Resources, Conservation & Recycling Advances 21 (2024) 200211

Contents lists available at ScienceDirect

Resources, Conservation & Recycling Advances

journal homepage: www.sciencedirect.com/journal/Resources-Conservation-and-Recycling-Advances

Archetypes to categorise upstream packaging strategies for a circular economy

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ARTICLE INFO

Keywords:
Packaging
Reuse
Refill
Reusable packaging systems
Design
Upstream innovation

ABSTRACT

Plastic pollution is a serious issue of global concern which requires an urgent and international response involving all relevant actors at different levels of the supply chain. Increasing production of single use plastics and the mismanagement of the resulting plastic packaging waste is one of the prominent reasons for this pressing environmental issue. Several potentially promising solutions, such as reusable, recyclable and compostable packaging systems exist. Many of these innovative approaches may contribute to achieving a circular plastic economy, but there is a need to categorise and collate these under unifying themes to facilitate the assessment and comparison of different strategies.

The aim of this research is to analyse and categorise the existing solutions that tackle the plastic packaging waste problem to identify the archetypes of these solutions. Literature and business practice reviews were conducted to discover existing solutions. 200 solutions were selected and categorised by exploring the common patterns. Finally, 10 archetypes and 17 sub-archetypes were introduced. These archetypes are: refill stations, mobile refill stations, refill at home solutions, prefilled packaging systems, reusable takeaway and delivery solutions, B2B reusable packages, packaging solutions led by elimination, compostable and biodegradable packaging, substitution to a non-plastic material and plastic recycling. The findings led to the development of an upstream packaging strategies framework. This paper makes an original contribution to knowledge with the development of this framework as a systematic way to map existing (and new) solutions that can potentially tackle the plastic packaging waste and pollution problem.

1. Introduction

Plastic pollution has become one of the most urgent global environmental issues as growing evidence shows that the presence of plastic waste leaking into the world's oceans and land-air pathways is leading to severe physical and chemical contamination of terrestrial and aquatic ecosystems (Bläsing and Amelung, 2018; Dris et al., 2015; Horton et al., 2017). Most plastic pollution comes from inadequate collection and disposal of plastic waste, 12 billion tonnes of which will likely be in landfills or the natural environment by 2050, if current trends continue (Geyer et al., 2017).

Currently, reducing production and consumption of single use plastic packages, decreasing the volume of waste streams going into oceans (Jambeck et al., 2015; Maes et al., 2021) and increasing the recycling rates (d'Ambrières, 2019) are some of the most pressing challenges regarding plastic waste. Single-use plastics (SUP) refer to products designed for a one-time use before being discarded (Chen et al., 2021). These include a wide range of products such as packaging, plastic bags, coffee stirrers, beverage and water bottles, straws and etc. SUP products constituted 50 % of the total global plastic production rate (PlasticOceans, 2020) which amounted to approximately 360 million metric tons in 2018 (PlasticsEurope, 2019). By 2022, this figure had escalated to approximately 400 million metric tonnes (PlasticsEurope, 2023) highlighting the growing environmental challenge posed by such plastics.

Packaging is the largest market of plastics, thus, one of the prominent reasons for the plastic waste problem (Van Eygen et al., 2018). It constitutes 40 % of SUPs (Chen et al., 2021). The packaging industry produced 36 per cent of plastic global production and accounted for 46 per

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https://doi.org/10.1016/j.rcradv.2024.200211

Available online 13 March 2024

cent of total plastic waste in 2017 (Geyer, 2020).

Research suggests that less than 10 % of the 7 billion tonnes of plastic waste created worldwide has been recycled so far (Geyer, 2020). Improving waste collection and management, increasing the recycling rates and passively collecting plastic debris from the ocean are part of the solutions that are currently applied to solve this problem. Although they are effective, these solutions are easing the symptoms not tackling the root cause of the issue.

It is crucial to focus on the solutions that get to the source of the problem, for example those that involve redesign of plastic products, materials and services (EMF, 2020). Among these solutions, reusable packaging systems, including refillable and returnable packages, stand out as effective ways to prevent plastic waste from being generated in the first place (Greenwood et al., 2021). However, it's important to note that the success of these solutions depends on various factors, including user adoption (Coelho et al., 2020; Long et al., 2022), environmental impact (Greenwood et al., 2021; Herrmann et al., 2022; Tan et al., 2023), product pricing (Martinho et al., 2015), design of the reusable packaging (Jiang et al., 2020; Miao et al., 2023), etc.

In the quest to tackle plastic packaging waste, numerous promising alternatives to reusable, refillable, and returnable packaging systems have emerged across different sectors. Interestingly, many of these businesses employ similar strategies to address the same problems. Categorising these solutions can provide valuable insights to designers, researchers, and business people. They can enable the assessment and comparison of different strategies, facilitating the identification of the most suitable solutions for specific contexts and goals. Thus, the aim of this research is to analyse and categorise the existing solutions that tackle the plastic packaging waste problem to identify the archetypes of these solutions. The plastic packaging waste problem refers to production, consumption, and improper disposal of plastic packages. An archetype in this research means a main model that other solutions of the same type merge into or are represented by.

Some publications exist that categorize circular packaging solutions, such as Lofthouse's (2007) investigation of refillable packaging and Long et al. (2020) analysis of reusable packaging systems. Tassell and Aurisicchio (2020) expanded this research to include recycling models for FMCGs, while Muranko et al. (2021) focused on characterizing reuse models. The Ellen MacArthur Foundation (2019), (2020) (EMF) further contributed with frameworks on reuse models and upstream innovation strategies. Nevertheless, these current categorizations are either too generic or do not encompass all strategies, such as compostable packaging, recycling, and the use of alternative materials to replace plastic. Thus, we have identified a knowledge gap that highlights the lack of a categorization system capable of systematically categorising circular packaging solutions and covering all upstream packaging strategies. The paper addresses this gap by developing a framework that presents a systematic categorisation of all the upstream packaging strategies accompanied by stakeholder system maps that visually communicate the key features of each archetype.

The remainder of this article is structured as follows. In Section 2, we present the studies in the literature that categorise reusable, refillable, and returnable packaging solutions. Section 3 presents how we selected and systematically compared 200 existing plastic packaging solutions that tackle the plastic waste problem. In Section 4, we describe 10 archetypes of plastic packaging solutions and the upstream packaging strategies (UPS) framework. We discuss how the findings relate to previous work done by others, present the key insights and their implications for the development of new packaging solutions in research and practice for a circular economy in Section 5. We explain the limitations and further research in Section 6 before concluding the study in Section 7.

2. Literature review

With the growing environmental problems related to single-use plastic packages, businesses focusing on reusable, refillable, and returnable packaging solutions have progressively emerged as well as the studies in the literature. For example, Lofthouse (2007) investigated refillable product packaging solutions in her study and identified 16 different types of refill approaches. This publication was part of a research project that aimed to explore the potential of the refillable packaging systems to enhance customer convenience and reduce packaging waste. In another publication from the same research project, Lofthouse et al. (2009) developed a framework that includes eight types of refill models. However, many new businesses and packaging solutions have emerged since then and no study addresses these new additions.

Aiming to develop a strategic design tool to support packaging professionals to design reusable packaging systems, Long et al. (2020) looked into reusable packaging systems and collected 57 case studies. The authors identified 10 dimensions based on the literature review including ownership of the product, location, value proposition, target group, reusable packaging operation, environmental sustainability potential, and innovation level. They classified these 57 cases according to the 10 dimensions and identified 15 archetypal models. Long et al. (2020) provide a comprehensive list of dimensions for the categorisation of reusable packaging systems, however, the proposed framework does not cover other solutions for the plastic packaging waste problem such as compostable packaging, elimination of parts, and using alternative materials to plastic. Similarly, Bradley and Corsini (2023) and Coelho et al. (2020) also only focus on the reuse models. Bradley and Corsini (2023) conducted a study to develop an analytical framework to assess the sustainability of reusable packaging systems, considering environmental, economic, social, and technical factors. Their research identified three primary reusable packaging models as follows: (1) Primary refillable packaging, (2) Primary returnable packaging, and (3) Secondary/tertiary returnable packaging. Coelho et al. (2020) conducted research on the current advancements in reusable packaging systems, categorising them into four main categories: (1) Refillable by bulk dispenser, (2) Refillable parent packaging, (3) Returnable packaging, and (4) Transit packaging.

Different from other studies that only focus on reuse models, Tassell and Aurisicchio (2020) explored reuse and recycling together. They also had a wider scope compared to focusing merely on packaging solutions as their work covers fast moving consumer goods (FMCGs). The authors developed a framework describing eight reuse and recycling models of FMCGs. This framework was based on four descriptive dimensions: enabling behaviour of the customer and provider, location, provided service, and the role of the customer and provider. This framework helps to see the ways in which reuse and recycling solutions evolved and to compare the descriptive dimensions of both types of solutions.

In a recent study, Muranko et al. (2021) developed a characterisation of reuse models. Similar to Tassell and Aurisicchio (2020)'s paper, this study also focused on FMCGs. The authors selected 92 reuse offerings and identified three reuse system elements including reuse behaviour, reusable product, and reuse-enabling infrastructure. They developed a framework including five reuse models. They identified that three of these reuse models involve exclusive reuse where the reusable product is used and kept by a single user throughout its use-life. The remaining two reuse models involve sequential reuse where the reusable product is used by multiple users throughout its use-life and is returned to the provider at the end of its use-life. This framework could help businesses differentiate the reuse systems with infrastructure and without infrastructure, as well as with containers that are used and owned only by one customer or used sequentially by different customers. Although the authors identified three reuse system elements, the framework was based on two of them which are first, 'reuse-enabling infrastructure' and second, the 'ownership of the reusable product'. The exclusive or sequential use dimension are actually the same dimension as the ownership of the product. The framework does not specify the types of reuse-enabling behaviour as reuse, refill, or return for each category. Overall, it is a simplified framework that has considered these two

dimensions of reuse leaving out two important dimensions including location and reuse-enabling behaviours.

The two dimensions that Muranko et al. (2021) left out formed the foundation of the EMF (2019)'s framework. These two dimensions namely the 'behaviour of refill and return', and the 'location where the behaviour occurs', home or on the go were used by EMF (2019). They mapped 69 cases, mostly including reusable packaging solutions and some business-to-business packaging solutions. This is also a simplified framework that proposes four reuse models which are refill at home, refill on the go, return from home and return on the go.

In another publication by EMF (2020), they presented upstream innovation strategies as practical solutions to a circular economy for packaging. Although this publication was presented as a guide to achieving circular packaging, it categorises existing circular packaging solutions into different upstream innovation strategies. 110 case studies of packaging solutions were also provided to exemplify each strategy. In this guide, upstream innovation strategies were divided into three main categories namely elimination, reuse, and material circulation. Elimination refers to the elimination of unnecessary packaging or packaging components (EMF, 2020). Two types of elimination strategies presented were direct elimination and innovative elimination. The second strategy, reuse, was divided into five categories including refill at home, return from home, return on the go, refill on the go, and business to business (B2B). The last category, material circulation refers to packaging that is kept in circulation after use via recycling or composting its materials (EMF, 2020). Plastics recycling, plastics composting, and substitution to a non-plastic material were the three strategies of material circulation that EMF (2020) identified in this publication. EMF (2020)'s guide covers a diverse set of upstream innovation strategies of a circular economy for packaging, but it does not present which strategies were employed by which sectors. Table 1 presents the summary of the categorisation of the circular packaging solutions highlighting the packaging type and the categories of each framework. This research aims address these gaps, by systematically categorising circular packaging solutions and covering the full spectrum of upstream packaging strategies.

3. Methods and procedure

The methods and procedure of this research is explained in the following sections. Fig. 1 presents the methodology diagram with the methods and the outputs of the research. We described the inclusion and exclusion criteria of the data in Section 3.1. Section 3.2 presents the data collection process. Section 3.3 presents the dimensions and the development of the categorisation grid. We described the development of the stakeholder system maps in Section 3.4. Finally, the analysis process and how we categorised the selected solutions was presented in Section 3.5.

3.1. Data collection

Literature and business practices were reviewed to find out the existing packaging solutions that tackle the plastic waste problem. The criteria in Section 3.1 were used to structure the literature search. First, Web of Knowledge, Scopus and Google Scholar were used for the literature search. Second, existing business practices were further investigated, by exploring:

- web search engines (grey literature, news articles, reports, blogs)
- websites of organisations (EMF, the ZeroWaste Living Lab)
- websites of identified businesses

Business practices were systematically reviewed to identify the existing examples from practice besides the ones we searched in the academic literature. It involved evaluating and analysing the business practices whether they fit the criteria we identified in Section 3.1. We gathered the data on business practices from their official websites.

Keywords such as "reuse", "reusable packaging", and "sustainable packaging" were used both for the business practice search and the literature review. In addition to these keywords, some terms specific to the product sectors such as "reusable coffee cups", "compostable food packaging", "reusable cosmetic packaging", etc., were also used for the internet search. Full list of keywords was presented in Appendix B.

We applied the manual and snowballing search methods for the literature review. The majority of the solutions were collected using literature on reusable packaging (Muranko et al., 2021; Long et al.,

Table 1
Summary of the categorisation of the circular packaging solutions as a result of the literature review.

Authors	Packaging type	Categorisation
Lofthouse (2007)	Refillable packaging solutions	(1) lightweight self-contained refill delivered through dispenser, (2) lighter weight refill through part reuse, (3) empty packaging refilled in shop, (4) self-dispense, (5) original packaging swapped for new product, (6) door to door delivery-packaging replaced, (7) deposit system, (8) top up card, (9) creation, (10) door to door delivery – packaging refilled, (11) refilled with different product, (12) dispensed concentrate, (13) dispensed product, (14) concentrate mixed in original packaging, (15) fill your own packaging, (16) bulk purchase
Lofthouse et al. (2009)	Refillable packaging solutions	(1) lightweight self-contained refill delivered through dispenser, (2) self-dispense, (3) original packaging swapped for new product, (4) deposit system, (5) top-up card, (6) dispensed concentrate, (7) dispensed product, (8) concentrate mixed in original packaging.
EMF (2019)	Reusable packaging systems	(1) refill at home, (2) return from home, (3) refill on the go, (4) return on the go
EMF (2020)	Upstream innovation strategies	**Reuse:** (1) refill at home, (2) return from home, (3) refill on the go, (4) return on the go, (5) business to business **Elimination:** (1) direct elimination, (2) innovative elimination **Material circulation:** (1) plastics recycling, (2) plastics composting, (3) substitution to a non-plastic material
Long et al. (2020)	Reusable packaging systems	Self-refill store, Franchised discounted refill shop, Owning packaging and free refilling, (4) Owning packaging and discounted refill, (5) Free refill station, (6) B2C home delivery and collection, (7) Canteen returnable packaging, (8) Concentrated refill pods delivery, (9) Refill the trackable packaging, (10) Subscripted service for refill, (11) Digital self-refill store, (12) Digital self-refill store (packaging rental), (13) Delivery and collection of your packaging, (14) On-the-go refill station, (15) Self-making product
Coelho et al. (2020)	Reusable packaging systems	(1) Refillable by bulk dispenser, (2) Refillable parent packaging, (3) Returnable packaging, (4) Transit packaging
Tassell and Aurisicchio (2020)	Reuse and recycling models of FMCGs	(1) consumer replenishes /reconditions, (2) consumer replenishes at home via service, (3) consumer replenishes on the go via service, (4) consumer brings and company replenishes /reconditions via service, (5) company replenishes for consumer via service
Muranko et al. (2021)	Reuse models of FMCGs	(1) exclusively reused products, (2) exclusively reused products with reuse-enabling infrastructure, (3) reuse-enabling infrastructure for exclusively reused products, (4) sequentially reused products with reuse-enabling infrastructure, (5) sequentially reused products

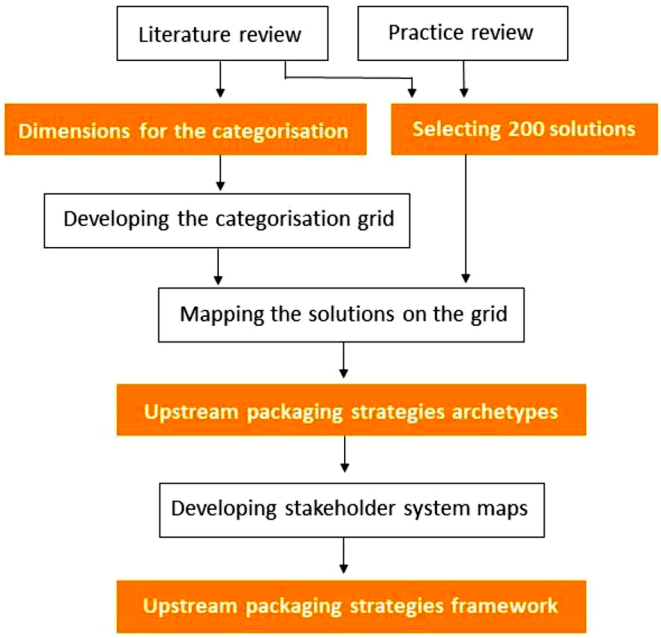

Fig. 1. Methodology diagram shows the utilised methods and the outputs of the research.

2020; EMF, 2017, 2019, 2020) and the Zero Waste Living Lab (n.d.). Information about each solution was collected by accessing the solution's official website between November 2021 and December 2022.

3.2. Criteria for selecting the existing packaging solutions that tackle the plastic waste problem

The inclusion and exclusion criteria of selecting the existing packaging solutions that tackle the plastic waste problem were established to ensure that the dataset represents a diverse range of packaging solutions, reflecting the current landscape. This included reusable, refillable, returnable, recyclable, and compostable packages. Both business-to-customer and business-to-business models operating within the packaging market were selected. Solutions that comply with the first criterion and one or more of the following criteria were added in the dataset:

- businesses providing packaging solutions, thus reusable products were not considered;
- businesses providing the customer with packaging that can be reused multiple times for its original purpose;
- businesses providing the customer with refilling option for the product they sell;
- businesses providing the customer with packaging that can be recycled or composted or that has recycling content;

200 existing solutions were included in the dataset that covers a wide range of solutions (Appendix A).

3.3. Dimensions of the categorisation grid

The literature was reviewed to find out existing dimensions that were used to categorise packaging solutions that tackle the plastic packaging waste problem. After reviewing the literature, we decided to use EMF (2020)'s upstream innovation strategies as one of the dimensions in this study to categorise the existing solutions. Upstream innovation refers to the strategies that are employed at the design stage. It typically involves design, research and development activities that take place before a product is ready to be brought to market. Upstream innovation strategies are effective as they get to the source of the problem rather than dealing with the symptoms. In this research we used the term upstream packaging strategies instead of upstream innovation strategies to be more specific because this research focuses on packaging solutions.

Table 2
Upstream packaging strategies were placed on the horizontal axis of the categorisation grid.

Upstream packaging strategies	
Elimination	Direct elimination
Reuse	Refill at home
	Refill on the go fill on the Go
	Return from home
	Return on the go
	Business to business
Material circulation	Plastics recycling
	Plastics composting
	Substitution to a non-plastic material

Table 3
Sectors were placed on the vertical axis of the categorisation grid.

Sectors
Grocery Shopping
Food Packaging
Beverage packaging
Beauty & personal care packaging
Home Care
Cup solutions
Takeaway and Ready Meals
Transport/ e-commerce/ tertiary/ secondary packaging
Other (Clothing, Electronics, Healthcare)

We selected the product sectors as the second set of dimensions to understand which strategies were used for which sectors. These two dimensions were used to develop the categorisation grid and they are presented in Tables 2 and 3. Additionally, the empty categorisation grid was presented in Appendix C.

The product sectors identified were grocery shopping, food packaging, beverage packaging, beauty and personal care packaging, home care packaging, cup solutions, takeaway and ready meals, transport/ e-commerce/ tertiary/ secondary packaging, and other (clothing, electronics, healthcare). These sectors were placed on the horizontal axis of the grid as nine columns. While six sectors were placed one by one in separate columns, others were grouped into three. For example, transport/ e-commerce/ tertiary/ secondary packaging sectors were counted as one group of sectors and positioned in the same column in the categorisation grid. The categorisation grid was finalised by placing the upstream packaging strategies on the vertical axis.

3.4. Stakeholder system map

Stakeholder system maps are used to design, co-design and visualise the configuration of a system. It is a graphical representation that

Table 4
Flows and interactions between the stakeholders and the product service system provider were graphically represented in the stakeholder system maps.

Flows	Core performance PSS
Material flow	
Labour performance flow	
Financial flow	
One-way flow	
Exchange	

contains two main elements of the system. These main elements are the stakeholders involved in the system and the flows and interactions between them (Jégou et al., 2004). Flows and interactions can be physical, financial and informational. Additionally, there are also flows of labour performance. Icons and short descriptions were used to facilitate the construction of the stakeholder system maps in a systematic and uniform way. Table 4 presents how these flows were graphically represented in the stakeholder system maps. Stakeholders were also graphically represented in the stakeholder system maps with structure icons and slogans.

Stakeholder system maps were developed to examine and collate the system configurations of archetypes and check whether the categories were allocated correctly or not. We only provided stakeholder system maps for the archetypes that were product-service systems (PSSs). PSS is a value proposition that provides a combination of products and services to satisfy a particular customer demand by shifting the business focus from physical products to functionality. Stakeholder system maps were not constructed for the last four archetypes namely packaging solutions led by elimination, compostable and biodegradable packaging, substitution to a non-plastic material, and plastic recycling. Most of the time, these archetypes do not provide a PSS to customers or businesses. They are mostly packaging solutions and do not have many flows and interactions with the customers compared to the PSSs.

We identified the common characteristics in the system configurations of the same archetypes and based the system maps on those findings. However, differences exist in the system configurations of different solutions. Additionally, some existing solutions use multiple archetypes. Therefore, the stakeholder system maps are not representative. They were developed to identify which stakeholders can be involved and what type of flows can exist in each archetype.

3.5. Analysis

The analysis process commenced after the categorisation grid was populated with 200 solutions. During this iterative procedure, clusters of solutions began to emerge organically. These clusters were subsequently organized based on their shared similarities and distinctions.

At this stage, we identified 11 clusters, with 10 of these clusters evolving into the archetypes. Archetypes represent solutions that share the same dimensions such as sectors and upstream packaging strategies. Besides these dimensions, they also share similar key characteristics such as product category, business models, or reuse models.

To validate the accuracy of category allocations, an evaluation was undertaken. System configurations were scrutinized by constructing dedicated stakeholder system maps for each cluster. One cluster, designated as "cup solutions," stood out among these 11 clusters. Following a detailed assessment, it was determined that "cup solutions" should be incorporated within the "reusable takeaway and delivery solutions" archetype due to the similarity of their stakeholder system maps.

Finally, 10 archetypal models were identified after analysing and comparing the clusters of solutions on the grid. Fig. 2 shows the archetypes, the categorisation grid and the solutions mapped on the grid. The solutions mapped on the grid can be seen in the bigger version of the Fig. 2 provided in Appendix D. 200 solutions that were listed and categorised under the related archetype can be found in Appendix A.

Archetypes were named after searching for the common names that were used for the existing solutions that belong to that archetype. For each archetype, first, we checked the terms used in the literature to describe these existing solutions. Then, we explored the websites of these solutions to see how businesses describe and name their solution. For example, for the fifth archetype, we observed that two terms were

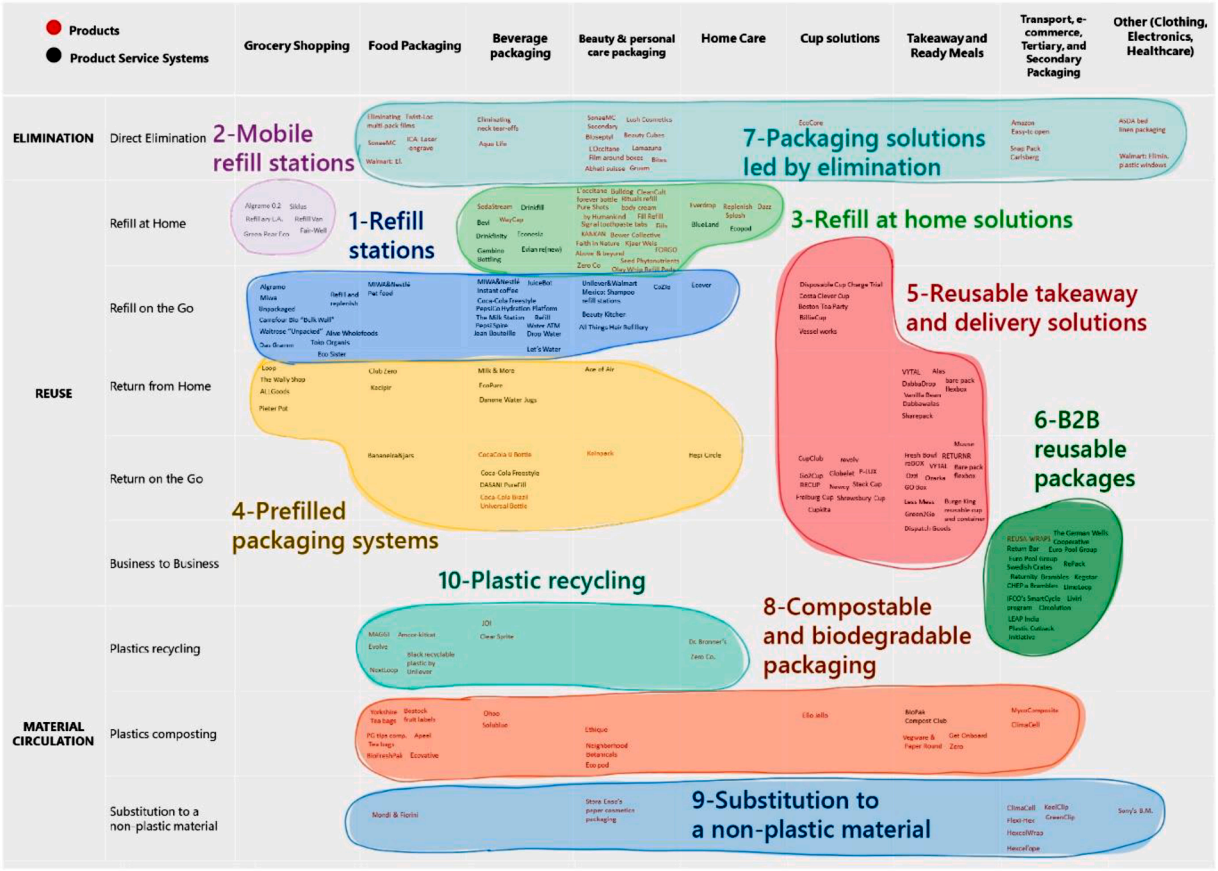

Fig. 2. The categorisation grid was populated with 200 solutions according to their sectors and upstream packaging strategies.

commonly used to explain these solutions namely prefilled and returnable. We observed that various dimensions were used in the literature and by businesses to name these solutions including the behavioural aspects such as refilling and returning, the location where the behaviour occurs such as on the go or at home, and the sector such as personal care refill stations. Additionally, some archetypes were named after the system elements combined with other dimensions such as refill stations and refill packages.

4. Results

After naming all the archetypes and comparing their stakeholder system maps we finalised the categorisation process. Observing the relationship between the archetypes and comparing their stakeholder system maps led to the theoretical construction of the UPS framework. Creating the stakeholder system maps helped us examine the system configurations and compare the solutions to assess whether each solution is in the right archetype or not. The UPS framework, three main strategies, each archetype and their sub-categories were explained with relevant examples in the next section. Stakeholder system maps were provided for the archetypes that are PSSs.

4.1. Upstream packaging strategies framework

The UPS framework is a systematic way to think about and work with the solutions that tackle the plastic packaging waste problem by categorising them under 10 archetypes according to the upstream packaging strategies that they employed (Fig. 3). The UPS framework makes it easier to understand these solutions and upstream packaging strategies by providing a common language that describes similar solutions under unified categories. Separate solutions using various upstream packaging strategies become organised when viewed through the UPS framework.

The archetypes were specified under three main strategies namely reuse, elimination, and material circulation:

- The **reuse** main strategy covers the packaging solutions where packaging is designed to have multiple use-lives by being refilled and reused for the same purpose. Six archetypes included under reuse are: refill stations, mobile refill stations, refill at home solutions, prefilled, reusable takeaway and delivery solutions, and business-to-business packages. With these six archetypes, the reuse main strategy includes the highest number of archetypes. This does not mean that these solutions are the most adopted in the market, but it means that the number of the types of solutions is more varied for the reuse main strategy compared to the other two main strategies.
- The **elimination** main strategy is implemented in two ways: first, by redesigning the product in a way that packaging is no longer needed; and second, by identifying and removing the non-functional components of the packaging. The first method is implemented by removing the water content of the products and redesigning the product into a solid form. This strategy is mostly used in personal care and home care products. The second method refers to the direct elimination sub-archetype. For example, for products that both have a plastic film and a plastic lid to close the packaging, one component can be removed as both of them are serving the same function. Although direct elimination is not an absolute solution to the plastic packaging problem, it is considered in this research because it can be the first step towards finding a better solution.
- The third main strategy, **material circulation** refers to keeping the packaging materials in the loop after each use through recycling or composting. It involves both the reverse flow of materials back to the recycling or composting systems after each use and the flow of materials for production after recycling the materials. Three archetypes included under this main strategy were compostable and biodegradable packaging, substitution to a non-plastic material, and plastic recycling.

4.2. Upstream packaging strategies framework archetypes

4.2.1. Archetype 1 - refill stations

Refill stations are manual dispensers or automated machines placed in either closed public environments such as grocery stores or in open public environments such as streets and parks. Refill stations are usually established to eliminate the use of single-use plastic packaging besides offering the customer affordability and convenience of buying the amount they need. As refill stations allow customers to buy small amounts of products, this archetype has the potential to reduce the plastic waste of sachets, especially in low-income areas.

Refill stations archetype is applied in the grocery shopping, food packaging, beverage packaging, beauty and personal care and home care sectors. The stakeholders involved in the refill station systems are the supplier, the PSS provider, the store, and the customer (Fig. 4). The PSS provider is responsible for installing and upkeeping the refill machine or dispenser. They also provide the containers, food, and beverage to store. The store serves as the primary point of interaction between the customer and the service. Customers fill their container and pay for the content. They can either bring their container or use the one provided by the service provider. After consuming the purchased items, customers return the container to the store. Containers are collected by the PSS provider to be cleaned and reused repeatedly. It is worth noting that the

Fig. 3. Upstream packaging strategies diagram showing three main strategies, 10 archetypes, and 17 sub-archetypes of existing packaging solutions.

configuration of refill station systems varies depending on their specific placement. In cases where refill stations are situated in open public spaces, the store might not be a part of the system. Similarly, the PSS provider operates and maintains the refill machine in the open public space.

Three different types of refill stations identified in this research were grocery shopping refill stations, beverage refill stations, and home and personal care refill stations.

4.2.1.1. Grocery shopping refill stations. Grocery shopping refill stations are manual dispensers or automated machines usually at the grocery stores that are used to sell basic items for households such as rice, detergent, cooking oil, etc. Additionally, zero-waste stores and retailers and supermarkets with packaging-free aisles were also included in this sub-archetype. Based on the location where these refill stations were situated, we identified three types of grocery shopping refill stations in this research:

- Refill stations in small shops;
- Refill stations in supermarkets;
- Zero waste stores.

These refill stations and stores offer multiple types of products from different sectors providing the customer convenience of buying their needs in one location. Algramo (n.d.), a Chilean start-up that aims to eliminate the use of single-use packaging, can be given as an example of this sub-archetype. Algramo installs automated machines in stores and sells affordable quantities of everyday products.

4.2.1.2. Beverage refill stations. Beverage refill stations are refill stations that are used to sell beverages to customers with reusable containers owned by the customers and/or offered by the service provider. For example, Water ATM, a scheme run by private water companies and the government of India (Vashisth, 2018) offers water for customers on the streets of India through automated machines that are solar-powered. Based on the types of beverages provided in these refill stations, we identified two types of beverage refill stations identified in this research as:

- Soft drink refill stations;
- Water refill stations.

4.2.1.3. Home and personal care refill stations. Home care and personal care refill stations are used to sell home care products, beauty and personal care products to customers with reusable containers owned by the customers and/or offered by the service provider. For example, Ecover (n.d.) is a Belgium-based company founded in 1979 that sells a range of washing and cleaning products through refill stations. They aim to elevate the refill experience and create the habit of refilling.

4.2.2. Archetype 2 - mobile refill stations (refill van)

A mobile refill station or refill van is a mobile device or vehicle that is equipped with a dispensing system and travels to customers' neighbourhoods to sell basic household items such as food and home care products. Customers pay for the quantity they buy and use their container and/or the reusable container offered by the service provider (Fig. 5). When a customer has an empty container, they can return it directly to the mobile refill station.

Similar to refill stations archetype, mobile refill stations offer multiple types of products. They provide the customer convenience of buying their various needs near their home. This archetype works particularly well in densely populated areas such as urban areas where the distance between the stops is short.

Mobile refill stations archetype is applied in the grocery shopping sector. For example, Algramo home delivery (Peters, 2019) is a mobile refill station on an electric tricycle that goes to customers' neighbourhoods. The mobile unit consists of a vending machine dispensing home care products such as washing detergent and dish soap. They provide reusable containers equipped with RFID code that enables discounts on future purchases to encourage customers to continue using the service.

The stakeholders involved in the mobile refill station systems are the supplier, the PSS provider, and the customer. The PSS provider buys the content from the supplier and operates the mobile refill station. Mobile refill station is the primary point of interaction between the customer and the service. Customers fill their container and pay for the content. They can either bring their container or use the one provided by the service provider. After consuming the purchased items, customers return the container to the PSS provider to be cleaned and reused repeatedly.

4.2.3. Archetype 3 - refill at home solutions

Refill at home solutions are products and services provided to customers to refill reusable containers at home. Customers pay for the content and in some cases for the containers, dispensers, and delivery. Two key dimensions that defined this archetype were reuse-enabling behaviour and the location where that behaviour occurs. In this archetype, the key reuse-enabling behaviour is refill performed by the customer and the location is home.

The stakeholders involved in the refill at home solutions are the product or PSS provider, delivery service provider, and the customer (Fig. 6). The primary points of interaction between the customer and the service are the online platform and the customer home where the product is delivered.

Refill at home solutions archetype is applied in the beverage packaging, beauty and personal care and home care sectors. This archetype particularly works well for products that are used regularly. Most of the businesses included in this archetype deliver refills through the mail. Most of them are delivered through a subscription service. Customers usually subscribe to the service online as the service requires information from the customer such as the customer's individual needs, address, and delivery frequency. Some of the refills are provided in plastic pouches but only programs that refill or recycle these pouches were included in this research. The refills are lighter in weight compared to single-use packages. Thus, they are advantageous in terms of packaging costs and transportation costs. Six different types of refill stations

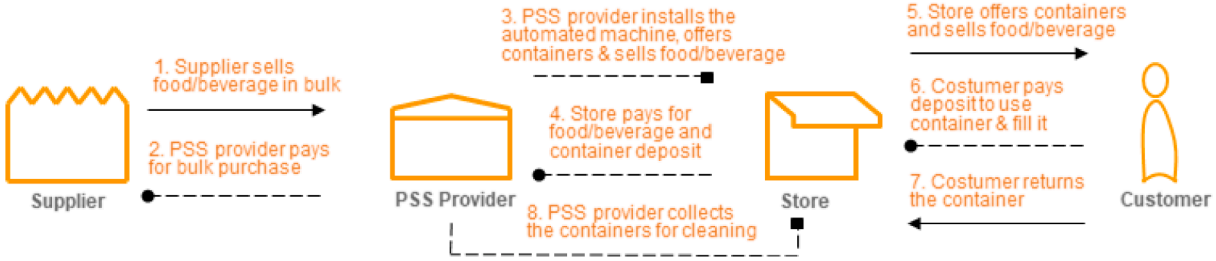

Fig. 4. Stakeholder system map of refill stations archetype showing the stakeholders and flows.

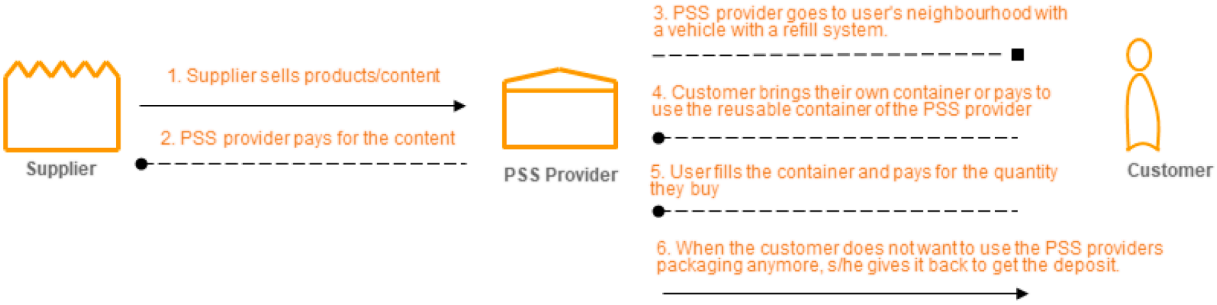

Fig. 5. Stakeholder system map of mobile refill stations archetype showing the stakeholders and flows.

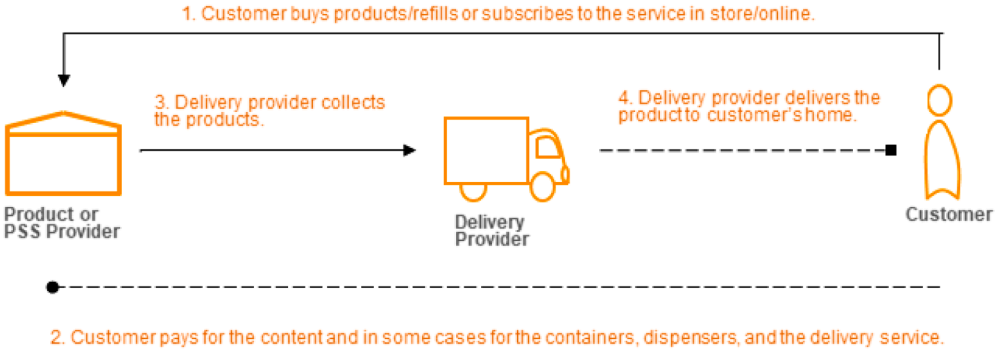

Fig. 6. Stakeholder system map of refill at home solutions archetype showing the stakeholders and flows.

identified in this research are presented below:

4.2.3.1. Concentrated products in refill packages. Products with reduced water content are sold to customers in refillable or recyclable packages and customers refill their reusable packages with the concentrated product and water at home. In some cases, customers buy a dispensing unit beside refills containing concentrated products. SodaStream (n.d.), a soda-making machine that can prevent the use of single-use bottles, can be given as an example of this sub-archetype. Customers buy the machine, a refillable carbonating container, concentrated flavoured syrups, and reusable bottles to make their drinks at home.

4.2.3.2. Bulk refill packages. Bulk refill packages are recyclable packages that are bigger than the product's usual package size. Customers buy in bulk and refill a reusable container at home. For example, Faith in Nature (n.d.) is a natural skincare company that offers 5-litre and 20-litre bottles to encourage customers to refill their small containers at home.

4.2.3.3. Recyclable refill packages. Customers buy recyclable refill packages usually in the form of recyclable pouches or compostable or biodegradable packages from the stores or order them online to refill their reusable containers at home. After emptying these packages, they put them in the recycling/compost bin or in some cases mail them to the provider to be refilled or recycled. For example, CleanCult (n.d.) offers reusable glass bottles to customers and ships refills for cleaning products in paper boxes that can be recycled or composted.

Some companies that provide recyclable refill packages also provide reusable containers that are long-lasting and suitable for refilling multiple times. Customers own these reusable containers and they can be recycled at the end of their use-life. L'occitane (n.d.) forever bottle is an example of a reusable container that can be refilled at home by ordering refill pouches. Forever bottle is made out of 100 % recycled aluminium and it can be recycled at the end of its use-life.

4.2.3.4. Refill inserts. Refills are provided in recyclable, biodegradable, or compostable single-use packages that can be inserted inside the reusable packaging at home without the need of transferring the product from the refill package to the reusable packaging. This solution is advantageous for creams and lotions such as face cream and body lotion that is hard to transfer to another container. It is more convenient and faster for customers to insert the refill package inside the reusable container rather than scooping the cream from one package and transferring to another.

According to our literature and practice review, this sub-archetype is used for beauty and personal care products, especially for high-end products with luxurious reusable packages. For example, Rituals (n.d.) refill body cream is provided with a plastic recyclable refill pod. The company states on its website that this refill uses 45 % less water and saves up to 70 % in CO2 emissions, and 65 % in energy use (Rituals, n.d.). Refill inserts can lower transportation costs as this solution does not require transporting the whole packaging which is heavier and bigger than the refill insert packaging.

4.2.3.5. Refilling dispensers. Refilling dispensers are packaging solutions that companies provide customers refilling dispensers that allow them to refill their containers at home. This sub-archetype specifically works well for frequently used products such as beverages and especially water. For example, Econesia (n.d.) is a water filtration service system for homes and hotels. They offer water dispensers with water purifying functions and the service of delivery, installation, and maintenance.

Dispensers can be refilled by the companies or by the customers when the content is finished. For the latter companies sell refills for the dispensers in recyclable refill packages. For the former, the refilling dispenser is usually owned by the company and they offer the regular maintenance service.

4.2.4. Archetype 4 – prefilled packaging systems (returnable)

Prefilled packaging systems archetype refers to a reusable packaging service that provides packaging that has already been filled with a

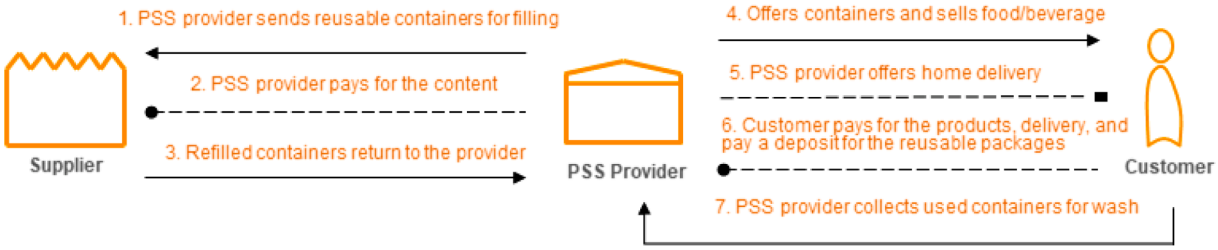

Fig. 7. Stakeholder system map of prefilled archetype showing the stakeholders and flows.

specific product. This archetype is also called returnable packaging (Coelho et al., 2020) as the key reuse-enabling behaviour is the customer's returning the packaging after each use (Fig. 7). Prefilled packaging systems archetype differs from other archetypes because the product is packaged and ready to use for the customer without the need for the customer to refill a package. This archetype can enhance customer convenience by saving them time and effort by eliminating the need for the customer to fill the packaging themselves.

Prefilled packaging systems archetype is applied in the grocery shopping, food packaging, beverage packaging, beauty and personal care and home care sectors. The supplier, the PSS provider, and the customer are the main stakeholders involved in the prefilled packaging systems. PSS provider sends the reusable containers to the supplier for filling. Prefilled containers are delivered to the customers' home by the PSS provider. The customers pay for the products, delivery and the deposit for the reusable packaging. After customers consume the purchased items, either customers return the products to the collection points or PSS provider collects the used containers for wash.

Two types of prefilled packaging systems were identified in this research namely the milkman model and prefilled return on the go.

4.2.4.1. Milkman model (prefilled return from home). In the milkman model, the service provider delivers the product to customers' homes and offices and retrieves the empty containers at the time of delivery. This model is mainly used for delivering water in reusable jugs and for milk delivery. However, it is also used by other sectors for example, Loop (n.d.) is a reusable packaging service offering staple products such as cleaning products and food in premium packaging delivered to customers' homes. Customers buy products online in reusable packaging from retailers. Their orders are delivered in a reusable tote. When a customer has an empty container, they can return it by home collection or to any participating retailer. The advantages for the customer are that they do not need to clean or sort out the empty packaging. They also do not need to carry heavy shopping bags home.

4.2.4.2. Prefilled return on the go. In the prefilled return on the go sub-archetype, customers buy products in reusable containers and return the container to stores or at the drop-off points. The PSS provider collects and cleans the returned packages and then redistributes them to the suppliers. Koinpack (n.d.) is an example of prefilled return on the go sub-archetype that aims to replace sachets in Indonesia. Koinpack provides daily needs such as soap, detergent, and shampoo in small reusable packages. Customers, pay a deposit for each package and bring back the packaging to the store after use to get their deposit back.

4.2.5. Archetype 5 - reusable takeaway and delivery solutions

Reusable takeaway and delivery solutions archetype refers to packaging solutions where food and beverages are sold in reusable containers with delivery and takeaway services. Reusable takeaway and delivery solutions archetype is applied as a part of cup solutions and in the takeaway and ready meals sector. Stakeholder system maps of reusable food and beverage delivery and reusable takeaway food and beverage sub-archetypes differ as the former requires a delivery provider. Other than that, the stakeholders involved in these systems are same including the PSS provider, the business, and the customer. The PSS provider sells containers and offer various services to the businesses including collection, wash and distribution of containers. Customers usually pay a deposit for the container and pay for food and beverages. They sometimes pay for the delivery when food and beverages are delivered to their home.

4.2.5.1. Reusable food and beverage delivery. Reusable food and beverage delivery sub-archetype refers to packaging solutions where food and beverages are delivered to customers' homes in reusable packages. Customers usually return the packaging through pick-up or at the drop-off points service (Fig. 8). For example, ALAS (n.d.) is a reusable food and beverage delivery packaging service in Indonesia. Customers order food from restaurants and the food is delivered in ALAS packaging. Customers can return the reusable packaging through arranging a pick-up or at the drop off points after enjoying their meal.

4.2.5.2. Reusable takeaway food and beverage. Reusable takeaway food and beverage sub-archetype includes takeaway container services for restaurants, cafes, dining centres, etc. These services are usually offered in organisations such as universities and work places. Customers buy their food and beverage in reusable containers, pay for the food and beverages, and return the reusable container after finishing their meal (Fig. 9).

OZZI (n.d.) is an example of a reusable takeaway container service for dining centres in organizations such as universities and companies. Customers pay the dining staff at the organization to buy food in an Ozzi container. After finishing their food, they return their empty container to the Ozzi container collection machines.

4.2.5.3. Reusable cup solutions. Reusable cup solutions sub-archetype refers to reusable cup services for on the go beverages. Most of the reusable takeaway and delivery services offer both reusable cup and container programs as food is often sold together with beverages. Nevertheless, the reusable cup solutions sub-archetype is included in this research because we identified 16 solutions that offer only reusable cup services (Appendix, A).

For example, CLUBZERO (n.d.) is an on the go reusable cup service for brands and retailers. Customers subscribe to CLUBZERO to use their cups in any of the participating coffee shops and pay the coffee shop for the coffee. They can check the CLUBZERO app for their nearest drop-off point, and return the cups after use.

Two types of reusable cup solutions were identified in this research: return on the go cup solutions (Fig. 9) and refill on the go cup solutions. Business usually own the cup and offers cup usage with the return on the go cup solutions. Customer pays to use the cup and pays for the beverage. Whereas, with refill on the go cup solutions, the customer owns the cup and the business offers the beverages. This solution does not require a stakeholder system map because the customer carries out most of the activities such as carrying the container and cleaning the container except for refilling it.

4.2.6. Archetype 6 - B2B reusable packages

B2B reusable packaging archetype refers to reusable packaging and

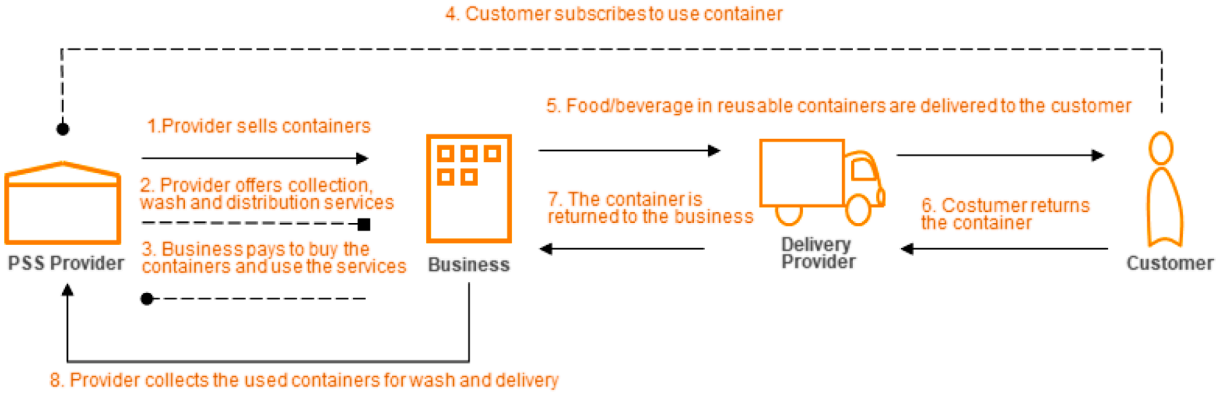

Fig. 8. Stakeholder system map of reusable food and beverage delivery sub-archetype showing the stakeholders and flows.

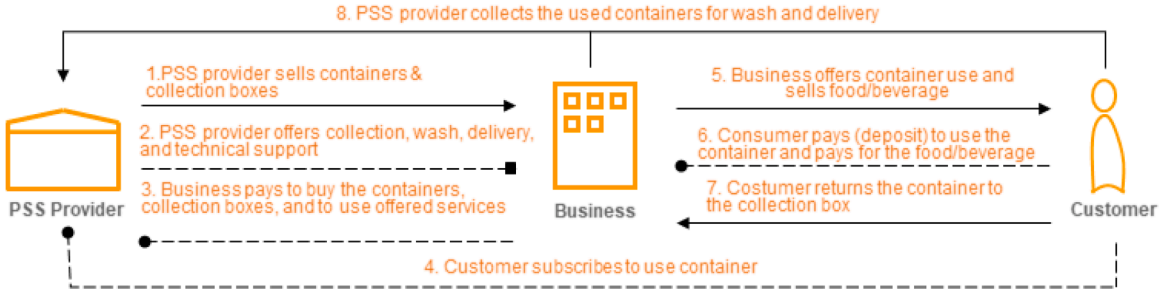

Fig. 9. Stakeholder system map of reusable takeaway food and beverage and return on the go cup solutions sub-archetypes showing the stakeholders and flows.

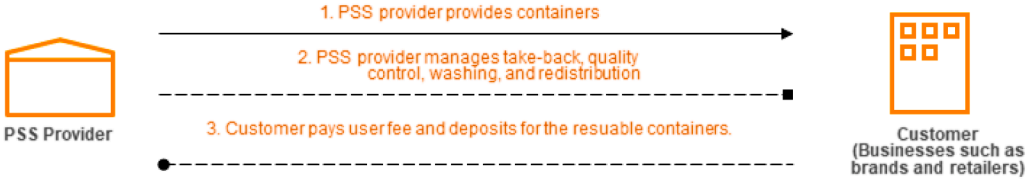

Fig. 10. Stakeholder system map of B2B reusable packages archetype showing the stakeholders and flows.

services used between businesses rather than businesses and consumers. Customers (businesses such as brands and retailers) usually pay for the user fee and deposits for the containers to receive this service (Fig. 10). B2B reusable packages archetype is applied in the transport/ e-commerce/ tertiary/ secondary packaging sectors. The stakeholders involved in B2B reusable packaging systems are the PSS provider and the customer. Three types of flows can be seen in the stakeholder system map (Fig. 10). The material flow of containers provided by the PSS provider goes to the customer. PSS provider also manages the take-back, quality control, washing, and the redistribution of the containers. Customer directly contacts with the PSS provider and pays directly to them.

This archetype offers benefits to businesses such as decreasing material and transportation costs. It also benefits the environment by eliminating single-use packaging. The German Wells Cooperative's (n. d.) refillable bottle service can be given as an example of this archetype. This service is also referred to as the pool system for beverage containers. In this system, bottlers use refillable PET bottles for carbonated beverages and mineral water products. When the contents are consumed, these bottles are returned via a deposit return program, where they are cleaned and refilled by the bottlers. They can be refilled up to 25 times until they are recycled at end of their life to become new PET bottles (Genossenschaft Deutscher Brunnen eG, n.d.).

4.2.7. *Archetype 7 - packaging solutions led by elimination*

The 'packaging solutions led by elimination' archetype includes solutions where packaging or parts of packaging is eliminated through design, innovation, and rethinking the business (EMF, 2020).

This archetype is applied in six out of the nine sectors presented in Table 3. These include food packaging, beverage packaging, beauty and personal care and cup solutions transport/ e-commerce/ tertiary/ secondary packaging, and other (Clothing, Electronics, Healthcare) sectors. In these sectors, the strategy is implemented to eliminate unnecessary packaging and non-essential components. For instance, this involves removing plastic films where multi-buy packs are wrapped together or employing laser engraving on organic fruit and vegetable products to distinguish them as organic from conventionally grown produce (ICA, 2017). Two types of elimination of packaging are direct elimination and elimination through creating solid products.

4.2.7.1. Direct elimination. Direct elimination is removing the packaging or parts of packaging that does not have an essential function and can be regarded as unnecessary (EMF, 2020). Removing secondary packaging such as multi-buy packaging, and removing plastic films where unnecessary such as the plastic film over fruits and vegetables can be given as examples of this sub-archetype. A Twist-Loc (n.d.) is an example of the direct elimination sub-archetype. It is a packaging tub that ensures the food packaging remains unopened prior to use. It

replaces and eliminates non-recyclable film and tear-off bits, providing retailers and consumers with confidence that the products within the tub are pristine and safe for purchase.

4.2.7.2. Solid products. Solid products sub-archetype refers to the strategy of eliminating the need for packaging by reducing the water content of products. Redesign of products as solid products is needed when packaging serves an essential function and cannot be eliminated directly. Lush Cosmetics (n.d.) is an example of solid products sub-archetype. It is a British beauty company that offers solid personal care products for the hair, body, fragrance, oral, and beauty care categories. Most of their products are handmade and they can be taken home from the stores with no packaging. Similarly, the products purchased online are placed directly into the parcel box as they call it 'naked'.

4.2.8. Archetype 8 - compostable and biodegradable packaging

Compostable and biodegradable packaging archetype includes packaging that is designed and manufactured to biodegrade or to be composted in industrial composting facilities or home compost bins. This archetype is applied in six out of the nine sectors presented in Table 3. These include food packaging, beverage packaging, beauty and personal care and cup solutions, takeaway and ready meals, transport/ e-commerce/ tertiary/ secondary packaging sectors. A composting and biodegrading process breaks the packaging down into CO2, water, and biomass. Different than biodegrading, composting occurs under specific conditions and within a specific timeframe. For example, BioFreshPak is a compostable plastic film made from a blend of starch from cassava processing waste and other compostable polymers (Creech, 2020). This new material is developed aiming to reduce food waste and plastic waste.

To successfully facilitate the composting and biodegrading process, caution needs to be taken about the collection system. Leakage from the collection system could have detrimental environmental effects for example it could contaminate the recycling stream or it could persist in the environment (Balestri et al., 2017) and be mistaken as food by the animals.

4.2.9. Archetype 9 - substitution to a non-plastic material

Substitution to a non-plastic material archetype includes packaging solutions that replaced plastic with a more environmentally friendly, recyclable non-plastic material such as paper, and aluminium. This archetype is classified under the material circulation strategy because these alternative materials facilitate the loop of material use. The recyclability of these alternative materials ensures that they can be reprocessed and reused, thereby contributing to the material circulation strategy. It can be implemented across various sectors. In our review, we identified four sectors including food packaging, beauty and personal care and transport/ e-commerce/ tertiary/ secondary packaging, and other (Clothing, Electronics, Healthcare) sectors. For example, KeelClipTM (n.d.) is apllied in secondary packaging. It is apaperboard packaging to fasten multipack products such as beverages in cans. It is made out of cardboard to replace plastic rings, tops and shrink wraps and the design is suitable for a wide range of can sizes. Substitution to a non-plastic material may not always be the most environmentally friendly solution. A holistic and systemic analysis considering the whole lifecycle of the packaging is required including the availability of local resources, the impact of transportation and manufacturing, collection, composting, recycling, etc.

4.2.10. Archetype 10 - plastic recycling

Recycling plastics is one of the most common material circulation strategies to tackle the plastic packaging waste. It is employed both as a downstream and upstream strategy, however, in this research, the focus is on upstream packaging strategies. This archetype is applied in food packaging, beverage packaging, and home care sectors. Two types of plastic recycling sub-archetypes identified in this research were design for recycling and using recycled content.

4.2.10.1. Design for recycling. Design for recycling sub-archetype refers to designing and manufacturing a product, in this case, packaging, so that it can be easily recycled at the end of its use-life. A notable example of this is the deposit-refund system, which is recognised for its effectiveness in recycling (Zhou et al., 2020). In this system, an additional charge is applied to the product's price, which customers can recover by returning the product's packaging for recycling (Walls, 2011).

While designing packaging for recycling, users' waste separation process, collection services, and sorting processes should be considered to successfully facilitate this strategy.

4.2.10.2. Using recycled content. Using recycled content sub-archetype refers to packaging that is made from recycled materials. Including recycled content helps to increase the demand for recyclable packaging and could improve the recycling rates. Evolve, a ready meal tray by Waitrose & Partners (n.d.) can be given as an example where both design for recycling and using recycled content sub-archetypes were employed. Evolve trays are in mixed colours as they are made predominantly from mixed-coloured recycled PET bottles and trays. They are suitable for design for recycling as multi-coloured trays are more widely recyclable because it allows for greater material sourcing flexibility.

While we identified ten archetypes to delineate the upstream strategies for reducing plastic packaging waste, it's important to note that the boundaries between some of these archetypes are not always clear-cut. The key differences between each archetype:

- **Refill Stations**: Focus on providing manual dispensers or automated machines in public or private spaces for customers to refill their containers, reducing single-use plastic usage.
- **Mobile Refill Stations**: Similar to refill stations but mobile, traveling to customers in neighbourhoods to offer refill services directly, enhancing accessibility and convenience.
- **Refill at Home Solutions**: Products and services that allow customers to refill reusable containers at home, emphasizing convenience and regular use through subscription models or direct purchases.
- **Prefilled Packaging Systems (Returnable)**: Offers products in reusable packaging that is prefilled and ready for customer use, emphasizing the ease of use without the need for customers to fill packaging themselves.
- **Reusable Takeaway and Delivery Solutions**: Focus on providing reusable containers for food and beverages, catering to takeaway and delivery services, with systems in place for the return and reuse of containers.
- **B2B Reusable Packages**: Targets business-to-business interactions, offering reusable packaging solutions for commercial transactions, aiming to reduce material and transportation costs and environmental impact.
- **Packaging Solutions Led by Elimination**: Involves strategies to eliminate unnecessary packaging or parts of packaging through design and innovation, aiming for minimalism without compromising functionality.
- **Compostable and Biodegradable Packaging**: Includes packaging designed to biodegrade or compost under specific conditions, reducing plastic waste and its environmental impact.
- **Substitution to a Non-Plastic Material**: Involves replacing plastic with more sustainable, recyclable materials like paper or aluminium, aiming to find environmentally friendly alternatives to traditional plastic packaging.
- **Plastic Recycling**: Focuses on designing packaging to be easily recycled at the end of its use life and using recycled content in packaging to support the recycling ecosystem.

As can be observed in some of the existing solutions, an archetype may be employed alone in a solution or several archetypes can be combined to increase users' acceptability (Long et al., 2022) or the environmental benefits of the solution. For example, Koinpack provides both reuse and refill options for the user's convenience. While the lines between some archetypes may blur, reflecting the complexity and interconnectedness of environmental solutions, this demonstrates the flexibility and adaptability required to meet the challenges of plastic waste.

5. Discussion

The comparison between the findings of this study and existing research reveals both similarities and differences. For example, Lofthouse (2007)'s study covers a diverse set of refill approaches as she identified 16 refill approaches. However, it has been almost 16 years since that publication so it needs to be updated to reflect the most up-to-date models. Whereas, Long et al. (2020)'s publication is a recent one with an extensive list of dimensions to categorise reusable packaging systems. However, it focuses only on reusable packaging systems. It does not cover other strategies that address the plastic packaging waste problem as compostable and biodegradable packaging, elimination of parts, and using alternative materials to plastic. Similarly, Muranko et al. (2021) did not consider strategies for plastic packaging waste other than reuse. Different than that, Tassell and Aurisicchio (2020) explored reuse and recycling together but left out the other strategies.

EMF (2020) covers a diverse set of upstream innovation strategies in their Upstream Innovation Guide. Thus, we want to thoroughly discuss the differences and similarities between the UPS framework and EMF (2020)'s Upstream Innovation Guide. First, differently from EMF's guide, besides the main strategies and archetypes we identified sub-archetypes and groups under these sub-archetypes. For example, we identified two sub-archetypes under the plastic recycling archetype namely, recycling content and design for recycling. Furthermore, the refill at home solutions archetype of the UPS framework is similar to the model in EMF's guide with the same name but we identified 5 sub-categories under this archetype. The sub-archetypes and groups are essential to gain a more comprehensive understanding of the categories of solutions and their similarities and differences.

We also identified two archetypes that EMF did not propose as a model in their guide, namely reusable takeaway and delivery services and prefilled archetypes. EMF's return on the go model has similarities with UPS's prefilled return on the go sub-archetype as both of them include return on the go solutions. However, EMF's return on the go model is a main category with a more general definition that covers a wider scope of solutions whereas the UPS prefilled return on the go is a sub-archetype with a more specific definition and includes a narrower range of solutions. Additional to the prefilled return on the go archetype, we identified another sub-archetype, the milkman model, under prefilled archetype. The milkman model was covered under the return from home model in EMF's guide.

Considering the differences related to the reuse main strategy, the archetypes that we identified under it were different from what EMF proposed as reuse models. EMF's reuse strategy comprises five models. Similarly, we identified six archetypes under it but most of these archetypes were different from EMF's five models. Additionally, we identified 13 sub-categories and five groups under these sub-categories.

The refill stations archetype of the UPS framework is similar to the refill on the go model in EMF's guide. Differently from EMF's guide, three sub-archetypes were identified under the refill stations archetype and five groups were identified under these sub-archetypes. The refill stations archetype is more specific compared to the refill on the go model because the latter includes a wider range of strategies. The refill stations archetype mainly includes refill dispensers and stores in public environments whereas the refill on the go model, for example, comprises the coffee on the go solutions.

We did not include innovative elimination, which is one of the elimination strategies of EMF (2020), in the categorisation grid because first, this strategy was not clearly defined; and second, the solutions that EMF put under this strategy was categorised under other strategies in our categorisation grid. For example, EMF categorised NOTPLA's strategy as innovative elimination but in our grid, it went under compostable and biodegradable packaging because that is the strategy they use to eliminate the packaging. As most of the strategies included in this study can be regarded as innovative, this created a dilemma. Removing this strategy enabled a more accurate, defined mapping process. Lastly, another different finding related to packaging solutions led by elimination archetype was that we identified solid products as a sub-archetype. This study brought EMF's (2020) work one step further by creating new knowledge based on systematic inquiry in accordance with suitable methods. Consequently, it makes an original contribution to knowledge by developing a framework that presents a systematic categorisation of all the upstream packaging strategies accompanied by stakeholder system maps that visually communicate the key features of each archetype.

This research has a range of practical implications that are significant for the packaging industry and environmental sustainability. One of the key outcomes is the UPS framework, which has the potential to inspire and inform packaging designers and the industry about existing solutions. This inspiration could lead to an increased application of these solutions or even inspire the development of new, innovative solutions that align with the principles of a circular economy.

Furthermore, the identification and explanation of the archetypes could facilitate their implementation on a global scale, helping to make sustainable packaging practices more widespread. Packaging firms aiming to mitigate negative environmental impacts can use the archetypes and stakeholder system maps as tools to reshape their packaging services, design, and business models towards sustainability.

The archetypes can be used as examples in research settings with experts, industry or users such as workshops and focus groups. They can be used to draw inspiration for new packaging systems and business models for sustainability during co-design activities for idea generation. For example, the authors conducted a workshop with a group of experts on the Indonesian plastic packaging waste problem and had a productive discussion about the barriers to implementing the archetypes.

Archetypes represent the preferred approaches that innovators and the industry chose to solve plastic packaging pollution. For example, reusable packaging systems are one of the preferred strategies according to the categorisation grid in Fig. 2. Another preferred strategy is to close the material loops. However, some strategies do not appear to be implemented widely enough. The UPS framework might inspire innovators and businesses to implement similar solutions that might show the potential of these solutions for tackling the plastic waste problem.

6. Limitations and further research

This suggested categorisation has some limitations. First, the archetypes were identified based on the currently existing solutions. The cases were collected between the end of 2021 and the end of 2022. While this study has the potential to support innovation, it may need to be updated as new solutions emerge to reflect the most up-to-date models. Secondly, we acknowledge that the cases studied are predominantly from developed countries, despite our efforts to explore solutions from a wide range of geographical areas. This limitation could affect the applicability of our findings in different cultural or economic contexts, particularly in developing countries where packaging solutions might differ. Another limitation is that some of the cases included in this research might not be the most environmentally friendly solutions. Further exploration of the environmental impact of these solutions is recommended. Greenwood et al. (2021) studied the environmental impact of takeaway plastic food containers in a certain scenario. They presented that these reusable and refillable packaging systems have

lower environmental impact potential compared to single-use plastic containers after 2 to 4 uses. However, each system has different combinations of interactions and flows such as transportation, cleaning of the containers, maintenance of the refill machines, etc. So, each system's impact should be assessed considering these specific factors.

Based on the findings of this research, we propose three areas for future exploration that could enhance our understanding and effectiveness of these solutions. The first area is the Lifecycle Assessment of each archetype, which involves conducting detailed assessments of their environmental impacts. This could include evaluating their carbon footprint, resource usage, and overall environmental impacts from production to disposal. Another important aspect is consumer behaviour and acceptance studies. Understanding how consumers respond to different packaging solutions is crucial for their success. Lastly, the economic viability and business models of these sustainable packaging solutions can be further investigated. Analysing the cost-effectiveness, market potential, and business models associated with each archetype can identify the most economically viable solutions for scaling up.

7. Conclusion

To address the global plastic packaging waste problem, numerous potentially effective upstream solutions exist based on strategies such as reusing, refilling, recycling, and composting. The research presented here shows that these can be classified in 10 archetypes categorised under reuse, elimination, and material circulation main strategies.

The aim of these archetypes is to develop a common language that can be used to accelerate the development and implementation of packaging solutions for a circular economy. 200 existing solutions were systematically categorised and analysed to identify the archetypes. Then, each archetype was explained with stakeholder system maps and examples. Finally, the UPS framework was developed to contribute to the innovation process in practice and research.

The findings presented here can be of use to innovators, designers, packaging professionals, and researchers. The UPS framework has the potential to incorporate circularity into packaging design and the industry, inform packaging professionals about the types of existing solutions, and eventually increase the implementation of these solutions. The archetypes highlight the emerging models, strategies, and preferred solutions proposed by the innovators and the industry to tackle the plastic packaging waste issue. They may also encourage the development of new packaging solutions for a circular economy in research and practice.

CRediT authorship contribution statement

Nazlı Terzioğlu: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Fabrizio Ceschin:** Conceptualization, Funding acquisition, Writing – review & editing. **Susan Jobling:** Funding acquisition, Writing – review & editing. **Karnik Tarverdi:** Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Susan Jobling reports financial support was provided by NERC grant.

Data availability

No data was used for the research described in the article.

Acknowledgements

The research is part of PISCES project funded by NERC grant (NE/V006428/1).

Appendix A. List of packaging solutions that tackle the plastic packaging waste problem and the archetypes of the UPS framework

The following table shows 200 packaging solutions included in this research that tackle the plastic packaging waste problem (second column) and the archetypes of the UPS framework that they correspond to (first column).

Archetype name	Packaging solution name
1. Refill Stations	
1.1 Grocery Shopping Refill Stations	
- Refill Stations in Small Shops	1. Algramō
- Refill Stations in Supermarkets	2. Miwa
	3. Carrefour Bio "Bulk Wall"
	4. Waitrose "Unpacked"
	5. Refill and Replenish
- Zero Waste Stores	6. The Refill Larder
	7. Toko Organis
	8. Eco Sister Bulk Store
	9. Das Gramm
	10. Alive Wholefoods
1.2. Beverage Refill Stations	11. Miwa&Nestlé Instant Coffee
	12. Coca-Cola Freestyle
	13. Pepsico Hydration Platform
	14. The Milk Station
	15. Italian Milk Dispensers
	16. Refill
	17. Pepsi Spire
	18. Juicebot
	19. Jean Bouteille
	20. Drop Water
	21. Water Atm
	22. Let's Water
	23. Refill

(*continued on next page*)

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Archetype name	Packaging solution name
	24. Join the Pipe
	25. Waterhub
1.3. Home Care and Beauty & Personal Care Refill Stations	26. Unilever & Walmart Mexico: Shampoo Refill Stations
	27. Beauty Kitchen
	28. All Things Hair Refillery
	29. Cozie
	30. Ecover
	31. Ecopod
	32. Qyos
	33. L'Occitane Refill Fountain
	34. Bleach London Refill Stations
2. Mobile Refill Station	35. Algramo 2.0
	36. Gambino Bottling
	37. Siklus
	38. Refillary L.A.
	39. Green Pear Eco
	40. Refill Van
	41. Allgoods groceries without garbage
	42. Fair-Well
3. Refill at Home Solutions	
3.1. Concentrated Products İn Refill Packages	43. Soda Stream
	44. Bevi
	45. Drinkfinity
	46. By Humankind
	47. Signal Toothpaste Tabs
	48. Forgo
	49. Seed Phytonutrients
	50. Blueland
	51. Everdrop
	52. Dazz
	53. Cif Eco Refill
	54. Replenish
	55. Splosh
	56. Pepsi Home-Made
	57. Ecodrops
	58. Myro
	59. Gatorade Gx Pods
	60. Spruce
3.2. Bulk Refill Package	61. Faith in Nature
	62. Bulldog
	63. Fill Refill
	64. Attitude Bulk to Go
3.3. Recyclable Refill Packages	65. Fills
	66. Bower Collective
	67. Zero Co
	68. Cleancult
	69. Kankan
	70. L'Occitane Eco-Refills
	71. Plaineproducts
	72. Ren&Loop
3.4. Refill Inserts	73. Pure Shots
	74. Dove Refillable Deodorant
	75. Olay Whip Refill Pods
	76. Kjaer Weis
	77. Rituals Refill Body Cream
	78. Above & Beyond
3.5. Reusable Containers	79. Waycap
	80. L'Occitane Forever Bottle
3.6. Refilling Dispensers	81. Evian *Re*(New)
	82. Econesia
	83. Drinkfill
4. Pre-Filled Packages	
4.1. Milkman Model (Pre-Filled Return from Home)	84. Ecopure
	85. Danone Water Jugs
	86. Milk&More
	87. Loop
	88. Kecipir
	89. Pieter Pot
	90. The Wally Shop
4.2. Pre-Filled Return on the Go	91. Koinpack
	92. Bananeire&Jars
	93. Coca Cola U Bottle
	94. Coca Cola Freestyle
	95. Dasani Purefill
	96. Coca Cola Brazil Universal Bottle
	97. Ace of Air

(*continued on next page*)

(*continued*)

Archetype name	Packaging solution name
	98. Hepicircle
5. Reusable Takeaway and Delivery Solutions	
5.1. Reusable Food and Beverage Delivery	99. Allas
	100. Dabbadrop
	101. Vanilla Bean
	102. Dabbawalas
	103. Sharepack
	104. Vytal*
	105. Muuse*
	106. Bare Pack Flexbox*
5.2. Reusable Takeaway Food and Beverages	107. Ozzi
	108. Fresh Bowl
	109. Returnr
	110. Rebox
	111. Ozarka
	112. Go Box
	113. Less Mess
	114. Vytal*
	115. Muuse*
	116. Bare Pack Flexbox*
	117. Burge King Reusable Cup and Container
	118. Green2Go
	119. Dispatch Goods
5.3. Reusable Cup Solutions	120. Cupclub/Club Zero
	121. Go2Cup
	122. Recup Reusable Cups
	123. Revolv
	124. Globelet
	125. P-Lux
	126. Stack Cup
	127. Newcy
	128. Frelburg Cup
	129. Shrewsbury Cup
	130. Cupkita
	131. Vessel Works
	132. Billiecup
	133. Disposable Cup Charge Trial
	134. Costa Clever Cup
	135. Boston Tea Party
6. B2B Reusable Packages	
	136. Swedish Crates
	137. Reusa-Wraps
	138. Return Bar
	139. Euro Pool Group
	140. Returnity
	141. Chep A Brambles
	142. Repack
	143. Brambles
	144. Kegstar
	145. Limeloop
	146. Plastic Cutback Initiative
	147. Liviri
	148. The German Wells Cooperative
	149. Circolution
	150. Ifco'S Smartcycle Program
	151. LEAP India
7. Packaging Solutions Led by Elimination	
7.1. Direct Elimination	152. Snap Pack Carlsberg
	153. Ecocore
	154. Asda Bed Linen Packaging
	155. Walmart: Eliminating Plastic Windows
	156. Amazon Easy-to Open
	157. Sonaemc Secondary
	158. Ica: Laser -Engrave
	159. Aqua Life
	160. Eliminating Neck Tear-Offs
	161. Eliminating Multi-Pack Films
	162. Twist-Loc
	163. L'Occitane Film Around Boxes
7.2. Solid Products	164. Lush Cosmetics
	165. Lamazuna
	166. Beauty Cubes
	167. Gruum
	168. Abhati Suisse
	169. Bites
	170. Bioseptyl

(*continued on next page*)

(*continued*)

Archetype name	Packaging solution name
8. Compostable and Biodegradable Packaging	
	171. Biofreshpak
	172. Biopak Compost Club
	173. Yorkshire Tea Bags
	174. PG Tips Compostable Tea Bags
	175. Bostock Fruit Labels
	176. Vegware & Paper Round
	177. Get on Board
	178. Mycocomposite
	179. Ecovative
	180. Vegware
	181. Ethique
	182. Eco Pod
	183. Neighborhood Botanicals
	184. Apeel
	185. Ohoo
9. Substitution to A Non-Plastic Material	186. Greenclip
	187. Keelclip
	188. Sony's B.M.
	189. Flexi-Hex
	190. Hexcelwrap
	191. Hexcel'Ope
	192. Mondi&Florini
	193. Climacell
	194. Stora Enso's Paper Cosmetics Packaging
10. Plastic Recycling	
10.1. Design for Recycling	195. Maggi
	196. Clear Sprite
	197. Black Recyclable Plastic by Unilever
10.2. Using Recycled Content	198. Evolve from Waitrose
	199. Nextloop
	200. Joi
	201. Amcor- KitKat
	202. Dr. Bronner's
	203. Zero Co.

*These three brands offer two types of solutions and they were included in two categories.

Appendix B. List of keywords related to reuse and packaging were used for the internet search and the literature review

List of keywords used for literature review
1. reuse
2. reusable packaging
3. reusable packaging systems
4. sustainable packaging
5. compostable packaging
6. biodegradable packaging
7. reusable coffee cups
8. compostable food packaging
9. reusable cosmetic packaging
10. refill stations
11. refill at home
12. refill on the go
13. return from home
14. return on the go
15. prefilled
16. returnable packaging
17. mobile refill stations
18. milkman model
19. beverage refill stations
20. home care refill stations
21. personal care refill stations
22. refill packages
23. bulk packaging
24. refill dispensers
25. reusable takeaway containers
26. reusable cups
27. reusable cosmetic packaging
28. reusable beverage packaging
29. reusable food packaging
30. zero waste stores
31. reusable transport packaging
32. B2B reuse
33. eliminating unnecessary packaging

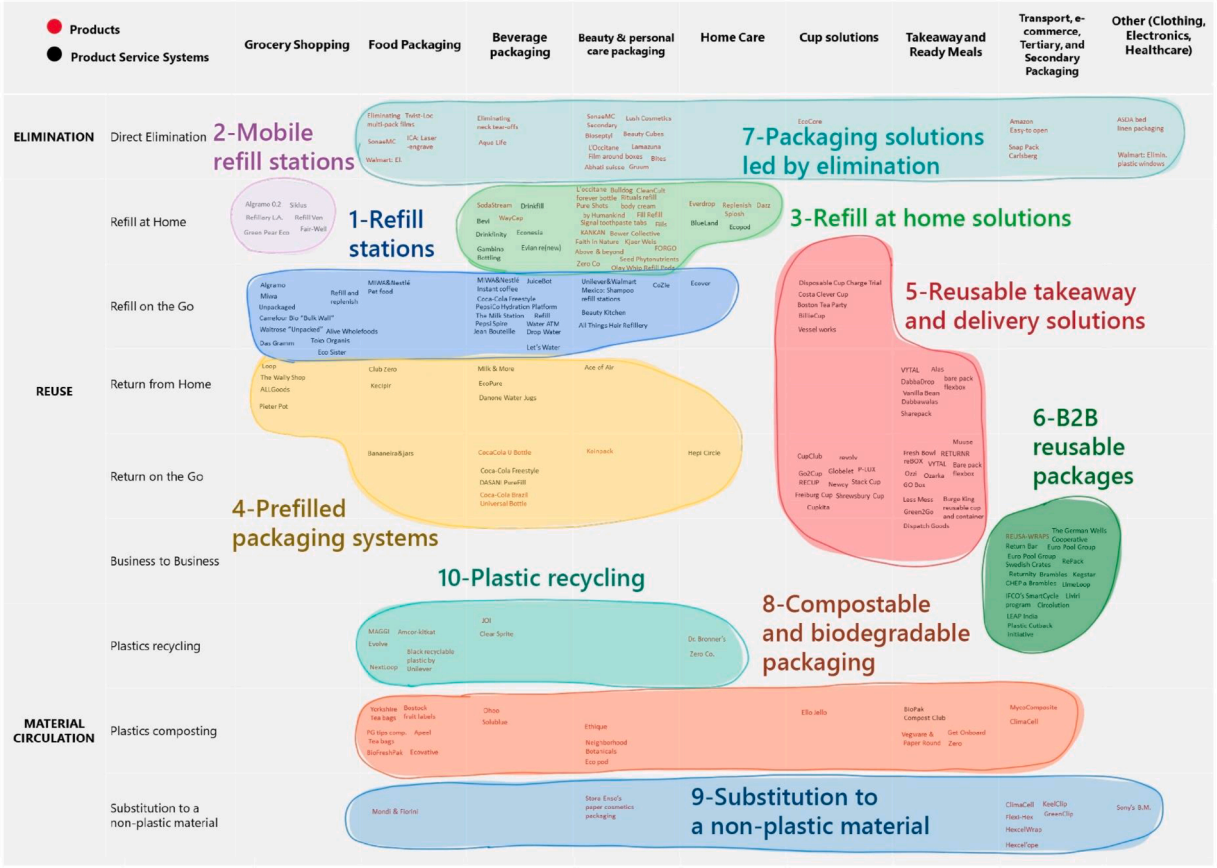
Appendix C. Empty categorisation grid

Upstream packaging strategies were placed on the vertical axis and product sectors were placed on the horizontal axis to develop the categorisation grid.

		Grocery Shopping	Food Packaging	Beverage packaging	Beauty & personal care packaging	Home Care	Cup solutions	Takeaway and Ready Meals	Transport, e-commerce, Tertiary, and Secondary Packaging	Other (Clothing, Electronics, Healthcare)
ELIMINATION	Direct Elimination									
REUSE	Refill at Home									
	Refill on the Go									
	Return from Home									
	Return on the Go									
	Business to Business									
MATERIAL CIRCULATION	Plastics recycling									
	Using Upcycled Materials									
	Plastics composting									
	Substitution to a non-plastic material									

Appendix D. Categorisation grid with identified archetypes

The categorisation grid was populated with 200 solutions according to their sectors and upstream packaging strategies.



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