited access to recycling infrastructure, economic constraints, and socio-political limitations.

Chapter 3 presents original research conducted in Indigenous and non-Indigenous communities in NL. This study explores public perceptions regarding the management of CDGs, particularly in the context of circular economy principles and sustainable waste practices. Through qualitative interviews, participants provided insights into repairing, reusing, recycling, and discarding CDGs. These findings deepen our understanding of the barriers and facilitators for adopting CE approaches in community contexts, contributing to developing localized, culturally relevant solutions for CDG management.

Chapter 2 and chapter 3 are manuscripts written that include their own introduction, methods, results, discussion and conclusion sections.

Chapter 4 addresses the general discussion and conclusion, limitations and scope for future work in this research study.

Chapter 2:

Integrating Traditional Ecological Knowledge into a Circular Economy Framework using the example of Consumer Durable Goods for Northern Rural Communities

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Yasamin Atabaki: Investigation, Methodology, Analysis, Writing. Atanu Sarkar: Review and Editing. Shegufta Shetranjiwalla: Review and Editing.

Abstract

Consumer Durable Goods (CDG)s has a large energy and water footprint during their lifecycle and are one of the largest contributors to municipal waste on disposal. While CDG waste becomes invisible for consumers in urban communities, due to a relatively well-established waste management infrastructure, it is inequitable in rural communities where deteriorating/decomposing goods remain on native lands/landfills and pose a risk to people and ecosystems. Therefore, a sustainable approach that emphasizes resource efficiency, waste reduction and an inclusive framework for CDGs design, use and circularity is imperative. This manuscript examines the circular economy (CE) as a promising approach for CDGs in the Canadian context, where there are unique geographical challenges, particularly in remote, rural, and Indigenous communities with limited recycling and repair infrastructure. It carefully regards the integration of Traditional Ecological Knowledge (TEK) in developing sustainable strategies for circular materials management of CDGs to mitigate these challenges. This critical analysis explores global and national consumption trends and translates them to local knowledge gaps to

reveal the barriers to effective adoption of CE practices and identifies the opportunities and challenges in integrating TEK in CE for CDGs in the remote and rural communities. It also provides recommendations and insights into how CE principles infused with TEK and Indigenous wisdom can address UN SDGs 10, 11, 12, 13, 14, 15 and 3 globally and help build capacity to support local solutions for waste reduction, resource efficiency, improved community economy and environmental health of remote and rural communities.

1. Introduction

According to the US Census Bureau (Bureau, n.d.), consumer spending is the largest driver of the economy, contributing billions of dollars to the world economy with significant power to directly impact jobs and tax revenue. The six-year annual revenue trends for the Organization of Economic Cooperation and Development (OECD) consumer expenditure and emerging economies such as China and India in Asia show that consumer expenditure is consistently growing globally (Table 2) (Statistics - Euromonitor: Passport, n.d.). Table 3 includes Canada's household final consumption expenditure data. Personal expenditure on durable goods includes house trailers, new and used automobiles, furniture, household appliances, radio and television sets and sporting and wheeled goods. This data provides a clearer understanding of spending trends within Canadian communities, complementing the global context presented in Table 2.

Table 2. Growth trend in annual revenue from consumer expenditure for consumer durable goods in OECD and emerging economies (India and China)

Countries	**Revenue from Consumer Durable Goods (USD, In Billions) ***					
	2017	**2018**	**2019**	**2020**	**2021**	**2022**
OECD	2441	2540	2605	2658	3104	3456
India	38	43	41	41	52	59
China	525	564	598	592	674	698

* *Fixed 2022 Exchange Rates*

Table 3. Household Final Consumption Expenditure

Chained (2017) Dollars (In Billion Canadian Dollars)						
Country	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Canada	644.11	662.14	663.17	613.62	673.15	674.27
Source: (S. C. Government of Canada, 2012)						

Durable goods are products that have a lifetime of more than three years as defined by the US Environmental Protection Agency (EPA) (US EPA, 2017b). Consumer durable goods (CDGs) (such as refrigerators, televisions, washing machines, vacuum cleaners, etc.) constitute a large part of the consumer expenditure worldwide. The CDGs market is a major driving force in the economy, and businesses benefit from increased manufacturing, transportation, sales, profits and taxes when consumers spend more (Consumer Spending, n.d.). These include large and small appliances, furniture/furnishings, rubber tires, lead acid batteries, electronics and miscellaneous durable goods such as luggage, sporting goods and household goods. For long lasting function and durability, CDGs are made with materials that include wood, metals, plastics, glass, paper and paperboard, rubber, leather and other miscellaneous inorganic and organic wastes (US EPA, 2017c). The US EPA and the solid waste diversion report by the Canadian government measure the generation, recycling, composting, combustion, energy recovery and landfilling of these materials from the durable goods in the municipal solid waste (MSW) (E. and C. C. Canada, 2015). The data from these measurements indicate that the waste management of these goods and materials requires strategic sustainable materials management, planning and reporting (E. and C. C. Canada, 2015; US EPA, 2015). Table 4 shows the categories of CDGs and their associated generation, landfilling and recycling as characterized in 2018 by the US EPA.

Table 4. Consumer durable goods categories and their waste management data (Source: Author)

CDG Category	Example Items	Recovered items	Generated (Million tons)	Recycled (Million tons, %)	Landfilled (Million tons, %)	Comments
Major Appliances	Refrigerators, washing machines, water heaters	Ferrous metals, plastics,	5.3	3.1 58%	2.1 40%	Not accepted for combustion or composting with energy recovery
Small Appliances	Toasters, hair dryers, electric coffee pots	Not Provided.	2.2	0.12 5.6%	1.6 75.9%	To recover energy, an insignificant number of small appliances were combusted (18.5%).
Furniture & Furnishings	Sofas, tables, chairs, mattresses	Potential unmeasured recovery of wood, textiles and metals	12.1	0.04 0.3%	9.7 80%	To recover energy, significant number of furniture was combusted (19.5%).
Carpets & Rugs	Carpets	carpet fiber, backing and padding	3.4	0.31 9.2%	2.48 73%	To recover energy, a slightly larger number of carpets and rugs were combusted (17.8%).

Vehicle tires	Only included tires from passenger cars, trucks and motorcycles	rubber, steel, fiber and nylon	6.5	2.61 40%	1.2 18.5%	Tires used in large equipment, aviation or industrial applications are not included. Tires recovered for fuel are not included Tires going to combustion facilities as fuel were included in the combustion estimates.
Lead Acid Batteries	lead-acid batteries from automobiles, trucks and motorcycles	some electrolytes and other materials in batteries from solid waste, along with recovered lead and polypropylene	2.9	2.87 99%	<1%	Lead acid batteries are not accepted at combustion facilities.
Consumer Electronics	Computers, TV, video cameras, DVDs, VCRs, stereo systems	Not Provided	2.7	1.04 38.5%	N/A	EPA does not currently have information on the amount of selected consumer electronics that were sent to landfills. These products are included in Total Miscellaneous Durables.
Total Miscellaneous Durable Goods	consumer electronics such as television sets, videocassette recorders, personal computers,	ferrous metals, as well as plastics, glass, rubber, wood and other metals	24.8	1.5 6%	20 81%	—

	luggage and sporting equipment.					

In 2018, in the US and Canada, 57 and 36 million tons of MSW were generated, where waste from CDGs contributed 20% and 36% of the overall MSW respectively (Jairo Yunis & Elmira Aliakbari, 2021; US EPA, 2017b).

All member states of the United Nations (UN) adopted the 2030 Agenda for Sustainable Development in 2015, providing a blueprint for peace and prosperity for people and the planet, now and in the future. The 17 Sustainable Development Goals (SDGs) are at its heart. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth, while tackling climate change and working to preserve our oceans and forests (THE 17 GOALS | Sustainable Development, n.d.). From Table 4 it is evident that the large appliances have a large generation and landfilling footprint and are also dependent on energy resources for their use without contributing to energy recovery by combustion. These have direct implications for the UN SDGs 12 (responsible consumption and production), 7 (clean and affordable energy) and 13 (climate action) and provide opportunities to redesign renewable energy CDGs with an equitable, circular, regenerative model keeping both rural and urban communities in mind.

Preventing and diverting waste by reusing, repairing, refurbishing, remanufacturing, repurposing, recycling and composting is a key component of a more circular economy which can help reduce the impact of solid waste on the environment (E. and C. C. Canada, 2015). In Canada, although the diversion rate of MSW from landfills has increased consistently since 2002, the province of

Newfoundland and Labrador (NL) showed the lowest diversion rate at 11.4%, (Jairo Yunis & Elmira Aliakbari, 2021) compared to Ontario and Quebec which had the highest diversion rates at 25% and 33% respectively (Jairo Yunis & Elmira Aliakbari, 2021). Although this seemingly appears to be a consumer and waste management failing, it requires a deeper insight into the population demographic, geographical location and the systemic understanding of the rural *versus* urban waste management criteria and the inequities associated with waste management in northern rural communities that result in these statistics. These statistics impel a more circular, equitable and proactive approach to design of materials that make up CDGs of ubiquitous use, especially for an inclusive net-zero transition by 2050.

Due to increasing affordability, the CDGs are more accessible to consumers, which has resulted in an increase in demand and manufacture (Table 2) (Bureau, n.d.). With the growing influence of the CDGs industries on the economy, there are significant influences this sector has on businesses, policymakers, and societies in general. Therefore, understanding the drivers and trends of the CDG sector and their resource, environmental and health impacts along the product life cycle is critical (*Consumer Spending*, n.d.). The Ellen MacArthur Technical Cycle is particularly useful in understanding how CDGs can be maintained, repaired, reused, refurbished, remanufactured, and ultimately recycled within the technical cycle of the CE (Figure 1). This model emphasizes extending product life through repair, refurbishment, and second-hand markets before final recycling (*What Is a Circular Economy? | Ellen MacArthur Foundation*, n.d.).

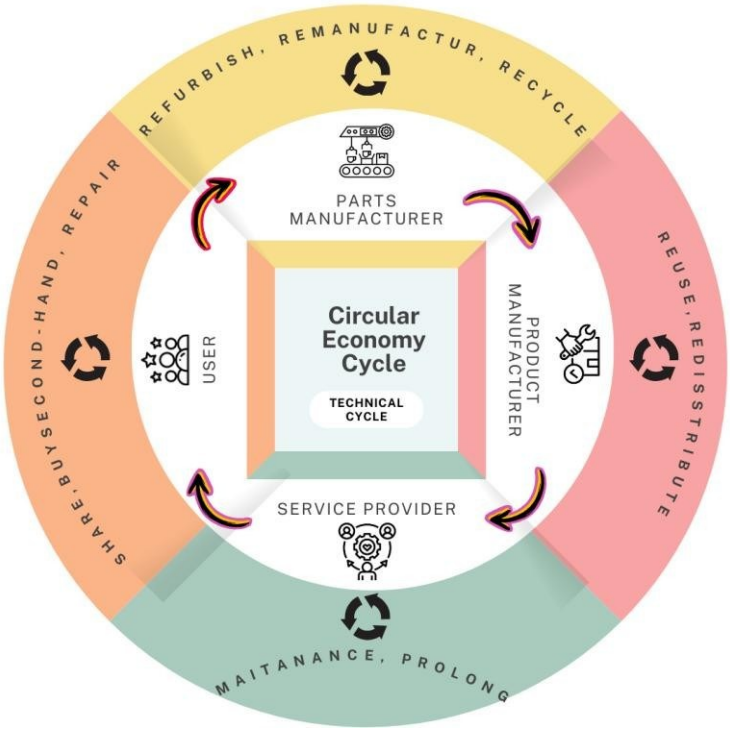

Fig.1. The Circular Economy Product Technical Cycle (Source: Author)

The Inner Circle shows the power of CE to keep products, materials, and resources circulating within a local system through repair, reuse, and remanufacturing to minimize resource extraction and waste. This principle is especially relevant to rural and Indigenous communities, wherein TEK has encouraged resource conservation, localized repair economies, and sustainable craftsmanship (Kirchherr et al., 2017; Moreau, V., Sahakian, M., van Griethuysen, P., & Vuille, F., 2017).

Studies show that Indigenous circular practices resonate with closed-loop systems, reducing dependency on external supply chains (Winans et al., 2017). In rural settings, community connections enable sharing, repairing, and refurbishing durable goods in line with inner-circle waste minimization and value preservation principles (Ghisellini, P., Cialani, C., & Ulgiati, S., 2016). These practices contrast with conventional linear economic models and highlight the sustainability benefits of localized circular systems.

Enhancing policy support for CE transitions in rural and Indigenous regions will require scaling up local repair economies, revitalizing traditional craftsmanship, and building the inclusion of TEK-based models into mainstream circular economy strategies (Lacy & Rutqvist, 2015). Strengthening these practices aligns with global CE goals while respecting Indigenous self-sufficiency and sustainability principles.

The CDG product life cycle (Fig. 2) includes the (i) beginning of life that includes both the design and production stages, (ii) the middle of life cycle which includes the use and second life stages and (iii) end-of-life stage that includes the disposal.

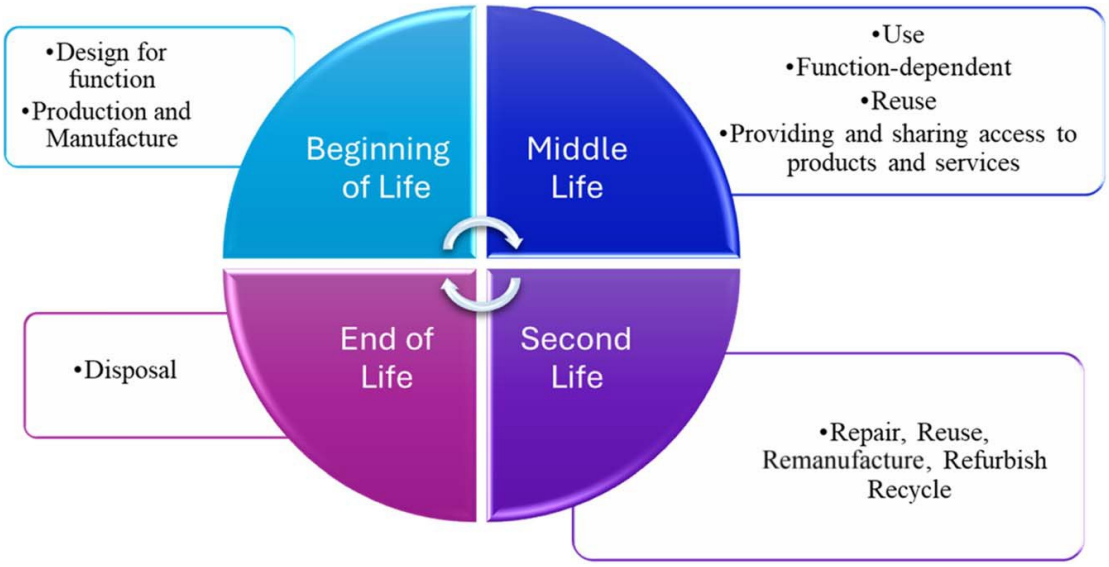

Figure 2. The typical life cycle of consumer durable goods (Source: Author)

Current CDGs product design in the beginning of life phase and market strategies that maximize profitable production and sales in the use phase, accompanied with planned obsolescence just beyond the mandated three years that denies a second product life are becoming common (Bureau, n.d.). The latter further encourages modular designs in the beginning of life that prevent convenient repairs to promote the purchase of new products made from virgin materials (What Is a Circular Economy? | Ellen MacArthur Foundation, n.d.). These stratagems have led to an

intentionally reduced product shelf life to increase sales of newer products without any extended producer responsibility (EPR) (Jairo Yunis & Elmira Aliakbari, 2021; Mayers et al., 2005). Without any known mandate regarding discarded products mandatorily getting back to the producers, all disposed products ultimately end up in landfills at the end-of-life stage (UN SDG 12) causing severe ecological damage (Katherine Monahan, 2018). These have amplified impacts on traditional food sources (UN SDG 3) that become contaminated from leached metal and plastic additive pollutants emerging from the disposed CDGs leading to adverse effects on local ecosystems including water, soil and air (UN SDGs 14, 15 and 13). Ultimately, these impacts are biomagnified to species and humans living in the surrounding areas where vulnerable populations in the remote and rural communities (UN SDG 10 and 11) without access to advanced waste management systems are most inequitably affected. Mitigating these collateral consequences calls for a circular, sustainable approach to the management of CDGs in their end-of-life stage with a proactive innovative redesign stage that minimizes their adverse impacts throughout all the life cycle phases of the CDGs.

Another innovative measure that can influence the design stage is to include already existing knowledge that is local and environmentally sensitive. The Indigenous people living in remote locations have traditional ecological knowledge (TEK) and use for their daily decision making. They have used this knowledge to make tools for daily usage in local environments that work in a symbiotic manner with their surroundings. Since TEK emphasizes the interconnectedness of all living beings and the importance of living in harmony with nature,(Whyte, 2013) it can contribute towards sustainable resource management, waste reduction, and energy efficiency and be a source of inspiration at the design stage of the CDG life cycle (Houde, 2007).TEK can also guide the selection of materials and products that can be both accessible and equitably used by the

communities at the end-of-life stage of a CDG without having to discard the product entirely UN SDG 12). This extends product shelf life and potentially serves to reduce greenhouse gas (GHG) emissions, promoting energy efficiency, and enhancing local resilience to climate change (SDG 13) (Houde, 2007; Kellam, M., Talukder, S. K., Zammit-Maempel, M., & Zhang, S., 2020).

One of the challenges of implementing CE is ensuring that marginalized communities, particularly rural and Indigenous populations, have equitable access to sustainable infrastructure and policy support (Murray et al., 2017). This study advances the discussion by showing how localized, TEK-driven CE strategies can bridge this gap, fostering a more contextually sensitive approach to sustainable consumption and production. This review aims to focus on the strategic application of CE principles to the life cycle management of CDGs in the context of northern and rural Canadian communities by highlighting the need to integrate TEK principles for an inclusive and just transition towards net-zero. It compares the global and Canadian contexts of two life cycle stages of CDGs, the design and production and the use stages to identify the barriers to circular and sustainable systems in particular for the northern remote rural communities inhabited by predominantly Indigenous people.

2. Circular Systems and the Circular Economy

The International Standards Organization (ISO) defines the Circular Economy (CE) as an economic system that is embedded within the social and environmental systems (Fig 3) and that maintains a circular flow of resources, by recovering, retaining or adding to their value, while contributing to sustainable development (ISO 59004:2024(En), Circular Economy — Vocabulary, Principles and Guidance for Implementation, n.d.). ISO recently introduced the first standard for CE, the ISO 59004, which provides the above international definition of the circular economy and identifies six complementary and interconnected principles of (i) systems thinking, (ii) value

creation, (iii) value sharing, (iv) resource management, (v) resource tracking, and (vi) ecosystem resilience within the three circular systems that are interdependent (Fig 3). The economic system is nested primarily within the social system that are both encompassed by the planetary environmental system (Fig 3), clearly demonstrating that the social system and the economic system can only exist within a healthy environmental framework.

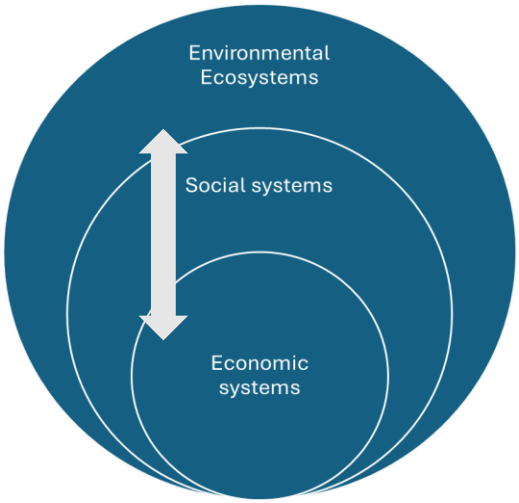

Figure 3. The interdependent circular economic, social and environmental systems for sustainable development (Source: Author)

The CE principles impel the use of various complimentary tools for evaluating threats to the planetary boundaries including biodiversity, resource and energy flows. The CE Standard encourages the use of life cycle assessment (LCA) at all stages of product and process life cycles to cross these principles. One check to evaluate the resource flows is to ensure that virgin resources and extraction for production are kept as low as possible and energy flows are also circularized to minimize waste, losses and release from the economic system, leading to both social and environmental benefits. A successfully implemented, quantified circular economic system then amplifies the three pillars of sustainability positively.

Circular Economy places a high value on products, materials and energy conservation. It differentiates between end-of-life mechanisms for materials that can and cannot be processed or decomposed by living organisms (WCEF2021 Summary Report, 2021). It classifies the former as biological materials and the latter as technical materials (Fig 4). Since decomposition by living organisms such as microbes, divert waste whereas the technical materials need processing either in a landfill or in the process of re-design for CE, the main outcome for these classes is to minimize resource leakage (Ellen MacArthur Foundation, n.d.). Applying the CE priorities from ISO 59004 to technical materials such as CDGs prioritizing concepts of refuse, rethink, source, reduce, repair, reuse, refurbish, remanufacture, repurpose, cascade, recycle, recover energy, and re-mine are essential (Introducing the New ISO Standards for the Circular Economy, n.d.).

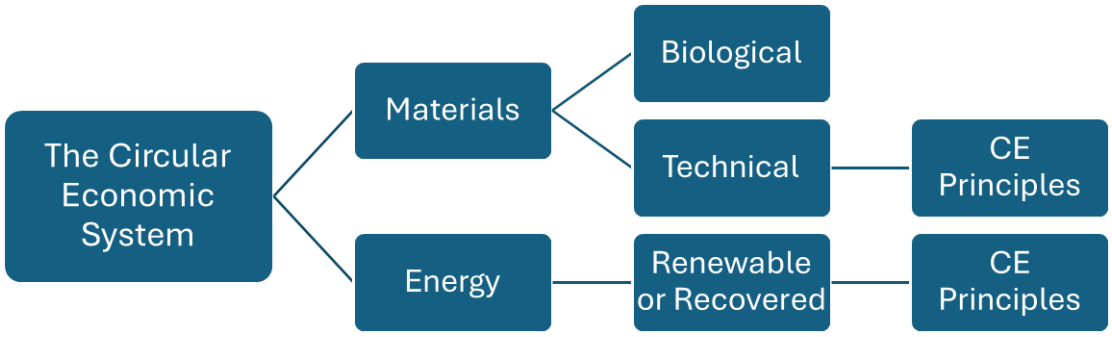

Figure 4. The Circular Economic System (Source: Author)

2.1 Consumer Durable Goods and their Life Cycle in the Circular Economic System

Mass production and growing prosperity in the 1950s led to the development of the modern consumer society, encouraging the 'consume and throw away' mentality. It encouraged consumption and planned obsolescence to sustain consumption. Planned obsolescence is an intentional production of goods and services with short productive and economic lives, stimulating

consumers to repeat purchases frequently, (Planned Obsolescence: Exploring the Issue., 2016) increasing consumer debt, especially among the most vulnerable. Short product life also affects product quality; for example, battery failure in electronic devices such as smartphones, outdating of operating system updates and older models slowly becoming non-functional over time (WEEE Directive on Waste Electrical and Electronic Equipment., 2012). despite their materials being robust and useful. Also, large appliances like entire washing machines become useless when one part fails, for example, when the sealed drum has issues, it becomes economically unfeasible for the consumer to repair or replace it, decommissioning the entire machine.

A circular system does not replace traditional systems but aims to include *reducing*, *recycling*, and *recovering* in current traditional systems, eventually taking the conservation of natural resources as a starting point in which economic, social, and environmental values are incorporated in every part of the system (Sarkar, 2022). In preparation for the production phase of the life cycle, (Figure 2) materials are mined and extracted from the earth, which are eventually discarded as waste (What Is a Circular Economy? | Ellen MacArthur Foundation, n.d.). Reintroducing the materials in the production phase of the life cycle again using a CE approach is expected to reduce the burden on mining and extraction and associated environmental, social, and economic harm and loss (Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017; Geng, Y., Sarkis, J., & Ulgiati, S., 2016; Ghisellini, P., Cialani, C., & Ulgiati, S., 2016; Millar, N., McLaughlin, E., & Börner, J., 2019; Walzberg J, Lonca G, Hanes RJ, Eberle AL, Carpenter A and Heath GA, 2021). Circular products and systems can be designed to prevent planned obsolescence in the production stage by ensuring a better, durable product design, by providing the consumer with useful information and by standardizing technical designs for the benefit of the consumer in the use phase, and introducing cost-efficient reparability of products in the second life stage (Planned

Obsolescence: Exploring the Issue., 2016). For this stage, the existing models for CDGs design are not conducive to repair and reuse due to the modular design and proprietary nature of production methods. The training and infrastructure required for repair and recycling are lacking, especially in less densely populated communities. Therefore, improving access, equity, capacity, and other logistical resources is crucial for CE to be successfully adopted in these communities.

3. Challenges with CDGs in the Current Linear Economy

3.1 Environmental Challenges from CDGs

Just as the waste from discarded CDGs such as refrigerators, washing machines, dryers, heaters, or mattresses lie visibly on the land due to the inaccessibility of recycling and recovery facilities, particularly in remote locations, the toxic burden from hazardous elements also adds undesirable adverse impacts (Katherine Monahan, 2018). The contamination of local terrestrial and aquatic ecosystems and biomagnification of the contamination in food chain particularly affect Indigenous people who rely upon local traditional land-based and marine food. Electronics and large and small appliances, among other consumer durables, have raised significant concerns regarding human health and the environment. For instance, electronic waste (e-waste) from products like smartphones and electronic parts in large appliances contains hazardous substances that pose serious health risks, including neurological damage, kidney disease, and cancer (Robinson, B. H., 2009). Local garbage collectors and workers who handle e-waste are at risk of exposure to over 1,000 harmful substances, including lead, mercury, and polycyclic aromatic hydrocarbon contaminants. The disposal and decay of these goods release toxic substances into the environment, contaminating soil and water and entering the food chain, affecting both wildlife and humans (Heacock et al., 2016). In addition to contributing to environmental degradation, the beginning of the life cycle stages, especially the production process stage itself, increases

greenhouse gas emissions and contribute to climate change. The mining and extraction of raw materials for these products often lead to habitat destruction, loss of biodiversity, and water pollution, severely impacting ecosystems (Stiannopkao, S., & Wong, M. H., 2013). In the middle life cycle stage (Fig 2), consumption of energy and water associated with these consumer durables is significantly higher in areas with inefficient infrastructure, which exacerbates environmental and health problems for these vulnerable populations (Schubert & Stadelmann, 2015). As a result, environmental damage can be further exacerbated, contributing to habitat destruction and climate change impacts, which, in turn, can have an adverse effect on population health (Katherine Monahan, 2018).

The contamination of soil and water caused by improperly disposed appliances can have long-term effects on local ecosystems. Degradation of the environment can disrupt traditional land-based activities and further threaten food security and cultural practices. The combination of these factors - from production to disposal - contributes to broader environmental concerns, such as habitat destruction and loss of biodiversity.

3.2 Recycling Challenges for CDGs

Several challenges exist when it comes to recycling consumer durables, including electronics and large household appliances, primarily because of their complexity in design and presence of numerous hazardous materials. Toxic components in these items, such as lead, mercury, and flame retardants, pose a major challenge during the separation of various materials, particularly when safety regulations are not in place (Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M., & Böni, H., 2005). These hazardous substances require specialized procedures for safe extraction and disposal to prevent environmental contamination and health risks to the community (Ogunseitan, O. A., Schoenung, J. M., Saphores, J. D., & Shapiro, A. A., 2009).

The diversity of materials used in CDGs, including plastics, metals, and electronic components, further complicates recycling efforts. This material complexity necessitates sophisticated and often expensive recycling technologies to effectively separate and recover usable materials (Zeng, X., Mathews, J. A., & Li, J., 2017). It is also important to prioritize end-of-life disassembly and material recovery when designing products, which hampers an efficient recycling process (Bakhiyi, B., Labrèche, F., & Zayed, J., 2017). These challenges become more focused for rural, remote and Indigenous communities due to the factors iterated above. Table 5 lists the various challenges for the recycling of CDGs in the current linear economy, especially with a focus on challenges in remote, rural settlements.

Table 5. Repair and Recycling Challenges of Consumer Durable Goods in Rural Settlements (Source: Author)

Challenges in Recycling CDGs	**Description of Challenges**	**References**
Lack of facilities and technicians for repair	Rural areas often have few shops that offer repair services for appliances and electronics. Several reasons can explain the shortage of such shops and technicians in rural areas. • The low population density of these areas makes it challenging to sustain repair businesses economically. • Low wages and limited opportunities for career advancement need to be improved in attracting and retaining skilled technicians. • Rural areas lack training facilities for developing local talent.	(*Repairing Electronics*, n.d.) (*The Invisible Rural Access Barrier (SSIR)*, n.d.)
Lack of specialized equipment Non-recyclable materials	Consumer durable goods often contain materials that are not recyclable, such as certain plastics and liquids, making separation and processing challenging without specialized equipment	(*What Can We Do About the Growing E-Waste Problem?*, 2018)

Insufficient volume for economic viability	In rural areas, there is often a low population density, resulting in insufficient volumes of recyclable materials to justify collection and processing costs	(*Recycling Programs Evolve In Rural Settings*, n.d.), 38
Low market demand for recycled materials	Recycled materials are often perceived as less desirable due to their comparability to buying second-hand goods at full price, making them less attractive than virgin materials for businesses	(P. S. and P. C. Government of Canada, 2002a) (Solid Waste Management in Newfoundland and Labrador: Final Report Review., n.d.)
Limited access to recycling infrastructure	Remote rural communities often lack recycling facilities, making it difficult and costly to transport recyclable materials for processing	(*What Can We Do About the Growing E-Waste Problem?*, 2018) (*Recycling Programs Evolve In Rural Settings*, n.d.)
Lack of Education and Awareness about recycling	Many people are unclear about what items are recyclable leading to the inclusion of non-recyclable materials in the recycling stream, contamination of recyclable materials, and damage to recycling machinery	(*Recycling Programs Evolve In Rural Settings*, n.d.)
Loss of traditional knowledge and with modernization	Modern consumer durable goods rapidly replace traditional knowledge and skills for creating, maintaining, and repairing traditional tools and items in remote and Indigenous communities. Consequently, long-standing cultural practices, economic systems, and relationships with the local environment are being altered by this shift. Increasing consumption of modern, durable goods can lead to waste management issues in remote areas that are not equipped to handle them	(Gómez-Baggethun, 2022) (Sokk, 2024)

4. Traditional Ecological Knowledge in an Emergent Circular Economy

The aforementioned challenges with regard to CDGs are more complex with remote and rural communities including Indigenous population that follow a different paradigm of spiritual and environmental stewardship with the land. Hence, rural and Indigenous communities face distinct challenges regarding CDGs. As a result of a lack of repair facilities and waste management systems, these communities often encounter difficulties in accessing, maintaining, and disposing of CDGs. The inability to purchase and replace CDGs in rural areas is partly due to lower average incomes, higher transportation costs, and fewer retail options compared to urban centers (Keske et al., 2018).

These environmental changes can profoundly impact the well-being of Indigenous communities with strong spiritual and cultural ties to the land. There is also a growing concern over consumer durables' energy and water efficiency, particularly in communities with limited resources (Schubert & Stadelmann, 2015). The water usage associated with durables such as washing machines and dishwashers can strain local water supplies, which are often under pressure due to agricultural demands and climate change (Katherine Monahan, 2018).

Traditional Ecological Knowledge (TEK) is the accumulated knowledge and practices of local communities that are rich with culture, customs and environmental sensitivity that are passed from generation to generation, evolving with the changes in the community (Houde, 2007). TEK emphasizes the interconnectedness of all living beings and the importance of living in harmony with nature (Whyte, 2013). The integration of TEK with scientific approaches is recognized as a valuable resource for climate change solutions (Houde, 2007). Collaborative efforts involving Indigenous communities have been shown to lead to more effective and culturally appropriate climate change policies and practices, respecting their rights and ensuring equitable outcomes (S.

Canada, 2022; Manseau M, Parlee B, Ayles G-B., 2005). TEK offers valuable insights into sustainable environmental management because it is based on centuries of observations, practices, and cultural understandings of Indigenous communities (Dawson et al., 2021; Manseau M, Parlee B, Ayles G-B., 2005). Contributions from TEK have been particularly relevant in developing urban green areas, awareness-raising, water and energy saving, the cultivation of more resilient agricultural species, and entomological surveillance. Howeverthe use of TEK for the design of CDGs is not known and has not been used to inform the development of existing products and processes of emergent appliances in circular economy.

In Canada, TEK is being increasingly recognized and incorporated as part of the Canadian environmental management and conservation effort. The Indigenous communities collaborate with scientists and policymakers to integrate their time-honored practices and observations into climate change solutions and sustainable resource management. Nature Conservancy of Canada (NCC) has forged partnerships with Indigenous Peoples, combining Western scientific approaches with traditional knowledge in conservation projects. This integration of TEK is enhancing conservation efforts and contributing to reconciliation between Indigenous and non-Indigenous communities in Canada (I. A. A. of Canada, 2013; *Traditional Ecological Knowledge Leads to Better Conservation*, n.d.). Similar concerted efforts and policy facilitation requires to be implemented in the integration of TEK in sustainable circular strategies for CDGs.

Apart from product design, TEK has potential for promoting sustainability in the use phase and the end-of-life phase of the product life cycle. CDGs such as washing machines that are widely used in northern rural communities use a lot of water and energy in their operation. TEK offers practices like the traditional management of water resources through terracing and the use of renewable energy sources like biomass, which indigenous communities have known to use

sustainably for generations. Therefore, integration of TEK principles in the use phase, second life phase and the end-of-life (Table 6) of the consumer durable life cycle (Figure 2) would contribute to mitigating the undesirable environmental impact and managing water and energy resources.

Table 6. Integration of TEK at the various life cycle stages of CDGs (Source: Author)

Life cycle Phase	**Description**	**Integration of TEK principles**	**Example**	**References**
Beginning of Life Design for function	Function & quality in design	Sustainability and respect for the environment can be integrated. Equitable use, gender sensitivity, geriatric sensitivity and culturally responsive design can be considered.	Leap is involved in the development of circular business models, particularly in the context of packaging for household appliances using alternative cellulose fibers It emphasizes sustainable production, focusing on businesses with methods that allow for the sustainable regeneration of natural resources. This approach aligns with the principles of the CE, which emphasize resource efficiency and waste reduction	(*Communities LEAP*, n.d.; Republic of Slovenia Government Office for Development and European Cohesion Policy., 2023) (Bakker et al., 2014; Whyte, 2013)
Production & Manufacture	Demand for raw materials	Equitable use and consideration for benign production that is sustainable, water and energy efficient can be integrated. Local biomass sources for energy flows can be incorporated in the infrastructure.	British Columbia's Coastal First Nations have been at the forefront of implementing TEK into ocean management practices. Their Guardian Watchmen program uses traditional stewardship practices and modern conservation techniques to help monitor and protect marine ecosystems. This program enables	(Alejandre, C., Akizu-Gardoki, O., & Lizundia, E., 2022; Bjørnbet MM, Vildåsen SS, 2021;

			Indigenous communities to track changes in ocean temperatures, monitor fish populations, and adopt sustainable harvesting practices.	Hischier R, Reale F, Castellani V, Sala S., 2020)
		Historical background knowledge with modern technologies can be merged.		(Dawson et al., 2021; Sokk, 2024)
		Nature-compatible end-of-life scenarios can be incorporated especially for emergent technologies such as renewable energy products.		("Giving Traditional Ecological Knowledge Its Rightful Place in Environmental Impact Assessment," n.d.; Houde, 2007)
		Energy source options can be included allowing for function with various sources and intensity variations		(Kellam, M., Talukder, S. K., Zammit-Maempel, M., & Zhang, S., 2020;

				WCEF2021 Summary Report, 2021)
Middle Life	Use	Appliances as a Service, Incorporate TEK into usage practices and maintenance, enable customization to suit local environmental conditions and cultural needs, develop shared/second-hand use models, utilize traditional skills to integrate repair and maintenance practices	HOMIE provides appliances as a service, which stimulates sustainable usage of appliances. It provides appliances as a service, which stimulates sustainable usage.	(Boldoczki et al., 2020; Gagnon & Berteaux, 2009; Hertwich et al., 2015; Proulx et al., 2021)
Second Life		Pay-Per-Use, Collaboration for Upcycling, sharing systems, material substitutions to recycle or renewable materials, refurbishing	The Share, Reuse, Repair Hub was first launched by Circular Innovation Council in 2022, with funding from York Region's Circular Economy Initiatives Fund, as a community-based virtual resources to easily access share, reuse, and repair services in their community. It also provides a platform for local businesses to amplify their role in the CE.	(*Apparel News, Textile News, Fashion News & Trends*, n.d.; *Communities LEAP*, n.d.; *Nordic Circular Hotspot*, 2024; *Our Story and Origin of Homie Pay-Per-Use - Circular Economy*, n.d.; *The Circular*

				Economy Leap, n.d.; Republic of Slovenia Government Office for Development and European Cohesion Policy., 2023; X, n.d.)
End-of-Life		Benign biodegradation	Accus is a small Swedish company that has been working actively to develop a circular business model for light signs. They have demonstrated a strong commitment to sustainability by using recyclable and used materials in their production. It has taken the company creative methods and a proactive mindset to achieve circularity, with a special focus on finding recyclable aluminum, which has been a challenge.	-

The design phase of the CDGs is very crucial since function and quality for the next generation products and their uses are integrated. It is in this phase that sustainability and respect for the environment and equitable uses and end-of-life of the products require to be incorporated especially with the emerging technologies such as renewable energy products in the CDG categories (Bakker et al., 2014). Integrating TEK with modern technologies would benefit equity

and sustainability at all stages of development of the CDGs product life cycle. Rich, and culturally responsive history of TEK, can provide resource conscious design of products and processes can be implemented in these phases (Whyte, 2013). This can effectively decrease the demand for raw materials, mitigating emissions and adverse environmental impacts from mining, extraction, production and energy use and maximize the use of local resources and energy loops within these communities (Circular Economy Action Plan for Canada. Circular Economy Leadership Canada, 2023; "Giving Traditional Ecological Knowledge Its Rightful Place in Environmental Impact Assessment," n.d.). One of the most important guidelines from TEK that can serve the design phase is the cultural, gender, geriatric and environmental sensitivity in the product design that can create a product that can be used equitably and in an inclusive manner rather than focusing only on function and price of the product. This in turn will also lead to the use of raw materials responsibly for the production and manufacture phase of the life cycle of the product.

5. The Circular Economy and TEK in Northern Rural and Indigenous Communities

There is a knowledge gap concerning the application of CE principles to the life cycle of CDGs in the Canadian context. Due to its vast and varied geography, Canada faces unique challenges when it comes to implementing CE, especially in remote, rural, and Indigenous communities, where recycling and repair facilities may be limited, and environmental sustainability is imperative for maintaining traditional lifestyles and food security. Research indicates that Canada's northern rural and Indigenous communities are particularly susceptible to contamination due to nearby landfill waste contaminating their food supplies (P. S. and P. C. Government of Canada, 2002b). These communities follow a lifestyle markedly different from urban areas, as they are heavily dependent on subsistence activities and closely related to their environment (Rural-Urban Differences in Environmental Concern in Canada - Huddart-Kennedy - 2009 - Rural Sociology - Wiley Online

Library, n.d.). Additionally, there are significant disparities between urban and rural waste management systems, with rural systems lacking the infrastructure and technological support found in urban settings, increasing environmental and health risks (Keske et al., 2018).

Incorporating TEK in combination with the principles of a circular economy provides a potential avenue for achieving sustainability in rural and Indigenous communities. This approach utilizes local expertise and resources, ensuring conservation and social-economic resilience (Kellam, M., Talukder, S. K., Zammit-Maempel, M., & Zhang, S., 2020). Therefore, the shift towards a circular economy does not merely represent a technical or economic adjustment but a deeper cultural and ecological integration, where TEK can play a pivotal role in shaping sustainable futures. This can help strengthen the treatment of CE aspects in remote rural and Indigenous communities. Table 6 shows how TEK and CE intersect with respect to communities, highlighting rural communities in particular. The use of TEK can complement in making consumer products more sustainable, especially regarding resource use, product longevity design for end of life, and reduction of adverse environmental impacts. Using this approach is critical to addressing the broader environmental challenges identified through life cycle assessment studies, which have highlighted significant concerns regarding the consumption of water and energy during the lifetime of household appliances. These findings underscore the need for a shift towards more sustainable practices in producing and using consumer goods, where TEK can provide valuable insights and methodologies (Alejandre, C., Akizu-Gardoki, O., & Lizundia, E., 2022; "Giving Traditional Ecological Knowledge Its Rightful Place in Environmental Impact Assessment," n.d.; WCEF2021 Summary Report, 2021).

Rural and Indigenous people face distinct difficulties and opportunities concerning the consumption of CDGs, and tailored environmental measures must be formulated with knowledge

and support from the communities. As shown in Table 4, major appliances, furniture, and miscellaneous durable goods generate significant waste with recycling rates varying greatly between categories. For instance, 58% of major appliances are recycled, but only 5.6% of small appliances are recovered. These issues emphasize the need to develop better recycling technologies and infrastructure for recycling processes, particularly in rural areas where such facilities are scarce (Recycling Programs Evolve In Rural Settings, n.d.). Thus, it explains the need for better, less wasteful manufacturing methods and more mindful, engaged consumption. Concerning these aspects, avoiding such situations is very important in order to prevent severe health and environmental issues, especially in remote areas where there are several issues regarding a lack of repair service facilities, low recycling amounts, and erosion of traditional skills for repairing and maintaining durable goods.

Innovative approaches, such as regional cooperation, mobile recycling units, and community-based initiatives, are emerging to address these issues. Rural, remote communities can benefit from improving education, developing local processing capabilities, and creating incentives for recycling to move towards more sustainable waste management practices and contribute to the circular economy by improving waste management practices (Table 7) (P. S. and P. C. Government of Canada, 2002b; Keske et al., 2018).

Table 7. Aligning the Circular Economy principles established by ISO 59004 with principles of CE for consumer durable goods and TEK for rural communities (Source: Author).

ISO 59004 Principle	CE Principles	Description	References
System Thinking Resource Management Ecosystem Resilience	Designing Out Waste	*Role of TEK in Sustainable Management:* Guides the sustainable management of biological materials, which is central to the circular economy. *Contribution to Consumer Electronics:* Uses traditional practices and materials to develop long-lasting and sustainable consumer electronics. *Measures for Sustainable Electronics:* Use biodegradable materials. Design products that are easily repaired and recycled. Incorporate energy-efficient components.	(Manseau M, Parlee B, Ayles G-B., 2005; WCEF2021 Summary Report, 2021; Whyte, 2013)
		TEK often emphasizes: • The use of every part of an animal or plant. • This approach aligns with the CE principle of designing out waste. It can be particularly transformative in: • Rural communities • Remote communities These areas often have limited access to markets and resources.	(Manseau M, Parlee B, Ayles G-B., 2005; WCEF2021 Summary Report, 2021; Whyte, 2013)
	Keeping products and materials in use/ Community-based Approaches	*Community Decision-Making in TEK:* • Involves inherent community-based decision-making processes. *Support for Localized Circular Economy:* • Enhances localized CE initiatives through community involvement. *Development of Local Sharing Systems:* • Facilitates the creation of local sharing systems for tools and resources. • Reduces the need for external input. • Minimize waste by leveraging local resources.	(Manseau M, Parlee B, Ayles G-B., 2005; WCEF2021 Summary Report, 2021; *What Is a Circular Economy? | Ellen MacArthur Foundation*, n.d.; Whyte, 2013)

	Extending product lifespan	The design of durable products and the ability to repair them are essential in remote areas where replacements are not readily available. *A contribution of TEK can be made by:* • providing insight into the properties of natural materials. • Traditional crafting techniques that result in more durable products.	(WCEF2021 Summary Report, 2021; *What Is a Circular Economy? | Ellen MacArthur Foundation*, n.d.; Whyte, 2013)
Value Sharing	Localizing Resource Loops	*Communities can minimize emissions by:* • Focusing on local resource loops and reducing their dependence on external goods. For example, local recycling programs tailored to a community's specific needs and outputs can keep materials in use locally and support local industries.	(Kellam, M., Talukder, S. K., Zammit-Maempel, M., & Zhang, S., 2020; WCEF2021 Summary Report, 2021; *What Is a Circular Economy? | Ellen MacArthur Foundation*, n.d.)
Value Creation	Integrating renewable energy sources	Remote communities must incorporate renewable energy sources as a critical component of CE. *A TEK approach can:* • guide the sustainable harvesting of biomass for energy production or the design of structures in accordance with passive solar principles adapted to local conditions.	(Kellam, M., Talukder, S. K., Zammit-Maempel, M., & Zhang, S., 2020; WCEF2021 Summary Report, 2021)

	Creating and maintaining local jobs	CE provides opportunities for job creation in Indigenous and remote communities through: • repairs, refurbishments, and recycling of consumer durable goods. • Creating local centers for these activities can reduce waste and bolster local economies with new skills and professions. • Reduces the need for transportation and related carbon emissions, making it both an economically and environmentally beneficial model.	(Manseau M, Parlee B, Ayles G-B., 2005; WCEF2021 Summary Report, 2021; *What Is a Circular Economy? | Ellen MacArthur Foundation*, n.d.)
Resource Tracking	Reducing reliance on external resources	*Logistical Challenges in Remote Areas:* • Transportation of goods is costly and adds to the environmental footprint. • Emissions and infrastructure demands are significant concerns. *Benefits of a Circular Economy Approach:* • Maximizes the lifespan of consumer goods through repair and refurbishment. • Reduces reliance on new goods and decreases transportation needs. • Promotes durability and sustainability of products. *Promotion of Local Solutions:* • Encourages local solutions to minimize frequent transportation. • Aligns with themes of incremental learning and sustainable practices observed in Indigenous communities. *Environmental Harmony:* • Emphasizes the balance between local solutions and environmental well-being, as discussed by Turner & Berkes (2006).	(Katherine Monahan, 2018; Manseau M, Parlee B, Ayles G-B., 2005; Turner, N.J., Berkes, F., 2006; WCEF2021 Summary Report, 2021)

The integration of TEK at all stages of the CDG product life cycle will also positively impact not only the environment but also embed inclusivity and equity in design, use and safe disposal for rural communities. In the production and manufacture phase of the product, resource efficiency, reliable, repairable, regenerative, re-purposable and recyclable materials may be used, keeping in mind the production with sustainable biomass residues, renewable energy and equitable end-of-life outcomes for both a positive use and environmental outcome, all following the guidelines from TEK. The middle life that constitutes the use phase of the life cycle is a consumer driven phase where the CDG undergoes value creation from the use and service. In this phase, TEK can guide the use of renewable energy, sacred nature of water and therefore the responsible use of the product with a mindset that it's use is connected and interdependent on sharing of resources with other natural species and there is an accountability associated with it. The second life is the phase where the product goes through reuse, making it the most suitable phase to proactively include product eco-design. In this phase the shift in consumer behavior would also be the most impactful making reuse, sharing, repurposing, pay-per-use, and other collaborative measures to extend shelf life of a product or service a part of the business models (Apparel News, Textile News, Fashion News & Trends, n.d.; Communities LEAP, n.d.; Nordic Circular Hotspot, 2024; Our Story and Origin of Homie Pay-Per-Use - Circular Economy, n.d.; The Circular Economy Leap, n.d.; X, n.d.). The end-of-life phase is another phase where significant development in circular repurposing, refurbishment, redesign, recycling and benign disposal scope has to be integrated. Traditional knowledge of natural decomposition processes may also be used in the design of environmentally safe biodegradable materials (Admin, 2018). TEK may inform the disposal stage with indigenous waste management practices that have been refined and passed down through generations if practiced (Finn et al., 2017) or provide culturally appropriate upcycling programs that are aligned

with the values and traditions of the local community (Admin, 2018). Case studies of Indigenous-led circular economy initiatives in northern rural Canada incorporating TEK were studied to provide practical examples of Indigenous-led circular economy initiatives in northern rural Canada. These projects showcase best practices for addressing waste, recycling, and using sustainable materials in Indigenous communities. These projects are summarized in Table 8 and illustrate how TEK is being used as a solution to local sustainability (Parks, 2023).

Table 8. Case Studies of Indigenous-led CE Projects

Indigenous Community/ Organization	Projects
Daylu Dena (Kaska Nation)	Reducing disposable tableware use and addressing plastic waste through fabric reuse, community recycling bins, a quilt-making program, and reusable dinnerware for gatherings.
Gitxaała Nation (Git Lax M'oon)	Expanding a reuse and recycling facility and piloting a method to eliminate single-use containers by integrating commercial dishwashers and reusable containers.
Gwa'sala-'Nakwaxda'xw Nations	Reducing and processing plastic waste within the community, installing sorting bins, and providing reusable dishes for community events.
Kanaka Bar Indian Band (T'eqt''aqtn'mux)	Providing a commercial dishwasher and reusable dinnerware at the community hall to reduce single-use dinnerware at events.
Mother Earth Recycling Inc.	Recycling windshields and laminated glass using specialized machinery, diverting material from landfills and recovering value.
Tsleil-Waututh Nation (səlilwətaɬ)	Leading a year-long awareness campaign through community events and school-based activities to prevent and reduce plastic waste.
Vitatek Cleaning Solutions	Providing zero-waste, reusable containers for commercial cleaning supplies in the Okanagan region.

6. Challenges in Implementing Circular Practices

The CE, an economic model that aims to reduce waste and optimize resource usage, presents organizations and societies with inherent and external challenges (Korhonen et al., 2018). One of the most significant challenges in a CE is the complexity of supply chains. Global supply chains introduce complexity, as CE principles must be implemented and coordinated across different regions with varying economic, environmental, and regulatory contexts (Korhonen et al., 2018). A circular model requires the integration of recycling, refurbishing, and reuse processes instead of traditional linear models in which products are manufactured, used, and discarded. This integration demands a comprehensive understanding of material flows, product design, and end-of-life management, posing logistical and operational difficulties (Blomsma, F., & Brennan, G, 2017). To facilitate these processes, CE requires substantial investments in new technologies and infrastructure, a challenge particularly acute for small and medium-sized enterprises (SMEs) with limited financial resources (Ritzén & Sandström, 2017).

Another critical challenge is changing consumer behaviors. Circular models depend heavily on consumer participation in recycling and product return schemes. However, changing consumer habits is a slow and complex process, often hindered by a lack of awareness or incentives (Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017). A variety of factors can influence this transition, including policy frameworks, market demand, and technological solutions. As well as investing in research and development, the CE may require new, more sustainable products and processes (Information on Circular Economy Policies., n.d.). In addition, regulatory frameworks play a deciding role. The absence of supportive legislation or conflicting regulations can prevent circular practices from being adopted. Effective policies encouraging

circular economy initiatives, such as extended producer responsibility or incentives for sustainable product design, are crucial (Kirchherr et al., 2017).

Addressing the skills gap is a crucial part of transitioning to a CE. Business models and processes inherent to this system require specific skills in areas like sustainable design, waste management, and reverse logistics (Moreau, V., Sahakian, M., van Griethuysen, P., & Vuille, F., 2017). The CE model presents a unique set of challenges and opportunities for rural communities. Geographic isolation and limited infrastructure often exacerbate the complexity of these supply chains, making the implementation of recycling, refurbishing, and reuse processes more challenging (Korhonen et al., 2018). SMEs in rural areas may face significant financial obstacles when investing in new technologies and infrastructure necessary to implement CE practices. Changing consumer behavior in rural areas can be challenging due to limited access to recycling facilities and product return programs (Ritzén & Sandström, 2017).

Rural communities, however, typically have stronger social ties and a stronger connection to natural resources, which can be utilized to promote the principles of CE. The skills gap in sustainable design and waste management may be more pronounced in rural areas, necessitating targeted education and training programs (Houde, 2007). Despite these challenges, rural communities have the unique opportunity to implement CE practices, such as local food systems and renewable energy projects, which can contribute to their economic resilience and environmental sustainability.

Numerous technical challenges and issues are also associated with the transition to a CE even though it represents a sustainable alternative to the traditional linear economic model. Designing circular products is one of the primary challenges (Bakker et al., 2014). This involves creating products that are not only durable and long-lasting but also designed for easy disassembly and

recycling. Achieving this requires overcoming significant technical hurdles in materials science and engineering, as well as in the design process itself (Bakker et al., 2014). Another technical challenge is the need for standardized materials to facilitate recycling and remanufacturing. The variety of materials used in products, especially in complex electronics, makes recycling and remanufacturing processes difficult and costly (Ghisellini, P., Cialani, C., & Ulgiati, S., 2016). Moreover, the development of efficient and effective recycling technologies is essential. Consequently, rural communities may rely on less efficient recycling processes that result in downcycling (Haas et al., 2015). This challenge requires advanced recycling technologies that can maintain or even improve material quality.

The management of supply chains in a circular economy also presents technical challenges. Managing the return of used products and materials for reuse, remanufacturing, or recycling requires sophisticated logistics systems (Haas et al., 2015). Managing circular supply chains in rural areas presents additional logistical challenges due to geographic isolation and limited transportation networks (Pinilla & Pinilla, 2022). In order to implement such systems, it is necessary to overcome technological barriers related to the collection, sorting, and transportation of used materials (Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017).

The integration of renewable energy sources into circular economy models is another issue. For maximum sustainability, circular economies should be powered by renewable energy for production, use, and recycling. Integrating these energy sources poses technical challenges, particularly in storing and distributing the energy (Korhonen et al., 2018). Rural settings can be particularly challenging when integrating renewable energy sources due to infrastructure limitations and a lack of specialized energy storage and distribution knowledge (García-Madurga & Grillo-Mendez, 2023).

For a better understanding of the concepts discussed regarding the problems, challenges, advantages, and options in rural and urban areas, all the information discussed above has been mentioned in Table 9. This table compares the challenges and opportunities in rural and Indigenous communities.

Table 9. Comparative Analysis of Rural and Urban Challenges and Opportunities in Circular Economy

Category	Challenges in Rural Areas	Challenges in Urban Areas	Opportunities in Rural Areas	Opportunities in Urban Areas
Waste Management	Limited waste collection; accumulation of discarded goods in landfills or informal dumps	High waste generation; landfills at capacity; difficulties in segregating recyclables	Community-led waste management strategies; reuse and upcycling programs	Advanced sorting technology; potential for high-efficiency recycling.
Access to Repair Services	Lack of repair facilities and trained technicians; high transport costs make repairs costly	Repair services are available but expensive; planned obsolescence discourages repairs.	Local training initiatives and community workshops for self-sufficient repair	Government incentives can strengthen repair culture and consumer awareness
Infrastructure & Recycling	Scarce recycling facilities; low profitability due to small populations	More recycling facilities but issues with contamination and logistical inefficiencies	Potential for small-scale, decentralized recycling hubs and mobile units	Investment in large-scale recycling infrastructure and product take-back programs
Circular Economy Integration	Limited policy enforcement and awareness; reliance on external markets for disposal	Strong policy frameworks exist but face bureaucratic resistance from industries	TEK integration for sustainable product lifecycles and repair strategies	More stringent CE policies pushing industries toward sustainability
Economic Viability	Small businesses struggle with circular models due to logistical	More investment opportunities but strong competition	Circular models can create localized economic resilience and jobs	CE startups have access to investment, innovation, and consumer markets

	and financial constraints	and regulatory burdens		
Community Engagement	Traditional knowledge and community-based approaches exist but lack formal integration	Consumer-driven approach to sustainability but lacks community-centered engagement	Stronger community ties facilitate knowledge-sharing and participation	Digital platforms improve engagement in CE initiatives
Sustainability Potential	High dependence on local natural resources; risk of depletion without regulation	CE solutions are growing, but urban resource consumption remains disproportionately high	Localized circular strategies promote regenerative land use and conservation	Tech-driven solutions can improve circularity outcomes

Finally, developing appropriate business models for CE practices is a technical and economic challenge. Traditional business models may not be suitable for achieving circular practices and creating new economically feasible and environmentally sustainable models is a complex process (Lewandowski, 2016).

The challenges described above are either amplified or impossible to overcome in the current northern rural communities' landscape without a systemic change. Therefore, a customized, equitable and inclusive solution is warranted for implementing CE in these communities. In northern rural communities in Canada, by integrating TEK, (Whyte, 2013) the concept of CE can lead to sustainable and culturally responsive resource management practices. TEK can contribute to CE practices through sustainable resource management, waste reduction, and energy efficiency (Houde, 2007). For instance, TEK can inform the design of circular systems that mimic natural cycles, such as utilizing biomass residues and by-products as resources, using renewable energy and recycling of materials (Houde, 2007).

7. Conclusions and Further Recommendation

Adopting an integrated approach that addresses various challenges and leverages multiple strategies to achieve the CE for consumer durables while incorporating TEK is necessary (Houde, 2007). This paradigm involves embracing Indigenous and national knowledge systems, factoring circular futures into the design process of products, building ecosystems with circular supply chains, active participation of consumers, adequate policies, and renewable technologies (Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017; Ghisellini, P., Cialani, C., & Ulgiati, S., 2016; Korhonen et al., 2018; Lewandowski, 2016). Organizations can design more sustainable and culturally fitting products by integrating TEK in product design and lifecycle management, reaching out to remote and Indigenous populations, and applying eco-design methods (Gabriel Swain, n.d.; Gagnon & Berteaux, 2009). These efforts are further supported by the development of localized, interconnected supply chains, as well as sophisticated reverse logistics systems (Gabriel Swain, n.d.; Sitra Website, n.d.; What Is a Circular Economy? | Ellen MacArthur Foundation, n.d.). Also, educating consumers, providing them with incentives, and reporting on progress achieved in implementing such a practice will help facilitate a more active approach to circular economy practices by the consumers (Henriques, R., Figueiredo, F., & Nunes, J., 2023; Information on Circular Economy Policies., n.d.; Sitra Website, n.d.). These approaches are consistent with many of the defined UN SDGs, in particular supporting SDG 12 (Responsible Consumption and Production) since the concept is about eco-friendly design and decreasing the amount of waste produced. It also promotes the achievement of SDG 9 (Industry, Innovation, and Infrastructure). This is achieved by developing innovative circular supply chains and applying eco-design concepts. Likewise, the integration of TEK and the importance given to public involvement advance SDG 10 (Reduced Inequalities) and SDG 11 (Sustainable Cities and Communities). The

advocacy for using renewable energy in the framework contributes to the realization of SDG 7 (Affordability and Clean Energy) and SDG 13 (Climate Action). Furthermore, the concentration on local economies and sustainable areas and activities facilitates the attainment of SDG 8 (Decent Work and Economic Growth) and SDG 15 (Life on Land). Applying these circular economy concepts, including TEK and a sustainable and fair society, where consumerism and industrialism correspond to nature and native principles, can be achieved along with other SDGS and promote environmental health and economic vitality (THE 17 GOALS | Sustainable Development, n.d.).

Limitations of The Study

This review analyzes existing literature using previously analyzed data to draw conclusions about barriers to implementing a circular economy integrated with TEK in northern rural communities of Canada. Policy implications that inform improvements and provide recommendations are considered in this review; however, a systematic policy evaluation is needed to emphasize how TEK can be integrated to build an inclusive and equitable CE for CDGs rather than simply relying on indirect regulatory frameworks. Data derived from the literature may be limited in their generic application to all regions as CE strategies must consider regional and local socio-economic, environmental and cultural contexts.

Chapter 3:

Exploring Barriers in Promoting Circular Economy of Consumer Durable Goods in Remote and Indigenous Communities in Newfoundland and Labrador

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Author's Contribution

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Abstract

Consumer durable goods (CDGs), including large appliances and electronics, contribute substantially to global waste generation, presenting significant challenges for remote, rural communities, both Indigenous and non-indigenous with limited access to waste management infrastructure. While managing CDGs waste is a pressing global issue, rural and remote communities suffer the consequences significantly due to the lack of access to repair services, recycling programs, and sustainable disposal options. Discarded products that could otherwise be repaired or reused lead to buildup of waste in the absence of such facilities in these communities,

contaminating surroundings but also resulting in undesirable spending on new products. Circular economy (CE), offers a viable solution to these challenges through product design that maintains products and materials in use for longer, keeping out waste and pollution, and regenerating natural systems. However, CE design is informed by urban models where waste becomes invisible whereas it is not inclusive for northern remote and rural communities with limited waste management infrastructure. Therefore, this work aims to explore the implementation of CE as a strategy for Northern, Rural and Remote Communities (NRRCs) and examine the barriers to implementing CE in northern remote and rural communities using the example of two Newfoundland and Labrador (NL) communities: Harbour Main, a remote non-Indigenous community, and Conne River, a Mi'kmaq First Nations community in Canada. CDGs are the most ubiquitous products used in these communities and were used to understand the CE product design changes that would help make the CE model inclusive in northern remote and rural communities.

Also, to understand the challenge of implementing CE practices in remote and Indigenous communities despite their alignment with sustainability principles, a qualitative approach rooted in Traditional Ecological Knowledge (TEK) that considers the voices of these communities in CDG design with CE principles were explored. Semi-structured interviews with both community members were conducted covering areas of waste disposal behaviors, repair and reuse practices, economic and cultural influences on product lifespan decisions, and the role of TEK in sustainable waste management. The response information was translated into nine distinct themes. The thematic analyses revealed major systemic barriers in three distinct areas (i) logistical, (ii) attitudinal and (iii) cultural. The themes also provided insights into logistical issues such as restricted access to repair services, high transport and repair costs, and the pervasive impacts of planned obsolescence and socio-economic factors, such as the affordability of new goods

compared to repair costs. It was interesting to note that there was a the diminishing role of TEK in managing modern waste streams in Indigenous communities. The findings underscored the critical need for targeted infrastructure investments such as those aimed at improving waste management, repair accessibility, and recycling capabilities in remote and Indigenous communities, coupled with policy reforms tailored to the specific requirements. Such efforts are essential to ensure equitable participation in CE practices and advance global sustainability objectives.

1.0 Introduction

Durable goods are products which have a lifespan of more than three years as defined by the US Environmental Protection Agency (EPA) (US EPA, 2017c). CDGs, such as household appliances and electronics, play a significant role in global consumption, and their production and disposal have serious environmental and health consequences. As planned obsolescence has increased, new technology has become less durable and not reparable, generating more waste after the end of life (Nes & Cramer, 2006). Moreover, many of these products contain toxic substances, such as heavy metals and flame retardants ("Electronics," n.d.). For instance, due to the ineffective management of electronic waste (e-waste), precious metals such as gold, silver, copper, nickel, and aluminum, which could otherwise be recovered and reused, are lost, leading to increased demand for virgin resource extraction (Grant et al., 2013). Moreover, toxic and hazardous substances are released into the surrounding environment, contaminating the global environment by releasing persistent organic pollutants (POPs) and mercury and posing health risks to the workers and communities that reside nearby toxic waste dumps ("Electronics," n.d.).

Despite increasing concerns about environmental sustainability, CE principles such as reusing, refurbishing, remanufacturing etc., remain primarily absent in CDG manufacturing and disposal, intensifying environmental degradation and resource depletion (Milios, 2018). Although

CE frameworks have been developed to encourage waste minimization, resource efficiency, and product longevity, limited research has been conducted specifically regarding public perception, consumer behaviors, and socio-economic barriers such as high repair costs compared to replacement, lack of financial incentives for refurbished goods, limited access to recycling facilities, and consumer preferences for new products over repaired ones (Cooper, 2010). Most of the existing studies focus on general waste management, overlooking cultural and local perspectives that could drive circularity at the community level (Kirchherr, J., Reike, D., & Hekkert, M., 2017; Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E., 2018; Laitala et al., 2018). The widespread reliance on a linear "take-use-waste" model, which prioritize convenience and disposability over sustainability, discourages consumers from participating in repair, reuse, and material recovery, highlighting a critical gap in transitioning towards CE-based CDG management (Bakker et al., 2014).

In Canada, particularly in NL, waste management challenges are exacerbated by geographic isolation and limited infrastructure (MMSB, 2022). The Canadian government's solid waste diversion report measures the generation, recycling, composting, combustion, energy recovery, and landfilling of these materials from the CDGs in municipal solid waste (MSW). In 2022, Canada's national solid waste diversion rate stood at 27.1%, meaning that just over a quarter of all municipal solid waste was kept out of landfills through recycling, composting, and other recovery processes However, NL had the lowest diversion rate in the country at just 11.4%, falling well below the national average (Environment and Climate Change Canada, 2024).

This is especially true in rural and Indigenous communities in NL, which are often without access to repair facilities, recycling programs, or sustainable means of disposal, resulting in limited options and a tendency to landfill CDGs (P. S. and P. C. Government of Canada, 2002b). These

Challenges conflict with TEK, which emphasizes environmental stewardship and sustainable resource use (Whyte, 2013). Despite these abovementioned issues, no research has specifically focused on CE strategies for CDGs in the rural and Indigenous communities of NL. This underscores an urgent need for community-led approaches to explore TEK for Indigenous communities with modern CE practices. This study addresses this gap by identifying obstacles to CE adoption and proposing culturally appropriate waste management solutions for CDGs in rural and Indigenous communities in NL.

2.0 Objectives

This study aims to identify the barriers and challenges in promoting a CE for CDGs in remote and Indigenous communities of NL. In order to contribute to a sustainable and inclusive CE model, the study will integrate Traditional Ecological Knowledge (TEK) of Indigenous community and community voices to develop a comprehensive framework. The following objectives of the study are shown in the table below:

Table 10. Research Objectives

Objective Number	Objective Description
1	To identify the barriers and challenges in the current 'take-make-waste' linear economy that hinder recovery, reuse, and regeneration in CDGs.
2	To determine the current/dominant product design's negative impacts on the community in the current linear economy.
3	To explore how TEK can contribute to understanding the impact of waste from CDGs.
4	To develop an inclusive CE framework based on insights from remote and Indigenous communities to guide the waste management of CDGs.

3.0 Methods

3.1 Study Design

Using a thematic analysis based on TEK and CE principles, this research takes a qualitative, community-based participatory approach. The study design utilizes content-rich, descriptive narratives from a community of members to understand barriers to CE implementation. This approach aligns with the study objectives to first understand perceptions of community experiences with CDGs and waste management practices in remote and Indigenous communities before applying external models of CE implementation

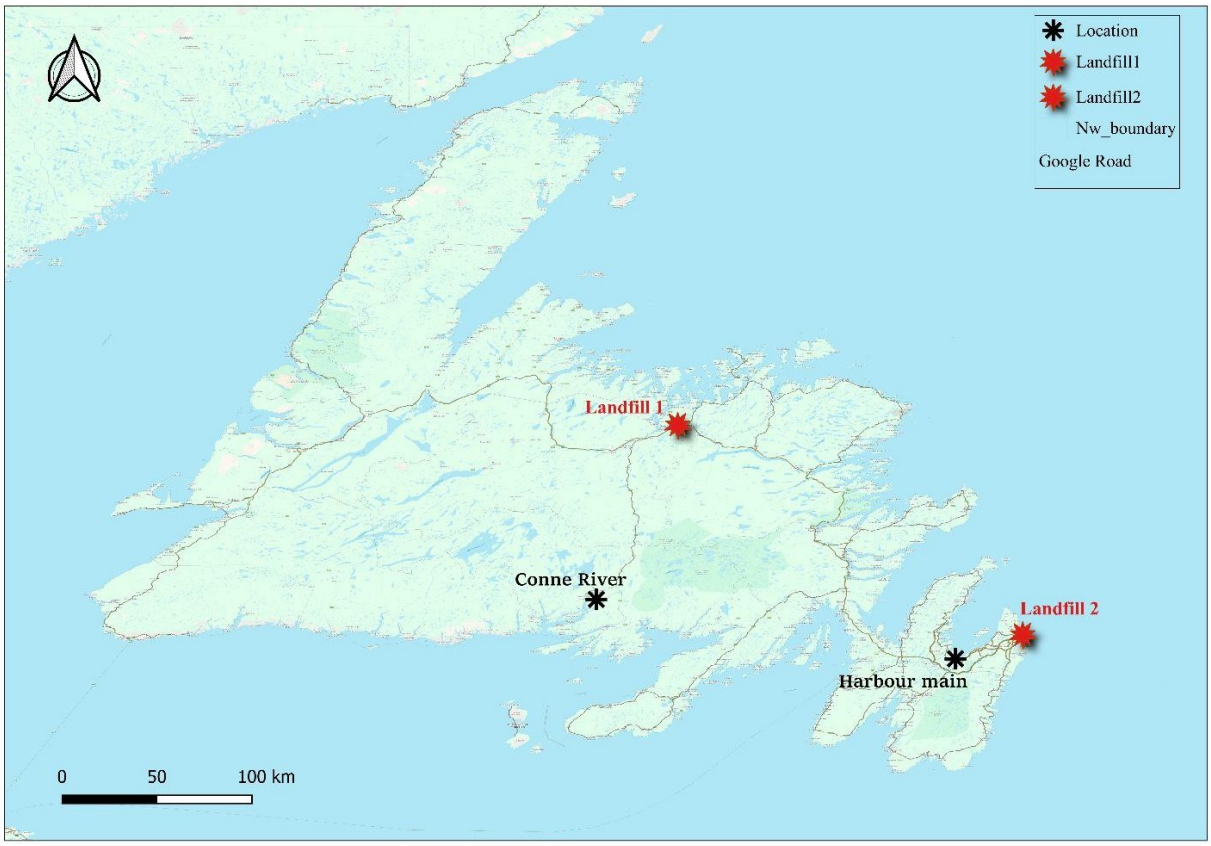

Figure 5. The approximate distance of each community from its respective landfill (Source: Author)

As shown in Figure 5, Harbour Main is located approximately 65 km from its expected waste management facility at Robin Hood Bay. In comparison, Conne River is approximately 172 km from the nearest regional waste site in Norris Arm. The considerable distance and limited

transportation resources and facilities make waste disposal a significant challenge for the Miawpukek First Nation community (Conne River). Consequently, many residents dispose of waste, including CDGs, in a local landfill just a few kilometres away from the community. This highlights the systemic waste management disparities affecting remote Indigenous communities.

3.1.1 Participants

It is very important to first establish a relationship with communities before co-producing research objectives with their elders and members. For this research, northern non-indigenous and the Indigenous communities were selected based on the established relationships and their expressed interest in this research outcomes.

The two communities that helped develop the research objectives and work with the supervisory team in NL are:

- Harbour Main – Rural, non-Indigenous community and
- Conne River (Miawpukek First Nation) –First Nations community

These communities helped researchers capture both remote and Indigenous perspectives in the study. According to the 2021 Canadian Census, Harbour Main has a population of 1,065 and Conne River has 953 residents, providing important context for understanding the scale of community engagement and the representativeness of the respondent sample in this study (Government of Canada, 2022b, 2022a).

From these communities, at first ethics applications were developed with the collaborators from these communities and participants were identified with their assistance. This study was duly approved by the McMaster Research Ethics Board (MREB) and the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland to ensure compliance with ethical guidelines. Ethics approval was granted on July 21, 2023, under MREB #6008. The Interview questions are provided in appendix D.

Adults, 18 years of age and older, were considered eligible to participate in the study.

Participants included:

- Community leaders (band members of the council, Mayor).
- Community members (Youth and seniors of all genders).
- Representatives from the public service sector.

3.1.2 Data Collection Method

Semi-Structured interviews were prepared with the help of the community collaborators and passed ethics approval. These questions were open ended to allow participants to share their views and provide insights and intended recommendations on waste management practices for various CDGs categories, including large household appliances such as TVs, washing machines, dryers and, etc., and electronics. The interview questions were adopted from the validated questionnaire from the study Rogers et al. (2021), *"Repairing the Circular Economy: Public Perception and Participant Profile of the Repair Economy in Hull, UK," which* investigated public perceptions of repair practices in the context of the CE (Rogers et al., 2021).

The interviews were conducted in-person, lasting around 30 to 40 minutes. Drawing on the study's insights, the study explored themes similarly within the frames of remote and Indigenous communities in NL. 18 members were interviewed in the Conne River community and 14 in the Harbour Main community.

Participants were recruited via community leaders (Band Chief for Conne River, Mayor for Harbour Main). Recruitment initiatives included postings on community Facebook pages; flyers hung in public spaces, and in-person outreach. The participants received an information letter explaining the study's purpose, interview questions, and their rights, including the option to withdraw at any

time. Informed consent was obtained through a signed consent form, and for those who could not sign in advance, oral consent was accepted. Data was stored securely following Memorial University's ethics guidelines, and confidentiality was guaranteed. After the interview, participants were compensated with a gift card as a gesture of gratitude.

3.1.3 Qualitative Analysis

The primary data received from interviews was transcribed and analyzed using standard data processing software. In this study, the information from the interviews was transcribed by using Sonix.ai website (Purchased plan and licensed) and was uploaded into ATLAS.ti (version 25.0.0.32864) software for qualitative data analysis. During the primary coding process, emerging codes were developed from the interviews as they arose, incorporating both the software's suggested codes and the researcher's insights (ATLAS.Ti | The #1 Software for Qualitative Data Analysis, n.d.; Automatically Convert Audio and Video to Text, n.d.). A separate coding process was conducted for each community to capture the unique perspectives and contextual differences within each community. After completing the initial coding, themes were developed based on interview quotes, and the researcher categorized the distribution of these quotes among themes. As a result of the diversity and size of some primary codes, sub-themes were created to provide a more comprehensive and detailed analysis of the data. A structured synthesis of the qualitative data was achieved through this process, thereby allowing for a more nuanced understanding of the barriers and opportunities related to CE practices in each community. This process is illustrated in the flow chart show in Figure 6.

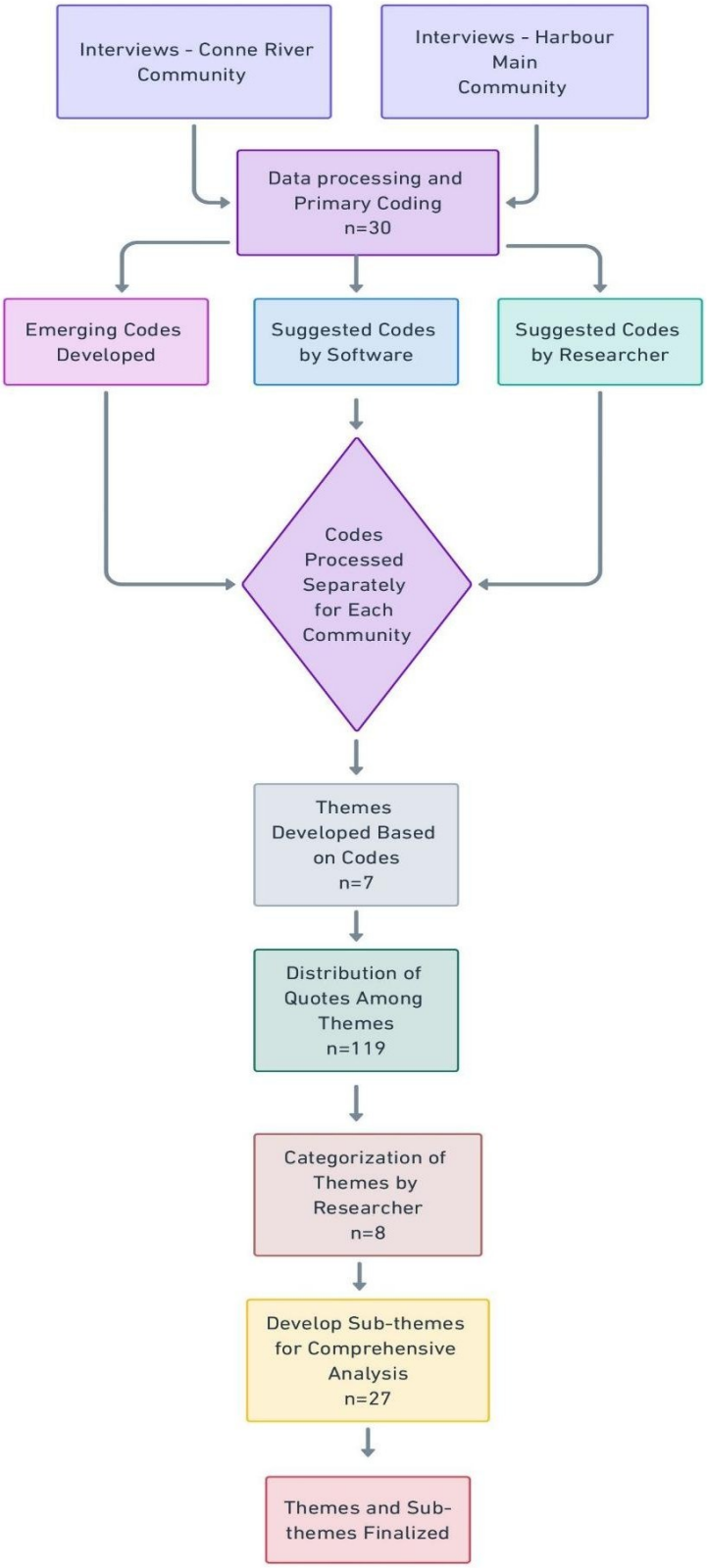

Figure 6. Data Analysis Flow Chart (Source: Author)

4.0 Results

Qualitative analysis was crucial for this research because it considers these communities' nuanced experiences, attitudes, and contextual difficulties. Seven themes and sub-themes were developed from the data sourced from the interviews, the suggested themes by the software and the emerging codes developed (figure 6). The researcher developed these themes through careful coding and interpretation of interview transcripts. While ATLAS.ti was used to support this process, it did not generate themes independently. Instead, the software suggested potential codes and thematic groupings by highlighting frequently occurring keywords and phrases. These suggestions served as prompts for deeper interpretation, but the researcher determined and defined the final themes.

Using Atlas.ti, from the codes and sub-codes generated during the analysis, broader themes and sub-themes were constructed to represent the main challenges (Figure 7).

Figure 7. Themes and Associated Sub-Themes (Source: Author)

The sub-themes provide a more granular insight into specific issues raised by participants. Two figures have been provided to provide a better understanding of the categories. As shown in Figure 8, the number of quotes for each created theme category is accompanied by the significance of each category compared to the other categories, and as shown in Figure 9, the number of quotes corresponds to each of the various sub-themes identified by participants.

Disclaimer 1: "The numbers in this chart represent selected, illustrative quotes and may not reflect the full range of data collected."

Disclaimer 2: “Some quotes may appear in multiple theme groups due to their relevance to more than one category. This overlap reflects the interconnected nature of the themes and sub-themes identified in the qualitative analysis.”

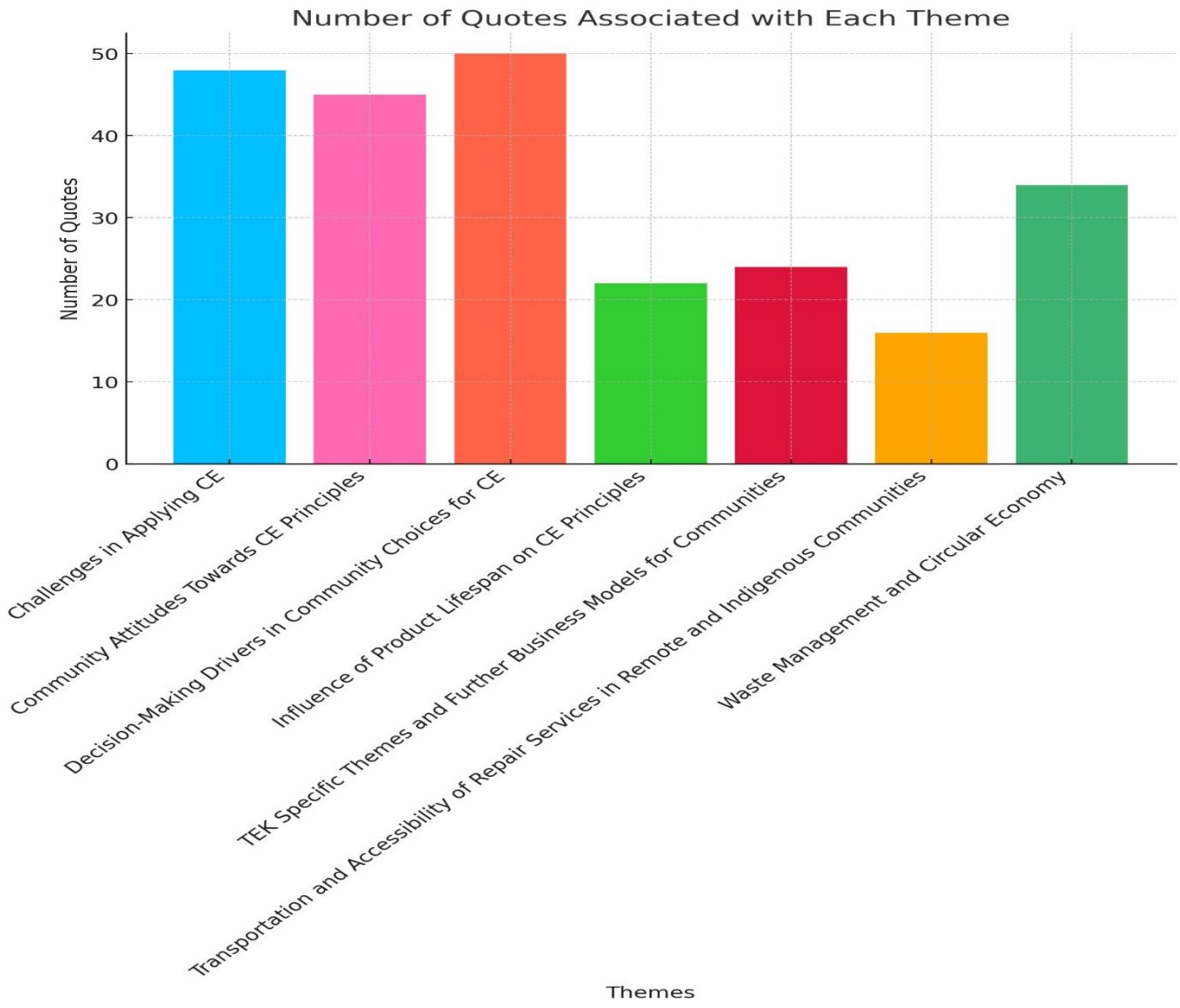

Figure 8. Frequency of Themes mentioned by participants and Number of Selected Quotes (Source: Author)

It is clear from Figure 8 that the community members showed a great interest in applying CE principles (45 to 50 quotes) as indicated by the maximum quotes in the theme of challenges in

applying CE principles (blue bar), in their attitudes towards CE principles (pink bar) and the decision-making drivers in their choices for CE (orange bar). They were also interested in waste management related to CE (darker green bar) but had less interest in applying TEK or knowledge about the transportation and product design in the CE (light green, red and yellow bars, 15-22 quotes) as shown in Figure 8.

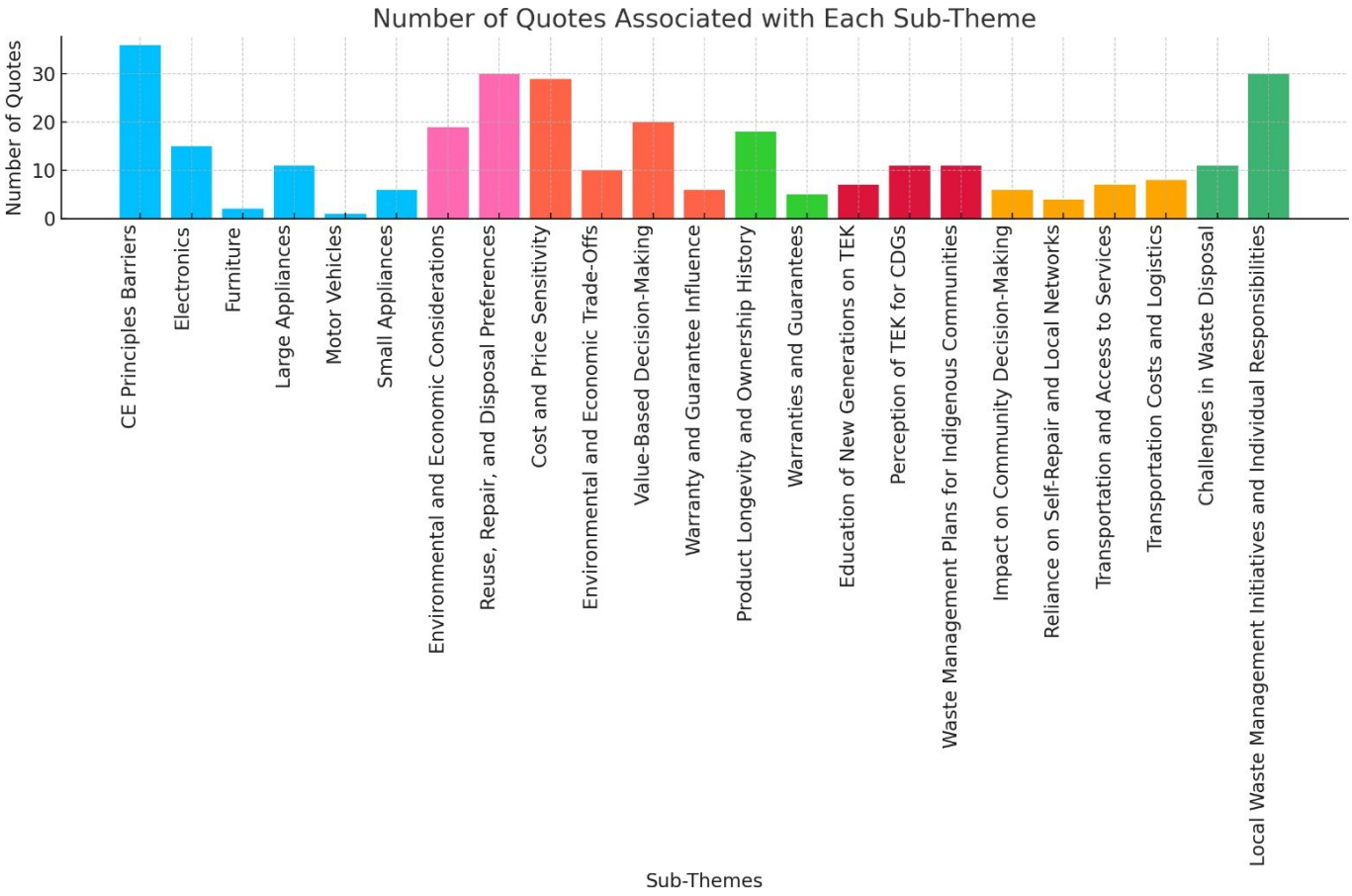

Figure 9. Frequency of Sub- themes Mentioned by Participants and Number of Selected Quotes (Source: Author)

From Figure 9 it is evident that community members had barriers to CE and waste management at the consumer level highest on their mind and these showed up as the most frequent themes in the interviews (blue and darker green bars, 30-35 quotes). Repair and reuse including costs and price considerations were second and these overshadowed environmental sensitivities and any good intentions clearly indicate opportunities for systemic and policy changes in these areas.

These findings have been discussed in detail in the following sections.

4.1. Demographic Profiles of Participants

Participants recorded their demographic profile which included self-identification of their gender, educational level, income, and occupation.

Thirty-two community members participated of which eighteen members identified as women (56.2%) and fourteen identified as men (43.8%).

Figure 10 shows that most participants had achieved higher education levels, with the majority ((13 participants, 40%) holding post-secondary or bachelor's degrees (10 participants, 31%). Other education levels, such as college diplomas, and trades in specific technical programs, were less common, with minimal representation from participants with Grade 11 or 12 education or specialized certifications.

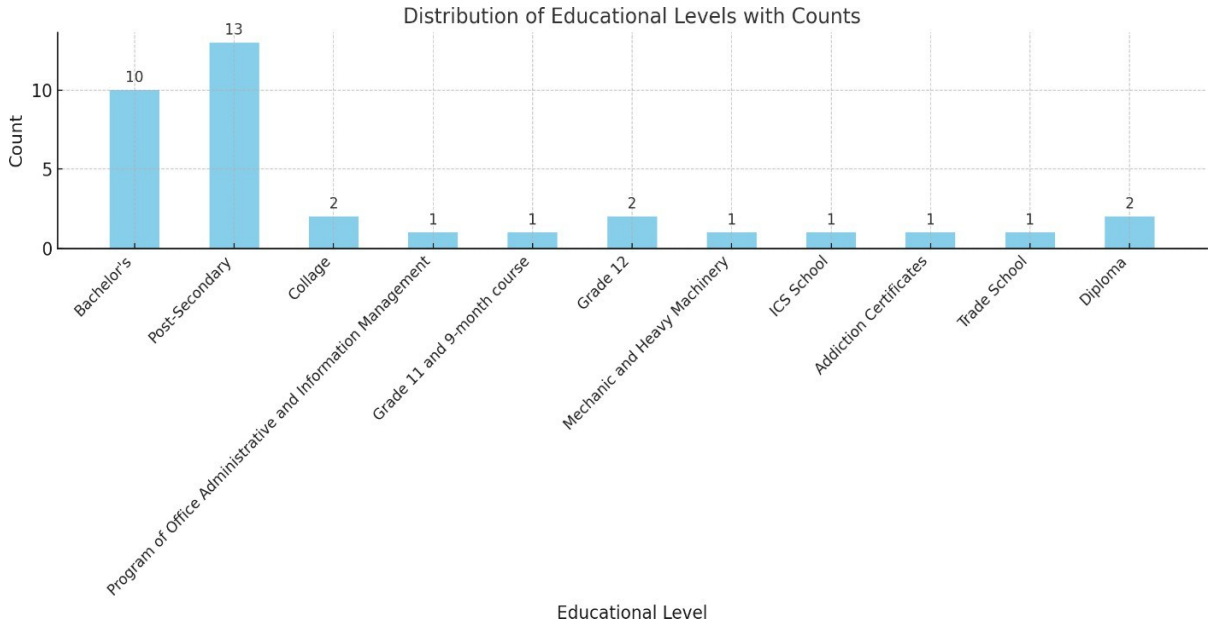

Figure 10. Educational levels of the participant (Source: Author)

Participants were also asked about their income as shown in figure 11. The figure comparing individual and household incomes reveals a clear trend: household incomes are significantly higher than individual incomes, indicating the impact of multiple earners within households. Income levels vary widely, with some participants reporting household incomes above $200,000 while others fall into much lower ranges. Individual incomes tend to concentrate on lower brackets, with relatively few exceeding $100,000. This variation likely impacts participants' ability to engage with CE practices and access to repair and waste management services.

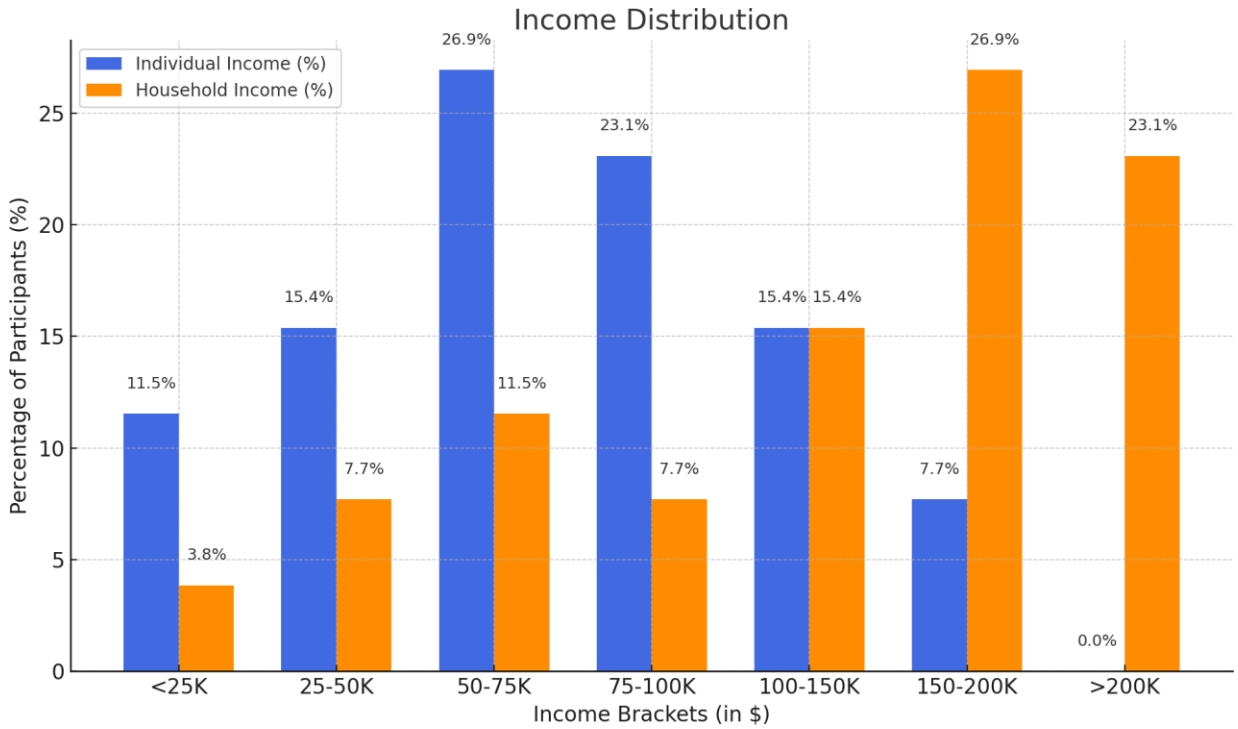

Figure 11. Comparison of Individual and Household percentage of Income in Canadian Dollars (Source: Author)

Participants were also asked about their occupation (Figure 12). The figure highlights a diverse array of participant occupations, with retired individuals, teachers, healthcare, administration and trade jobs representing the most common roles among participants. This occupational diversity spans fields such as health, education, finance, and manual labor, offering the study a wide range of expertise and perspectives.

Figure 12. Participant's Occupations (Source: Author)

The themes in Figure 8 are discussed in detail here and quotes from community members that provide the frequency in Figures 8 and 9 are indicated in this discussion.

4.2. Theme 1: Challenges in Applying CE Principles

Based on the themes and sub-themes identified, participants identified large and small appliances and electronics as the most challenging product categories to apply CE principles. These categories were highlighted due to frequent struggles related to repair costs, accessibility of repair services, and the complexity of modern technology. The following analysis further examines these categories and identifies their core barriers inhibiting participants from practicing CE successfully. More quotes from participants are provided in the supplementary documents for each theme.

4.2.1. Large Appliances

As a result of their complexity, high repair costs, and technological advancements, large appliances, such as washing machines, refrigerators, and dryers, present significant barriers to implementing CE principles.

Due to the integration of electronic and specialized components in modern large appliances, repairs are more challenging and costly than those of older models.

Van Nes and Cramer (2006) state that the lack of accessible repair services and expensive proprietary parts contribute to higher replacement rates for large appliances (Nes & Cramer, 2006). Milios, L. (2018) highlights that this issue is exacerbated in rural or remote areas, where repair services are scarce, and that geographical isolation often discourages repair due to logistical costs (Milios, 2018).

"If my dryer, if it was broken, and if there was somebody around here who could fix it, uh, fairly quickly. And if I didn't have to drive, I guess 150km to Grand Falls, wait 3 or 4 weeks to get it fixed and then get it shipped back to me. So, I still would need something in the meantime. Not like there's a laundromat around here so probably just as easy to get one delivered the next day. So, I still have a dryer, right? It's just we're isolated down here. We don't have repair shops and stuff like that."

4.2.2. Small Appliances

The low cost and short lifespan of small appliances such as toasters and coffee makers often lead to their replacement. The repair cost often exceeds the replacement cost, resulting in a culture of

throwaway consumption. Moreover, due to their affordability and perceived disposability, small appliances are discouraged from being repaired.

"They're just cheap to buy. I just wouldn't, I don't know. And then one of them, I guess it's just it's accessibility that no one says, hey, I'm a toaster repairman or I'm a hairdryer repair person, right? You just so and they're just cheap to buy and go down to Walmart and get one for $12. So, it cost me more in gas to get a repairman out here than it would be to go to Walmart and get a new one."

4.2.3. Electronics

The topic of this theme is based on the most frequently mentioned electronic categories highlighted by participants, including mobile phones, larger electronics such as televisions, and printers. Each category presents unique challenges related to planned obsolescence, repair costs, and replacement behavior, which hinder the adoption of CE principles.

Many participants reported that fully functional phones became obsolete due to the discontinuation of software updates or compatibility issues.

"I just somehow think these high-tech companies are aware of how old your phone is, and then they start pop ups, start coming on your phone of issues. There's no more storage space. There's no more backup. You can't back up your Gmail and all this kind of stuff, and the phone becomes basically dysfunctional. So, I was at the point where none of my calls would go through, or I'd try to call from places where the calls would work before and they would no longer work. So, it becomes so frustrating trying to operate that you're driven to get another one. So, I hated to give

up on my phone because it was perfect. It wasn't damaged, it was no scrapes on it. I kept it meticulous, but I felt I had to."

Furthermore, Proske et al. (2016) highlight that younger consumers are influenced by trends and a desire for the latest technology, which can lead to the disposal of older devices even if they are still functional (Proske et al., 2016).

Over time, the declining cost of larger electronic devices, such as TVs, makes replacement more cost-effective than repair. Participants noted that the cost of repairing a TV often equals or exceeds the price of a new one. Printers illustrate a unique challenge in applying CE principles due to the high cost of ink refills compared to the price of new printers. Consumers are driven to replace their printers frequently due to this cost imbalance.

"*To get the ink for it was more expensive... than just buying a printer at Costco with ink in it. The printer we have upstairs was $80, and new ink would be $140."*

Also, without any facilities for extended producer responsibility and access to returning obsolete hardware, disposal is only limited to landfilling instead of recycling or refurbishing.

4.2.4. CE Principles Barriers

A broader understanding of the barriers to applying CE principles can be divided into three main categories: Cost of Repair versus Replacement, Availability of Repair Services, and Technological Complexity.

The high cost of repairs relative to the low cost of replacements has been identified as a significant obstacle.

"In Grand Falls, there's somebody who could do it. But I have to pay him to come from Grand Falls to do that and then go back up. So that's a full day for him. So, he's going to want his mileage. He's going to want an eight-hour day on top of the repair costs and everything else. So, I'm paying $1,500 to get him to repair a $1,000 fridge."

Another significant barrier is the lack of access to repair services, particularly in rural and remote areas. Participants frequently mentioned the difficulty of finding repair professionals nearby, long wait times, and high transportation costs, making repairs impractical.

Moreover, from the interviews, we learned that modern electronics become increasingly challenging to repair through their next-level designs, proprietary components, and failure to standardize components. Participants mentioned that even a minor problem with a device will often require an extensive diagnosis and require one-of-a-kind components that cannot be replaced without professional help.

4.3. Theme 2: Community Attitudes Toward CE Principles

An examination of community behaviors, preferences, and challenges associated with the adoption of CE principles is presented in this theme. It is divided into two main sub-themes: Reuse, Repair, Disposal Preferences, and Environmental and Economic Considerations.

4.3.1. Reuse, Repair, Disposal Preferences

Participants demonstrated a range of attitudes toward reusing, repairing, and disposing of products, often shaped by the type of product, available resources, and their confidence in repair attempts. Community members are also interested in repair and reuse, especially with sentimental or high value items. However, time, cost, and accessibility are common barriers to repair. While emotional attachment motivates some repair efforts, lack of convenience often leads to disposal instead.

- Frequent Repair Attempts: Several participants expressed a willingness to repair certain items, particularly furniture and tools, which they viewed as durable and worth maintaining. One participant explained how they often repair tools to extend their lifespan:

"We share tools in our neighborhood, and if something breaks, we try to fix it. Tools are expensive, so it's better to keep them working for as long as possible."

- Ease of Online Resources: The availability of online tutorials (e.g., YouTube) has enabled some community members to attempt repairs themselves. Those with Do It Yourself (DIY) confidence used these platforms to repair smaller appliances and household items. More complex repairs, however, remain challenging.

"…Getting repair guys out here is a challenge. So, the last two things—my dryer and fridge—I fixed myself with YouTube's help. Once you get the part numbers, it's straightforward…"

- Recycling and Disposal Challenges: Small appliances are often disposed of despite efforts to repair them due to limited recycling options and repair feasibility. Individual circumstances, such as time constraints, life stages, and resource availability, play a significant role in disposal decisions. Disposal often becomes the default option when repairing or recycling requires considerable effort.

"As someone with limited time and two kids, I think how you answer that question is based on your support network and where you live and like where you're privileged or what space you're

in in your life. Because when the kids were small, I would have put anything in the garbage because if it... the overhead to get something done."

The participants also identified significant logistical and infrastructure barriers to responsible disposal. A lack of nearby disposal facilities often makes proper disposal inconvenient or impossible, especially in remote communities.

Responses showed that there is genuine interest among the community members in repairing and reusing items, particularly high-value or sentimental items, yet systemic barriers such as time constraints, high repair costs, low technical skills, local repair service options, and a lack of disposal and recycling infrastructure undermines engagement with circular behaviors.

4.3.2. Environmental and Economic Considerations

Community attitudes reflect a mix of environmental awareness and economic considerations. In some cases, sustainability is prioritized, while short-term financial convenience is the priority in other cases. Despite the tension between environmental values and financial realities, cost remains an important factor in decision-making.

Additionally, some participants noted that there is a growing awareness of the environmental impact of waste, encouraging behaviors such as repurpose, recycling, and passing on items. As this consciousness spread, people became resourceful within their community, making new use of older furniture or other possessions. They expressed how not only do these practices minimize

waste, but they also provide economic benefits, from earning cash back on recycled materials to saving money by reusing household items.

"I just find that people are more, uh, have a bit more awareness. They understand, like, you know, the impact of waste and on our environment. So, I find that people they're just more aware. So, they repurpose more, they sell more. You'd see people putting out stuff for the bulk garbage. But then there's always people who drive around looking, um, and can repurpose some of these things. Like we've noticed we had a gentleman that would cut the cords off TVs and stuff to kind of get the metal and the wire and stuff, to bring. And when he collects so much, then he would get, um, get a refund for the items when he stripped off the plastic. And the same thing goes for recycling batteries and different items. So, you can see the awareness, you can see people being smarter and passing on items."

4.4. Theme 3: Decision-Making Drivers in Community Choices for CE

This theme investigates drivers of community decisions on CE practices. The results show that decisions arise from value-driven considerations, economic realities, warranty effects, and environmental consciousness. These elements address the complexity of decision-making at the community level and the nuanced trade-offs involved. This helps understand which products are more likely to be repaired or replaced, operationalizing CE principles in practice.

4.4.1. Value- based Decision making

Several participants emphasized the importance of value-based considerations in their decision-making, particularly when evaluating the quality, durability, and practicality of new or second-

hand items. This is particularly evident when purchasing large appliances and high-cost items like large electronics. Purchasing a higher-quality item highlights a community preference for investing in reliable products that offer greater longevity and reduce the need for frequent repairs or replacements. Participants frequently compared this approach to choosing cheaper, lower-quality items, which may have a lower upfront cost but are perceived as less durable and offering limited long-term value.

"I would say most of those items that you mentioned, the thing I would look at would be the quality of the item, right? So yeah, there is a price point, but I'd rather spend a little bit extra money on a brand that I knew would last as compared to one that, you know, some of these TVs are a prime example, you can go to Walmart and pick up a 60-inch TV for 400 bucks. Now, I don't know how long it lasts, there's only so many TV manufacturers out there and they're all swapping parts in and out. So, you know, uh, but I would generally look at price, and I guess the quality of the item would be my biggest thing when we purchase."

Despite varying levels of skepticism, value-based decision-making was also applied to the purchase of second-hand goods. Some individuals view second-hand items as a practical and affordable option, whereas others are concerned about their reliability and condition.

"Some second-hand things are sort of better than others. You know, a second vehicle is certainly no issue. Secondhand furniture is okay. I am not sure if I'd be keen to buy a second-hand fridge or something like that. Cause I don't know if. cause with the car, you can look at the mileage and look at the shape of the vehicle. And that can give you an indication. That might give you an idea of

what you're getting and maybe this is just some ignorance on my part of an understanding of those things. But I wouldn't be able to look at a fridge and say, oh yeah, it's got another five years in it for sure… so, I don't know if I have the, the ability to make a good judgment call on those sorts of second-hand things, but say, for instance, vehicles or furniture and that sort of things you can do."

As a result of these attitudes, it is evident that a critical decision-making driver is a trade-off between perceived value and risk when purchasing second-hand goods, with a preference for items whose quality can be more easily determined (such as cars and furniture) and hesitation around goods such as appliances.

4.4.2. Cost and Price Sensitivity

Economic considerations primarily influenced repair, reuse, and replacement decisions. Often, participants weighed the repair cost against the replacement price, with many opting to replace when repair costs were deemed excessive. Many participants noted that they make repair or replacement decisions based on the relative costs involved.

"So, it would really be the availability of a repair person to come here specifically in rural, because that's shifted 20 years ago, you'd be able to find someone easily, and now it's not so easy. And so, it's the availability of someone who would physically come to your house and then how much that would cost, and the likelihood of the age of the object on how much money you would potentially spend on it. And so, if that was, you know, if we could get someone to come here and they came here and they said it was $500, but a new fridge is like a thousand, then it would be a conversation of like, what's the best investment, fixing it or buying a new one?"

The balance between short-term affordability and long-term risks and the financial implications of unforeseen issues often influences the decision to purchase second-hand. This view reflects the security and reliability of purchasing something new, especially when given a warranty. For many, warranties provide protection against having to pay out-of-pocket costs for repairs and peace of mind. In contrast, when purchasing second-hand, buyers generally accept a more significant financial uncertainty since if something purchased is defective, the buyer bears the risk of having to repair/replace that property. Participants were particularly concerned about these issues for specific categories of items (e.g., electronics or appliances) as the potential repair cost could overcome the initial savings for buying second-hand.

4.4.3. Environmental and Economic Trade-offs

Participants often discussed how historical changes in consumption patterns influence present-day attitudes toward environmental and economic decisions. One participant reflected on generational differences, recalling how their mother, born in 1937, witnessed the waste transformation firsthand. The waste patterns have changed dramatically in such a short period — especially since the 1950s and 1960s when disposable items became widespread. People owned fewer things, and those things were often made from more substantial materials like wood. However, the rise of plastics and mass-produced materials like Formica created a disposable culture.

Furthermore, participants often had difficulty choosing between environmental values and practical experience when replacing older appliances with new, energy-efficient models.

"When it comes to the appliances I don't know. I haven't had good success I haven't really. It kind of discourages me actually going and buying new appliances. But I know new is better because it's better for the environment. And, you know, it's all low efficient, energy efficient. Um, but the old stuff lasts us forever."

This perspective reveals the tension between older appliances' perceived durability and newer models' environmental advantages. Although participants recognized that energy-efficient appliances are better for the environment, many were reluctant to purchase them based on earlier experiences involving reduced reliability or shorter lifespan. The trade-off between its durability vs. the sustainability benefits of the modern options is still seen as a dilemma that naturally leads to delayed decisions and unwillingness to replace items.

These findings emphasize the importance of addressing durability concerns in modern appliances while promoting their environmental benefits to encourage broader adoption. By bridging the gap between environmental efficiency and product longevity, manufacturers and policymakers can help reduce the hesitancy associated with sustainable choices.

4.4.4. Warranty and Guarantee Influence

Participants noted that their relationship with products often changed once the warranty period expired. Sometimes, items were discarded or replaced once warranty coverage was no longer available. Moreover, participants expressed frustration with the limitations of warranty periods and the challenges associated with their use.

"We got warranty on that stuff, so we would send it away for warranty work. And then probably once the warranty was gone, we'd get rid of it and get something new."

Proactive engagement must be undertaken with companies since the expiration of a warranty often serves as a psychological and financial tipping point that influences the decision to replace instead of repair.

4.5. Theme 4: Influence of Product Lifespan on CE Principles

The product lifespan significantly impacts on the participants' decisions regarding repair, reuse, or replacement. In line with CE principles, items with longer lifespans were considered more valuable, while those with shorter lifespans were disposed of more frequently.

4.5.1. Product Longevity and Ownership History

Participants praised the durability of older appliances and furniture compared to newer models. Participants often reminisced about older products' superior durability and repairability, noting that they were designed for easy maintenance and built to last.

"I think that before people knew each other really well. And so, it would be more apt to pick up something that somebody else wasn't using, like down the street or whatever, because they knew each other, but that's just not necessarily the case. Products were more easy. They were built more durable. and a better quality. And they were built in a way that was meant to be fixed and live on for a long time. And now it's not. And I think that that's not necessarily a knowledge that I could share and fix in some way. It's just an unfortunate way that our society has moved towards making

things more convenient and less expensive. So, nothing that I think would be very useful. Just unfortunate kind of the way society has moved."

Several examples have been cited of decades-old appliances still being used compared to newer products that have a shorter lifespan. One respondent stated that furniture retailers now tell them that major appliances only last an average of 5 to 6 years, compared with older appliances that remained functional for decades.

Several participants expressed disappointment at the decline in product quality, emphasizing that modern items are often viewed as disposable rather than long-lasting. Another participant reflected that products were considered valuable investments in the past, with appliances like microwaves being expensive luxury items. However, in today's world, mass production and lower-quality materials have made household goods cheaper and more disposable, reinforcing a culture of frequent replacement rather than long-term use.

These insights bring nostalgia to durable goods that lasted longer and aligned better with sustainable practices. Across the diverse group of participants, they expressed that modern products are often designed to prioritize convenience and affordability rather than longevity and/or repairability, creating challenges for integrating CE principles into everyday life.

4.5.2. Warranties and Guarantees

It is important to note that the discussion of guarantees and warranties in this section differs from that in Section 4.4.4, which focuses on how the availability of warranty influences purchasing decisions for CDGs. Alternatively, this section addresses the challenges associated with warranty coverage, mainly when dealing with newer technologies and additional components that often fall outside standard warranty terms, making repair and reuse more difficult for consumers.

A warranty can provide financial security and influence choices, particularly for high-cost items; however, participants also expressed frustration with the limitations and challenges associated with warranty processes.

Many participants noted that the availability of a warranty encouraged them to seek repairs rather than replacements. Warranties were seen as a safety net that reduced the financial risk associated with repair costs.

"If it was covered under warranty, yeah, I would go for repairs, but warranty work sometimes really hard to get done. And, repairs like, I've gone through probably three fridges, four fridges since, you know, in the last 20 years. And it seems like they don't last half as long as the older technology. this newer technology with the displays in them and the apps for the cell phone where you can go like to me, that's only just, it's a waste. You know, and it's way too expensive to repair."

Participants highlighted the importance of engaging directly with manufacturers to address repair needs, especially when warranties have expired. The level of support manufacturers provide plays a significant role in whether consumers choose to repair or replace their products, highlighting inconsistencies in key areas. While some manufacturers go the extra mile by offering repairs or replacements beyond the warranty period as a goodwill gesture, Others are less flexible, leaving

customers dissatisfied. Furthermore, accessibility is another challenge; some manufacturers lack local repair services, especially in remote areas, discouraging repair attempts, discouraging people from attempting repairs, and pushing them toward replacements. Moreover, repair costs vary widely. While some manufacturers offer reasonably priced options, others impose high fees that make repairs unfeasible. Addressing these challenges by making repair services more accessible, affordable, and transparent could build consumer trust, encourage repairs over replacements, and align manufacturer's practices with the principles of a CE.

4.6. Theme 5: TEK Specific Themes and Further Business Models for Communities

This theme examines the role of TEK, and innovative business models tailored to the needs of local communities. It discusses the contribution of TEK to sustainable practices, especially in Indigenous communities, and identifies methods through which local businesses can align with circular economy principles. The analysis focuses on three sub-themes: Perception of TEK for CDGs, Education of New Generations on TEK, and Waste Management Plans for Indigenous Communities.

4.6.1. Perception of TEK for CDGs

Participants expressed a variety of viewpoints regarding TEK's role in managing life cycle stages of CDGs. While traditional knowledge remains a vital part of Indigenous culture, its role in managing CDG has been limited and often overshadowed by modern approaches and systemic challenges.

- **Cultural Values and Community Support**

TEK strongly emphasizes community support and reducing waste, values deeply rooted in Indigenous practices today. Participants shared that they prioritize repairing and repurposing items rather than throwing them away, mainly when these items can serve others in their community.

"Like us Indigenous, I guess we really like to help out family members and people in our own community. Like, instead of throwing something away, if we can get it fixed and it could serve someone else a better purpose, I would much rather do that."

This approach reflects TEK principles, prioritizing the community's well-being over individual convenience. By repairing items for redistribution, they minimize waste and foster sustainability within their community.

- **Traditional Practices vs. Modern Challenges**

Historically, lifestyles guided by TEK naturally generated minimal waste, as they were shaped by resource scarcity. In contrast, transitioning to modern living has brought about a disposable culture and new challenges in managing waste associated with CDGs. Many participants expressed frustration with current waste management systems, often citing landfills as a symbol of systemic inefficiency and environmental harm.

Traditional knowledge passed down through generations—through parents, grandparents, and elders—has long emphasized social and cultural norms that promote well-being and environmental stewardship. Following the principle of sustainability, the teachings about respect and cleanliness were shared through daily interactions rather than formal schooling.

However, one participant noted that modern practices often violate such teachings as current behaviors increasingly disregard the principles of environmental responsibility that were once deeply embedded in everyday life.

"They find it appalling. Every one of them. Actually, if you speak to 90, I say 90% of the community will say they're blown away by the landfill. And I think, and you spoke of being in the position that I am in. And it's really frustrating. It is frustrating and I remember when I first got on the council, somebody looked up and said, you must feel powerful. And I said, I never felt so weak before in my life. And that's the God's honest truth because you feel like."

These concerns reflect a deep alignment with TEK's principles of environmental stewardship. However, participants also highlighted the lack of infrastructure and support needed to apply these principles to managing CDGs effectively.

Another participant mentioned that several traditional practices have been diminished due to modernization. This observation emphasizes the challenge of balancing the preservation of traditional practices with modern life's economic and cultural demands, where affordability and convenience frequently take priority.

- **Contrasts Between Past and Present Waste Practices**

Participants reflected on how waste generation and management have changed over time, comparing the minimal waste of earlier generations to the modern disposable culture.

"It definitely not, well it kind of got the pros and cons too, because back in the day you didn't have a whole lot. I mean, for our community, you were lucky if you had TVs. I remember when we were growing up, we didn't have a TV. And the disposal of those kinds of things wasn't so much in your face kind of thing. But we didn't have, back when we were growing up, we didn't have a disposal site
kind of thing. So, you could have been something like, if you walked around the beach, you could see a mic, it wouldn't be a microwave back then, but whatever, over there. But right now, even though it's not the best, but it's in a confined area."

This contrast highlights how TEK was rooted in sustainable living, with little interaction with CDGs, which were nonexistent or considered luxuries. The emergence of consumer culture and the accessibility of inexpensive, disposable items have significantly transformed these practices, posing new challenges in applying TEK to today's waste management needs.

4.6.2. Education of New Generations on TEK

Participants from Indigenous communities frequently emphasized the importance of passing down ecological values to younger generations. However, these teachings were available for broader sustainability principles rather than specific methods for managing or disposing of CDGs.

"I don't know if it's concentrated but have it incorporated into the schooling, the different aspects of Aboriginal content kind of thing, you know, like the food, taking care of mother Earth, like that kind of thing. So, yeah, you could go off to universities and get degrees and stuff like that, but be

conscious of your history like you are kind of what you've been exposed to, kind of thing. We were kind of not very well off and we didn't have much. So, you took care of your things. You learned how to repair things when you can, or whatever the case may be, you could follow that through. It doesn't matter that you get 80 or 90 or $100,000. You still could do the same thing because it was instilled into you."

4.6.3. Waste Management Plans for Indigenous Communities

Participants from Indigenous communities highlighted ongoing challenges and emerging solutions in managing waste, particularly for CDGs. A critical need for community-driven waste management programs was highlighted, as no structured waste management systems are available.

As identified by participants, the absence of local infrastructure was a common barrier to effective waste management. The logistical burden of transporting waste to distant facilities—requiring personal time, effort, and money—discourages responsible for disposal, highlighting the need for community-driven solutions like mobile collection programs to help alleviate some of the environmental burden on communities.

Proactive efforts to partner with regional waste management entities demonstrate a strong commitment to enhancing waste disposal practices. However, challenges like disagreements over tipping fees must be addressed to ensure the success of these collaborations.

In order to address these challenges, participants proposed innovative solutions that emphasize a locally driven and collaborative approach. There has been discussion about establishing

community recycling and disposal depots and leveraging existing resources and programs for support. Electronics and other recyclable materials could be collected at these depots. A community-operated depot offers two key advantages: enhancing access to recycling services and creating local job opportunities. Moreover, these depots could generate revenue by processing and tagging recyclable items.

"There's things you can do. So that's one thing I'm interested in now is, can we set up a depot here? Something simple, and it's not necessarily that somebody's going to own this and make money off of it, but it's in the community, it's offering that recycling service, and we have employees that we can utilize for this through that program. So, it's not costing the depot any money to hire anybody. And now we've got people being put to work. People can drop off their stuff. Tag it. Money goes into an account. When they want to pull it out, they can pull it out."

The research objective to explore TEK as a potential framework for managing CDGs faced a significant limitation: transportation and access to services emerged as the primary barriers in Indigenous communities. Participants often identified logistical challenges as a barrier to proper disposal. The lack of infrastructure and geographic isolation prevent Indigenous communities from fully participating in CE practices despite their cultural alignment with sustainability.

4.7. Theme 6: Transportation and Accessibility of Repair Services in Remote and Indigenous Communities

This theme delves into the challenges remote and Indigenous communities face in accessing repair services, emphasizing transportation barriers, logistical limitations, and their impact on CE

practices. Interviews highlight that limited repair infrastructure and high costs often force residents to replace items rather than repair them, leading to increased waste and missed opportunities for sustainable practices.

4.7.1. Transportation and Access to Services

Several participants quoted geographic isolation as a significant barrier to receiving repair services. The lack of local repair professionals and the distances required to access services result in substantial inconvenience and costs.

"Well, one of the things, I guess, in where we're so far away from a, you know, service center is that it's very difficult to get stuff repaired, even from a personal perspective with my house. You know, if there was an opportunity to get it repaired, it would have to do it. But a lot of cases, you have to buy new because you can't take it somewhere to get it repaired unless you have to drive two hours away and then you're two weeks getting someone to look at it. So, you almost have to purchase. You have to purchase a new product."

The lack of local services also means fewer repair opportunities for CDGs, discouraging attempts to extend their lifespan.

4.7.2. Transportation Costs and Logistics

The financial strain of transporting items for repair was a recurring theme. For larger appliances, the combined cost of transportation and repair frequently surpasses the expense of purchasing a new item.

Consumers often anticipate that large companies will include transportation and installation services with their products. However, rural areas frequently encounter obstacles such as limited-service availability and added transportation costs, making access to these services more challenging.

"It's not worth the hassle of taking it up the highway. You know, for the actual cost of a new one. Traveled up the highway, get a service personnel to look at it, get it repaired and go out and pick it up. It's just as, probably even cheaper to purchase a new one. You know, if you had a bigger ticket item, then you can weigh the pros and cons and see what the cost would be."

For large and small appliances, the logistical challenges and high costs associated with transporting items for repair often outweigh the benefits, mainly when replacement costs are comparable.
The economic burden of transportation costs often creates a tipping point where replacing an item becomes more cost-effective than repairing it. This challenge is widespread with mid-range appliances, which fall between inexpensive and high-end options

4.7.3. Impact on Community Decision-Making

Transportation challenges also have a direct and significant impact on community decision-making, especially in remote and Indigenous communities. Logistical and financial obstacles often drive whether people repair, replace, or even buy CDGs, as analyzed in a previous section of the Decision-Making Drivers in Community Choices for CE analysis. The absence of integrated services, such as delivery, installation, and old equipment removal, aggravates these challenges, influencing purchasing behavior and waste management practices.

"I'm reluctant to buy anything in St. John's because I figure that they're going to charge me whack of money for transportation. I think we bought the fridge and stove from Sears in Bay Roberts when it existed. And they end up giving us a number of somebody who would do the transportation. And, that was an annoyance, because it seems to me a big company like Sears should do the deliveries and do the installation and take away the old equipment."

The absence of extended services from large companies is viewed as a missed opportunity to promote sustainable practices. If delivery and installation were included, community members would face fewer barriers to acquiring or maintaining CDGs, fostering alignment with CE principles.

4.7.4. Reliance on Self- Repair and Local Networks

The limited availability of repair services and the high transportation costs in remote and Indigenous communities often drive residents to depend on self-repair and local networks to maintain CDGs. This behavior demonstrates community resilience and resourcefulness but also highlights systemic barriers to professional repair services.

Participants often shared that their first response to malfunctioning appliances or other CDGs was to attempt repairs themselves. With professional repair services typically located hours away, self-repair has become a practical necessity in many cases.

"He would work really hard first to repair it himself. We have had things break down before. So, if a Maytag or if a fridge or a freezer or anything breaks down and you call the manufacturer, they'll say, okay, what's the closest repair person? And it's six hours away, it's St. John's. You don't get anything closer. So normally the company will sell, send the parts out to us, and we will try to repair it ourselves first. If that fails, then we replace it. So, then we dispose of it then. Yeah, but we try to repair it ourselves first if we can."

In addition to self-repair, community members frequently turn to informal networks, including neighbors or local professionals, for help diagnosing and repairing items. These networks are essential in areas with limited or unavailable professional repair services.

Furthermore, as it was mentioned in previous sections by participants, to enhance their self-repair efforts, they are increasingly utilizing online resources like YouTube tutorials, which offer step-by-step instructions and guidance for troubleshooting and fixing a variety of issues. These tools empower them with limited technical expertise to take on repairs themselves, minimizing their dependence on professional services.

4.8. Theme 7: Waste Management and Circular Economy

This theme examines the integration of waste management practices with CE principles in remote and Indigenous communities. Sub-themes such as Local Waste Management Initiatives and Challenges in Waste Disposal highlight how these communities address unique environmental and logistical challenges to align with CE principles.

4.8.1. Challenges in Waste Disposal

Participants often pointed out that the absence of formalized waste management systems places rural and remote areas at a significant disadvantage compared to urban centers. With limited infrastructure, waste in these regions frequently ends up in landfills or is improperly disposed of. This gap in waste management infrastructure highlights systemic inequities, as rural communities are left to depend on makeshift solutions. These challenges emphasize the pressing need for a unified and well-resourced approach to waste management.

"They're working on a plan for waste management in this area. I think we're behind, like, most areas of the province, especially in urban areas, because they have more resources, more human resources and stuff. So, our garbage, I mean, has to be trucked up the highway. So right now, without a formalized plan in place, I mean, people are doing what they have to do to move it, people don't want garbage in their yards. So, we're doing what we have to do to get it out. But I would like to see a more unified approach to disposing of items, much like there is in St. John's and more urban areas. But we just don't even have that here. Like, our garbage is going into the garbage. You know, they come and pick it up once a week."

Participants expressed frustration over discontinuing localized hazardous waste collection programs, which once provided accessible and environmentally responsible disposal options. This gap poses significant ecological risks and highlights the consequences of inadequate community-specific waste management solutions. The absence of programs like hazardous waste collection days leaves residents without convenient disposal alternatives, increasing the risk of harmful

practices such as illegal dumping or contamination of natural resources. Reinstating these programs could reduce environmental harm and promote responsible waste management.

Furthermore, a member in the band council emphasized the urgent need for funding to develop resources and ensure their proper utilization by the community when discussing immediate solutions for waste management in an Indigenous community.

"Funding. Funding to get these resources, make these resources available to the community and the community, to uphold to them and to use these resources."

4.8.2. Local Waste Management Initiatives and Individual Responsibilities

This sub-theme highlights the interplay between community-led waste management efforts and the role of individuals in addressing waste disposal challenges. The results emphasize that localized programs and personal responsibility to maintain long-lasting waste practices are the keys to conservation, particularly in Indigenous and remote communities.

In Indigenous community, repair programs are already in progress, allowing people living in Section 95 housing to access this service. This specific initiative is a practical application of CE principles that attempted to repair appliances before discarding them. Taking this model community-wide could dramatically limit waste while offering fair access to repair resources for all income groups.

Many participants commented on the cultural change from habits of repairing to an attitude of disposability. In the past, communities practiced sustainability out of necessity, ensuring nothing

went to waste. These traditions align with CE principles but have lost prominence in modern consumption culture.

"I think people reference how things have changed, and they'll reference what it was like for when their parents were growing up or their grandparents. And they'll speak about it in a romantic way, you know, like you never threw anything out or someone always used… you know, my grandmother had a plastic hen on the fridge that was full of buttons because you just didn't throw anything out. You always used it. And so, no one would have used the term circular economy."

"Well, in the past, I think that people were reluctant to get rid of things they were more inclined to repair. Now we live in a climate where everybody is getting rid of it. As soon as something goes wrong with it, they're chucking it out. I can't say from my experience that that's the case in my house, because I'm fortunate, because now I would have to throw it out because I can't fix it. But my husband, he's handy, and he will fix it if he can. But the climate generally is for people when something breaks or when the newest thing comes on the market, they'll just get rid of it. Whereas before I don't think it was like that. People wanted to repair."

Traditions that once embedded behaviors such as repair and reuse in daily life have been replaced by modern-day consumerism, placing convenience and disposability at the forefront of priorities. Education and incentives can re-establish a repair culture to counter this trend.

The remote community of Harbour Main has implemented convenient waste disposal services to encourage responsible practices. These include twice a year bulk cleanup events, recycling

initiatives, and year-round metal dumpsters for large appliances and other items. These services offer convenience, reduce the risk of illegal dumping, and help share waste management's financial and logistical burdens with residents.

Moreover, when asked about waste management initiatives, Harbour Main's mayor highlighted ongoing efforts to improve sustainability.

"In the town right now we're in the process of a lot of recycling. There's going to be a composter soon up in operation at the community garden. So, things are going to be moving along a lot better in town with regards to composting. And also, we have a glass crusher. So that's going to be up and going very soon. I recycle all my cans and stuff really."

Municipal programs such as composting and glass recycling are crucial advancements in decreasing landfill reliance and fostering CE practices. When combined with standard recycling efforts, these initiatives demonstrate the capacity of local governments to set a positive example.

5.0. Discussion

Through the integration of community voices, the research locations revealed systemic barriers to the adoption of CE as well as opportunities for TEK integration into waste management strategies.

Therefore, this study highlights the need to address systemic barriers to adopting CE practices in remote and Indigenous communities. From themes 1, 6 and 7, it is clear that key obstacles include inadequate infrastructure, such as inadequate repair services, recycling facilities, and localized

waste management programs. These challenges are particularly imperative in Indigenous communities, where logistical limitations and economic constraints worsen the difficulties of implementing sustainable waste management practices.

In remote areas, limited infrastructure — including the lack of local repair services and recycling facilities — is a significant obstacle. High transportation costs and logistical inefficiencies make the situation worse, as it is often cheaper to buy a new item rather than have the old one repaired. According to McCollough (2009), repair costs for large appliances often exceed the cost of replacement, making disposal a rational choice for consumers (McCollough, 2009). In addition, Cooper (2010) also discusses the barriers created by advancements in appliance technology, particularly with integrated electronics, which require specialized tools and skills to repair them (Cooper, 2010). Milios, L. (2018) also emphasized that the logistics of transporting large appliances to remote locations for repair are prohibitively expensive (Milios, 2018). This issue aligns with findings in the white paper on Durable and Repairable Products: 20 Steps to a Sustainable Europe by the European Environmental Bureau (2020), emphasizing that design choices focusing on functionality over reparability significantly contribute to product disposability (Marco, 2020).

Furthermore, the complexity of modern consumer goods, characterized by proprietary components and planned obsolescence, further hinders CE practices. Bakker et al. (2014) identify the trend of planned obsolescence in small appliances, where products are designed for limited lifespans. As they have observed, consumers are discouraged from investing time and money in repairing small appliances due to their perceived low value (Bakker et al., 2014). Furthermore, Huisman, J. (2007)

emphasizes that limited access to spare parts and repair services makes it easier for consumers to replace these items, particularly in rural areas (Huisman et al., 2007).

Economic considerations also play a significant role. Participants frequently mentioned the high cost of repairs relative to the affordability of new products. Likewise, Laitala et al. (2018) assert that this economic disparity discourages repair, mainly when budgets are limited (Laitala et al., 2018). As such, this reflects the razor-and-blade business model, in which the primary device (example of printers) is sold cheaply, while the consumables (ink) are expensive (Armstrong & Vickers, 2022). As a result of the frequency with which printers are discarded, Mayers et al. (2005) highlight the detrimental effects of this model on the environment, particularly concerning plastic and electronic waste (Mayers et al., 2005).

Participants from the Indigenous community emphasized that sustainability principles are rooted in TEK. TEK advocates repairing, repurposing, and sharing resources to reduce waste. However, the study also indicated that there are no traditional practices for CDGs, and modernization has diluted the existing traditional practices.

5.1. Limitations and Future Research

There were several limitations in this study. First, the research team could not interview garbage collectors, who provided insight into operational difficulties and real-world experience with waste handling. Second, in Harbour Main, most participants were from an aging demographic, and younger community members were underrepresented in the interviews. This demographic may have influenced the findings regarding attitudes toward technology and repair.

Future research should broaden its scope to encompass a more extensive range of remote and Indigenous communities, ensuring the inclusion of diverse perspectives. Conducting quantitative analyses to evaluate the environmental and economic impacts of CE interventions, such as repair subsidies and localized recycling programs, would offer critical insights for policymakers and practitioners.

6.0. Conclusions

This research presented an original qualitative study aimed at exploring the barriers to implementing CE practices for CDGs in two NL communities: Harbour Main, a remote non-Indigenous community, and Conne River, a Mi'kmaq First Nation community. The study used a community-based participatory approach, where semi-structured interviews were conducted with community members and local governance representatives to assess their perceptions and experiences with the disposal, repair, and reuse of CDGs. The research utilized grounded theory methodology, with thematic coding and analysis conducted using ATLAS.ti software.

Moreover, the study highlighted significant barriers to adopting CE principles in remote and Indigenous communities by incorporating community voices and identified opportunities to incorporate TEK into local-scale waste management practices. Findings from both Indigenous and non-Indigenous participants highlight the gap between circular intent and systemic feasibility, with high repair costs, lack of local recycling or waste diversion services, and limited infrastructure being the key barriers to CE engagement.

Recent literature on CE highlights significant gaps in contextual and community-specific applications, particularly at the micro-level where real-world implementation occurs. Heras-Saizarbitoria et al. (2023) underscore that CE practices at the firm level are often superficial and limited to recycling and waste management, lacking transformative depth and systemic integration

(Circular Economy at the Company Level, 2024). This observation resonates with challenges in rural and northern contexts, where localized knowledge systems, such as TEK, are undervalued or excluded from sustainability strategies.

The foundational framework by Velenturf and Purnell (2021) proposes ten principles for a sustainable CE, emphasizing contextual sensitivity and citizen participation. Additionally, one of the principles advocates for the co-production of CE solutions with local communities to ensure cultural compatibility and long-term success (Velenturf & Purnell, 2021). In northern and rural areas, this principle aligns closely with the ethical imperative to include TEK, which offers a holistic, place-based understanding of resource use, seasonal cycles, and interspecies relationships. Such knowledge is often more sustainable than technologically centric CE models, emphasizing efficiency over ecological reciprocity.

Achieving equity in CE implementation requires addressing the infrastructural disparities between urban and rural areas. Indigenous communities should not be left behind in the global transition toward sustainability. By providing these communities with the necessary tools and resources, we can enable them to become leaders in sustainable waste management, contributing meaningfully to global efforts to combat environmental challenges and promote circularity.

Chapter 4:
General Discussion, Conclusion, Limitations, and Future Work

4.1. General Discussion and Conclusion

The findings of this research aim to identify significant barriers and potential facilitators to adopting CE principles for CDGs, especially in remote and Indigenous communities in NL. Although CE provides a novel opportunity to address the shortcomings of the linear economic model, its implementation is still underdeveloped in marginalized regions due to systemic, infrastructural, and socio-economic barriers (*Waste Management In Remote Rural Communities Across The Canadian North: Challenges And Opportunities*, 2018).

Many Indigenous and non-Indigenous participants in this study expressed frustration over limited access to repair options, which often forces them to dispose of appliances and electronics prematurely rather than refurbishment or recycling. Moreover, the high transportation costs make it economically unfeasible to transport damaged goods for repair. Repairing does not make sense from an economic standpoint for many goods; McCollough (2009) found that repair costs for large appliances often exceed the cost of replacement, where simple disposal of the item is usually less expensive than the repair itself (McCollough, 2009). Likewise, Milios (2018) emphasized that transporting large appliances to repair facilities is costly, discouraging sustainable consumption habits (Milios, 2018). Furthermore, Economic barriers are also one of the main drivers of consumer behavior toward CDGs. Participants frequently mentioned the high cost of repairs compared to the affordability of new products as a barrier to repairing and maintaining existing goods. For example, participants noted that printers are thrown out because replacing the ink is more expensive than buying a new printer; this issue adds considerably to e-waste accumulation (Mayers et al., 2005).

Additionally, financial incentives for repair and reuse are limited, as Canada lags other countries in offering repair support, tax breaks for refurbished goods, and extended producer responsibility programs. Such models could be adapted to rural Canada; for example, Sweden has reduced taxes on repair services to encourage consumers to repair goods instead of replacing them (Sweden Is Paying People to Fix Their Belongings Instead of Throwing Them Away, 2016).

Traditional Ecological Knowledge and Its role in CE

As TEK has been established in managing natural resources, biomaterials, or organic waste within the biological cycle of CE frameworks, this study finds that TEK-based practices for CDGs are mainly missing or not adopted. Through participant interviews, it became evident that while Indigenous communities have deep-rooted traditions of sustainability, such as repairing, repurposing, and sharing bio-based resources, but there is no long history of managing modern, mass-produced CDGs.

This conclusion is drawn from participant responses, with many Indigenous community members expressing deep-rooted cultural values of sustainability. However, they mentioned that these principles were not traditionally applied to CDGs. Instead, technologies and the rise of mass-produced goods have disrupted local sustainability practices, increasing reliance on disposable products and imported materials (Bakker et al., 2014). However, the absence of historically practiced TEK for CDGs is an opportunity to integrate TEK into CDG management moving forward.

Indigenous communities can create hybrid models that merge TEK with modern CE strategies by incorporating TEK. For example, repair initiatives that draw on Indigenous expertise in tool maintenance and craftsmanship could be expanded to include training in modern appliance repair.

Additionally, community-based circular systems, such as waste-to-resource programs and localized upcycling projects can be developed with indigenous leaders to ensure alignment with traditional sustainability values (Jiraphanumes & Sansompron, 2024).

4.2. Limitations

Despite the valuable insights gained from this study, certain limitations must be acknowledged.

The review on Chapter 2 analyzes existing literature using previously analyzed data to draw conclusions about barriers to implementing a circular economy integrated with TEK in northern rural communities of Canada. Policy implications that inform improvements and provide recommendations are considered in this review; however, a systematic policy evaluation is needed to emphasize how TEK can be integrated to build an inclusive and equitable CE for CDGs rather than simply relying on indirect regulatory frameworks. Data derived from literature may be limited in their generic application to all regions as CE strategies must consider regional and local socio-economic, environmental, and cultural contexts.

Furthermore, there were certain limitations in the study on chapter 3. First, the research team could not interview garbage collectors, who provided insight into operational difficulties and real-world experience with waste handling. Second, in Harbour Main, most participants were from an aging demographic, and younger community members were underrepresented in the interviews. This demographic may have influenced the findings regarding attitudes toward technology and repair.

4.3. Scope for Future Work

Future research should broaden its scope to encompass a more extensive range of remote and Indigenous communities, ensuring the inclusion of diverse perspectives. Conducting quantitative analyses to evaluate the environmental and economic impacts of CE interventions, such as repair subsidies and localized recycling programs, would offer critical insights for policymakers and practitioners.

Additionally, integrating more diverse stakeholder engagement, including waste management professionals, local policymakers, and Indigenous governance representatives, would be valuable for a broader understanding of how the CE principles can be effectively translated within different socio-economic and environmental contexts. In addition, exploring new initiatives, such as decentralized repair hubs, localized material recovery networks, and incentives for circular design in CDGs in rural settings, may provide actionable recommendations for improving waste management and resource efficiency.

By expanding interdisciplinary research, we can address these limitations and ensure that CE policies are inclusive, effective, and tailored to the needs of diverse communities.

Ethical Considerations: The proposal of this research and the research methodology were reviewed and approved by the McMaster Research Ethics Board (MREB) to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2), as well as the McMaster University Policies and Guidelines for Research Involving Human Participants. Additionally, ethical clearance was granted by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland (Approved on 21st July 2023, MREB#6008).

Before the interview, all participants were provided with information letters and consent forms about the study's objectives. Informed consent was obtained before conducting interviews, ensuring that participants fully understood the purpose, scope, and potential implications of their involvement and the voluntary nature of their participation. Confidentiality and anonymity were maintained throughout the research process, with all personal identifiers removed from transcripts and findings to protect participant privacy.

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APPENDICES

Appendix A: MREB and ICEHR Ethics Clearance

McMaster University | Research Ethics Board

McMaster University Research Ethics Board (MREB)
c/o Research Office for Administrative Development and Support
MREB Secretariat, GH-305
1280 Main St. W.
Hamilton, Ontario, L8W 4L8
email: ethicsoffice@mcmaster.ca
Phone: 905-525-9140 ext. 23142

CERTIFICATE OF ETHICS CLEARANCE TO INVOLVE HUMAN PARTICIPANTS IN RESEARCH

Today's Date: Jul/21/2023

Principal Investigator: Professor Devashish Pujari
PI Faculty/Dept: Business - Marketing
Co-Investigator: Dr. Atanu Sarkar, Dr. Shegufta Shetranjiwalla-Merchant , Dr. Stephen Hill
Research Assistant/Coordinator: Ms. Fatima Sadat Ghaderi, Ms. Yasamin Atabakifardtehrani
Applicant: Dr. Devashish Pujari
Project Title: Identifying barriers in design for recovery, reuse and regeneration in consumer durables and emergent renewable energy products
MREB#: 6008

Dear Researcher(s)

The ethics application and supporting documents for MREB# 6008 entitled "Identifying barriers in design for recovery, reuse and regeneration in consumer durables and emergent renewable energy products" have been reviewed and cleared by the MREB to ensure compliance with the Tri-Council Policy Statement and the McMaster Policies and Guidelines for Research Involving Human Participants.

The application protocol is cleared subject to clarification and/or modification as identified below:

We are still waiting for the community review from Conne River. Given this delay and your wish to get started on this research, MREB is providing you with conditional ethics review clearance to proceed with the recruitment and data collection at Harbour Main and with the design professionals. As we are still waiting for the community review from Conne River, this part of the project must be on hold until we receive the review and any concerns from the community are addressed, or it is confirmed that there are no additional ethics concerns from the community perspective. If changes are required due to the community review feedback, they can be submitted via an Amendment.

The above named study is to be conducted in accordance with the most recent approved versions of the application and supporting documents.

Ongoing clearance is contingent on completing the Annual Report in advance of the yearly anniversary of the original ethics clearance date: Jul/20/2024. If the Annual Report is not submitted, then ethics clearance will lapse on the expiry date and Research Finance will be notified that ethics clearance is no longer valid (TCPS, Art. 6.14).

An Amendment form must be submitted and cleared before any substantive alterations are made to the approved research protocol and documents (TCPS, Art. 6.16).

Researchers are required to report Adverse Events (i.e. an unanticipated negative consequence or result affecting participants) to the MREB secretariat and the MREB Chair as soon as possible, and no more than 3 days after the event occurs (TCPS, Art. 6.15). A privacy breach affecting participant information should also be reported to the MREB secretariat and the MREB Chair as soon as possible. The Reportable Events form is used to document adverse events, privacy breaches, protocol deviations and participant complaints.

Document Type	File Name	Date	Version
Community Engagement	6.5&6.7Letter of Support MFN	Mar/24/2023	1
For Information Only	DOC-20230327-WA0000	Mar/27/2023	1
Interviews	11.14.5. Interview Guide- Design Professionals	Mar/31/2023	2
Letters of Support	14.8 Support document-Community	Mar/31/2023	2
Interviews	11_14_5_Interview_Question_and_guide_town_band,council_Community	Apr/05/2023	3
Recruiting Materials	10.6.6_Telephone Oral Script- Design Professionals_v2	May/19/2023	v2
Recruiting Materials	10.6.10 Recruitment - Snowball Script- Community version 2	May/19/2023	v2
Community Engagement	11.13. Support Letter Harbour Main- Community	May/19/2023	v2
Interviews	11_14_5_Interview_Question_and_guide_Community_members_version_2	May/19/2023	v2
Interviews	11_14_5_Interview_Question_and_guide_garbage_collectors_Community_v2	May/19/2023	v2
Consent Forms	16.6.1. Oral Consent Log - Design Professionals_v2	May/19/2023	v2
Consent Forms	16.6.2_Oral-Telephone Consent Script_v2	May/19/2023	v2
Consent Forms	16.6.2 Consent - Oral Consent Script-Community version 2	May/19/2023	v2
Recruiting Materials	10.10 Screening Question-community-version 1	May/19/2023	v1
Consent Forms	16.6.1. Oral Consent Log - community_v1 (1)	May/19/2023	v1

Document Type	File Name	Date	Version
Recruiting Materials	10.6.9_Recruitment Email Script for Follow-up interview_Design Professsionaals_v3	Jun/06/2023	v3
Recruiting Materials	10.6.4_Social Media Post_Design Professional_v3	Jun/06/2023	v3
Recruiting Materials	10.6.7_Email Script_Design Professionals_v3	Jun/06/2023	v3
Consent Forms	16.6.3_Letter_of_Information_Consent_form_Design Professionals_v3	Jun/07/2023	v3
Recruiting Materials	10.6.4 Recruitment - Social Media post- Community version3	Jun/15/2023	v3
Consent Forms	16.6.3. LOI- Community	Jun/15/2023	v3
Recruiting Materials	10.6.6 Recruitment - Telephone Script -Community version 3	Jun/15/2023	v3
Response Documents	Reply to MREB Review_June 15	Jun/15/2023	v3

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McMaster University | Research Ethics Board

McMaster University Research Ethics Board (MREB)
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MREB Secretariat, GH-305
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CERTIFICATE OF ETHICS CLEARANCE TO INVOLVE HUMAN PARTICIPANTS IN RESEARCH

Today's Date: Dec/05/2024

Principal Investigator: Professor Devashish Pujari
Co-Investigator: Dr. Atanu Sarkar, Dr. Shegufta Shetranjiwalla-Merchant , Dr. Stephen Hill
Research Assistant/Coordinator: Ms. Yasamin Atabakifardtehrani, Mr Deep Patel, Mr. Kevin Mackenzie, Dr. Uyen Dao
Applicant: Dr. Devashish Pujari
Project Title: Identifying barriers in design for regeneration in consumer durables and emergent renewable energy products
Full Project Title: Identifying barriers in design for recovery, reuse and regeneration in consumer durables and emergent renewable energy products
MREB#: 6008

Amendment Information:

Amendment Submission Date	Amendment Label	Transfer Amendment Date	Transfer Amendment Project Tree Info
Dec/04/2024	Addition of Post Doc Research Assistant		

Dear Researcher(s)

This amendment for MREB#6008 entitled "Identifying barriers in design for recovery, reuse and regeneration in consumer durables and emergent renewable energy products " has been reviewed and cleared by the MREB to ensure compliance with the Tri-Council Policy Statement and the McMaster Policies and Guidelines for Research Involving Human Participants.

The amendment request is cleared as presented without questions or requests for modifications.

Form Documents Table

Dr. David Ogborn

Appendix B: Letter of Information Document

Information letter for Conne River and Harbour Main community

Title of Research Project: Exploring the barriers in promoting circular economy of consumer durables and emergent renewable energy products in remote and indigenous communities in Newfoundland and Labrador.

Researchers

- Dr. Atanu Sarkar, Division of Community Health and Humanities, Faculty of Medicine, Memorial University, 300 Prince Philip Drive, St John's NL, Tel: 709 864 4920, Email: atanu.sarkar@med.mun.ca
- Yasamin Atabaki Fard Tehrani, Master of Science (M.sc) student, Division of Community Health and Humanities, Faculty of medicine, Memorial University, 300 Prince Philip Drive, St. John's NL, Tel: 7093276520, Email: yatabakifard@mun.ca
- Community Band Leaders (representing Conne River the Indigenous community), Community Mayor (representing Harbour Main the non-Indigenous community)

Approximately six million tonnes of hazardous waste are produced annually in Canada, and one tenth of this waste comes from discarded consumer durable goods (CDGs) (such as refrigerators, televisions, washing machines, vacuum cleaners, etc.) and renewable energy products (such as solar panels, batteries and etc.) destined for 10,000 landfills. Several landfills are located outside the towns and the cities, mostly in rural areas. While 19% of Canadians live in rural areas, 40% of the population of the Atlantic Provinces, such as Newfoundland and Labrador (NL), live in rural areas. Therefore, the rural population of NL is more vulnerable to adverse environmental impacts due to landfills. As a result of the remote locations of the Indigenous communities and their strong connection to the land for food and spiritual values, they are particularly vulnerable. We, a group of researchers from the faculty of medicine and the community band leader (Conne River as a representative of Indigenous community) and mayor (Harbour Main as a representative of non-Indigenous community) intend to explore, how traditional ecological knowledge of Indigenous communities could contribute to the implementation of new economy where no waste and hazardous materials is being produced and as a result, there will be no waste dumped in the landfills. If you participate, we will do the following, a) Interview of questionnaire: the interview will take place at the residence of participants, you will be asked to answer questions toward your recycling and consumption behaviours and any knowledge towards waste management. A telephone interview or Zoom meeting can also be arranged, and before the interview, participants will receive a consent form to sign and return via email. You will be asked to give an oral consent if you fail to sign the consent form before the interview; b) As a token of appreciation we will give you a $20 gift card after the interview. For those who are doing the interview online, an online gift card (E-gift card) will be sent to their email address All the data will be kept in Professor Sarkar's office in a locked cabinet at Memorial University, and all the electronic data will be encrypted. Your participation is very important for the population of the province. The final results are expected to make changes in
policies with regard to environmental protection. We ensure that your identity will not be revealed. Please read and sign the informed consent form. When we visit you at the time of the interview, please bring this information letter for verification. Please see the attached poster for your further information and share with your family members and friends.

Thank you for your participation,
Yasamin Atabaki

Appendix C: Consent Form

1. Why am I being asked to join this study?

The province of Newfoundland and Labrador had the lowest rate in reducing waste by source, recycling, and reusing. Due to the Indigenous community's strong connection to the land for food and spiritual values, they are more vulnerable. As a result, you are being invited to join this study. This study is being done to explore how the current situation could enter a new economy called Circular economy (CE) in which not any waste is produced; instead, all of the materials in different industries could re-enter the production line. Additionally, we want to explore and identify the traditional knowledge in Indigenous communities that can contribute and integrate to a greater understanding of the impacts of waste from CDGs in this new economy. The immediate benefit of the study is that it will give us first-time information on how the remote communities, particularly the Indigenous communities, think of consumerism, the usage of consumer durables, and how its waste can affect the environment and their spiritual values and also it gives an idea about how the community members and leaders are thinking of managing this solid waste. So based on this information, the community can take some immediate steps to reduce waste generation and improve the lifespan of the products. As a result, your participation is very important for the province's population. The final results are expected to make changes in policies concerning environmental protection and improve the community's quality of life.

2. How many people will take part in this study?

This study will take place in two communities in Newfoundland and Labrador. The mentioned communities are Conne River (representative of the Indigenous community) and Harbour Main (representative of non-Indigenous community). The study will enroll a total of 30-40 people and in each community 15-20 participants are interviewed. Each interview will take 30-40 minutes. We will organize an interview with the community leaders (chief of the indigenous community, band officials), garbage collectors and community members (general public) in each community. A telephone interview or Zoom meeting can also be arranged, and before the interview, participants will receive a consent form to sign and return via email. You will be asked to give an oral consent if you fail to sign the consent form before the interview.

3. What will happen if I take part in this study?

If you agree to take part in this study, the following procedures will take place:

If you agree to take part in the study, you will be

- Audio recording used: You will be audio recorded during the interview. The audio recording will be transcribed (written down) after the interview and will be analyzed by the research team. The transcription will be done by members of the study team. Your name or any other identifying information will not be included during the recording, except your voice. The audio recording will be destroyed after it has been transcribed and checked for accuracy.

4. Are there risks to taking part in this study?

Psychological Risks:

During the questionnaires and/or the interview, you may become uncomfortable or experience some anxiety, emotional and/or psychological distress due to the question about your income, lifestyle and educational background. You can skip questions, take a break or stop answering at any time. The following resources are available for you to contact for psychological support:

For Conne River: the central health council,

website: https://www.centralhealth.nl.ca/

phone number: 256-5438/2813

For Harbor Main: Eastern health

website: https://www.easternhealth.ca/

phone number: 1-888-737-4668

Audio Recording:

There is a potential risk of loss of your confidentiality because even though your name will not be part of the audio recording or the transcription, your voice may still be identifiable as your voice. If anyone mentions identifiers (e.g., your name), during the recording, this may identify you.

Inconvenience of time:

There is an inconvenience of time. Each study visit will take about 30-40 minutes for the entire research study.

Social Risk:

Despite protections being in place, there is a risk of unintentional release of information. Researchers will make every attempt to protect your privacy. Due to the small population of the community, there are going to be some potential social risks. All of the participant's discomforts and concerns would be addressed. The interview will be conducted at mutually agreed place between the participant and the researcher. Also, at the moment of the interview, only the participant and the researcher will be present to avoid a breach of confidentiality. Since during the interview there will not be a local person, so the chance of the participants being identified will be minimum.

Online Interviews:

Using Zoom for interviews can present some added risks that should be considered. These risks include privacy and data security concerns and challenges in obtaining informed consent. Obtaining informed consent and ensuring data confidentiality can be more challenging in virtual interviews. Consent is more difficult to obtain, and data confidentiality requires caution in virtual interview settings. We will ensure that participants fully understand the implications of participating in a virtual interview and that their data

will be handled securely.

5. What are the Possible Benefits?

By participating in the study; the participants may not directly be benefited from the participation. However, the data that will be generated can be effectively used by the community leaders to reduce contamination and waste generation. In turn, it will benefit the entire community, including the participants.

6. Incentive/Payment

A 20-dollar gift card will be given to the participants at the beginning of the interview as a gesture of appreciation for participating in the study. For those who are doing the interview online, an online gift card (E-gift card) will be sent to their email address. We hope that the information learned from this study can be used in the future to benefit the whole population and change the current economy.

If I decide to take part in this study, can I stop later?

It is your choice to take part in this study, participation is voluntary. You can can withdraw from the study up to two weeks after the interview. The study team may ask why you are withdrawing for reporting purposes, but you do not need to give a reason to withdraw from the study if you do not want to. If you decide to leave the study, you can contact your researcher.

The process of withdrawn is as follows:

- You may fully withdraw from this study. This means that the researcher/study staff will no longer use your data for research and all data collected about you will be destroyed. We will no longer contact you for any reason. Any data that has already been merged with other data and analyzed cannot be destroyed or removed from the study. This is because we have to preserve the study's scientific integrity. However, your data will not be used in future research.

- You have the right to request the destruction of your information collected during the study, or you may choose to leave the study and allow the investigators to keep the information already collected about you until that point.

7. What are my rights when participating in a research study?

You have the right to receive all information that could help you make a decision about participating in this study, in a timely manner. You also have the right to ask questions about this study at any time and to have them answered to your satisfaction.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form you do not give up any of your legal rights against the research team or involved institutions for compensation, nor does this form relieve the research team or their agents of their legal and professional responsibilities.

You have the right to be informed of the results of this study once the entire study is complete. After the analysis of the data, we will organize a virtual meeting with both of the community members and share and present the results. Also we will hand over the final report to the community leaders, the executive summary will be posted in social media by the community leaders. You will be given a copy of this signed and dated consent form prior to participating in this study.

8. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. If you decide to participate in this study, the researchers will collect and use information from your answers. sincet these are in-depth interviews where participants are sharing stories and opinions, which will feature in the study analysis, it is important to remind you that you can only share what they you are comfortable sharing. we will only collect and use the information they need for this study, including:

- gender
- information from study interviews and questionnaires

The personal information collected about you will have your directly identifiable information removed (i.e., name, Income) and replaced with a code or with a “study number”. There will be a master list linking the code numbers to names.

Study information collected during the study will kept at the Professor Sarkar's office at memorial university, in the medicine building and the researchers computer and pen drive. nobody will be present except the interviewer and the interviewee at the time of the interview and the information will be stored in a secure, locked place that only the study staff will be able to access. After the study closes, study information will be kept as long as required by law, which could be 5 years or more. This information will be stored in Professor Atanu Sarkar's office in the medicine building. He is the person responsible for keeping it secure.

When the results of this study are published or presented at scientific meetings, your name and other personal information will not be used in the publication. All information that identifies you will be kept confidential, and to the extent permitted by applicable laws, will not be disclosed or made publicly available, except as described in this consent document. Every effort to protect your privacy will be made. Even though the risk of identifying you from the study data is very small, it can never be completely eliminated. If there is a breach of your privacy resulting from your participation in this study you will be notified.

9. Who will see my personal information?

Your name and identity information will only confine to the researcher and professor Sarkar. During the analysis, all the information is codified. There will not be any chance of identity being revealed.

Your access to records

You have the right to see the information that has been collected about you for this study. If you wish to do so, please contact the research team.

11. What about questions or problems?

If you have any questions about taking part in this study, you can meet with the principal investigator who is in charge of the study. That person can be reached through:

Project coordinators (Yet to be selected)

And

Ada Roberts (For Conne River)

Telephone: +1 709-882-2710 EXT.5102

Email: ADAROBERTS@CRHSS.COM

and Nicholas Fairbridge (For Harbour Main)

Telephone: +1 (709) 864-4978

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This study has been reviewed by the McMaster Research Ethics Board and received ethics clearance under project [MREB#6008]. If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Office

Telephone: (905) 525-9140 ext. 23142

E-mail: mreb@mcmaster.ca

Signature Page

My signature on this consent form means:

- I have had enough time to think about the information provided and ask for advice if needed.
- All of my questions have been answered and I understand the information within this consent form.
- I understand that my participation in this study is voluntary.
- I understand that I am completely free at any time to refuse to participate or to withdraw from this study at any time, without having to give a reason, and that this will not change the quality of care that I receive.
- I understand that it is my choice to be in the study and there is no guarantee that this study will provide any benefits to me.
- I am aware of the risks of participating in this study.
- I do not give up any of my legal rights by signing this consent form.
- I understand that all of the information collected will be kept confidential and that the results will only be used for the purposes described in this consent form.

_____

Signature of participant Printed name Day Month Year

_____

_____

Signature of person conducting Name printed Day Month Year

the consent discussion

_____

<u>To be signed by the investigator:</u>

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant/substitute decision maker fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

_____

Signature of Researcher Name Printed Day Month Year

I hereby confirm that I have received the gift card.

Signature of participant Printed name Day Month Year

Appendix D: Interview Questions

Interview Questions Community members:

EXPLORING BARRIERS IN PROMOTING CIRCULAR ECONOMY

Yasamin Atabaki, (Masters of Community Health)

(Division of Community Health and Humanities, Faculty of Medicine, Memorial University of Newfoundland)

1. Have you heard of the term "Circular Economy"?

2. Please describe the concept of circular economy based on your opinion. There is some guidance, you can rationalize the option that you think fit the description. (If you have not heard of this concept before, choose the option that you think it will describe it in the best way)
   - Make-use-dispose:
   - Swapping, bartering, lending:
   - Re-use, repair, re-purpose, remanufacture, recycle:

3. What are you going to do if the following items were damaged or broken?
   - Large goods (such as fridge, refrigerator, washing machine and etc.):
   - Small appliances (such as toaster, dryer and etc.):
   - Furniture:
   - Expensive tools:
   - Small electronics (such as mobile phones, camera and etc.):
   - Large electronics (such as TV, stereo and etc.):
   - Motor vehicle:

4. What are the main reasons that you wouldn't repair or reuse an item?

5. Please specify with yes/ No if you ever have done the following, and if so please also specify how and which item:
   - Recover/recycle:
   - Re-use/ re-purpose (e.g. reusing the jars for storage or buy second-hand goods):
   - Repaired broken items:
   - Reduce consumption (e.g. not upgrading your phone):
   - Jointly purchase/share items with family, friends (e.g. kitchen equipment, vehicle):

6. When buying goods, excluding food, what is the most important to you?

7. What are the main reasons you might buy second-hand goods?

8. What are the main reasons you might not want to buy second-hand goods?

9. How often do you buy second- hand/used goods?

10. Is there any knowledge toward waste and disposal from the past that you would like to share and think was better than the current knowledge?

11. What is your income?

12. Are you above 18 years old? (As of today's date)

13. What is your educational level?

14. How many people are there in your family?

15. Please specify your gender.

Interview Questions for garbage collectors:

EXPLORING BARRIERS IN PROMOTING CIRCULAR ECONOMY

Yasamin Atabaki, (Masters of Community Health)

(Division of Community Health and Humanities, Faculty of Medicine, Memorial University of Newfoundland)

16. Please describe the concept of circular economy based on your opinion. There is some guidance, you can rationalize the option that you think fit the description.
    - Make-use-dispose:
    - Swapping, bartering, lending:
    - Re-use, repair, re-purpose, remanufacture, recycle:

17. What are you going to do if the following items were damaged or broken?
    - Large goods (such as fridge, refrigerator, washing machine and etc.):
    - Small appliances (such as toaster, dryer and etc.):
    - Furniture:
    - Expensive tools:
    - Small electronics (such as mobile phones, camera and etc.):
    - Large electronics (such as TV, stereo and etc.):
    - Motor vehicle:

18. What are the main reasons that you wouldn't repair or reuse an item?

19. Please specify with yes/ No if you ever have done the following, and if so please also specify how and which item:
    - Recover/recycle:
    - Re-use/ re-purpose (e.g. reusing the jars for storage or buy second-hand goods):
    - Repaired broken items:
    - Reduce consumption (e.g. not upgrading your phone):
    - Jointly purchase/share items with family, friends (e.g. kitchen equipment, vehicle):

20. When buying goods, excluding food, what is the most important to you? (please mention at least five)

21. What are the main reasons you might buy second-hand goods?

22. What are the main reasons you might not want to buy second-hand goods?

23. How often do you buy second- hand/used goods?

24. Please describe your occupation:

10. How does your work influence your understanding of waste and waste management?
11. Are there any health issues that you encountered, related to managing the waste?

12. Is there any knowledge toward waste and disposal from the past that you would like to share and think was better than the current knowledge?

13. What is your income?

14. Are you above 18 years old? (As of today's date)

15. What is your educational level?

16. How many people are there in your family?

17. Please specify your gender.

Interview Questions for community band officials:

EXPLORING BARRIERS IN PROMOTING CIRCULAR ECONOMY

Yasamin Atabaki, (Masters of Community Health)

(Division of Community Health and Humanities, Faculty of Medicine, Memorial University of Newfoundland)

25. Please describe the concept of circular economy based on your opinion. There is some guidance, you can rationalize the option that you think fit the description.
    - Make-use-dispose:
    - Swapping, bartering, lending:
    - Re-use, repair, re-purpose, remanufacture, recycle:

26. What are you going to do if the following items were damaged or broken?
    - Large goods (such as fridge, refrigerator, washing machine and etc.):
    - Small appliances (such as toaster, dryer and etc.):
    - Furniture:
    - Expensive tools:
    - Small electronics (such as mobile phones, camera and etc.):
    - Large electronics (such as TV, stereo and etc.):
    - Motor vehicle:

27. What are the main reasons that you wouldn't repair or reuse an item?

28. Please specify with yes/ No if you ever have done the following, and if so please also specify how and which item:
    - Recover/recycle:
    - Re-use/ re-purpose (e.g. reusing the jars for storage or buy second-hand goods):
    - Repaired broken items:

- Reduce consumption (e.g. not upgrading your phone):
- Jointly purchase/share items with family, friends (e.g. kitchen equipment, vehicle):

29. When buying goods, excluding food, what is the most important to you? (please mention at least five)

30. What are the main reasons you might buy second-hand goods?

31. What are the main reasons you might not want to buy second-hand goods?

32. How often do you buy second- hand/used goods?

33. Please demonstrate your occupation:

34. What are the current policies toward waste and waste management in the community?

35. Is there any knowledge toward waste and disposal from the past that you would like to share and think was better than the current knowledge?

36. Do you think that your Indigenous values and perspectives can be used in managing the consumer durables (usage and disposal)?

37. What is your income?

38. What is your educational level?

39. How many people are there in your family?

40. Please specify your gender.

Appendix E: Participant's Quotes

4.1.1. Large Appliances
• *"Possibly, yes, a repair. Um, but with the newer technology, like the newer fridges, they have a lot more electronics in the back, and they have a lot more circuit boards and way, way more difficult, expensive parts to fix."* • *"It depends. If it's still used damaged, then I would keep it and keep using it. Um, unfortunately, the way they make things now is often, especially here, more cost effective to buy a new one. I would like to have it fixed, but the reality is that when we've talked to people about having them fixed in the past, they say it's not worth it. It is more economical to buy one."*

4.1.2. Small Appliances

- *"A lot of those things you can't get parts for. I find with bigger appliances, you typically can. But the smaller stuff seems to be more of a throwaway type of thing."*

4.1.3. Electronics

- *"My daughter has been asking for a replacement now for a few months, and we're just holding off because her phone works. It's just that it's not trendy. To her, it's outdated."*
- *"Back in the day, I guess you would go for repair. But now, I mean, you get a TV that used to be $1,600 is $400 now, so to repair something is probably just as cheap as buying new."*

4.1.4. CE Principles Barriers

- *"That's going to be a financial decision. That's going to be totally depending on what our budget is. Meaning, if we have disposable income, then we could afford to get I mean, our living room is small, so we would repair it if that was a better financial decision."*
- *"It's probably more convenient and cheaper to just buy something new instead of trying to get a repair person into your house or bring in your item. I know one time, when I think I was, I mentioned to you about my washing machine. I had to bring the washing machine in my truck and bring it down to the repair place, the repair guy didn't come to my house, so that was quite inconvenient."*
- *"…So, I know that there are limited services in our area to get somebody to come in to do these things. Um, so that's kind of a factor, too, because we may want to repair it, but we may not have access to somebody to come in and actually repair them for us."*
- *"… I guess the expertise of it as well. Like, I'm from the old school, so I have challenges with technology anyway. So, if something is broken, I have no idea what to do with it …"*
- *"… My husband would try to fix it because he can tinker. It's older. Um, but the newer stuff he can't work on because he doesn't know about the electronics of the newer stuff, but where this is an older stereo. He would see what he could do."*

4.2.1. Reuse, Repair, Disposal Preferences

- "*First thing, they should actually build a place here where we could actually dispose of our stuff properly and not actually at the dump. Because realistically, every time something breaks down in Conne River, you're not going to put aboard, a big old refrigerator or stove, put aboard a vehicle, go 2.5 hours to dispose of it properly. People are not going to do that. If they had a place here in the community, or even in the Bay, which what we call the Bay, even if it was there, it would be better. At least then we could just take it there and get rid of it."*

4.2.2. Environmental and Economic Considerations

- *"… Now the machine was only worth $300. That's something that we would kind of like get done every few, every couple of years. We would get this water pump fixed. And I was content to do that because, you know, even when it passed the $300, because I'm like, well, it's good for the environment and convenient for me. And, then when we moved here, there was no place to bring it. And it went in the garbage. The coffee maker went in the garbage because there was no place to fix it."*

4.3.1. Value- based Decision making

- *"I try to find something that is reliable. Um, you know, that is, if you're looking for, from a cost perspective, um, you know, I would rather pay a few extra dollars to have something that's reliable than something that is lower scale and then causing me issues all the time."*

- *"I rarely buy anything secondhand because my view is that, you know, its second-hand for a reason, like you're just picking up somebody else's trouble. And I don't mean that in a mean way, but if its second-hand it's been used and it's been, you know, potentially open for more trouble to come."*

4.3.2. Cost and Price Sensitivity

- *"I think basically you buying new, you have warranty and you have that kind of thing. You buying second hand, you have no warranty, then you're going to be stuck with the cost of repairing or getting rid of or whatever. So, I kind of, if at all possible, I would kind of like to buy new with warranty on it. That kind of gives you that little bit of, protection, I guess."*

4.3.3. Environmental and Economic Trade-offs

- *"Like garbage changed pretty significantly in a really short period of time. Whereas like in the 50s and 60s, there would have like been a rise of disposable items in a way that there had never been before for like hundreds of years. And so, people would have had like wooden furniture that like, and they would have had very little of it. And, and now all of a sudden there's like plastic products and there's like Formica and there's, you know, I mean, my mom would talk about my mom was born in 1937, and she would talk about, like, all this stuff because I would ask her, I'm like, did your parents have this and that? And she's like, oh, yeah. She's like, I could have had all of that. But I gave it to my sister because I didn't need it."*

4.3.4. Warranty and Guarantee Influence

- *"It had a runaway burner after a year. So just outside of the warranty period, which meant I would have had to pay for it. But I talked to the company, and they actually covered it on warranty under a bit of prompting. For me, it was literally a month outside the warranty period."*

4.4.1. Product Longevity and Ownership History

- *"Furniture place told us that typically these type of appliances is only lasting 5 to 6 years. So, it's not that you're getting the long longevity out of appliances now. So, I wouldn't get rid of any appliance like our microwave is the original microwave in our house. And I know, uh, I have relatives that have their original appliances from when they moved in, like 20 and 30 years. So, it seems like the quality of the appliance is. Yeah, it's is much better the old ones than what the new ones are."*

- *"It seemed like, items were better quality and lasted longer. Yeah, that's, that's the way I would put it. They were better quality and last longer. They were built stronger and with different materials. And now the items aren't that good anymore. And like, the items now are more viewed as more disposable. They're not of the quality that they used to be. So, and in the past, the items were more expensive and seen as, like a microwave was more expensive and seen as a luxury item. Whereas now you can go to Walmart and get one for like 80 bucks."*

4.4.2. Warranties and Guarantees

- *"I'd try to fix first. I'd also go to the manufacturer to see if they're willing to repair at a reasonable price, or even for free."*

4.5.1. Perception of TEK for CDGs

- *"I mean, what you are being taught by your parents, your grandparents or elders that, you know, not as a school kind of teaching. In normal day to day interacting with your child. You are growing up, your teen girls and young women that are different interactions talk about do's and don'ts, social norms, cultural norms. And we often, those are very much linked to your well-being, societal well-being, and protection of environment. Living in a clean environment. But what we are practicing in a modern time, it is almost going, as if you are actually completely disobeying what you have been told."*

- *"I feel like some aspects of traditional living still stand within our community, but a lot of it has died out, I guess, over the years. Such as, like the language and stuff, like, it's not as big in the community as it once was. I know there's still people who make handmade items and stuff like that, so you can get clothing traditionally made, but it does come at an expense which is typically more expensive than fast chain clothing stores where you can buy online."*

- *"I guess it's hard to say, better or worse because it's totally different. When I go back to my parents' times here, like this was a different area. Like they didn't have electricity here until the late 60s. My parents grew up without running water, so they didn't have waste products as such. They had the bare necessities. So, you didn't have stuff that was getting used and tossed aside if you had it, typically you needed it or wanted it. So, it's hard to compare. In general, I'd say, yeah, we're, well more wasteful just because the environment we live in right now. Um, I know there are opportunities to reduce waste that aren't taken advantage of."*

4.5.3. Waste Management Plans for Indigenous Communities

- *"I feel there needs to be, like if there were more programs available and not like, not necessarily having something here in the community that you can go drop it off, like maybe do like a monthly thing where we get a truck or something sent down, anything that's broken or going to be essentially dumped into the dump in there, send it off or find a facility that takes it. You can do that once a month or once every couple of months and it would definitely cut down on what you're going to throw back into the environment. But again, that would be, I guess, the Band to kind of, start working on that. Other than that, I just think about like if you had to go do that yourself, you're going to put it in your truck, you're going to fill up your truck with gas, go in there to drop it off like it's a lot of time and money. To be honest, it's easier to throw it in there. That's what it is and that's what it comes down to."*
- *s"we're in actual discussions now with Central Newfoundland Waste Management. So, the region overall, like I said, is not on board for waste management as the rest of the island is. So, we're trying to adopt something as a community so that we will have our waste trucked out or we'll have them come and pick it up and it'll go to their landfill in Norris Arm. Once the region comes on board with, waste management for the Coast of Bays region, we will join with them. But right now, there's not a lot of movement between all of the actual communities, because there's some actual dispute among them because of the tipping fees and stuff like that. So, we're trying to be proactive and as a community, we're going to try to set the bar off what we're doing for the Coast of Bays."*

4.6.1. Transportation and Access to Services

- "*And you can't. We don't have any services here. I mean, you're going to go do something like that, you'll have to go at least to Grand Falls. And sometimes that opportunity don't present itself.*"

4.6.2. Transportation Costs and Logistics

- *"Sometimes I guess then when you're weighing out the options of the cost. So, for us, we only have a couple of local stores. So, the markup of items in those stores are a lot more than we would get at a Costco or Dominion or Sobeys in CBS. So, for us, then you'd have to factor in, would I drive 30 minutes to buy something on sale, or would I just drive 2 or 3 minutes away and purchase something that the item would cost just a couple of dollars more? So, depending on like, you know, if it's, uh, a carton of milk or something, that's something that you seemed a tendency to run out quicker. Um, I have made the decision to buy locally, closer, knowing that it would probably cost me more to drive further away to get the same item."*

4.6.4. Reliance on Self- Repair and Local Networks

- *"Actually, the first thing I would do is call the neighbors, because around here the men are all iron workers and electricians and things. And so, for instance, when the fridge started kicking up a fuss, we got a neighbor who came in and told us what he thought was wrong with it. So, and he said, phone a repairman. And that's what we did."*

4.7.1. Challenges in Waste Disposal

- *"We used to have a hazardous waste day. I think they phased that out. Maybe last year. We've regionalized with some other communities. So, I think now they do a regional one. But we used to have one twice a year here in our own community, which was handy because sometimes in rural communities, people dispose of things in improper ways. And, you know, there's times when you see, you know, cans of paint being dumped or and people think just because you put it down the sink, that it's disposed of. Our sewer runs into the harbor, which anyway. Some of our best fishing grounds are just on the other side of this…"*

4.7.2. Local Waste Management Initiatives and Individual Responsibilities

- *"The section 95 people would look at it first and they would see if it's worth fixing up or if it's worth trashing, like throwing away. And if they find that it is repairable, they will send someone to fix it. But if it's not, then it has to be thrown away and replaced."*

- *"Twice a year we have bulk cleanup. So, residents have the opportunity to remove any large appliances or furniture … we do have a metal dumpster that's behind our town office that's available for residents to drop off any large metal appliances or any type of metals that they may have home. So that's accessible all year round for residents to drop off items. We do encourage our residents to recycle. We have a recycling program every second week."*