ENVIRONMENTAL IMPACT AND MANAGEMENT OF FOOD PACKAGING AT THE UNIVERSITY OF LETHBRIDGE WITH RESPECT TO SUSTAINABILITY AND STUDENTS' CHOICES

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DEDICATION

To my family, especially my parents, Alfredo and Victoria, and my sisters, Ana, Tina, Gloria and Vitu, whom I love and miss.

To Bente Toft Hansen, your warrior spirit and fervent belief in me has inspired this work. I have learned more than what I ever expected and I am so thankful that you have been on this evolutionary journey with me. Thank you, my beautiful friend.

ABSTRACT

Food packaging is a vital component of food security. The growth of distribution networks due to globalization has meant that packaging is safer and guarantees the quality of the product to its final destination. The objective of this study was to examine potential effects that use and disposal of food packaging has generated at the University of Lethbridge, with respect to the environment. The study employed an environmental matrix method to measure significant aspects in the operations of the system, a model to calculate the generated emissions and a survey that measured the perception of students and their preferences for the packaging materials. The project results indicate that operations such as transport and landfill have generated the highest emissions while recycling has helped to decrease emissions. Survey results consistently show that students understand that the university has made significant changes to improve sustainability and know that they are a fundamental part of caring for the environment.

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LIST OF ABBREVIATIONS

3R	Reduce, Reuse, and Recycle
AFNOR	Association Francoise de Normalisation
CAP	Climate Action Plan
CEA	Canadian Environmental Assessment
CEP	Canadian Environmental Protection Act
CEPA	Canadian Environmental Protection Act
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CSR	Corporations Supporting Recycling
EM	Environmental Matrix
EMS	Environmental Management System
EPA	Environmental Protection Act US
EPIC	Environment and Plastic Industry Council
ESAC	Environmental Sustainability Advisory Committee
GHG	Greenhouse Gas
HSRC	Human Subject Research Committee
ISO	International Standards Normalization
ISU	Iowa State University
IWM	Integrated Waste Management Model
JMP	Statistical Software
LCA	Life Cycle Assessment
MB	Megabytes
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
Mt	Metric tons
$MTCO_2E$	Metric tons of Carbon Dioxide Equivalent
NCDOT	North Carolina Department of Transportation
NOx	Oxides of Nitrogen
NS	Not Significant
S1	Significant break point one
SD	Standard Deviation
SOx	Oxides of Sulfur
SPC	Sustainable Packaging Coalition
U of A	University of Alberta
VOC	Volatile Organic Compounds
WARM	Waste Reduction Model (US EPA)

Chapter 1 - Introduction

1.1 Overview

Sustainability is defined as management that is designed to meet current needs (such as food management and recycling of package material) without compromising the needs of management or those of future generations (Brundtland, 1987), often in ways in which economic, environmental and social sectors are interconnected to support quality of life (Tillbury, 2011). In the case of interest here, higher education institutions can generate substantial changes in a society by preparing students for more sustainable living, not only through their academic programs but as management and life style examples. Furthermore, education regarding sustainability has grown from the study of the environment to a wider study of relationships with the environmental resources that support life (Johnston, 2012).

Governments have formalized some management in support of sustainability through the enactment and implementation of environmental regulations. For example, in the 1970s, the United States Congress enacted an unprecedented volume of federal legislation to protect the environment (Kuehn, 1996). In 1999, the Canadian government established principles for managing the environment and natural resources (Masterson, 2017). Additionally, non-governmental organizations such as the International Standards Normalization (ISO) have developed a series of guidelines and practices like the Life Cycle Assessment (LCA), ISO 14040, with the objective to provide standardized techniques in support of management and analysis of environmental impacts of product systems (Russell, 2014). LCA standard ISO 14040 is part of the ISO 14000 family, which offers standardized techniques in support of management and analysis of environmental impacts. Canada (CSA, Canadian Standards Association) and France (AFNOR, Association Françoise de Normalisation, France) were the first two countries that established LCA standards prior to ISO 14040 being enacted (Klöpffer & Grahl, 2014).

The industrial sector is often associated with potential concerns and solutions regarding health, environmental, social and economic aspects, and may have effects on the environment that require anticipation and management (Medicine & Council, 2015). Manufacturing processes, transportation, and product use generate considerable volumes of waste that needs to be managed. The degradation, decomposition, and transportation of waste produces CO_2 emissions, which may result in broader ecosystem impacts that should receive attention (Russell, 2014). These impacts can include large-scale results such as climate change, global warming, and acid rain (Klöpffer & Grahl, 2014), as well as more local and regional direct effects on the quality of soil, air, and water. Despite government regulations requiring environmental management and safety programs designed to minimize the impact, further vigilance is needed regarding potential negative impacts of food production on the environment, in particular with regard to food packaging systems, choice of materials, and disposal. The characteristics of some of these packaging materials result in slow degradation rates so they remain in landfills and water sources for long periods of time (Nanda, Sahu, & Abraham, 2010). Food packaging represents an important portion of municipal solid waste and therefore, to facilitate continuous improvement in packaging environmental performance in the system, a measure on the tangible indicators is required (Sonneveld et al., 2005). Environmental indicators (e.g., parts per million of particulate matter in the air), are key metrics to detecting potential hazards and apply aspects optimization. They facilitate recognizing the danger of environmental targets, provide data for environmental reports and comparisons, and estimate future performance (Comoglio & Botta, 2012). Waste management is of great interest to both the food industry and regulation agencies. Management depends on information regarding types, amounts, and movement of waste, as well as knowledge of the attitudes, preferences, knowledge, and goals of users. This thesis addresses collection and summary of the evidence based on all of these variables, in the context of University of Lethbridge operations and student choices.

Packaging is one of the most important parts of processed and non-processed food products, necessary to maintain quality, extend shelf life, transport, and support convenient and efficient end-use (Yam, Takhistov, & Miltz, 2005). Packaging systems have become versatile, offering a great variety of designs and alternatives in terms of materials and costs (Rodriguez-Aguilera et al., 2011). New, innovative, and biodegradable food packaging materials are being developed by the packaging industry with the objective of minimizing potential detrimental environmental impacts (Marsh & Bugusu, 2007). Edible films are an example of a new packaging material - a thin layer of edible material that directly coats the item like a food wrap and is composed of polysaccharides, proteins, lipids and other components (Otoni et al., 2017).

One of the most commonly employed materials for packaging applications is polyethylene, due to its attributes as a transparent fine film. It has no odor or toxicity, good ductility, low water vapor permeability and excellent heat seal ability (Tharanathan, 2003). However, polyethylene has a slow degradation rate after disposal and consequently, a high likelihood of polluting the environment and altering processes in ecosystems (Bastioli, 2005). A study done to quantify the production, use, and fate of all plastics ever made revealed that 8.3 billion metric tons (Mt) of virgin (unrecycled) plastics have been produced to date. Since 2015, 6.3 billion (Mt) of plastic waste have been generated (Eriksen et al., 2014). Approximately 9% of all plastic ever manufactured has been recycled, 12% has been incinerated, and 79% has been accumulating in landfills. More than 5 trillion plastic pieces weighing more than 250,000 tonnes can be found in ocean regions around the world with a majority of larger pieces accounting for the greatest weight (Eriksen et al., 2014). According to projections based on this trend, it is estimated that by 2050, 12 billion (Mt) of plastic waste will end up in landfills or in the ecosystem (Geyer, Jambeck, & Law, 2017).

This study centers around food packaging and how managing it can promote sustainability on campus and reduce potential negative environmental results on and off campus. I intend to apply suitable methods to summarize evidence and data, assess activity choices and attitudes, and make recommendations in support of environmental management regarding current and future food packaging. Summary of recent and current data and choices regarding food packaging in this community and campus will bring to light accurate solutions that will improve sustainability and will aid in future investigations into this topic.

1.2 Purpose of the study

There are few studies that detail the diverse effects and choices that food packaging may cause on the environment. A study from the University of Calgary, "Food-related environmental beliefs and behaviors among university undergraduates", found that simple changes in food consumption practices can have significant and beneficial impacts on the environment, and that the connection between student food choices and environmental quality is a starting point in promoting effective change (Campbell-Arvai, 2015). A study from Thailand, "Greening of a campus through waste management initiatives" found that initiatives like the "3R" program ("Reduce, Reuse, and Recycle"), have positive effects on environmental attitudes and awareness regarding the reduction of waste generation. This study occurred in a highly educated community where a recycling-only effort was not a sustainable solution due to non-recyclable packaging making up a large percentage of the municipal solid waste. Employing economic incentives as a strategy in this case seemed to minimize the use of non-recyclable packaging (Tangwanichagapong et al., 2017). In another study done by the University of Calgary entitled "Environmental management systems at North American universities: What drives good performance?", the overall size of the university was demonstrated to be an important factor for the amount of waste produced, and has a direct effect on environmental impact. Furthermore, students' attitude and awareness clearly affect the development of Environmental Management Systems (Herremans & Allwright, 2000). It is generally well known that discarded packaging is a pollutant and can be a significant strain on landfill sites. It requires considerable energy to produce and distribute, details of which may not be apparent to consumers. The University of Lethbridge has recently implemented a sustainability policy, but assessments of the extent to which food packaging contributes to the waste going to landfill, potential savings of time, waste that could enhance sustainability, and other environmental impacts, have not been measured.

Students' knowledge and preferences regarding packaging and consumer choice may also be important factors in managing food waste generated on campus, but are largely unknown. For example, questions like are attitudes determined by environmental conscience, by considerations of financial costs and time management, or simply as a response to lifestyle have not really been addressed? This study has four objectives: first, to compile an evidence-based assessment of the potential environmental impact of food packaging waste at the University of Lethbridge. Second, to determine to what extent the waste management system has a potential environmental effect. Third, to identify environmental gains that could result from waste management policy, attitudes of the students, knowledge of fate of materials, personal choices, and environmental motivations of consumer behavior. Fourth, to determine if using the US EPA waste reduction model (WARM) as a method of calculation of potential impacts can help to quantify emissions and their reduction for continuous improvement of the system.

1.3 Significance of the research

This study provides a summary of previous and current data, new evidence for inference, and theoretical contribution to knowledge concerning the importance of food packaging choices and their disposal for environmental protection and sustainability. It brings to light the need for a new perspective in terms of probable results from participants' choices, and solutions that will support better comprehension and visualization of these issues. The methodology used involves the analysis of many different relevant scenarios, which serve to show the effects that each variable exerts on the system. Data to support the study came from a compilation of management data, and collection of new data through surveys.

Chapter 2 - Evolution of food and beverage packaging and targeting sustainability on university campuses

2.1 Introduction

This chapter includes a review of relevant literature regarding the history and evolution of food and beverage packaging, and targeting sustainability on university campuses. In addition, there is a description of the data and modelling methods employed in the study.

2.2. Literature review

In the early nineteenth century, Nicolas Appert invented canning as a method to preserve food - this was referred to as Appertisation. Later, in the early 20th century, other packaging inventions (like Robert Gair's concept of cutting dies for paperboard cartons or Michael Owens' mechanical production of glass bottles) were employed for food and beverage distribution (Twede et al., 2014). During the First and Second World Wars, many packaging innovations appeared out of the need to protect military goods and food from extreme conditions of time and temperature. Some of these inventions included aluminum foil, electrically powered packaging machinery, plastics, aseptic packaging, flexographic printing, and flexible packaging (Brody et al., 2008). In the 1960s and 70s, pop tops were developed to match the growing popularity of aluminum containers for carbonated beverages and beer. The plastic industry developed new and more flexible materials to pack food that replaced metal, glass and paperboard packaging (Lord, 2008). In the late 20th century, a new packaging technology was developed that protected the product with innovative characteristics such as oxygen controllers, antimicrobials, respiration mediators, and odor/aroma control (Brody et al., 2008). Other innovations included flexible pouches with zipper closures, and the coextrusion of materials to create semi-rigid carbonated beverage and water containers. In the 21st century, advances in nanotechnology has improved the barrier quality and structural mechanical properties of packaging materials (Brody et al., 2008). Nanotechnology promises innovative changes in packaging by improving the quality of materials that protect and preserve food. This will also promote the distribution of intelligent packaging through communication and marketing (Yam et al., 2005) (Figure 2.2.1).

Figure 2.2.1 Active and intelligent functions of packaging (Yam et al., 2005)

Indeed, food nano-packaging can be designed to release antimicrobials, antioxidants, enzymes, flavors and extend shelf life. Improved packaging can regulate temperature and moisture stability, mechanical strength and durability while smart packaging allows for sensor indicators, product identification, anti-counterfeiting, and active tagging (Cha & Chinnan, 2004). The bio-based packaging materials (such as edible and biodegradable films from renewable resources) could aid in reducing packaging waste and improving shelf life of the product (Figure 2.2.2). Edible films are materials produced from edible biopolymers and food-grade additives. The majority of biopolymers are naturally existing and include proteins, polysaccharides, and lipids (Gennadios, Hanna, & Kurth, 1997).

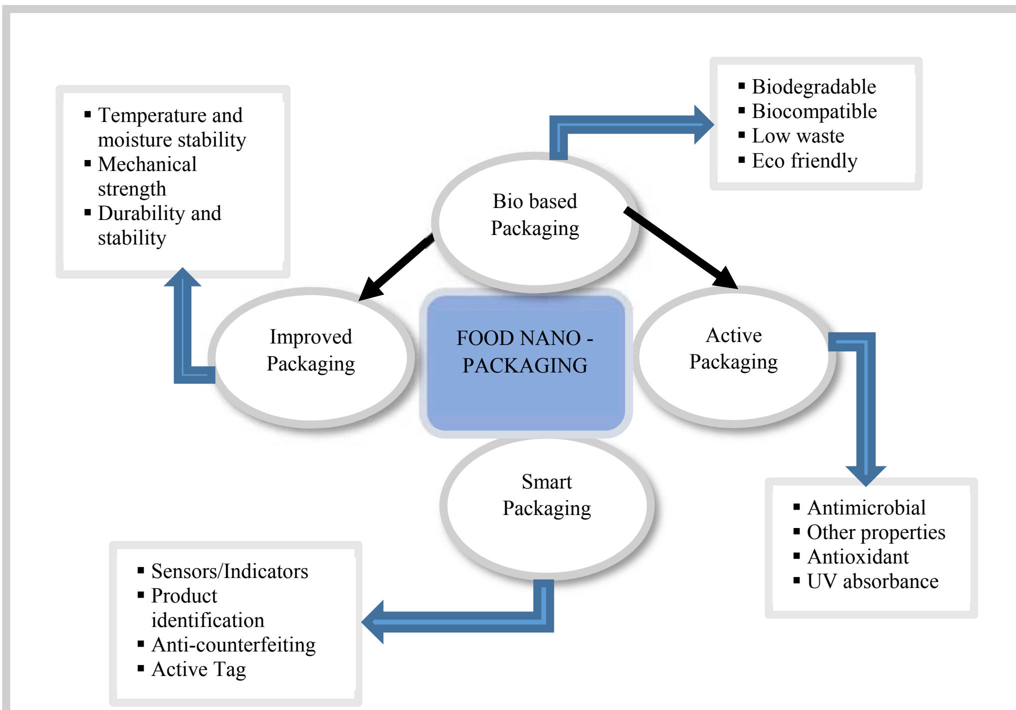

Figure 2.2.2 Food nano packaging innovative functions (Kuswandi, 2017)

The packaging industry has been under intense pressure to reduce waste and improve recyclability. Global concerns about packaging related to sustainability demand that packaging businesses incorporate environmental objectives without compromising economic growth, jobs and standards of living. The Sustainable Packaging Coalition (SPC) is a membership-based organization that includes small, medium and multi-national companies. SPC promotes the ideal that all parties should work together towards the same vision of sustainable packaging, making it beneficial, safe and healthy for all individuals throughout its life cycle. Packaging should be sourced, manufactured, transported and recycled using renewable energy and must be designed to optimize materials and energy (Sonneveld et al., 2005). The new policies and the technological advances of packaging aim at reducing further environmental impacts. In this way, packaging waste should not cause environmental deterioration but fulfill its initial function of protecting food and extending its useful life.

Sustainability projects in the majority of the North American Universities contain policies related to the reduction in the use of natural resources and a management system for waste. All universities share the common goal of minimizing operating cost by implementing more sustainable practices (Berg, 2013). At a provincial level, in British Columbia, for example, it is mandatory under the province's Greenhouse Gas Reductions Act (2007) that all universities and colleges submit an annual report on the emissions and emission reductions, and develop and implement a Climate Action Plan (CAP) (Vaughter et al., 2016).

Understanding students' perception of the environmental implications is key to resolving sustainability issues on campus (Emanuel & Adams, 2011). Popular perceptions expressed by participants in terms of the food-environment linkage show that many individuals chose reduced packaging, composting food waste, and using locally grown foods as the most effective means by which to reduce environmental impacts. Organic and vegetarian foods were identified as being less effective (Lea & Worsley, 2008). Universities are exceptional places to support sustainable development as they provide significant contributions to society by creating new solutions to benefit society through their teaching and research programs. The hope is to influence adoption of sustainable methods by other facilities, and also to produce a generation possessing a greater level of environmental education throughout society in regards to sustainability and developing knowledge in these areas (Sordo et al., 2016).

Many educational institutions have begun to explore innovative projects regarding improved sustainability in dining services by providing funds for sustainability projects. An example is the compost system that was implemented at Iowa State University in spring of 2009. With over 31,040 students, a large scale of food consumption was guaranteed. The system processed and diverted compostable food waste, relieving some of the massive disposal challenge the university was facing. This included additional costs due to food scraps, which congest the garbage disposal. For a cost of $45,000 over five years (funded with a loan through ISU's Live Green), the university reduced landfill and water treatment costs enough to pay the loan back. Below is a photograph of the compost system at Iowa State University (Berg, 2013).

Figure 2.1 Iowa State University stores the finished compost product from campus dining halls in the university's Hoop building (Berg, 2013)

Oberlin College in Ohio is another institution that supported a small project to promote behavioral shifts in the dining halls. They invested $7000 for the acquisition of reusable food containers to replace disposable ones, which aided in the reduction of garbage generated by students. The results saw a large environmental and financial impact, with the institution saving money and reducing the amount of waste generated by students (Berg, 2013).

2.3 Methodology

2.3.1 Study area

The fieldwork and data collection for this study was conducted at the University of Lethbridge. The university, located in west Lethbridge in Southern Alberta, plays a leading role in promoting liberal education, research, policy development, environmental research, and is committed to providing a greener campus in the future. It is determined to become a sustainable institution as is evidenced by the creation of the Environmental Sustainability Advisory Committee (ESAC) in June 2017. This committee was tasked with designing a strategic plan to improve the sustainability of the University. The guiding principles of the ESAC, listed in the April 2018 Terms of Reference, are as follows:

"i. healthy spaces for students, employees, and visitors;

ii. environmentally sustainable teaching, service, research and operational practices;

iii. reduction of environmental impacts such as carbon emissions and greenhouse gases by reducing energy and resource consumption;

iv. sustainable building practices for new buildings and major retrofits."

The Lethbridge campus includes 190 hectares, and is known for its unique style with the Central University Hall designed by Arthur Erickson. University Hall is set in the coulees overlooking the Oldman River (University of Lethbridge, 2017b), surrounded by largely undeveloped grassland and riparian habitat. It is also known as a multicultural educational institution, with a student population of 8,724, and employs 1,172 people in various roles (University of Lethbridge, 2017b). The campus physical infrastructure includes academic buildings, residential zones, sport facilities, and food services areas, where most of the food packaging waste is generated. The Lethbridge main campus dining areas are shown in Figure 2.3.1

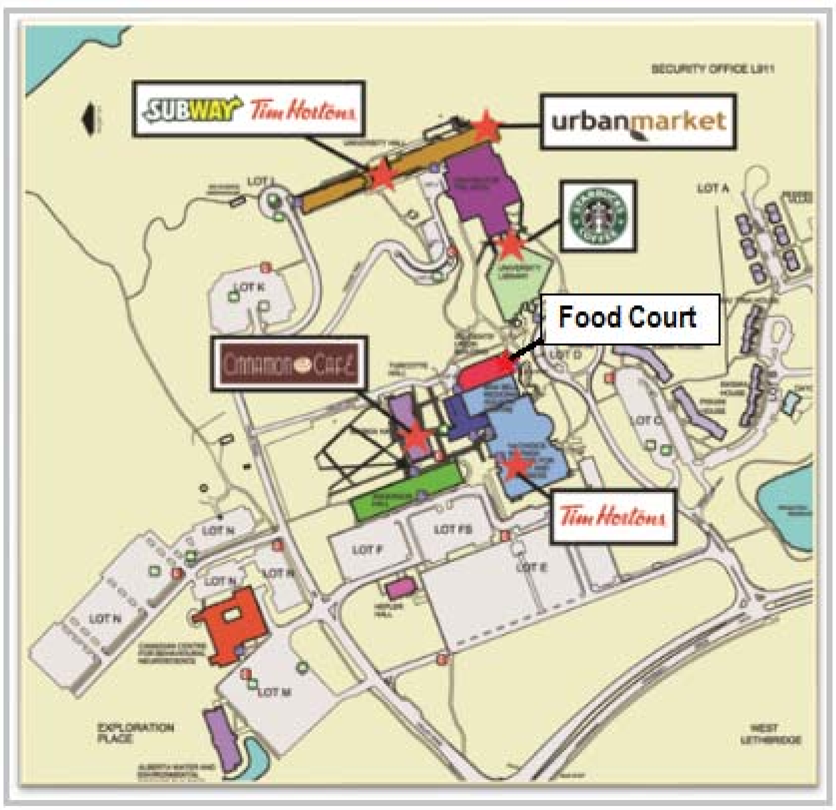

Figure 2.3.1 Food Services (Map Source: University of Lethbridge, 2017)

2.3.2 The Lethbridge campus dining areas

1. Student Union Building: Food Court Service Complex
2. University Hall: Urban Market, Subway and Tim Hortons
3. Markin Hall: Cinnamon Coffee
4. Level 9 between the Library and UCA: Starbucks
5. 1st Choice Savings Centre: Tim Hortons

2.3.4 Food packaging waste flow

The University of Lethbridge has placed waste bins and, in particular, recycling bins to collect waste materials in all dining areas and around the University. The bins contain a plastic bag to help the collector pick up and transfer the material. University community consumers first deposit recycled materials and waste into separated bins according to the type of material: paper, plastic, cardboard, and compost. Once the bins are full, the plastics bags are closed and transferred by carts to temporary storage areas (garbage rooms) in the university. One “garbage room” is located in the Students Union Building and another in University Hall. In these “garbage rooms”, all recycling materials are hand-sorted according to type (i.e., plastic, glass, cups, cardboard, paper) and then sent to a recycling destination.

Recently, the university stopped recycling disposable coffee cups, because they found that those cups have a wax lining inside and therefore, the mixture of cardboard and plastic material makes it difficult to recycle. Non-recyclable waste is not sorted, but left in black plastic bags that are not opened and are destined for the landfill. Canadian Waste Collection Inc. transports all recycling (with the exception of beverage containers) and waste materials to their final destination. Recyclables end up at the Lethbridge Waste and Recycling Center while non-recyclable waste is distributed to three different types of landfills. Beverage containers from the blue bins (pop, juice, water) are transported by a company called Quest Support Services Inc. to the Picture Butte, Alberta, bottle depot where they are separated and counted according to packaging material. This information, with the corresponding total number of containers and the profit, is delivered to the Students Union, who is responsible for managing student scholarships. (See Figure 2.3.2).

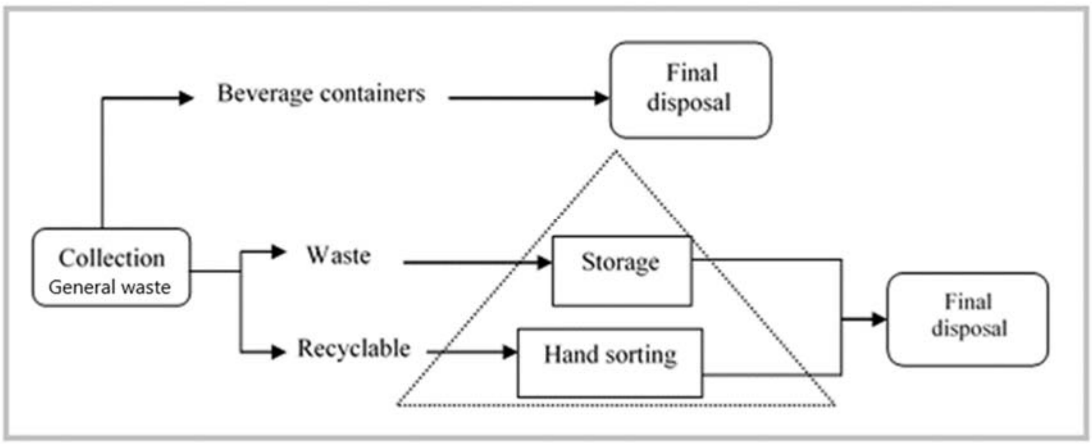

Figure 2.3.2 University of Lethbridge waste management process flow diagram

2.3.5 Methods

Three methods were used in the study to analyze the recent and current management of food waste. First, an Environmental Matrix approach was used based on the application of ISO 14001 principles, an international standard of environmental management system, to determine frequency, score, and significance of the estimated impacts. Second, a waste reduction model (WARM, from US EPA) was used to calculate the CO_2 emissions generated at the Lethbridge campus over time. This model's analysis was limited to activities in which food packaging is involved and generates waste. The third general method was a survey (conducted twice) that provided information about student preference regarding packaging and consumer choices. Additional key data was obtained from the University of Lethbridge Sustainability Report Card (Jaeger, 2017). The data was used to compile descriptive statistics regarding the breakdown of records concerning food packaging waste by type and quantity. In addition, an interview with a specialist at the Waste and Recycling Center in Lethbridge aided in terms of interpretation.

2.3.6 Description of the thesis results structure

Chapter 1 and 2 provided a general description of the objectives, scope and contribution of the study, a description of the history and evolution of food packaging, literature review, and a discussion of actions taken by other universities regarding sustainability. The next three chapters deal with the research methods used to process data and information in order to meet the evidence summary objectives of the study, and to apply information to the model. Finally, the conclusions of each chapter are recounted and applied to a comparison of results that supports ideas and recommendations for both management and future research.

Chapter 3 - Risk level classification and environmental impacts

3.1 Introduction

This chapter includes a description, application and the results obtained from the Environmental Matrix (EM) method, the research method used to identify the environmental aspects of the waste system. In addition, I examined the risk level classification and the environmental impacts, including environmental factors, and changes over time. The method was based on ISO 14001 Standard, North Carolina Department of Transportation (NCDOT, 2006), and the Canadian Environmental Act (Environment Canada & CSR, 2000).

3.2 Methods

3.2.1 Environmental Matrix

The method is based on the ISO 14001 (International Standard Organization) as a way of assessing and demonstrating environmental responsibility and commitment to improvement (NCDOT, 2006). The norm defines environmental aspects (cause) as any element of an organization's activities (e.g., greenhouse gas emission, GHG) and environmental impacts (effect) as any change in the environment, beneficial or detrimental, wholly or partially resulting from an organization's environmental aspect (NCDOT, 2006). The environmental aspects cause environmental impacts. For example, CO_2 emissions (aspect) change the quality of air (impact), and represents a case in which an environmental impact is the result of the environmental aspect on people, plants or animals (SCCM, 2014). Figure 3.2.1. illustrates an example of differences between an environmental aspect and its environmental impact.

Environmental factor: Air

Environmental aspect: CO_2 emissions from transport, heating, etc.

Environmental impact: Human health: allergies, asthma, or cancer.

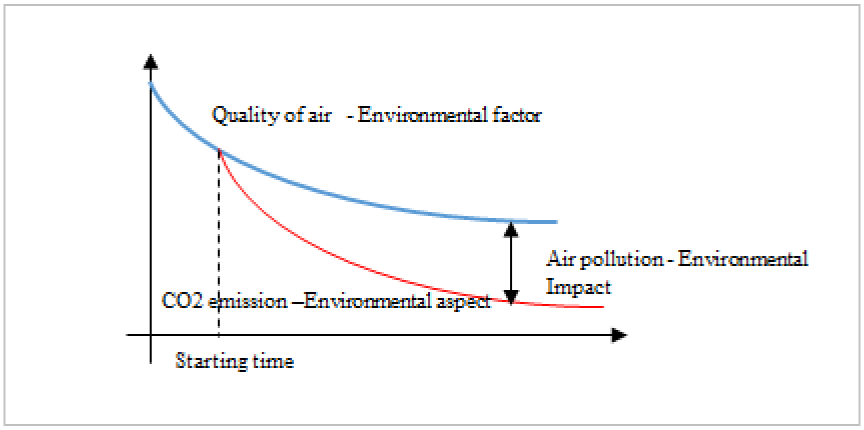

Figure 3.2.1 Environmental impact (air pollution) effect caused by CO_2 emissions (environmental aspect) in air quality (environmental factor) (Arboleda, 2008)

The method can be applied to identify critical operations of a waste management system, and evaluate environmental impacts, including factors, changes, and the actions that can be controlled or modified to improve its efficiency. A study done on European harbours ("A procedure for identifying significant environmental aspects in sea ports" (Darbra et al., 2005)) developed a matrix of environmental activities and aspects. Sea ports have an enormous impact as they produce a large amount of pollutants which affect not only marine, but also land habitats (e.g., fisheries, industrial installations, storage of hazardous material) by releasing environmental waste into the water, air and soil. The results of this study were very useful for the management of the system as they provide evidence of significant environmental aspects related to port activities. The author (Darbra) found that identifying these aspects is an important feature of the method. The significance can be calculated and represented on the matrix by following the criteria established by the procedures of the method. This was the first step to get environmental certification, which also leads to others enhancements and achievements to reduce water contamination (Darbra et al., 2005).

In November 1999, The United States postal service in Gaithersburg, Maryland, realized that they had no current means by which to improve their business decision making and environmental performance. They decided to implement an Environmental Management System (EMS) plan that included an evaluation of environmental impacts and intoduced legal requirements that would have a major effect on defining significant environmental activities. This resulted in the organization becoming much more pro-active in their treatment of environmental, health and safety issues. By monitoring this, the company could flesh out their business decisions to provide continuous improvement to those areas. As a result, the company benefitted by promoting the conservation of natural resources while reducing the cost of operations. Through the use of this method, the postal service identified the best way to deal with certain activities that would benefit health, leading to a decrease in environmental incidents (GETF, 1999).

I also explored a "simplified LCA and matrix methods in identifying the environmental aspects of a product system" (Hur et al., 2005). In this case, designers of the product were finding it difficult to assess the potential environmental impact that it could cause. Their choice to use the matrix method was based on the consideration of available alternatives and the provision of information that could lead to possible improvements in the given product, determined by which alternatives were available for use. Because of the inherent features of the matrix method, it is applicable to many different facets of determining environmental safety by evaluating a product and improving it using supporting tools. The method is not only good for established products, but also in the development of new design/eco-innovation as it can help to provide a means through which new products can be developed. The study found that the matrix method relates to a number of different product categories as it provides enlightenment on which aspects of a product system will have the most effect on the environment. The results can provide a neutral overview, which can be the generator of discussion in regards to the data (Hur et al., 2005).

3.2.2 Procedure

Application of this method begins with detailing the operations involved in the waste system and identifying the associated environmental aspects of these operations. Next, selected impacts associated with environmental aspects are scored for significance, indicating those considered high risk for the environment. The resulting basic matrix can estimate how changes in components or management could affect the resulting total impact.

3.2.3 Advantages of the EM (Arboleda, 2008).

- The matrix allows considerations and conclusions regarding potential relationships between environmental factors and actions.
- The matrix approach is widely used by practitioners and scholars.
- It allows comparing events that may not be otherwise comparable.
- It provides an integrated vision of the environmental impacts involved.

- It can be used in any phase of evaluation in the life cycle of a product or service.
- It can be prepared and applied with different levels of information, for example low versus high precision and sample size.

3.2.4 Disadvantages of the EM

- Matrix applications are normally not selective because it does not distinguish between long and short terms effects.
- The basic method does not have mechanisms to highlight areas of interest
- It does not allow visualizing the temporality of the impacts (Arboleda, 2008).

3.2.5 Legal and other requirements for environmental aspects

Waste management and recycling are regulated by all levels of government: federal, provincial/territorial, and municipal. The federal government oversees international and inter-provincial activities through regulations such as The Canadian Environmental Protection Act, (CEPA) (C. E. P. Act, 1999) and The Canadian Environmental Assessment Act (C. E. A. Act, 1992). Waste and recycling facilities are monitored by provincial and territorial governments through regulations such as Alberta Environment AENV's Environmental Protection and Enhancement Act Part 9, Division 1 (Protection & Act). Finally, municipalities assume the responsibility of waste collection and disposal programs (Environment Canada & CSR, 2000).

The federal government regulates transportation and emissions through The Canadian Environmental Protection Act (C.E.P. Act, 1999). The Department of The Environment promotes a uniform approach for the regulation of air pollution across Canada through the Environmental Contaminants Act (Taylor, McMillan, & SpringerLink, 2014).

The Environmental Protection Act and the Code of practice for landfills (C.E.P. Act, 1999) regulates landfills.

3.2.6 Pareto analysis

Pareto is a statistical technique used for decision making by choosing or determining certain operations that produce a relevant global effect. It is commonly known as the 80/20 rule, as by identifying 20% of the causes, 80% of the problems can be determined. Pareto principle is based on “estimating the benefit delivered by each action with subsequent selection of a number of the most effective actions that deliver the total benefit reasonably close to the maximal possible one” (NCDOT, 2006).

In order to perform an analysis of the most significant breakpoints (S1 and S2), detrimental and the beneficial respectively, I took data from column 16 of the EM and separated the negative from positive values into two groups. I took 20% of the total values in each group for calculation. To identify 20% of the most detrimental (20% of the most negative scores) assign the least negative of that 20% as value S1. Anything less negative is preliminary and non-significant (NS).

Later, to identify 20% of the most beneficial (20% of the most positive scores), I assigned the lowest score of the 20% as value S2. Anything below this is preliminary and non significant (NS) (NCDOT, 2006).

3.2.7 Method application

The Environmental Matrix method (EM) is prepared with information about activities, operations, services or products and their possible interactions with the environment (Arboleda, 2008). This method combines a quantitative and a qualitative component, combining environmental aspects and the resulting environmental impacts.

The qualitative component: The first step was to identify environmental aspects through performing an inventory of the system. The second step was to relate environmental impacts with aspects (Table 3.2.1).

Table 3.2.1 General list of environmental activities and related impacts (Arboleda, 2008)

	Factor	No	**Environmental Aspects**	No	**Related Impact**
1	Air	A	Greenhouse gas emissions C0 and CO_2	1	Air Pollution
				2	Contribution to global warming
				3	Damage human health
		B	Particular matter emissions/dust	1	Air Pollution
				2	Contribution to global warming
				3	Damage human health
				4	Degradation to agriculture
				5	Degradation to natural landscape
		C	NOx emissions	1	Air Pollution
				2	Contribution to global warming
				3	Damage human health
		D	SOx emissions	1	Air Pollution
				2	Damage to vegetation and aquatic ecosystems
				3	Damage to human health
		E	Volatile organic compounds VOC emissions	1	Air contamination
				2	Contribution to global warming
				3	Damage to human health
		F	Offensive odor production	1	Air pollution
				2	Discomfort to community
		G	Noise pollution	1	Air pollution
				2	Damage to human health
2	Waste	A	Waste collection	1	Contribution to clean natural landscape
				2	Reduction of potential damage to human health
		B	Waste storage	1	Air pollution due to offensive odors
				2	Potential attraction of vectors (mouse, flies)
3	Consumption	A	Energy consumption	1	Increase in demand for natural sources
		B	Consumption for oil, coal and other fossil fuel for energy	1	Reduction on non-renewal natural sources

Factor		No	Environmental Aspect	No	Related Impact
		C	Consumption of hydraulic oils, lubricants, greases	1	Reduction on the natural sources
		D	Raw materials	1	Reduction natural sources
			Transfer material/cleaning spaces	1	Improving natural landscape conditions
				2	Reduction of natural ecosystem contamination
				3	Reduction on discomfort to community
5	Recycling	A	Recycle collection	1	Reduction of degradation on natural landscape
				2	Reduction on damage to natural sources
		B	Material classification	1	Reduction of waste to landfill
		C	Decrease landfill space	1	Reduction of soil contamination (leaking, filtrations and spills)
				2	Reduction of water contamination (leaking, filtrations and spills)
				3	Reduction of air pollution due to offensive odors
				4	Reduction damage to human health
				5	Reduction soil loss productivity
				6	Reduction ground water contamination
		D	Storage and final disposal	1	Reduction on soil pollution (leaking, filtrations, spills)
				2	Reduction on air pollution due to offensive odors
				3	Reduction on damage to human health
				4	Reduction on soil loss productivity
				5	Reduction on damage to natural landscape

	Factor	No	Environmental Aspect	No	Related Impact
				6	Reduction on water pollution (leaking, filtrations, and spills)
				7	Reduction on ground water contamination
				8	Reduction damage to natural sources flora and fauna
6	Social	A	Employment generation	1	Improving community quality of life

The third step was to classify the level of risk. The method provides a breakdown of environmental impacts. Table 3.2.2 outlines these impacts into a color-coded chart showing the detrimental and beneficial aspects and identifying the level of risk. All aspects are scored in the matrix with regard to each environmental impact classified as detrimental with negative (-) values, or beneficial with positive (+) values (NCDOT, 2006). Colors denote the significance of the matrix and differentiate the levels of risk. Red indicates a negative high risk, orange a negative medium risk, and yellow a negative low risk. Green indicates a high benefit, light green a medium benefit, and light blue a low benefit.

Table 3.2.2 Environmental Impacts classification levels (NCDOT, 2006)

Impact	Score	Detrimental	Score	Beneficial
High	-10	Alters the habitat and community causing damage or degradation. Legislation or regulations apply.	10	Highly beneficial environmental effects are likely.
Medium	-5	Possibility of or apparent environmental degradation.	5	Environmental beneficial effects are likely.
Low	-1	Environmental effects are not likely or there is no regulation for the activity.	1	Minimal possibilities for beneficial effects.

The quantitative component: The last step is to calculate the significant aspects of the system.

3.2.8 Calculations

The matrix is divided into 17 columns. The first column corresponds to operations/products/service. The second column is a list of the environmental aspects related to each operation/product/service. Columns 3 to 13 detail environmental impacts and the associated aspect with each related impact. Calculations occur in columns 4 to 17 in Table 3.2.3.

Table 3.2.3 Environmental matrix calculations (NCDOT, 2006)

Column	Operations or activities	
1		1-Deposit/Collection 2-Storage 3-Transportation 4-Recycling 5-Landfilling
2	Environmental aspects	Related environmental aspects are listed for each operation or activity
3	Air	Air pollution
4		Global warming
5	Soil	Soil contamination
6		Soil loss productivity
7		Degradation natural scape
8	Water	Water pollution
9		Groundwater contamination
10	Natural sources	Renewable natural sources (flora, fauna)
11		Nonrenewable natural sources
12	Social	Cultural/community effect (human health/quality of life)
13	Regulations	Regulated aspects
14	Total impact	Add the total score of environmental impacts
15	Frequency	Add value according to the frequency scale of each aspect: Unlike/rare (1) Occasional (2) Frequently (3)
16	Score	Calculate by multiplying total (column14) x frequency (column 15)
17	Pareto Analysis Significant = Y Non-significant = N	S1=most detrimental S2=most beneficial

3.3 Results

Tables 3.3.1 to 3.3.4 show the resulting matrix after calculating the significant aspects of the system

Table 3.3.1 Collection and hand sorting operations (NCDOT, 2006)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Environmental Impacts														
		Air		**Soil**			**Water**		**Natural sources**		**Social**	**Regulation**		**Frequency**		
Operation/ product /service	**Environmental Aspects**	Air Pollution	Global warming	Soil contamination	Soil loss productivity	Degradation natural landscape	Water pollution	Groundwater contamination	Renewable natural sources (flora, fauna)	Non-renewable natural sources	Cultural (human health/quality of life)	Regulated	**Total Impacts**	**1- Unlikely** / **2- Occasionally** / **3- Frequently**	**Score (Total x Frequency)**	**Pareto Analysis –Significant*S or NS (S1 or S2)**
1- Collection	Waste collection	1	1	1	1	10	1	1	1	1	5	Y	23	3	69	Y
	Recycle collection	5	1	5	1	10	5	1	10	1	1	Y	40	3	120	Y
	Employment generation	1	1	1	1	1	1	1	1	1	10	N	19	3	57	N
2- Storage	Transfer garb. for cleaning	1	1	1	1	10	1	1	10	1	5	Y	32	3	96	Y
	Storage in garbage rooms	-10	1	1	1	1	1	1	1	1	-5	N	-7	3	-21	Y
	Hand sorting	10	1	10	10	10	10	10	1	1	10	Y	73	3	219	Y
	Employment generation	1	1	1	1	1	1	1	1	1	10	N	19	2	38	N

Table 3.3.2 Transport operations (NCDOT, 2006)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Operation/ product/ service	**Environmental Aspects**	**Environmental Impacts**											**Total Impacts**	**Frequency**	**Score (Total x Frequency)**	**Pareto Analysis –Significant*S or NS (S1 or S2)**
		Air		**Soil**			**Water**		**Natural sources**		**Social**	**Regulatio**				
		Air Pollution	Global warming	Soil contamination	Soil loss productivity	Degradation natural landscape	Water pollution	Groundwater contamination	Renewable natural sources (flora, fauna)	Non-renewable natural	Cultural/ (human health/quality of life)	Regulated		**1- Unlikely** **2- Occasionally** **3- Frequently**		
3- Transport Service	Consumption of oil, coal and other fossil fuel for energy	-1	-1	-1	-1	-1	-1	-1	-1	-10	-1	N	-19	2	-38	Y
	Consumption of hydraulic oils, lubricants, greases	-1	-1	-1	-1	-1	-1	-1	-10	-1	-1	N	-19	2	-38	Y
	Greenhouse gas emissions CO - C02	-10	-10	-1	-1	-1	-1	-1	-1	-1	-10	Y	-37	3	-111	Y
	Particulate matter (PM) emission	-10	-10	-1	-1	-10	-1	-1	-10	-1	-10	Y	-55	3	-165	Y
	Noise pollution	-10	1	1	1	1	1	1	1	1	-10	N	-12	3	-36	N
	Employment generation	1	1	1	1	1	1	1	1	1	10	N	19	2	38	Y

Table 3.3.3 Recycle operation (NCDOT, 2006)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			16	17
Operation/ product/ service	**Environmental Aspects**	**Environmental Impacts**											**Total Impacts**				**Score (Total x Frequency)**	**Pareto Analysis –Significant*S or NS (S1 or S2)**
		Air		**Soil**			**Water**		**Natural sources**		**Social**	**Regulation**		**Frequency**				
		Air Pollution	Global warming	Soil contamination	Soil loss productivity	Degradation natural landscape	Water pollution	Groundwater contamination	Renewable natural sources (flora, fauna)	Non-renewable natural sources	Cultural/Community effect (human health/quality of life)	Regulated		**1- Unlikely**	**2- Occasionally**	**3- Frequently**		
4- Recycling (process)	Decrease landfill space	10	1	10	10	1	10	10	5	1	10	N	68	3			204	Y
	Decrease in raw materials consumption	1	1	1	1	1	1	1	10	1	1	N	19	3			57	Y
	Decrease in energy consumption	1	1	1	1	1	1	1	10	1	1	N	19	3			57	Y
	Storage and final disposal	10	10	10	10	10	10	10	10	10	10	Y	100	4			400	Y
	Employment generation	1	1	1	1	1	1	1	1	1	10	N	19	2			38	N

Table 3.3.4 Landfill operation (NCDOT, 2006)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Operation/ product /service	**Environmental Aspects**	**Environmental Impacts**											**Total Impacts**	**Frequency**	**Score (Total x Frequency)**	**Pareto Analysis –Significant*S or NS (S1 or S2)**
		Air		**Soil**			**Water**		**Natural sources**		**Social**	**Regulati**				
		Air Pollution	Global warming	Soil contamination	Soil loss productivity	Degradation natural landscape	Water pollution	Groundwater contamination	Renewable natural sources (flora, fauna)	Non-renewable natural sources	Cultural (human health/quality of life)	Regulated		**1- Unlikely** **2- Occasionally** **3- Frequently**		
5- Landlfill (waste final disposal)	Particulate matter emission/dust	-10	-10	-1	-1	-10	-1	-1	-10	-1	-10	N	-55	3	-165	Y
	NOx emissions	-10	-10	-1	-1	-1	-1	-1	-1	-1	-10	N	-37	3	-111	Y
	SOx emissions	-10	-1	-1	-1	-1	-1	-1	-10	-1	-10	Y	-37	3	-111	Y
	GHG C0 - $C0_2$	-10	-10	-1	-1	-1	-1	-1	-1	-1	-10	N	-37	3	-111	Y
	VOC	-10	-10	-1	-1	-1	-1	-1	-1	-1	-10	N	-37	3	-111	Y
	Offensive odor	-10	-1	-1	-1	-1	-1	-1	-1	-1	-10	N	-28	3	-84	N
	Waste disposal	-10	-1	-10	-10	-10	-10	-10	-1	-1	-10	Y	-73	3	-219	Y
	Employment generation	1	1	1	1	1	1	1	1	1	10	N	19	2	38	Y

[redacted]

Using the EM method, I could define five operations involved in the university waste management system as well as the environmental aspects and impacts associated with them. These operations are Collection, Storage, Transport, Recycling, and Landfill.

A summary with the most significant detrimental and beneficial aspects for each operation are identified in table below (Table 3.3.5).

Table 3.3.5 Significant break points (<S1 or S2)

Operations	Detrimental SBP (S1)	Beneficial SBP (S2)
Collection	0	120
Storage	-21	219
Transport	-165	38
Recycling (general)	0	400
Landfill	-219	38

1- Collection operation: In Table 3.3.1, Recycling collection (green) was identified as highly beneficial, and had a total score of 120, which impacts the aspects of degradation of the landscape and renewable natural sources (in some cases, potential impacts on flora and fauna have been noted) (Arboleda, 2008). There are no detrimental aspects identified with this operation.

2- Storage operation: In Table 3.3.1, Hand sorting (green) was identified as highly beneficial and had a total score of 219, which reduces the potential impacts on the following aspects: air pollution, soil contamination, soil loss productivity, degradation of the natural landscape, water and groundwater contamination and finally, quality of life (Arboleda, 2008). Storage in garbage room (red) was identified as highly detrimental and had a total score of -21, which impacts air pollution (Arboleda, 2008).

3- Transporting services: In Table 3.3.2, Employment generation (green) was identified as highly beneficial, had a total score of 38, and impacts quality of life (Arboleda, 2008).

Greenhouse gas emissions CO and CO_2 (red), were identified as highly detrimental and had a total score of -111, which affects the following aspects: air pollution, global warming, and human health (Arboleda, 2008). In addition, particular matter (PM) emissions (red) were identified as highly detrimental, had a total score of -165, and affects the following aspects: air pollution, global warming, degradation of the natural landscape, renewable natural resources (such as flora and fauna), and human health (Arboleda, 2008).

4- Recycling process: In Table 3.3.3, Storage and final disposal (green), was identified as highly beneficial, and had a total score of 400. This affects the following aspects: air pollution, global warming, soil contamination and loss productivity, degradation of the natural landscape, water pollution and groundwater contamination, renewable natural sources (flora and fauna), non-renewable natural sources and finally, human health (Arboleda, 2008). There are no (S1) values identified in this process.

5-Landfill waste final disposal: In Table 3.3.4, Employment generation (green) was identified as highly beneficial, had a total score of 38, and affects quality of life (Arboleda, 2008). Particular matter emission/dust (red) was identified as highly detrimental and had a total score of -165, which affects the following aspects: air pollution, global warming, degradation of the natural landscape, renewable natural resources (flora and fauna) and last, human health. In addition, waste disposal (red) was identified as highly detrimental and had a total score of -219, which affects the following aspects: air pollution, soil contamination, soil loss productivity, degradation of the natural landscape, water and groundwater contamination and last, human health (Arboleda, 2008).

3.4 Discussion and Conclusions

The student population of the University of Lethbridge shows, for the most part, a growth trend, increasing by 7.08% from 2007 to 2017. (See Table 3.4.1).

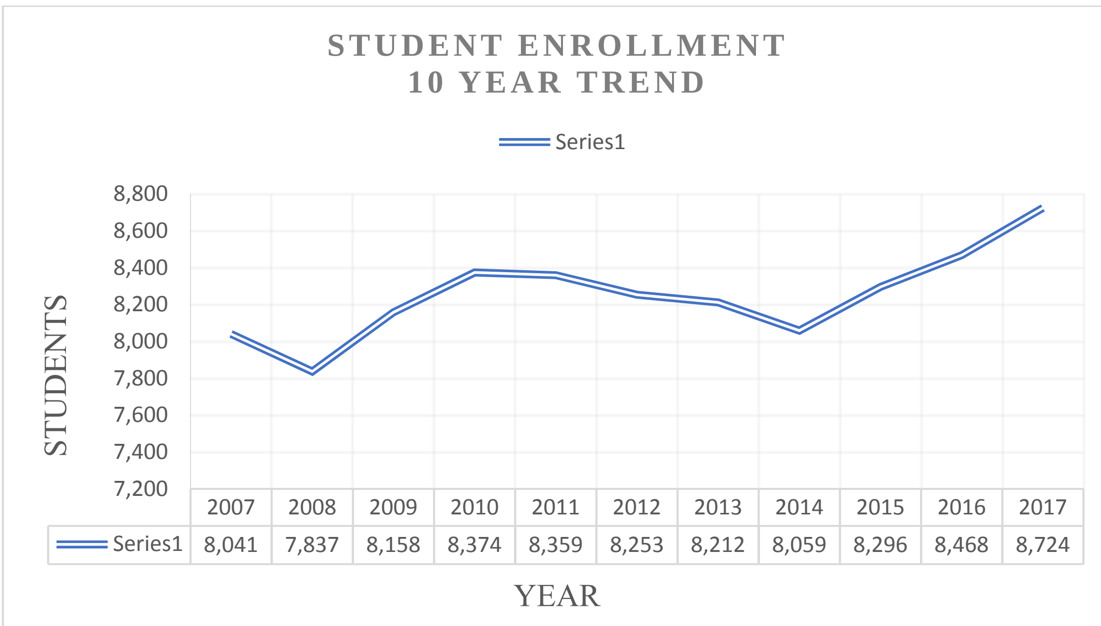

Figure 3.4.1 University of Lethbridge student enrolment (University of Lethbridge, 2017b)

The increase in the number of students naturally leads to a larger generation of food packaging waste. Waste is generated mainly around the dining areas where students have their meals. The waste system in this study is based on the waste life cycle, which starts with waste collection in these areas and ends with the final disposal in the landfill as shown in Figure 2.3.2 (University of Lethbridge waste management process flow diagram).

This study used an EM to analyze the impact of waste on the environment and, in particular, food packaging waste generated on campus. The calculation of the impacts was made based on Table 3.2.2 (Environmental impacts classification levels). The matrix method sets as a general rule that all environmental aspects that are regulated by law are considered significant for the analysis. For example, recycling operations are regulated by Alberta Regulation 192/1996 /Waste Control Regulation, and landfills are monitored by the Environmental Protection and Enhancement Act, and are therefore considered significant. Finally, a Pareto statistical analysis was completed with the EM total scores, which defined the most significant effects of the waste system.

The method used contributes, in part, to achieving the main objective of this study, which is to get a better understanding of the actions in the waste system and to thrive for a more sustainable environment. It allowed for the identification and tracking of the most significant aspects of waste management at the university. Additionally, the university waste management facility seeks continuous improvement in these areas, to promote the conservation of natural resources while reducing the cost of operations. In the case of the university, I find that aspects such as transporting generated considerable emissions and consequently affected several environmental aspects (Figure 3.3.2).

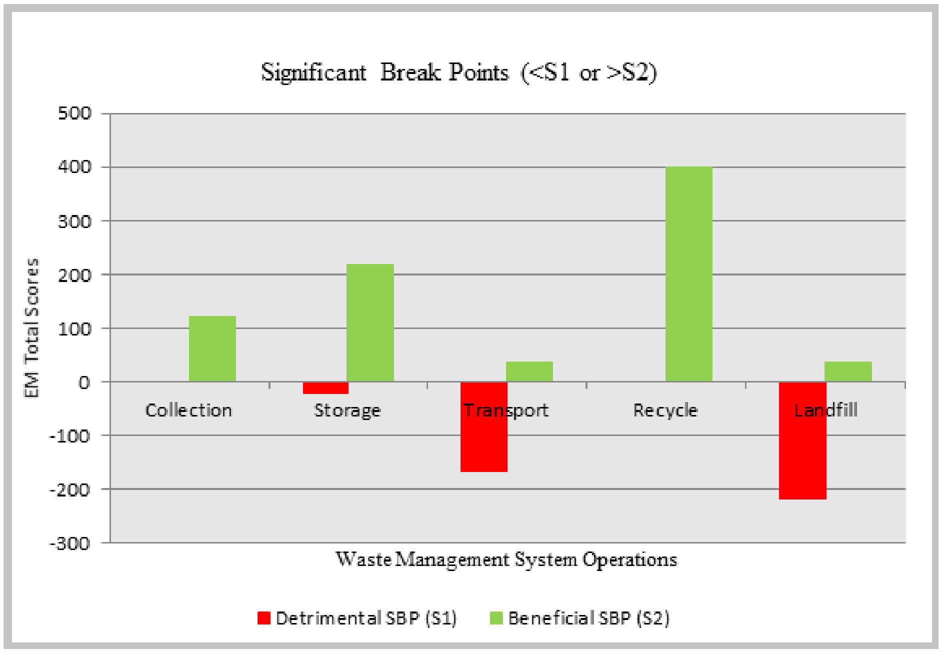

Figure 3.4.2 Significant break point from EM Environmental aspects and impacts

These results reveal that one of greatest environmental impacts is when waste is picked up at the university, and transported to the final dump or landfill. This is due to the cumulative quantity of negative effects that take place, including the known environmental costs of transportation. With this knowledge, a plan can be drawn up to consider alternative solutions that help reduce the amount of waste that goes to the landfill here, thus minimizing its negative impacts. According to the Pareto statistical analysis, 20% of the effects cause 80% of the problems. The results should be taken as a starting point to evaluate the general situation of the waste management system at the university. In reality, this would be reflected in greater quantities when the total percentage is considered. Likewise, the results of the recycling activity show significant positive results for the environment and therefore, should be constantly monitored to maintain efficiency, as this will reduce local waste and costs, and contribute to meeting challenges of global problems (such as energy use, greenhouse gas production, and the potential for pollution from discarded, unrecycled packaging).

3.5 Recommendations

To gain a better understanding of the actions in the waste system and to increase environmental benefits, it is recommended that the EM method to monitor and assess the University of Lethbridge waste system be implemented. This has two key points that require attention.

1. Collection – The recent progress is significant and provides positive environmental management results. However, implementation of clearer directions in terms of separating material is needed. Replacing the word "waste" with the word "landfill" will make it apparent that items going into such bins will end up in such a facility. This may make people think twice before they throw things away that may, indeed, be recyclable and will hopefully push them to become more informed, and invest the extra effort in separating waste by type. Improvements can also be made in the collection of plastic containers – as the university asks for such materials to be cleaned before depositing them in receptacles marked for plastic recycling, it is suggested that the university implement cleaning stations near to such depositories to facilitate the efficient washing of these items.

2. Recycling – in order to build a recycling culture at the university, it is suggested that the community is engaged through educational activities and visible campaigns in an attempt to procure a successful system that will convert practice into action. The university could also look into innovative composting projects that would allow them to

process more waste on campus, thus reducing the negative effects of the waste transport operation.

Chapter 4 - Modeling greenhouse gas emissions with EPA's Waste Reduction Model "WARM"

4.1 Introduction

This chapter includes a description of the Environmental Protection Act's (EPA) Waste Reduction Model (WARM) – this model measures and calculates CO_2 emissions generated at the University of Lethbridge over time. Additionally, I established the factors that have a better chance of contributing to a sustainable environment. The scope of the study was determined by operations in which food-packaging waste was involved.

4.2 Method

EPA's Waste Reduction Model (WARM)

The US Environmental Protection Agency (EPA), designed a Waste Reduction Model in 1998 to help waste managers estimate greenhouse gas (GHG) emission reductions in their waste management systems (EPA, 2016). The first version of the model was applied to a few operations like recycling materials, such as metal cans. As new versions were published, the model included more elements. The latest version (version 14, released March 2016) recognizes 54 materials, and calculates associated GHG emissions. The model has two options for calculating emissions – the baseline and alternative scenarios. Emissions from baseline includes the mass (in units of tons, in the EPA model) managed and the resulting GHG emission/energy consumption per material and management practice. Emissions from alternative scenarios, includes the tons handled and the resulting GHG emission/energy consumption per relevant material and management practice for the alternative scenario. The model identifies five alternative waste management practices (recycling, combustion, composting, anaerobic digestion, and landfilling). The model calculates GHG emissions in metric tonns of carbon dioxide equivalent ($MTCO_2E$) (EPA, 2016). The WARM model can process and assess multiple scenarios based on the material type and management practice. WARM calculates the GHG emissions and energy using specific emission factors. These factors are based on the LCA that evaluates not only the environmental impacts of products but also of waste. The model estimates the amount of energy used and emissions generated from the recycled material, compost and energy activities, to determine the benefits of these activities. The user can modify some key inputs such as landfill gas recovery practices and transportation distances to the MSW (Municipal Solid Waste) facilities (EPA, 2016).

4.2.1 Application of the Waste Reduction Model (WARM)

The University of Alberta (U of A) employed the EPA WARM model, applying it to current and potential MSW at the university (Scott, 2007). They analyzed the GHG emissions generated from a landfilling at the U of A as compared to the current U of A waste management practices. Additionally, they examined different MSW strategies using the EPA WARM model. They also analyzed other alternatives that could lower GHG emissions. In addition, the U of A evaluated the level of user friendliness and expertise needed to use this and found that WARM is a basic general model with various waste category data entry that makes it convenient for use as a decision support tool. The data associated with the WARM model were averages based on MSW from the United States, which are equal to related practices at the U of A. The WARM model estimated 556 metric tonns carbon equivalent ($MTCO_2E$) of greenhouse gas emissions were produced at U of A. The university also evaluated alternative scenarios with the WARM model. For example, 80% recycling and 50% composting resulted in sequestration of 492

$MTCO_2E$. Combustion of all waste leads to sequestration of 312 $MTCO_2E$, on the other hand, landfilling with gas collection for energy recovery sequesters 584 $MTCO_2E$. Source reduction of 35% yields greenhouse gas emission of 315 $MTCO_2E$. Finally, they found that the WARM model is simple, efficient and calculates a reliable estimate of greenhouse gas emission from municipal solid waste management practices (Scott, 2007).

A second study was conducted in the region of Waterloo, Ontario, Canada entitled "Evaluation of waste Reduction and Diversion as Alternatives to Landfill disposal" (Lai et al., 2014). This study examined a quantitative comparison of the environmental, economic, and social impacts of the waste disposal program in the region. WARM was used to assess environmental impacts for the base case and each of the three alternatives. The model evaluates the GHG emissions, expressed in equivalent carbon or CO_2, including five waste management strategies: source reduction, recycling, incineration, composting, and landfilling. The results showed that implementing alternative reduction strategies could enhance the management program in the region of Waterloo, and prolong the life of the Waterloo landfill. The highest GHG reduction (86%) was incineration with energy capture followed by the expansion of the recycling program (41% GHG reduction compared with the base case).

Another study was conducted in the hotel industry at five hotels in University Park, Center County, Pennsylvania, entitled "Looking for Green strategies for hotels: Estimation of recycling benefits" (Singh, Cranage, & Lee, 2014). This study investigates the role of recycling to improve its contribution to the environment. Additionally, it evaluated potential environmental impacts from recycling and its potential economic benefits. WARM was the method used to calculate the GHG emissions. The results showed that the hotels did not realize the potential savings from recycling as significant based on their own cost-benefit analysis. However, hotels can profit from proper recycling practices in the long-term. According to this study, the average hotel can save around $23,371 – $24,395 per year and can reduce their GHG emissions (equivalent to 90 passenger vehicles) annually by proper recycling of their waste.

4.2.2 Advantages of WARM

- The WARM model is an efficient and easy tool to use
- Requires limited spreadsheet data input
- It does not require great knowledge of the methodology to use it efficiently (Freed, Driscoll, & Stafford, 1998)
- Provides the user with several options to generate the reports
- Shows the environmental effect of baseline cases and alternative scenarios.

4.2.3 Limitations of WARM

- The handling of the current mix of recycling against 100% virgin inputs that do not use accurate emission values. According to Denison (1996), when comparing a parameter mix of recyclables against 100% virgin inputs, the former seems not to have an impact on the emissions with respect to increased recycling. Using 100% virgin materials in manufacturing requires more energy, creates more solid waste, and in consequence, more air emissions are emitted than with the use of mix recyclables (Denison, 1996). WARM applies the mix/100% effect emissions only with source reduction, when it should be more reflected in the model because of its importance in the emissions results.

4.2.4 WARM model requirements

The waste reduction model can be downloaded from https://www.epa.gov/warm. The requirements to run the model and the instruction regarding the input data are shown in (Appendix O).

4.2.5 Data collection

This research method served to estimate GHG emissions over time at the University of Lethbridge, and analyzed information based on an evidence assessment of the potential environmental impact of food packaging waste. The scopes of the analysis in these applications were limited to the activities in which food packaging is involved, including recycling and waste. The reason waste is included in this study is because food packaging is one of the constituents of the collected material.

The study employs data from University of Lethbridge Sustainability Report Card (Jaeger, 2017). A summary of the data is shown below in (Table 4.2.1).

Table 4.2.1 Sustainability Report card data University of Lethbridge (Jaeger, 2017)

Activity	Units	Data From – To
BFI Compactor Waste Collection	MT	
Buildings: Parkway Service Complex		2010 - 2017
Student's Union		2001 - 2017
University Hall		2001 - 2002
Cardboard Picked Up	MT	2001 - 2017
Paper Recycling/Mixed		2000 - 2017
Paper Recycling/White Bond		2000 - 2009
Other recycling	Kg	
Metal cans		2011 - 2017
Plastic		2012 - 2017
Compost collection	G	2010 - 2017
Bottle Recycling	Unit	2006 - 2017
Waste to landfill	MT	2001 - 2017

The WARM model requires that data must be entered in the value of short tons (US tons), so all data was converted into short tons, as shown (1 short ton = 2,000 lbs. = 907.18 kg). The table below shows all converted data (Table 4.2.2).

Table 4.2.2 Waste and recycled materials collected over time University of Lethbridge. Units Short Tons (US Tons) (Jaeger, 2017)

	Short tons (US tons)							
	Waste	Paper	Cardboard	Plastic	Metal cans	Compost	Bottle recycled	Total
2000	n/d	10.82	n/d	n/d	n/d	n/d	n/d	10.82
2001	212.31	17.36	22.61	n/d	n/d	n/d	n/d	252.28
2002	187.43	40.30	29.26	n/d	n/d	n/d	n/d	256.99
2003	164.17	62.95	30.75	n/d	n/d	n/d	n/d	257.87
2004	168.15	62.45	27.66	n/d	n/d	n/d	n/d	258.26
2005	178.02	60.19	19.64	n/d	n/d	n/d	n/d	257.85
2006	179.90	52.62	9.12	n/d	n/d	n/d	0.18	241.82
2007	181.95	59.63	28.57	n/d	n/d	n/d	0.22	270.37
2008	218.75	76.56	26.05	n/d	n/d	n/d	0.19	321.55
2009	220.79	52.71	29.72	n/d	n/d	n/d	0.18	303.40
2010	214.14	58.81	31.59	n/d	n/d	0.95	0.16	305.65
2011	234.88	51.24	29.16	n/d	0.20	10.54	0.14	326.16
2012	230.48	49.59	47.11	0.07	0.18	21.22	0.12	348.77
2013	223.42	49.92	73.83	0.11	0.17	48.69	0.18	396.32
2014	265.67	57.46	72.35	n/d	0.13	48.44	0.18	444.23
2015	257.52	52.45	78.91	2.30	0.23	64.34	0.06	455.81
2016	257.59	42.47	75.90	4.88	0.23	74.21	0.05	455.33
2017	270.70	40.02	76.05	5.57	0.23	77.11	1.05	470.73

*n/d = no data available

Table 4.2.3 Compost collected over time, University of Lethbridge (Jaeger, 2017)

	Compost Total			
Year	Gallons	m3	kilos	tons
2010	480	1.82	863.08	0.95
2011	5320	20.14	9565.81	10.54
2012	10705	40.52	19248.50	21.22
2013	24565	92.99	44169.95	48.69
2014	24440	92.52	43945.19	48.44
2015	32461	122.88	58367.62	64.34
2016	37442	141.73	67323.88	74.21
2017	38905	147.27	69954.48	77.11

p = m/v compost density=475kg/m3
m3=US gal liq/264.17

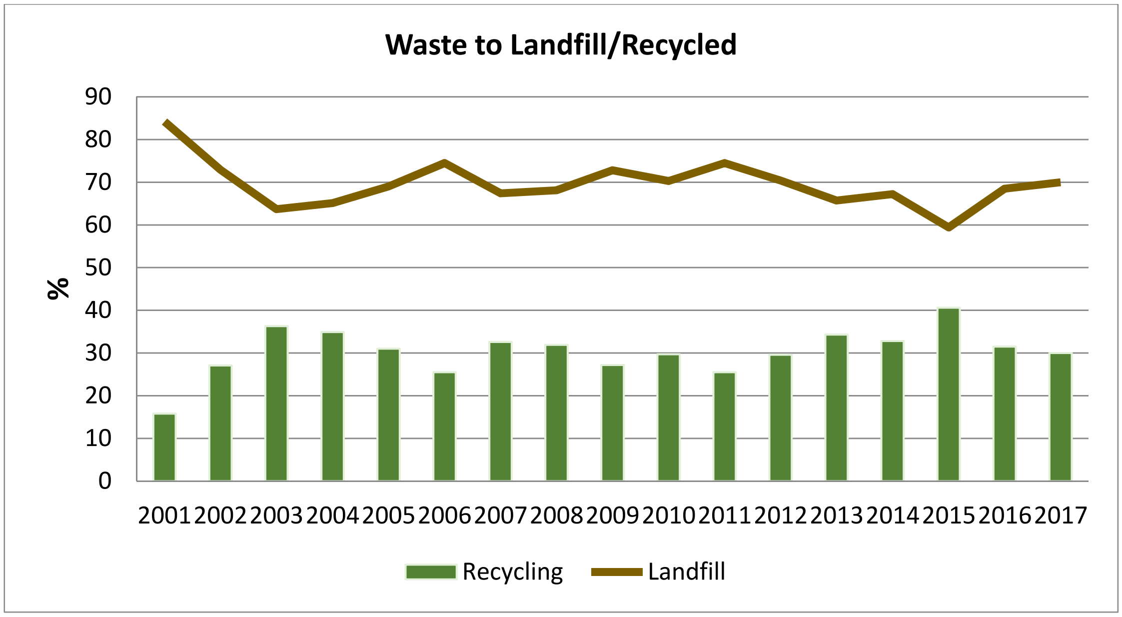

Figure 4.2.1 Line and Column chart representing the percentage of waste to landfill and recycled material (Jaeger, 2017)

Table 4.2.4 Percentage of Waste and Landfill (Jaeger, 2017)

	Recycling %	Landfill %
2001	15.8	84.2
2002	27.1	72.9
2003	36.3	63.7
2004	34.9	65.1
2005	31.0	69.0
2006	25.5	74.5
2007	32.6	67.4
2008	31.9	68.1
2009	27.2	72.8
2010	29.7	70.3
2011	25.5	74.5
2012	29.6	70.4
2013	34.3	65.7
2014	32.8	67.2
2015	40.6	59.4
2016	31.5	68.5
2017	30.0	70.0

4.3 Results

The University of Lethbridge started recycling paper and cardboard in 2001. Consequently, waste quantities also decreased due to this change in the waste system. In 2006, the collection of bottle containers garnered the same results. In 2010, a compost program was implemented to collect food waste from dining areas and around the university campus. This was followed by the collections of metal cans in 2011 and general plastics in 2012. Since 2013, there have been no data collected for any other activities (Figure 4.3.1).

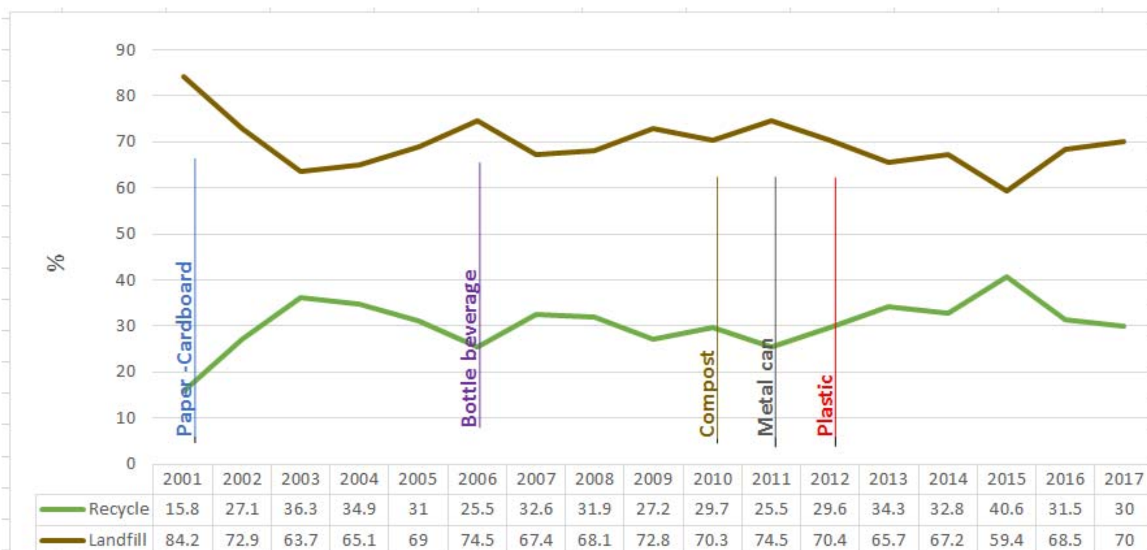

Figure 4.3.1 Line charts presenting percentage of landfill and recycled material at the University of Lethbridge over time (Jaeger, 2017)

4.3.1 Scope 1

Waste material is the first scope of the analysis, which is calculated in WARM to estimate the GHG emissions generated from 2001 to 2017. Waste material includes all kind of scraps of food and food packaging such as fast food containers, disposable plastic cups, cutlery, and plates. The material selected for the baseline scenario in the model that best fit with this category is MSW which according to (EPA, 2016), is defined as "waste materials typically discarded by households". The distance defined for landfill management option is 13.23 miles (the EPA model uses miles as distance units) because that corresponds to the distance from the university to the landfill facility. GHG Emissions Analysis –Summary Report (Appendix A).

Figure 4.3.2 Line chart presenting Scope 1-Greenhouse gas emissions of waste materials collected over time University of Lethbridge

4.3.2 Scope 2

The second scope for the study includes recyclable bottle containers. The University of Lethbridge started the bottle-recycling program in 2006, and its maintenance remained steady until 2017. The material selected for the baseline scenario in the model that best fit with this category is PET which according to (EPA, 2016), is defined as "Polyethylene terephthalate, [is] typically labeled plastic code #1 on the bottom of the container. PET is often used for soft drink and disposable water bottles, but can also include other containers or packaging". The distance defined for recycling management option is 18.36 miles because that corresponds to the distance from the university to the bottle depot Picture Butte. According to the last data provided by facilities in 2017, there was an increase in the total count for this material. GHG Emissions Analysis –Summary Report (Appendix B).

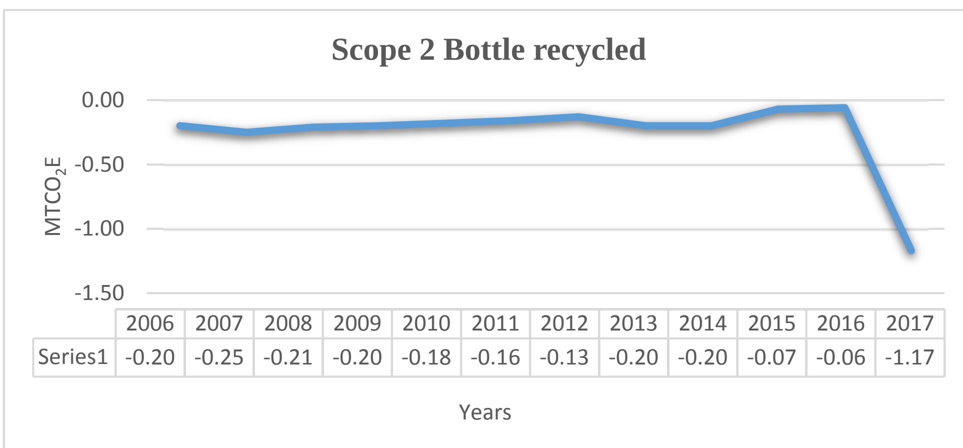

Figure 4.3.3 Line chart presenting Scope 2-Greenhouse gas emission of bottle recycled collected over time University of Lethbridge

4.3.3 Scope 3

For the third scope of the study, I considered metal cans collected at the University of Lethbridge from 2011 to 2017. For the last three years, the amount received has been steady. The material selected for the baseline scenario in the model that best fit with this category is Aluminum Cans which according to (EPA, 2016), is defined as "cans produced out of sheet rolled aluminum ingot". The distance defined for recycling management option is 13.23 miles because that corresponds to the distance from the university to the Recycling Center. GHG Emissions Analysis –Summary Report (Appendix C).

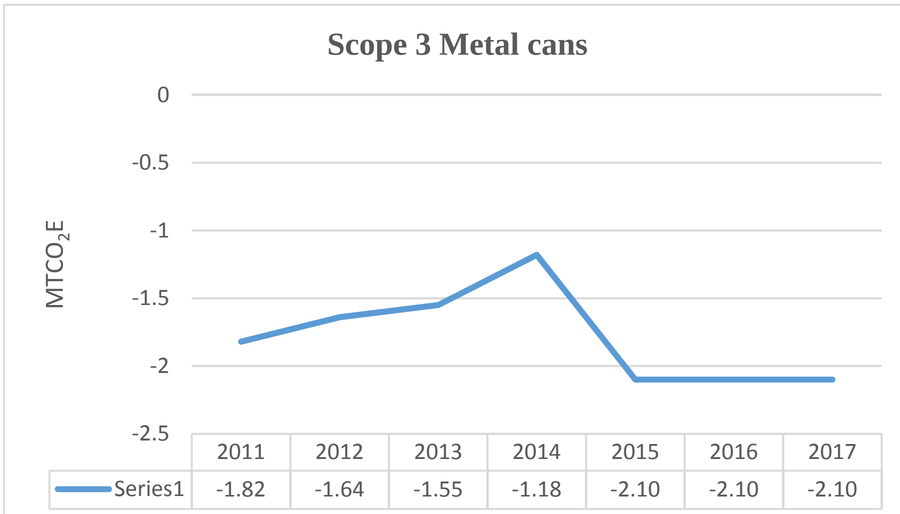

Figure 4.3.4 Line chart presenting Scope 3-Greenhouse gas emission of metal can collected over time University of Lethbridge

4.3.4 Scope 4

The last scope of the study includes plastic - all related packaging types included as general plastic material. In 2012, the University of Lethbridge began collecting this material. In 2014, no data related to the collection, weighing, and documentation procedures was available for this activity. The University collected data from 2015 to 2017. The material selected for the baseline scenario in the model that best fit with this category is PET. The distance defined for recycling management option is 13.23 miles because that corresponds to the distance from the university to the Recycling Center. GHG Emissions Analysis –Summary Report (Appendix D).

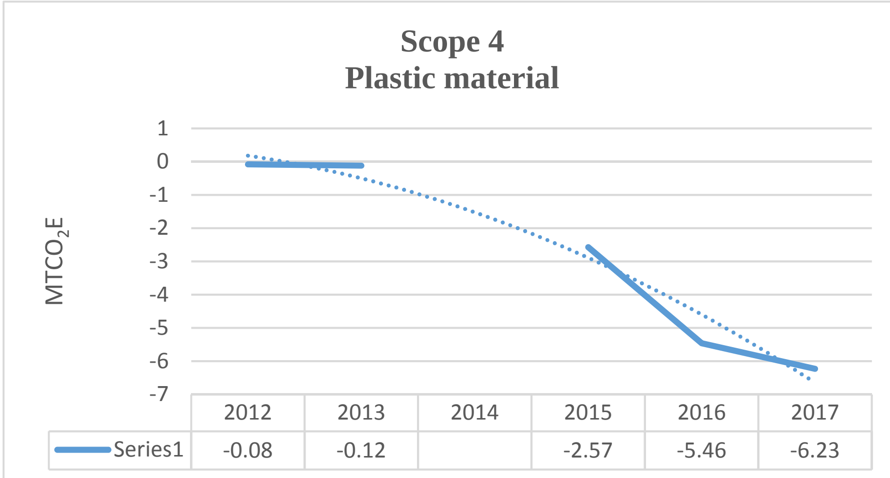

Figure 4.3.5 Line chart presenting Scope 4-Greenhouse gas emission of plastic material collected over time University of Lethbridge

4.4 Discussion and Conclusions

The University of Lethbridge began recycling in 2001, (15.8%), and subsequently the quantity of recycling had increased to 30% by 2017 (See Figure 4.2.4). This trend experiences several fluctuations. A low point of recycling (25.5%) occurred in 2006, but after this year the university implemented bottle and beverage recycling. For this reason, the trend started increasing moderately. From 2010 to 2012, the university initiated programs to recycle compost (2010), metal cans (2011), and plastics in general (2012). In 2015, recycling reached a high of 40.6% after which it plateaued and these variables levelled out. With respect to landfill, once the university implemented recycling, the amount of landfill material decreased from 84.2% in 2001 to 70.0% in 2017.

The first scope of the study analyzes GHGs generated through waste material modeled in WARM, as shown in Figure 4.3.2 (GHG emissions of waste materials) from 2001 to 2017. The proportion of waste has increased over the last ten years due to lifestyle changes, which has a growing trend of replacing traditional food packaging such as glass, metal and paper with plastic, cardboard, and styrofoam materials (Pankaj et al., 2014) .

The University of Lethbridge (population - 9896 people) generated 1169.97 Kg of waste per day in 2017, (Table 4.2.3), which corresponds to 0.118Kg of waste per capita. This value is comparable with a study done in 2015 at a University in Thailand, “Comparison of solid waste composition between regular and weekend programs at Nakhon Ratchasima Rajabhat University” (Viriya, 2015) in which waste generated from regular and weekend programs was 0.141 and 0.278 kilograms/person/day. Communicating the sustainability results of the campus to the community via campus news is an incentive that can produce great benefits, promoting students sustainable commitment.

The increase of emission from 63 $MTCO_2E$ in 2007, to 93.7 $MTCO_2E$ in 2017, and the population growth of 7.8% in the last 10 years, predicts an annually increase of 3% in the generation of emissions. The university waste system must apply stronger measures that not only avoid the tendency to generate emissions but also minimize them in the future. In addition, by establishing campus waste management indicators using parameters like (CO_2) that determine the level of emission, University of Lethbridge can plan sustainability goals in the future.

A positive relationship between $MTCO_2E$ per student and years are indicated in a regression line shown in Figure 4.4.1.

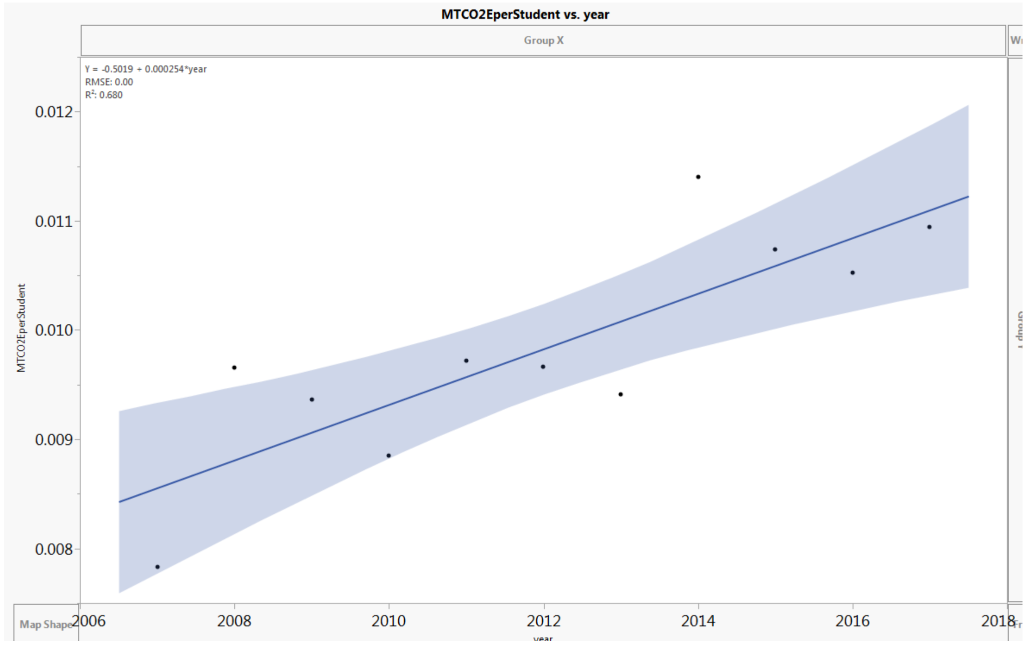

Figure 4.4.1 Scatter plots chart presenting $MTCO_2E$ per student vs. years, from 2006 to 2017 at the University of Lethbridge (University of Lethbridge, 2017b)

The negative values in the WARM analysis represent the emissions that have been avoided during the management of specific materials (EPA, 2016).

The second scope of the study analyzes the environmental effect produced by recycling beverage containers. (Figure 4.3.3). From 2006 to 2017, the University of Lethbridge had a reduction in the emissions generation of -1.80 $MTCO_2E$. This is equivalent to conserving 202 gallons of gasoline and 74 cylinders of propane used for home barbeques (Appendix B1).

The third scope of the study analyzes the environmental effect produced by recycling metal cans. After an initial decrease over the next three years, a sharp upswing in emission occurred (-2.10$MTCO_2E$) in 2015. From 2011 to 2017, the University of

Lethbridge reduced emissions by 5.75 $MTCO_2E$. This is equivalent to adding annual emissions from 1 passenger vehicle consuming 647 gallons of gasoline, or 239 cylinders of propane used for homes barbeques (Appendix C1).

The last scope of the study analyzes the environmental effect produced due to recycling plastics. From 2012 to 2017, the University of Lethbridge decreased emissions by 14.01$MTCO_2E$. This is equivalent to removing annual emissions from two passenger vehicles, conserving 1576 gallons of gasoline or 583 cylinders of propane used for home barbeques. (Appendix D1).

4.5 Recommendations

Reducing the gap between recycling (30%) and landfill (70%), would be one of the main objectives to address in the future. Activities that lead towards sustainability goals must include establishing campus waste management indicators using parameters (CO_2) that determine the efficiency of the system and the measurement of campus emissions (WARM model). Monitoring the performance of the system and having waste reduction targets will provide a positive direction for the waste system. Communicating the sustainability results of the campus to the community via campus news is an incentive that can produce great benefits. Keeping people informed and sensitive to campus endeavors and encouraging environmentally friendly activities and practices can potentially make a huge difference in terms of maximizing waste reduction. The sustainability results can also serve as a source of reliable information in terms of how the institution can make decisions regarding adequate intervention in reducing waste.

Chapter 5 - Food packaging and environmental survey

5.1 Introduction

A research study on social attitudes towards packaging materials showed that consumers are uncertain when they make a decision about what kind of material to choose, and that environmental impacts of packaging are often not relevant for consumers when making purchasing decisions in the supermarket (Lewis et al., 2007). This chapter examines the food packaging and environment survey that serves to identify student awareness with respect to sustainability on campus as well as their attitudes and behaviors towards food packaging preferences.

5.2 Method

A survey was designed for this study, and posted in the SONA (a software that supports universities, managing research and recruiting participants in a cloud-based environment) system of the psychology department at the University of Lethbridge. It was available for two periods: 1-month from March to April 2018; and 20 days from May 30 to June 18, 2018.

Sample

Participants in the online survey were University of Lethbridge students from the Psychology department, aged 18 and older, who were eligible to participate in studies open to recruitment in the SONA System in order to receive bonus marks over the duration of a semester. There was no obvious reason for expected bias or sampling abnormalities with the groups in either survey.

The final study sample for the first period was 380 participants involved in a simple and short-term (three months) opinion/action survey. For the second period, I recruited 48 participants. The time estimated for completion of the survey was approximately 10 -15 minutes per person. Recruited students received a 1% bonus mark for their participation, indicated in the consent form (Appendix E). Their participation was voluntary and partially protected; they had an option to withdraw consent at any time with no repercussion.

5.2.1 Ethics approval

The survey application for ethical approval was reviewed and approved by the University of Lethbridge Human Subject Research Committee (HSRC) under the ethical principles and standards of the University (protocol #2018-029) (Appendix F).

5.2.2 Data collection

In order to collect data and information about student preferences regarding food packaging and the impact on the environment, a survey was conducted on-line through the SONA system. Once the survey had closed, the data and the survey key values were exported into a Microsoft Excel spreadsheet. Participation was partially protected as no names were requested during the data collection, and no identification was recorded during survey completion; participants were associated with an identification number only. All data for this study was collected by the principal investigator and retained in a folder kept in a locked drawer, as per University of Lethbridge policy. Data will be kept by the principal investigator and the University of Lethbridge until March 30, 2023, after which the material will be deleted or destroyed.

5.2.3 Materials

Participants completed 19 questions in the survey that required responses expressed through checkboxes. It was organized into four parts, the first of which was related to general information about the respondents. This was followed by a section on packaging (drink) preferences with an options of five answers: glass, metal, styrofoam, paperboard and other. Meal preferences were indicated by yes or no answers. The last section of the questionnaire assessed methods used to dispose of recyclables, compost waste and beverage containers (five-point Likert scale - e.g., “Do you think that plastic bottles are biodegradables?” 1=extremely disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=extremely agree). Survey format in (Appendix G).

5.3 Results

A summary with the results of the two surveys is shown in Table 5.3.1.

Table 5.3.1 Summary of packaging and environmental surveys one and two

Section 1	Response	Survey 1		Survey 2		Total	
1	**How often are you at the University of Lethbridge?**						
	Every day	253	64.9%	13	26.5%	266	60.6%
	One to two days/week	12	3.1%	11	22.4%	23	5.2%
	Three to four days/week	121	31.0%	23	46.9%	144	32.8%
	Occasionally	0	0	2	4.1%	2	0.5%
	No answer	4	1.03%	0	0	4	0.9%
	Total	**390**	**100%**	**49**	**100%**	**439**	**100%**
2	**What is University of Lethbridge doing to become more sustainable? Please check all that apply.**						
	Locally produced food	55	8.8%	8	10.0%	63	8.9%
	Renewable energy	48	7.7%	4	5.0%	52	7.4%
	Waste disposal	298	47.5%	37	46.3%	335	47.4%
	Water bottle re-use	226	36.0%	31	38.8%	257	36.4%
	Total	**627**	**100%**	**80**	**100%**	**707**	**100%**
3	**What meals do you eat at the University of Lethbridge? Please check all that apply**						
	Breakfast	91	12.2%	7	9.7%	98	12.0%
	Dinner	120	16.1%	5	6.9%	125	15.3%
	Lunch	256	34.3%	29	40.3%	285	34.8%
	Snack	277	37.1%	31	43.1%	308	37.7%
	Non answer	2	0.3%	0	0	2	0.2%
	Total	**746**	**100%**	**72**	**100%**	**818**	**100%**
Section 2	**Response**	**Survey 1**		**Survey 2**		**Total**	
4	**I prefer my cold drinks in this material**						
	Glass	207	54.5%	25	52.1%	232	54.2%
	Metal	82	21.6%	12	25.0%	94	22.0%
	Other	62	16.3%	6	12.5%	68	15.9%
	Paper board	21	5.5%	2	4.2%	23	5.4%
	Styrofoam	8	2.1%	3	6.3%	11	2.6%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
	Response	**Survey 1**		**Survey 2**		**Total**	
5	**In terms of hot drinks (coffee, tea, cocoa) in this material**						
	Glass	41	10.8%	10	20.8%	51	11.9%
	Metal	78	20.5%	14	29.2%	92	21.5%
	Other	33	8.7%	2	4.2%	35	8.2%
	Paper board	197	51.8%	21	43.8%	218	50.9%
	Styrofoam	31	8.2%	1	2.1%	32	7.5%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**

6	**Which material is easiest to clean?**						
	Glass	295	77.6%	35	72.9%	330	77.1%
	Metal	66	17.4%	12	25.0%	78	18.2%
	Other	3	0.8%	0	0.00%	3	0.7%
	Paper board	11	2.9%	1	2.1%	12	2.8%
	Styrofoam	5	1.3%	0	0.0%	5	1.2%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
7	**Do you have any of these products with you now?**						
	Glass	83	17.5%	18	28.1%	101	18.8%
	Metal	101	21.3%	15	23.4%	116	21.6%
	No I don't	137	28.9%	14	21.9%	151	28.1%
	Other	107	22.6%	13	20.3%	120	22.3%
	Paper board	43	9.1%	4	6.3%	47	8.7%
	Styrofoam	3	0.6%	0	0.0%	3	0.6%
		474	**100%**	**64**	**100%**	**538**	**100%**
8	**Which material provides the best taste for your drink?**						
	Glass	290	64.6%	39	59.1%	329	63.9%
	Metal	66	14.7%	12	18.2%	78	15.1%
	Other	39	8.7%	4	6.1%	43	8.3%
	Paper board	43	9.6%	8	12.1%	51	9.9%
	Styrofoam	9	2.0%	3	4.5%	12	2.3%
	Non answer	2	0.4%	0	0	2	0.4%
	Total	**449**	**100%**	**66**	**100%**	**515**	**100%**
9	**Which material is friendlier to the environment?**						
	Glass	175	37.4%	25	39.1%	200	37.6%
	Metal	95	20.3%	13	20.3%	108	20.3%
	Other	35	7.5%	2	3.1%	37	6.7%
	Paper board	151	32.3%	23	35.9%	174	32.7%
	Styrofoam	12	2.6%	1	1.6%	13	2.4%
	Total	**468**	**100%**	**64**	**100%**	**532**	**100%**
10	**Which do you think will break down first?**						
	Glass	18	4.6%	4	8.0%	22	4.9%
	I don't know	31	7.8%	5	10.0%	36	8.1%
	Metal	3	0.8%	0	0.0%	3	0.7%
	Other	9	2.3%	1	2.0%	10	2.2%
	Paper board	301	76.2%	37	74.0%	338	76.0%
	Styrofoam	33	8.4%	3	6.0%	36	8.1%
	Total	**395**	**100%**	**50**	**100%**	**445**	**100%**

Section 3	Response	Survey 1		Survey 2		Total	
11	**Do you prefer to bring your own food to school?**						
	No	105	27.6%	8	16.7%	113	26.4%
	Yes	275	72.4%	40	83.3%	315	73.6%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
12	**In terms of food protection, is the type of food packaging important to you?**						
	No	99	26.1%	13	27.1%	112	26.2%
	Yes	281	73.9%	35	72.9%	316	73.8%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
13	**Would you prefer less packaging in fast food?**						
	No	82	21.6%	9	18.8%	91	21.3%
	Yes	298	78.4%	39	81.3%	337	78.7%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
14	**Do you have a reusable bottle for coffee or water? (14)**						
	No	16	4.2%	2	4.2%	18	4.2%
	Yes	364	95.8%	46	95.8%	410	95.8%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
15	**Reusable containers are good for environment? (15)**						
	No	3	0.8%	1	2.1%	4	0.9%
	Yes	377	99.2%	47	97.9%	424	99.1%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
16	**Is it better to reuse rather than to recycle?**						
	No	29	7.6%	3	6.3%	32	7.5%
	Yes	351	92.4%	45	93.8%	396	92.5%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
Section 4	**Response**	**Survey 1**		**Survey 2**		**Total**	
17	**For Plastic Recycling, I follow the instructions "Please rinse off your container before putting it into the bin".**						
	Agree	148	38.9%	17	35.4%	165	38.6%
	Disagree	101	26.6%	9	18.8%	110	25.7%
	Strongly Agree	55	14.5%	15	31.3%	70	16.4%
	Strongly Disagree	19	5.0%	0	0.0%	19	4.4%
	Uncertain	57	15.0%	7	14.6%	64	15.0%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**
18	**I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel.**						
	Agree	161	42.4%	19	39.6%	180	42.1%
	Disagree	73	19.2%	7	14.6%	80	18.7%
	Strongly Agree	86	22.6%	16	33.3%	102	23.8%
	Strongly Disagree	20	5.3%	1	2.1%	21	4.9%
	Uncertain	40	10.5%	5	10.4%	45	10.5%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**

	Response	Survey 1		Survey 2		Total	
19	**I use the blue bin for beverage containers (Plastic, aluminium or glass beverage)**						
	Agree	146	38.4%	10	20.8%	156	36.4%
	Disagree	11	2.9%	0	0.0%	11	2.6%
	Strongly Agree	200	52.6%	32	66.7%	232	54.2%
	Strongly Disagree	6	1.6%	1	2.1%	7	1.6%
	Uncertain	17	4.5%	5	10.4%	22	5.1%
	Total	**380**	**100%**	**48**	**100%**	**428**	**100%**

Table 5.3.2 Section 1 general information, survey results for both groups of students

Section 1 General Information

1 How often are you at the University of Lethbridge?

	Every day	One to two days/week	Three to four days/week	Occasionally	Non answer	Total Responses
Freq	266	23	144	2	4	439
Share	60.6%	5.2%	32.8%	0.5%	0.9%	

Share Chart	Every day	One to two days/week	Three to four days/week	Occasionally	Non answer	
	0.606	0.052	0.328	0.005	0.009	439

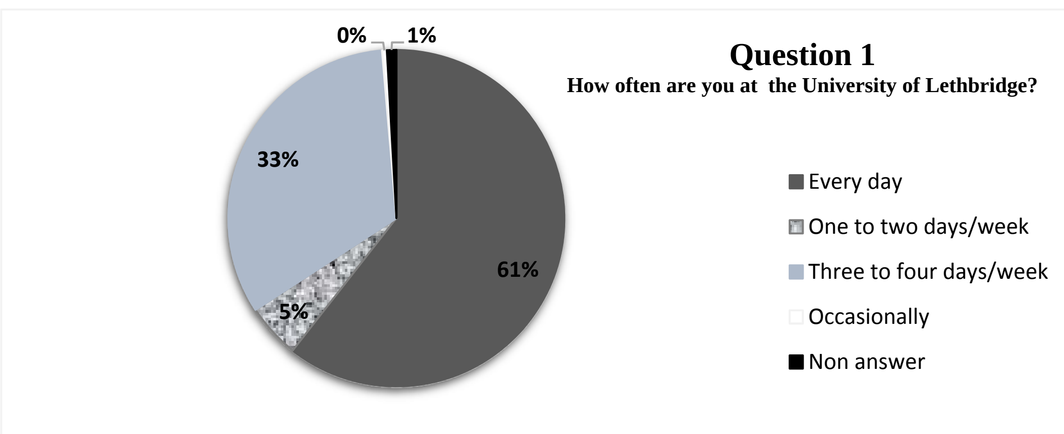

*Figure 1*Figure 5.3.1 Pie chart representing the percentage proportion of students' attendance at the University of Lethbridge

2 What is University of Lethbridge doing to become more sustainable? Please check all that apply.

		Locally produced food	Renewable energy -	Waste disposal	Water bottle re-use	Total Responses
Freq		63	52	335	257	707
Share		8.9%	7.4%	47.4%	36.4%	

Share Chart		Locally produced food	Renewable energy	Waste disposal	Water bottle re-use	
		0.089	0.074	0.474	0.364	707

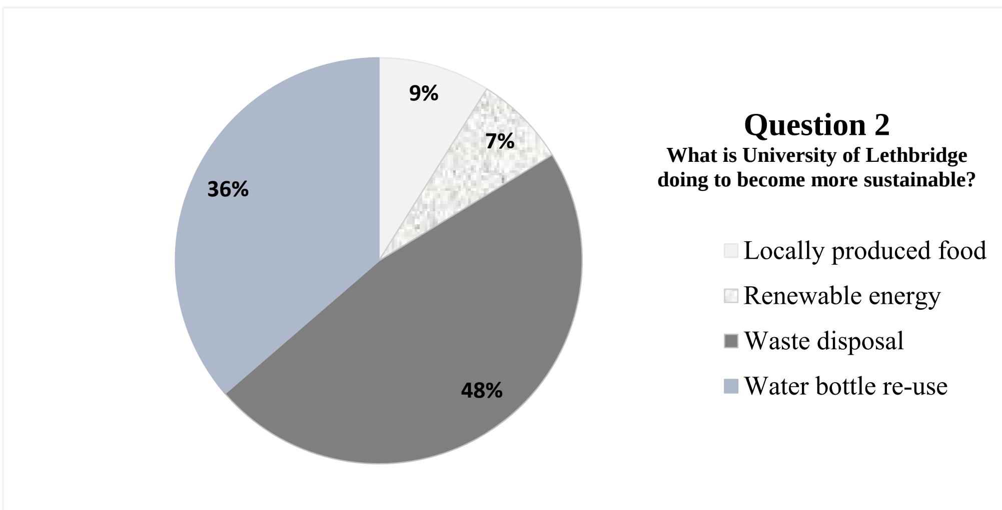

Figure 5.3.2 Pie chart representing the percentage proportion of students' opinion about sustainable at University of Lethbridge

3 What meals do you eat at the University of Lethbridge? Please check all that apply

	Breakfast	Dinner	Lunch	Snack	Non answer	Total Responses
Freq	98	125	285	308	2	818
Share	12%	15.3%	34.8%	37.7%	0.2%	

Share Chart	Breakfast	Dinner	Lunch	Snack	Non answer	
	0.120	0.153	0.348	0.377	0.002	818

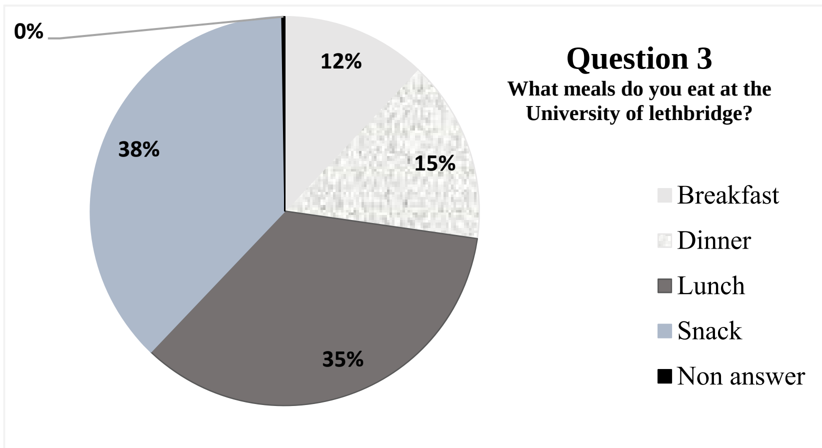

Figure 5.3.3 Pie chart representing the percentage proportion of students' opinion about their meal preferences at University of Lethbridge

Table 5.3.3 Section 2 packaging uses preferences, survey results

Section 2 Packaging uses preferences							
4	I prefer my cold drinks in this material						
		Glass	Metal	Other	Paper board	Styrofoam	Total Responses
	Freq	232	94	68	23	11	428
	Share	54.2%	22%	15.9%	5.4%	2.6	
	Share Chart	Glass	Metal	Other	Paper board	Styrofoam	
		0.542	0.220	0.159	0.054	0.026	428

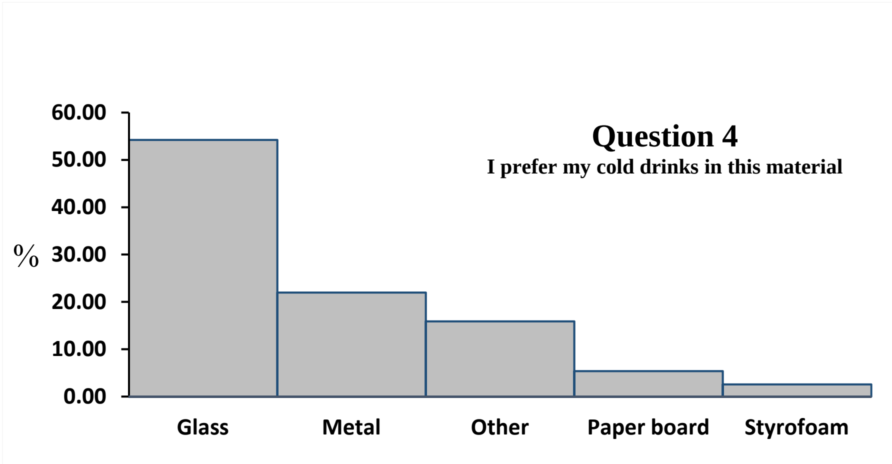

Figure 5.3.4 Histogram chart representing the percentage proportion of students' cold drink preferences

5 In terms of hot drinks (coffee, tea, cocoa) in this material

	Glass	Metal	Other	Paper board	Styrofoam	Total Responses
Freq	51	92	35	218	32	428
Share	11.9%	21.5%	8.2%	50.9%	7.5%	

Share Chart	Glass	Metal	Other	Paper board	Styrofoam	
	0.119	0.215	0.082	0.509	0.075	428

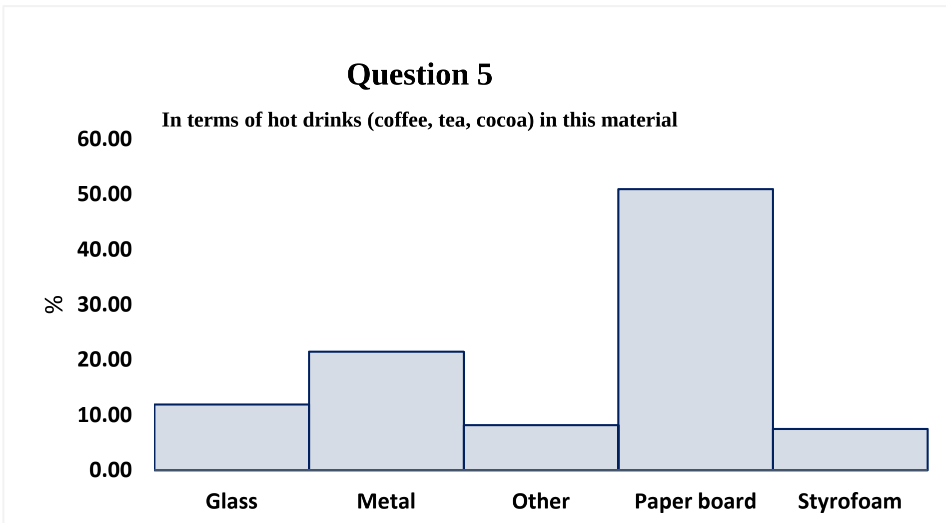

Figure 5.3.5 Histogram chart representing the percentage proportion of students' hot drink preferences

6 Which material is easiest to clean?

	Glass	Metal	Other	Paper board	Styrofoam	Total Responses
Freq	330	78	3	12	5	428
Share	77.1%	18.2%	0.7%	2.8%	1.2%	

Share Chart	Glass	Metal	Other	Paper board	Styrofoam	
	0.771	0.182	0.070	0.028	0.012	428

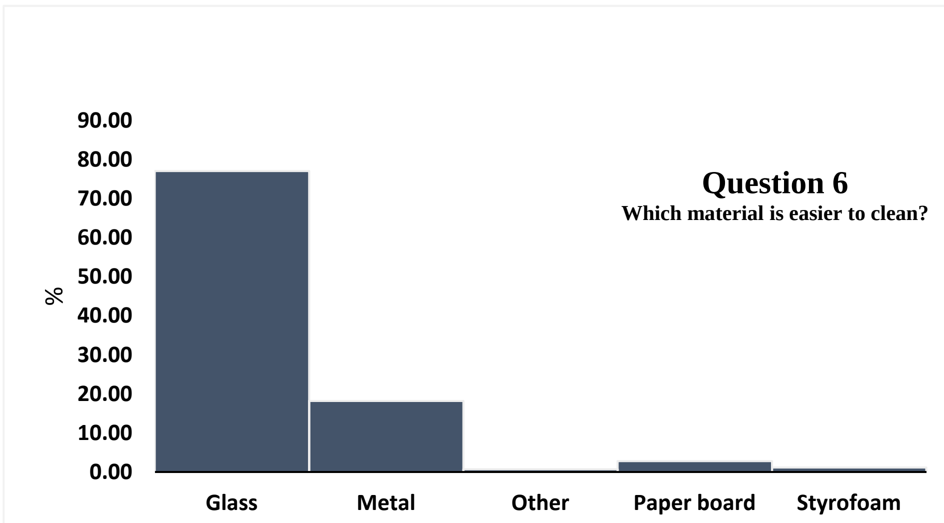

Figure 5.3.6 Histogram chart representing the percentage proportion of students' opinion about cleaning packaging

7	Do you have any of these products with you now?						
	Glass	Metal	No I don’t	Other	Paper board	Styrofoam	Total Responses
Freq	101	116	151	120	47	3	428
Share	18.4%	21.6%	28.1%	22.5%	8.7%	0.6%	

Share Chart	Glass	Metal	No I don’t	Other	Paper board	Styrofoam	
	0.184	0.216	0.281	0.225	0.087	0.006	428

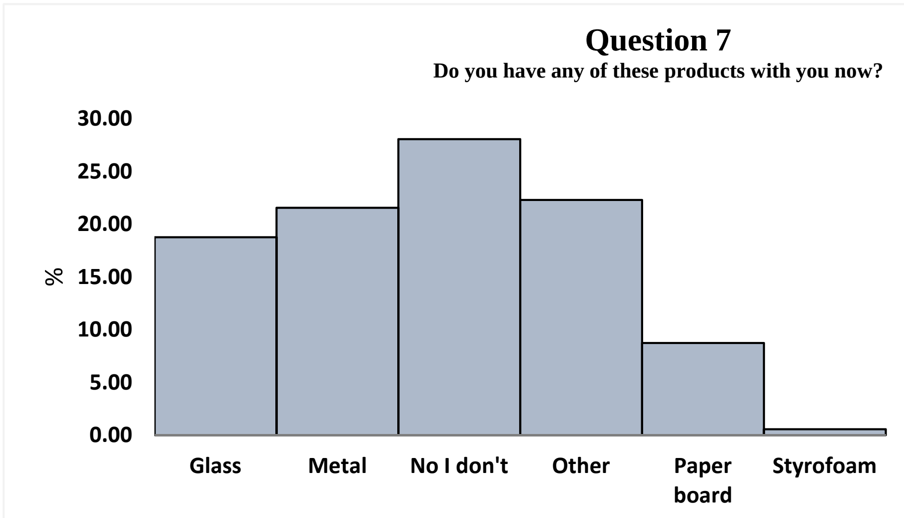

Figure 5.3.7 Histogram chart representing the percentage proportion of students’ opinion about packaging belongings

8 Which material provides the best taste for your drink?

	Glass	Metal	Other	Paper board	Styrofoam	Non answer	Total Responses
Freq	329	78	43	51	12	2	428
Share	63.9%	15.1%	8.3%	9.9%	2.3%	0.4%	

Share Chart	Glass	Metal	Other	Paper board	Styrofoam	Non answer	
	0.639	0.151	0.083	0.009	0.012	0.004	428

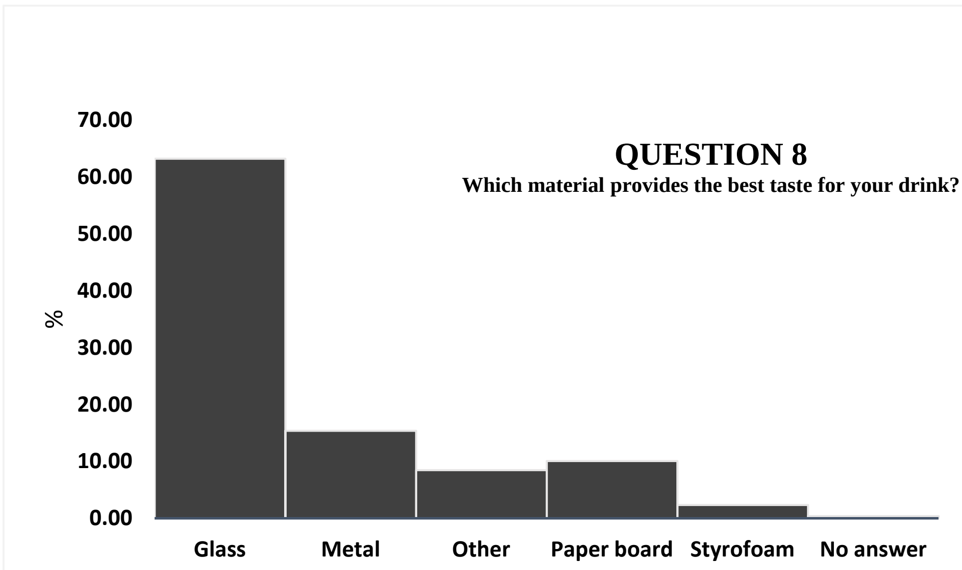

Figure 5.3.8 Histogram representing the percentage proportion of students' opinion about packaging material that provides the best taste

9 Which material is friendlier to the environment?

	Glass	Metal	Other	Paper board	Styrofoam	Total Responses
Freq	200	108	37	174	13	428
Share	37.6%	20.3%	7.0%	32.7%	2.4%	

Share Chart	Glass	Metal	Other	Paper board	Styrofoam	
	0.376	0.203	0.007	0.327	0.002	428

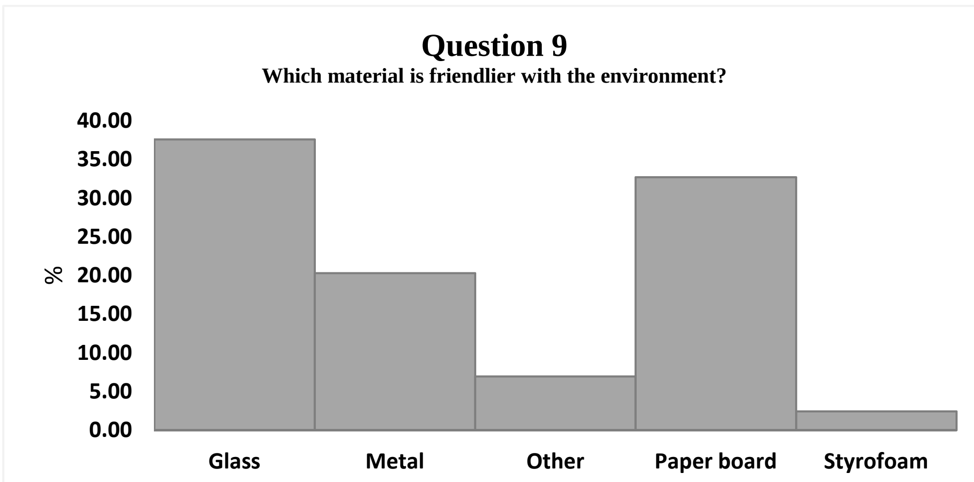

Figure 5.3.9 Histogram chart representing the percentage proportion of students' opinion about packaging preference for friendlier environment

10	Which do you think will break down first?						
	Glass	I don't know	Metal	Other	Paper board	Styrofoam	Total Responses
Freq	22	36	3	10	338	36	428
Share	4.9%	8.1%	0.7%	2.2%	76%	8.1%	

Share Chart	Glass	I don't know	Metal	Other	Paper board	Styrofoam	
	0.049	0.0081	0.007	0.002	0.076	0.081	428

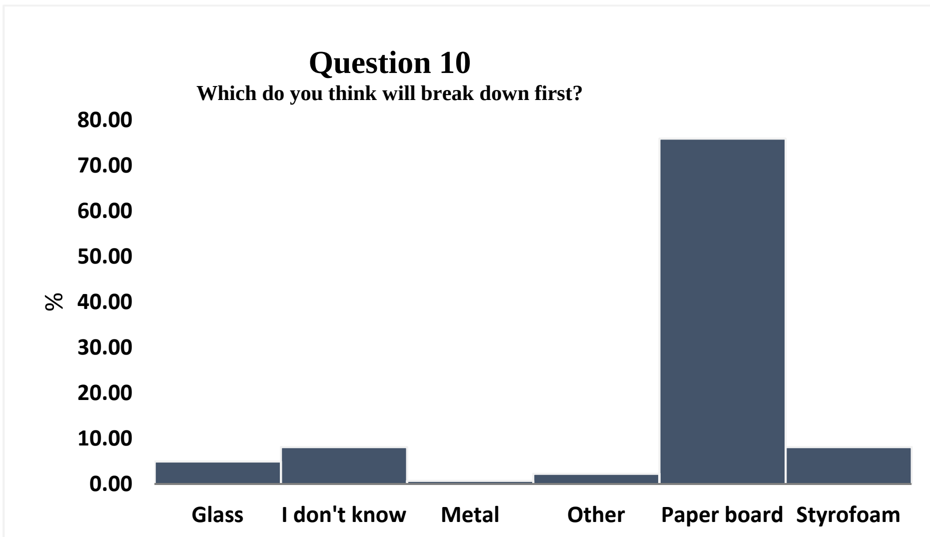

Figure 5.3.10 Histogram chart representing the percentage proportion of students' opinion about packaging material that breaks down first

Table 5.3.4 Section three meals preferences, survey results

Section 3- Meals preferences

11 Do you prefer to bring your own food to school?

	No	Yes	Total Responses
Freq	113	315	428
Share	26.4%	73.6%	

Share Chart	Q11	Q11	
Share Chart	No	Yes	
	0.264	0.736	428

12 In terms of food protection, is the type of food packaging important to you?

	No	Yes	Total Responses
Freq	112	316	428
Share	26.2%	73.8%	

Share Chart	Q12	Q12	
Share Chart	No	Yes	
	0.262	0.738	428

13 Would you prefer less packaging in fast food?

	No	Yes	Total Responses
Freq	91	337	428
Share	21.3%	78.7%	

Share Chart	Q13	Q13	
Share Chart	No	Yes	
	0.213	0.787	428

14 Do you have a reusable bottle for coffee or water?

	No	Yes	Total Responses
Freq	18	410	428
Share	4.2%	95.8%	

Share Chart	Q14	Q14	
Share Chart	No	Yes	
	0.042	0.958	428

15 Reusable containers are good for environment?.

	No	Yes	Total Responses
Freq	4	424	428
Share	0.9%	99.1%	

Share Chart	Q15	Q15	
Share Chart	No	Yes	
	0.009	0.991	428

16	Is it better to reuse rather than to recycle?			
		No	Yes	Total Responses
	Freq	32	396	428
	Share	7.5%	92.5%	

Share Chart	Q16	Q16	
Share Chart	No	Yes	
	0.075	0.925	428

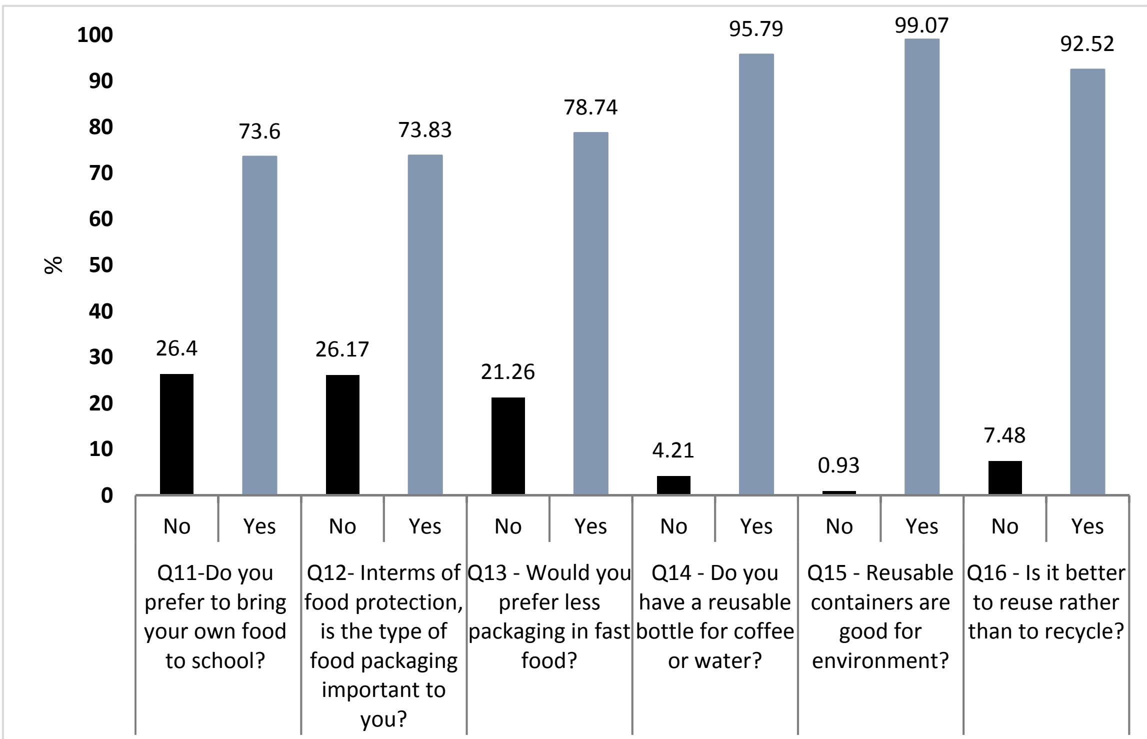

Figure 5.3.11 Column chart representing the percentage proportion of students' opinion about meal preferences

Table 5.3.5 Section 4 disposal methods of waste and recycling, survey results

Section 4- Disposal methods of waste and recycling

17 For Plastic Recycling, I follow the instructions "Please rinse off your container before putting it into the bin".

	Agree	Disagree	Strongly Agree	Strongly Disagree	Uncertain	Total Responses
Freq	165	110	70	19	64	428
Share	38.6%	25.7%	16.4%	4.4%	15.0%	

Share Chart	Q17	Q17	Q17	Q17	Q17	
Share Chart	Agree	Disagree	Strongly Agree	Strongly Disagree	Uncertain	
	0.386	0.257	0.164	0.044	0.15	428

18 I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel.

	Agree	Disagree	Strongly Agree	Strongly Disagree	Uncertain	Total Responses
Freq	180	80	102	21	45	428
Share	42.1%	18.7%	23.8%	4.9%	10.5%	

Share Chart	Q18	Q18	Q18	Q18	Q18	
Share Chart	Agree	Disagree	Strongly Agree	Strongly Disagree	Uncertain	
	0.421	0.187	0.238	0.049	0.105	428

19 I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).

	Agree	Disagree	Strongly Agree	Strongly Disagree	Uncertain	Total Responses
Freq	156	11	232	7	22	428
Share	36.4%	2.6%	54.2%	1.6%	5.1%	

Share Chart	Q19	Q19	Q19	Q19	Q19	
Share Chart	Agree	Disagree	Strongly Agree	Strongly Disagree	Uncertain	
	0.364	0.026	0.542	0.016	0.051	428

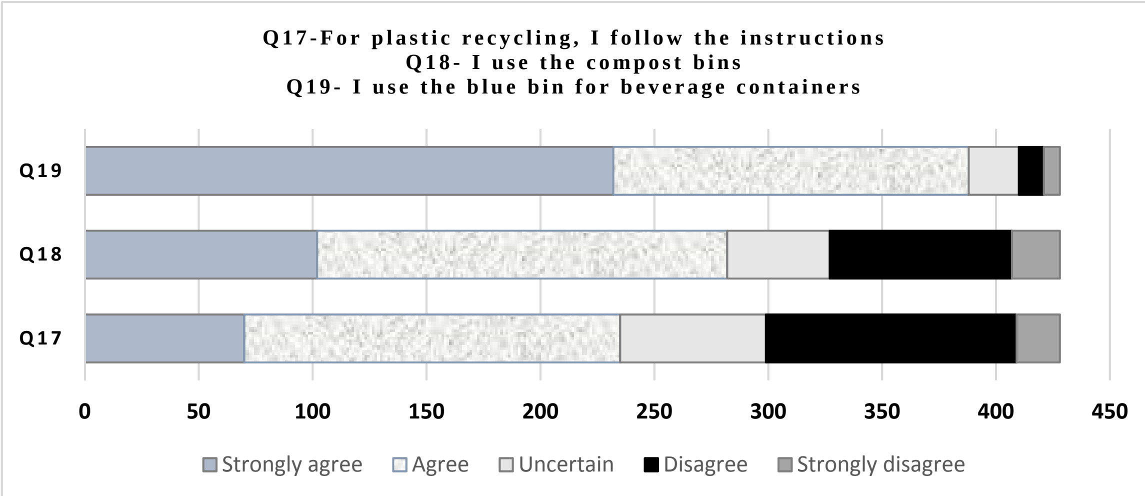

Figure 5.3.12 Stacked bar chart representing the percentage proportion of students' opinion about disposal method for beverage containers, composting and recycling at the University of Lethbridge

5.4 Statistic Analysis

5.4.1 Distributions

Description: In question two of the survey, "what is University of Lethbridge doing to become more sustainable?". I analyzed all options separately. I categorized the responses into "not chosen" and "chosen". Data is summarized as the sum of counts and the percentage for each response (Appendix H). Figure 5.3.13 below shows the distributions between not chosen and chosen for each variables.

Distribution (left=not chosen, right=chosen)

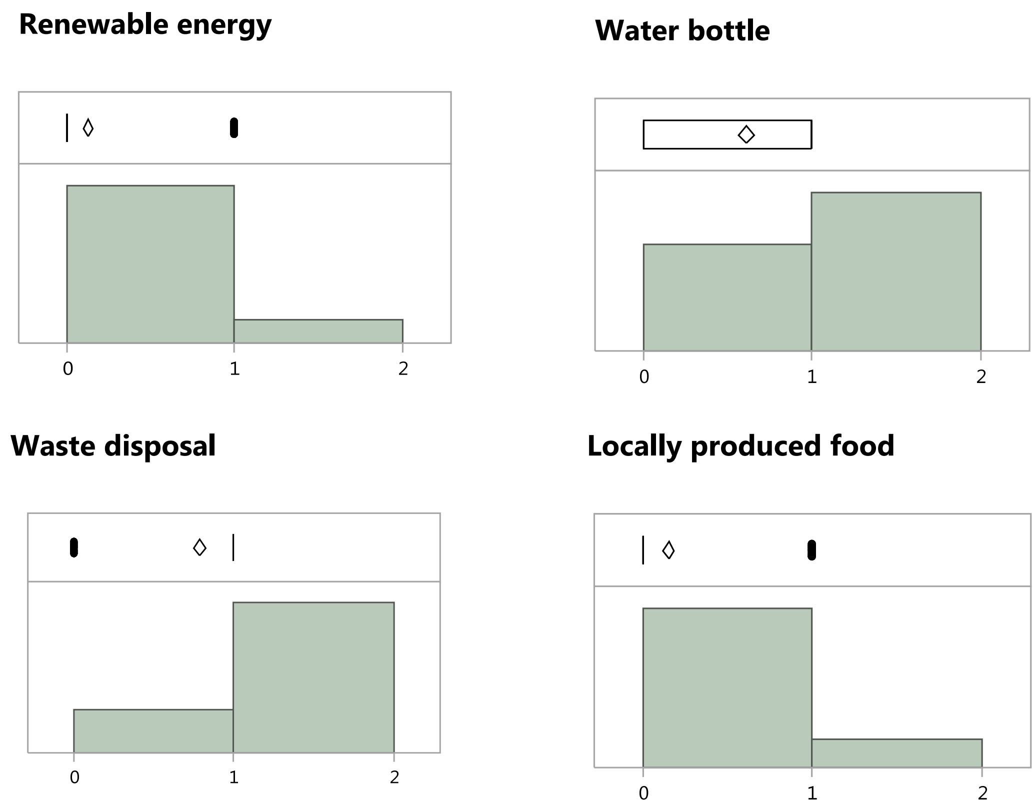

Figure 5.3.13 Histogram chart presenting the distributions of answers to question #2 of the packaging and environmental survey by JMP breakdown

The two graphs regarding water bottles and waste disposal show a majority of answers for the “chosen” option, contrary to the graphs of renewable energy and locally produced food that show a preference for the “not chosen” option. Unlike the other three graphs, the distribution in the water bottle graph is much closer in regards to the two options, with slightly more participants landing on the “chosen” side.

5.4.2 Cross tabulation description

Description: For section 3- Meals preference, as seen in questions 11 through 16 (answered with yes and no responses) are cross tabulated with questions 17, 18 and 19 in graphs found in appendices I, J, K, L, M, N

Cross tabulation #1: Question 11 (Do you prefer to bring your own food to school?) with questions 17, 18, and 19. Distribution graphs (Appendix I)

Table 5.3.7 Cross tabulation#1, question 11 of section 3 vs questions 17, 18 and 19 of section 4 of the survey, software JMP

	Frequencies	**No**		**Yes**	
	Level	**Count**	**Prob.**	**Count**	**Prob.**
Q17	For Plastic Recycling, I follow the instructions “Please rinse off your container before putting it into the bin”.				
	Agree	35	0.3097	130	0.4127
	Disagree	39	0.3451	71	0.2254
	Strongly agree	17	0.1504	53	0.1683
	Strongly disagree	4	0.0354	15	0.0476
	Uncertain	18	0.1593	46	0.1460
	Total	**113**	**1.0000**	**315**	**1.0000**
Q18	I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel				
	Agree	47	0.4159	133	0.4222
	Disagree	23	0.2035	57	0.1810
	Strongly Agree	21	0.1858	81	0.2571
	Strongly disagree	9	0.0797	12	0.0381
	Uncertain	13	0.1150	32	0.1016
	Total	**113**	**1.0000**	**315**	**1.0000**
Q19	I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).				
	Agree	36	0.3186	120	0.3810
	Disagree	2	0.0177	9	0.0286
	Strongly agree	69	0.6106	163	0.5175
	Strongly disagree	0	0	7	0.0222
	Uncertain	6	0.0531	16	0.0508
	Total	**113**	**1.0000**	**315**	**1.0000**

Students who bring their own food to school were more likely to a correctly recycle plastic materials than students who bought food at school. Both groups were even when it came to correctly composting food waste. Students who bought their food at the university were more likely to recycle beverage containers (Table 5.3.7).

Cross tabulation #2: Question 12 (“In terms of food protection, is the type of food packaging important for you?”) with questions 17, 18, and 19. Distribution graphs (Appendix J)

Table 5.3.8 Cross tabulation #2, question 12 of section 3 vs questions 17, 18 and 19 of section 4 of the survey, software JMP

	Frequencies	**No**		**Yes**	
	Level	**Count**	**Prob.**	**Count**	**Prob.**
Q17	For Plastic Recycling, I follow the instructions “Please rinse off your container before putting it into the bin”.				
	Agree	41	0.3661	124	0.3924
	Disagree	31	0.2768	79	0.2500
	Strongly agree	11	0.0982	59	0.1867
	Strongly disagree	7	0.0625	12	0.0380
	Uncertain	22	0.1964	42	0.1329
	Total	**112**	**1.0000**	**316**	**1.0000**
Q18	I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel				
	Agree	54	0.4821	126	0.3987
	Disagree	29	0.2589	51	0.1614
	Strongly Agree	10	0.0893	92	0.2911
	Strongly disagree	6	0.0536	15	0.0475
	Uncertain	13	0.1161	32	0.1013
	Total	**112**	**1.0000**	**316**	**1.0000**
Q19	I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).				
	Agree	39	0.3482	117	0.3703
	Disagree	3	0.0268	8	0.0253
	Strongly agree	62	0.5536	170	0.5380
	Strongly disagree	2	0.0179	5	0.0158
	Uncertain	6	0.0536	16	0.0506
	Total	**112**	**1.0000**	**316**	**1.0000**

Whether students agreed or disagreed in terms of the importance of food packaging for protection, their opinion on recycling of plastics was almost the same (39% for those who thought food packaging was important as opposed to 36% who thought food packaging was not important). This differed from their responses to compost where those who did not think food packaging was important (48%) were more inclined to use compost bins as opposed to those who saw food packaging as an important consideration (39%). Again, regardless of their thoughts on food packaging, both groups were very positive about beverage container recycling (Table 5.3.8).

Cross tabulation #3: Question 13 (Would you prefer less packaging in fast food?) with questions 17, 18, and 19. Distribution graphs (Appendix K)

Table 5.3.9 Cross tabulation#3, question 13 of section 3 vs questions 17, 18 and 19 of section 4 of the survey, software JMP

	Frequencies	No		Yes	
	Level	**Count**	**Prob.**	**Count**	**Prob.**
Q17	For Plastic Recycling, I follow the instructions "Please rinse off your container before putting it into the bin".				
	Agree	30	0.3297	135	0.4006
	Disagree	29	0.3187	81	0.2404
	Strongly agree	12	0.1319	58	0.1721
	Strongly disagree	4	0.0440	15	0.0445
	Uncertain	16	0.1758	48	0.1424
	Total	**91**	**1.0000**	**337**	**1.0000**
Q18	I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel				
	Agree	40	0.4396	140	0.4154
	Disagree	20	0.2198	60	0.1780
	Strongly Agree	17	0.1868	85	0.2522
	Strongly disagree	5	0.0550	16	0.0475
	Uncertain	9	0.0989	36	0.1068
	Total	**91**	**1.0000**	**337**	**1.0000**
Q19	I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).				
	Agree	30	0.3297	126	0.3739
	Disagree	3	0.0330	8	0.0237
	Strongly agree	49	0.5385	183	0.5430
	Strongly disagree	2	0.0220	5	0.0148
	Uncertain	7	0.0769	15	0.0445
	Total	**91**	**1.0000**	**337**	**1.0000**

In terms of plastic recycling, 32% of those respondents who answered no to less fast food packaging recycled plastic containers correctly. Those who answered yes to the same question made 40% of the positive respondents to this question. In terms of compost and beverage container recycling, the two groups were close, with 43% of those who said no and 41% of those who said yes agreeing to use compost bins regularly. Recycling beverage containers saw even higher numbers with 53% saying no and 54% saying yes to properly using the blue bins at the university (Table 5.3.9).

Cross tabulation #4: Question 14, (Do you have a reusable bottle for coffee or water?) with questions 17, 18, and 19. Distribution graphs (Appendix L)

Table 5.3.10 Cross tabulation #4, question 14 of section 3 vs questions 17, 18 and 19 of section 4 of the survey, JMP

	Frequencies	**No**		**Yes**	
	Level	**Count**	**Prob.**	**Count**	**Prob.**
Q17	For Plastic Recycling, I follow the instructions "Please rinse off your container before putting it into the bin".				
	Agree	4	0.2222	161	0.3927
	Disagree	4	0.2222	106	0.2585
	Strongly agree	2	0.1111	68	0.1659
	Strongly disagree	1	0.0556	18	0.0439
	Uncertain	7	0.3889	57	0.1390
	Total	**18**	**1.0000**	**410**	**1.0000**
Q18	I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel				
	Agree	8	0.4444	172	0.4195
	Disagree	4	0.2222	76	0.1854
	Strongly Agree	4	0.2222	98	0.2390
	Strongly disagree	0	0	21	0.0512
	Uncertain	2	0.1111	43	0.1049
	Total	**18**	**1.0000**	**410**	**1.0000**
Q19	I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).				
	Agree	7	0.3889	149	0.3634
	Disagree	0	0	11	0.0268
	Strongly agree	9	0.5000	223	0.5439
	Strongly disagree	0	0	7	0.0171
	Uncertain	2	0.1111	20	0.0488
	Total	**18**	**1.0000**	**410**	**1.0000**

Among students who used reusable bottles for coffee or water, 39% of students were more likely to agree and follow the instruction "Please rinse off your container before putting it into the bin". Those students who did not have reusable bottles were more likely to be uncertain about this, with 38% of the students choosing that option. In terms of compost, both groups of students responded quite positively (44% for the students with no reusable container; 41% of students with one). Over half the respondents on both sides of this question responded favorably with “strongly agree” to beverage container recycling (Table 5.3.10).

Cross tabulation #5: Question 15 (Reusable containers are good for environment?) with questions 17, 18, and 19. Distribution graphs (Appendix M)

Table 5.3.11 Cross tabulation #5, question 15 of section 3 vs questions 17, 18 and 19 of section 4 of the survey, JMP

	Frequencies	**No**		**Yes**	
	Level	**Count**	**Prob.**	**Count**	**Prob.**
Q17	For Plastic Recycling, I follow the instructions “Please rinse off your container before putting it into the bin”.				
	Agree	1	0.2500	164	0.3868
	Disagree	0	0	110	0.2594
	Strongly agree	2	0.5000	68	0.1604
	Strongly disagree	0	0	19	0.0448
	Uncertain	1	0.2500	63	0.1486
	Total	**4**	**1.0000**	**424**	**1.0000**
Q18	I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel				
	Agree	1	0.2500	179	0.4222
	Disagree	0	0	80	0.1887
	Strongly Agree	3	0.7500	99	0.2335
	Strongly disagree	0	0	21	0.0495
	Uncertain	0	0	45	0.1061
	Total	**4**	**1.0000**	**424**	**1.0000**
Q19	I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).				
	Agree	1	0.2500	155	0.3656
	Disagree	0	0	11	0.0259
	Strongly agree	2	0.5000	230	0.5425
	Strongly disagree	1	0.2500	6	0.0145
	Total	**4**	**1.0000**	**424**	**1.0000**

Within the group of students who agreed that reusable containers are good for the environment, 38% of them chose “agree” when following instructions for plastic recycling. Interestingly, 50% of those that disagreed with the concept of reusable containers “strongly agreed” with correctly recycling plastic materials. In terms of compost, 42% of those who deemed reusable containers good for the environment said they agreed with the use of compost bins. Those who disagreed with the environmental soundness of reusable containers overwhelmingly strongly agreed to the use of compost bins (75%). In terms of beverage containers, at least half of the students in both groups strongly agreed with recycling this material (Table 5.3.10).

Cross tabulation #6: Question 16 (Is it better to reuse rather than to recycle?) with questions 17, 18, and 19. Distribution graphs (Appendix N)

Table 5.3.12 Cross tabulation #6, question 16 of section 3 vs questions 17, 18 and 19 of section 4 of the survey, JMP

	Frequencies	**No**		**Yes**	
	Level	**Count**	**Prob.**	**Count**	**Prob.**
Q17	For Plastic Recycling, I follow the instructions “Please rinse off your container before putting it into the bin”.				
	Agree	11	0.3438	154	0.3889
	Disagree	3	0.0938	107	0.2702
	Strongly agree	5	0.1563	65	0.1641
	Strongly disagree	2	0.0625	17	0.0429
	Uncertain	11	0.3438	53	0.1338
	Total	**32**	**1.0000**	**396**	**1.0000**
Q18	I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel				
	Agree	14	0.4375	166	0.4192
	Disagree	6	0.1875	74	0.1869
	Strongly Agree	8	0.2500	94	0.2374
	Strongly disagree	2	0.0625	19	0.0480
	Uncertain	2	0.0625	43	0.1086
	Total	**32**	**1.0000**	**396**	**1.0000**
Q19	I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).				
	Agree	11	0.3438	145	0.3662
	Disagree	1	0.0313	10	0.0253
	Strongly agree	16	0.5000	216	0.5455
	Strongly disagree	1	0.0313	6	0.0156
	Uncertain	3	0.0938	19	0.0480
	Total	**32**	**1.0000**	**396**	**1.0000**

In terms of students who said that it is better to reuse than recycle, 39% of the students reported that they agreed with recycling plastic materials. Those that answered no to this question matched evenly with those who answered “agree” and “uncertain” (34.5 for each). In terms of compost, both group of students were fairly even in agreeing to this (43% for those who answered no to the first).

5.4.3 Two-way comparison

Description: For section 2 (packaging uses preferences), I executed a contingency table to summarize the relationship between students’ preferences of materials for cold and hot drinks (question 4 and question 5). Then I calculated the Chi square statistic value to determine if there is a significant relationship between the two questions, and p value to determine the strength of the association of the variables. I employed JMP software for the calculations. I combined styrofoam into “other” because of small styrofoam counts in the answers. The below Figure 5.3.14 shows questions four and five simultaneously.

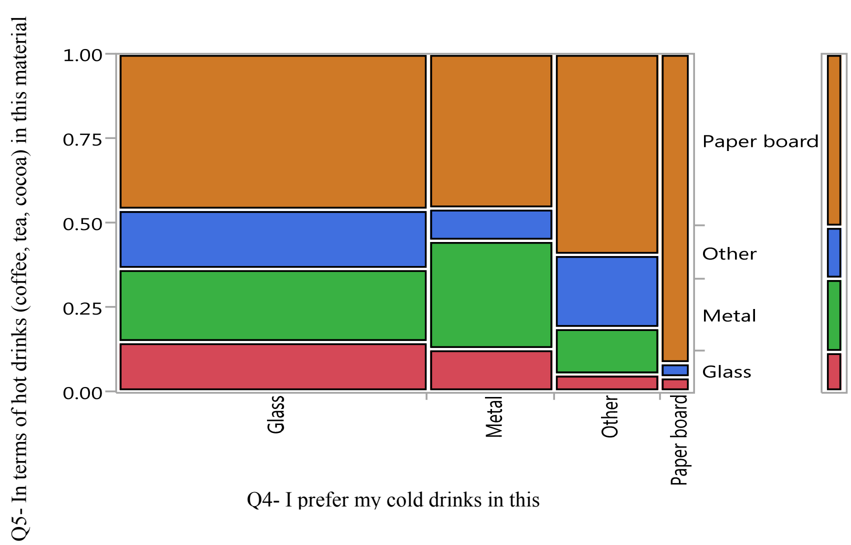

Figure 5.3.14 Mosaic plot chart showing a two-way comparison of students’ preferences of materials for hot and cold drinks

The above figure 5.3.14 shows a defined correlation between paperboard (orange) in the column with the materials in the glass, metal, other and paperboard rows.

Table 5.3.15 showing the percentage of total count for column and rows for Contingency analysis of question four and five - students' materials preferences for cold and hot drinks

Count Total % Col % Row %	Glass	Metal	Other	Paper board	
Glass	34	51	40	107	232
	7.94	11.92	9.35	25.00	54.21
	66.67	55.43	59.70	49.08	
	14.66	21.98	17.24	46.12	
Metal	12	30	9	43	94
	2.80	7.01	2.10	10.05	21.96
	23.53	32.61	13.43	19.72	
	12.77	31.91	9.57	45.74	
Other	4	11	17	47	79
	0.93	2.57	3.97	10.98	18.46
	7.84	11.96	25.37	21.56	
	5.06	13.92	21.52	59.49	
Paper board	1	0	1	21	23
	0.23	0.00	0.23	4.91	5.37
	1.96	0.00	1.49	9.63	
	4.35	0.00	4.35	91.30	
	51	92	67	218	428
	11.92	21.50	15.65	50.93	

The above Table 5.3.15 shows the relationship between materials from row and columns. The relationship of the column paperboard with the materials in the rows showed the highest values, which mean there exists an association between the two questions with respect to paperboard.

Table 5.3.16 Tests Chi square and Prob>Chi2

	N	DF	-Log Like	RSquare (U)
	428	9	19.534432	0.0375
Test			Chi square	Prob>Chi^2
Likelihood Ratio			39.069	<0.0001*
Pearson			33.816	<0.0001*

Table above 5.3.16 shows a large Chi^2 value, which means that there is a definite correlation between the two materials for question four and five. Students preferred paperboard material for both cold and hot drinks.

5.5 Discussion and Conclusions

The survey is a mechanism that allows for the collection of positive and current feedback on students' choices. Environmental attitude, awareness and knowledge are factors that affect recycling behavior. The role of attitudes and knowledge in this process makes survey data valuable in applying findings that are more technical in the required changes of the system. To raise awareness of sustainability on campus, education related to recycling activities can be given to new and international students, this is a convenient way to maintain the balance and normal functioning of the system. Lack of specific and clear information about where and how to recycle are obstacles to good recycling practices. A good way to communicate information to students is through campaigns. An example could be to conduct sustainability campaigns inviting the campus population to use more reusable containers and filtered water fountains rather than to buy bottles of water. In addition, to promote the use of reusable containers, participants could be asked to bring their own reusable containers for coffee or water instead of provide participants with cardboard cups or bottles of water when attending conferences at campus. Surveys can provide valid information on problems that require a quick solution. Efforts that focus on waste management alone is not a sustainable solution. There must be changes made to people's actions in order to obtain positive benefits. A total of 428 participants completed the survey. Two of the participants chose not to answer the questions – their responses were not included in the total count. There was a great amount of interest in this topic, which aided in my receiving so many completed surveys in the short time that I had it posted. This reflects that many students are committed to preserving the concept of sustainability on campus. Involving students in sustainable research could enhance their commitment with greener campus.

Questions Section 1

1. How often are you at the U of L?

Overall, 60.6% of the students reported that they come to campus every day. In survey 1, this comprised the largest percentage of respondents (64.9%) while in survey 2, the majority of students who responded (46.9%) only came to school three to four days per week. This makes sense since survey 1 took place during the spring semester and survey 2 occurred in the first summer session when not as many classes are in session.

2. What is University of Lethbridge doing to become more sustainable?

Responses to this question overwhelmingly favoured waste disposal (47.4%) and water bottle re-use (36.4%) over the other choices of locally produced food (8.91%) and renewable energy (7.4%). This means that local food and renewable energy are not well developed at school as option to become more sustainable.

3. What meals do you eat at the University of Lethbridge?

In terms of meals, lunch was the most prevalent choice among students at 34.8%. This proportion was much larger than breakfast and dinner, at 12% and 15.3% respectively. However, lunch was chosen as the main meal less often than snacks, which 37.8% of students chose as a response. A number of respondents chose multiple answers for this question.

Questions Section 2

4. I prefer my cold drinks in this material.

Respondents overwhelmingly chose glass as their preference (54.2%). This was more than double the next most popular answer of metal (22.0%). The remainder of the responses for this question were other at 15.9%, paperboard at 5.4% and styrofoam at 2.6%.

5. In terms of hot drinks (coffee, tea, cocoa) in this material.

Paperboard was by far the most popular choice for hot drinks with 50.9% of respondents choosing this material. This was followed by metal (21.5%), glass (11.9%) and other (8.2%). The least popular choice was styrofoam at 7.5%.

6. Which material is easier to clean?

Glass again topped the list, with 77.1% of respondents saying that this material was the easiest to clean. The second most popular choice was metal at 18.2% and the remaining materials (paperboard, styrofoam and other) only made up 4.7% of responses (2.8%, 1.2% and 0.7% respectively).

7. Do you have any of these products with you now?

Overall, most respondents did not carry any of the products mentioned in the questions (28.1%). However, in terms of the most popular answer, survey 1 agreed with the overall response (28.9%) while in survey 2, more respondents stated they had glass containers with them (28.1%). Combining the data from both surveys show that 22.3% of students chose other, 21.6% picked metal, 18.8% carried glass with them and 8.7% said they had paperboard. Only 0.6% admitted to having styrofoam.

8. Which material provides the best taste for your drink?

Glass was the most popular choice for this question, receiving 63.9% of the responses. Metal was chosen by 15.1% of the respondents and that was followed by paperboard at 9.9%, and other at 8.3%. Once again, styrofoam was lowest, with only 2.3% of respondents choosing this option.

9. Which material is friendlier to the environment?

This response saw much closer proportions for glass and paperboard, the former edging out the latter with 37.6% of the responses choosing glass as opposed to 35.9% feeling that paperboard was the environmentally friendlier choice. The other responses were metal at 20.3%, other at 7.0% and, once again, finishing last, styrofoam with 2.4%.

10. Which do you think will break down first?

Paperboard was the overwhelmingly most common choice for this question, topping the list at 76%. The statistics show a tie between those respondents who chose styrofoam and those who did not know (both at 8.1%). Rounding out the responses were glass at 4.9%, other at 2.2% and finally, metal at 0.7%.

Questions Section 3

11. Do you prefer to bring your own food to school?

A large majority of 73.6% of respondents prefer to bring their own food to school, leaving 26.4% who would rather purchase their food at the university.

12. In terms of food protection, is the type of the food packaging important to you?

The vast majority of survey takers (73.8%) responded that food packaging was an important consideration. The remaining respondents said that packaging type was not an issue (26.2%).

13. Would you prefer less packaging in fast food?

A total of 78.7% of respondents would prefer less packaging in fast food. The other 21.3% have no preference in terms of fast food packaging.

14. Do you have a reusable bottle for coffee or water?

An overwhelming 95.8% of the respondents carry reusable bottles for coffee or water. A mere 4.2% do not own or carry reusable bottles.

15. Reusable containers are good for environment?

Not surprisingly, 99.1% of survey takers responded positively to this question. Only 0.9% said that this was a negative concept.

16. Is it better to reuse rather than to recycle?

Respondents were overwhelmingly positive (92.5%) in terms of reuse over recycling. A much smaller percentage favored recycling over reuse (7.5%).

Questions Section 4

17. For Plastic Recycling, I follow the instructions "Please rinse off your container before putting it into the bin".

The response with the highest score was agree, with 38.6%, then in second place was disagree with 25.7%, which means that students do not follow the correct instructions when they recycle plastic. In third place respondents who answered uncertain with 14.95% and last, strongly agree and strongly disagree with 16.4% and 4.4% respectively.

18. I use the compost bins when I have tea bags, fruits, vegetables, coffee grounds, tissue paper, and paper towel.

The majority answered agree and strongly agree, with 42.1% and 23.8% respectively, disagree with 18.7%, uncertain 10.5% and, strongly disagree 4.9%. This means that more than half of the respondents do the correct recycle when it refers to compost.

19. I use blue bin for beverage containers (plastic, aluminium or glass beverage)

The most frequent answer was strongly agree, 54.2%, followed by agree with 36.4%, then, uncertain, disagree and strongly disagree, 5.1%, 2.6%, 1.6%, respectively. This means that positive answers for using the blue bins are of 90.6% for the correct containers and only 9.3% are uncertain or they do not use the correct bins.

5.6 Recommendations

Periodic surveys would be a good way of assessing the knowledge of not only students, but also instructors and staff in terms of sustainability. The role of attitudes and knowledge in this process makes survey data valuable in applying findings that are more technical. Campaigns could be conducted inviting the campus population to use refillable bottles and filtered water fountains rather than buying bottled water. By examining how the use of motivational measures (saving emissions), incentives (discounts for bringing individual cups and bottles in for beverages) and regulatory mechanisms (sustainability policy employed on campus) impact community behavior, the university can be even more proactive in terms of minimizing waste. Involving students in research and providing sustainability education to those entering as freshmen could be a means of raising awareness of sustainability on campus.

Chapter 6 - Interview with the City of Lethbridge specialist

6.1 Introduction

The management of solid waste in the City of Lethbridge has evolved from dump direct disposal to complex waste separation systems. The landfill master plan is seeking to incorporate new technologies that are financially and environmentally sustainable for the City of Lethbridge. This chapter examines the general information of the City of Lethbridge waste management plan, the potential contamination and preventive actions to reduce negative environmental impact. It also discusses the contribution of food packaging into the global amount of municipal landfill solid waste.

6.2 Method

An interview was conducted with Engineer Alex Singbeil, a specialist from the Waste and Recycling Center of the City of Lethbridge, on April 17, 2018. His participation was voluntary. The City of Lethbridge is identified in the report of results as indicated in the letter of consent form (Appendix Q). The time estimated for completion of the one-on-one interview was about 20 minutes.

6.2.1 Ethics approval

The interview form application for ethical approval was reviewed and approved by the University of Lethbridge Human Subject Research Committee (HSRC) under the ethical principles and standards of the university (protocol #2018-029) (Appendix F).

6.2.2 Material

The participant answered 22 open questions that were organized into three parts. The first part was general information about the evolution of the waste management system, followed by a section on questions related to landfill, compost and recycling. The last section of the interview was about the contribution of food packaging into the global amount of landfill solid waste in the City of Lethbridge. The interview format can be seen in (Appendix P)

6.3 Results

General information

1. Could you summarize the changes in the waste management evolution in the last 10 years?

> There have been very minor changes in the city of Lethbridge in terms of the way materials are collected. While this used to be a manual operation, now waste pick up is automatic, using bins and trucks equipped to pick up and empty them. There used to be seven recycling depots located on private property. Now, there are three new ones located on city property, improved with fencing for litter and wind.

2. Does waste now have more problematic components than in the past?

> There are more challenges because of the abundance of plastic, thin films and laminates used in plastic packaging (ex. nuts and raisin packaging). While the lighter weight is an advantage in terms of production, end-of-life recycling is much more problematic.

3. The volume of waste received in 2008 was 144,489 tonns and in 2009, 136,053. It has been reduced by 5.8%. How was it reduced?

Numbers can include more than food packaging. The industrial area may have contributed to these numbers. A look at tonnage from different depots could clarify how much food packaging had to do in regards to the decrease.

4. What happened in that period of time that stopped increasing the volume of waste?

Over this period of time, changes in the recycling habits of people helped spur the decrease in the volume of waste (e.g. recycling of newspapers and bottles). Changes in packaging manufacturing and a reduction in the weight of packaging material also contributed to this. The inception of the use of blue recycling bins is also a factor.

5. What have been the biggest challenges for the center in terms of reducing pollution through waste management?

Containment of liquid waste can prove to be a challenge as in order to prevent leakage at the landfill, it must be pumped out and sent to the waste treatment plant. In terms of solid pollution, the wind in this area is a big problem. To avoid wind-blown litter, fifty-foot fences have been erected for containment. Additional fencing has also been set up in working areas.

6. In terms of waste origin. You calculate waste from residential and commercial sectors. Are you calculating, how much waste comes from the University of Lethbridge.? Do you know what categories could be higher or lower than in the city or region?

No information was provided.

7. How do you calculate the expected requirements for waste treatment, or the consequences of certain pollutants?

Pollutants normally comes from the product not the packaging. Contents left over in the package produce gas emissions and leach acids into the landfill. Metal packaging can affect this leaching to a certain extent.

Landfill

8. What are the characteristics of Class II Landfill?

A Class I Landfill class accepts hazardous waste such as chemical waste; Class II Landfill deals only with non-hazardous waste – this is the kind of Landfill that Lethbridge has.

9. What are the characteristics for Class III Landfill?

A Class III Landfill accepts inert waste like construction and demolition materials.

Compost and recycling

10. Compost collection started in 2009 and generated 756 tonns. What was the composition of the compost at that time?

According to the Provincial Regulation Policy, all compost should be yard waste. This started with fall leave collection, wood, and gardening waste. Class II Composting only accepts yard waste materials.

11. Has it changed over time?

Because of the new depots, there may be changes. However, because Lethbridge has a Class II facility, only manure or vegetative matter can be accepted. This includes leaf and yard waste, brush, and wood waste. There may be variations in volume and water content, and a decrease in grass during dry years.

12. Since 2017, the University of Lethbridge has been recycling styrofoam. Is styrofoam still relegated to the landfill or are you recycling it?

We have no program for recycling styrofoam.

13. Are there any special needs or plans that should be considered?

As of right now, there is no existing plans. We are interested in learning how the University of Lethbridge is managing its styrofoam recycling. In Coaldale, a manufacturer is using recycled Styrofoam of a specific type to make foam insutation for heated floor. “Styrogo” is connected to this company in Coaldale, and provides extremely clean foam – this, unfortunately, precludes the use of food containers. The weight is significant but volume is large. Styrofoam is problematic in the landfills because the wind blows it around.

14. After recycling and compost stations were set up in the center, what was the reduction of waste that went to landfill?

No information was provided.

15. Advantages of new lessons learned.

A lot has been invested in preventing the spread of litter at landfills and recycling centers. More effort should be made to keep recycling bin doors shut and to close the landfill when the wind is over a certain speed (winds exceeding 50k/h restrict operations). Because the material is not bagged, there is potential for the recycling to blow all over the place. One idea is to receive the materials indoors and pack it into bales. Every day, the center has to be monitored for wind speed and weather conditions that could impact the recycling landfill.

Packaging

16. What is the contribution from the commercial sector in terms of packaging waste?

The center does not have much information on this. The city runs an event on Canada Day concerned with composting and all plastics. Participants can win a Green Vendor Award for using environmentally friendly packaging and compostable food ware. A contest with a financial incentive for food vendors is scheduled for next year's event.

17. Are there any data available for Lethbridge?

No information was provided.

18. Are manufacturers and producers interested in reducing packaging waste?

Yes, they are very interested in reducing packaging to minimize costs. However, because companies use packaging for advertising and marketing purposes, it cannot be eliminated completely.

19. Has the quantity of the packaging waste been calculated over time? Y/N

No, we do not track that information. Companies like Frito may have that information.

20. How long can packaging last in landfills?

That varies based on packaging type. The landfills are designed to contain the waste for an indeterminate length of time.

21. What part of waste does packaging represent?

Different studies can be looked at for waste audits. There has been a significant reduction in volume as packaging has become lighter and stronger.

6.4. Discussion and conclusion

The interview on April 17/18 with Engineer Alex Singbeil at the City of Lethbridge Waste & Recycling office was satisfactory. The engineer answered most of the questions except for a few for which he did not have the available information. The city of Lethbridge has evolved in its waste collection system by decreasing the volume of garbage that goes to the dump and recycling more. This has decreased the amount of packaging, particularly plastic, that used to indiscriminately end up at the dump. New packaging is more difficult to break down due to the complexity of its structure – it is lighter, but more resistant. One of the unique characteristics of the Lethbridge recycling centers is that they permanently monitor the level of the wind due to its frequency and strength. Actions have been taken prevent these strong winds from blowing the trash from the dump. The garbage handled by the center is materials that are accepted in a Type II dump. In terms of compost, there have been no changes due to the fact that only vegetable-type garden garbage is received. With regard to packaging, the interviewee considers glass to be the best because it does not generate emissions and does not cause harm to the environment. The interview provided updated information about the waste system. Sharing information is important for the University and for the City of Lethbridge as both can benefit from the experiences and knowledge of the waste systems. The City of Lethbridge has valuable data collection that could contribute to the university, in terms of evaluating the global level of emissions and be able to do comparisons of environmental impacts, and actions concerning to a continuous improvement to the system.

6.5 Recommendations

a) Cooperation - The communication between the City of Lethbridge and the University has been very effective in sharing information related to waste management. It would be more productive for both parties to continue communicating and share updated information. During the interview reported in this thesis, the possibility of accessing the database for the City of Lethbridge was investigated, because access to data is fundamental to the analysis and successful operation of the waste management system, and to monitoring and correcting aspects that may contribute to the deterioration of the environment. Being able to access the data from the City of Lethbridge would be very valuable for the university in terms of evaluating the global level of emissions and comparing them with the individual contribution of the campus. I recommend that expansion of this cooperation and information sharing be a priority. Also, the interviewee made the statement that glass is the least detrimental material in regards to leaving a carbon footprint and interestingly enough, the students also chose this material as the most preferable and easiest to clean and recycle. Perhaps the University can be made aware of this fact and that may alter their purchasing decisions in the future.

b) Data collection and monitoring - Detail data on the types and quantities of food waste are required for informed management. I recommend that the current effort devoted to keeping track of these data be maintained, and expanded to include fate of material, choices of campus consumers, and costs of the program, with respect to equivalent emissions saved. The EPA model could help to put the data in context, and I recommend that is be included in future research and accounting by students, staff, or faculty.

Chapter 7 - Conclusions

7.1 Summary

The purpose for food packaging lies in preserving the shelf life of products. However, in early studies and applications, the life cycle of the packaging itself was not taken into account. While there were concerns regarding the principal functions of packaging, no consideration was made for its final stage, its disposal or the fact that it could be detrimental to the environment. For this reason, there is a great debate regarding the use of packaging today. It is a double-edged sword, because on the one hand, packaging prolongs and protects the product, but on the other hand, it takes a long time to break down in the landfills. For that reason and at the demand of stakeholders, the technology employed in new packaging designs serves to improve functionality and resistance, replacing conventional materials with biodegradable ones. These new forms of packaging are intended to have greater sustainability and maintain ecological balance. Nevertheless, sustainability depends on several factors, and educational institutions are considered to be of great influence, not only in the community but also in regards to their population.

My interest in this thesis project was to analyze aspects and factors that influence the handling of food packaging waste, and the implication this has on the environment. I have applied several methods to achieve the objectives proposed for the study.

The first method of this study (EM) identified the activities and operations of the system. The method evaluated the environmental aspects involved and determined environmental aspects of the waste system that are beneficial and those that are tagged for monitoring, as they are detrimental to the environment, the frequency they occur and the signicance of each environmental impact. This facilitated an overall assessment of the current situation. Aspects evaluated as beneficial include recycling and storage of waste. The results of the recycling activity show significant positive results for the environment and therefore, should be monitored to maintain its efficiency, as this will reduce local waste and costs, and contribute to meeting challenges of global problems (such as energy use, greenhouse gas production, and the potential for pollution from discarded, unrecycled packaging- Figure 3.3.3). Examples of negative aspects include transportation of waste and the landfill. Transporting waste has generated considerable emissions and consequently, has affected several environmental aspects (air pollution, global warming, human health, renewable natural sources, and degradation of natural landscape- Figure 3.3.2). The university waste management facilities seeks continuous improvement in promoting the conservation of natural resources while reducing the cost of operations.

A second method (WARM) used the information resulting from the first method (EM), like the identification of activities, operations of the waste system to determine where the main points of emissions generation were. The method provided accurate measurements of the expected GHG emissions. I explored and used the data collected over time by the University of Lethbridge Manager of Facilities - Caretaking, Judy Jaeger, to calculate the emissions generated by food packaging at the University of Lethbridge. The data afforded me valuable information regarding each of the study's scopes and how the generation of emissions has changed over time. The results of the model showed that the emissions generated by the university population in 2017 amounted to 1170 kg of garbage per day. I calculated the emissions per capita to be 0.118

kg per capita of waste generated per day at the University of Lethbridge. From 2007 to 2017, emissions have risen by 30%. By implementing a controlled waste management system where activities are measured and analyzed, and by communicating this along with information about waste management results and achievements, the university could play a large role in engaging the community with sustainable projects and achieving a greener goal. WARM can be used in any waste management system as a decision support tool to lower GHG emissions.

The last method, I designed and conducted two surveys of students from the psychology department through the SONA system. The purpose of these two surveys was to gain current feedback on the role of students, and to assess the participants' level of perception regarding their knowledge of sustainability and the implications of food packaging on the environment. The two surveys garnered results from a total of 428 students, 60.6% of whom came to campus on a daily basis and 37.7% who purchased and consumed snack foods at the university. A majority of the respondents believe that the university's efforts to improve sustainability centers around the waste disposal system. Glass was the overwhelming choice for beverages as the material is easier to wash, provides the best flavor, and is considered to be better for the environment. The statistical analysis showed a great variety of responses in the variable of water bottle re-use compared with the variables of renewable energy, locally produced food, and disposal of waste, where the students' answers were more likely to reflect a single (unified) response. When analyzing the correlation between questions regarding the disposal of waste, I discovered that students who bring meals from home are more likely to recycle than those who buy their food at the university. This dual comparison showed a significant relationship between students' preference for receiving both hot and cold beverages in cardboard material.

Finally, I interviewed a specialist from the city of Lethbridge who gave me very valuable information regarding the management of the city's waste system, the challenges they have faced, and the impact of food packaging on a global platform. Frequent surveys and interviews must be conducted at the University of Lethbridge, as they are a valuable tools in regards to gauging the population's knowledge of the topic, and assessing their preferences.

This research will hopefully provide alternative tools (such as EM, WARM model, surveys posted on the SONA system, and interviews), for evaluating and comparing the environmental (aspects, impacts, emissions, factors), and social variables (opinion, behaviors, preferences) that allow for policy decisions that will benefit the system by increasing environmental sustainability.

There were many lessons learned from this study, perhaps the most important of which is the fact that knowledge and learning must go hand in hand, in order for the consumers to make the best choices regarding food waste and environment. The results indicate that education and access to information on the life cycle of waste, and consumer choices available, will lead to greater sustainability. As the situation of the planet continues to evolve, we too must learn to lessen our impact on the environment and contribute towards sustainability so that we can enjoy this lovely planet.

7.2 Recommendations

The results obtained in the first method of this study (EM with respect to the identification of activities and significant aspects of the waste system at the University of Lethbridge) served as a reference for the second method (WARM, which revealed more exact data as to the effect of food packaging with respect to the environment). The results indicate a trend pointing to an increase in the generation of emissions. It is true that measures have been implemented to curb pollution and harmful emissions, but it is not enough to control and minimize environmental deterioration. An annual 3% increase in emissions is a consequence of the results found in the student surveys, which indicate a lack of clarity in regards to the waste system. It is also evident in the large amount of garbage that is generated in the food areas could be better separated to lower the amount that ends up in the landfill. The results of the interview with the specialist reveal that the policies of a waste system must be based on legal regulations, and should adopt practices that have been successful in other systems. Taking all this information into account, two recommendations can be made and are detailed below.

1. The university needs to consider implementing a waste system with a feasible sustainable goal as a means to reduce the rising trend of emissions increase generated due to food packaging that currently exists at the University of Lethbridge over the last 10 years.
2. Packaging material needs to be controlled. More effort should be put into separating packaging materials from waste that is destined for the landfill. The university should invest in a bioreactor that would be situated on campus – this system can compost many materials. This would greatly reduce the negative emissions produced through

transportation of waste to the landfill. They should also increase their budget in regards to recycling.

Students should be encouraged to actively participate in sustainable programs, and given more options to purchase meals and drinks with packaging that is favored by students and cause the least damage to the environment.

7.3 Study limitations

The two surveys initiated during the spring and first summer semesters were offered on the SONA system. This limited the number of respondents, as the participants could only be recruited from the pool of students involved in psychology classes. While both surveys had similar responses, weather conditions and the number of available students changed due to the time of year. This caused some variability in regards to responses to certain questions.

I was initially going to use the Integrated Waste Management model (IWM) developed by Canadian Environment, Corporations Supporting Recycling (Environment Canada & CSR, 2000) and Plastics Industry Council (EPIC), (EPIC, 2000). IWM measures gas emission and was structured according to Canadian standards but unfortunately is no longer supported. For this reason, I chose to adopt a model designed by Environment US. This meets the objective of calculating emissions, but one must take into account that it is based around American parameters.

7.4 Future research

Sustainability at the University of Lethbridge is a wide topic that requires much further study. Future studies can be based on sustainability goals where all waste management system can be monitored and assessed. A continuous improvement of the system needs to be explored. New sustainable projects can be initiated centered on innovative methods to reduce waste, improve recycling, and put greater focus on composting. These studies can research the economical advantages for the university based on improving the recycling system.

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Appendix A - GHG Emissions Analysis –Summary Report Mixed MSW

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha A**
Project Period for this Analysis: **Jan 2001** to **Dic 2001**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	212.31	0.00	N/A	N/A	73.46
						73.46

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2002** to **Dic 2002**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	187.43	0.00	N/A	N/A	64.85
						64.85

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2003** to **Dic 2003**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	164.17	0.00	N/A	N/A	56.80
						56.80

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2004** to **Dic 2004**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	168.15	0.00	N/A	N/A	58.18
						58.18

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2005** to **Dic 2005**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	178.02	0.00	N/A	N/A	61.59
						61.59

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2006** to **Dic 2006**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	179.90	0.00	N/A	N/A	62.24
						62.24

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2007** to **Dic 2007**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	181.95	0.00	N/A	N/A	62.95
						62.95

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2008** to **Dic 2008**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	218.75	0.00	N/A	N/A	75.69
						75.69

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2009** to **Dic 2009**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	220.79	0.00	N/A	N/A	76.39
						76.39

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2010** to **Dic 2010**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	214.14	0.00	N/A	N/A	74.09
						74.09

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2011** to **Dic 2011**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	234.88	0.00	N/A	N/A	81.27
						81.27

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2012** to **Dic 2012**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	230.48	0.00	N/A	N/A	79.74
						79.74

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2013** to **Dic 2013**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	223.42	0.00	N/A	N/A	77.30
						77.30

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2014** to **Dic 2014**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	265.67	0.00	N/A	N/A	91.92
						91.92

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2015** to **Dic 2015**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	257.52	0.00	N/A	N/A	89.10
						89.10

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2016** to **Dic 2016**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Mixed MSW	N/A	257.59	0.00	N/A	N/A	89.12
						89.12

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2017** to **Dic 2017**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
Mixed MSW	N/A	270.70	0.00	N/A	N/A	93.66
						93.66

Appendix B - GHG Emissions Bottle recycled material

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2006** to **Dec 2006**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
PET	0.18	0.00	0.00	N/A	N/A	-0.20
						-0.20

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2007** to **Dic 2007**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
PET	0.22	0.00	0.00	N/A	N/A	-0.25
						-0.25

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2008** to **Dec 2008**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
PET	0.19	0.00	0.00	N/A	N/A	-0.21
						-0.21

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2009** to **Dec 2009**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
PET	0.18	0.00	0.00	N/A	N/A	-0.20
						-0.20

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2010** to **Dec 2010**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.16	0.00	0.00	N/A	N/A	-0.18
						-0.18

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2011** to **Dec 2011**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.14	0.00	0.00	N/A	N/A	-0.16
						-0.16

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2012** to **Dec 2012**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.12	0.00	0.00	N/A	N/A	-0.13
						-0.13

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2013** to **Jan 2013**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.18	0.00	0.00	N/A	N/A	-0.20
						-0.20

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2014** to **Dec 2014**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.18	0.00	0.00	N/A	N/A	-0.20
						-0.20

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2015** to **Dec 2015**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.06	0.00	0.00	N/A	N/A	-0.07
						-0.07

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2016** to **Dec 2016**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	0.05	0.00	0.00	N/A	N/A	-0.06
						-0.06

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2017** to **Dec 2017**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	1.05	0.00	0.00	N/A	N/A	-1.17
						-1.17

Appendix B1 – Source reduced GHG Emissions bottle recycled material

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **2006** to **2016**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	1.66	0.00	0.00	N/A	N/A	-1.86
						-1.86

Alternative Scenario							
Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
1.66	0.00	0.00	0.00	N/A	N/A	-3.65	-1.80
						-3.65	

Total Change in GHG Emissions (MTCO2E): **-1.80**

This is equivalent to...
Conserving **202** Gallons of Gasoline
Conserving **74** Cylinders of Propane Used for Home Barbeques

Appendix C- GHG Emissions Metal can recycled material

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2011** to **Dec 2011**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.20	0.00	0.00	N/A	N/A	-1.82
						-1.82

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2012** to **Dec 2012**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.18	0.00	0.00	N/A	N/A	-1.64
						-1.64

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2013** to **Dec 2013**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.17	0.00	0.00	N/A	N/A	-1.55
						-1.55

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2014** to **Dec 2014**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.13	0.00	0.00	N/A	N/A	-1.18
						-1.18

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2015** to **Dec 2015**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.23	0.00	0.00	N/A	N/A	-2.10
						-2.10

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2016** to **Dec 2016**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.23	0.00	0.00	N/A	N/A	-2.10
						-2.10

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2017** to **Dec 2017**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	0.23	0.00	0.00	N/A	N/A	-2.10
						-2.10

Appendix C1 – Source Reduced GHG Emissions Bottle recycled material

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **2011** to **2017**

Material	Baseline Scenario: Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
Aluminum Cans	1.37	0.00	0.00	N/A	N/A	-12.48
						-12.48

Alternative Scenario: Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
1.37	0.00	0.00	0.00	N/A	N/A	-6.73	5.75
						-6.73	

Total Change in GHG Emissions (MTCO2E): **5.75**

This is equivalent to...
Adding annual emmissions from **1** Passenger Vehicles
Consuming **647** Gallons of Gasoline
Consuming **239** Cylinders of Propane Used for Home Barbeques

Appendix D- GHG Emissions/ Plastic in general recycled material

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2012** to **Dec 2012**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
PET	0.07	0.00	0.00	N/A	N/A	-0.08
						-0.08

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2013** to **Dec 2013**

	Baseline Scenario					
Material	**Tons Recycled**	**Tons Landfilled**	**Tons Combusted**	**Tons Composted**	**Tons Anaerobically Digested**	**Total MTCO2E**
PET	0.11	0.00	0.00	N/A	N/A	-0.12
						-0.12

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2015** to **Dec 2015**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	2.30	0.00	0.00	N/A	N/A	-2.57
						-2.57

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2016** to **Dec 2016**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	4.88	0.00	0.00	N/A	N/A	-5.46
						-5.46

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan 2017** to **Dec 2017**

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	5.57	0.00	0.00	N/A	N/A	-6.23
						-6.23

Appendix D1- Source reduced, GHG Emissions/ Plastic in general recycled material

Material	Baseline Scenario					
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E
PET	12.93	0.00	0.00	N/A	N/A	-14.45
						-14.45

Alternative Scenario							
Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
12.93	0.00	0.00	0.00	N/A	N/A	-28.46	-14.01
						-28.46	

Total Change in GHG Emissions (MTCO2E): **-14.01**

This is equivalent to...
Removing annual emissions from **2** Passenger Vehicles
Conserving **1576** Gallons of Gasoline
Conserving **583** Cylinders of Propane Used for Home Barbeques

Appendix E - Letter of Consent (Survey)

Study Title: Environmental Impact and Management of Food Packaging at the University of Lethbridge, with respect to Sustainability, and Students choices

July 11, 2008

Information Sheet (first page of the online survey)

Introduction for respondents:

You are being invited to participate in a research project lead by Martha Astorquiza, a graduate student at the University of Lethbridge, AB.

Food packaging has generated a big impact on the environment and Greenhouse gas (GHG) emissions. The purpose of this survey is to gather information about students' preferences about use of packaging, and how their attitude impacts the environment. The questions will ask you about packaging uses and preferences, disposal methods of waste and recycling.

Your participation in this research is completely voluntary. You will not benefit directly from this research, nor are there any anticipated risks or discomforts. The survey should take 5-10 min and you will receive a 1% bonus mark for your participation. No personal identifying information will be collected. Individual responses will not be identified and your responses will remain anonymous. Although every effort will be taken to ensure your anonymity and the confidentiality of your data, these things cannot be 100% guaranteed in the case of an online survey. The privacy policy for the SONA system can be found at http://www.sona-systems.com/privacy.aspx. You can withdraw from the survey at any time by hitting the "withdraw" button at the top of the survey page to delete your responses and you will still receive your bonus mark. The results from the study may be presented in writing in academic publications and presentations as part of the requirements of Martha Astorquiza's Master's degree, and in the thesis research findings. If you wish to receive a copy of the study's findings, you may contact the researcher at the email given below.

If you require any information about this study, or would like to speak to the researcher (principal investigator), please email Martha Astorquiza at: astorquizaenriquez@uleth.ca

Questions regarding your rights as a participant in this research may be addressed to the Office of Research Ethics, University of Lethbridge (phone: 403 329 2747 or email: research.services@uleth.ca

If you wish to participate in the survey, please proceed to the questions now. Submission of your responses will be accepted as implied consent to participate. Thank you in advance for your participation.

Appendix F - Ethical Approval

University of Lethbridge

Office of Research Ethics
4401 University Drive
Lethbridge, Alberta, Canada
T1K 3M4
Phone: (403) 329-2747
Fax: (403) 382-7185
FWA 00018802 IORG 0006429

Monday, 19 March 2018

Student PI:	Martha Astorquiza, Graduate Student, Geography Department
Faculty Supervisor:	Dr. Dan Johnson, Geography Department
Study Title:	Environmental Impact and Management of Food Packaging Management at the University of Lethbridge, with Respect to Sustainability and Students' Choices
Action: HSRC Protocol Number:	Approved 2018-029
Approval Date:	March 19, 2018
Annual Renewal Report Due:	On or before March 18, 2019

Dear Martha,

Thank you for revising your human research ethics application titled "Environmental Impact and Management of Food Packaging Management at the University of Lethbridge, with Respect to Sustainability and Students' Choices". It has been reviewed and approved on behalf of the University of Lethbridge Human Subject Research Committee (HSRC) for the approval period **March 19, 2018 to March 18, 2019**, and has been assigned Protocol #2018-029. The HSRC conducts its reviews in accord with University policy and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (2014).

Please be advised that any changes to the protocol or the informed consent must be submitted for review and approval by the HSRC before they are implemented. An annual renewal report for continuing certification is also due to the Office of Research Ethics no later than **March 18, 2019**.

We wish you the best with your research.

Sincerely,

Susan Entz

Susan Entz, M.Sc., Ethics Officer
Office of Research Ethics
University of Lethbridge
4401 University Drive
Lethbridge, Alberta, Canada
T1K 3M4

Appendix G – Survey format

Food Packaging and Environment

QUESTIONNAIRE

University of Lethbridge
Developed by Martha Astorquiza
astorquizaenriquez@uleth.ca

General Information

1- What is U of L doing to become more sustainable? Please check all that apply.
☐ Renewable energy ☐ Water bottle re-use ☐ Waste disposal ☐ Locally produced food

2-How often are you at the U of L?
☐ Every day ☐ Three to four days/week ☐ One to two days/week ☐ Occasionally

3-What meals do you eat at the U of L? Please check all that apply.
☐ Breakfast ☐ Lunch ☐ Dinner ☐ Snack

Section 1 – Packaging uses preferences

Drinks preferences	Paper board	Styrofoam	Metal	Glass	Other
4-I prefer my cold drinks in this material	☐	☐	☐	☐	☐
5-In terms of hot drinks (coffee, tea, cocoa) in	☐	☐	☐	☐	☐
6-Which material provides the best taste for your drink?	☐	☐	☐	☐	☐
7-Do you have any of these products with you now?	☐	☐	☐	☐	☐
8-Which material is friendlier to the environment?	☐	☐	☐	☐	☐
9-Which do you think will break down first?	☐	☐	☐	☐	☐
10-Which material is easiest to clean?	☐	☐	☐	☐	☐

Meals preferences	Yes	No
11- Do you prefer to bring your own food to school?	○	○
12-In terms of food protection, is the type of food packaging important to you?	○	○
13-Would you prefer less packaging in fast food?	○	○
14-Do you have a reusable bottle for coffee or water?	○	○
15-Reusable containers are good for environment?	○	○
16-Is it better to reuse rather than to recycle?	○	○
17-Fast food should use less packaging?	○	○

Section 2- Disposal methods of waste and recycling

18- For Plastic Recycling, I follow the instructions "Please rinse off your container before putting it into the bin".

Strongly Agee	Agree	Uncertain	Disagree	Strongle Disagree
☐	☐	☐	☐	☐

19-I use the compost bins when I have tea bags, fruit, vegetables, coffee grounds, tissue paper, and paper towel.

Strongly Agee	Agree	Uncertain	Disagree	Strongle Disagree
☐	☐	☐	☐	☐

20-I use the blue bin for beverage containers (Plastic, aluminium or glass beverage).

Strongly Agee	Agree	Uncertain	Disagree	Strongle Disagree
☐	☐	☐	☐	☐

Appendix H – Data count

Question 2. What is U of L doing to become more sustainable?

Distributions (left=not chosen, right=chosen)

Q2	Count	Proportion
Locally produced food	4	0.00939
Locally produced food, Renewable energy, Waste disposal	1	0.00235
Locally produced food, Waste disposal	6	0.01408
Locally produced food, Water bottle re-use	1	0.00235
Locally produced food, Water bottle re-use, Waste disposal	3	0.00704
Renewable energy	7	0.01643
Renewable energy, Locally produced food	2	0.00469
Renewable energy, Waste disposal	9	0.02113
Renewable energy, Waste disposal, Locally produced food	1	0.00235
Renewable energy, Water bottle re-use	1	0.00235
Renewable energy, Water bottle re-use, Locally produced food	1	0.00235
Renewable energy, Water bottle re-use, Waste disposal	9	0.02113
Renewable energy, Water bottle re-use, Waste disposal, Locally produced food	3	0.00704
Waste disposal	128	0.30047
Waste disposal, Locally produced food	15	0.03521
Waste disposal, Locally produced food, Renewable energy	1	0.00235
Waste disposal, Locally produced food, Renewable energy, Water bottle re-use	2	0.00469
Waste disposal, Locally produced food, Water bottle re-use	3	0.00704
Waste disposal, Renewable energy	5	0.01174
Waste disposal, Renewable energy, Water bottle re-use	3	0.00704
Waste disposal, Water bottle re-use	27	0.06338
Water bottle re-use	58	0.13615
Water bottle re-use, Locally produced food	5	0.01174
Water bottle re-use, Waste disposal	109	0.25587
Water bottle re-use, Waste disposal, Locally produced food	14	0.03286
Water bottle re-use, Waste disposal, Locally produced food, Renewable energy	2	0.00469
Water bottle re-use, Waste disposal, Renewable energy	6	0.01408
Total	426	1.00000

n=428

None 2

Renewable 52

Water bottle reuse 257

Waste disposal 335

Local produced 63

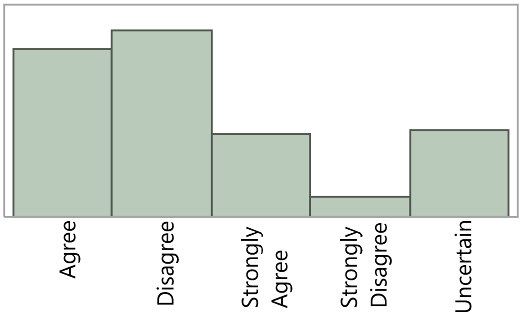
Table representing the percentage of answers for question #2 of the packaging and environmental survey

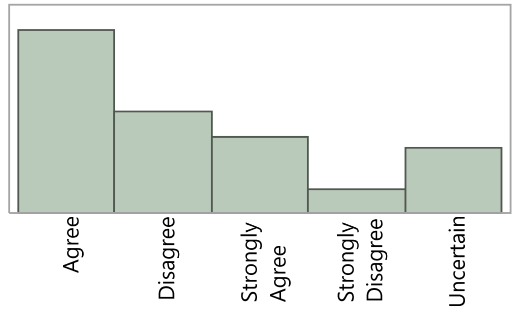
Renewable energy	Water bottle	Waste disposal	Local produced
7.4%	36.4%	47.4%	8.9%
Total responses 707			

Appendix I - Distribution graphs/ Question 11 with Q17-Q18-Q19

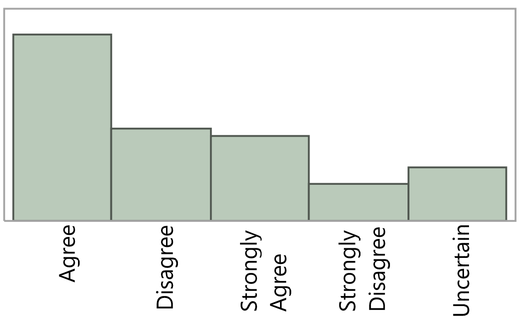
No | Yes

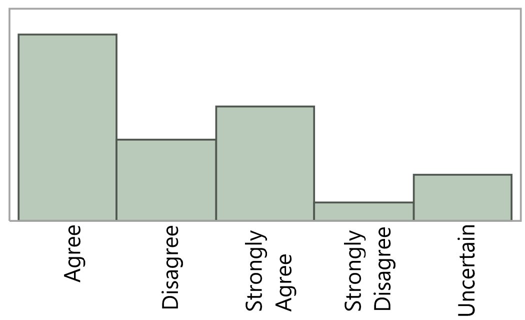
Q17



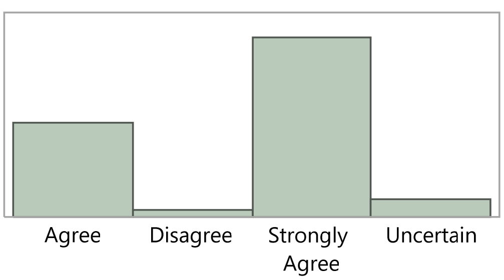


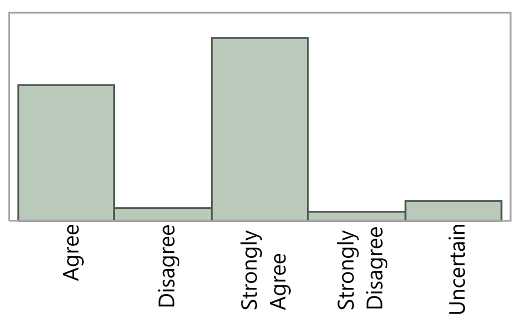
Q18



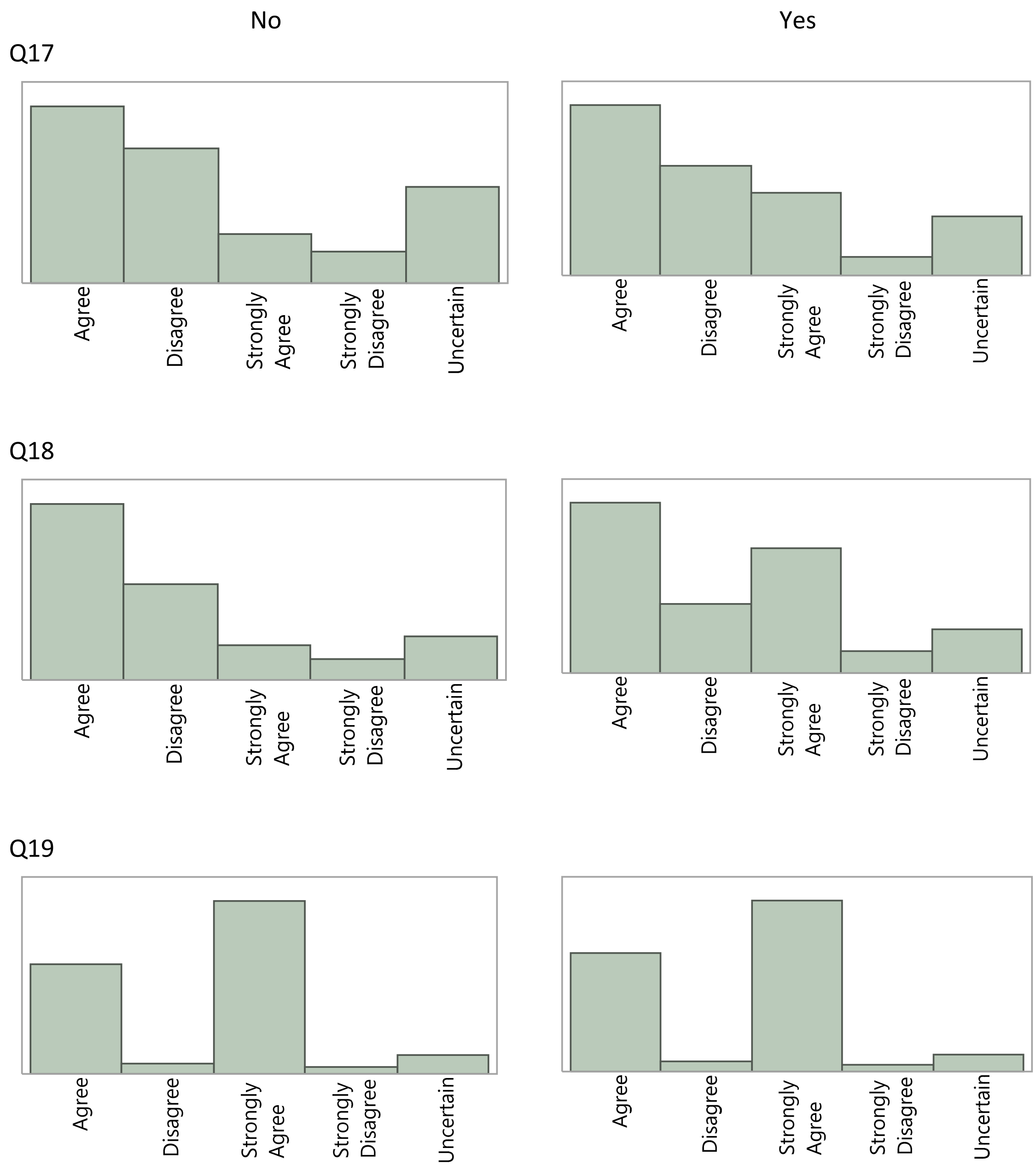


Q19

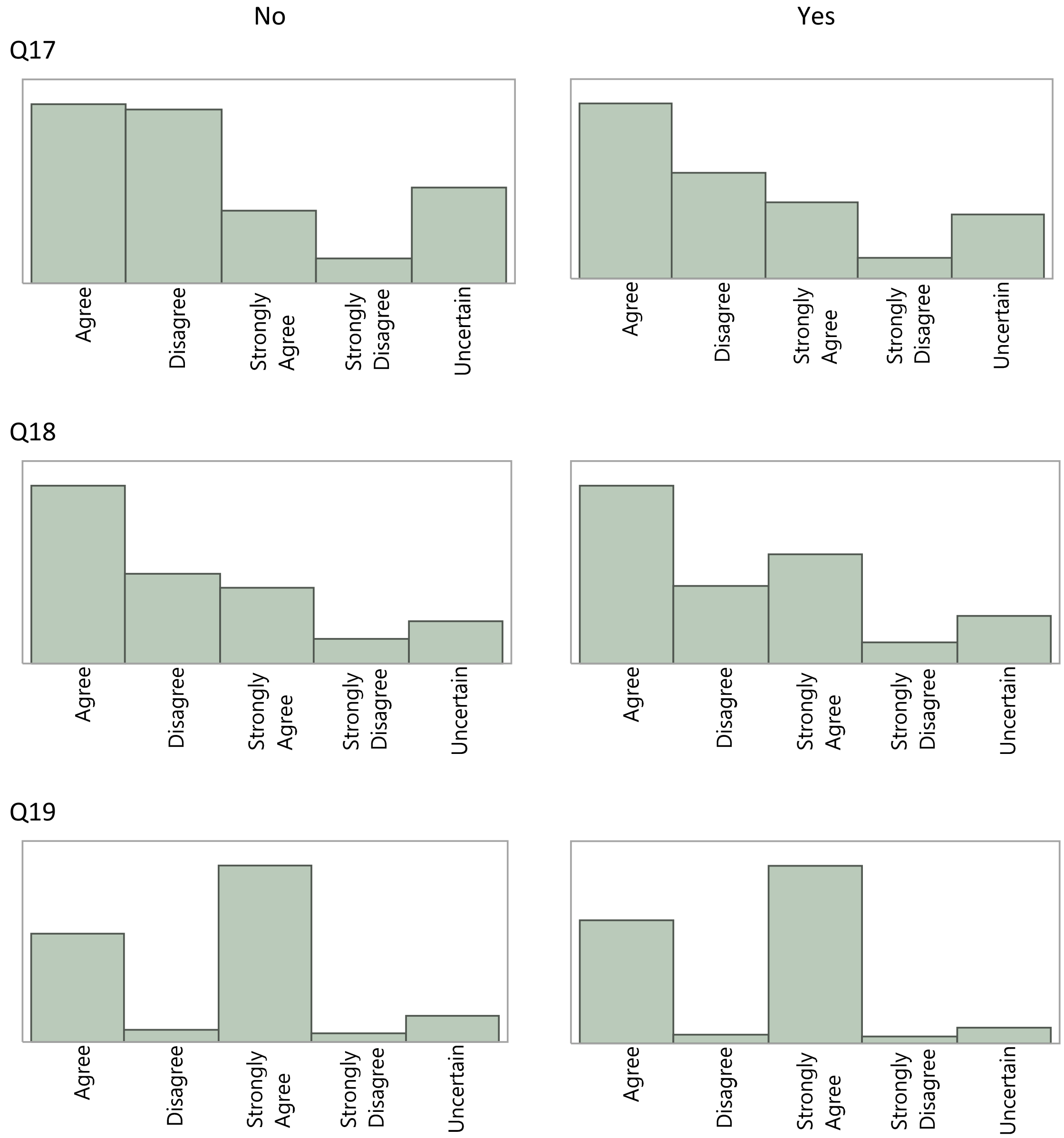




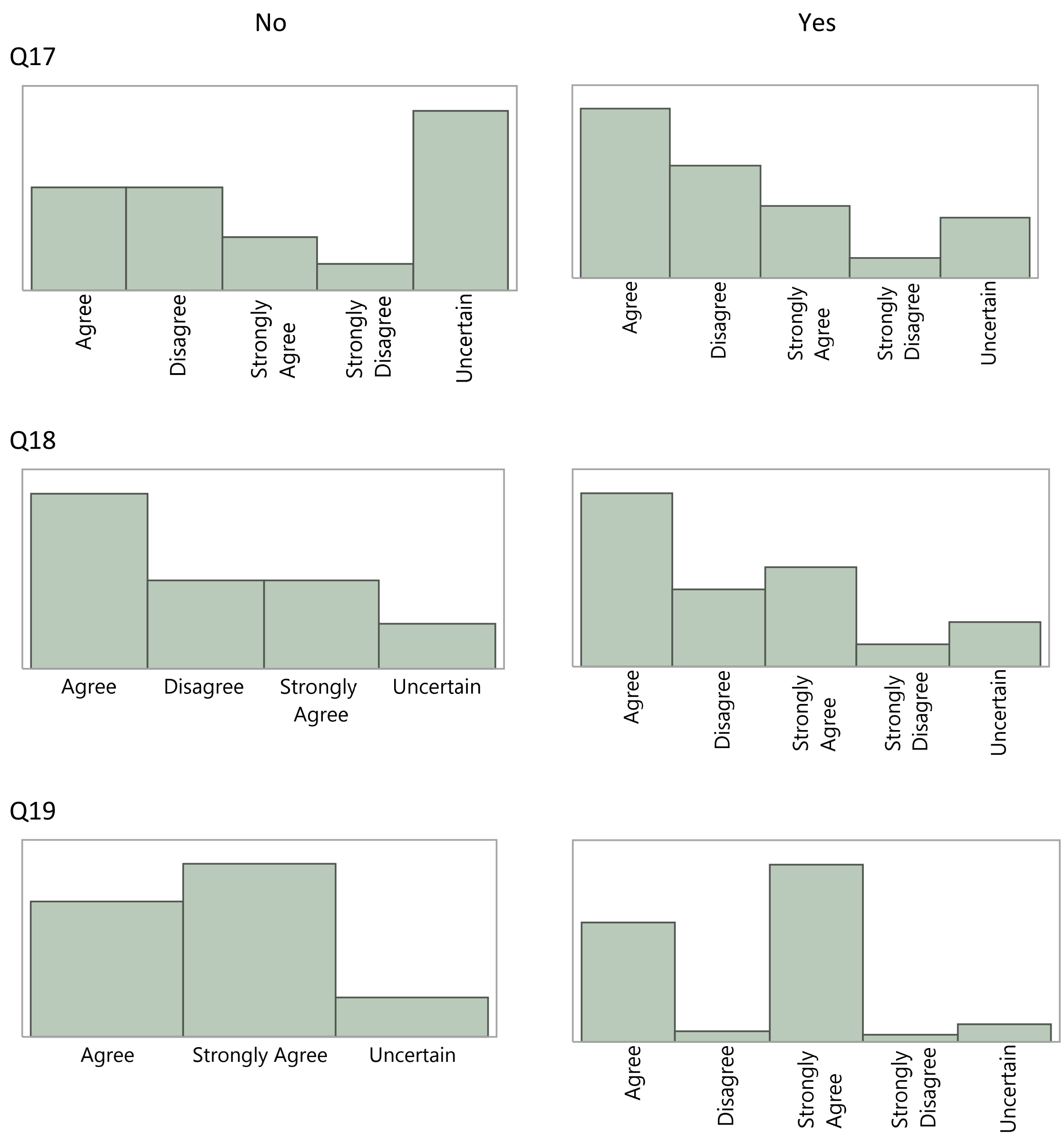
Appendix J –Distribution graphs/ Question 12 with Q17-Q18-Q19



Appendix K - Distributions graphs Question 13 with Q17-Q18-Q19



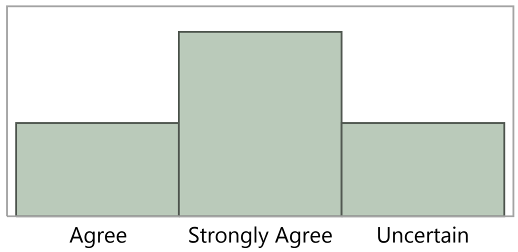
Appendix L - Distributions graphs Question 14 with Q17-Q18-Q19

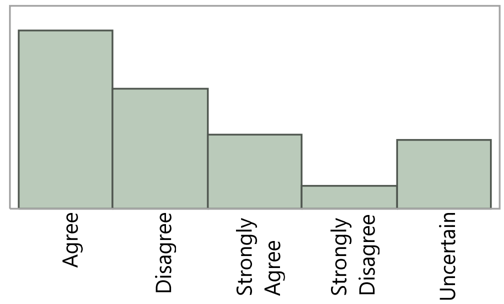


Appendix M - Distributions graphs Question 15 with Q17-Q18-Q19

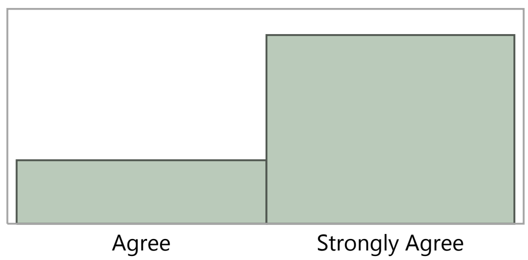
No | Yes

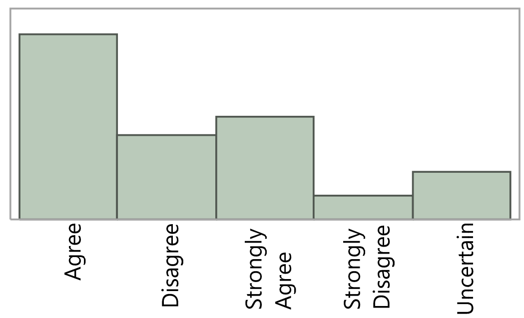
Q17



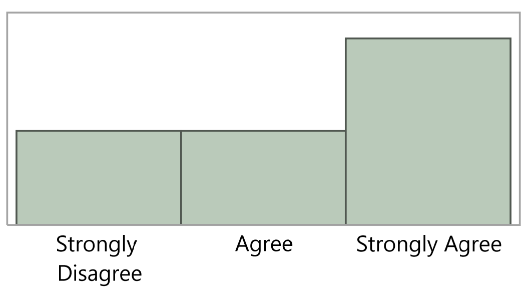


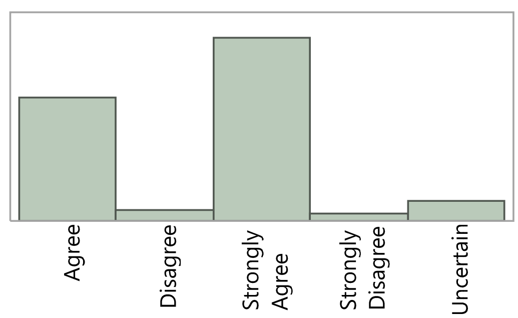
Q18





Q19

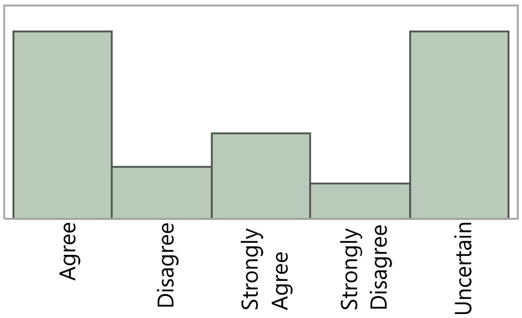


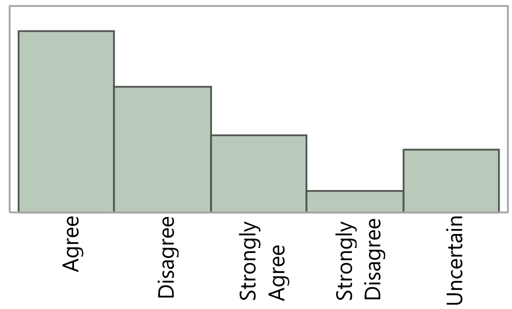


Appendix N – Distribution graphs Question 16 with Q17-Q18-Q19

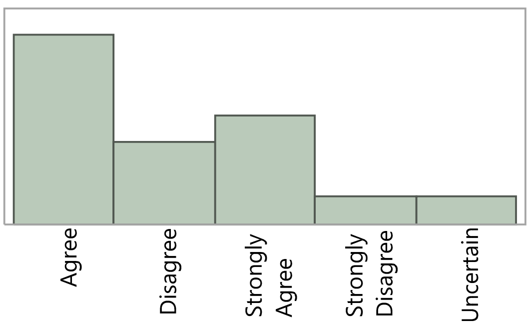
No | Yes

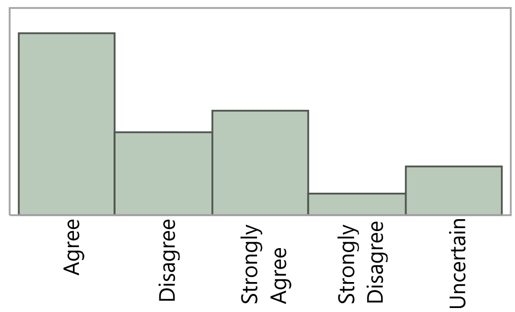
Q17



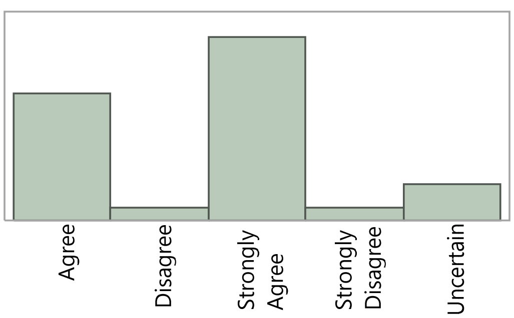


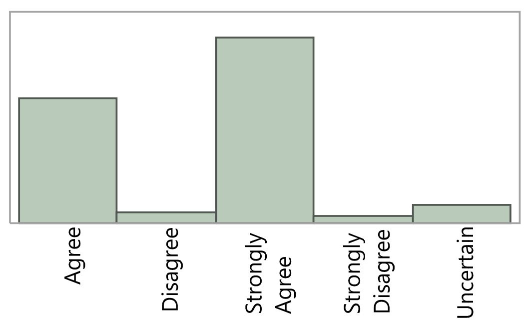
Q18





Q19





Appendix O – Instruction for entering data in the software (WARM)

The requirements to run the model are:

Hardware: 1GB RAM

140 MB (Windows), 64 MB (Mac) free hard disk space.

Software: Microsoft Visual C++ Runtime v10 needs to be installed on windows 64 bit for the display of HTML pages.

Instructions to enter data in the software

A. Input data

The home page of the model provides information about tips and reports, and then when opening the data entry screen, it shows four tabs consisting of four steps: Scenarios, characteristics, general information and calculation. To start running a new scenario in both baseline and alternative scenarios, the user needs to provide data by entering values into types of material (rows) and into the six management practices (columns): recycling, landfilling, combustion, composting, anaerobic digestion, and source reduction. Only data input is calculated; for the materials and management operations with no data, cells will remain as “0”. (Figure 4.2.1).

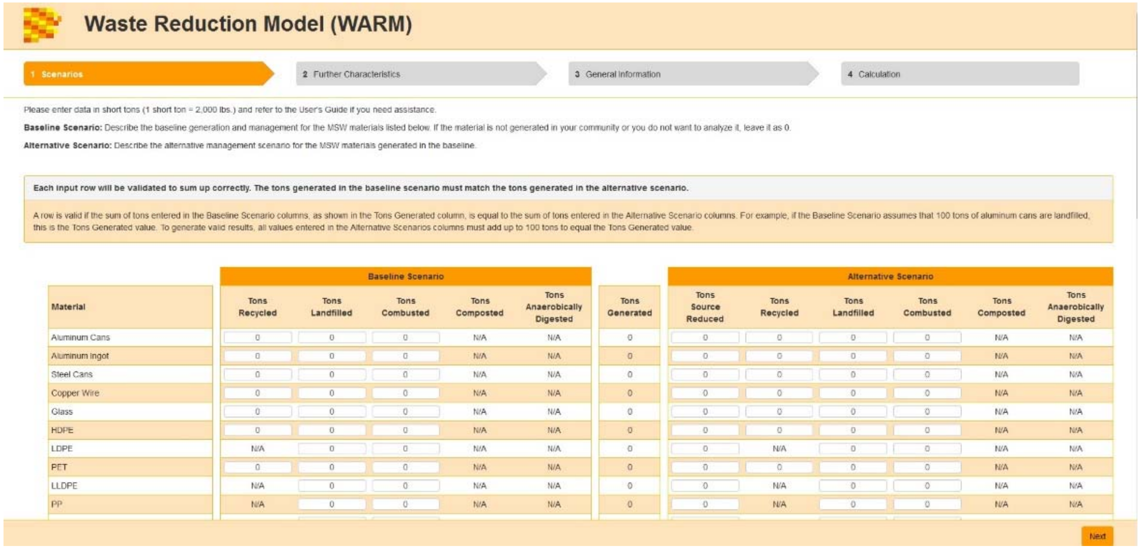


Figure 4.2.1 Data entry tab WARM model (EPA, 2016)

Requirements for entering the data

a. Data values must be entered in short tons (1 short ton = 2,000 lbs. = 907.18 kg)
b. Only numbers can be entered
c. "." Must be used as decimal separator
d. Both the baseline and alternative scenarios should be consistent with the amount of waste entered.

B. Further characteristics

WARM has information that can be modified by the user with respect to the following:

Locations - The user can select either their geographical location or the default value that corresponds to a National Average.

Waste transport characteristic - The user is able to modify distance (miles) between the waste collection point and facilities for landfill, combustion, recycling, composting, and anaerobic digestion. The default option by default is 20 miles for each location.

Source reduction -The user can select the material that is source reduced either from the current mix of recycled and virgin materials or from 100% virgin material. The default value is “Current mix”.

Landfill characteristics I, II, III - The user has four options:

a. No landfill gas (LFG) recovery

b. LFG recovery for energy

c. LFG recovery and flared

d. National average (based on the proportions of the other three types in 2012).

Anaerobic digestion

The user can determine digestion type (dry or wet) according to digester type, and digestate curing depend if the digestate is cured before land application or not cured.

C. General information

This screen shows the user’s name, the reporting period and a text field for the description of the assessment. The final report will show this information on the headline.

D. Calculation

a) WARM contains three possible calculation options

b) GHGs emissions in metric tons of carbon dioxide equivalent ($MTCO_2E$)

c) GHGs emissions in metric tons of carbon equivalent (MTCE)

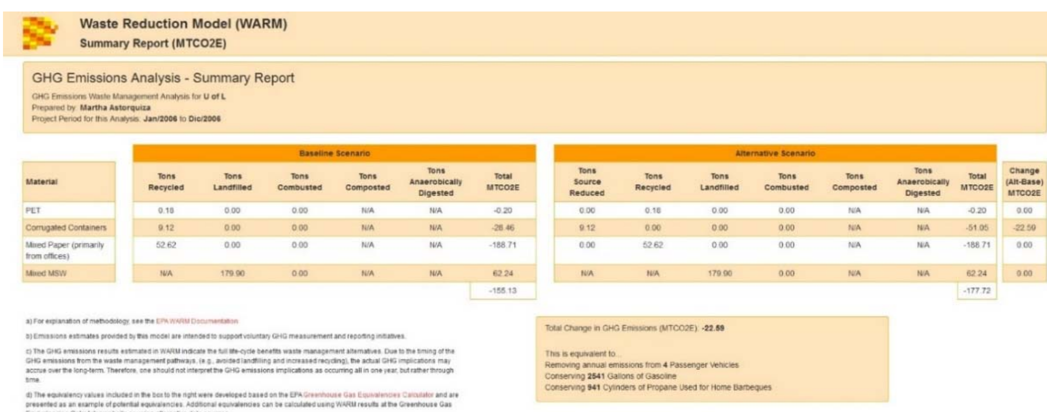
d) Energy consumed in million BTU

E. Results

WARM generates the report in a new tab where two sub-tabs appear in the bottom left corner of the report tab: summary and analysis. The negative values represents the emissions that have been avoided during the management of that specific material type and /or scenario. Similarly, if an energy consumption is negative, the modeled scenario averts the consumption of that amount of energy. If the total change between the baseline and the alternative scenario is negative, then the scenarios will result in fewer GHG emissions or energy consumption.

Summary

WARM incorporates the GHG emissions/Energy consumption per material and scenario. A column is presented on the right side with the change between the two scenarios. In addition, a summary with the equivalents in the bottom right of the page describes the resulting total change in GHG emission ($MTCO_2E$). WARM contains the amount of passenger vehicles' annual emissions equivalent to the total change in GHG emissions. Positive or negative signs represent the adding or removing of annual emissions. (Figure 4.2.2).



Waste Reduction Model (WARM)
Summary Report (MTCO2E)

GHG Emissions Analysis - Summary Report
GHG Emissions Waste Management Analysis for **U of L**
Prepared by: **Martha Astorquiza**
Project Period for this Analysis: **Jan/2006** to **Dic/2006**

Material	Baseline Scenario						Alternative Scenario							
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
PET	0.18	0.00	0.00	N/A	N/A	-0.20	0.00	0.18	0.00	0.00	N/A	N/A	-0.20	0.00
Corrugated Containers	9.12	0.00	0.00	N/A	N/A	-28.46	9.12	0.00	0.00	0.00	N/A	N/A	-51.05	-22.59
Mixed Paper (primarily from offices)	52.62	0.00	0.00	N/A	N/A	-188.71	0.00	52.62	0.00	0.00	N/A	N/A	-188.71	0.00
Mixed MSW	N/A	179.90	0.00	N/A	N/A	62.24	N/A	N/A	179.90	0.00	N/A	N/A	62.24	0.00
						-155.13							-177.72	

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

d) The equivalency values included in the box to the right were developed based on the EPA Greenhouse Gas Equivalencies Calculator and are presented as an example of potential equivalencies. Additional equivalencies can be calculated using WARM results at the Greenhouse Gas Equivalencies Calculator website or using alternative data sources.

Total Change in GHG Emissions (MTCO2E): **-22.59**

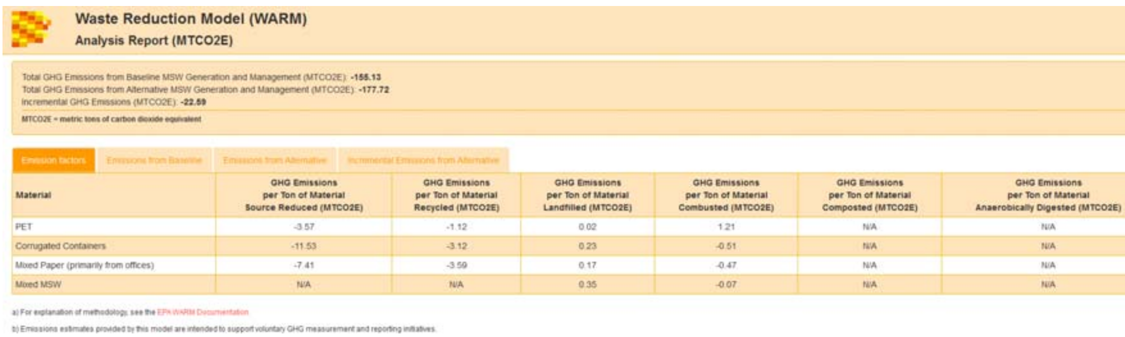
This is equivalent to...
Removing annual emissions from **4** Passenger Vehicles
Conserving **2541** Gallons of Gasoline
Conserving **941** Cylinders of Propane Used for Home Barbeques

Figure 4.2.2 Summary Report ($MTCO_2E$) sub-tab of the report Waste Reduction Model (WARM) (EPA, 2016).

Analysis

This analysis consists of four parts: emission factors, emission from baseline, emissions from alternative cases, and incremental emissions from alternative cases.

Emission factors. This section includes the emission factors according to the material type and management practice. These factors are used to calculate the GHG emissions/Energy consumption results. (Figure 4.2.3).


Waste Reduction Model (WARM)
Analysis Report (MTCO2E)

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-155.13**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-177.72**
Incremental GHG Emissions (MTCO2E): **-22.59**
MTCO2E = metric tons of carbon dioxide equivalent

Emission factors | Emissions from Baseline | Emissions from Alternative | Incremental Emissions from Alternative

Material	GHG Emissions per Ton of Material Source Reduced (MTCO2E)	GHG Emissions per Ton of Material Recycled (MTCO2E)	GHG Emissions per Ton of Material Landfilled (MTCO2E)	GHG Emissions per Ton of Material Combusted (MTCO2E)	GHG Emissions per Ton of Material Composted (MTCO2E)	GHG Emissions per Ton of Material Anaerobically Digested (MTCO2E)
PET	-3.57	-1.12	0.02	1.21	N/A	N/A
Corrugated Containers	-11.53	-3.12	0.23	-0.51	N/A	N/A
Mixed Paper (primarily from offices)	-7.41	-3.59	0.17	-0.47	N/A	N/A
Mixed MSW	N/A	N/A	0.35	-0.07	N/A	N/A

a) For explanation of methodology, see the EPA WARM Documentation
b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Figure 4.2.3 Emissions factor section in the Analysis sub-tab of the report Waste Reduction Model (WARM) (EPA, 2016)

Emissions from baseline. This section includes the tons managed and the resulting GHG emission/Energy consumption per material and management practice, as well as the totals per material, for the baseline scenario. (Figure 4.2.4).


Waste Reduction Model (WARM)
Analysis Report (MTCO2E)

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-155.13**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-177.72**
Incremental GHG Emissions (MTCO2E): **-22.59**
MTCO2E = metric tons of carbon dioxide equivalent

Emission factors | Emissions from Baseline | Emissions from Alternative | Incremental Emissions from Alternative

Material	Baseline Generation of Material (Tons)	Baseline Recycling (Tons)	GHG Emissions from Recycling (MTCO2E)	Baseline Landfilling (Tons)	GHG Emissions from Landfilling (MTCO2E)	Baseline Combustion (Tons)	GHG Emissions from Combustion (MTCO2E)	Baseline Composting (Tons)	GHG Emissions from Composting (MTCO2E)	Baseline Anaerobic Digestion (Tons)	GHG Emissions from Anaerobic Digestion (MTCO2E)	Total GHG Emissions (MTCO2E)
PET	0.18	0.18	-0.20	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-0.20
Corrugated Containers	9.12	9.12	-28.46	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-28.46
Mixed Paper (primarily from offices)	52.62	52.62	-188.71	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-188.71
Mixed MSW	179.90	N/A	N/A	179.90	62.24	0.00	0.00	N/A	N/A	N/A	N/A	62.24

a) For explanation of methodology, see the EPA WARM Documentation
b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Figure 4.2.4 Emissions from baseline section in the Analysis sub-tab of the report Waste Reduction Model (WARM) (EPA, 2016)

Emissions from alternative. This section includes the tons handled and the resulted GHG emission/Energy consumption per relevant material and management practice, as well as the totals per material, for the alternative scenario. (Figure 4.2.5).

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-155.13**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-177.72**
Incremental GHG Emissions (MTCO2E): **-22.59**

MTCO2E = metric tons of carbon dioxide equivalent

Emission factors | Emissions from Baseline | Emissions from Alternative | Incremental Emissions from Alternative

Material	Baseline Generation of Material (Tons)	Alternative Source Reduction (Tons)	GHG Emissions from Source Reduction (MTCO2E)	Alternative Recycling (Tons)	GHG Emissions from Recycling (MTCO2E)	Alternative Landfilling (Tons)	GHG Emissions from Landfilling (MTCO2E)	Alternative Combustion (Tons)	GHG Emissions from Combustion (MTCO2E)	Alternative Composting (Tons)	GHG Emissions from Composting (MTCO2E)	Alternative Anaerobic Digestion (Tons)	GHG Emissions from Anaerobic Digestion (MTCO2E)	Total GHG Emissions (MTCO2E)
PET	0.18	0.00	0.00	0.18	-0.20	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-0.20
Corrugated Containers	9.12	9.12	-51.05	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-51.05
Mixed Paper (primarily from offices)	52.62	0.00	0.00	52.62	-188.71	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-188.71
Mixed MSW	179.90	N/A	N/A	N/A	N/A	179.90	62.24	0.00	0.00	N/A	N/A	N/A	N/A	62.24

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Figure 4.2.5 Emissions from Alternative section in the Analysis sub-tab of the report Waste Reduction Model (WARM) (EPA, 2016)

Incremental emissions from alternative. This section includes the differences between the alternative and baseline scenarios with reference to tons handled and GHG emissions/Energy consumption per relevant material and management practice, as well as the total incremental results per material. (Figure 4.2.6).

Waste Reduction Model (WARM)
Analysis Report (MTCO2E)

Total GHG Emissions from Baseline MSW Generation and Management (MTCO2E): **-155.13**
Total GHG Emissions from Alternative MSW Generation and Management (MTCO2E): **-177.72**
Incremental GHG Emissions (MTCO2E): **-22.59**

MTCO2E = metric tons of carbon dioxide equivalent

Emission factors | Emissions from Baseline | Emissions from Alternative | Incremental Emissions from Alternative

Material	Source Reduction (Tons)	Incremental GHG Emissions from Source Reduction (MTCO2E)	Incremental Recycling (Tons)	Incremental GHG Emissions from Recycling (MTCO2E)	Incremental Landfilling (Tons)	Incremental GHG Emissions from Landfilling (MTCO2E)	Incremental Combustion (Tons)	Incremental GHG Emissions from Combustion (MTCO2E)	Incremental Composting (Tons)	Incremental GHG Emissions from Composting (MTCO2E)	Incremental Anaerobic Digestion (Tons)	Incremental GHG Emissions from Anaerobic Digestion (MTCO2E)	Total Incremental GHG Emissions (MTCO2E)
PET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	0.00
Corrugated Containers	9.12	-51.05	-9.12	28.46	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	-22.59
Mixed Paper (primarily from offices)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	0.00
Mixed MSW	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A	0.00

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

Figure 4.2.6 Incremental emissions from alternative section in the Analysis sub-tab of the report Waste Reduction Model (WARM) (EPA, 2016)

F. Export and saving data

The reports can be saved in a file with the extension (*.warm) and consequently opened again in the WARM tool. Likewise, the content can be exported as HTML, which can be opened in any modern web browser.

Appendix P - Interview Format

Food Packaging
and
Environment
University of Lethbridge
Developed by Martha Astorquiza
astorquizaenriquez@uleth.ca

INTERVIEW QUESTIONS

Part of my study will recount the general history of waste in regions like Lethbridge and Southern Alberta

General Information	1. Could you summarize the changes in the waste management evolution in the last 10 years? 2. Does waste now have more problematic components than in the past? 3. The volume of waste received in 2008 was 144,489 tonnes and in 2009 136,053. It's been reduced by 5.8%. How was it reduced? 4. What happened in that period of time that stopped increasing the volume of waste? 5. What have been the biggest challenges for the center in terms of reducing pollution through waste management? 6. In terms of waste origin. You calculate waste from residential and commercial sectors. Are you calculating, how much waste comes from the U of L.? Do you know what categories could be higher or lower than in the city or region? 7. How do you calculate the expected requirements for waste treatment, or the consequences of certain pollutants?

My investigation intents to assess potential contamination and solutions to reduce negative environmental impact.

Landfill	8. What are the characteristics of Class II Landfill? 9. And, for Class III Landfill?
Compost and Recycling	10. Compos collection started in 2009 with 756 tonnes. 11. What was the composition of the compost at that time? 12. Has it changed over time? 13. Since 2017, U of L is recycling Styrofoam, Is Styrofoam still part of land fill or are you recycling it? 14. Are there any special needs or plans that should be considered? 15. After recycling and compost stations were set up in the center, what was the reduction of waste that went to landfill? 16. Advantages on new lessons learned?

The contribution of food packaging into the global amount of landfill municipal solid waste in Lethbridge

Packaging	17. What is the contribution from the commercial sector in terms of packaging waste? 18. Are any data available for Lethbridge? 19. Are manufacturers and producers interested in reducing packaging waste? 20. Has the quantity of the packaging waste been calculated over time? Y/N 21. How long can packaging last in landfill? 22. What part of waste does packaging represent?

Appendix Q – Letter of Consent (Interview)

University of Lethbridge

Faculty of Fine Arts

Department of Music

4401 University Drive
Lethbridge, Alberta, Canada
T1K 3M4

Phone 403.329.2495
Fax 403.317.2841

www.uleth.ca/finearts

LETTER OF CONSENT (INTERVIEW)

(Place on Letterhead with University logo)

Study Title: Environmental Impact and Management of Food Packaging at the University of Lethbridge, with respect to Sustainability, and Students choices

April 17, 2018

Dear Participant:

You are being invited to participate in a research study on Environmental Impact and Management of Food Packaging at the University of Lethbridge, with respect to Sustainability, and Students choices.

The purpose of this study is to compile an evidence-based assessment of the potential environmental impact of food packaging waste at the University of Lethbridge to determine to what extent recycling has an environmental benefit, and to identify additional ways in which gains could result from waste management policy, attitudes of the students, personal choices and, environmental motivations of consumer behavior. This research will require about 20 minutes of your time for a one-on-one person interview. The purpose of the interview is to explore, in more detail, the waste disposal management of the city of Lethbridge. During the interview, I will take written notes of the discussion.

There are no direct benefits to you from participating in this study; however, you will be helping me to better understand City's integrated solid waste management system.

There are no anticipated risks or discomforts related to this research. Your participation in this research is completely voluntary. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. You may choose to not answer any question or you may withdraw from the interview at any time for any reason. If you do this, I will ask you for permission to use the information contributed up to that point for my study. If you do not given consent for use of the information, it will be destroyed.

Several steps will be taken to protect your anonymity and confidentiality. You will not be identified by name but the City of Lethbridge will be identified in the report of results. All of the data collected in this study will be kept in a locked drawer at my Supervisor Dr. Dan Johnson's office, and only he and I will have access to them. Collected information from interview will be retained for 5 years from the completion of the study before being deleted.

The results from this study will be presented in academic reports and presentations. At no time, however, will your name be used or any identifying information revealed unless you have given consent. A report of the results will be made available to you prior to any publication.

If you require any additional information about this study, please call me at 403-393-5008 or email me at astorquizaenriquez@uleth.ca. Questions regarding your rights as a participant in this research may be addressed to the Office of Research Ethics, University of Lethbridge (Phone: 403-329-2747 or Email: research.services@uleth.ca).

This research project has been reviewed for ethical acceptability and approved by the University of Lethbridge Human Subject Research Committee. Thank you for your consideration.

I have read the above information regarding this research study on the Environmental Impact and Management of Food Packaging at the University of Lethbridge, with respect to Sustainability, and Students choices and consent to participate in this study.

Alex Singbeil ____________________ (Printed Name of Participant)

[signature] ____________________ (Signature)

April 17, 2018 ____________________ (Date)

____________________ (Printed Name of Researcher)

____________________ (Signature)

____________________ (Date)

Martha L. Astorquiza