

UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

UBC Bookstore Plastic Bag Alternative

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Executive Summary

Single-use plastic bags have become a common household item since the 1970s. These are supplied nearly everywhere from grocery stores, to clothing stores and bookstores. Used to hold groceries, trash, and many other everyday items, they are immensely useful. Single use plastic bags however, have a destructive impact on the environment. UBC is a leader in global sustainability with UBC achieving a 34 percent reduction in greenhouse gas emissions since 2007, a reduction of campus water consumption by 50 percent since 1999, and natural gas consumption by 30 percent since 2014. In 2014, UBC created a Zero Waste Action Plan aiming to increase waste diversion towards an 80% target, and reduce waste disposal each year. However, the UBC Bookstore's plastic bag usage has been increasing more than 100% since 2012. Despite trying to reduce the usage and offering other alternatives, the purchase and usage of plastic bags continues to increase in the Bookstore. The UBC Bookstore is considered to be one of the biggest patrons of single use plastic carrier bags on UBC campus. Therefore, implementing an environmentally friendly, affordable alternative to single use carrier bags is an important change that will align with UBC's Zero Waste Action Plan.

The purpose of our research was to identify an alternative to the single use plastic carrier bags offered currently at the UBC Bookstore. The alternative to the single use carrier bags needs to have minimal environmental impact and also meet the needs of the UBC Bookstore's customers. To inform our decisions a thorough understanding of the current bag alternatives are required through a meta-analysis. A meta-analysis was done through UBC's online database and Google Scholar. 3 governmental documents and 2 peer-reviewed papers were found to be used for this project. Findings from the literature reviews have provided us with insights regarding

alternatives options suitable for the UBC Bookstore. Overall, the best ‘sustainable’ alternative found was to reduce or eliminate the usage of bags itself, and maximise the number of times reused. This report will provide recommendations for future research and actions taken by UBC Bookstore. The following includes an experimental design to determine how a psychological intervention can reduce the consumption of single-use carrier bags among customers, and further research surrounding carrier bag alternatives.

Introduction

For the past decade, sustainability has been a forefront priority for UBC. From efforts to reduce food waste, create green buildings and eliminate single-use plastics, the university has successfully integrated sustainability into its core operations (UBC Sustainability, 2014). Furthermore, in its statement of strategic goals, the university aims to incorporate sustainability in its community, research, as well as teaching activities (UBC Sustainability, 2014). UBC values sustainability for its ethics, how it impacts distributive justice, and quality of life (UBC Sustainability, 2014). The university recognizes the severe consequential impacts of unsustainability, on human life and climate (UBC Sustainability, 2014).

As part of UBC's overarching strategies to reduce greenhouse gas emissions, a zero-waste plan has been put in place since 2014. The plan targets 70% and 80% of waste diversion in 2016 and 2020 respectively (UBC Sustainability, 2014). This is in accordance with the 67% reduction target in GHGs emitted by the university by 2020 (UBC Sustainability, 2014). With the implementation of several recycling mechanisms and other changes, 61% of waste diversion was reached in 2017 (UBC Sustainability, n.d.). As part of various initiatives to reach 80% waste diversion, UBC hopes to be able to eliminate single-use plastic bags starting with the UBC Bookstore. Despite zero waste goals, UBC continues to offer single-use, biodegradable bags that are not accepted in either of its recycling or composting programs. Biodegradable plastic bags more often than not end up in the landfill which poses a threat to marine life, increases air pollution, and has many other harmful effects both on the environment and society. Although biodegradable plastics decompose quicker than regular plastic, degradation is dependent on both

environmental conditions and undergoes a process that can generate microplastics (Kubowicz & Booth, 2017).

As one of the largest distributors of biodegradable single-use plastic bags on campus, the UBC bookstore has committed to its gradual elimination. In a study done in collaboration with the SEEDS Sustainability Program, it was found that biodegradable plastic bags made from High Density Polyethylene (HDPE) was a contributor to the annual usage of 690,000 plastic bags distributed at UBC alongside two other types of plastic. As of late to reduce consumption, the store has implemented a charge of \$0.15 per bag. Additionally, introduced as part of a temporary measure in the recent past, the bookstore offered a reusable polypropylene cloth bag for students at \$1.00 per bag. A reusable cloth bag however, poses an issue because UBC currently does not accept textiles in its existing recycling programs. To eliminate plastic bags entirely, would require customers bringing their own bag, or the bookstore providing a different viable alternative. We recognize that in consideration of students being the largest demographic of users at the store, introducing bag alternatives may prove to be challenging as this needs to take into account variables such as budget, size, durability, style, and environmental impact.

In light of this, our team's research findings proved counterintuitive to what common views were on single use plastic bags: conventional materials used for plastic alternatives often pose larger environmental impacts.

Research Question

Studies have shown that the most beneficial way to reduce the impact of single use plastic bags on the environment, is to reduce the number of bags sold and produced as well as maximize the number of times bags are reused if purchased. As a result of this, we decided to investigate further on two aspects:

1. Whether the cost of alternatives outweigh the cost of the continued usage of single use plastic bags
2. If so, how a psychological intervention could be beneficial in reducing consumption instead

Methodology

This study has been conducted in the form of a meta-analysis of the literature reviewed below. These sources were combined in order to identify the sustainability of plastic bags and the alternatives. This research also incorporates an experimental design to determine how psychological interventions can change consumption in reducing the use of single use carrier bags at the UBC Bookstore based on a previous study done in Japan.

Research Methods: Literature Review

An exhaustive search of UBC's online databases (UBC Library, Web of Science, ScienceDirect) and Google was conducted using the search terms "plastic bag alternatives," "eco-friendly bags," "reusable bag," "carrier bag environmental impact," "environmental impact plastic bags vs. reusable," "green behaviour in consumers" and "psychological interventions for

consumption.” This search returned approximately 150,000 results in which we reduced to 3 government life cycle assessments and 2 peer reviewed journal articles. Information about single use carrier bags and alternative carrier bags were found using the following criteria: 1) English language articles, 2) bags mentioned are low density polyethylene, non-woven polypropylene, recycled polyethylene, paper bags, or cotton bags, 3) includes environmental, social, and/or economic impacts of producing the bag, 4) bags mentioned in the study are easily obtainable and are the main focus of the study, and 5) peer-reviewed or governmental. To determine how psychological interventions can affect consumption we selected those that demonstrated how indirect and direct actions could influence green behaviour in consumers.

Research Methods: Experimental Design

With our meta-analysis, we propose that the UBC Bookstore carry out a similar experiment done by Shoji Ohtomoa and Susumu Ohnuma in Japan conducted in 2014 with UBC bookstore customers by studying people’s reaction to voice prompts in offering the single-use carrier bags.

Before starting the voice prompt experiment, an ethics application needed to be approved. The TCPS 2: CORE certificate needed to be completed, in order to receive an issued ethics number for the ethics application. The TCPS 2: CORE is an online tutorial on the ethics of conducting research involving humans. Consent forms to participate in this study is required for all UBC Bookstore staff that are involved so that they are aware of procedures and the potential risks of the study and confidentiality. The experiment was designed with the collaboration of the

staff at UBC Bookstore and our professor for this course, Dr. Gunilla Oberg as well as input from Dr. Jiaying Zhou, an associate professor at UBC in the Department of Psychology.

The experiment was planned to be conducted over a span of three days (each prompt is given its own day) and each variable would be conducted for one-hour while the control is to be observed for a week before the experiment. The aim of this experiment was to study the effects of how cashier's actions can activate an eco-friendly intention in customers at the UBC bookstore. This would be done by the introduction of a simple voice prompt in order to encourage a reduction in the consumption of single-use carrier bags among customers. Our hypothesis was 1) that the number of customers taking a carrier bag will be lower than when they are not offered one, 2) an introduction of voice prompts by cashiers will promote a higher environmental-conscious decision by customers and 3) customers will find an alternative when no carrier bags are available from the bookstore.

The experimental design included 1 control and 3 different voice prompts. We would be standing at close proximity to the cashiers involved to observe and record the customer's initial reaction, questions asked, and attitude towards the prompt. We would be able to provide assistance if required by the cashier. At the end of this, there would be a sign near the check out as customers exit. This would explain the experiment so that they are aware they have taken part, and if they had any questions, concerns or would like to withdraw, they would be welcome to contact the principal investigator.

Voice Prompt Experiment

1. Control: Cashiers operate as usual where during payment the cashiers ask if a bag is wanted. The number of bags purchased will be calculated.

Script:

Cashier: "Are you okay without a bag?"

2. Treatment 1: Cashiers do not offer a bag during payment. If a bag is asked for, no prompts are given, however, will be given the bag for 15 cents (as usual).

Script:

Customer: "May I have a bag?"

Cashier: "It will be 15 cents."

3. Treatment 2: Cashiers operate as usual during payment but if a bag is asked for an environmental awareness prompt is given.

Script:

Cashier: "Are you okay without a bag?"

Customer: "Yes/No."

If "yes"

Cashier: "Sure, it will be 15 cents. But it is part of **UBC's sustainability initiative to reduce waste**, we encourage you to **bring your own bag next time**. We advise you to **reuse this bag** at least one more time."

*if the customer asks why they need to reuse the bag

Cashier: "This is to minimise their environmental impact."

*Cashiers may change the wording but words in **bold** are encouraged to be included in the prompt.

4. Treatment 3: The cashier does not offer any bag and no bags are available.

Script:

*If the customer asks for a bag

Customer: “May I have a bag?”

Cashier: “I’m sorry, but we are currently not offering a carry bag as a part of **UBC’s sustainability initiative to reduce waste**, we encourage you to **bring your own bag.**”

*Cashiers may change the wording but words in **bold** are encouraged to be included in the prompt.

*If the situation escalates (the customer gets angry), one of the students will step in to explain the situation.

Student: “I apologize. We are actually conducting an experiment on the effect of cashier’s actions in reducing the use of carrier bags.” (Give the customer a bag)

Interview

A brief interview with the cashiers should be conducted before and after the experiment to get an understanding of how the cashiers feel about carrying out the voice prompt in the experiment.

Results and Discussion

Comparing Single-Use Carrier Bags and Alternatives

In conducting our meta-analysis, we made a number of interesting discoveries that are contrary to what we had in mind before researching. A number of studies have been done in comparing the environmental impacts of different carrier bags for store purchases, and we found that the results from these studies are rather counterintuitive to the traditional view of plastic bags.

For the sake of simplifying the results, we decided to narrow down our research into five types of bags;

- I. Low-density polyethylene (LDPE)/ Plastic retail bag (PRB): the bag currently used by the UBC bookstore,
- II. Non-woven polypropylene (NWPP): the average reusable bag offered by stores across Canada
- III. Recycled polyethylene terephthalate (RPET): the bag alternative suggested by the UBC bookstore
- IV. Paper bags
- V. Cotton bags

In a past study done through a collaboration between UBC's Ocean Leaders and Sustainability and Engineering in Campus and Community Planning and SEEDS Sustainability Program, the author claims that LDPE bags poses the highest risk to marine life as they are not recycled in Canada and this increases the probability of them ending up in the marine environment (Sanchez, 2018). Although this is true for the effect of LDPE bags on marine life,

the result we find in our meta-analysis may prove that LDPE is the best alternative according to various factors.

In a life cycle assessment done by The Danish Environmental Protection Agency in 2018, they studied various environmental indicators (Appendix A) and found that the average supermarket plastic bags in Denmark (LDPE) are the carrier bags that provide the overall lowest environmental impacts. This is measured based on the energy and water used in making and decomposing the bags with various end-of-life (EOL) scenarios (Bisinella et. al, 2018).

A similar study was done by Clemson University in the United States in 2014 which provided a similar result. The authors tested 12 different environmental impacts on six different carrier bags, which includes the conventional plastic retail bags, NWPP and paper bags (Appendix B). They concluded that any reusable bag like NWPP will only bring a lower impact on the environment if they are used a sufficient number of times. For the case of paper bags, regardless if it is made with 100% recycled material, will still bring the highest impact compared to NWPP or plastic retail bags (Kimmel, 2014).

A life cycle assessment study done by the Environmental Agency of the United Kingdom in 2006 also shows similar claims. The paper was structured in a similar way and they studied seven different bags including LDPE, NWPP, paper and cotton bags and different environmental impacts (Appendix C). The paper states that bags that are intended to last longer would need more resources in their production and are therefore likely to produce greater environmental impacts. Thus, the conventional LDPE plastic bag would require the least amount of energy and have the smallest overall impact on the environment to dispose of (Edwards et. al, 2006).

The proposed recycled polyethylene terephthalate (RPET) bag is also present in the report by The Danish Environmental Protection Agency. RPET bags presented higher reuse times in order to leave an equivalent impact on many environmental indicators compared to LDPE bags. This is especially true for ozone depletion, terrestrial eutrophication, freshwater eutrophication and water use. For these indicators, the results of PP and RPET carrier bags were considerably higher (such as one order of magnitude) than the results obtained by the LDPE carrier bag. This occurred because RPET carrier bags require a higher environmental cost of production and this is not compensated by the energy or material recovered in disposing of them. While for the lighter LDPE carrier bag the environmental production costs are lower. (Edwards & Fry, 2018)

From these three studies, it is evident that the “more recyclable” or “environmentally friendly” carrier bags are not necessarily better for the environment as we previously thought. These studies show that by switching to an alternative to plastic bags, it will only leave a positive impact on the environment if the consumers actually reuse the said bags its designed number of times. Unfortunately, this is hardly the case that is seen in consumer behaviour.

In a paper that studied consumer behaviour trends (Kimmel & Roberts, 2014), it revealed the following trends in grocery bag usage:

- 28% of people had acquired a reusable grocery bag;
- 87% of those had used reusable bags for groceries;
- Consumers forgot to bring their reusable bags 40% of the time;

- Only 25-40% of people are reusing their NWPP (Non-Woven Polypropylene (NWPP) bags enough times (designed to be used more than 100 times) to warrant the per bag environmental impact.

This however, does not mean that we are promoting the use of plastic bags over their more “sustainable” alternatives. Instead, from these studies, we should be aware that the ultimate impact that needs to be addressed is the consumer attitude towards the carrier bags, regardless of what material it is made of. The best way to reduce a bag’s environmental impact is to reduce the number of bags produced/sold or maximise its number of time used if purchased.

Psychological intervention

Japanese Supermarket

Targeting our second research question, we found a number of studies exemplifying how psychological interventions could have the ability to influence green behaviour in consumers. Similar to the study our team designed, a study by Japanese researchers on a supermarket in Japan was conducted to determine whether a voice prompt would have an impact on the refusal rate of plastic bags among shoppers. In the control portion of the experiment, shoppers were automatically given plastic bags free of charge as normal. The week after, the intervention began where customers were asked by cashiers whether or not they would like to receive a bag. Bags were not given out unless the customer responded with “yes”, “please” or other similar responses (Ohtomo & Ohnuma, 2014). As a result, the 20% refusal rate before the intervention increased to 25% refusal rate a week after the intervention. Although the experiment was of limited scale, after 6 months of continuous intervention, the refusal rate was found to be 40%. The introduction of a voice prompt “...does not persuade people to change their behaviour, but to recall people’s

consciousness toward an action they intended to perform (Mckenzie-Mohr & Smith, 1999; Ohtomo & Ohnuma, 2014).” Rather than automatically receiving plastic bags habitually, the voice prompt gave customers the chance to consider making an alternative choice that they may not usually consider in their regular shopping experience. Although this experiment was limited to a supermarket, it demonstrates how a voice prompt could be beneficial in reducing plastic bag consumption.

To synchronize with the context and environment of what UBC cashiers have regularly been executing, our proposed study recognizes a voice prompt of slightly higher complexity than the Japanese study would be beneficial. The results of the study however, support the notion that the voice prompt method may be successful when applied at the bookstore, especially due to the fact that highly educated UBC students are the main customers and are aware about sustainability.

Israeli College Cafe

A second study supporting the value of psychological interventions is the Israeli coffee cup experiment, conducted to determine whether sustainable behaviour can be caused by multiple factors including public perception or norms (Tifferet, Rosenblit & Shalev, 2017). The study was conducted on students at a college cafe, where the influence of gender was examined in terms of having an influence on green behaviour. Students who were purchasing beverages, were offered the choice of adding 20 cents for purchase of a biodegradable cup. These cups in particular, had a design that was easily differentiable from the standard cup. Results showed that overall, 50% of students agreed to purchase a biodegradable cup. With this, it was found that

when facing a cashier of the opposite sex, there was a 46% increase of purchases for women and a 61% increase for men. One of the theories that this suggests is that “customers may have agreed to pay the premium as a way to display their prosocial, altruistic concern for the environment and for the welfare of others (Tifferet, Rosenblit & Shalev, 2017).” These findings are supportive of our hypothesis that sustainable behaviour can be influenced by a psychological intervention at the bookstore. By using voice prompts that encourage green consumption, consumers may decide on the choice that can display their social responsibility.

Voice Prompt Experiment

We conducted a baseline study at the UBC Bookstore where they operated as usual as a control to the experiment on March 9th - 11th, 2020. We had planned to conduct the experiment for one hour per day during the bookstore operation time on 16th - 18th of March 2020. Due to COVID-19, UBC had chosen to transition to online classes effective Monday March 16, 2020 for the remainder of the term. With this situation, we were unable to start the experiment.

Limitations

There are several limitations that should be considered when interpreting the results of this meta analysis. To begin, this synthesized research for plastic bag alternatives was limited to life cycle assessments (LCAs) done in the United States, United Kingdom and, Denmark. LCAs are only truly accurate for the location they describe. Accordingly, every municipality has different costs associated with waste management, changing the environmental impacts of a given material. Life cycle assessments are also only comparing what materials are conventionally available now, and this may change in the future. Further research is required in Canada if generalizations are to be made about the sustainability and environmental impacts of single use carrier bags and the other alternatives.

Additionally, the number of studies examined in this meta-analysis was a limitation. The small sample size was a result of the limited number of peer reviewed studies examining the environmental impacts of alternative carrier bags, instead mainly focusing on other forms of plastics (i.e. plastic bottles). Many studies only focused on the environmental impact of plastic bags and did not consider other factors such as how plastic may have social and economic impacts.

Lastly, the results of this meta-analysis are influenced by utilizing LCAs as a core component of our report and we recognize LCAs do not take into account all factors. For example, the life cycle assessment done by The Danish Environmental Protection Agency did not take into account marine life. Although it may seem as though our result section suggests that plastic bags are less impactful to the environment in comparison to carrier bag alternatives, we recognize the accumulation of plastic debris is still a global environmental problem due to its

durability, persistence, and abundance (Laist, 1987; Hardesty et al., 2015). The total degradation time for plastics is unknown, however it has been estimated to take over hundreds of years for many plastic products (Derraik, 2002; Hardesty et al., 2015). Thus, plastic pollution in the marine environment is a multi-generational problem (Hardesty et al., 2015). With the amount of plastic currently in the marine environment, combined with its durability, plastic is a physical hazard for wildlife that can ingest or become entangled in the marine debris (Derraik, 2002, Gregory, 2009). Plastic is still very much a problem in which we believe that focusing on its reduction is important. Although the reduction of single use carrier bags poses to be more environmentally favorable than offering an alternative at this time, there is still a lot of missing research and there is no guarantee that this option will best be continually applied in the future.

Conclusion

Unfortunately, we were unable to carry out the experiment ourselves as planned due to the circumstances of COVID-19 and the closure of the university on the week we planned to execute the experiment.

Based on the literature review we've done, we found that there is no 'right answer' between the debate of plastic single use carrier bags and alternative carrier bags. It is evident that the only way to reduce environmental impact from the use of a single use carrier bag is not to find the best bag alternative, but to reduce the consumption altogether by reusing the ones that customers have as many times as possible. We also found that psychological interventions could potentially change consumer behavior and the proposed experiment could be of benefit to the UBC Bookstore in seeing how that may be possible. This experiment may aid in the bookstore's decisions in finding the best approach to reduce the usage of single use carrier bags. We highly suggest that the bookstore carry out the experiment, if given the chance to in the future.

References

ANNEX A: Environmental Life Cycle Considerations of Bag Alternatives, 2016

Bisinella, V., Albizzati, P. F., Astrup, T. F., & Damgaard, A. (2018) "Life Cycle Assessment of grocery carrier bags." The Danish Environmental Protection Agency.

Derraik, J. G. B. (2002). *The pollution of the marine environment by plastic debris: A review*. England: Elsevier Ltd. doi:10.1016/S0025-326X(02)00220-5

Edwards, C., Fry, J. M. (2011) Life cycle assessment of supermarket carrier bags: a review of the bags available in 2006. Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH.

Gregory, M. R. (2009). Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1526), 2013-2025. doi:10.1098/rstb.2008.0265

Hardesty, B. D., Good, T. P., & Wilcox, C. (2015). Novel methods, new results and science-based solutions to tackle marine debris impacts on wildlife. *Ocean and Coastal Management*, 115, 4-9. doi:10.1016/j.ocecoaman.2015.04.004

Kubowicz, S., & Booth, M.A. (2017). Biodegradability of Plastics: Challenges and Misconceptions. *Environmental Science & Technology*, 51, 12058-12060. doi:10.1021/acs.est.7b04051

Laist, D. W. (1987). Overview of the biological effects of lost and discarded plastic debris in the marine environment. *Marine Pollution Bulletin*, 18(6), 319-326. doi:10.1016/S0025-326X(87)80019-X

Ohtomo, S., & Ohnuma, S. (2014). Psychological interventional approach for reduce resource consumption: Reducing plastic bag usage at supermarkets. *Resources, Conservation & Recycling*, 84, 57-65. doi:10.1016/j.resconrec.2013.12.014

R.M. Kimmel. (2014) "Life Cycle Assessment of Grocery Bags in Common Use in the United States." Clemson University Press.

Tifferet, S., Rosenblit, N., & Shalev, M. (2017). Promoting sustainability in a college café by opposite-sex cashiers. *International Journal of Sustainability in Higher Education*, 18(7), 1279-1290. doi:10.1108/IJSHE-01-2016-0013

UBC Campus + Community Planning. (n.d). Zero Waste Action Plan. Retrieved from: <https://planning.ubc.ca/sustainability/sustainability-action-plans/zero-waste-action-plan>

UBC Sustainability. (2014). *20-Year Sustainability Strategy For the University of British Columbia Vancouver Campus* [PDF file].

Retrieved from:

https://sustain.ubc.ca/sites/sustain.ubc.ca/files/uploads/CampusSustainability/CS_PDFs/PlansReports/Plans/20-Year-Sustainability-Strategy-UBC.pdf

Appendix

Appendix A

Table III. Carrier bags providing the lowest environmental impacts for all the environmental indicators considered. The order in which the bags are listed corresponds to the ranking of their LCA results starting from the lowest impact. Only the three lowest scoring bags are listed. The results refer to the reference flow provided in Table I.

Environmental indicator	Carrier bags providing lowest impacts
Climate change	Paper unbleached, biopolymer, LDPE
Ozone depletion	LDPE
Human toxicity, cancer effects	Paper unbleached, LDPE
Human toxicity, non-cancer effects	Composite, PP, LDPE
Photochemical ozone formation	LDPE
Ionizing radiation	LDPE
Particulate matter	LDPE
Terrestrial acidification	LDPE
Terrestrial eutrophication	LDPE
Freshwater eutrophication	LDPE
Marine eutrophication	PP, LDPE
Ecosystem toxicity	LDPE
Resource depletion, fossil	Paper unbleached, LDPE
Resource depletion, abiotic	PP, LDPE
Water resource depletion	LDPE, biopolymer

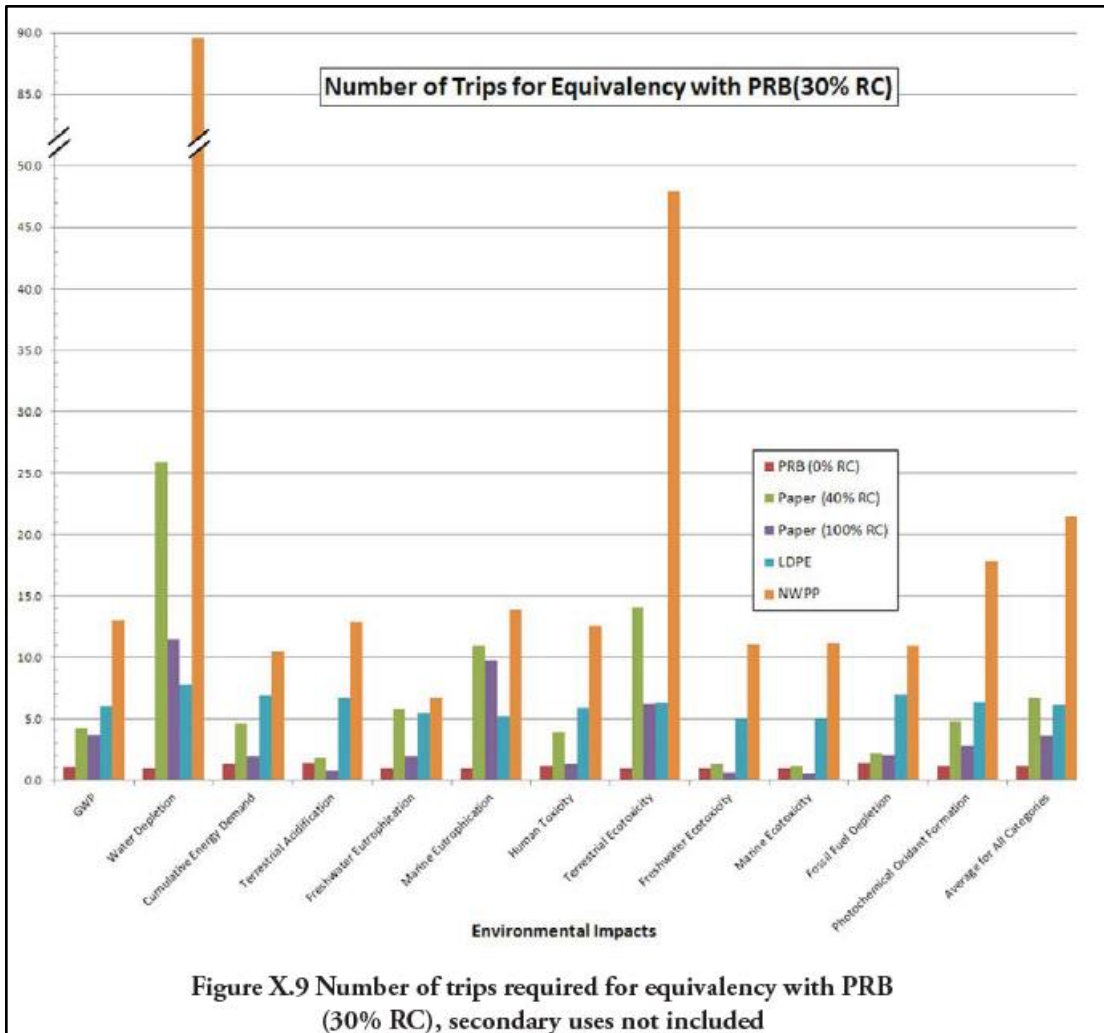
a.

Table IV. Calculated number of primary reuse times for the carrier bags in the rows, for their most preferable disposal option, necessary to provide the same environmental performance of the average LDPE carrier bag, reused as a waste bin bag before incineration. The results refer to the reference flow provided in Table I.

	LDPE average, reused as waste bin bag	
	Climate Change	All indicators
LDPE simple, reused as waste bag	0	1
LDPE rigid handle, reused as waste bag	0	0
Recycled LDPE, reused as waste bag	1	2
PP, non-woven, recycled	6	52
PP, woven, recycled	5	45
Recycled PET, recycled	8	84
Polyester PET, recycled	2	35
Biopolymer, reused as waste bag or incinerated	0	42
Unbleached paper, reused as waste bag or incinerated	0	43
Bleached paper, reused as waste bag or incinerated	1	43 ⁴
Organic cotton, reused as waste bag or incinerated	149	20000

b.

Appendix B



Appendix C

Type of carrier	HDPE bag (No secondary reuse)	HDPE bag (40.3% reused as bin liners)	HDPE bag (100% reused as bin liners)	HDPE bag (Used 3 times)
Paper bag	3	4	7	9
LDPE bag	4	5	9	12
Non-woven PP bag	11	14	26	33
Cotton bag	131	173	327	393

The amount of primary use required to take reusable bags below the global warming potential of HDPE bags with and without secondary reuse