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Reusable is Futurable

A Comparative Life-Cycle Assessment on the Environmental Performance of Reuse and Disposable Cup Systems in East Asia

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Disclaimer

This report briefing is based on a joint study conducted in collaboration between 4 Greenpeace East Asia offices above, Dr. Meike Sauerwein, Prof. Shaurat S. Chopra, and 5 East Asian reuse service providers, and is intended for informational purposes only. While we have made every effort to ensure the accuracy of the findings, we do not guarantee their completeness or applicability to other cases. Greenpeace East Asia and its affiliates shall not be liable for any consequences arising from the use or interpretation of this research.

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EXECUTIVE SUMMARY

There is increasing recognition of the environmental advantage of reuse cups as a viable solution to the pervasive throwaway practices in the Food and Beverage sector. The environmental viability of reuse cups is supported by a growing number of publications that use theoretical modelling as the dominant approach. The unclear applicability to the on-the-ground realities in the East Asia region that policymakers, businesses, and consumers navigate remains a knowledge gap of theoretical modelling.

The present research contributes to the quantitative evidence base that showcases the benefits of reuse cups by offering an in-depth comparative life-cycle assessment (LCA) analysis of an East Asia based rental reuse cup system and its disposable counterpart. By modelling the performance of the rental reuse cup system at various use frequencies, this research demonstrates the tangible environmental savings that the rental reuse cup system confers for a majority of environmental impact categories, when compared to its disposable counterpart. The most critical macro-level findings of this research are that: **(1) the rental reuse cup system's environmental performance rivals and even outshines its disposable counterpart even at lower use frequencies, (2) the production stage's contribution to the disposable cup systems' total emissions relative to other life-cycle stages is disproportionately high, and (3) the washing stage of the rental reuse cup system is responsible for a high proportion of the system's total emissions relative to other life-cycle stages.**

At the same time, this research offers a fresh approach that seeks to narrow the gap between theory and practice by centring the premise of the life-cycle inventories of the analysis on the operational experience of reuse businesses. The strength of this research lies in its context-specific approach which enables the study to reflect the on-the-ground reality of reuse service providers in East Asia's urban centres through the emphasised use of operational data from existing rental reuse cup providers in the East Asia region. While not meant as a manual on how to set up a rental reuse cup system, this piece of research offers insight into the environmental potential of reuse systems in East Asia. Furthermore, this research aims to inform policymakers, the corporate sector, and civil society on what the key considerations are for supporting rental reuse cup systems to establish a foothold, which remains a landmark in the region's transition away from disposables.

INTRODUCTION


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The problem

The global annual consumption of disposable cups amounts to a staggering 500 billion, driven by the ever-growing demand for convenience in our fast-paced lives.[1] In East Asia, specifically in regions like Hong Kong, Japan, South Korea, and Taiwan, coffee, bubble tea, and a variety of beverages that are served in disposable cups have seamlessly integrated into people's daily routines. Consequently, the sheer volume of disposable cup usage is astounding. Hong Kong residents alone discard approximately 400 million disposable, to-go coffee cups each year.[2] Japan's cafes, fast-food chains and convenience stores are responsible for 3.9 billion cups annually (as of 2016).[3] South Korea disposes of around 8.4 billion cups every year[4] while in Taiwan, the annual number of disposable cups consumed amounts to 4 billion.[5]

These numbers show a small part of a larger systemic problem — the wasteful manner in which we manage Earth's limited resources. Around 40 percent of the plastic produced annually is discarded after only one use and 80 percent of the 8 million tons of plastics that enter the ocean annually are disposable plastic products.[6,7,8]

In other words, plastics have flooded our planet. They pollute from the moment they are extracted as fossil fuels, by releasing an array of toxic substances into the air and water, along the way impoverishing communities of a healthy living environment, destroying biodiversity, and fueling the climate crisis at each stage of their life-cycle.[9]

This production and consumption of disposable plastics are threatening land and ocean wildlife as well as human health and well-being. Many animals, across different species, are affected by plastic accumulation, which can be ingested and block airways and digestive systems.[10,11] There is also growing evidence that harmful chemicals can move from ingested plastic into animals' tissues, and eventually enter the human food chain.[12,13,14,15] When plastics break down into tiny particles called micro- or nanoplastics, they become even harder to detect and remove from the water we drink, or the air we breathe.

While recycling has long been thought to be the solution to the plastic crisis, the reality is that globally only 9% of plastic waste is recycled.[16] Even if higher recycling rates would be achieved, the inherent problem, that the more plastics are recycled the more toxic they become and that recycling rounds are limited, remains.[17]

However, eliminating plastic without addressing the prevailing disposable, throwaway culture can lead to regrettable substitutions that are equally or even more environmentally harmful. Disposable alternatives often come at a higher cost and bring forth an array of environmental impacts, from deforestation to waterway pollution, ozone depletion or ocean acidification, and must not be automatically considered as preferable merely by their avoidance of plastic.[18]

It becomes evident that neither recycling efforts nor disposable alternatives can effectively address this crisis. Instead, the search for truly circular alternatives, which reduce our dependence on harvesting ever more of the Earth's finite resources, has highlighted reuse cups and containers as a promising solution.

What is a reuse system?

A reuse system is an established system that allows packages to be used and returned several times to fulfil the same purpose. The package is designed to be durable and is owned by the system (producer or third party) and loaned or provided to the consumer. The actual return and reuse are made possible by adequate logistics and promoted by suitable incentive systems, usually a deposit.[19,20]

Reuse

The Ellen MacArthur Foundation has categorised different **reuse systems**, among which are customers bringing their own containers (BYOC), **stores providing reuse containers, or third-party providers offering reusable containers to stores (Rental Reuse).**[21] This study focuses on this last approach, reuse systems, where reuse service providers supply cafes and other Food and Beverage outlets with reuse cups and handle the reverse logistics, including distribution, collection, cleaning, and maintenance. The implementation of these types of reuse systems can vary significantly in terms of user registration procedures, cup-tracking and collection systems, and collaborations with other businesses depending on their local context.

Rental Reuse	BYOC
Restaurants and cafes partner up with a reuse service provider to provide reuse options to their customers. Customers borrow, use, and return the reusable cups to designated spots, and the reuse service provider collects and washes the dirty cups and delivers the cleaned cups to the restaurants and cafes in a "reverse logistics" process.	BYOC stands for Bring Your Own Container and is a customer-led practice where users bring their own cups in place of using a disposable cup. In the BYOC system, the customers do their own washing and transportation and businesses might offer an economic incentive to entice user participation.

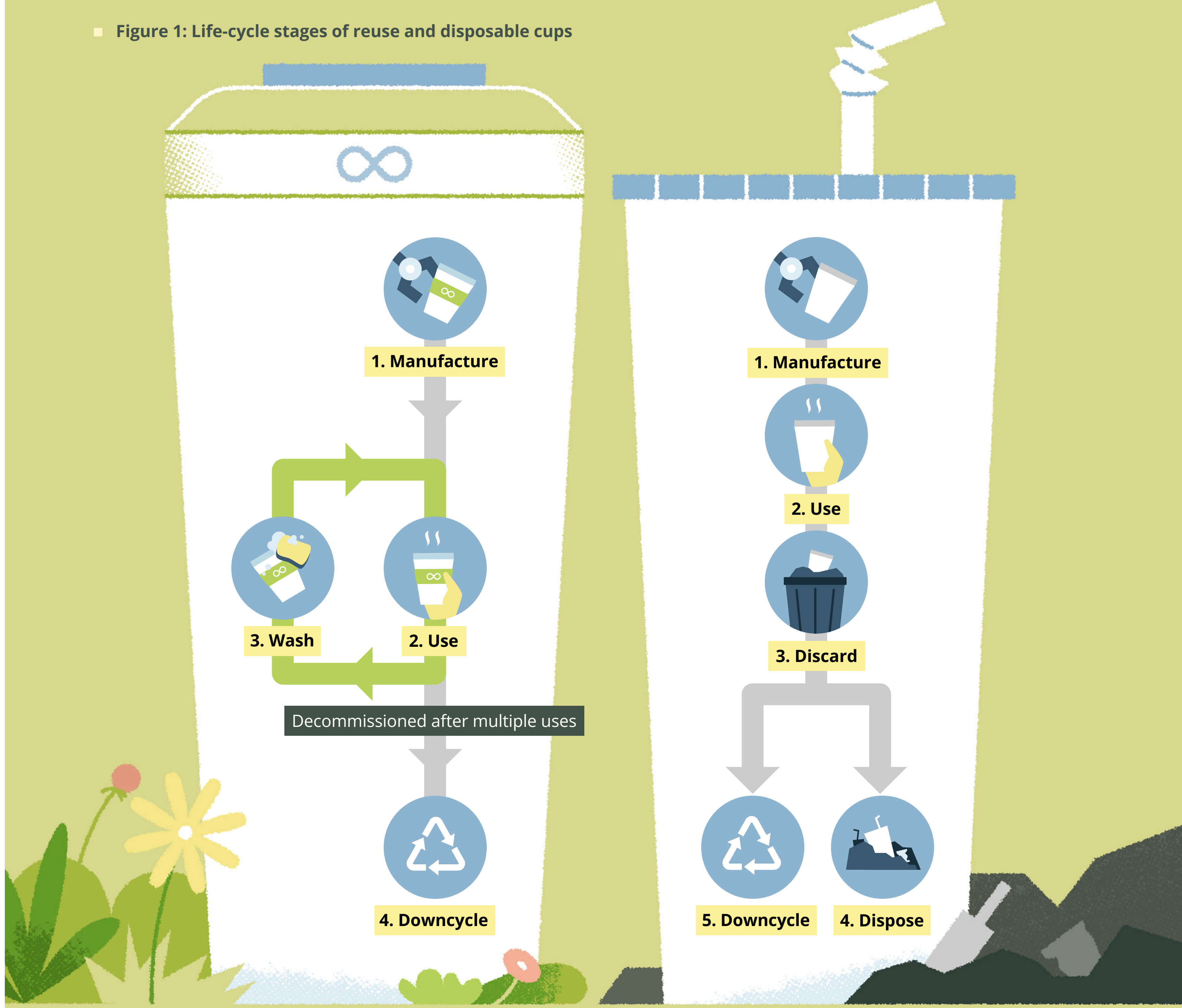
Although some studies have explored the environmental benefits of reuse systems compared to disposable their disposable counterpart in the European context, no adequate initiatives have been undertaken in East Asia to date.[22,23] However, the potential for success in this region is immense, as the demand for sustainable alternatives is increasing. People and businesses eagerly await the introduction of rental reuse cup systems that could significantly reduce environmental impacts.

This report aims to shed light on the potential of reuse systems as a sustainable alternative to disposable cups by conducting a comprehensive LCA comparing the disposable cup system to a rental reuse cup system modelled after real-life data. Data from emerging reuse service providers in four major cities within the East Asia region, Busan, Hong Kong, Taipei, and Tokyo, will be utilised to construct a model that examines each stage of the rental reuse cup system, from its inception ("cradle") to the cups' final disposal ("grave"), providing invaluable insights into its environmental impact and effectiveness as an eco-friendly solution.

REUSE VS. DISPOSABLE

The reuse and disposable cups go through different pathways from manufacture to the final disposal stage. The reuse system shown on the left allows the cups to undergo multiple rounds of reuses before the cups are decommissioned. Disposable cups on the other hand are only used once before they are discarded and enter end-of-life pathways.

Figure 1: Life-cycle stages of reuse and disposable cups



Reuse system | **Disposable cup system**

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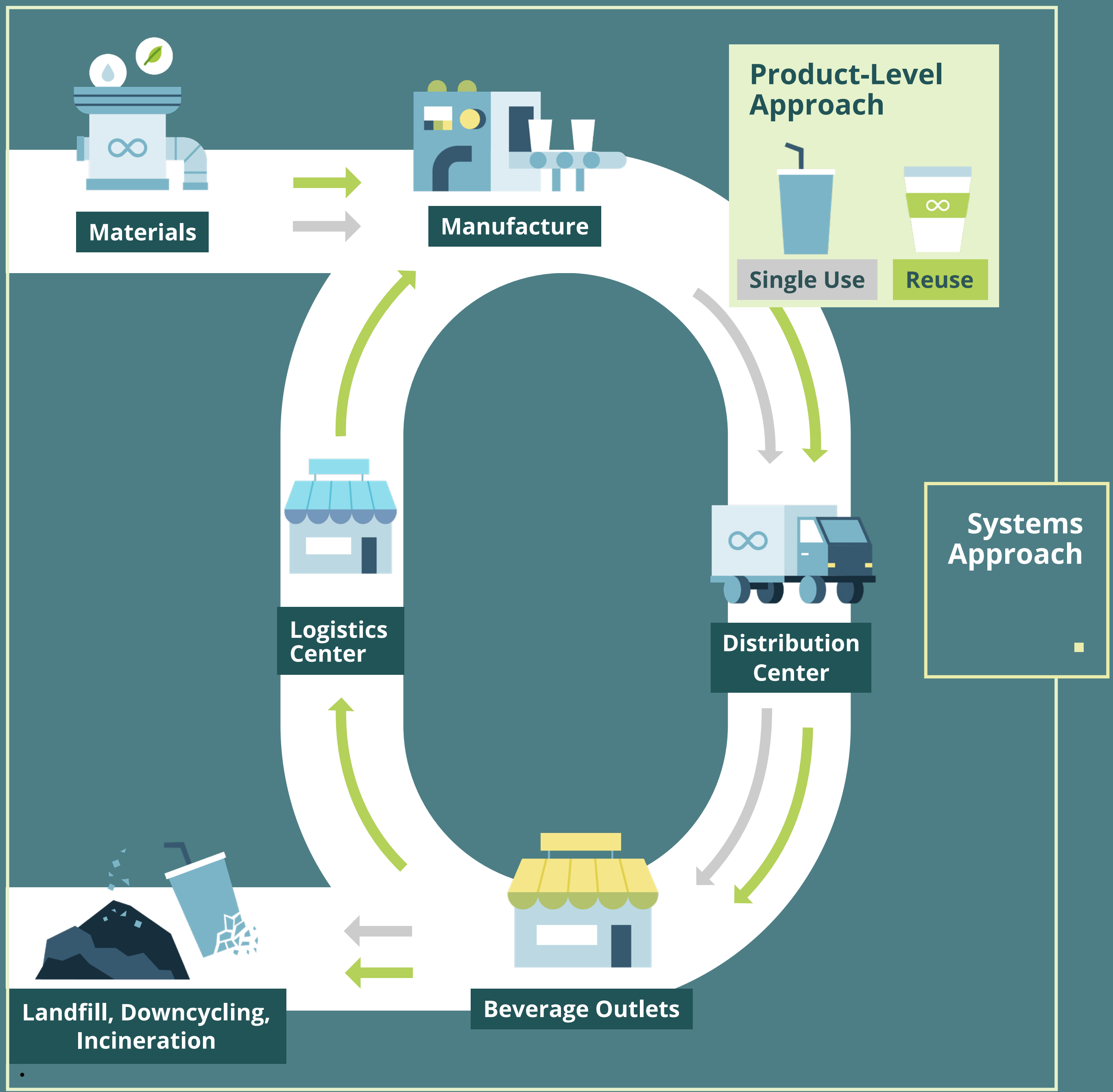
METHODOLOGY

The study uses the internationally standardised LCA analytical framework as outlined in ISO 14040 and ISO 14044, primary data from service providers of the East Asia region, and secondary data from the ecoinvent database.

Study description

This study models and assesses the environmental performance of reuse cups and compares it with the environmental footprint of disposable cups. A "Systems Approach" is taken which considers all the actors and processes and quantifies the cradle-to-grave impacts of both the rental reuse cup system and the disposable cup system (see Figure 2 below). Rather than using the much narrower "Product-Level Approach" that only considers the physical product of the cups, the cradle-to-grave approach considers the full range of impacts from the initial raw materials (the "cradle") to the final disposal of waste materials (the "grave") and all the life-cycle stages and processes in-between.

Figure 2: Product-Level and Systems Approach in relation to life-cycle stages of reuse and disposable cups



A Systems Approach considers all the steps and processes necessary for the cup to end up in our hands, rather than just the cup itself.

The methodology of this study identifies the resources (water, materials, energy, and etc.) consumed, the emissions caused, and the waste generated throughout the entirety of the life-cycle, from raw materials, transport, manufacture, consumer-use phase, and reuse phase (for reuse cups) to end-of-life disposal.

What is distinctive about this study is that the LCA analysis is actualised on a cross-sectoral collaboration among academia, the civic sector, and reuse businesses. The design of the study puts a pronounced emphasis on the use of real-life operational data from existing reuse service providers in the East Asia region wherever possible. The specific material requirements and the conditions of energy and waste disposal infrastructure in each jurisdiction are embedded in the study in a process of localisation in recognition of vast infrastructural variations in the region (refer to Figure 3).

LCA

The types of emissions can vary, and the emissions associated with transporting reuse cups from port to washing facility differ from the emissions from washing dirty cups with warm water and detergent. Similarly for disposable cups, the production-related and final disposal-related emissions differ. LCAs address this by grouping together different emissions that cause the same impact and describing the impact in one single metric that is easy to compare and contrast.

Localisation of the LCA

The localisation of the LCA analysis to the operational and infrastructural realities in Busan, Hong Kong, Taipei, and Tokyo allows for a context-specific assessment that grounds the LCA analysis on the actual conditions, opportunities, and barriers of current and emerging rental reuse cup operations. The localisation process takes into account energy generation and procurement (input) and waste disposal pathways (output) as elements of a reuse system that showcase significant variability among cities and for which a uniform assessment across cities is unsuitable. Whether the energy that a rental reuse cup system consumes is from coal, gas, or green energy is a significant contributory factor to the environmental performance of the system, and likewise for whether the waste is landfilled, downcycled, or incinerated (see Appendix I).

Impact categories

Impact categories represent different aspects of environmental impacts that are assessed in the analysis. These impact categories help to understand the potential effects of reuse cups and disposable cups on the environment. The following 16 impact categories have been chosen in accordance with the commonly applied environmental impact assessment method ReCiPe. The impact categories relate to the United Nations' Sustainable Development Goals (SDGs). Refer to Table 1.

Table. 1: The 16 LCA environmental impact categories and their relationship to Sustainable Development Goals (SDGs)[24]

	Impact Category	Description
13 CLIMATE ACTION	Climate change	Emissions of hydrocarbons, CO_2, CH_4, and etc that cause global warming
	Fossil depletion	Consumption of non-renewable fossil fuels
	Ozone depletion	Emissions that deplete the ozone layer
3 GOOD HEALTH AND WELL-BEING	Human toxicity	Emissions of toxic substances that negatively impact human health
	Particulate matter formation	Emissions of particles to the air that cause respiratory impacts in humans
	Photochemical oxidant formation	Emissions of gases that affect photochemical ozone formation
	Ionising radiation	Emission of radionuclides that are damaging to humans and ecosystems
6 CLEAN WATER AND SANITATION	Water depletion	Consumption of water
	Freshwater ecotoxicity	Emissions that cause toxic stress to the ecosystem
14 LIFE BELOW WATER	Freshwater eutrophication	Emissions that alter pH and nutrient availability in freshwater ecosystems
	Marine eutrophication	Emissions that alter pH and nutrient availability in marine ecosystems
	Marine ecotoxicity	Emissions that cause toxic stress to marine ecosystems
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Metal depletion	Consumption of metals
15 LIFE ON LAND	Agricultural land occupation	Occupation and transformation of natural land to agricultural plots
	Terrestrial acidification	Emissions that alter pH of terrestrial ecosystem
	Terrestrial ecotoxicity	Emissions that cause toxic stress to terrestrial ecosystems

Data sources

Primary data were collected from five reuse service providers that operate in select urban centres of East Asia: Busan, Hong Kong, Taipei, and Tokyo. They were provided with a comprehensive data-collection template in which they detailed the operational elements of their businesses and described their material, energy, and labour consumption. The main data-collection channels were questionnaires, flowcharts, data records, photographic or video evidence, operation manuals, and interviews. These primary data allowed for the quantification of the following life-cycle stages: production, delivery of cups to the reuse service provider, pre-cleaning and distribution, distribution to customers, use and collection logistics, cleaning, and end-of-life.

Secondary data were sourced from online channels and provided information about the physical and organisational infrastructure and supporting services in each of the four urban centres in which the analysis was carried out. Governmental statistics, regulatory frameworks, transport and logistics cost structures, and scientific literature were the key sources.

Study scope

The study is about the rental reuse cup system, one of many ways to set up a reuse system. In the rental reuse cup system, a reuse service provider organises the acquisition and final disposal of the reuse cups, provides the reuse service to Food and Beverage outlets and their consumers, and arranges the reverse logistics between reuses. The target users are consumers of made-to-order beverages, e.g., coffee and tea at a coffeehouse or bubble tea.

The rental reuse cup system involves minimal technology-enablement and mechanisation in line with the operational constraints of small- to medium-scale reuse service providers of reuse solutions. The dispensation of clean reuse cups and the collection of used reuse cups occur over the counter at the Food and Beverage outlets.

The system boundary starts with raw materials production and ends with the final disposal of waste materials. Impacts from potential downcycling processes with the final disposed materials are not considered.

For best comparability, a reuse polypropylene cup is compared with a disposable cup system composed of 50% polyethylene-lined (PE-lined) paper cups and 50% polyethylene-terephthalate (PET) cups (50/50 mix).[I,II] All cups measure 16 fluid ounces (473 ml).

During the use phase, users are assumed to not require additional travelling to return the reuse cups due to the density of East Asia's urban centres. 2% of users are assumed to rinse the reuse cups prior to returning them, based on estimation from service providers.

Disposable cups are used once and tossed while reuse cups are assumed to have a lifespan of three years[III], irrespective of the number of uses. Reuse cups are decommissioned after three years in the reuse system.

The study considers three use scenarios based on the number of drinks that are served in the reuse cup per year. 20 reuses per year is the approximate average use frequency among reuse service providers in East Asia at the time of this study.

~ 20 reuses
Light-use

~ 40 reuses
Medium-use

~ 60 reuses
High-use

per year over the course of three years.

The analysis of the environmental performance of disposable cups follows the assumption that the disposable cups are imported and reach the beverage stores via a local logistics centre, and are disposed of along the average waste disposal pathways in each jurisdiction. The reuse cups are assumed to be manufactured locally.

The functional unit is per beverage served; one disposable cup representing one beverage served is compared against one reuse of a reuse cup.

[I] Recycled polyethylene terephthalate (rPET) is used in Hong Kong and Tokyo, and virgin polyethylene terephthalate (PET) is used in Busan and Taipei. South Korea and Taiwan's regulations did not permit the use of rPET in the production of disposable cups at the time of this study.

[II] The 50/50 composition reflects the consumption of disposable cups in the East Asia region's made-to-order beverage sector, based on surveys that Greenpeace East Asia conducted in Hong Kong and Tokyo.[25,26]

[III] The approximated lifespan of the reuse cups is three years. It is conservative and set in order to define a finite time scope for the LCA analysis. Depending on use, logistics, and management, reuse cups can have a longer lifespan.

Table 2: Rental reuse cup system's systems setting

The following metrics define the rental reuse cup system:

10,000 reuse cups

3 years per operational cycle

3 years lifespan of reuse cups

7 % loss rate per year[IV]

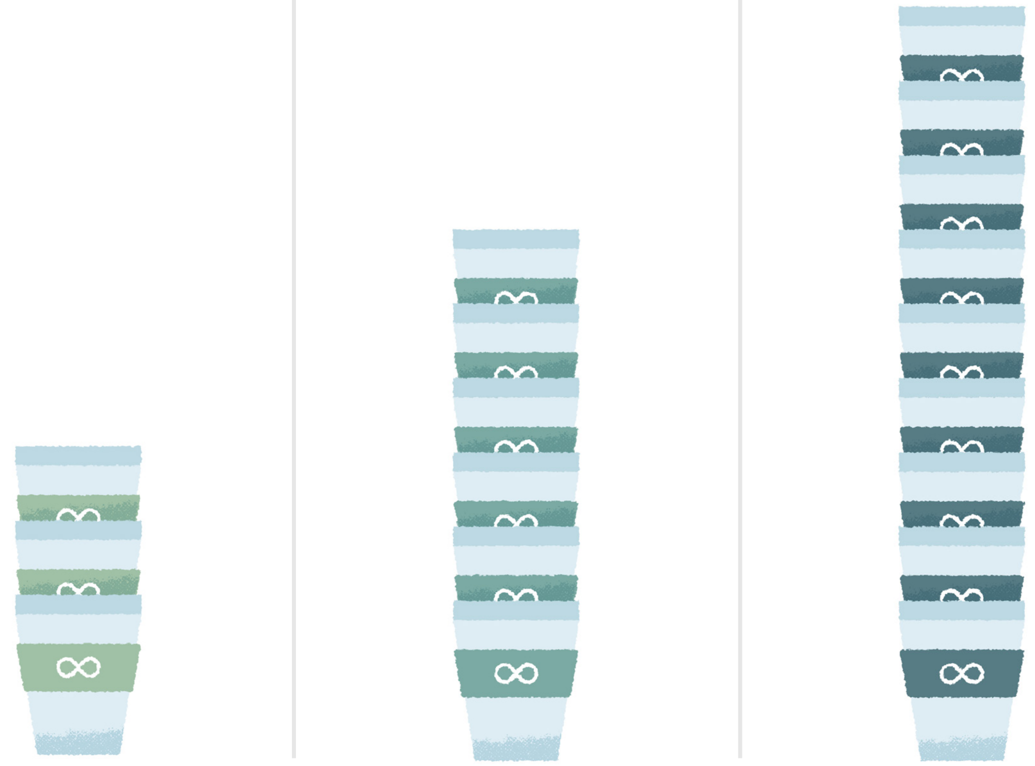
40 stores

1 washing facility

1 reuse service provider

Number of drinks served per operational cycle (3 years):

Light-use	Medium-use	High-use
563,143	1,126,286	1,689,429



For the full systems setting metrics, please refer to Appendix II and Appendix III

[IV] The reuse service provider is assumed to lose 7% of its reuse cups every year. About half of these losses come from unreturned cups, about one-quarter from cups that are returned broken, and one-quarter lost due to damage during the handling process or due to being sorted out of service if they are too worn out to enter another reuse cycle.

Figure 3: Methodology flowchart

1
Explore how our rental reuse cup service provider partners operate in East Asia

2.a
Model a reuse system framework that characterises East Asia's rental reuse service providers (refer to Figure 4)

2.b
Model the characteristic disposable cup system in East Asia based on secondary data (refer to Figure 5)

3
Gather and insert real-life operational data from rental reuse service providers into the reuse system framework

4
The LCA calculation framework converts the operation and material use into emissions and impacts for each Impact Category

→ LCA results for East Asia region for disposable and reuse systems

5
Localise energy and waste disposal infrastructure-related emissions in urban areas

→ LCA results for Busan, Hong Kong, Taipei, and Tokyo for disposable and reuse systems

6
Perform additional analysis on impacts of each process of the reuse system

→ **Results:** Scenario modelling: Life-cycle stage contributions to environmental impact

7
Compare environmental performance scores of rental reuse cups and disposable cups

→ **Results:** Comparative LCA analysis between disposable and reuse systems

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Figure 4: Rental reuse cup system's diagram and boundary

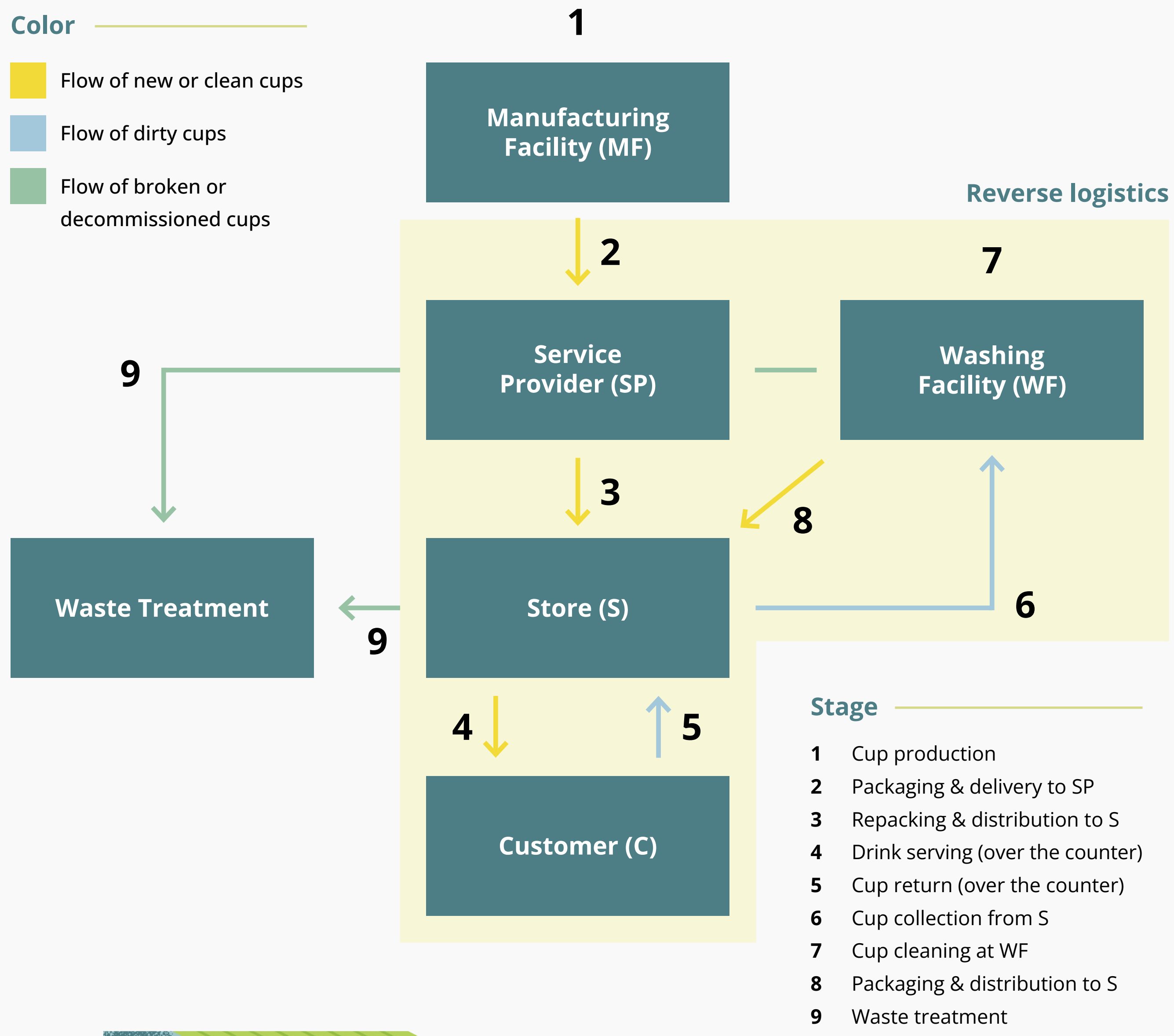
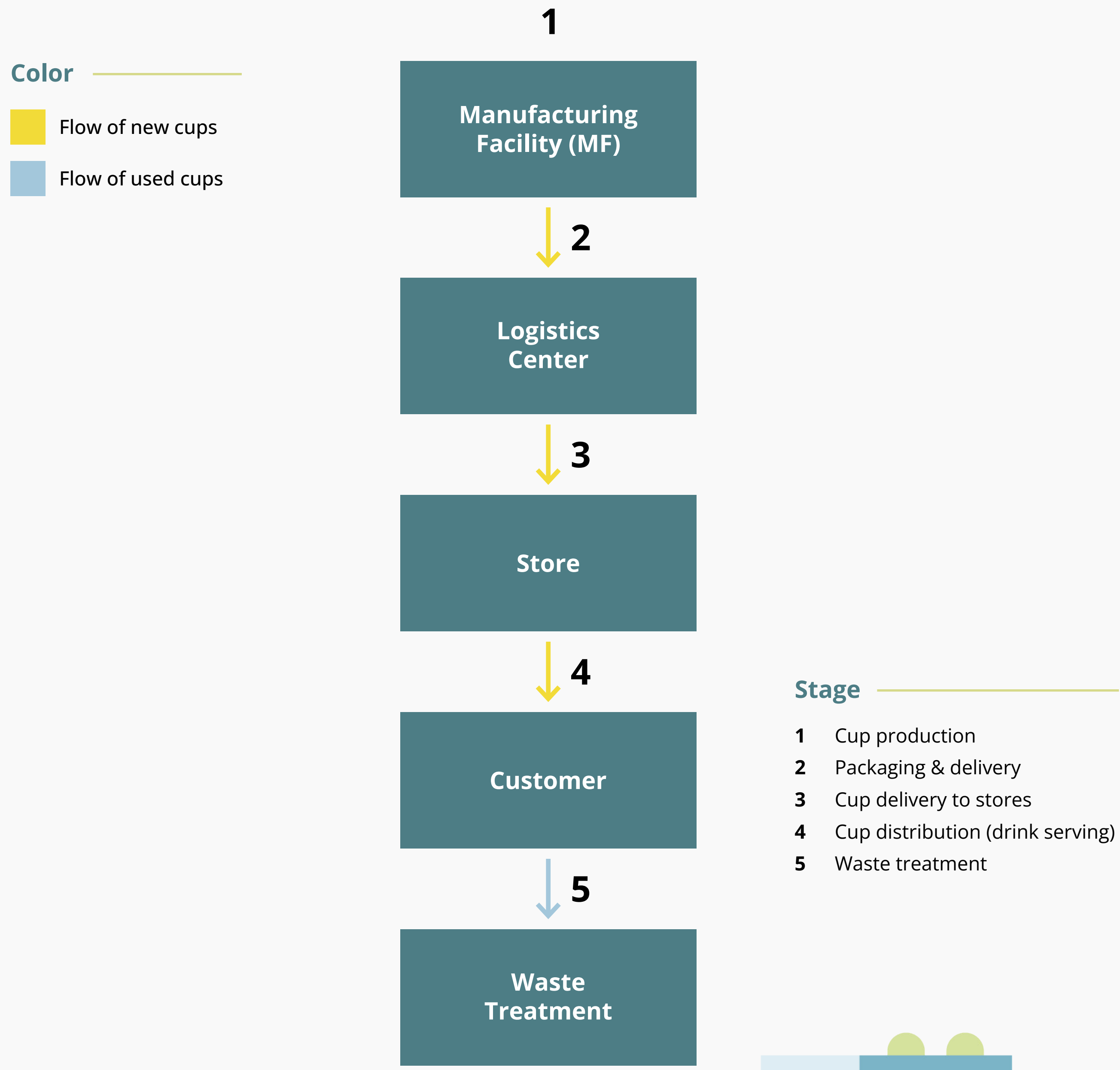


Figure 5: Disposable cup system's diagram and boundary



Limitations

The rental reuse cup system in this research and the data obtained from the five rental reuse service providers are not representative of the entire reuse ecosystem that comprises various setups and business models. The operational dimensions of the studied model are specific to the rental reuse service volume that a reuse service provider can operate given the assumed systems settings. The operational dimensions of the system's other stakeholders such as the stores and washing facilities have not been explicitly defined. The applicability of the findings of this study does not extend to all types of rental reuse cup services; rather, the findings of the study are meant as an examination of a particular setup of the reuse system. Only impacts within the boundaries of the system are quantified within the LCA framework, while indirect, downstream impacts of the emissions outside the systems boundaries are excluded. The list of indirect impacts is long and includes impact on fisheries, biodiversity, industry, livelihoods, and impact of climate change on individuals and communities.

RESULTS

Comparative LCA analysis between disposable and reuse systems

By and large, **the results of the LCA analysis reveal that the rental reuse cup system has an environmental edge over the disposable cup system with lower emissions and lesser impacts. The main positives of the rental reuse cup system are the reduction in greenhouse gas emissions, the lessened impact on freshwater and marine ecosystems, and the improved air quality performance.** The results show that a higher use frequency generally leads to a better performance and increasing adoption and utilisation rate of reuse cups within the system would enable us to unlock the full environmental potential of the reuse system.

The disposable cup system outperforms the rental reuse cup system in select environmental impact categories at one or multiple use intensities of the system's setting of this study, noticeably for Photochemical Oxidant Formation, Fossil Depletion, and Freshwater Eutrophication. These depletions and emissions should be key considerations for stakeholders setting up a rental reuse cup system. Photochemical Oxidant Formation can be addressed by introducing transport options that do not entail tailpipe emissions, whilst increasing use intensity and choosing eco-friendly chemicals (e.g., for the washing process) can curb Fossil Depletion and Freshwater Eutrophication, respectively.

The results for seven select environmental impact categories at each of the three use frequencies are highlighted in the next section, representing how rental reuse and disposable cup systems affect the planet's ecosystems, human health and well-being, and the use of natural resources (Table 3). For the full range of the results, please refer to Appendix IV.

The numbers show the magnitude of difference in emissions or impacts between a one-time use of a disposable cup compared to one reuse of a reuse cup. A number of 20, for instance, represents that choosing a reuse cup offers a 20% decrease in the respective impact category compared to opting for a disposable cup. Green cells signify that reuse cups perform better than disposable cups and grey cells represent the opposite.

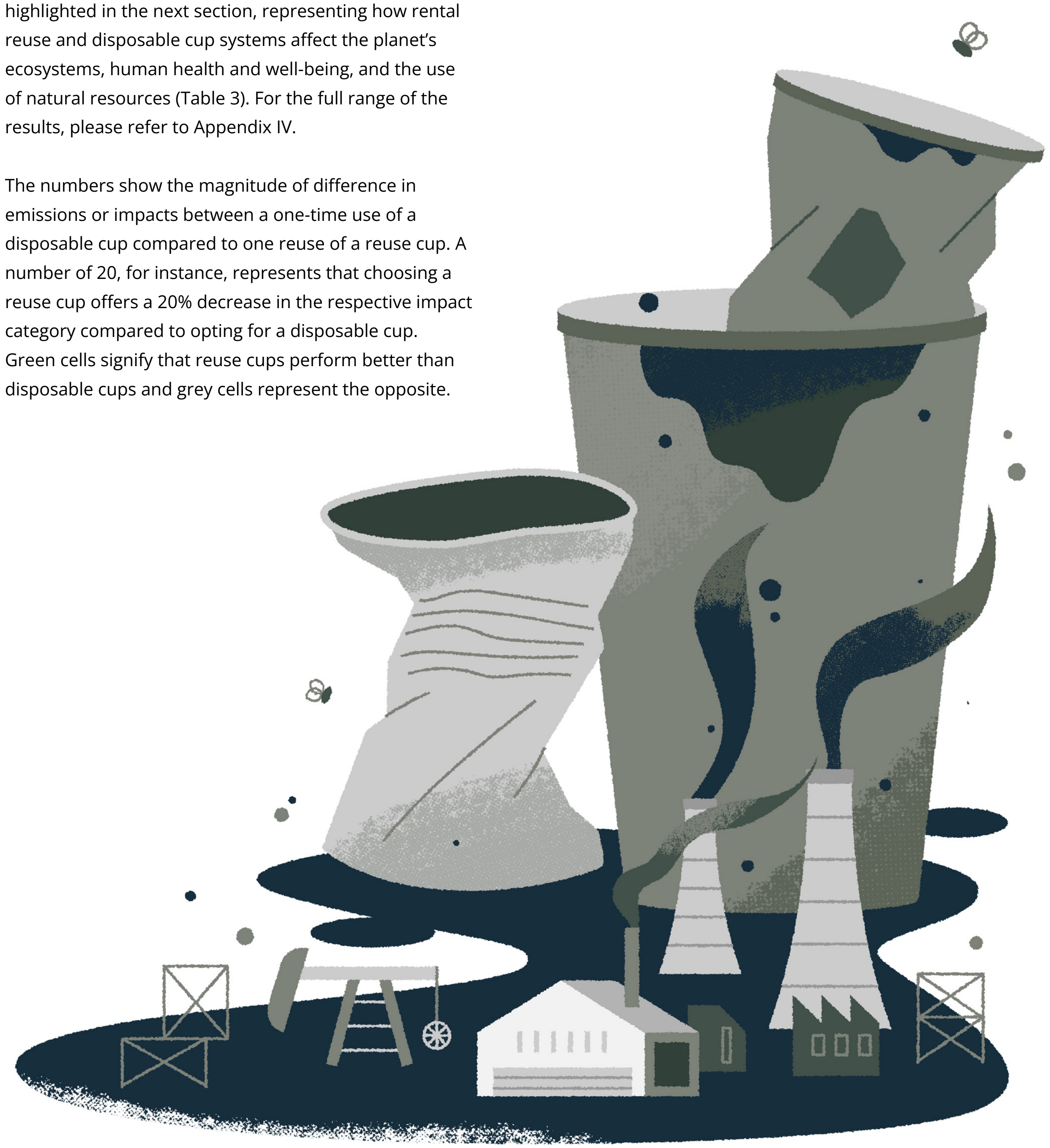


Table 3: Percentage improvement of rental reuse cup system's environmental performance for seven select environmental impact categories, compared to disposable cup system

Reuse cups are better

Disposable cups are better

1,4-DCB is a toxic compound found in pesticides, insecticides, and degreasers for car parts. It is used as a reference unit and the emissions of other toxic compounds are adjusted to the toxicity-level of 1,4-DCB.

Toxicity assessments are based on tolerable concentration guidelines for air and water for ecosystems, and on tolerable and acceptable daily intake for human beings.

Climate Change (emission of CO_2 -equivalents)

	Light-use	Medium-use	High-use
East Asia	14.5	22.6	24.6
Busan	36.6	**42.4**	44.3
Hong Kong	15.5	22.4	24.7
Taipei	25.4	31.7	33.8
Tokyo	18.3	27.2	30.2

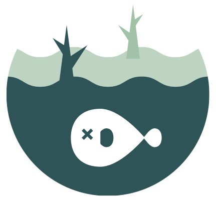
In the medium-use scenario; everytime you swap out a disposable cup with a reuse cup in Busan, you are emitting 42.4 % less CO_2!

Particulate matter formation (emission of PM10-equivalents)

	Light-use	Medium-use	High-use
East Asia	16.4	21.8	24.0
Busan	50.3	54.9	56.4
Hong Kong	17.8	23.5	25.4
Taipei	36.0	41.0	42.7
Tokyo	42.5	48.3	50.2

Human toxicity (emission of 1,4-DCB-equivalents)

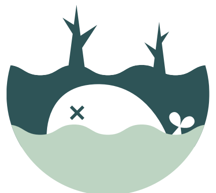
	Light-use	Medium-use	High-use
East Asia	28.6	34.1	34.1
Busan	32.2	36.1	37.4
Hong Kong	25.9	31.6	33.6
Taipei	19.6	24.0	25.4
Tokyo	48.9	54.8	56.7



Freshwater ecotoxicity (emission of 1,4-DCB-equivalents)

	Light-use	Medium-use	High-use
East Asia	20.5	20.5	27.2
Busan	23.3	27.0	28.3
Hong Kong	25.7	31.5	**33.4**
Taipei	7.8	11.7	13.0
Tokyo	21.5	27.3	29.2

When use intensity increases, the environmental performance of the reuse system becomes even better.



Marine ecotoxicity (emission of 1,4-DCB-equivalents)

	Light-use	Medium-use	High-use
East Asia	20.9	28.1	28.1
Busan	23.2	27.1	28.4
Hong Kong	26.7	32.6	34.6
Taipei	7.3	11.2	12.5
Tokyo	25.1	31.2	33.2

South Korea and Taiwan's regulations only allow virgin PET to be used in the production of disposable plastic cups while the other regions allow the use of recycled PET, leading to the disposable PET cups in Busan and Taipei to have the highest fossil fuel demand and for the Busan- and Taipei-based reuse system to perform comparatively better than their disposable counterpart.

Fossil fuel depletion (depletion of fossil fuel)

	Light-use	Medium-use	High-use
East Asia	-14.3	7.1	7.1
Busan	**47.3**	54.8	57.3
Hong Kong	-12.3	2.4	7.2
Taipei	**42.2**	50.4	53.1
Tokyo	-19.6	-2.9	2.7

Water depletion (use of water)

	Light-use	Medium-use	High-use
East Asia	33.8	35.7	35.7
Busan	33.3	35.9	36.8
Hong Kong	34.7	36.0	36.5
Taipei	36.9	39.3	40.1
Tokyo	35.8	38.2	39.0

Life-cycle stage contributions to environmental impact

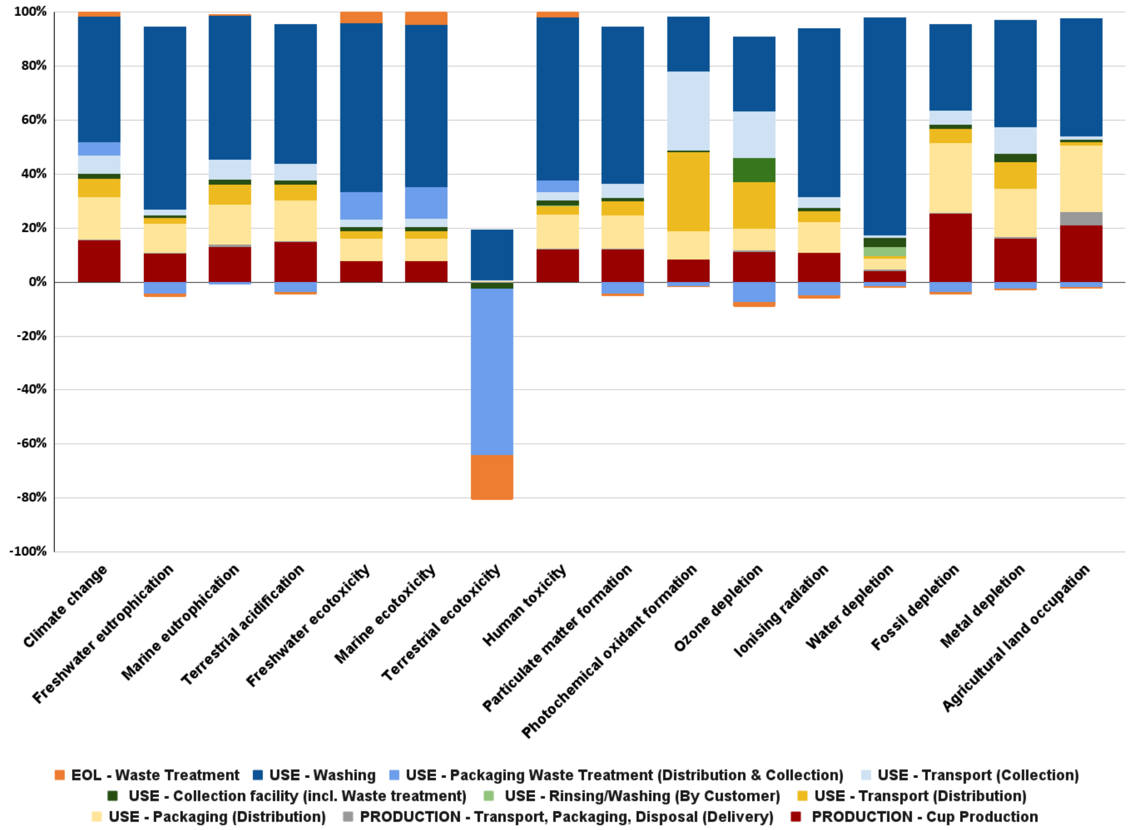
The contribution of each life-cycle stage to the cumulative environmental impact for both the disposable and rental reuse cup systems is disproportionate. For the rental reuse cup system, the washing stage is the dominant source of emissions for all impact categories with the exception of Photochemical Oxidant Formation. Sustainability-focused efforts for the rental reuse cup system should therefore keep a keen eye on solutions to optimise the washing stage in order to accrue further environmental savings. **The preponderance of the impacts caused by the production stage for both disposable PET/rPET and PE-lined paper cups** is noteworthy as production represents the dominant emission source across all 16 impact categories. The emissions from the end-of-life pathways of the disposable cup system are comparatively smaller. The outsized contribution of the production stage highlights the impactful potential of cutting emissions by reducing the number of disposable cups produced.

The following four plots represent the distribution of environmental impact across the life-cycle stages of the disposable and reuse cup systems. For the rental reuse cup system, the light-use use scenario is considered. For the disposable cup system, the three cup material types, namely (virgin) PET, rPET plastic cups and PE-lined paper cups, are analysed separately in order to illustrate the contribution of material type to environmental impacts.

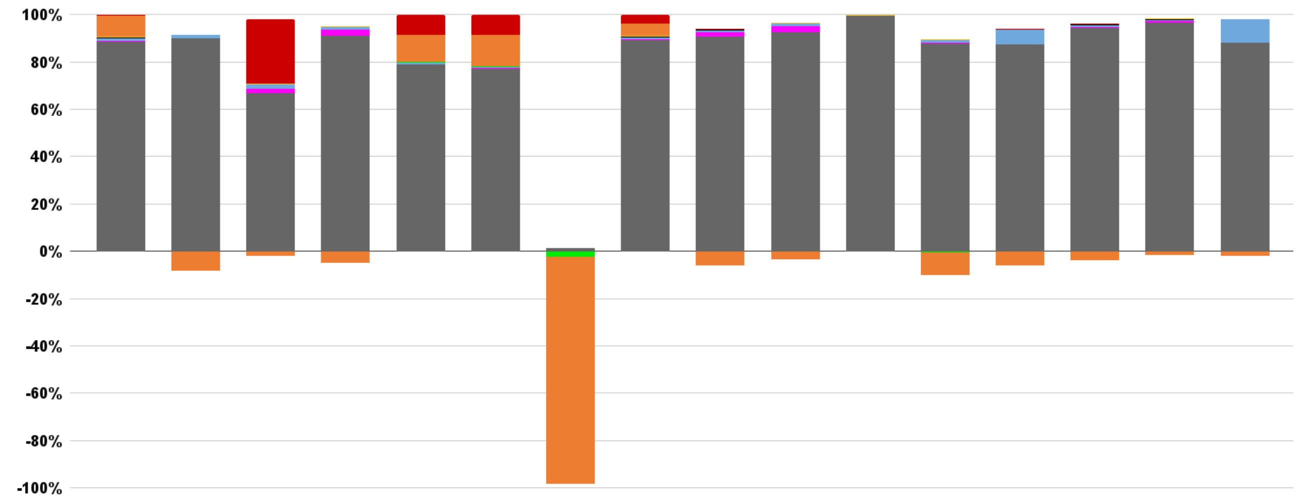
The height of each segment of the bars corresponds with the share to which the life-cycle stage contributes for the environmental impact category. The area above 0% relates to the amount of emissions that the life-cycle stage causes, whereas the area below 0% denotes emissions that are averted or the repurposing of outputs that are credited back to the system. Waste-to-Energy processes that feed electricity back to the local grid in place of using the conventional fuel-mix are an example of repurposed outputs that are credited back to the system.

Figure 6: Analysis of distribution of individual life-cycle stages to total emissions of light-use rental reuse system (i), and disposable virgin-PET (ii), recycled-PET (iii), and PE-lined paper cup disposable systems (iv) along 16 environmental impact categories for the East Asia region

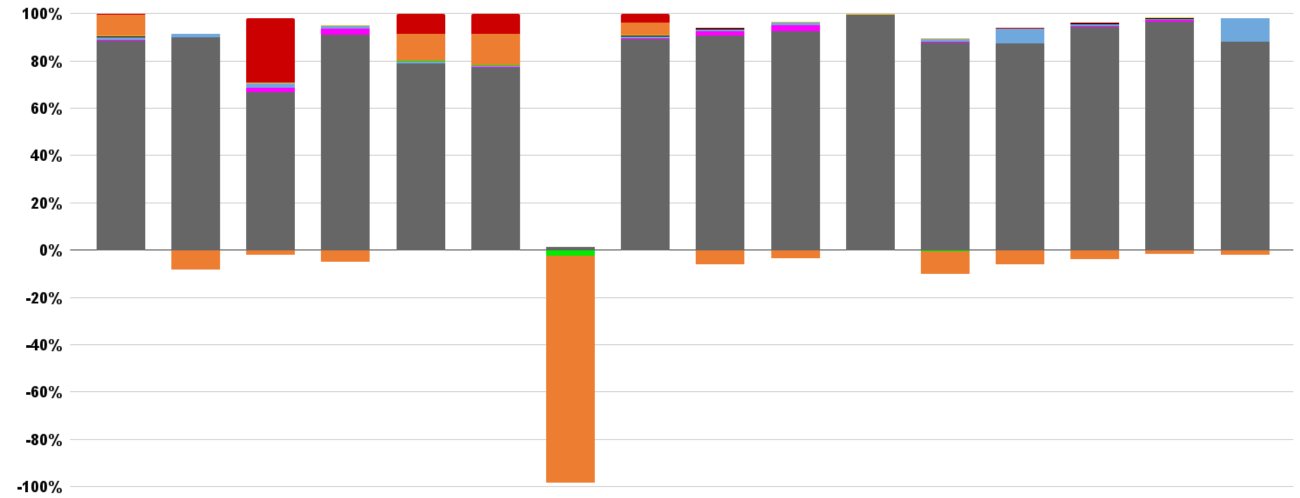
(i)



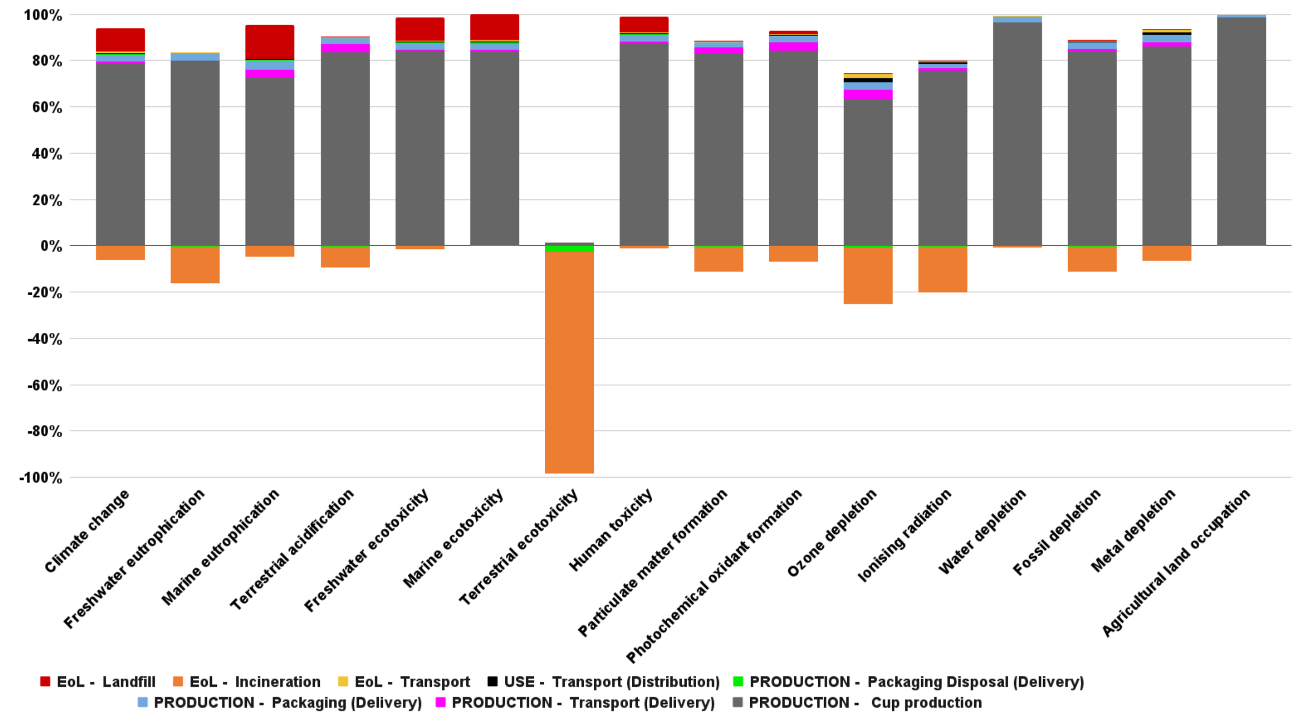
(ii)



(iii)

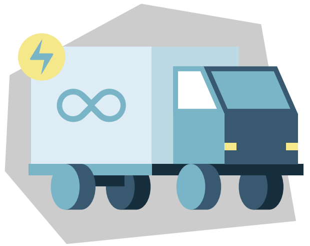


(iv)



Scenario modelling

The sensitivity of each component of the rental reuse cup system operation to the total emissions of the system is explored through scenario modelling by creating alternative scenarios to the systems setting outlined in Appendix II. The scenario modelling analysis identifies components of the rental reuse cup system with an elevated risk of unchecked emissions, but also components with the highest potential for system optimisation and the reduction of environmental impact. The key findings of the scenario modelling analysis are summarised below:



In the reverse logistics stage, the transport of clean and dirty cups among the stores, the washing facility, and the storage site can be a big source of emissions which can be addressed by the use of electric vehicles, route optimisation, and integrated logistics for delivery and collection.

In the use stage, rinsing or washing of dirty reuse cups with warm water and detergent before returning can cause unnecessary additional greenhouse gas emissions.

In commercial washing facilities, the type of detergent, whether it is eco-friendly or not, can have a big impact on toxic discharge and the environment.

Vending machines for cup dispensation and collection can be energy-intensive due to their high electricity consumption.

In the washing stage, the energy efficiency of the equipment and the washing throughput are key aspects to optimise environmental performance.

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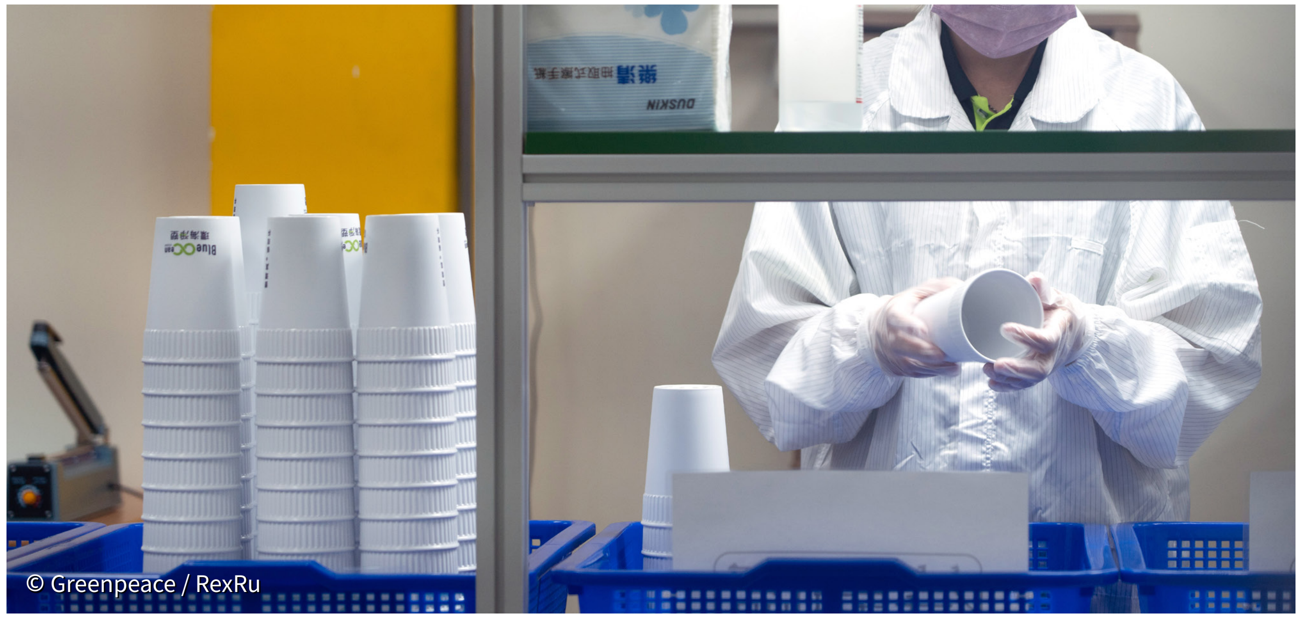

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Visualising potential environmental savings

From the results of this study, the environmental savings that could be achieved through the transition to a reuse system were quantified by first determining the difference in environmental performance between disposable cup (50/50 mix) and reuse system (high-use use frequency scenario) on a per-one use then multiplying the environmental savings with a specified quantity of cups based on the consumption patterns in the four East Asian regions explored in this study. The purpose of the potential environmental savings quantification is to depict the benefits of using the rental reuse cup system in a tangible and visual manner. By using both the East Asia and the region-specific results, the quantification enables the four regions to be viewed separately, as well as combined into a broader East Asia regional analysis. The quantification assumes that the rental reuse cup system operates within the defined system settings of this research (Table 2).

East Asia

If a total number of 10 billion cups consumed in the four regions of this study were to be served in reuse cups, we would save:

Hong Kong

In Hong Kong, residents discard approximately 400 million disposable, to-go coffee cups each year. If this number of drinks were to be served in reuse cups, we would save:

Japan

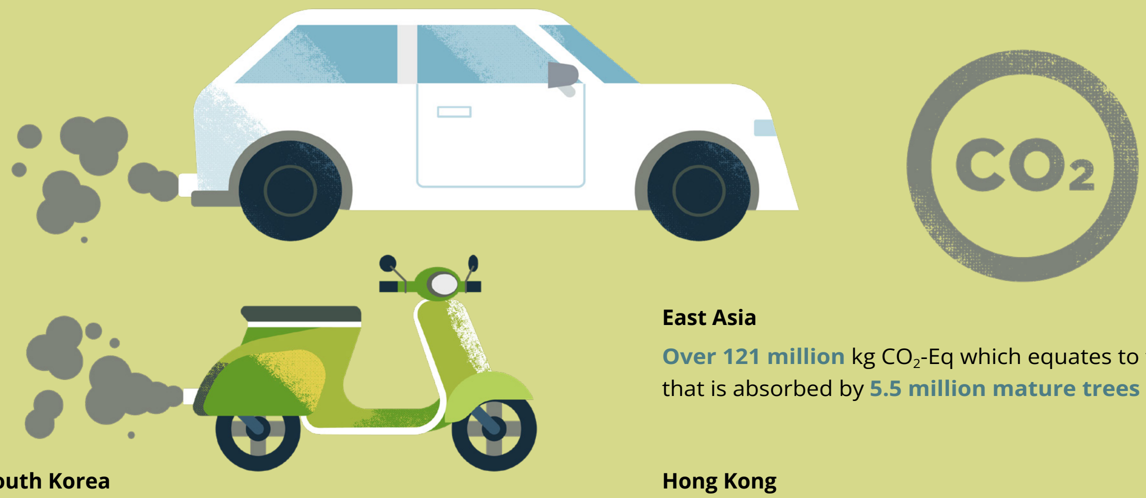
Japan's cafes, fast-food chains, and convenience stores are responsible for 3.91 billion cups annually. If this number of drinks were to be served in reuse cups, we would save:

South Korea

In South Korea, plastic cups and paper cups have contributed to the disposal of around 8.4 billion cups. If this number of drinks were to be served in reuse cups, we would save:

Taiwan

In Taiwan, the annual number of disposable cups amounts to 4 billion. If this number of drinks were to be served in reuse cups, we would save:



East Asia

Over 121 million kg CO_2-Eq which equates to the CO_2 that is absorbed by **5.5 million mature trees** in a year.

South Korea

Over 247.8 million kg CO_2-Eq, which equates to over **92,000 cars** being taken off the streets of South Korea for **1 whole year.** Or the amount of CO_2 that is absorbed by **11.3 million mature trees** in a year.

Hong Kong

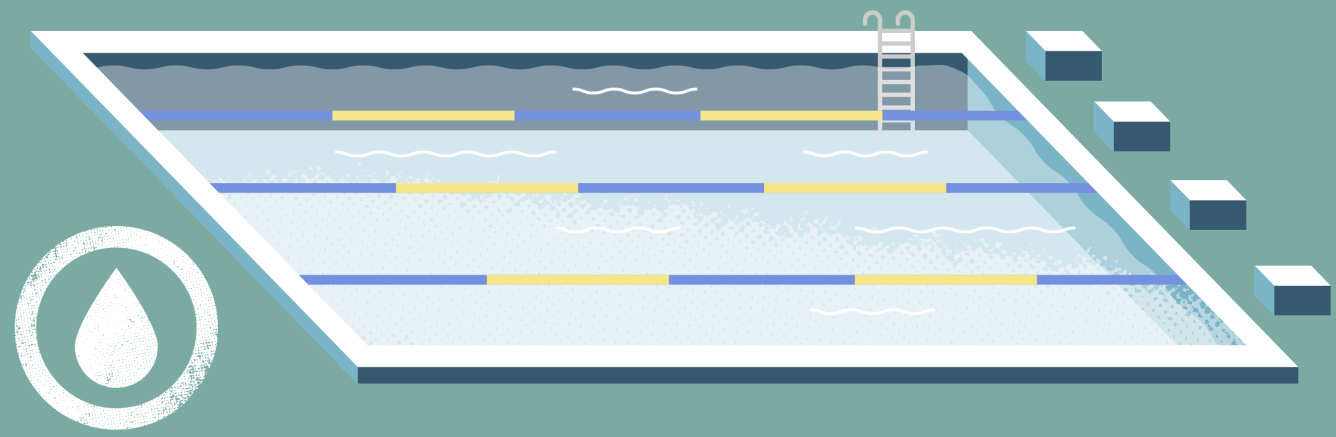
Over 5 million kg CO_2-Eq, which equates to over **1380 cars** being taken off the streets of Hong Kong for **1 whole year.** Or the amount of CO_2 that is absorbed by **232,000 mature trees** in a year.

Taiwan

Over 78.1 million kg CO_2-Eq, which equates to **over 319,000 scooters** being taken off the streets of Taiwan for **1 whole year.** Or the amount of CO_2 that is absorbed by **3.5 million mature trees** in a year.

Japan

Over 60.3 million kg CO_2-Eq, which equates to over **44,000 cars** being taken off the streets of Japan for **1 whole year.** Or the amount of CO_2 that is absorbed by **2.7 million mature trees** in a year.



East Asia

Over 1.8 million m^3 of water saved, which equates to over **500 Olympic swimming pools**

South Korea

Over 1.8 million m^3 of water saved, which equates to over **480 Olympic swimming pools**

Hong Kong

Over 78,000 m^3 of water saved, which equates to over **21 Olympic swimming pools**

Taiwan

Over 920,000 m^3 of water saved, which equates to over **245 Olympic swimming pools**

Japan

Over 793,000 m^3 of water saved, which equates to over **212 Olympic swimming pools**

East Asia

Over 10 million kg oil-Eq, which equates to over **73,000 barrels of oil**

South Korea

Over 140 million kg oil-Eq, which equates to over **1 million barrels of oil**

Hong Kong

Over 450,000 kg oil-Eq, which equates to over **3,300 barrels of oil**

Taiwan

Over 59 million kg oil-Eq, which equates to over **433,000 barrels of oil**

Japan

Over 1.2 million kg oil-Eq, which equates to over **9,400 barrels of oil**

DISCUSSION & CONCLUSION

As a viable alternative to the commonplace use-once-and-dispose practice, this study builds on a growing mound of evidence that corroborates the environmental advantages of reuse systems. **Our ecosystems, the health and well-being of human beings, and the planet's scarce resources are all beneficiaries of the reuse model within the parameters of the LCA framework**, but the indirect benefits reach much farther. The modelling and quantification of the magnitude of environmental savings contribute to an elaboration of the reuse system debate from a theoretical basis to a more in-depth understanding that assists in equipping stakeholders for implementation. The advantages of transitioning to the reuse model are demonstrable even when operating on a smaller, pilot-level scale, as visualised in the previous chapters – the estimated environmental benefits in each region and in the broader East Asia region.

We see in the study's rental reuse cup model that increasing the use frequency, thereby enabling the reuse cups to achieve a higher number of reuses within their life-cycle, amplifies the environmental savings that are accrued from every single reuse, compared to opting for a disposable cup. **Therefore, targeted effort to expand the adoption and utilisation rate of reuse cups is the key to unlocking the full environmental potential of the reuse system.** Moving from a single rental reuse cup system to considering reuse systems on a societal level; as rental reuse cup systems expand and the number of rental reuse cup users grow, so does the potential of achieving a higher cumulative environmental saving from the desisted emissions of disposable cups – assuming that the rental reuse cup systems operate at an adequate utilisation rate. The opportunities from economies of scale and the challenges associated with large-scale logistics are important aspects to understand as we advance the adoption of reuse throughout society.

Building the analysis on the realities of reuse service providers allows for a unique insight into the operational parameters that are environmentally sensitive in the East Asian context. The preponderance of the washing stage in emissions contribution is noteworthy, while cup transport has an outsized impact on air quality. Choosing eco-friendly and energy-efficient solutions for washing and cleaning, eliminating tailpipe emissions in reverse logistics, and optimising delivery and collection logistics are three key considerations that warrant targeted attention to ensure optimal performance and smart design as reuse systems become more mainstream and the scale of their operations expands.

The solution to mitigating the environmental impact of disposable cup systems is to curb production towards an eventual full elimination. The production stage accounts for the lion's share of emissions across all 16 impact categories and targeting production would lead to significant reductions in emissions across the board. The potential of cutting emissions by recycling is limited. Recycling cannot be the ultimate solution to the world's dependence on disposables. Elimination at the source is the key.

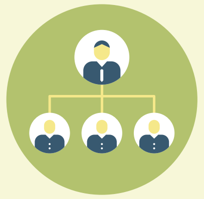
The reuse system that replaces the dominant and environmentally damaging disposable cup systems needs to be both environmentally competitive and economically viable. There is a necessity for further studies that look into the economic performance of reuse systems at various scales of adoption, and particularly studies that move beyond theoretical modelling and base their analysis on context-specific metrics and systems settings that reflect what reuse providers encounter in the real world. Along the same lines, it is also time to explore how a combined, intersectoral effort by the civic, public, and private sectors could take shape in the transition from disposables towards reuse solutions – an aspect which has not been addressed in this study.

The rental reuse cup system is one of many reuse models that exist. Reuse packaging is gaining traction around the world and addresses the need for reuse options in the other segments of the Food and Beverage sector (including restaurants, cafes, and catering) and Pre-Packaged Foods sector (including bottled drinks and readymade meals). These different reuse applications may require further studies to ensure that the reuse systems are established as an environmentally preferable alternative to disposables.

The findings of this study align with a wealth of studies worldwide that show the environmental benefits of well-designed reuse models, while at the same time addressing the knowledge gap of how reuse systems could perform in the East Asian urban context. The variability in the environmental performance among East Asian urban centres highlights the importance of context-specific analysis. This study is also intended as a window into the operating realities of reuse systems in East Asia through the extensive and focused use of real-life data from East Asian reuse service providers.

GREENPEACE EAST ASIA RECOMMENDATIONS

There is an urgent need to develop reuse systems to curb the excessive use of disposable packaging, not only in the Food and Beverage sector, but also in all other sectors that use disposable commodity packaging. Ending the plastic overuse crisis is the responsibility of policymakers and businesses, and reuse solutions should be enabled by stakeholders in a decisive and collaborative manner. **Greenpeace East Asia urges our governments and businesses to adopt a reuse target of 50% by 2030 to spearhead a complete phase-out of single-use packaging in the region.**The core obligations of the governments and businesses shall be:



Policymakers should set up sectoral reuse quotas.

These quotas should be phased in starting from the most technologically viable sectors including the Prepared Food and Beverage and Pre-Packaged Foods industries.

Governments should introduce financial incentives

to harmonise and scale up reuse system infrastructure, which should be prioritised over investing in recycling schemes. These investments in infrastructure include, but are not limited to, the development of standardisation and interoperation specifications, container design, collection and logistics, training, washing facilities, etc.

Businesses should be responsible for setting a clear roadmap for the adoption of different reuse systems,

and publicly disclose the consumption and reduction of disposables.

Extended Producer Responsibility (EPR) for packaging

should be introduced with a clear differentiation for the reuse system and disposable packaging. Economic incentives should be created in the EPR program to facilitate individual consumers and small and medium enterprises to adopt reuse systems.

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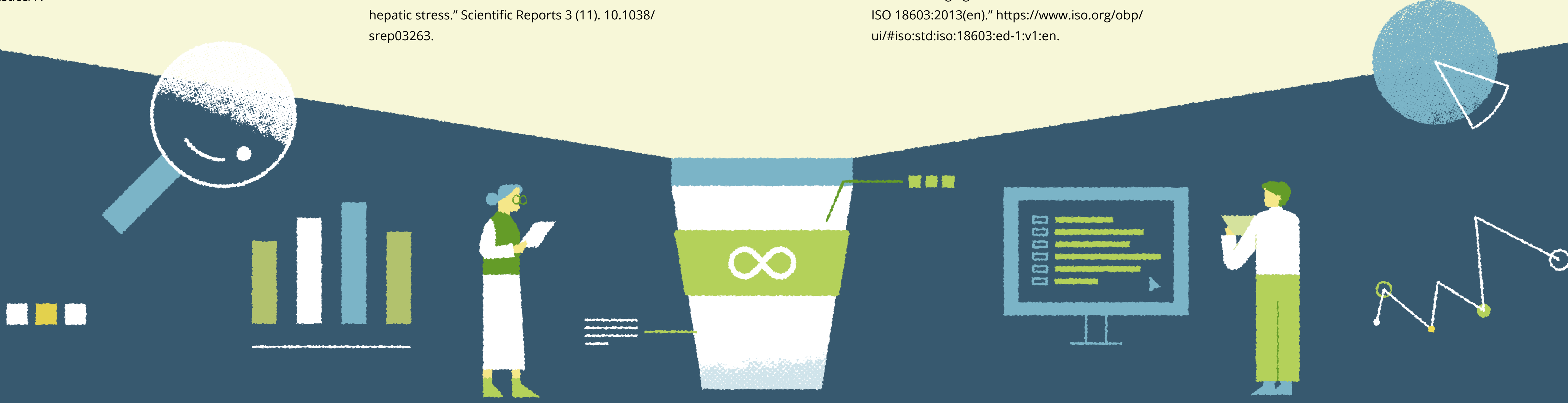

APPENDIX I

End-of-Life pathways

Data obtained from the official statistics released between 2019 and 2021 for the relevant regions. The cut-off point for downcycling waste stream is at waste collection, and neither the reuse nor the disposable cup system gets credited from secondary raw material outputs of downcycling processes.

Table 4: End-of-life waste streams for East Asia, Taiwan, Hong Kong, Japan, and South Korea, by material type

	Baseline model (East Asia)	Taiwan	Hong Kong	Japan	South Korea
Waste Treatment					
Non-Recoverable Waste	70% Incineration 30% Landfill	93% Incineration 7% Landfill	100% Landfill	89% Incineration 11% Landfill	95% Incineration 5% Landfill
PET and PP	25% Incineration 25% Landfill 50% Downcycling (Cut-off)	3% Incineration 97% Downcycling (Cut-off)	89% Landfill 11% Downcycling (Cut-off)	70% Incineration 6% Landfill 24% Downcycling (Cut-off)	20% Incineration 80% Downcycling (Cut-off)
PE	50% Incineration 25% Landfill 25% Downcycling (Cut-off)	47% Incineration 53% Downcycling (Cut-off)	89% Landfill 11% Downcycling (Cut-off)	70% Incineration 6% Landfill 24% Downcycling (Cut-off)	20% Incineration 80% Downcycling (Cut-off)
Cardboard	20% Incineration 15% Landfill 65% Downcycling (Cut-off)	34% Incineration 66% Downcycling (Cut-off)	53% Landfill 47% Downcycling (Cut-off)	17% Incineration 2% Landfill 81% Downcycling (Cut-off)	27% Incineration 1% Landfill 72% Downcycling (Cut-off)

APPENDIX II

System setting parameters for the rental reuse cup system

Table 5: Quantitative system setting parameters for the rental reuse cup system at light-, medium-, and high-use scenarios

Variable	Value		
Number of Food and Beverage stores	40 stores		
Total number of cups	10000 units		
Annual loss rate	7%		
Number of active cups in the system (initial)	8000 units		
Number of cups replaced from stock (annual)	560 units/year		
Number of cups active in the system over 3 years	9680 units		
Cup volume	16 fl. oz.		
Cup and lid material	Polypropylene		
Cup weight	85 g		
Lid weight	15 g		
Technical lifespan of cups	300 (re)uses		
Distribution of new cups to stores	Light-use	Medium-use	High-use
	1/week	2/week	3/week
Number of cups delivered to store per delivery	90 units		
Total lifespan of 10,000 cups, from initiation to final disposal	3 years		
Total number of drinks served over 3 years	Light-use	Medium-use	High-use
	563,143	1,126,286	1,689,429
Number of reuses per cup over 3 years	Light-use	Medium-use	High-use
	58	116	174
Number of reuses per cup per week	Light-use	Medium-use	High-use
	0.37	0.74	1.11

APPENDIX III

System setting parameters for the disposable cup system

Table 6: System setting parameters for disposable PET and PE-lined paper cup system that comprise the 50:50 disposable cup system

Variable	Value	
	Disposable PET cup	Disposable PE-lined paper cup
Cup materials	Recycled polyethylene terephthalate, except for Busan and Taipei where it is virgin polyethylene terephthalate[V]	Bleached paperboard coated with low density polyethylene
Lid materials	Recycled polyethylene terephthalate, except for Busan and Taipei where it is virgin polyethylene terephthalate	Polypropylene
Cup and lid weight	Cup: 15.6 g Lid: 3.5 g	Cup: 13.5 g Lid: 3.5 g
Packaging (manufacture)	50 disposable cups are packed in one PE-film pack (weight: 4 g), 25 of these packs are put in 1 cardboard box (weight: 700 g). 50 disposable cups are packed in one PE-film pack (weight: 6.3 g), 20 of these packs are put in 1 cardboard box (weight: 836 g).	50 disposable cups are packed in one PE-film pack (weight: 4 g), 25 of these packs are put in 1 cardboard box (weight: 700 g). 50 disposable cups are packed in one PE-film pack (weight: 6.3 g), 20 of these packs are put in 1 cardboard box (weight: 836 g).
End-of-Life	Incineration, landfill, downcycling – following local pathways	Incineration, landfill – following local pathways

[V] At the time of this study, South Korea and Taiwan's regulations did not permit the use of rPET in the production of disposable cups.

APPENDIX IV

Full sets of LCA results for four regions and the broader East Asia region

Table 7: Comparative LCA results of environmental performance between rental reuse and disposable cup system along 16 environmental impact categories for the East Asia region

East Asia	Impact Category (ReCiPe Midpoint H)	Light-use	Medium-use	High-use
Ecosystem Impacts	Climate change	14.5	22.6	24.6
	Freshwater eutrophication	-25.0	-16.7	-16.7
	Marine eutrophication	43.9	47.9	49.2
	Terrestrial acidification	20.5	20.5	27.2
	Freshwater ecotoxicity	25.0	25.0	31.3
	Marine ecotoxicity	20.9	28.1	28.1
	Terrestrial ecotoxicity	67.2	72.6	74.5
Human Health	Human toxicity	28.6	34.1	34.1
	Particulate matter formation	16.4	21.8	24.0
	Photochemical oxidant formation	-70.1	-63.3	-63.3
	Ozone depletion	3.6	18.8	18.8
	Ionising radiation	-45.5	-38.2	-34.5
Resource Use	Water depletion	33.8	35.7	35.7
	Fossil depletion	-14.3	7.1	7.1
	Metal depletion	39.0	42.7	44.5
	Agricultural land occupation	95.5	96.2	96.2

Table 8: Comparative LCA results of environmental performance between rental reuse and disposable cup system along 16 environmental impact categories in Busan

Busan	Impact Category (ReCiPe Midpoint H)	Light-use	Medium-use	High-use
Ecosystem Impacts	Climate change	36.6	42.4	44.3
	Freshwater eutrophication	-6.1	-1.8	-0.4
	Marine eutrophication	37.6	42.0	43.5
	Terrestrial acidification	50.9	56.0	57.7
	Freshwater ecotoxicity	23.3	27.0	28.3
	Marine ecotoxicity	23.2	27.1	28.4
	Terrestrial ecotoxicity	2700.9	2430.7	2340.6
Human Health	Human toxicity	32.2	36.1	37.4
	Particulate matter formation	50.3	54.9	56.4
	Photochemical oxidant formation	-17.3	-12.1	-10.4
	Ozone depletion	98.2	98.5	98.5
	Ionising radiation	-22.9	-19.1	-17.8
Resource Use	Water depletion	33.3	35.9	36.8
	Fossil depletion	47.3	54.8	57.3
	Metal depletion	67.9	71.2	72.3
	Agricultural land occupation	95.2	95.8	96.0

Table 9: Comparative LCA results of environmental performance between rental reuse and disposable cup system along 16 environmental impact categories in Hong Kong

Hong Kong	Impact Category (ReCiPe Midpoint H)	Light-use	Medium-use	High-use
Ecosystem Impacts	Climate change	15.5	22.4	24.7
	Freshwater eutrophication	1.4	7.7	9.8
	Marine eutrophication	57.5	60.7	61.7
	Terrestrial acidification	-15.0	-8.5	-6.4
	Freshwater ecotoxicity	25.7	31.5	33.4
	Marine ecotoxicity	26.7	32.6	34.6
	Terrestrial ecotoxicity	-338.7	-340.3	-340.9
Human Health	Human toxicity	25.9	31.6	33.6
	Particulate matter formation	17.8	23.5	25.4
	Photochemical oxidant formation	-78.9	-71.6	-69.2
	Ozone depletion	27.5	36.6	39.6
	Ionising radiation	55.5	62.1	64.3
Resource Use	Water depletion	34.7	36.0	36.5
	Fossil depletion	-12.3	2.4	7.2
	Metal depletion	39.6	45.8	47.9
	Agricultural land occupation	96.0	96.6	96.8

Table 10: Comparative LCA results of environmental performance between rental reuse and disposable cup system along 16 environmental impact categories in Taipei

Taipei	Impact Category (ReCiPe Midpoint H)	Light-use	Medium-use	High-use
Ecosystem Impacts	Climate change	25.4	31.7	33.8
	Freshwater eutrophication	-35.0	-29.3	-27.4
	Marine eutrophication	40.1	44.9	46.5
	Terrestrial acidification	41.7	47.1	48.9
	Freshwater ecotoxicity	7.8	11.7	13.0
	Marine ecotoxicity	7.3	11.2	12.5
	Terrestrial ecotoxicity	52.3	53.4	53.7
Human Health	Human toxicity	19.6	24.0	25.4
	Particulate matter formation	36.0	41.0	42.7
	Photochemical oxidant formation	-18.7	-13.1	-11.2
	Ozone depletion	98.1	98.3	98.4
	Ionising radiation	-1.4	4.3	6.2
Resource Use	Water depletion	36.9	39.3	40.1
	Fossil depletion	42.2	50.4	53.1
	Metal depletion	67.1	70.5	71.7
	Agricultural land occupation	96.3	96.9	97.1

Table 11: Comparative LCA results of environmental performance between rental reuse and disposable cup system along 16 environmental impact categories in Tokyo

Tokyo	Impact Category (ReCiPe Midpoint H)	Light-use	Medium-use	High-use
Ecosystem Impacts	Climate change	18.3	27.2	30.2
	Freshwater eutrophication	26.0	32.5	34.7
	Marine eutrophication	38.4	43.5	45.1
	Terrestrial acidification	16.1	22.8	25.0
	Freshwater ecotoxicity	21.5	27.3	29.2
	Marine ecotoxicity	25.1	31.2	33.2
	Terrestrial ecotoxicity	65.4	73.0	75.5
Human Health	Human toxicity	48.9	54.8	56.7
	Particulate matter formation	42.5	48.3	50.2
	Photochemical oxidant formation	-77.4	-69.8	-67.2
	Ozone depletion	11.7	21.9	25.2
	Ionising radiation	7.8	13.9	15.9
Resource Use	Water depletion	35.8	38.2	39.0
	Fossil depletion	-19.6	-2.9	2.7
	Metal depletion	26.5	32.5	34.5
	Agricultural land occupation	94.9	95.5	95.7

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