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Sustainable Packaging in Logistics: Reducing Waste Through Recycling and Reuse

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Introduction

In today's globalized world, logistics plays a crucial role in connecting producers and consumers across vast distances. However, with the rise of e-commerce, international trade, and an ever-growing demand for goods, the environmental impact of logistics has become a significant concern. A major contributor to this environmental footprint is packaging waste, which accounts for a substantial portion of municipal waste worldwide. As businesses and consumers increasingly prioritize sustainability, there is a pressing need to address the challenges associated with packaging materials and to adopt more sustainable practices in logistics.

Sustainable packaging, which emphasizes reducing waste through recycling and reuse, has emerged as a promising solution. This approach aims to minimize resource consumption, reduce carbon emissions, and alleviate pressure on landfills by extending the life cycle of packaging materials. From recyclable plastics and biodegradable materials to innovative designs that reduce the volume of packaging, sustainable packaging solutions offer a range of benefits for the logistics sector and the environment.

However, implementing sustainable packaging on a large scale is not without its challenges. Complex supply chains, cost considerations, and regional disparities in waste management infrastructure make it difficult for companies to universally adopt these solutions. Countries like Hungary, for instance, face unique recycling challenges that hinder the efficient management of packaging waste, further complicating the journey toward sustainable logistics.

This essay will explore the current landscape of sustainable packaging in logistics, examining research studies, case studies, and experiments that highlight both successes and ongoing struggles in this field. The discussion will delve into the types of sustainable materials available, the environmental and economic impact of reducing packaging waste, and the barriers that hinder widespread adoption. By understanding these elements, we can better appreciate the complexities of sustainable logistics and the steps needed to reduce packaging waste through effective recycling and reuse strategies.

1 Literature review of sustainable packaging in logistics

Consumer behavior is changing with time, and now consumers are getting in details of the packaging. It is not just enough to buy and consume any product; customers need to know the source of raw material, its processing, and its effects on the environment. Considering the United Nations sustainable packaging goals, sustainability has shifted from being a non-factor for package producers and customers to becoming a driving force. United Nations 193 members created new global objectives for sustainable development during the UN-Sustainable Development Summit in 2015. The objectives created a roadmap for every industry to strive toward sustainability. The proposed Sustainable Development Goals (SDGs), which are being established by the international community under the charter of the United Nations, set targets for eliminating poverty, safeguarding the climate, and empowering individuals and organizations.

The packaging sector is among the most applicable industries that, quite rightfully, receives a lot of attention. As per UN sustainable development goals, by 2030 all materials used will be environmentally friendly, with the goal of completely implementing packaging that does not need the usage of additional coal and oil. Polyethylene terephthalate material utilization per bottle should also be decreased by 35% by 2030. From manufacturing to logistics and from warehousing to end consumer, the packaging industry plays a crucial role in each transition. Making sustainable packaging and implementing it in mass industrialization can be a tough task due to supply-chain challenges that are further studied in the article. The key focus of the study is to analyze, through the perspective of supply-chain professionals, the importance of sustainable supply chains in the packaging industry. Since packaging impacts overall supply chain, from material producers to product manufacturers and retailers then to trash collection organizations, then it is back to the recyclable facility.

Unsustainable packaging practices have become a threat to sustainable development and, ultimately to the development of a circular economy. The packaging industry plays an important role in the world economy. Packaging is not only about a

simple carton or a box or a plastic wrap, but it is a process that ensures safe, cost-effective, and efficient storage, delivery, and handling of the products from the point of production till the point of consumption. Although packaging is an important aspect of the supply chain and the economy, there is still a lack of proper implementation of policies with respect to packaging; many local companies continue to rely on environmentally degrading options for packaging, such as single-use plastics and multilayered packaging, where unsustainable consumption and dumping of packaging by end consumers creates ecological complications. These growing concerns for the climate and for the world of tomorrow have made companies think out of the box in order to achieve competitive advantage by taking the sustainability aspect into consideration in terms of better management of their processes, mainly those to do with packaging in the supply chain.

With the world moving rapidly toward sustainability by adopting sustainable practices in their processes, it is important for our local supply chain management to adopt sustainability in their operational aspects and logistics processes and their strategic decisions in order to stay competitive with the global shift toward sustainable development. Sustainable packaging has become a vital force in shifting the packaging industry toward recyclable materials. In Pakistan, the shift is negligible; however, according to Europe's Circular Economy policy, the countries that have trade with Europe, must make their process aligned with the circular economy policy by 2030. As nearly 60% of exports are done with Europe in Pakistan, therefore moving toward sustainability has become vital for Pakistan at a faster pace.

Packaging performs diverse and complex functions in the supply chain, as it is the most important aspect for any product; a well-packed product can assure protection to the consumer. Packaging is not only about a simple carton or a box or a plastic wrap, but it is a process that ensures safe, cost-effective, and efficient storage, delivery, and handling of the products. However, there are various studies among developing and developed economies that highlight the emission of greenhouse gases (GHG) due to packaging production. Duan et al. (2019) identified approximately 7.80 m²t of packaging disposal was dumped every year in China due to e-commerce activity. Similarly, Orzan et al. (2018) evaluated that approximately 1.5 m²t was an outcome of

online food delivery service (OFDS), which includes consumption of fuels, paper, and plastic utensils.

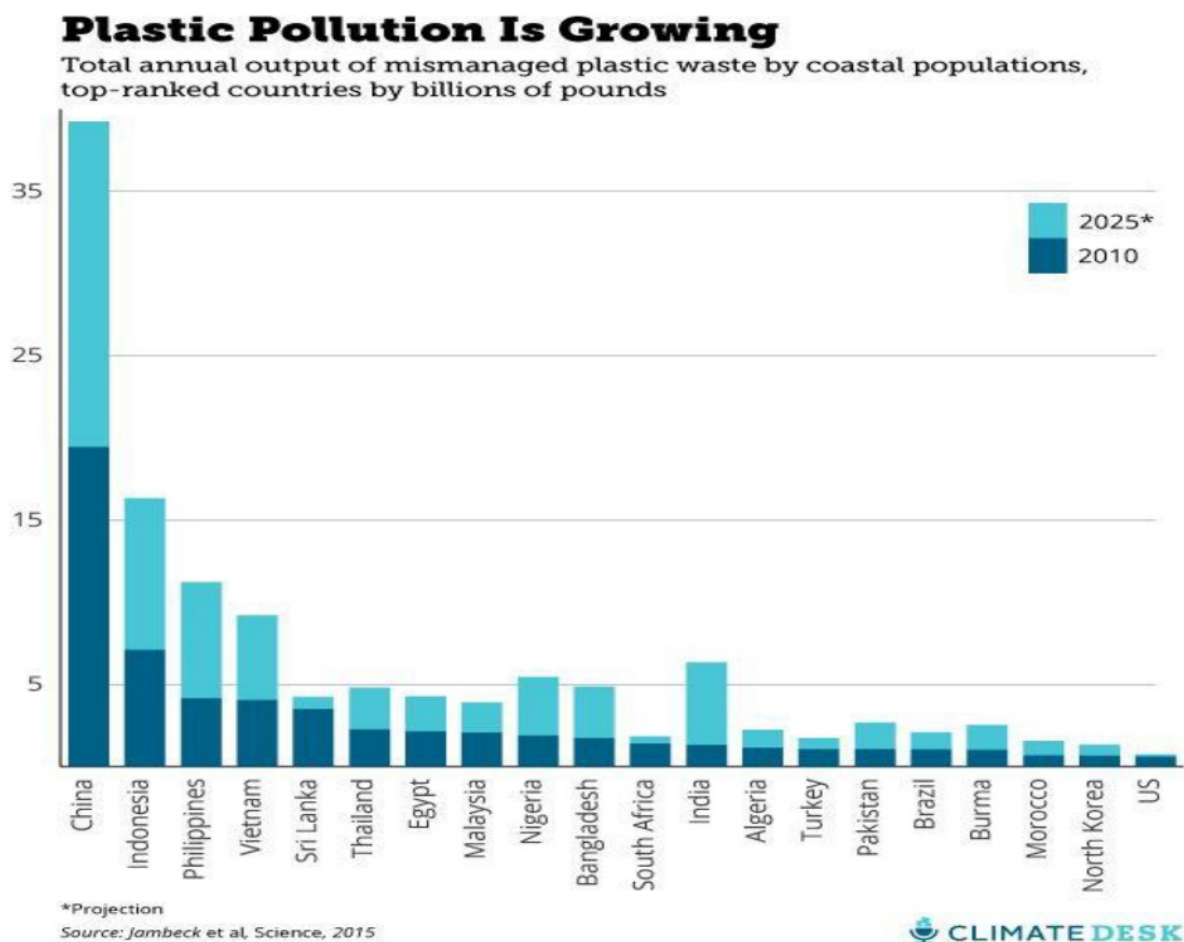
Huge quantities of natural resources such as raw materials and natural energy are consumed in order to manufacture packaging; the large quantity consumption of energy and raw materials causes a strain in the environment due to the depletion of resources and emission of greenhouse gases. Packaging largely consumes multiple resources (for instance, consumption of energy based on multiple sources). The utilization of multiple energy sources leads to a burden on the environment through the consumption of multiple natural resources, allowing manufacturing companies to emit harmful greenhouse gas (GHG). Impaired packaging and dispatch can also lead to the discharge of a variety of harmful impurities in the shape of natural and synthetic contamination into the ecosystem. However, according to the International Organization for Standardization (ISO), Life Cycle Assessment (LCA) can be applied to gauge the environmental impact related to packaging production. This perspective quantifies the comprehensive environmental aspect of product flow occurring during the entire product life cycle, starting from the unfinished product to its final dispatch. According to Yi et al. (2017), in 2015 alone, the production and packaging contribute up to 1.2 Mt of CO₂ emission from China.

1.1 Plastic packaging

Plastic packaging is one of the most used packaging methods around the world. Though plastic is known for its longer lifespan and toughness, it is frequently used for single-use applications. Plastic output has been steadily increasing for more than half a century, peaking at 299 million metric tons in 2013. A growing utilization of plastic packaging due to its economical production cost and permanence is considered a specific area of interest among many firms, as pollution due to the massive involvement of plastic has surfaced as a potential threat to the ecosystem in recent time. Despite of its characteristics, plastic roots ecological complications at the disposal stage, such as impacting human life, the environment, and ocean life; around 5000 million tons of plastic has accumulated in the natural environment and landfills and is predicted to be

increased by 12,000 million tons by the mid-century. Single-use plastic must be reduced, and this implies that people play a critical part in this effort.

In 2021, the European Union imposed restrictions on several single-use plastic products which enter the marine environment every year. single-use plastics refer to disposable plastic that can only be used once before they are thrown away; however, the ban imposed by the European Union has decreased the use of single-use plastic by 10–20% (Herberz, Barlow, & Finkbeiner, 2020). How much plastic waste has been generated till 2010 what will be the world's situation by the end of 2025, and where is number one in production of plastic waste as shown in **Figure 1**



The Supply chain industry is now evolving into Sustainable Supply Chain Management SSCM with the concept of an eco-friendly environment that has already been adopted by many manufacturing industries; but with adopting such concepts come

obstacles which affect the efficiency of sustainable supply chain management SSCM. According to Shalke et al. (2017), the factors such as supplier's eco-practices, cost, and lack of available sustainable options in the manufacturing and packaging process, raising awareness about sustainable products and the recycling process are a few barriers that create obstacles in the implementation of SSCM (Sustainable Supply Chain Management).

SSCM is an advanced concept that has already been implemented in developed countries, and now these countries are moving toward implementing Green Supply Chain Management (GSCM); GSCM has changed the organization's objective viewpoint, which not only helps in achieving profit and market share (by attracting customers from sustainable initiatives) but also helps ecologically.

The supply chain network involves all stakeholder in the business cycle, from farms to retail stores. Therefore, everyone has to share their part for ecological packaging. The green packaging's multipurpose character necessitates the fulfilment of business requirements (capacity to make a product stand out), logistics (by making purchasing, packaging, processing, warehousing, and transportation more efficient), and eco-friendly or reverse logistics (exploring the adoption of waste, recycling, and recovery strategies), all elements that have a significant impact on the profitability of an organization.

Interest in green packaging has been formed due to global distress on petrochemical-based plastic materials such as polyethylene terephthalate, polyvinyl chloride, and polystyrene and packaging automation. Recycling consumes energy therefore, compostability is a critically important factor in green packaging as it enables the packages to be disposed of in the soil by converting them into water, CO₂, and inorganic chemicals. For making green packaging commercially viable, it is important that the packaging should have barrier properties; it should not allow smell, moisture, and light to transfer. PLA (polylactide) has grown in popularity as a food packaging material over the past decade due to its ease of production from renewable resources. Despite PLA production expenses are higher than traditional polymers, this is expected to alter over time as capacity utilization and consumption both rise. PLA is taking steps toward being

a “green” packaging solution. Vilarinho et al. (2017) concluded that bionanomaterials are a feasible option polymer in industrial applications, notably those produced from oil. Nevertheless, the materials’ weak mechanical and moisture barrier characteristics prevent them from being widely used in food packaging. Nanocellulose materials have outstanding characteristics; therefore, they might be termed green packaging materials because they are neutral, ecological, biodegradable, and non-hazardous.

Companies are now looking forward to adopting green and lean supply chains and production methods in their operations for better environment management. A lean supply chain is an approach that focuses on cost reduction by eliminating non-value-added activities, which ultimately results in waste reduction by helping companies to cut down on the activities that do not add any value by reducing the redundant use of time, labour, inventories, equipment across the supply chain. On the other hand, a green supply chain refers to the efforts in order to reduce the negative environmental effect of businesses and their supply networks and focuses on the analysis of internal processes and operations in terms of the environmental consideration in development of a product and product’s life cycles. However, there is still a gap between lean and green supply chains, as the lean strategies refer to the approaches such as just-in-time delivery, which requires increased transportation and packaging, which may challenge the concept of the green supply chain, which mainly focuses on dealing with suppliers and customers, analyzing internal operations and process and product development while keeping the environmental aspects in consideration.

In order to reduce plastic waste, researchers are currently focusing on utilizing biopolymers derived from renewable resources to develop green packaging. These components can be carbohydrates such as starch and chitosan, as well as enzymes such as casein, fibro, gluten, and milk solid, which are produced from cellulose or derivatives. Single-use packaging for reverse logistics is a common practice in the supply chain industry. Paper packaging is not reliable as is not strong enough, and the chances of product damage are higher with paper packaging; cloth and jute packaging are quite expensive therefore, finding alternatives for plastic packaging has become a hurdle, as there is an immediate need to reduce the cost of packaging with the increase in demands

of global consumers for products from various industries and at the same time, it is necessary to keep the sustainability factor in consideration while looking for cost-effective packaging solutions. Therefore, there is a need for reusable packaging for reverse logistics, which is both sustainable and cost-effective.

Plastic packaging is the most suitable option for reusable packaging as it ensures safe product flow from raw material to a finished product and is used for storing, moving, and distributing products across the entire supply chain. Reusable packaging is important in a wide range of industrial sectors, such as textile, chemical, pharmaceutical, food and beverages, apparel, printing, automotive, and electrical.

1.2 On-demand packaging

SWM (solid waste management) is a foremost issue in major cities around the world and is considered an essential element of sustainable supply chain management, which appears to be a realistic method for integrating social, environmental, and economic goals as pillars for an organization's and supply chain's long-standing development. In order to address environmental issues related to SWM, basic social issues such as education, security, and infrastructure must be addressed with the participation and support of government, the local community, and industry. In addition to the industrial focus, the government and community perspective point to practical actions based on SSCM enablers, reinforcing a holistic and multi-perspective view and understanding the need for cohesive management for better solid waste management in developing countries. Because this is a first step in this direction, more research in similar settings is needed to refine the analysis and make it more generalizable.

On-demand packaging technology is considered a process innovation in the packaging industry and enables the customization of transport packaging to the size of products being shipped. Compared to product innovation, where the customer is usually addressed directly, the customer's interest in the manufacturing process of the packaging is usually lower. However, customers benefit from better quality, increased convenience and lower prices achieved through process innovation. The standardization of packaging sizes enables the automation of the handling process. For on demand packaging machines, packaging dimensions are adjusted 1- or 3-dimensionally. This results in

lower transport and protection costs for the goods because no filling material is necessary. Furthermore, economies of scale result in price advantages in procuring packaging material. 162 Twelve providers of on-demand packaging technology were identified in the survey, out of which nine to be interviewed within this research: Beck Packautomaten, CMC, Kolbus, Packaging by Quadient, Packontime (Kern), Packsize, Panotec, Ranpak, Sealed Air. The majority of the on-demand providers use mainly corrugated boards as production material, followed by paper and plastic foils. Some providers offer both variants. Providers for corrugated boards use the volume optimally and the packages are mainly created in the 3D process. Additional filling material is necessary to a limited extent only, yet Ranpak, for example, additionally offers paper-based filling material. In terms of design options, all providers except CMC are at the same level, the exception being CMC in this category, as full-colour personalization on the packs has been offered by them since 2016. This "PackVertizing" concept enables selling advertising space on the packaging to third-party companies as an additional revenue stream. This eliminates the need to produce pre-printed cartons, which reduces stocks. Regarding energy consumption, it can be seen that corrugated packaging machines have a higher energy consumption than the polybags packaging machines. Compared to the other providers mentioned above, the machines from Sealed Air have the lowest energy consumption, followed by Beck Packautomaten. Corrugated boards can also be stacked optimally in contrast to polybags and, therefore, lead in this category. As for the end of packaging service life, leading companies are Beck Packautomaten and Sealed Air. Beck Packautomaten allows customers to choose between recyclable films, films made from recycled (plastic that has already been used) or organic films, or films made from renewable raw materials (sugar cane, corn, potatoes). Sealed Air offers LLDPE films in various material thicknesses and designs (recycled, sugarcane molasses), biodegradable films (thistle base) or corrugated boards. Ranpak also offers biodegradable and renewable paper in the category of filling materials. Customers of on-demand machine manufacturers mainly pack general merchandise products, clothing and textiles. These machines are also used by pharmaceutical industry. Grocery and cosmetics sectors use on-demand machines to a limited extent only. For large-scale coverage of the industries, the providers Beck Packautomaten, Ranpak and Sealed Air

are recommended, as they already have experience and the required expertise in all areas. Providers that focus on specific products include Kolbus for luxury packaging and Sealed Air for fresh products such as meat and fish and pharmaceutical products. CMC is, above all, a leader in the e-commerce sector and has already won several awards in this industry. Packaging by Quadiant is a provider that can optimally compensate for seasonal fluctuations in demand due to the high performance of its machines.

Non-renewable resources in e-commerce packaging have been identified as a main cause of environmental problems. Thus, the European Commission has set the goal of decreasing municipal waste by at least 65%. Furthermore, 75% of packaging waste should be recycled, and the volume of municipal waste in landfills should be reduced by at least 10%. For that reason, the search for alternative resources has gained interest among scholars. The strategies used for sustainable innovations as such are summarized in the 4R Strategy developed by the Delft University of Technology, 4R standing for 'Recycle', 'Reuse', 'Renew' and 'Rethink'. In this context, recycling means the use of materials used for producing new materials for new packaging; reusing refers to the process of using packaging multiple times; renewing is the use of biodegradable, compostable or renewable materials for packaging; and rethinking is finding new design methods to improve existing packaging solutions socially and environmentally. In the past, researchers proposed new solutions, which consist in using biodegradable, compostable or renewable packaging materials. Escursell presented a number of material innovations in both primary and secondary packaging. Paptic is an innovative material made of wood pulp and wood cellulose. The material is completely biodegradable under industrial composting conditions. Due to its technical parameters, resistance and durability, it appears to be applicable for use cases where plastic is usually used. The Paptic material is used to replace plastic bags, polybags and form-fill-seal packaging. The main advantage is that the material can be used with existing packaging machines. Another alternative option is using grass for the production of cartons. This supports the strategy of rethinking packaging by improving its eco-balance. The amount of water needed in the production of grass cartons is as little as 2 liters, compared to up to 6000 l used in producing traditional carton. Moreover, life cycle analyses show energy savings of 80%, reduction of CO₂ emissions by 75% and less use of chemicals in the

production process. This is due to the high volume of grass, and therefore, less material is required. Compared to other innovative materials, grass carton can influence the odor of the packaging, depending on the amount of grass used. The smell of grass conveys a sustainable and ecofriendly image. The material is used for cartons by Kneipp and Claro and is being tested for OnDemand machines by Ranpak. For temperature-sensitive shipments, there are a number of alternative insulation materials. For example, Temperpack developed ClimaCell, which consists of insulating panels made from corn starch and paper. According to the producer, this allows for CO₂ savings of 65%, compared to a traditional EPS carton. Packit has developed Foodmailer made from corrugated cardboard instead of styrofoam. FSC- certified wood-based raw materials are used for production. Furthermore, paperbased Icepackeco enables keeping perishable food cold. Landbox (from Landpack) is a box made from biomaterials, mainly straw. It can thus be disposed of with organic waste or even in nature. 164 Sustainability was also taken into account in the sourcing of the materials as part of the multi-criteria evaluation scheme. The straw in Landpack is straw that would otherwise be considered as waste and therefore, it does not compete with food production. SEAclic produces boxes from bioplastics, made from 80% bio-based materials. The low weight and very good insulation properties of the product are reminiscent of conventional EPS materials, which, however, are made from non-renewable resources. However, the use of polyacids made from corn is believed to increase food shortages. In addition, EcoCool has developed packaging made from alternative materials. EcoCool uses filling material made from 80% recycled PET bottles. In the case of packaging for food delivery, rethinking refers not only to the packaging, but also to the functionality of materials when keeping shipped items fresh. Better thermodynamic properties of certain materials are considered as more sustainable. Ecovative used the rethink strategy to change the whole process of producing insulation. The outcome is insulation made from mushrooms instead of styrofoam. The material consists of mushroom mycelium, agricultural waste and hemp shives.

1.3 Closed-loop Innovation

The amount of waste generated by linear business models has raised considerable interest in terms of circular solutions. Compared to the linear take-make-dispose approach, circular models allow for maintaining the value of the resources in each cycle by applying strategies such as reuse, refurbishment and recycling. However, the development of closed-loop packaging is still in its infancy. The providers of circular solutions within this research are mainly start-ups, ranging from pilot-phase to more mature start-ups who have already tested their solutions in the first pilot projects. There have been identified thirteen providers of closed-loop innovations (bags and boxes); nine of them agreed to be interviewed in this research: BOOXit, LimeLoop, Livingpackets, Memo, Packoorang, Repack, Returnity, Temprify and xpacksystem. All providers assured that the innovation must not only consist of circular packaging design but also requires a supporting system, software which shall fulfil a supporting function by tracking parcels and rewarding consumers for returning the packaging. Many providers' offer includes software to be used by the customer and an app or a software kit which allows for integrating the end-consumer. Differences can be seen in the protection provided by circular packaging. Some solutions (e.g. Limeloop, Packoorang) provide padding to protect the product from damage during transport. Furthermore, some solutions enable keeping cold or hot temperatures inside the packaging (e.g. Livingpackets or BOOXit). This makes it feasible to transport temperature-controlled goods such as food or drugs with closed-loop packaging solutions. Multi-criteria evaluation also covers business models and as such, different approaches in the use of business models among the providers interviewed are identified. Repack offers its customers multi-use bags in the form of a subscription model, and it thus remains the owner of the bags. Other providers sell packaging to their customers, and maintenance is ensured through the service offering model. However, the scope of the service differs among individual providers. While Packoorang includes service throughout the cycle (repair, pick-up, cleaning process, transport to customer), other providers transfer the responsibility of certain cycle steps to the consumer.

1.3.1 Evaluation and Use Cases for Sustainable Transport Packaging

A multi-criteria evaluation scheme was used to evaluate the feasibility of the identified packaging solutions for different use cases. This evaluation scheme was developed in cooperation with an industry expert panel to ensure that its criteria are relevant to the practical handling and operation of transport packaging. The evaluation scheme comprises five categories, each of which contains five to nine evaluation criteria. The first category addresses packaging characteristics ranging from size flexibility volume fill to visual, sensory and tactile packaging properties. The second category relates to both product and consumer protection and addresses the quality, load-bearing capacity and safety of packaging. The third category considers sustainability and includes factors such as the origin of packaging, reuse and disposal, as well as storage and transportation of packaging. The fourth category focuses mainly on the supplier's business model. Here, a distinction is made between whether on-demand solutions or closed-loop models are involved, whether pilot projects are already in progress, and whether the packaging product is already established on the market. The economic aspects of the solutions (e.g. acquisition and operational costs) constitute the fifth category. In the evaluation, each criterion was assigned a value between zero and twenty, depending on how much it meets a given criterion. In addition, the evaluation scheme enables weighting individual aspects more or less heavily, as required by the specific use case.

Three evaluation classes were used to recommend a suitable packaging solution for

1. grocery,
2. fashion and textiles and
3. electronic goods use cases.

These three evaluation classes are as follows:

- Quick Win (best cost-benefit ratio, fast to implement, (comparably)) low implementation risk and a low degree of innovation),
- Go Green (high positive environmental effects, longer preparation and implementation time required, medium implementation risk) and
- Thought Leadership (a very high degree of innovation, high implementation risk and costs, longer-term projects). For each use case (food, fashion and textiles,

electronic products), a "winner" was determined in the evaluation classes, whose solution best meets the objectives according to the evaluation.

In today's business, sustainability goals are increasingly important and prerequisites for the business to be sustainable in addition to well-known goals such as profitability, market shares, revenue growth, occupational health and safety and so on. These sustainability goals consist of providing sustainable products and services from cradle to grave. This deals with reducing consumption and/or improving the usage efficiency of limited resources such as energy, water, land, raw materials etc. At the same time, renewable and/or recyclable resource consumption is increased to reduce waste at all stages of the supply chain. (Fitzpatrick et al., 2012)

1.3.2 Sustainable Packaging and Environmental Impact Considerations

In the past decade, environmental concerns of unsustainable consumerism have risen dramatically through political and consumer campaigns, especially on packaging which is sometimes seen as unnecessary and bad for the environment. As a product, packaging generates environmental impacts and costs throughout its life cycle by consuming materials, energy and water, and by generating wastes and emissions. In popular belief, as the product's environmental impact is often higher than the packaging one, it is not worth the trouble to focus on packaging. However, products and the relative packaging cannot be separated in order to avoid sub-optimization, which thereby acts as a system. Then, initiatives on packaging sustainability aim to reduce the environmental impact of the product-packaging system as a whole. (Fitzpatrick et al., 2012) In order to reach sustainability via packaging, the economic, environmental and social values added to the product by the packaging system have to be monitored. To do so and to identify opportunities the following principles have to be considered during the design process (Sustainable Packaging Alliance, 2002): – The entire packaging system life cycle has to be taken into account from raw materials through to disposal and recycling; – The interactions between the packaging system and the product system have to be understood as well as how this interacts in the ambient (moisture, oxygen ...) and macro (marketing, legislation ...) environments. Four sustainable principles for designing packaging are described in the following Sustainable Packaging Framework

There are four pre-requisites that a packaging needs to fulfil to be sustainable in alignment with the triple bottom line approach (Lewis, 2012):

- Effectiveness in delivering the functional requirements;
- Efficiency in its use of materials, energy and water throughout its life cycle;
- Cyclicity in its use of renewable materials and recoverability at end-of-life;
- Safety for people and the natural environment.

2 Analyzing the current situations

Although consumers have started to be more and more conscious about getting to know the harm that lies in using non-reusable plastic-based products (for example: packaging; single-use plastic bags; plastic straws and utensils; plastic film packaging; Polystyrene foam containers (e.g., Styrofoam, which is commonly used for takeout food containers and disposable cups, this material is lightweight but breaks easily, making it challenging to collect and recycle)), but in many cases there is still no clear way ahead of them in choosing the right path in this.

In Hungary, several sustainable in-store packaging options are gaining traction. One notable example is SPAR Hungary's initiative with recycled and reusable bags. These include recyclable bags created from the store's own plastic waste, as well as reusable bags for fresh produce and baked goods, which help cut down on single-use plastics. The store also offers washable, BPA-free options like the Snack'n'Go bags and Boc'n'Roll wraps for sandwiches and snacks, which are designed for everyday use and are more environmentally friendly than disposable materials.

For bulk food items and loose produce, options such as reusable fabric bags are offered, as they are lightweight and reduce plastic use. Bulk stores around Hungary also encourage the use of glass or metal containers for items like grains, nuts, and spices. These sustainable choices align well with EU policies aiming to minimize packaging waste and encourage recycling, which are becoming increasingly influential across Hungary and other European nations.

These packaging options not only promote waste reduction but also support the broader circular economy and meet increasing consumer demand for sustainable solutions in daily shopping practices.

In today's logistics, consumers and their buying habits play a crucial role. Unfortunately, as long as there is a demand for certain types of non-reusable packaging, there will be a supply. Of course, manufacturers can change this supply, with a number of consequences.

The first and foremost consequence is that the consumer will be dissatisfied, which can create a deficit not only for the manufacturer but also for the supplier and even the retailer. This is obviously one of the worst options. But, as we can see from this example, in this case the dissatisfaction of the end consumer can set off a chain reaction.

Suppose that, in a similar supply chain, one member becomes dissatisfied for similar reasons. We can see that the closer we are to the manufacturer in the chain, the more influence we can have, not only on packaging issues but also on other important issues.

2.1 What if?

If harmful packaging options, such as single-use plastics, non-recyclable materials, and other environmentally damaging packaging, could be entirely phased out, it would lead to both positive environmental impacts and significant shifts in industry practices. Here's what we could expect in my opinion:

Firstly, environmental benefits:

- **Reduction in Plastic Pollution:** Eliminating harmful packaging would drastically reduce plastic waste, which often ends up in oceans and landfills, harming wildlife and ecosystems. Without single-use plastics, the load on waste management systems would decrease, reducing pollution and the risk of microplastics entering the food chain.
- **Lower Greenhouse Gas Emissions:** Many harmful packaging materials, like plastic and certain non-recyclable composites, require substantial fossil fuels for production. Switching to sustainable alternatives, such as recycled or biodegradable materials, would reduce the carbon footprint associated with packaging. This could also help companies meet global climate targets set by agreements like the Paris Accord.
- **Conservation of Resources:** Phasing out non-recyclable packaging would lessen the extraction of finite resources, like crude oil for plastics, and encourage more sustainable resource management through the use of renewable or recycled materials.
- **Economic Shifts**

- **Increased Costs for Alternative Packaging:** Sustainable packaging options, such as biodegradable plastics, plant-based materials, or reusable containers, often cost more to produce than conventional materials. This could lead to increased costs for producers and, ultimately, consumers unless economies of scale make these alternatives more affordable.
- **Market Growth for Sustainable Materials:** The demand for sustainable packaging could stimulate growth in industries specializing in green alternatives, such as biodegradable films, paper-based packaging, and reusable containers. This market shift would encourage innovation, potentially bringing down costs as these materials become more mainstream.

Logistical and Operational Challenges

- **Adaptation of Supply Chains:** A switch to sustainable packaging could initially disrupt supply chains, as companies would need to identify and source eco-friendly materials. Due to the differing durability, weight, or temperature requirements of sustainable packaging, adapting manufacturing processes, storage, and transport may present operational challenges.
- **Need for Expanded Recycling Infrastructure:** If companies shift to recyclable materials, the demand for effective recycling systems would increase. Many regions would need investment in infrastructure to support the recycling and processing of alternative materials, ensuring they don't end up in landfills. This could encourage governments to invest more heavily in waste management systems and circular economy strategies.

Consumer Behavior and Perception

- **Shift in Consumer Expectations and Practices:** Consumers would become accustomed to sustainable packaging and might change their shopping habits accordingly. Reusable packaging, for instance, could lead to more bulk purchasing and encourage a shift towards buying in larger quantities to minimize packaging waste.
- **Greater Awareness and Responsibility:** Cutting out harmful packaging could also increase consumer awareness about waste reduction and sustainable practices.

With fewer wasteful options available, consumers might begin to favor companies that are transparent about their sustainable packaging practices and committed to minimizing their environmental footprint.

Long-Term Sustainability Impact

- **Support for Circular Economy:** Removing harmful packaging aligns well with circular economy goals, as sustainable alternatives are often designed for reuse or recycling. This shift could encourage businesses to adopt circular practices, such as creating products and packaging that can be returned, repurposed, or broken down into new materials.
- **Progress Toward Zero-Waste Goals:** As businesses eliminate harmful packaging, they can better achieve zero-waste or low-waste production goals, ultimately leading to more sustainable business practices and reduced reliance on landfill disposal.

In summary, cutting out harmful packaging options could yield significant environmental and societal benefits, although it would come with economic and logistical challenges. These challenges would also open up new areas for development and flexibility, which would only increase the need for security through logistics and adequate supply.

Although there are many good things to be gained from such a drastic change, it must be admitted that these major changes in logistics would make certain activities more difficult and create a whole new set of problems. The new packaging materials that such changes would impose on logistics would also bring to the surface various problems that ill-equipped companies would find difficult or impossible to deal with. However, change has to start somewhere with the world heading in this direction. There is no better place to start than with the companies at the heart of the supply chain itself.

Of course, it would not be an easy initiative for any company to introduce a change of this magnitude. Based on my past experience, most of which is based on my summer internships, the best place to start a change is with recycling and beyond that, returning so-called "waste" to logistics in other forms.

2.2 *Recovering used packaging materials*

First of all, increasing the percentage of recovered packaging materials from used items requires a blend of innovation in materials, improved recycling technologies, and circular business models that could also help even the smallest companies start to be more environmentally conscious. In my opinion, these are the best options to extract more usable materials from discarded packaging:

Enhancing Recycling Technologies:

- **Chemical Recycling:** Advanced recycling methods like chemical recycling can break down plastics at the molecular level, creating virgin-quality material from waste. This process is especially useful for mixed or contaminated plastics, which are difficult to process through traditional recycling. Chemical recycling can transform plastics that would otherwise end up in landfills into new, high-quality packaging materials.
- **Improved Sorting and Processing:** Automated sorting technology, including AI and robotics, can increase the efficiency and accuracy of sorting waste by material type. This ensures that a higher percentage of recyclable materials are correctly identified and processed, improving the quality of recycled output.

Designing for Recyclability

- **Mono-Material Packaging:** Packaging made from a single type of material (e.g., all-paper or all-polyethylene packaging) is much easier to recycle than multi-layered or composite materials. Designing packaging with fewer components or recyclable materials alone make it easier to reclaim usable material after the item has served its purpose.
- **Easy-to-Disassemble Packaging:** Some products use mixed materials that are hard to recycle together. If packaging is designed for easy disassembly, consumers can separate different materials more easily, improving the recycling rate for each component. For example, plastic windows in cardboard boxes could be attached in a way that lets consumers remove them easily before recycling.

Incentivizing Return and Reuse:

- **Deposit and Return Programs:** Encouraging consumers to return used packaging, especially for products like glass bottles or plastic containers, can help companies retrieve high-quality materials for reuse. Deposit programs, where consumers receive a small financial incentive for returning packaging, have proven effective in many regions for reducing packaging waste.
- **Closed-Loop Supply Chains:** Some companies operate closed-loop systems where they collect, clean, and reuse packaging. These systems are particularly popular in industries like beverages, where reusable containers can circulate multiple times before they wear out. Closed-loop systems allow companies to capture more packaging material without needing new resources.

Upcycling and Repurposing Materials:

- **Turning Waste into New Materials:** Certain types of used packaging, such as cardboard and PET plastic, can be upcycled into different products or even repurposed as packaging for new goods. For example, shredded cardboard can be used as padding for new packaging, while PET can be spun into fibers for textiles.
- **Industrial Symbiosis:** In this model, waste from one company becomes the raw material for another. For example, recycled plastics from one sector could be processed and supplied as packaging materials to another. This approach allows industries to use each other's waste streams and reduces the need for virgin materials.

Biodegradable and Compostable Materials

- **Using Biodegradable Options:** For packaging that is difficult to recycle, switching to biodegradable materials can allow it to break down naturally, especially when facilities to handle these materials are available. Compostable packaging is particularly effective for food and organic products, where contamination might make traditional recycling harder.
- **Promoting Organic Recycling (Composting):** Certain biodegradable materials, such as food waste, can be composted. While composting doesn't allow for

material recovery traditionally, it returns organic matter to the soil and minimizes landfill waste, supporting sustainability goals.

Consumer Education and Engagement

- **Clear Recycling Instructions:** Many recyclable materials waste due to consumer confusion about proper disposal methods. Packaging can include clear, simple recycling instructions, which makes it easier for consumers to dispose of it correctly.
- **Incentivizing Sustainable Choices:** Educating consumers on sustainable packaging choices and incentivizing proper disposal can lead to higher recycling rates. For instance, loyalty programs that reward customers for recycling used packaging or using reusable bags can drive behavioral changes that reduce packaging waste.

When combined, these approaches can create a comprehensive strategy that aligns with circular economy principles, where materials are continually reused, recycled, or composted, minimizing waste and preserving resources.

As I have mentioned before, this transition may not be as easy as I have written it before, but in my opinion, this is one of the paths that can be taken.

3 Think Lean

Many companies find it easier to use so-called lean thinking. Lean thinking gained significant popularity starting in the 1980s and 1990s, though its roots go back to earlier manufacturing philosophies. Initially developed and practised by Toyota in Japan, lean principles were inspired by Toyota's Production System (TPS), which was designed to minimize waste and optimize efficiency. The approach was primarily influenced by the work of Taiichi Ohno and Eiji Toyoda, who, after World War II, focused on streamlining Toyota's processes in response to Japan's limited resources.

Lean thinking began gaining broader recognition in the West following the publication of the book *The Machine That Changed the World* in 1990 by James P. Womack, Daniel T. Jones, and Daniel Roos. This landmark book analyzed the automotive industry's performance and highlighted Toyota's practices as a model for efficiency and quality, sparking interest in lean methods across various industries worldwide. Following this, Womack and Jones's subsequent book, *Lean Thinking* (1996), further established lean principles, such as value stream mapping and continuous improvement, making lean accessible and adaptable to other sectors beyond manufacturing.

By the 2000s, lean thinking had been widely adopted in automotive and manufacturing and healthcare, software development, and supply chain management. Its integration with digital tools and Industry 4.0 technologies continues to expand its relevance as companies seek to leverage lean principles alongside automation and data analytics.

Lean thinking has gained significant traction, especially among manufacturers, with its focus on waste reduction, process efficiency, and continuous improvement. Although exact statistics on lean implementation vary by industry and region, many companies are adopting lean principles to enhance their operational performance. For example, a survey of production managers revealed that around 70% of respondents in automotive manufacturing considered lean management highly relevant today, with expectations that this will increase by 2030. However, when lean thinking is combined with digital tools from Industry 4.0, only about 5% of companies currently reach high maturity in

this integrated approach. This gap highlights both the increasing popularity and challenges of fully adopting lean methodologies alongside newer technologies.

In general, lean thinking is well-regarded for improving productivity and cost-efficiency, which explains its sustained adoption. As lean methods continue evolving with digitalization, the rate of companies adopting these principles is expected to grow.

3.1 Key Principles of Lean Thinking in Logistics

- Value Stream Mapping (VSM): Identify each step in the logistics process to assess where value is created and where waste occurs. VSM helps pinpoint delays, excessive handling, overproduction, and bottlenecks that don't add value to the final product.
- Just-in-Time (JIT): JIT is a lean concept that emphasizes delivering the right products at the right time, in the right quantities, with minimal lead time. This reduces inventory costs and ensures the product flows smoothly through the supply chain.
- Continuous Improvement (Kaizen): Lean logistics is a continuous journey of finding ways to reduce waste and improve efficiency. Employees at all levels are encouraged to contribute ideas for small, incremental changes that enhance the process.
- Reduce Inventory: By keeping inventory levels low, companies can save on storage costs and reduce the risk of damage or obsolescence. Lean logistics strives to balance supply with demand to avoid overstocking or stockouts.
- Standardization: Lean thinking encourages standardizing processes to create predictable and reliable workflows. This standardization reduces errors, makes training easier, and simplifies troubleshooting.
- Eliminate Waste: Lean identifies seven types of waste (overproduction, waiting, transportation, extra processing, inventory, motion, and defects). In logistics, minimizing these wastes can mean fewer empty trucks, fewer double-handling, or less unnecessary paperwork.

- **Customer-Centric Approach:** Lean thinking focuses on what the customer values, aiming to deliver quality and reliability. In logistics, this may involve ensuring products arrive in good condition and on time, increasing customer satisfaction.
- By adopting lean thinking, logistics companies can increase efficiency, reduce operational costs, and improve customer satisfaction.

When smaller companies adopt lean thinking, they often experience a noticeable improvement in their waste management. Lean principles, which focus on waste reduction and efficiency, can help small businesses minimize unnecessary materials, energy, and effort, resulting in cost savings and a smaller environmental footprint.

Here are some ways lean thinking can positively impact their waste problems:

1. **Reduction of Overproduction:** Lean thinking discourages overproduction, a common source of waste. By producing only what is needed, smaller companies can reduce excess inventory, avoid the risk of unsold products, and lower their disposal costs. This helps to conserve resources and minimize waste from unsold items.
2. **Optimized Material Use:** Lean encourages precise material use through value stream mapping, which identifies inefficiencies in production processes. For smaller businesses, this often means they can cut down on raw materials, packaging waste, and even energy consumption, leading to lower operational costs and less waste to manage.
3. **Improved Process Efficiency:** Lean promotes continuous improvement and standardizes efficient practices, such as just-in-time (JIT) inventory management. JIT can be especially beneficial for smaller businesses by helping them avoid overstocking materials that might go unused and ultimately become waste. Process improvements also reduce time spent on non-value-added activities, allowing employees to focus on productivity-enhancing tasks.
4. **Enhanced Recycling and Reuse:** Lean thinking often encourages the reuse and recycling of materials. Small companies can establish practices that repurpose leftover materials for new production, reducing waste and cutting costs.

associated with raw materials. Some companies even create closed-loop systems to repurpose waste as input for new products.

5. **Cost Savings and Competitiveness:** Reducing waste and optimizing resource usage directly impacts a company's bottom line, making it more competitive. By keeping costs low, small companies can reinvest in sustainable practices and growth, creating a positive feedback loop where efficiency drives financial health.
6. **Positive Environmental Impact and Brand Image:** Adopting lean thinking aligns smaller businesses with sustainability, which can improve their public image. More consumers are interested in sustainable brands, and lean thinking helps these companies demonstrate their commitment to environmental responsibility.

For smaller companies, lean thinking provides a structured approach to tackling waste that is scalable and adaptable, enabling them to reap benefits in cost savings, efficiency, and sustainability.

As ideal as all this may sound at the moment, I think it is not enough to simply introduce a new way of thinking or a few new principles and expect everything to work itself out. As something that can evolve into a beautiful future, it can also backfire.

3.2 The drawbacks of Lean

While lean thinking offers many advantages, it also has some potential drawbacks and limitations, especially when not implemented carefully. Here are some of the common disadvantages:

1. **Initial Implementation Costs and Complexity:** Implementing lean principles often requires upfront investment in training, process reorganization, and technology to support lean practices like just-in-time (JIT) inventory. Smaller companies or those with limited budgets may find these costs challenging, and the complexity of redesigning processes can strain resources and disrupt regular operations initially.
2. **Employee Stress and Burnout:** Lean practices require continuous improvement, efficiency, and eliminating non-value-adding activities, which can pressure

employees to maintain peak productivity. Over time, this pressure can lead to burnout, especially in workplaces where lean practices are pushed aggressively without adequate support.

3. **Reduced Flexibility:** Lean thinking emphasizes minimizing waste, including excess inventory and capacity. However, by cutting down on “buffers” such as extra inventory or personnel, companies may find it harder to adapt to sudden changes in demand, supply chain disruptions, or unexpected operational issues. This lack of flexibility can be a serious disadvantage, especially in volatile industries.
4. **Risk of Quality Compromises:** Lean’s focus on speed and efficiency might lead companies to prioritize productivity over quality. While Lean itself values quality, the pressure to maintain constant improvement and avoid downtime can sometimes result in shortcuts that compromise the end product. This is especially true if quality control systems aren’t robust enough to catch issues early.
5. **Short-Term Focus on Efficiency:** Lean thinking is heavily focused on immediate waste reduction and productivity gains, which can lead to a short-term outlook. This may cause companies to prioritize fast returns and overlook long-term investments, such as innovation and research, that could have a more sustainable impact on growth.
6. **Dependency on Reliable Suppliers and Processes:** JIT inventory, a core component of lean, requires a dependable supply chain to deliver materials exactly when needed. If suppliers are unreliable or if logistics are interrupted (e.g., due to transport delays or resource shortages), operations can be quickly impacted, leading to production delays.
7. **Difficulty Sustaining Continuous Improvement:** Lean requires a mindset of constant evaluation and refinement. Over time, maintaining this continuous improvement can be challenging, as companies may reach diminishing returns on their improvement efforts. Without ongoing motivation and clear metrics, employees may struggle to keep up with lean initiatives, leading to a gradual decline in lean performance.

8. Potential Over-Reliance on Lean Tools: Sometimes, companies focus heavily on specific lean tools (like Kanban or value stream mapping) without fully understanding the broader principles. This can lead to ineffective application and limited results, where the tools are applied mechanically rather than as part of a holistic strategy for process improvement.

In conclusion, while lean thinking is a powerful approach, companies must be cautious about these potential downsides. Successful lean implementation requires careful planning, employee support, and a balanced approach to efficiency and flexibility.

4 Alternative approaches

Companies can adopt several management approaches and frameworks beyond lean thinking to improve efficiency, reduce waste, and enhance overall productivity. Here are some key alternatives:

1. Six Sigma: This methodology focuses on reducing process variation and improving quality by identifying and removing defects. Six Sigma uses a data-driven approach, often represented by the DMAIC process (Define, Measure, Analyze, Improve, Control), to achieve near-perfect quality levels. While lean prioritizes waste reduction, Six Sigma emphasizes precision and consistency, making it ideal for industries where quality control is critical, such as manufacturing and healthcare.
2. Agile Management: Originally developed for software development, agile is a flexible approach focusing on iterative progress, customer feedback, and cross-functional team collaboration. Agile is well-suited for industries that require rapid adaptation to changing customer needs or technology advancements, such as IT, product development, and marketing.
3. Theory of Constraints (TOC): TOC centers on identifying the "bottleneck" or constraint that limits overall system performance and improving it to enhance productivity. This method is particularly useful for optimizing production lines or complex workflows. TOC emphasizes continuous improvement and resource optimization but with a focus on the single most limiting factor in a process, which makes it distinct from Lean's broader approach to waste.
4. Kaizen: Kaizen, a Japanese term meaning "continuous improvement," focuses on small, incremental changes that cumulatively improve processes over time. Although Kaizen is often used within lean frameworks, it can also stand alone as a philosophy or approach to drive cultural change in organizations. Kaizen encourages employee involvement at all levels, making it a powerful tool for organizations looking to build a culture of continuous improvement.
5. Total Quality Management (TQM): TQM is a comprehensive approach that seeks to embed quality in every aspect of a company's operations, from customer

service to product design and supply chain management. TQM involves everyone in an organization and is often guided by quality-focused metrics. This holistic approach is particularly beneficial in industries that prioritize customer satisfaction and quality.

6. Business Process Reengineering (BPR): BPR is a more radical approach that involves rethinking and redesigning entire workflows to substantially improve performance and cost-efficiency. Unlike incremental methods like Kaizen, BPR often entails dramatic changes in processes and organizational structure, making it suitable for organizations in need of major restructuring.
7. Balanced Scorecard: The Balanced Scorecard approach combines financial and non-financial performance metrics to provide a more comprehensive view of organizational health and strategy execution. It balances four perspectives—financial, customer, internal processes, and learning/growth—to ensure that no single area dominates, which can help companies align their operations with strategic goals.

Each of these approaches offers unique benefits, and companies can choose or combine them depending on their specific goals, industry requirements, and organizational culture. Some companies also blend these methods, creating hybrid approaches to leverage the strengths of multiple frameworks.

4.1 Larger scale solutions

For larger and better-equipped companies, I think there is another way to reduce and reuse waste. That is an in-house solution, meaning that recycling could be solved within the company without using a third party.

In my view, setting up on-site recycling or a nearby waste processing facility can benefit companies significantly, but there are also some potential drawbacks. Let's take a look at some of the possible implications of having an in-house recycling process:

Advantages

1. Reduced Transportation Costs and Emissions: Companies can eliminate or significantly reduce transportation needs by recycling materials on-site or close

to the facility. This cuts down on fuel costs, reduces carbon emissions, and minimizes the environmental footprint associated with transporting waste to third-party recyclers.

2. **Faster Recycling Process:** In-house recycling means that materials can be processed and reused more quickly, creating a “closed-loop” system that allows for faster turnaround times. This can help companies respond faster to production demands, as recycled materials are readily available and can be reintegrated without long wait times.
3. **Enhanced Control and Quality:** Managing recycling in-house or nearby gives companies more control over the quality of the recycled materials. This can be crucial for industries where material purity or consistency is essential, as companies can oversee the recycling process to meet specific standards and avoid contamination.
4. **Potential Cost Savings:** Over time, on-site recycling can reduce the costs associated with waste disposal and third-party recycling services. While the initial investment can be high, companies can benefit from lower ongoing expenses as they avoid paying external providers for recycling services and disposal fees.
5. **Sustainability and Brand Image:** In-house recycling demonstrates a strong commitment to sustainability, which can enhance brand image. Many consumers favor brands that prioritize environmentally friendly practices so that this shift can boost a company’s reputation and customer loyalty.

Disadvantages

1. **High Initial Investment:** Establishing an in-house recycling system can require substantial upfront investment in machinery, technology, and skilled personnel. Small- to medium-sized companies may find this cost prohibitive, especially if they lack the capital to invest in the necessary equipment and processes.
2. **Space and Infrastructure Requirements:** On-site recycling requires dedicated space and infrastructure, which can be a challenge for companies with limited facility space. This could mean reallocating existing spaces or expanding facilities, both of which can be costly and disruptive to normal operations.

3. **Maintenance and Operational Costs:** Recycling machinery requires regular maintenance, and operating these systems can be resource-intensive. Companies must also hire or train staff to oversee the recycling process, adding to operational costs that can reduce the overall savings from on-site recycling.
4. **Regulatory Compliance and Safety Concerns:** On-site recycling facilities must adhere to strict environmental and safety regulations, which vary by location. Ensuring compliance can add complexity, as companies must navigate permitting, environmental impact assessments, and waste management rules. Failure to comply can lead to fines or reputational damage.
5. **Limited Capacity for Complex Materials:** Some materials, like multi-layer plastics or hazardous waste, require specialized recycling processes that might be impractical or too costly to set up on-site. Third-party recyclers may still be necessary in such cases, as they have the equipment and expertise to handle complex or hazardous materials effectively.

4.2 Overall Impact

If companies were able to recycle materials on-site or very close to their operations, they could potentially improve operational efficiency, reduce costs, and enhance sustainability efforts. However, the practicality of this approach depends on the company's size, the types of materials it handles, and its financial capacity for initial investments. For some industries, a hybrid model—where simpler materials are recycled in-house while complex waste is sent to specialized recyclers—might offer a balanced solution.

In summary, on-site recycling can contribute to faster, more sustainable production cycles. Still, the feasibility largely depends on each company's specific circumstances, including cost considerations, regulatory demands, and space availability.

4.3 Final conclusion

The overall conclusion I've drawn from my research is that no matter what your company does to contribute to a brighter and waste-free future, it won't be easy. Every idea or programme you adopt will have its drawbacks, but it'll all be worth it in the end.

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