Review

Not peer-reviewed version

Towards Sustainable Cosmetics Packaging

Manu Dube * and Sema Dube

Posted Date: 2 August 2023

doi: 10.20944/preprints202308.0120.v1

Keywords: Sustainable Cosmetics; Sustainable Packaging; Sustainability Strategies; Consumer Behavior; Corporate Social Responsibility; Technological Developments

Review

Towards Sustainable Cosmetics Packaging

Manu Dube [1,*], Sema Dube [2]

[1] Faculty of Computer and Information Sciences, Yeditepe University; manu.dube@yeditepe.edu.tr
[2] Faculty of Business and Public Administration, Yeditepe University; sema.dube@yeditepe.edu.tr
* Correspondence: manu.dube@yeditepe.edu.tr

Abstract: In spite of the significant progress towards sustainable cosmetics, mass-produced sustainable packaging has proven to be a challenge. The complexity of environmental, economic, social, technological and policy considerations in conjunction with varying consumer behaviors and corporate goals can make it difficult to select an optimal strategy across heterogeneous supply-chain components spread over the globe; and the cost and effort of developing, testing and validating alternative strategies discourages empirical exploration of potential alternatives. This review discusses the challenges that can be expected in the context of broader sustainability efforts, as well as the experience gained in related fields such as sustainable cosmetics and sustainable packaging, to identify potential pitfalls as well as promising trends towards development of sustainable cosmetics packaging. The findings suggest there may be little to be gained from attempting to induce customers to change their behavior; waiting for a significant increase in global recycling infrastructure; or expecting regulatory constraints to substitute for the lack of technological and business solutions. A research strategy is delineated towards development of sustainable packaging that, with appropriate policy support, could minimize externalities and provide mass-produced packaging that is acceptable to both consumers and producers.

Keywords: sustainable cosmetics; sustainable packaging; sustainability strategies; consumer behavior; corporate social responsibility; technological developments

---

1. Introduction

Industrialization had reduced the number of people in extreme poverty, from 964.93 million in 1820 to 733.48 million in 2015, even as the population had increased from 1.06 billion to 6.64 billion [1]. Illiteracy had dropped from 87.95% to 13.75%, infant mortality 43.3% to 4.05% [*Ibid.*]. It has also facilitated social mobility in tradition-bound societies [2]. The fundamental desire for improvement in living standards drives growth. Personal care and beauty are important components of well-being. Development of chemicals to replace more expensive natural ingredients, and innovations in production techniques for improved quality and consistency in the 19th century, led to rapid growth in the cosmetics industry starting the 20th century [3]; supported on the consumer side by increased prosperity, population growth and aging, and more women in the workplace [4]. The global beauty and personal care market was around US $565 billion in 2022 and is projected to be US $758 billion by 2025 [5]. The cosmetics segment is estimated to be the third fastest overall in terms of growth [6].

Rapid growth places excessive demands on the environment. Over the half-century since environmental and social concerns started to warrant regulatory interest in the form of the US National Environmental Policy Act (NEPA) of 1970 and with the United Nations emphasizing the link between poverty eradication and growth at Stockholm in 1972, earth overshoot day has advanced from December 30 in 1970 to July 28 for 2022 due to increased demand for resources and a decline in the regenerative capacity of the environment [7]. Biodiversity is under greater threat with accelerating rates of extinction, particularly due to habitat loss and fragmentation arising from human activities [8,9] and almost 20% of the Brazilian Amazon forest has been lost [10]. Plastics are associated with more than 906 chemicals many of which are dangerous to humans and the environment [11]; can enter aquatic systems as meso-, micro- or nano-particles and into the food chain which can cause

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

concentration at higher levels [12–19]; and leach heavy metals, requiring controlled waste management [20]. Approximately 79% of the 6.5 billion tonnes of plastics produced until 2015 has been discarded or land-filled, of which about 150 million tonnes have ended up in the oceans [21], currently at a rate of 4.8-12.7 million metric tons per year [22]. Other estimates are that at least 250000 tonnes is currently floating in the oceans and that there is a significant loss of microparticles from the surface [23]. In spite of significant efforts towards achieving a circular economy, the EU exported more than 33 million tonnes of waste to non-EU countries in 2021, 77% more than in 2004 [24]. The quantity of new, petrochemicals-based, single-use plastics has continued to increase faster than it has been possible to scale-up recycling, which remains a marginal activity depending on economic conditions [25]. In spite of regulatory targets, the plastics sector is behind in its attempts to transition to a circular economy [26]. A mere 200 or so of the more than 85,000 chemicals being produced were tested by the Environmental Protection Agency for safety under the Toxic Substance Control Act of 1976 in the US [27] and more than 350,000 chemicals and chemical mixtures have now been registered, with production methods and disposal techniques varying across countries [28]. Industry had discovered the toxic effects of polyfluoroalkyl substances (PFAS), also known as "forever chemicals" by 1970, forty years before the public health community became aware of these findings, suggesting serious concerns arising from the lack of transparency in industry research on chemicals [29]. Lawsuits related to PFAS are still being resolved [30] and the EPA remains concerned about its impact [31]. All the environmental damage has also been accompanied by a consistent increase in income inequality within most developed countries over the past decades [32–34], at times even more so in emerging ones [35].

The cosmetics industry has faced concerns in terms of health, environmental impact and animal testing since the 1970s, including for packaging [3,4]. Less than 20% of the 12,000 industrial and synthetic chemical in cosmetics products are considered safe [36,37]; and these often reach the aquatic environment directly or indirectly [38–40]. In addition to concerns regarding surfactants, chemicals such as UV filters, parabens and triclosan are now considered as emerging contaminants [41] as information accumulates regarding their ubiquity and their impact [42], including their toxicity to microorganisms and crustaceans [43]. Fake and chemical cosmetics containing toxic ingredients remain a concern in developing countries such as Malaysia [44]. Animal testing is still permitted in 80% of the world [45]. Microplastics are a serious concern and regulatory prohibitions on microbeads in cosmetics have only started to come into force suggesting a long road ahead in reversing the damage [6,46], although a primary focus on microbeads may not necessarily be optimal in the context of overall microplastics pollution [47].

Popular brands typically do not offer sustainably-packaged color cosmetics leading to "*consumer helplessness in this regard, and a belief that changes should be led by cosmetics producers and government regulatory action*" [48]. Searches for plastics-free cosmetics in 2020 increased by 897% relative to 2019 [49] indicating potential demand. This may not suffice to motivate companies as the success rate for green products has been so low that research in green consumer behavior has mainly been towards explaining why self-reported positive attitudes towards environmental protection and green purchase intent do not always translate to green purchase behavior [50]. Even with a desire to lessen environmental impact, economic conditions may prevent purchase of higher-priced green products [51,52].

Sustainable cosmetics packaging needs to move beyond being a niche to have a meaningful environmental impact. The current industry view is that the cosmetics sector is one where bioplastics innovation is "*particularly poorly covered*" and that rectifying the situation would require significant upstream and downstream knowledge for implementation [53]. Industry experts advise that it is currently not feasible to use bioplastics or biodegradable plastics for all applications; that they are especially difficult to source for smaller cosmetics manufacturers; and companies may need to continue to focus on the product requirements first [54]. Given the difficulty of finding appropriate materials, such materials may not prove to be optimal in all cases and could be considered depending on the post-use practice in the intended markets [*Ibid.*].

 doi:10.20944/preprints202308.0120.v1

The goal is to develop sustainable packaging that is acceptable to both consumers and producers [55]. Employee attitude towards green products and their willingness to share information and knowledge towards green package design, and the effect of green package design on consumer purchase behavior, are interrelated [56]. Early literature often treated green product development as a new field [57]. The possibility of publication bias towards positive results has been noted for areas in sustainability, such as for the environmental effects of product-service systems [58]. It has been noted that a few successful case studies on sustainability projects are "endlessly repeated" as best-practices although very few of them go to scale [59]. The same holds for sustainable packaging as well [60]. The phenomenon is common across fields and, for instance, positive results for clinical trials are four times more likely to be published than negative ones in healthcare [61]. While the advantages noted may indeed be real, literature often does not adopt a systemic viewpoint, focusing instead on particular benefits such as CO_2 reduction without consideration of other effects [58] and the inability to scale up implies lack of any actual impact [59].

It is important to learn from the vast literature that has been accumulated in areas of environmental protection strategies, sustainable packaging, and sustainable cosmetics to identify promising directions as well as potential pitfalls. Section 2 provides an overview of the complexities that may arise in efforts to incorporate sustainability in cosmetics packaging and fundamental obstacles that have been encountered in scientific literature with regard to environmental protection and sustainability efforts. Section 3 reviews the broad approaches that have been attempted with respect to sustainability including deregulation and liberalization; impact assessments; voluntary corporate strategies; regulatory policies and consumer behavior. Section 4 focuses on the literature on strategies for sustainable packaging and sustainable cosmetics. Section 5 analyses the findings towards development of a research approach that could help move towards the goal of mass-produced sustainable cosmetics packaging.

2. Background

A simplified representation of the traditional cosmetics industry is in Figure 1. Solid arrows represent material flows while dashed arrows are information flows. Packages are designed based on customer requirements in terms of shape, size, color and finish. Packaging production is typically outsourced (e.g. [4]). Raw materials flow from suppliers to packaging producers. The product is then filled, distributed and sold without any consideration of the post-use stage. Feedback at any stage is usually related to quality issues and delivery schedules. Each stage represents a complex set of activities and potentially global supply chains. Multiple companies may supply materials and parts to a packaging manufacturer who may also outsource some of the production steps. Some cosmetics companies regularly add new products, while others may not, depending on their business models [3]. Even when the materials and processes are mostly well-understood, attempts to change packaging materials based on customer demand or cost considerations can be problematic [62].

 doi:10.20944/preprints202308.0120.v1

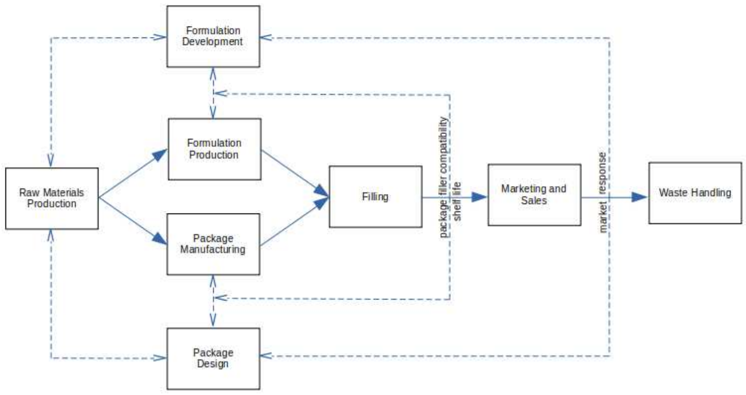

Figure 1. Schematic of Traditional Cosmetics Industry.

Sustainability considerations add significant complexity as shown in Figure 2. New, circular, business models must be developed [63–65]. Processes and products need to be redesigned and harmonized across the supply chain in view of new regulations and sustainability frameworks [66]. Novel packages, formulations and additives must be validated for compatibility in terms of functional requirements such as shelf-life [67,68] as well as their health and environmental impact keeping in mind the waste-handling infrastructure. The supply chain may need to be reformulated [66] and there remains a possibility of lock-in [69]. Even manufacturers of machines for processing the new materials may be relevant to the value chain [70]. Greater information sharing is needed across the supply chain [71] which may not be always be welcome for competitive reasons [72,73]. Innovations such as Smart Circular Supply Chains need to be implemented across the chain, and varying levels of readiness and maturity levels across firms can influence further adoptions by their suppliers and customers [74]. New marketing approaches need to be employed to target different segments of consumers [75]. Based on literature, external factors including suppliers, distributors, customers, waste handlers, competitors, legislators, financial institutions, academia, media and NGOs may be relevant to green product development in addition to internal factors including management, R&D, product development, marketing, as well as purchasing, manufacturing and sales [57]. The European Commission [76] notes that "*Rethinking and improving the functioning of such a complex value chain requires efforts and greater cooperation by all its key players, from plastics producers to recyclers, retailers and consumers. It also calls for innovation and a shared vision to drive investment in the right direction.*". It is imperative to foster upstream and downstream collaboration, develop design capabilities for recyclable products, understand the effects of collaboration networks and investigate supply-chain power relationships [26].

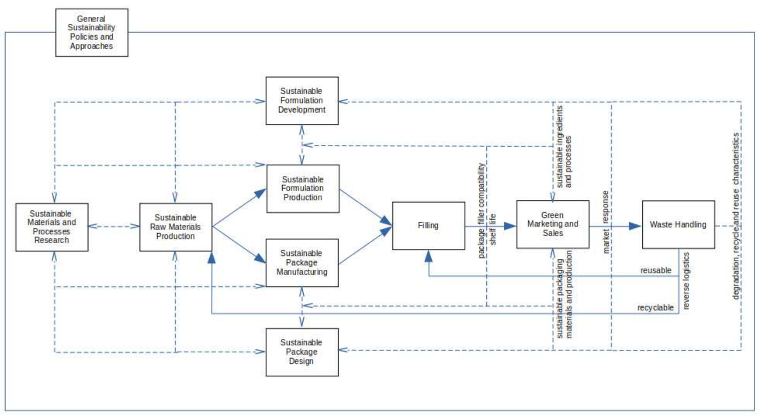

Figure 2. Impact of Introducing Sustainability Considerations.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

2.1. Fundamental Issues

Environmental issues are inextricably intertwined with technological, social and economic issues and, especially for consumer industries, psychological factors with individual-to-individual variations. The inclusion of environmental considerations often requires engineers to interact with areas outside of their expertise [57]. Transdisciplinary frameworks are important for the circular bioeconomy [77], and with increasing digitalization and technological convergence, cross-industry innovation is a significant part of open-source innovation including for areas such as such as food, pharmaceuticals, personal care, chemicals, plastics and machinery [78]. Re-engineering the supply chain and internal processes could require input from several areas as indicated in Figure 3.

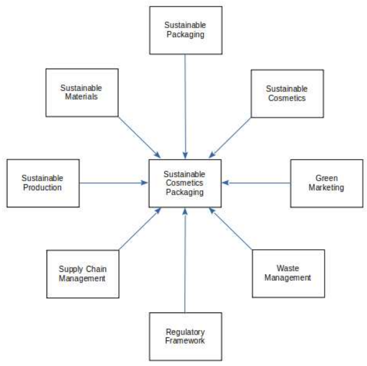

Figure 3. Areas Related to Sustainable Cosmetics Packaging.

2.1.1. Terminology

It is difficult to encompass all facets of a complex issue into a succinct definition and literature, especially in different fields, can define a concept differently depending on the specific aspect of interest. EU objectives such as zero pollution have been criticized as being unscientific as pollution itself is not defined [28].

Sustainability and sustainable development [79,80]; corporate social responsibility (CSR) [81]; and circular economy (CE) [82] all have multiple definitions, often hundreds; and alternate sets of indicators that make it difficult ascertain what compliance actually means. For instance, companies often "meet" their stated renewable energy goals by purchasing cheaper clean energy certificates instead of power actually generated from renewable sources, which interferes with science-based targets as well as net zero goals [83]. Aston Martin attempted to comply with 2012 EU fleet average emission requirements by introducing the Cygnet, a rebranded Toyota iQ. Changing the definition of when a material is called recycled can lead to a drop in the reported EU recycling rates from 41% to 29 − 32% [26]. Industry response to customer perceptions of sustainability in the dairy industry can be in conflict with the economic pillar of sustainability [84]. Divergence in industry focus on business viability versus consumer needs for managing food storage can exacerbate household food wastage [85], while 40% of food-borne illnesses were related to household sustainability practices, whether for environmental protection or for financial reasons [86]. The discussion between the incompatible approaches of weak and strong sustainability has led to the concept of critical natural capital but this itself leads to more questions and differences in opinions [87]. There are conflicts between reactive and proactive CE strategies in plastics [26].

Similar issues are present with regard to terms such as innovation [88–90] and knowledge [91–94] which often appear in the context of sustainability. There is consensus that an "*appropriate corporate culture*" is a prerequisite for knowledge-management [91,95,96], innovation (e.g., [97]) and sustainability (e.g., [98,99]). However individuals' perceptions as to the efficacy of a particular system can vary [100–102], and within-firm variations in employees' perceptions as to whether their firm is innovative, manages knowledge well, and has competitive advantages can be as large as across-firm differences [103]. Information management is key to sustainable development [104].

Multiple definitions exist for Green Marketing, linked to different concepts such as ecological marketing in response to moral issues, green marketing in response to market pressures, and sustainable marketing which seeks to find a trade-off between business and environmental objectives, and these can also evolve over time [75]. "Social marketing" to change human behavior, and "demarketing" to discourage use of goods such as energy in times of shortage have also arisen while "critical marketing" reflects a criticism of marketing in general, including its existence, and "positive marketing" is all actions that create value for firms, customers and society [*Ibid.*]. Whether "sustainable consumption" should be "reduced consumption" has been a problematic issue [105]. Reduction of inequality has been an important social goal and it is not clear whether this involves equality of outcome or equality of opportunities [*Ibid.*].

Terms such as "environmentally friendly" or "green" are essentially meaningless, and lead to attempts such as selling recyclable products in areas without recycling facilities [106] or P&G and Wal-Mart labeling plastic-packaged, chlorine-bleached, paper towels made of unrecycled paper "green" because the inner tube was made of recycled material [107]. On the other hand, the proliferation of classifications for ingredients such as synthetic, natural, natural-derived, nature identical, and organic; each with specifications of maximum and minimum limits of ingredient types, and packaging requirements, with regard to a multitude of product certifications such as BDIH, Natrue, Ecocert, Greenlife and COSMOS [87,108] issued by numerous certification authorities such as Icea, Ecocert, Demeter [109]; creates confusion and is a significant factor in the neutral attitudes of consumers towards green cosmetics, with purchasing decisions being made based primarily on price and performance [51]. ISO-16128 has been introduced as a means towards unifying some of the concepts but can create further confusion across jurisdictions such as due to the inclusion of GMOs in natural products [109]. Labels such as the seedling label refer to industry composting, but are vague enough to be confused as being compatible with home composting for food waste [110]. Incorrect disposal of compostable plastics and contamination with other plastics or harmful chemicals has meant some industrial composters decline compostable plastics [22].

As against Type I labels by third parties or Type III labels obtained through independent scientific analyses, consumers respond better to the confusing and generic claims of Type II labels made by the firms themselves and extrapolate from them to falsely infer additional attributes [75]. This is observed in the food packaging industry as well, such as for Canada where trust in agri-food industry is slightly higher than the institutions that oversee it; confidence in labeling is greater than other aspects; and consumers trust labels based on trust in the source, regardless of certification [111]. Nevertheless certifications may be helpful for bio-based products, especially in food, nutrition and personal care products [112].

With the harm caused by chemical ingredients being a primary motivation for green cosmetics, it becomes necessary to emphasize that "natural" does not inherently mean safe and that a natural product is not necessarily safer than its chemical substitute [113]. The goal of a "toxic free environment" for the EU Chemical Strategy for Sustainability can be ambiguous as several toxins exist in nature and play important roles in ecosystems, and all man-made chemicals could be toxic depending on the exposure levels and duration [28]. Even the term chemical is not defined in the strategy, leaving open questions as to whether plastics are included, or nanomaterials introduced into such polymers [*Ibid.*]. The same product may or may not be classified as a cosmetics product depending on the jurisdiction, and at times even its intended use as stated [114].

Early on, the 1-7 recycling terminology for plastics was identified as being confusing to consumers [115]. While consumers may be willing to separate plastic waste [116], development of new materials requires further separation as presence of biodegradable plastics along with traditional ones can complicate recycling [117]. Post-collection separation of plastic waste may be preferable to at-home

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

separation in terms of both costs as well as environmental impact [118]. Further discussion is needed for achieving consensus across disciplines and sectors on terms such as "bio-based plastics", "bioplastics", "biodegradable plastics" and "plastic recycling" which pertain to complex properties and mechanisms [119].

In practice, lack of a common language can inhibit environmental progress as the same term meaning different things to different people limits its credibility; its applicability; and its usefulness in gauging improvements [79,82]. Multiple taxonomies of knowledge and inconsistent terminology make it is infeasible to create a unified knowledge-based theory of firms [120,121]. The controversy within the cosmetics industry regarding the definition of "cruelty-free" has led to "*companies condemning each other's activities over dubious claims*" and, in one instance, certain companies exiting a major industry association in the UK [4].

2.1.2. Predicting Outcomes

Policy and corporate decisions as to the optimal strategy rely on an ability to estimate their outcomes, and empirically-validated models based on theoretical considerations are key towards implementing effective change. Models are being developed for skin-spreading behavior of sustainable alternatives to emollients [122]. Numerical approaches have been developed towards formulation of shampoos and cleansing formulations for modeling the behavior of new ingredients [123]. A model for shelf-life estimation that can reduce the time and costs for empirical testing with new packaging materials has been developed [68]. Decision-making through mathematical methods reduces costs, time and risk, such as for reverse logistics for packaging and should be used to analyze the supply chain [124]. The overall outcome of any change, however, depends on the interaction of a myriad of internal and external considerations. There is a need for integrating various areas such as business considerations, engineering tools and models as well as policy making as part of the broader context of green product design process [57]. An integrated design strategy incorporating technical models at various scales, from molecular to macro-level, as well as process, product, consumer and business models is needed for emulsified cosmetic products [125].

Issues with integrated socioeconomic models requiring a large number of parameters, including the need for their validation and for subsequent monitoring and updating of projections, were emphasized early on [126]. Apart from typical issues such as data quality, coverage and heterogeneity along with methodological differences (e.g., for income equality [32]; for healthcare costs [127]), a fundamental issue is the inability to conduct controlled experiments, restricting testing to historical data [128,129]. Agent-based simulations require overly-complex modeling of humans agents [*Ibid.*]. Such issues make validations exceedingly difficult at the least.

In Finance, widespread belief in a model can itself impact outcomes [130] and for portfolio performance, "*Given the plethora of factors that may be included in a model, choosing among competing models is an open challenge.*" [131]. Investing in firms with high ESG rankings may direct funds to companies that are already green without improving their environmental performance to a great extent, while removing funds from firms with poor environmental performance ends up worsening their impact [132].

There are more than twenty different models for green purchase behavior involving various values, attitudes and beliefs along with external and internal factors related to demographic, product and social contexts [133]. None of these come even close to a complete explanation [134]. Commonly used models are difficult to validate, have low predictive power, provide context-specific results, and there is only one report in literature of an intervention designed based on the dominant model [135]. The trend is towards models that integrate concepts and factors of various models [136], which can increase their complexity.

The wide range of CE approaches, as well as heterogeneity in organizations, makes it difficult to develop methodologies and tools for identifying CE strategies as there is little consensus vis-a-vis which method to use for selecting the most appropriate CE strategy [64].

 doi:10.20944/preprints202308.0120.v1

Modeling issues also exist in emerging areas in technology. The pressure to quickly introduce more powerful wind turbines has led to an increase in catastrophic structural failures of recently-manufactured turbines across major manufacturers, leading to increased liability claims as well as higher insurance rates [137]. Soldering was considered a dark art even as the electronics industry grew rapidly and the complexity of models for joint reliability was sufficient that gross errors in the underlying models and commercial software [138–141] could go undetected for years even as the popularity of lead-tin solder itself had waned in the meantime due to environmental considerations. In spite of the research efforts and advances, formulation of emulsified products remains an art based on heuristic considerations rather than exact formulas or systematic procedures, and only a few products and processes are designed through model-based techniques due to the absence of adequate data and theory [125]. Lack of sufficient and consistent information on biodegradability of different plastics makes it difficult to discern the relationship between their properties and degradation and while model based analyses can help, issues remain for small molecules [110].

While it is possible to perform repeated tests under controlled conditions in physical sciences, such results do not necessarily transfer to real life situations. Examples range from automation machines [142], to biodegradability characteristics where real life conditions can vary and be substantially different from the conditions specified by standards, often implying over-optimistic test results [22,110]. Materials claimed to be 100% biodegradable were found to degrade approximately 8% in the digestive tracts of turtles, while in another study only four of the six materials claimed to be biodegradable actually turned out to be so indicating misuse of the term [*Ibid.*]. Case-based reasoning (CBR), a data-driven approach that requires less theoretical knowledge, may be used in such situations and such a model for biodegradation prediction has been proposed to help reduce experimentation time for material selection [143].

The presence of natural climate change, the lack of our ability to compare the earth to similar planets, and the use of large models can all introduce significant uncertainty in climate-change predictions [144], even on centennial time scales for circulation-related aspects, necessitating probabilistic, risk-based, approaches [145] and improvements in physical parametrization for sub-grid scale processes [146]. The uncertainty arising at the various stages in the modeling chain for the impact of climate change on water resources requires results be treated with caution [147]. Basin-level risk assessment is required for predicting the impact of climate change on hydropower, which involves a sequence of hydrologic, hydraulic, infrastructure and financial models, as well as additional factors, and the results are susceptible to high uncertainty [148]. Even as efforts are ongoing to reduce model uncertainty for various factors related to climate change (e.g., [149]), the assumption of anthropogenic climate change is itself not necessarily universally accepted [150–154].

The difficulty of long-term experimental research and a lack of scientific consensus on how to determine the best nutritional profile of a food implies the same food could be ranked “healthy" or “unhealthy" making it difficult to determine whether such systems are improving diet quality, and this can erode consumer trust [155]. There is some evidence that directive labels based on potentially changing and arbitrary algorithms and portion sizes could be counterproductive in terms of healthy eating and may also contradict the aim of empowering consumers with robust information [156]. Even literature on specific issues, such as the efficacy of a particular labeling technique, can be interpreted differently [157,158]. While labels may be successful in inducing changes in eating habits amongst target groups [159], not all consumers utilize the information the same way and other marketing attributes can be more influential [160]. Their impact may be diminished with purchase of green-labeled products compensating for red-labeled ones [161]. Given the complexity of the issues involved neither directive nor non-directive labels can be considered a health policy tool [162] and research is ongoing to improve these and find the most effective formats [163–165].

Absence of comprehensive field measurements for the flow of plastic debris to the environment requires use of modeling and simplifying assumptions that ignore certain factors, implying estimates are only an indication of the scale of the issue [22]. Simplified models for estimating waste entering

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

rivers and being transported to the oceans only have limited data and cannot account for complex processes in watersheds, and quantitative estimates "*remain crude*"[*Ibid.*].

Continued research and better computational power can provide more accurate models, but this also implies policy initiatives based on existing models could be misinformed. Use of higher-resolution data along with incorporation of effects such as wind direction and its impact on transportation of plastics, precipitation and terrain slope suggests the number of rivers that contribute significantly to ocean plastic pollution is higher than prior estimates by about 2 orders of magnitudes [166]. In terms of social sciences, healthcare costs have been a major policy issue and early results, that variation in healthcare expenditures with increasing per-capita GDP had an income elasticity of greater than 1, were subject to revision based on subsequent advances in statistical considerations such as stationarity and cointegration [127].

The empirical nature of technology makes it difficult to anticipate the entire range of possible effects due to synergistic effects, delayed effects, cause-effect chains and even abuse, and early on this led to growing disenchantment with impact assessment techniques [167,168]. Technology has only grown more complex since, from nanomaterials to genetically-modified organisms. Information technology tools such as automation, Internet of Things (IoT), big data, artificial intelligence (AI) and blockchain are increasingly being considered for application under Industry 4.0 for sustainability and CE [169–172] in areas such as green supply-chain management [74,173,174]; operations management [175]; manufacturing [176], biowaste remediation and valorization [177]; in sectors such as pharmaceuticals [178]; green consumer research [179], computing Environmental, Social and Governance (ESG) ratings [180] climate science modeling [181], and even solar panel cleaning [182].

The advent of Industry 4.0 and the IoT has implied that larger production packaging companies increasingly sell not just a machine, but the entire interconnected and networked line, which makes it difficult to insert new machines to deal with customer demands for sustainable packaging materials [70]. AI is already creating concerns with regard to whether it will replace or augment human workers [183], especially as it can also replace mental labor, threatening middle-level jobs in the near future [184]. Social considerations have not been included to a significant extent in CE literature and research has focused on areas such as the necessity for creating new higher skilled jobs via appropriate educational programs in areas related to CE implementation, to balance the potential disappearance of lower-skilled jobs [185] but there is little consensus in literature on the impact of technological development on issues such as employment, and seemingly benign policies promoting education and technological development for improving workforce skills can lead to unanticipated outcomes [186]. How CE improves equity remain vague, and there is a need to investigate the NIMBY phenomenon vis-a-vis participatory decision-making [185].

Sustainability literature related to cosmetics and packaging often suggests switching over to renewable energy sources for reduction of environmental impact as well as use of electric vehicles for transportation of goods. For the US, carbon-neutral energy strategies diverge primarily after 2035 and that there is high confidence that increasing the capacity of renewable sources such as wind and solar, along with electrification of light vehicles and buildings, are essential steps regardless of the scenarios that materialize in the future [187]. Furthermore, a switch to 100% renewables would only require a 10-15% rate of growth over the next thirty years, less than the current growth rate, for renewable power and could provide power at lower costs; a distributed system that could also be designed for justice, equality, diversity and inclusion; while maintaining markets via recycling and refurbishment of older equipment for newer, more efficient, technologies [188]. There is a need to resolve issues related to grid reliability in the face of voltage and frequency fluctuations, as well as access to storage technologies [*Ibid.*].

Solar power has been associated with increasing lead emissions in China and India [189], with the potentially low economic potential for recovery of waste photovoltaic modules requiring fiscal policy considerations for its feasibility in China [190]. Implementing end-of-life management for photovoltaic

 doi:10.20944/preprints202308.0120.v1

materials could provide an opportunity for energy savings for the US with regard to the expected exponential growth in the future waste stream [191]. It is important to consider the balance of system, comprising 45% of the material in photovoltaic systems, for assessing the waste generation related to solar power systems in Mexico [192]. California had heavily subsidized and promoted solar power; and earlier-generation solar panels, which had 80% recyclable materials, are starting to fill landfills having exhausted their 25-30 year lifetimes creating potential threats of heavy-metal contamination of groundwater, as disassembly is difficult and expensive [193]. Several US states are now considering proposals similar to the European Union that has started to require manufacturers to fund end-of-life collection and recycling [*Ibid.*], similar to the case of plastics producers which are also often heavily subsidized [194,195]. Wind power has at times been considered wholly inadequate from various perspectives including fluctuations in supply due to issues both at low and high wind speeds, low energy density in terms of area requirements for turbines to be able to generate significant power under ideal conditions, and the harm to birds [196].

As against the tank-to-wheel efficiency, the well-to-wheel efficiency of electric vehicles is not necessarily much of an improvement over traditional vehicles unless the electricity is generated from hydroelectric sources [197], where hydroelectric dams come with their own environmental and social concerns (e.g., [198]). Switching to electrical vehicles could increase emissions in nations with coal-dependent power grids [197]. Use of metals such as lithium and rare earths in electric vehicles, wind turbines and solar panels is an environmental concern [199]. Lithium mining is a potential hazard for leakage of toxic contaminants into the environment that could effect humans, flora and fauna, and could lead to severe depletion of aquifers due to use of the evaporatory brine process [200]. Mining, extraction and roasting, the stage of the maximum environmental impact for rare-earth oxides, has shifted to China based on labor costs and regulatory considerations [201]. This can also lead back to resource dependence issues. With the melting of the ice sheet presenting an investment opportunity in addition to it being a serious environmental concern, there are plans to initiate mining for materials such as nickel and cobalt in Greenland for electric vehicle batteries [202]. Research into new solar technologies is ongoing, with greater emphasis reported on incorporating all stages of the life-cycle (e.g., [203]).

Recycling of batteries remains uneconomical on the whole while uncontrolled disposal could lead to significant hazards [204]. Given that 30% of existing cars in the UK are already estimated to be exported illegally rather than scrapped in line with regulations, and a significant number of cars are simply abandoned across the UK and EU [205,206], the high costs of disposal could simply increase illegal exports again shifting environmental costs to lesser-developed economies.

While larger vehicles to consolidate loads have been suggested as one avenue for decreasing the environmental impact of transportation along with electric vehicles [207], heavier electric vehicles are associated with greater non-exhaust particulate emissions, especially PM2.5 which presents a greater risk to health, and countries may need to reconsider the blanket exemptions such vehicles receive in congested areas. [208]. A major shift towards electric vehicles could cause significant issues with evacuations during disasters by overloading the power grid resulting in cascading grid failures [209,210]. To avoid the high public cost for incentivizing electric vehicles, a dual-credit regulation has been implemented in China in conjunction with corporate average fuel consumption regulation and a rapid increase in new electric vehicles could actually result in a relaxation of fuel consumption restrictions, especially after 2025 [211].

Biodegradable plastics have been proposed as a solution to traditional petroleum-based polymers and while their degradation in marine environments has not been studied extensively [212], literature suggests poly(lactic-acid) microparticles can significantly impact freshwater fish [110,213] as well as marine life [*Ibid.*]. Lab-grown meat could potentially be orders of magnitude more damaging in terms of global warming as compared to traditional meat unless further technological developments allow for its production from food-grade ingredients rather than pharmaceutical-grade ones, and even then there is am estimated range of 80% less to 26% more for its relative impact [214].

 doi:10.20944/preprints202308.0120.v1

It is not even clear if it pays for companies to be green, or if companies engaging in CSR on a micro-scale can make a difference in the overall impact of human activities on the environment [59]. The answer to the first question is highly context and sector specific, and cannot be generalized [70].

It is not easy to inform consumers about the benefits of a recyclable product if experts disagree on its environmental impact [107]. Inconsistent findings in literature regarding consumer environmental behavior and willingness to pay could be explained by the observation that consumers pay only for packaging they perceive as sustainable, and it is unclear how they can be expected to assess such issues if experts, companies and government disagree on sustainability characteristics of different packaging [215].

2.2. The Challenge

Sans a common language and reliable predictions, it is difficult to determine the optimal course of action; to implement it; and to monitor its effects. Germany increased its emissions from electricity generation in an effort to reduce them [216–220]. Bans or fees on plastic grocery bags in many countries increased sales of small garbage bags [221,222]. It has been difficult to trace back changes in greenhouse gas emissions in Canada to specific regulations [223]. Such issues occur in other complex systems as well, such as faults in electronics devices not being easily traceable back to the source (e.g. [224–226]). The enhancement of sustainability characteristics may be risky, as people could use more of a product when it is sustainable [227] and there has been some discussion as to whether individuals may adopt environmentally friendly behavior in areas it costs them less to compensate for lack of such behavior in other situations [228].

The presence of divergent economic interests adds to the confusion. Issues related to degradable plastics in terms of the impact of the resulting "plastic dust" were already being considered in the 1990s [4]. Lack of consensus in literature regarding the impact of oxo-plastics, in conjunction with the growth of competing interests such as the bioplastic industry, have intensified the debate [212,229]. There is discord at the international level where developing countries remain focused on environmental degradation issues such as desertification, soil degradation, and air and water pollution which are directly related to poverty while developed countries have moved on to emissions and climate change [230]. Agreement has been difficult to achieve in international fora as to the responsibilities of developing versus developed economies (e.g., [231]). Poorer countries which may already have lower per-capita emissions may need to spend a greater proportion of their GDP to achieve such goals [232]. Estimates of investments needed to achieve net zero by 2050 are varied, such as $50 trillion [233], $125 trillion [234] and $273 trillion [232], although the costs will be offset by the resulting savings. For instance for the UK, the total expenditures are expected to be £1.4 trillion and the savings are estimated to be approximately £1.1 trillion [235]. Furthermore it is argued that not doing anything would be more costly [233]. Net cost estimates are computed based on alternate scenarios, such as for carbon-neutral plastics for the US, and can be impacted by assumptiond regarding consumer behavior [187].

2.2.1. Public perception

It has been suggested that only a consumer-driven CSR may be practicable [236]. Companies are not entirely new to "green" in that behavior such as recycling of bottles and use of natural products has been forgotten under "progress", making green marketing "back to the future" in one sense [115]. Reversing human behavior that has been extremely beneficial in the recent past may be difficult. Progress has provided many benefits that consumers may not be willing to give up. Concepts such as "social marketing" for responsible consumption are also viewed negatively as attempts towards "social engineering" [75]. Use of fossil fuels was instrumental in the reduction of poverty and improvement in living standards, and renewable sources that had been used previously could not support large populations and may still be problematic in spite of technological developments [196]. Unilever estimates 70% of its emissions are due to customer product choices [227]. It is difficult to have consumers use less water during shampooing [237], to induce customers to recycle [238] or to not mix biodegradable plastics along with other plastic waste [117].

Consumers quickly adapt to conveniences such as online shopping, especially in conjunction with free and fast home deliveries even though higher delivery speeds involve partial loads in vehicles and delivery during working hours requiring redelivery [239]. The last-mile segment can be a significant portion of the environmental impact of the delivery process, and yet customers are very sensitive to delivery charges and reluctant to pay for delivery making it difficult for retailers to incorporate price differentiation or use financial incentives to direct them towards greener options [*Ibid.*]. Studies have established that while consumers are willing to wait longer for delivery which allows for better consolidation and more efficient routing, those who tend to shop more are also willing to pay subscriptions for services such as Prime delivery which currently offer advantages in terms of speed [*Ibid.*]. More frequent users of cosmetics may be less inclined to consider sustainability characteristics of their packaging [48]. Companies can apply varying strategies based on their business models and IKEA charges a high price for home delivery while online supermarket Ulabox does not [240]. Even though individuals traditionally prefer to buy cosmetics in-store, online shopping is an increasingly significant component of such purchases such as due to the pandemic and potentially for young consumers [241–243] which can also complicate their marketing.

Enhancing environmental concern may not necessarily help, as consumers willing to pay more for green products and those unwilling to do so are both aware of the issues and the latter simply trust companies to take appropriate actions (e.g., [107]). After Volkswagen was found to be using its own innovative means for compliance with emissions standards in 2015, its sales for 2016-2017 actually increased after several other manufacturers were found to be indulging in similar practices, with the public inured to such corporate behavior in terms of frequent safety recalls, the Enron case as well as the BP Deepwater Horizon incident [244].

Worldwide, the support for collective climate action is greater than expected [245]. Nevertheless, skepticism vis-a-vis climate change and its anthropogenic origin, in spite of broad scientific consensus, remains a major impediment towards implementing change and is an active area of research [246–248]. The issues involved are not simply political partisanship, even as skepticism is correlated with conservative beliefs and individualistic values along with demographic factors such as being older, male and living rurally [*Ibid.*]. Skepticism could be towards the existence of climate change, human activities being its cause, the impact of climate change, or the need to follow the path recommended by scientists for its remediation; while the reasons for skepticism include trust in alternate science as being superior and more legitimate, climate change being part of a natural cycle, mistrust in climate science, failure of prior climate science predictions, and ulterior motives of interested parties [247]. Efforts to change beliefs have included the use of experimental manipulations to induce analytical thinking modes although greater cognitive sophistication and numerical ability is associated with increased partisanship; and deliberation could place a greater emphasis on prior beliefs as it may be rational for an individual to conclude that the information source is unrealiable than to assume that their prior beliefs that have been built over time are wrong [246,247]. Strategic use of framing in climate change communications to support an agenda can also lead to polarization in audiences [248].

Reducing the level of economic activities directly reduces their environmental impact and the pandemic was the only period during which “earth overshoot day” was delayed [7]. Even so, it added to pollution with overuse of soap and water [249–251], and plastic personal protective equipment [252]. Crises often necessitate short-term policy initiatives geared towards protecting the existing linear economy [253] and there is a need to incorporate creativity, especially under such conditions [254].

The broad public support for collective climate change action can quickly disappear if policy trade-offs in terms of the relative costs and benefits are not made explicit [245]. Examples include Sri Lanka [255], the Netherlands [256], and the UK [257]. There is an incipient counter-trend towards funds that eschew ESG principles [258]. Soon after the largest asset managers in the US, viz., Blackrock, Vanguard and State Street, began to advocate for “stakeholder capitalism” rather than the traditional "shareholder capitalism" with a view towards ensuring long-term profitability [259], Blackrock put green shareholder proposals on hold as being too extreme given the energy security situation [260], while Vanguard in 2022 quit the Net Zero Asset Managers initiative it had joined in 2021 [261]. Several US states are proscribing ESG as a consideration for state pension fund investments or disallowing financial institutions supporting ESG criteria from working with the government [262,263] while Sweden has abandoned its goal of 100% renewable-sourced energy to attain net-zero by 2045 [264]. In 2023 only 37% of Americans are "very" or "somewhat familiar" with ESG with 40% being "not familiar" at all; and most have no opinion on the movement and lean slightly against factoring it into investment decisions [265]. The Exxon board has declined to incorporate in its financial statements "*risks that are remote as the IEA NZE path*" as "*it is unlikely society would accept the degradation in global standard of living required to permanently achieve a scenario like the IEA NZE*" [266]. Lloyd's, AXA, Allianz and Swiss Re are amongst ten major organizations that have resigned from their membership in the Net Zero Insurance Alliance [267]. Social influence has been suggested as a means towards inducing green behavior [227] but such attempts against traditional social norms can also create significant backlash and can exacerbate mistrust against such endeavors in general. While higher-priced, low-quality, sustainable cosmetics may not by themselves kindle mass public unrest, there remains a risk of a more immediate change in the political climate that could not only set back attempts towards the environmental progress that still needs to be made, but also undo the progress made thus far.

Environmental protection efforts have been ongoing for at least half a century and similar issues have been encountered in other areas where sustainability has been sought to be incorporated. It is of interest to consider the broad approaches towards environmental protection and sustainability.

3. Broad Approaches

Characteristics such as individualism versus collectivism may play a role in determining individuals' green behavior, and their impact has often been studied at an aggregate level [50]. Such differences have long been reflected in economic philosophies as well, which have often proved irreconcilable [268] because of different assumptions as to what makes people happy; and whose, which, rights need to be protected (e.g., [269,270]). The dichotomy is reflected in the two broad approaches, viz., the market approach and the regulatory approach, that have been attempted towards ensuring environmental protection within the scope of promoting development for poverty alleviation. The market-based approach was that of deregulation, and subsequently voluntary CSR implementation based on the premise that it would pay to be green, as well as research into consumer behavior. Regulatory approaches started with impact assessments for future developments and have increasingly shifted to policies requiring changes in existing economic activities.

3.1. Deregulation

The rate of growth for improving living standards should ultimately be self-limiting vis-a-vis its environmental effects. Pollution is itself a health hazard and a stressor that can decrease the quality of life [271]. The health impacts of pollution are serious [28,272], increase healthcare costs [273,274], and have resulted in the need to relax Covid-related safety measures at times (e.g., [275]). Severe pollution can lead to lockdowns (e.g., [276]) which can hamper economic activity, as can depletion of resources due to overuse (e.g., [277]). The markets-based approach suggests that markets will find their own optimal balance most efficiently and there is no need for regulations.

Deregulation and liberalization with a singular focus on development and growth, favored by Bretton-Woods institutions [230], was supported by the Environmental Kuznet's Curve (EKC) hypothesis that posited an inverted-U shape for the relationship between income and environmental impact with some empirical support across nations except for Turkey, China and Spain [278,279]. While deregulation reduced across-country differentials which are the major component of global inequity, primarily due to Chinese growth [280], it failed as an environmental measure.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

Global inequality often implied the potential for shifting of polluting activities to less-developed regions without an overall decline in the environmental impact and the result was the alternate race-to-the-bottom "pollution haven" scenario for attracting growth which proscribes the final reduction phase [279]. Integration with the global economy has often led to a worsening of environmental degradation in developing countries [278,279] which remain stuck in the middle income trap [281] even as the turning point for environmental impact is beyond the start of the high-income range [278]. Rapid industrialization in developed countries was, at times, achieved by shifting at least some of the environmental and economic costs elsewhere (e.g., [282]) and there are not enough resources in the world to allow developing economies to attain the same standards of living by following the same path [283]. In the meantime, depletion of nonrenewable resources and new pollutants can permanently damage the environment [278] while renewable resources have been depleted due to over-consumption [7]. The recognition of the failure of the deregularory approach to sustain growth, especially by the UN, led to explicit incorporation of the Equator Principles by major international lenders [284].

Under deregulation, plastics production shifted to Asia, and post-consumption waste was also often sent to developing economies for disposal. Land-based plastics constitute almost 70-80% of ocean pollution via runoff from rivers and the coastline, overwhelmingly from Asian rivers [166]. Globalization also helped create large cosmetics multinational corporations (MNCs) which often off-shored production and manufacturing facilities to developing economies [285]. Companies such as L'Oreal acquired Helena Rubenstein, while Unilever acquired Rimmel and Faberge, and Revlon bought Max Factor and Almay. By 2000, L'Oreal had 16.8% of the global market share, followed by Estee Lauder (10.9%), P&G (9.3%), Revlon (7.1%) and Avon (4.7%), with the top 10 accounting for 62.1% of the global market [3,4]. Cosmetics firms typically outsourced packaging [4]. Large cosmetics companies with sufficient clout to ensure adherence to terms by suppliers could outsource packaging to China, and at times this had substantial impact on the business models of cosmetics packaging producers in countries such as Turkey [62]. Nevertheless, products sold in specific markets required localization and in many markets western products have since been replaced by local, traditional ones [285].

The EKC hypothesis does provides some insight into the challenge of sustainable development in that a decrease in income or living standards in developed economies could lead to an increase in their environmental impact while, as reported in 1996, insofar as 25 percent of the world's population consumed 85% of its wealth and produced 90% of the waste even if the poor 75% ceased all economic activity the reduction in pollution would only have been 10% [230]. It would probably be less as some of the "dirty" but essential outsourced activities may need to be moved back to high-income regions. In terms of I = P x A x T of Ehrlich and Commoner [80], with growing global Population, and Affluence in the context of consumption, the only realistic way in the near future could be to use Technology to reduce the Impact by developing novel solutions to reduce the environmental impact of economic activities.

3.2. Impact Assessments

With rapid growth the initial regulatory effort was to prevent new developments from adding to environmental and social disruptions, starting with NEPA in the US in 1970 [286]. This took the form of requirements for environmental impact assessments (EIA) which, unless there was a finding of no substantial impact (FONSI), would lead to environmental impact statements, EIS. Such assessments considered the environment in general including its physical, chemical, biological, cultural and socioeconomic components. The approach, especially subsequent to the 1979 Council on Environmental Quality regulations, emphasized a scientific methodology based on quantification of the various factors and use of appropriate mathematical techniques [*Ibid.*]. Since then, 191 of 193 countries in the UN have either signed an international treaty or have domestic legislation which contains "Environmental Impact Assessment" or equivalent terms [284]. The complementary Social

 doi:10.20944/preprints202308.0120.v1

Impact Assessment (SIA) methodology was developed alongside EIA to especially ensure avoidance of negative impacts of industrialization on society [287]. While not as widely implemented initially, it has since attained prominence due to the emphasis placed by the United Nations on the need for all businesses and agencies to ensure human rights are not violated in any projects they undertake and to focus on shared benefits and values [288].

Such efforts were intended to change the thinking of regulatory agencies and guide policy development with greater public participation. While public interest groups and individuals may use EIA results to successfully mobilize opinion against specific projects [289], assessments have had far less influence than originally desired in terms of decision-making [284]. The difficulty is that "*[P]roject activities lead to a whole series of disturbance in the surrounding environment (both physical and non-physical) which may trigger a complex sequence of effects and potentially lead to a 'synergistic new totality'*" [290].

The initial rationalist approach of quantification and scientific analysis using mathematical models, often computer based, was soon discovered to be susceptible to so many issues that EIA is now viewed additionally through multiple political models such as symbolic politics, political economy, organizational politics, pluralist politics and institutionalist politics [284]. Problems start with screening for which projects need impact analyses, due to attempts at avoidance (e.g., [291,292]). Screening procedures that work well for land take for projects such as ski-resorts and small urban developments may fail for other types such as quarries or roads, and while the focus is on projects with large land takes, the total of smaller projects that often do not require a full EIA is significant [293]. For scoping where "issues, scales and methods are determined", impact assessment reports uniformly failed to properly quantify and evaluate ecological impacts and were reluctant to address complex, cumulative and indirect effects among their other deficiencies [8]. Impact prediction, especially cumulative effects, may still be handled inadequately although there is renewed interest in improving the performance of this stage [284]. The notion that utilization of state-of-the-art predictions in decision-making carries significant risk was supported for Norway where due to lack of clarity in data and assumptions, and reported values not being accompanied by the associated uncertainty, a significant number of analyses failed to predict the impact to within 10%, or even 25% [294]. Efforts are still underway to study the efficacy of the various procedures related to EIA [295]; and how sustainability assessments and the various measures and indicators can be placed in the context of local governance considerations [296]. The difficulty of incommensurability, such as for the value of individuals being able to use natural areas for recreational purposes, can also make quantification difficult [297]. Finally, EIA has grown and evolved over decades and it could even have deviated from its desired goal under various interventions [298].

Variants such as Strategic Environmental Assessment (SEA) have been developed to incorporate environmental considerations in earlier stages of decision-making [299,300]. While its use has been increasing and in spite of some successes, concerns remain regarding the ability of SEA to generate alternatives and to influence decisions [254]. Tiering and better communication between SEA and EIA has the potential to enhance the effectiveness of both impact assessments as well as decision-making [301]. Issues with environmental impact assessment approaches have at times been characterized "*not as an oversight*" but rather as a "*policy decision shaped by those with a vested interest*", representing "*a political success for elite interests rather than a policy failure towards environment protection*" [284].

The difficulty of SIA is in "*learning to make public (and private) decisions that will look good in 50 years, after the evaluation criteria by which they are judged have changed*" [302]. The need to include psychological and cultural issues makes quantification difficult [287,288,303]. Studies viewed as detrimental to the potential user's organizational interest were almost never used, and their credibility in terms data, methodology, the confidence in their conclusions and the amount of new information provided was likely to be rated low [304]. SIAs have been characterized alternately as "*attempts towards project legitimization at best*" [287,288]; or as "*heavily influenced by an anti-growth bias rather than substantiated social theory*" [305]. It has been recognized that there is no one best way for all cases and that methodological convergence needs to be on the main pattern of assessment steps [302]. Lack of

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

public participation often added to the mistrust in spite of its priority for SIA [306]. The basic issue remains identifying who benefits and who loses, and how to transfer the costs to those who benefit [302]. Different groups have different interests and the mandate for public participation could be ambiguous in terms of whose issues take precedence [*Ibid.*]. Poor public knowledge of planning and legal issues; a mistrust of the waste disposal industry, perhaps not entirely misplaced (e.g., [307]); the NIMBY syndrome (e.g., [308]); alongside regulatory constraints [284], all make effective public participation difficult.

The inadequacy of impact assessments for future developments has necessitated increasing regulations on existing economic activities encompassing a diverse range of sectors such as energy, transportation, manufacturing and even agriculture. Experience with impact assessment sounds a cautionary note in that if it is not feasible to accurately predict the impact of a specific project in a given location with high degree of confidence, and there are fundamental divergences in stakeholder interests, the impact of policies towards environmental protection may also be difficult to predict. While models can be developed for specific tasks such as optimal location of recycling facilities based on supply-chain criteria, it may be difficult to accurately predict the realized social and environmental impacts of such facilities.

3.3. Voluntary Corporate Strategies

With deregulation failing to stem environmental degradation and a growing realization changes would be needed in existing economic activities, the market approach shifted to encouraging CSR with enthusiastic industry support at least in part to forestall regulatory and legal interventions [309]. The European Commission, in 2001, defined CSR as "*[A] concept whereby companies integrate social and environmental concerns in their business operations and their interaction with stakeholders*" [310]. The idea was to involve environmental considerations, for both products and processes, as part of the overall management strategy [4] under the assumption that environmental and social costs affect everyone and so investors and consumers, out of self-interest, would reward corporations that minimized these. It has been suggested though that the relationship between a firm's social performance and its financial performance could be an inverted-U curve [311]. In spite of interest in CSR since the 1950s, the area of implementation has not been well-explored academically in terms of an integrated view of individual, firm, institutional and country levels; and its theoretical underpinnings are still being developed, primarily using stakeholder theory, at times in conjunction with theories from psychology, communications, sociology and biology [312].

Neither all investors [313] nor all consumers [107] are willing to pay for the common good and such attempts reignited the debate vis-a-vis management responsibility to shareholders versus that to stakeholders [81]. Those supporting socially-responsible behavior often did not indicate what such behavior actually entailed [4], something which is still not entirely clear [81]. A large proportion of early business literature was not empirically tested; often use a normative tone such as "*business and society must meet/should be responsible to the challenge of sustainability*" without providing a general explanation of green product development, which was always treated as a new field and reflected a Western perspective [57]. Concerns as to whether businesses had the expertise or the ability to find solutions to social issues, and that initiatives unrelated to firm functions would help neither the company nor society, led to the concept of Strategic CSR [314]. The basic design steps are identifying the stakeholders and their interests, identifying the firm's interest in CSR in terms of the value chain and competitiveness, and considering social and environmental problems as business opportunities [*Ibid.*]. For this, organizations need to include innovation in the supply chain; and implementation requires greater communication, often training by the focal company that is facing regulations or stakeholder demands, and joint initiatives with its suppliers [315]. There may be an optimal level, though, beyond which innovation can hurt performance [316]. Continuing concerns as to whether attempts by individual companies to improve environmental impacts could suffice have led to versions such as CSR2.0 [59] and CDCSR [236] being proposed.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

Stakeholders are heterogeneous and may have conflicting demands (e.g., [317]). Country-to-country differences, such as the "Bottom of the Pyramid" approach recommended for India [314] and only retaining the top 10-20% of customers in the US [115], could make CSR implementation challenging for international firms [311]. Empirically, contrary to expectations, international firms or companies with international partners are reported to have better sustainability as well as financial performance in spite of multi-jurisdictional operations [318]. US firms with directors exposed to international changes in regulations and reporting requirements also improve their ESG/CSR performance, although only for firms in "clean" sectors and with good financial performance [319].

3.3.1. Implementation Strategies

The concept of circular economy (CE) has arisen as a widely-accepted approach towards implementing sustainable development, as a closed-loop system that avoids new inputs as well as waste and emissions [80]. It is now possible to integrate CSR and CE into the overall aim of achieving sustainable development goals [320]. Alternate ways may exist for a company to implement CE as paths to different competitive strategies and, given the typically top-down nature of Circular Business Models (CBM), it is essential to couple strategic planning to CBM [65]. The wide range of CE approaches, as well as heterogeneity in organizations, make it difficult to develop methodologies and tools for identifying CE strategies as there is little consensus in which method to use for selecting the most appropriate CE strategy [64]. The BS 8001 standard presents a framework with a list of generic guiding principles that can be extended and there are hundreds of papers on potentially useful CE strategies; changes needed in decision-making frameworks; and CE improvements for manufacturing processes [*Ibid.*]. Lack of consumer interest and a hesitant company culture, along with high up-front investment requirements and low prices for traditional materials may act as barriers for CE, along with technical feasibility issues such as those related to process design and optimization [99]. Strategies vary by product and technological developments, and for instance, reuse of ICT network infrastructure could be harmful as improvements in energy efficiency outweigh the impact of manufacturing even for low-impact power [321].

LCA has gained prominence as a quantitative tool for evaluation of products, services and systems in the context of CE [64,322]. The focus on sustainability is typically on the overall impact of a product over its lifetime, such as the carbon footprint including direct emissions controlled by the company; secondary emissions from the generation of purchased electricity that occur where the electricity is generated; and potentially indirect greenhouse gas emissions spanning the supply chain [323]. Assessments based on ISO-14040 and 14044 standards can be used to assess environmental effects associated with the product from raw material extraction all the way to disposal or recycling [*Ibid.*]. LCA can also be applied at the organizational level (O-LCA), especially in conjunction with life-cycle costing (O-LCC), where the methodologies may recommended different courses of action [64].

The steps of LCA can be summarized as determination of the scope and the reference; inventory of the flows between the product system and the natural environment; collection of data including that related directly to the specific process or plant, or publicly available data such as industry averages, depending on the product and the scope of the study; impact assessment for various impact categories; and overall characterization and interpretation which often involves subjective weights [323]. A planetary boundaries based procedure could help remove the subjectivity introduced by prioritizing the indicators although weighting factors for most indicators should be based on regional or local data rather than global values [324].

Quantifying the impact of activities through LCA can be complicated. For pineapple production, estimated impacts for the production of 1 kg of fresh pineapple ranged from 0.172 to 0.520 kg of CO_2 equivalent with even wider variations in water requirements, and prior studies variously found $32\% - 60\%$ of the carbon footprint to be during the agricultural stage, corresponding to $68\% - 40\%$ for the industrial stage [325]. While use of multiple datasets may increase the accuracy, LCA results depend significantly on assumptions and studies have variously found the global warming potential of biodegradable mulch films to be 2-3 times lower that landfill and incineration, and also composting and anaerobic biodegradation to have a higher impact than incineration and energy recovery [110]. LCC and S-LCA applications have focused on technically mature and well-established biopolymer products because of available data, an understanding of the manufacturing processes, as well as consumer attitudes and companies being unwilling to disclose proprietary information to competitors in terms of the basis for their decisions for specific implementations [73]. Lack of global standards for LCC and S-LCA implies the possibility of novel techniques relevant to specific scenarios [*Ibid.*].

Design for sustainability is critical but Life Cycle Impact Assessment based on LCA remains unpopular in manufacturing as selection of appropriate datasets based on linked, international databases is extremely challenging and high-level conceptual models and decision support systems may help bridge the gap between raw data and eco-design [326]. LCA is also unsuitable for startups considering circular strategies as it is too technical and time-consuming [65]. Design for Sustainable Behavior is related to LCA, but rather than focusing on consumption process of the product, it also incorporates the impact of consumer behaviors which can indirectly affect the overall environmental impact [327].

3.3.2. Measuring Corporate Sustainability

Recent crises have reemphasized the need for non-financial measures to augment traditional measures for risk estimation [328]. Factors related to social responsibility are not incorporated in technical and fundamental analyses, which has led to a focus on supplementary ESG rankings for guiding investment decisions [*Ibid.*]. ESG, by including governance directly rather than via its indirect influence on social and environmental considerations, is a more expansive terminology [329]. Communication of CSR activities in reports may help companies reduce their ESG-related and reputational risks [310].

There is little to suggest that the approach has been effective, even as there has been a significant increase in assets for funds that seek to invest in socially-responsible corporations [330]. From a financial perspective, evidence for enhanced fund performance except during periods of high volatility and crises, or for higher ESG ratings being correlated with greater firm-level performance except for a lower probability of default, is mixed at best (e.g., [330–336]). ESG-related news has a significant effect on credit default swap spreads [337]. Markets primarily focus on downside ESG risks and greater incorporation of ESG scores in corporate ratings is in general negative for capital markets as it leads to a negative impact on stocks and an increase in credit default swap spreads [338]. Investors may also focus on ESG risk exposure, which incorporates unassigned risks and sector adjustments of ratings [339]. Investing based on ESG ratings can even harm the environment [132].

Improving its ESG ratings is a strategic business decision for a firm, to be undertaken to the extent that the costs incurred contribute towards increasing market returns while minimizing risk. There is insufficient research on how ownership structure affects the impact of ESG on firm risk [337], and somewhat conflicting results regarding institutional ownership, investment horizon and ESG ratings [329].

Firms are rewarded with reduced credit risks for social performance in line with the ESG performance of the country in which they operate, with greater economic and social development having a positive impact on CSR [340,341]. Studies conducted in the US and Sweden found family firms to be more responsible to shareholders in environmental decisions while in East Asia they had lower ESG performance [329]. For Turkey, firms listed on the Borsa Istanbul Sustainability Index have higher performance in ESG issues [342] but results as to financial performance are mixed (e.g., [343,344]).

Strategic decisions as to optimal corporate social policies depend significantly on the industry and its characteristics, and the impact of the overall ESG score versus E, S and G components on performance may differ by sector and the extent to which it is regulated [345] (e.g., for banking [346];

 doi:10.20944/preprints202308.0120.v1

for IT [347]; for the financial sector [341]; and for real-estate[348]). The impact of ratings on probability of default also varies by sector [334,335] with corporate governance issues being the primary concern for markets [338].

The costs associated with reducing risk via improved ESG ratings are too high for small firms while the impact is not significant for large companies who indulge in such activities for organizational legitimacy instead, and the effects of higher ESG ratings are seen primarily for medium-sized firms [335]. ESG ratings are biased towards larger firms which have greater resources for providing data [349].

Voluntary SME adoption of standards such as ISO-14001 is limited and compliance-driven or profit-driven SMEs do not utilize these if market conditions do not provide sufficient motivation [350]. SME participation in the Philippines towards supply-chain greening is due to increased customer awareness, especially vis-a-vis exports [351]. Chinese SMEs understand the importance of green practices but lack the knowledge to integrate them to improve operational performance [352]. Turkish SMEs that could benefit from changes to improve their efficiency may not have the requisite technical skills and may lack awareness of environmental issues [353]. Comparing Swiss SMEs and MNCs, small firms have the organizational characteristics to better integrate CSR in core-business practices while constraining external communications and reporting, and large firms can better implement external communications and reporting while constraining internal implementation [354].

SMEs are highly heterogeneous and diverse and there is especially little understanding of whether the benefits of CE induce such companies into transitioning to CE [99]. Swiss, French, Greek, Spanish and British SME's can improve environmental performance through energy and resource efficiency, and waste reduction, and a framework has been developed for CE adoption in business operations [355]. Austrian SMEs can be clustered into front-runners, fast followers, a late majority and laggards; and fast followers, companies that understand the need for CE but require support towards implementing it, should constitute the ideal target for policymakers and economic development agencies [99]. Private and public sector contributions for financing of CE for European SMEs has been recommended due to their barriers to accessing financing such as private costs, industry standards, lack of human and technological capital, limited information and low market demand to avoid the reinforcing the triple environmental-knowledge-financial market failures [356]. SMEs have varied preferences vis-a-vis self-learning toolkits versus hand-holding, and there is a need to differentiate between different types of external financial support [350].

There is a convergence in CSR and CE amongst cosmetics MNCs; and CSR reports of eight cosmetics MNCs show a focus on CE which is is not observable in the CSR actions of SMEs [357]. MNCs fall under mandatory reporting requirements, and several of the statements are goals, such as objectives of zero waste in landfill and more than 90% recycling, or a recycling rate of 50%. Using the same sample, in terms of adoption or pursuit of CE objectives, only four of the companies were clear about their CE objectives and none of the firms used circularity ratios, although some used alternative sustainability ratios [320]. A sample of sustainable reports for the Italian cosmetics industry for the period 2014-2019 shows terms related to the environment to be somewhat more frequent, but CE to be under-reported for governance, strategy, management and performance; indicating the need for greater institutional, regulatory and stakeholder pressure on companies [358]. International cosmetics companies are increasingly creating lines using natural products, particularly for shampoos in conjunction with large chemicals manufacturers who have set up lines for natural raw materials; support fair trade and social programs in various countries; but do not report on the economic impact of sustainability [207]. A sample of eight small and large cosmetics companies in Brazil suggests the companies to be focused on environmental aspects in design and sourcing, and while CSR compliance is improving, compliance with Design for Sustainability (DfS) principles is still in early stages [359].

Companies such as Burt's Bees, Tom's of Maine, and The Body Shop were all interested in the ethical dimension of consumer marketing and in creating an aesthetic that was biocentric and ethical, rather than an anthropocentric, going beyond skin-deep beauty [360]. Cosmetic companies in the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

British Union for Abolition of Vivisection (BUAV) were significantly smaller than those not in the association, and were concentrated on a small segment of the industry such as soaps and skin-care products, implying far greater impact in markets for the latter group [4]. BUAV member companies were more concerned about environmentally-acceptable attributes of their products with non-BUAV members satisfied with one or two attributes while continuing to develop products with animal testing for certain consumer segments, although there was internal disagreement within BUAV members regarding "cruelty-free" products. However The Body Shop has since been bought by L'Oreal, and then sold to Natura [361] which is representative of many such startups while large companies have often re-assimilated their divisions focused on sustainability into traditional ones [106]. Several prominent cosmetics companies also continued to use microbeads in their products suggesting a compliance mentality, necessitating regulatory prohibitions [46].

It is not sufficient to simply raise stakeholder awareness and motivate firms to improve their ESG ratings. A more fundamental issue is that such ratings may not necessarily help investors who wish to promote socially-responsible corporations without regard to short-term returns. ESG is a composite concept that incorporates disparate objectives. Ratings of firms by major issuers have correlations ranging from 0.36-0.71 with an average of 0.51, with firms providing greater disclosure showing greater disagreement amongst alternate ratings methodologies [362]. Even the relationship between firm performance and ESG ratings may depend on the rating methodology used [332]. Markets are still researching appropriate ratings methodologies such as AI-based ratings as an alternative to traditional measures [180]. Within the context of a particular methodology, ESG ratings are not absolute but are industry-adjusted [339] implying it is difficult to compare the actual performance of firms across sectors. Ratings are focused on policies and activities, with only 8% measuring the actual effects of the policies [362] and decoupling of organizations' formal policies from actual implementation always remains a possibility [313]. Sustainability principles such as footprint analyses to promote life-cycle thinking may not be fully integrated into ESG assessment processes [363], which is a significant drawback as the complex issues involved are beyond the control of individual organizations. While the level of disclosure by companies is increasing, the availability of data remains problematic [364]. Ratings often rely on unaudited or imputed data [362] with significant potential for greenwashing or even brownwashing (e.g., [313,365–367]).

Financial viability remains key to the survival of firms. Ratings firms that aimed to aid and establish socially responsible investing as an alternative to the traditional profit-based model were themselves often not sustainable, and the resulting industry consolidation has led to the reestablishment of the traditional institutional framework even in this industry [368].

3.3.3. Social Entrepreneurship

Environmental degradation and social issues such as income inequality and lack of income mobility have also led to entrepreneurship specifically directed to redressing social [369] and environmental concerns [370]. This is consistent with the core of entrepreneurship which is to create and extract value as the entrepreneur lives in society and could have moral values that allow them to transcend the traditional measures of economic value maximization [*Ibid.*]. Public demand and regulations may create additional economic opportunities for environment-conscious entrepreneurs or "ecopreneurs" in various industries who, while fundamentally business-centric, can improve the environmental impact of their products either as independent ventures or through separate divisions or spin-offs for large companies; as well as for "green entrepreneurs" whose business is specifically in the environmental marketplace [371]. The key role of technology, combined with the ability of entrepreneurial firms to explore disruptive innovations, has led to an increasing trend of academic spin-offs focused on areas such as smart product-services, technical processes, biochemical, renewables, and biosphere regeneration [372]. Incumbent firms in general are not clear on how to modify their linear business models [373] while entrepreneurs are often well positioned for advancing sustainability [253] but lack the resources to strengthen their value proposition in the face of costly

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

actions needed to change the existing rules of the game [374]. These include policy areas such as patient capital, regulatory hurdles, public procurement, performance labels and organization of networks (e.g., [375,376]). The success rate of startups has always been a concern and policies may be needed to help with the survival of new companies [377]. Even though the timing of several "enviropreneurs" was in line with customer needs, they were often driven more by founder values rather than detailed customer needs analysis and many boutique companies stalled while traditional companies often rolled back their green divisions back into traditional ones [106].

The insufficiency of the voluntary approach has led to increasing regulations on economic activity. The original EU definition of CSR specified it to be "*on the voluntary basis*" and was modified in 2011 to also include respect for legal obligations [357]. The disclosure requirements for large companies previously implemented by the EU have not sufficed and are being modified [378], while most companies are unprepared for it and may be overstating their sustainability [379]. Such regulations typically leave out SME's for which data may simply not be available. Some jurisdictions have moved beyond mandatory reporting and have started to mandate CSR conduct that was previously voluntary [81].

3.4. Regulations on Existing Activities

Several issues including lack of green awareness and ethics, as well as economic, business and technological barriers, can contribute to continuing environmental pollution and governmental involvement is necessary for efficient environmental protection [207]. The initial legal measures were complemented, starting the mid-1970s, with economic ones such as fees and taxes as well as financial support to influence the behavior based on economic interest. The Fifth Environmental Action Programme of the EU encourages companies to produce green products by economic measures such as tax incentives and provides support systems in terms of education, IT, research and financial assistance; covers several categories of pollution and takes measures to deal with surface and underground water; sets water standards for various activities; regulates production, packaging and use of harmful chemicals as also fuel emissions and noise pollution for various machines; and regulates the collection, reuse, disposal and transportation of waste while limiting its transnational transportation. Cosmetics companies are expected to play a greater role in promoting health consciousness due to governmental regulations [*Ibid.*].

There have been efforts to curb practices such as the direct export of waste, and the United Nations, through the Basel Convention, aims to prevent the export of hazardous waste from developed countries to developing ones for disposal. Such exports from Europe have been decreasing in recent years, with EU countries increasingly acting in accordance with proximity and self-sufficiency principles [380]. The EU is attempting to promote a circular economy and recycling rates for plastics waste surpassed landfilling rates in 2016 [381] with landfilling being at 24.9% in 2018 compared to 32.5% for recycling, 81% of it inside the EU [382]. Nevertheless it exported 77% more waste in 2021 than in 2004, primarily to Turkey [24], with exports to China dropping significantly after China, in 2017, banned the import of most plastics waste [383]. Turkey had also cut back on plastic waste imports based on a Greenpeace investigation that found most of the waste was not being recycled as required but rather was being landfilled or incinerated, mostly near low-income neighborhoods, but subsequently reversed the ban except for HDPE and LDPE [307]. The EU Emissions Trading System promotes production of packaging in non-EU countries, and will continue to do so until 2030 when such requirements are extended to external producers exporting to the EU [70].

3.4.1. Heterogeneous Impacts

Implementing changes for environmental protection and social welfare is costly which is why regulations to enforce such changes are almost always opposed by industry [313], although large firms may at times welcome, or even demand, stricter regulations to gain a competitive advantage over smaller and weaker rivals [384]. Around 800000, or two-thirds, of gas stations in the US were shut down by 2001 for economic reasons due to expensive mandatory upgrades for preventing leaks from underground storage tanks to aquifers which were too costly for smaller businesses [115]. At the same time attempts at environmental protection have a significant negative impact on the productivity of large firms, as against for smaller firms where they do not have a significant effect [385]. Several large companies do not report how sustainable packaging efforts impact their business operations suggesting lack of a connection between sustainability and business considerations [207].

For China, greater regulatory concentration may inhibit green innovation in state-owned firms while having greater impact in areas with weak regulation, with the impact also varying by sector in terms of its level of pollution; and positive ESG performance by firms has a negative effect on the relationship bewteen environmental regulation intensity and green innovation suggesting a substitution effect [386]. If a U-shaped effect of regulation intensity on green innovation is assumed, weak regulations may encourage companies to adopt low-cost methods to improve their performance and high-quality green innovation may only be forthcoming after a certain intensity threshold. Technological advancement, such as via R&D expenditures [387], can provide the highest returns but involves high fixed costs [388]. However green harvesting behavior involving stopping when costs for further improvements start to increase has been identified as one of the typical forms of failure in green marketing [106]. Established companies may find it difficult to develop and implement new technological solutions and often use third-party collaboration with NGOs and other companies, followed by a scale-up [388]. Intense CSR implementation in SMEs has been associated with exploitation in terms of incremental benefits via refinement, efficiency and focus; rather than exploration which involves experimentation, flexibility and divergent thinking [389] and SMEs may be able to benefit from radical innovation more via informal CSR [390].

Exempting SMEs from regulations can be problematic as while individual SMEs may not consider their impact to be large, their combined impact is significant (e.g., [291,350]. SMEs constitute more than 99% of the total enterprises in the EU and employ more than two-thirds of the labor force while contributing more than half of the value added, but have limited availability of skilled labor; do not invest in training; and are already often hampered by increased costs, excessive regulatory burdens and lack of access to funding [391]. While some compulsory regulation may be essential until consumer awareness can drive SME environmental efforts, high costs of compliance such as high fees for waste management may simply lead to workarounds such as illegal dumping where financial penalties do not work unless enforcement is fair and uniform which can itself be costly; and may encourage compliance behavior rather than environmental commitment (e.g., [350]). Turkish firms, other than customer demand, focus on areas regulated by law and attempt to avoid areas that would require incurring additional costs [392]. Lack of appropriate technical knowledge may also make it difficult for SMEs to comply with requirements (e.g., [352]).

While promoting entrepreneurship may be helpful especially with regard to environmental concerns as well as employment opportunities, the impact of entrepreneurship vis-a-vis inequality involves extremely complex considerations [35,393–400], and there are disagreements on the effects of inequality on growth [32,33,401]. The situation is not any better regarding the role of regulations on issues such as technological and green innovation [386], or employment [402,403] and their effects are typically heterogeneous across enterprises and even the level of corruption may be relevant [*Ibid.*].

3.4.2. Heterogeneous Frameworks

Differences in regulatory frameworks for cosmetics across markets and countries, including the very definition of cosmetics, are sufficiently large as to create hurdles for trade and for innovation; and organizations such as the International Cooperation on Cosmetics Regulations, along with OECD and ISO, seek to promote inter-country regulatory discussions [114]. Within the EU, while regulation 1223/2009 requires a cosmetic product safety report before it is placed in the market, except for the person being qualified in pharmacy, toxicology, medicine or a similar discipline as recognized by the member state, there is no other criteria specified implying the safety report can be different for each country depending on the background of the responsible person; and other countries have their own requirements [*Ibid.*]. Cosmetics packaging needs to comply with EU cosmetics regulation EC1223/2009 as well as REACH, the Packaging and Packaging Waste Directive 94/62/EC as well as other relevant regulations, such as for packaging that may come in contact with food; prohibitions on marketing of products such as cosmetics which could be mistaken for foodstuff due to their appearance, smell or packaging; and labeling that must not imply characteristics that are not present in products [114,404]. None of the regions of EU, US, Canada, Japan, China or Brazil have authority to approve cosmetics claims before a product is placed on the market which often leads to non-compliance, and different claims can be allowed or prohibited in different countries [114].

Although an increasing number of countries such as Australia, all EU countries, Guatemala, India, Israel, New Zealand, South Korea, Taiwan and Turkey have banned animal testing for cosmetics, with partial bans in certain states in Brazil and the US, approximately 80% of countries allow it and China still mandates such testing [405,406]. This can lead to questions such as whether a product that was developed without animal testing elsewhere can still be classified as cruelty-free, if it is also introduced in China.

In terms of natural ingredients, several standards such as the IBD in Brazil, ECOCERT in France, the USDA in the US along with QAI and Oregon Tilth, BDIH in Germany, NASAA in Australia, ICEA in Italy and COSMOS in the EU all have attempted to classify natural and organic products [407]. It has been difficult to achieve harmonization in such guidelines and there is a need to further evaluate natural products for efficacy and toxicology as side effects such as allergic contact dermaitis, irritant contact dermatitis, phototoxic reactions and contact urticaria have been reported [*Ibid.*]. The various certifications are sought to be unified under the ISO 16128 standard, however it does not cover aspects related to labeling and claims meant for the final consumer; is not exhaustive; does not use minimum threshold values to ensure all products are covered; and allows for ingredients that are otherwise banned such as GMOs, or not considered suitable for natural products such as silicones and diethyl phthylates, into formulations as long as a suitable natural index is calculated [109]. Food labeling legislation in Brazil may need to be modified to ensure that front-of-package labels do not give a false impression of products as being healthy [408].

The EU regulation 834/2007 limits use of environmentally harmful substances such as artificial fertilizers, herbicides and pesticides [109]. Safety of even natural products, especially those used outside of their traditional use concentrations remains a concern [113]. Lists pertaining to restrictions on usage of substances, and their labeling including those of natural origin and potentially allergenic fragrances and essential oils are updated under regulation 1223/2009 [109]. Antimicrobial substances that could lead to development of antimicrobial resistance are governed by the Biocidal Products Regulation in the EU which emphasizes human, animal and environmental health; while as preservatives in cosmetics they are considered under Cosmetic Products Regulation which focuses primarily on human health, making their use easier [409]. There is a move towards "one substance - one assessment" in this regard [*Ibid.*]. The complexity of the issues however make such efforts difficult as well. The new EU Chemical Sustainability Strategy suffers from several defects, starting from whether there is a need for it when existing regulations already cover the areas; lack of rational and clearly stated objectives; lack of definitions; lack of priority in setting criteria for selection of chemicals; oversimplification of risk assessment methodology especially with regard to one substance - one assessment along with inconsistencies such as lack of exposure measurements for effect of chemicals on humans and other species; lack of practical details as to how to assess mixtures of chemicals; and unclear cost-benefit analysis [28]. Other issues include lack of clarity on exactly how it improves upon existing methodologies, how it will enable a common methodology, how it reduces resource requirements for testing and whether it will facilitate progress towards an internationally-harmonized risk-assessment methodology [*Ibid.*].

In the context of food certification by the EU such as via the Quality Package EU Regulation 1151/2012 which improves the operation of Geographical Indications, or organic certifications, while

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

compliant companies showed superior social performance, environmental performance was not better as lower productivity negated any per-ton gains in environmental impact [410].

Increasing use of nanomaterials, including smart nanomaterials, can be a challenge for regulations as not much data is available on their long-term risks [411]. Food packaging with nanomaterials needs to be evaluated on a case-by-case basis based on detailed information as to the intended function, manufacturing process, psysiochemical properties, the intended use, migration data, and toxicological data as well as impurities and degradation products. For cosmetics, information on the quantity of nanomaterial, size of particles, physical and chemical properties, intended function, toxicological profile and exposure conditions needs to be submitted six months prior to the proposed introduction of a product in the market, and safety concerns can trigger a referral to the Scientific Committee on Consumer Safety for scientific opinion. The assessment needs to be for individual components as well as the entity as a whole. Differences in definitions implies REACH may not cover specific features of some nanomaterials and it is possible that an ingredient considered as a nanomaterial under cosmetics regulations is not considered one under REACH [*Ibid.*].

3.4.3. Plastics and Packaging

Overall the regulatory strategy for plastics has been to avoid the amount of waste that ends up in landfills, such as via the 2015 EU directive requiring member states to apply economic penalties against single-use plastic bags [47] and the directive 2019/904 towards limiting single-use of plastics including in packaging; along with various countries implementing extended producer responsibility schemes [412]. By 2018, 127 out of 192 UN members had adopted some legislative controls [*Ibid.*], although actions such as fees for grocery bags may have simply led to increased sales of small garbage bags across countries [222]. For packaging, the EU waste legislation defines the target for waste recycling and the levels of reuse and recycling of municipal waste was set to be 55%, 60% and 65% by 2025, 2030, and 2035 respectively under the Waste Framework Directive 2018/851 [413]. Given the significance of plastic packaging waste, a minimum of 65% and 70% of packaging waste must be recycled at the end of 2025 and 2030 respectively as per directive 2018/852, and a European Strategy for Plastics in a Circular Economy has also been released [*Ibid.*]. Such actions have led to national level and regional regulations and policies as well. In response to such actions, large companies have often set up impressive goals for cosmetics packaging, however such efforts take substantial investments and time; are often economically unfavorable; and face additional challenges of technical difficulties and cross-team alignments resulting in solutions not being implemented, especially in the absence of a business case, and only a few of the "award-winning" solutions are commercialized [60]. Such issues are common across applications, and for the pharmaceutical supply chain, "*high costs and time consumption, little expertise and training, enforcement of regulations, the paucity of business incentives, ineffective collaborations and coordination across the supply chain, lack of objective benchmarks and poor end-customer awareness*" [178] have been reported to be the major challenges towards sustainability, along with a need for design of new regulation systems.

In spite of calls from non-governmental organizations and the growing public concern with regard to microbeads, although the EU moved to restrict cosmetics with microbeads starting 2014 there was no Europe-wide ban until 2022 and only a few European and other countries, as well as individual US states, had taken legislative action because of the belief that cosmetics industries had responded significantly [47]. Sources other than microbeads such as glitter have been ignored although they may be more widely used, and there has been industry resistance to rapid reformulation of leave-on products as opposed to rinse-off ones [*Ibid.*].

With increasing focus on bio-based and biodegradable plastics, standards such as EN 13432 for Europe, and its counterparts ASTM D 6400 and 6868 for the US, AS4736 for Australia and ISO 17099 and ISO 18606 worldwide set out the requirements for compostability [414]. Standards have also been developed for home composting (NF T51−800), EN/NF 17033 for mulching films in agriculture, along with test procedures such as ISO 16620 for determining the extent of biobased components of plastics ;

 doi:10.20944/preprints202308.0120.v1

EN/ISO 14855-1 2013, EN/ISO 14855-2 2018, EN/ISO 17556 2019 or ASTM D5988-96 for composting as well as soil biodegradation [119]. Materials that are classified as biodegradable by 14855-1, such as PLA involving testing at 58^{o}C which is above its glass-transition temperature, may not be classified thus under ISO 14851 2019 or ISO 14852:2021 for bacterial activity present in soil or water at lower temperatures. Such issues are a reflection of the lack of consensus in the definition of biodegradability [*Ibid.*].

Policy initiatives remain critical towards implementing sustainability. The true impact of policies may only emerge over time after their effects and interactions with social and economic systems start to become apparent. In the meantime, technological advancements could provide alternative pathways towards creation of materials, manufacturing of products, as well post-use handling.

3.5. Consumer Behavior

Downstream customers are most often the impetus for upstream change [415] and consumers remain the final arbiters of the feasibility of a product within the existing regulatory framework. Green purchase behavior could differ from that for general products as it relies on benefits that could be altruistic and are achieved through longer-term outcomes rather than instant gratification [50]. It has gained research interest since the 1970's [107]. By the early 1990's surveys showed an increasing number of consumers reporting their preference for, or rejection of, products based on environmental considerations [4]. A majority of consumers even indicated they were ready to pay more for green products [107].

3.5.1. Green Marketing

The concepts of ecological, green and sustainable marketing were developed in response to consumer demand for sustainable products [75]. The high incidences of early failures of green marketing have led to studies focusing on failure as well [416]. Many companies had developed green products but only a few of these had been successful [50]. The green consumer has remained elusive [227].

Green spinning based on excessive PR, especially in "dirty" industries in reaction to concerns; green selling, involving post-hoc identification of environmental features in existing products for furthering promotional activities, later with the support of certifications and logos available from multiple external sources; green harvesting in terms of implementing change for efficiency but not passing on savings to customers, and then stopping after the easier initial attempts after which cost-reduction becomes difficult; enviropreneural marketing that focused too much on the product at the expense of the customer, which resulted in environmentally-friendly products that underperformed and were overpriced; and compliance marketing involving use of compliance with mandatory regulations as promotion of green credentials are some of the types of green marketing that led to customer disaffection and mistrust, at times inviting regulatory crackdowns [106].

Only 5% of the marketing messages from Green campaigns may be entirely true [417] and studies also find 67.75% of manufacturers provide incorrect recycling information and that 98% of the labels are false or are based on greenwashing to deceive customers [240]. Consumers may also have misconceptions such as the "bio" in bioplastics implying readily biodegradable although in most cases it implies compostability under industrial conditions at best [60]. Cosmetics companies that have developed their own procedures and tools for sustainable products, such as Sustainable Product Optimization Tool (SPOT) for L'Oreal [237]; companies that have attempted to remove all packaging, such as Lush [418,419]; and brands that were started explicitly for ethical and environmentally friendly cosmetics, such as The Body Shop [420,421]; along with Colgate-Palmolive and Proctor & Gamble have all been condemned for copious use of microbeads in their products [46]. Lush is acknowledged as a leader in efforts towards reducing packaging, and is still accused of greenwashing as its products contain parabens and other harmful chemicals contrary to the image of naturalness projected by items sold without any packaging in its stores [422].

 doi:10.20944/preprints202308.0120.v1

The definition of green marketing has evolved over time, and it is now a fundamental input for the various functional areas of a company that need to integrate environmental issues into business strategies and activities, including segmentation and targeting of customers, positioning and differentiation to increase green perceived value and green trust [75]. A brand represents the core characteristics of a company and consumers on the whole form positive associations with brands they perceive to be credible and consistent over time [423]. Brand identity is a significant asset and using a product while knowing it activates different areas in the brain compared to using it without being aware of the brand [424]. Positive brand associations override the basic pleasure response and products should conform to the brand image [425]. Prior "good" practices, developed over years, may have helped establish brand characteristics which may be difficult to modify and such attempts could even be counterproductive such as with New Coke. Individuals expect the same brand experience across platforms such as in apps [426]. While MNCs create separate divisions and brands for sustainable products, the same company selling environmentally friendly products in one division and those with a high environmental impact in others; or engaging in animal testing in markets that require them while selling "cruelty-free" products elsewhere could lead to perception problems. Empathy virtue is a significant factor in emotional attachments to brands, and multinational corporations buying sustainable startups can be problematic in this regard [427]. Green products are often more costly to produce and are subjected to greater uncertainty, and if successful, could also reduce sales of existing traditional products of a company implying little intrinsic motivation to introduce such products [428].

Factors for low adoption of green products could include consumption values of consumers, resistance to new technologies or behaviors, resistance to premium prices, motivation by relative status, social imitation, short-term versus long-term considerations, low regard for intangible issues as also issues related to quality, efficacy and availability and skepticism regarding the firm's commitment to the environment [133,136]. It was pointed out that while it was known what people consume, and to a reasonably extent how they consume, there was little understanding of why they consume [105].

Eye-tracking indicates individuals pay more attention to the price of green products rather than the product image in comparison with traditional products [429], and price increases may impact sustainable products more [112]. Research, early on, (e.g., [107]) sought to identify customers who would likely pay more for environmentally-friendly products in terms of demographic, knowledge, values, behavior and attitude-related factors. Results [*Ibid.*] showed that while being married, female and having children living at home contributed towards such willingness; and not age, homeowner status, income or work status; attitudes had the greatest discriminatory power. This included the perception of inconvenience associated with being environmentally friendly, followed by the perceived importance of being environmentally friendly, and trust in corporations to act responsibly. In terms of values, collectivism and security were important, while the behavior that was relevant was considering environmental issues when making purchases, and not recycling or buying environmentally friendly products. Ecoliteracy was irrelevant. Consumers who recycle plastic may not necessarily be willing to pay more for low-phosphate detergent, implying such behavior was not transferable across sectors [228].

3.5.2. Models of Green Purchase Behavior

The importance of behavioral factors (e.g., [75]) has led to significant research based on various theoretical models, especially the Theory of Planned Behavior (TBP). Heterogeneity in pro-environmental behavior has led to several alternate theoretical approaches that seek to explain such behaviors [430]. Consumer behavior is sufficiently complex that no single model or theory provides a framework that is anywhere near complete [134].

Twenty consumer theories relevant to green marketing have been classified into categories based on values and knowledge, beliefs, attitudes, intentions, motivations and social dimensions, including models which incorporate multiple theories, such as the alphabet model (VBN-ABC-D-K-IS-H) which provides a framework wherein demographic factors impact values, beliefs and norms and are updated by information seeking behavior, knowledge and context [133]. Alternately, studies conducted during 2015-2020 for green purchase decisions were considered in a framework that includes psychological-level theories such as planned behavior, value-attitude-behavior (VAB) model, and value-norm belief theory as well as integrated models; and theories such as ABC that combine internal and external factors as well as those considered to be determinants of green purchase such as individual factors, product and marketing factors, and social factors [136]. Individual factors could include psychological factors, habits, experiences and lifestyle factors, and socio-demographic factors. Product related factors include product attribute as well as marketing. Social factors include social norms and social capital [*Ibid.*]. A review of the applications and limitations of the dominant model in green consumer research, TPB, notes the difficulty of obtaining validated measures of pro-environmental behavior as against commonly-used measures that often simply end up measuring intention; that the relationships proposed in TPB, such as beliefs influencing behavior via attitudes are not unanimously accepted in literature; and that it has often been used with additional factors such as moral values and past behavior that have been adopted from other models developed specifically for green purchase intentions [135]. Furthermore, there was only one reported use of TPB theory to design an intervention, and it was successful in reducing electricity consumption [*Ibid.*].

The typical framework for studies on green purchase behavior consists of the model depicted as a directed graph to show the proposed relationship between the variables where the edges form the hypotheses; determination of the values of the variables from surveys; and then testing the hypotheses using techniques such as Structural Equation Modeling (SEM). In a rare direct comparison, the more generic TPB was found to better explain recycling intent (43%) and behavior (37%) of Spanish housewives as compared to the Value-Belief-Norm (VBN) model (7.5%) developed specifically for pro-environmental behavior [430]. Subjective norm was not found to be significant in that those who recycled had a more favorable attitude towards recycling than other family members [*Ibid.*].

While studies set up surveys carefully and take precautions to ensure the intended variables are measured, and literature suggests surveys to be highly effective [431], the entire field of neuromarketing is premised on people being unable, or unwilling, to report their true opinions [426]. Surveys are also known to be susceptible to several issues (e.g. [103]). The debate as to the efficacy of neuromarketing has been ongoing and includes the diverse range of instruments [432,433]; the high cost and questionable usefulness of measurements relative to traditional methods [434,435]; the difficulty in decoding brain processes [436]; the interaction of the brain's spontaneous activities on decision-making and external stimuli which may be different in a retail product choice context [435]; issues related to causation and backward inference [*Ibid.*], subjective interpretations [437] and uncertainties in metrics and interpretation [438]. Predictive models for neuromarketing are still in the development phase as well [439]. Some studies also use focus groups. Insofar as consumer disposal behavior is a significant determinant of the success or failure of a product in terms of its environmental impact, and existing techniques have not been able to provide a full understanding, remote ethnography has also been suggested as an alternative [440]. Very few studies can provide actual samples of bioplastics products to participants [441]. With the shift to online marketing, Virtual Reality may provide an efficacious means towards consumer evaluation of packaging [442].

3.5.3. Empirical Results

Literature suggests the effects of factors, such as for collectivist versus individualist values, to be somewhat subtle. Those with individualistic tendencies may opt for resource conservation while those with collectivist values may be more inclined towards recycling [50]. The effect of the collectivist value orientation was found to influence ecological purchase only through Perceived Consumer Effectiveness (PCE) using the VAB framework, and not through environmental concerns or directly [*Ibid.*]. Studies focusing on areas ranging from green restaurants to electricity conservation, have variously found personal values such as self-transcendence rather than environmental concerns [443]; product knowledge, depending on whether the goods were convenience goods or those

 doi:10.20944/preprints202308.0120.v1

whose purchase involved significant shopping effort [444]; personal norms for energy conservation, along with trust in information provided by energy companies for buying energy-efficient products and that provided by family and friends for curtailment behavior, but not trust in information provided by NGOs and government [134]; green trust and its antecedents [445]; biospheric values and environmental self-identity, in a merger of TPB and Value-Identity-Personal norm (VIP) models [446]; not brand coolness [447]; and hedonistic and biospheric values [448] to be relevant. The studies almost always find both supporting and contradictory results in prior literature, and are not directly comparable to each other, making it difficult to discern an overall, unified, picture. Similar issues exist with such studies in other areas as well. For instance in some studies knowledge management impacts performance directly, and indirectly through an increase of innovation capacity [449]. Factors such as firm size and age, and industrial and environmental turbulence can also impact the relationships [450]. Elsewhere, managemnt innovation has been found to not impact performance directly, but only through the mediating effect of knowledge management [451].

Circular behaviors represent a range of activities including recycling and reusing goods; acquiring certified green products or recycled, remanufactured or reconditioned products; refilling products; product care and maintenance; waste separation; returning products at their end of life; sharing products and services; reducing consumption; and local and organic consumption with political, economic, environmental and demographic factors influencing such behaviors [452]. Consumer mindsets towards circular systems in literature variously include favoring acquisition and utilization of circular products; preferring access to ownership; participation in material recirculation; favoring dematerializaton in terms of digital services and shared circular services; resistance to obsolescence and valuing multi-functional products (Id.). These have been related to specific circular business models such as life extension and reuse, recovery of secondary raw materials and by-products, product-service systems, sharing economy and collaborative consumption systems, and dematerialization for a variety of products ranging from electronics and apparel to fast-moving consumer goods as well as food and drinks [*Ibid.*].

Continued research to investigate the applicability and usability of various marketing and management theories is needed, and significantly more effort needs to be directed towards identifying green customer segments based on demographic, psychographic, and behavioral characteristics and their relationships to green behavior, especially using techniques such as data mining and artificial intelligence [179]. Several possible criteria for segmentation have been considered in literature and there is significant heterogeneity in customers with regard to willingness to pay extra for environmental performance, implying it may not be feasible to have a single marketing strategy for all such segments [75]. Literature suggests competitive and fair prices as potential determinants of consumer engagement with circular products and services; that perceived high prices of new products could encourage individuals to seek refurbished or remanufactured products; and that income can determine the nature of circular activities such as purchase of organic food at high incomes and take-back systems for electrical and electronic waste for poorer groups [452].

3.5.4. Consumers and Sustainable Cosmetics

Consumer interest in environmental effects of the cosmetics industry arose due to use of animals for testing and of animal based substances, as well as use of harmful substances ([4]; and those interested in one cause were not necessarily aware of, or interested in, others. The industry is related to vanity and such attributes play a larger role in purchase intentions of, for instance, personal grooming products [453] although companies have attempted to change the aesthetic of beauty [360].

The TPB theory was supported for Indonesian consumers who had bought environmentally products in the six months prior, specifically for environmental reasons [454]. The pro-environmental reasoned action (PERA) model, that added Perceived Environmental Concern as well as Perceived Authority Support (PAS) as antecedents found PAS to have a positive effect on PEC, and that both of these had a positive impact on attitude and subjective norms, which could explain 62.6% of the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

Behavioral Intention for green products, with attitude being key [455]. Green Brand Positioning, Green Brand Attitude, and Green Brand Knowledge were all found to positively influence Green Cosmetic Purchase Intention (GCPI), with the relationship with Green Brand Knowledge and GCPI additionally being mediated by Green Brand Attitude [456]. Men were found to be more concerned about environmental issues in a study related to an e-recycle program by Garnier and functional, social and emotional values were important towards intention but social values did not impact green trust [457].

For Malaysia the penetration of green cosmetics is low overall even as significant health issues may arise due to availability of fake and chemical cosmetics which is triggering regulatory crackdowns on such sellers [44]. Using the VBN framework, altruistic and hedonic values, with greater effect for the latter, were both found to positively effect pro-environmental beliefs which affects personal norm, which in turn impacts green purchase behavior. Furthermore electronic Word-of-Mouth (eWOM) is increasingly influential in changing consumer behavior and in forming their opinions, and it moderates the relationship between personal norm and green purchase behavior [*Ibid.*].

Based on Perceived Value Theory, Perceived Functional Value was found to impact ethical concern and consumer purchase intention for Thai customers. It was found to be correlated with ethical concern but not consumer purchase intention. Perceived Social Value had no impact on either. Ethical concern was a strong predictor of green purchase intention which mediated a positive relationship between functional value and intention, as well as emotional value and intention, but social value did not [406].

Factors influencing green purchase intention in India include opinions of friends and family, labeling and packaging, social influence, environmental concerns, price, availability and product features [458]. There are variations in cosmetics purchase patterns and males are more likely to buy green cosmetics; the market is dominated by young consumers with family and friends influencing purchase decision the most, followed by doctors, celebrities and colleagues [459]. Product quality, followed by brand, origin, variety of products, composition, pricing, discounts, packaging and salesperson recommendation are also relevant, in decreasing order [*Ibid.*]. Both hedonistic and utilitarian values may be relevant towards purchase of herbal cosmetics; and consumers shop based on previous experience and visual merchandising, prefer online shopping, get frustrated with excessive variety, may be willing to try new products with technology-assistance and focus on branded products even without discounts with usability information being important [243].

While interest in healthy cosmetics ingredients can be related to healthy food choices, for Hungary, consumers who prefer natural cosmetics; those who prefer traditional ones; and those who use either had no correlation to the purchase of bio-foodstuffs [113]. Women were more open to buying cosmetics and natural cosmetics, and consumers would not use natural cosmetics if they were not as effective as their chemical counterparts [*Ibid.*].

For Romania, based on a Situmulus-Organism-Response approach, economic, social and environmental sustainability were all found to be associated with brand attractiveness, as was social prestige; and brand attractiveness along with social prestige had a positive effect on brand attachment which influenced positive word by mouth that triggered purhcase intention and the intention to join an online brand community [460].

For the UK, based on a focus group of 30 females, it was found that price and performance were the key factors in cosmetics purchases, although neutral attitudes towards environmental issues may change with awareness of natural and green products although there was considerable confusion as to what constituted green products [51]. In this regard, it has also been emphasized that natural does not mean safe and natural products are not inherently safer than their synthetic counterparts, in view of the issue of extrapolation from Type II labels. Furthermore, green products are akin to luxury products, associated with expensive spa products, and consumers may not trust cheaper brands' claims and supporting green products required sufficient finances that were unavailable to lower-end consumers.

Based on TPB, a survey of buyers of cosmetics products of a Canadian cosmetics and hygiene brand showed external factors such as attitude towards marketing claims and internal psychological variables such as subjective norms and altruistic concerns with animal welfare were found to influence the attitude towards, and purchase intention of, "not tested on animals" personal care products; along with egoistic concerns such as personal appearance [461]. While literature has considered the framing context in the impact of labels that provide the same information, such as "95% natural ingredients" versus "5% of chemical ingredients", comparing claims based on addition of a beneficial product versus removal of a harmful one for products, using an extended TPB model, it was found that while both types of claims have a positive impact on attitude, negative claims were superior [49]. Personal appearance was not relevant in this case, as the product under consideration was a shampoo bottle [*Ibid.*].

3.5.5. Consumers and Sustainable Packaging

Packaging is often the first and only contact the customer has with a product before purchase, and the quality of the product and its ingredients must often be inferred from the packaging [462]. For beauty products which have an implicit promise towards making the customer more beautiful, where beauty is itself an abstract concept, consumers may rely on visual cues for forming efficacy beliefs [463]. Proctor & Gamble suggests shoppers decide about a product in 3-7 seconds, just as they notice it, and brand awareness is key towards expectations of functionality in the absence of prior usage [*Ibid.*]. Even when product characteristics are known, given that most purchase decisions are made at the Point of Sales for such goods, a brand using a distinctive packaging can simplify the decision for the consumer [464] who may have to look through thousands of products within a few minutes during a typical shopping trip to a store. On the other hand consumers may only use contextual cues primarily for unfamiliar brands, which implies sustainable packaging information will have a greater impact for unfamiliar brands [423].

Several factors such as shape, color, material, textual and artistic features [465], as also convenience and functionality [464] are relevant to consumer purchase behavior. Functionality is also important from a sustainability point of view as appropriate packaging could, for instance, reduce food waste [60], which can contribute far more to the overall environmental impact [466] while consumers, paradoxically, may tend to waste more food if they consider the packaging to be unsustainable [85]. Purchase decisions may also depend on availability and the time available for consumers, knowledge of green packaging products and the sources of that knowledge, as well as demographic factors such as age, gender and income level [467]. Factors affecting B2B purchases may differ from that for B2C purchases [468], and there may be tradeoffs between packaging producers and product distributors (e.g. [469]). Awareness of environmental issues may not suffice if there is a dearth of information regarding sustainably-packaged products and low consumer budgets relative to the high price of such products (e.g., [51,52]).

There is lack of consensus in literature as to whether environmental attributes of packaging impact consumer purchase decisions [238]. In general, positive attributes of sustainable packaging could include health benefits, convenience in terms of ease of eliminating or transforming packages post-use, social norms and signaling, and altruistic benefits including protection of the environment and the well-being of others; while negative attributes may be a more austere consumption experience, hygiene and quality concerns related to reduced packaging, the fear of being subject to greenwashing as well as higher costs [470]. Lack of awareness and implementation of laws; poverty; the convenience and low or zero price for plastic packaging for essentials such as food; lack of information about alternative materials; cultural and social considerations; the presence or otherwise of local institutions; and the existence of, and ease of access to, refuse collection centers could be additional factors in developing countries in addition to personal attributes [471]. On the other hand, only financially-constrained consumers or those in developing countries practice end-use consumption that avoids the infrastructure costs and emissions associated with recycling [472]. Consumers may try to avoid perceived risks when purchasing eco-design packages that reduce waste, and are less likely to waste food based on personal benefit considerations such as preserving their health rather

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

than social factors such as protecting the environment [473]. Some research suggests consumers with greater environmental concerns and those who participate frequently in pro-environmental behaviors, and not those who mistrust corporations vis-a-vis greenwashing, may have a greater propensity to seek out information which in turn promotes purchase of products with circular packaging [474]; although other literature emphasizes that skepticism of green claims is a key factor towards seeking new information [475].

Packaging can account for up to 40% of the retail price of cosmetics [463] and pricing has been a factor across studies, but the effect of price on the purchase of cosmetics is complex. Consumers view sustainable cosmetics as a luxury item; may mistrust cheaper brands with green claims; would be willing to pay a premium for it provided they could [51] and may equate price with quality [241]. Consumer perception of luxury can be difficult to change. Glass packaging is considered an indicator of luxury which requires secondary packaging for protection, and secondary packaging is further associated with higher price [237]. Weight is also associated with luxury which can be problematic for attempts to reduce packaging weight towards reducing environmental costs, while use of large packaging formats can dimnish the image of luxury and make products unsuitable for travel [*Ibid.*].

Paper, cardboard and glass are considered indicators of sustainable packaging while use of plastic may be deleterious for sustainability communications [470]. Industry differences in definitions of sustainability and sustainable packaging, and use of new words such as TerraCycling, cause confusion amongst consumers who find it difficult to differentiate between sustainable and less-sustainable packaging [60]. Scientific literature also uses a multitude of theories, with different definitions of variables, making it difficult to compare across studies within a unified theoretical framework and a common understanding of terms [471]. LCA studies often do not cover all environmental aspects, as also pre- and post-purchase consumer behavior, and may not provide the true environmental impact of the various materials that are often asserted as being the most sustainable by their respective industries [60]. Consumers often overlook the production part of the impact and focus only on post-consumption utilization or the origin of the material, leading to widespread misconceptions such as the relatively high ranking of paper-wrapped glass containers or bioplastic cups as being sustainable [55,60,84].

Low awareness and knowledge of properties amongst consumers including source, the relationship to biodegradability and appropriate disposal methods; uncertainty regarding prior exposure, given that bioplastics products are very similar to traditional ones; mostly positive emotions and perceptions such as for environmental impact whose significance can differ by particular issues, but negative perceptions and emotions related to land use and uncertain benefits along with fear of greenwashing governing purchase intentions; purchase intentions differing by product category; and contradictory findings in literature as to prior experiences, consumer perceptions, material preferences, significance of physical properties, willingness to pay, and the influence of age and gender summarize the state of consumer research for bioplastics [441,476]. Studies agree that price, functionality and information are significant features for products and green values are an important component of purchase intention [*Ibid.*]. The willingness to pay is 10-20% for horticultural equipment, 6-24% for food packaging; and 20-40% for other products and various demographic factors such as income, gender, residence, family-size and occupation may all influence results [*Ibid.*]. Materials-conscious consumers favor plastics from bio-mass, environmentally-conscious ones prefer characteristics such as biodegradability or compostability, and origin-conscious ones prefer local products and raw materials [441]. While consumer adoption is key, the avilability, price and labeling of ecological products depends on government and industry as well. In terms of use of nanotechnology, health concerns and neophobia remain primary barriers while strong microbial activity, antioxidant properties and the potential for smart packaging can help reduce food waste [477].

Changing the color of the packaging of a cholocate bar to green could increase its market share, indicating the potential for greenwashing [478]. Certain colors could be emphasized for plant-based burgers [479], although consumers may react differently to packaging colors and names for cultured meat depending on their neophobic characteristics [480]. Green may not always be the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

most appropriate color for indicating sustianability and white and blue may outperform it, while earth colors such as brown in addition to green and white may also be helpful [470]. For beverages, cool packaging colors such as green and blue denote healthier and more sustainable products, but also lower expectations of taste and are less likely to be selected by young consumers [481]. Overpackaging may detract from the green characteristics of packaging and may be a financial burden on consumers [56], however secondary packaging may also be an indication of a luxury product that allows for a premium, and may also be required for certain primary packaging such as glass bottles [237].

While some studies suggest changes in packaging for sustainability are immediately visible in packaging design variations [482], others argue sustainable packages are not distinctive in terms of differences from traditional ones, either by design or because the differences are not necessarily meaningful indicators of sustainability; and explicit or implicit clues can help consumers become aware of such characteristics [483]. Too much information can be negative, though, and the use of explicit clues to sustainability along with meaningful implicit clues can reduce the perception of sustainability, although presence of explicit clues can help if the implicit clues do not already provide an indication of sustainability [*Ibid.*]. Consumers are misled by excessive use of clues and techniques such as introduction of easily-discernible paper waste in recycled cardboard could help [484].

Simple, prototypical, images are important with nature images more prevalent in sustainably-packaged products [470]. Labels and eco-sustainability claims have also been recommended for packaging [*Ibid.*]. Traffic-light style labels lead to more environmentally-friendly choices [485]. For the UK, nutrition labels did not lead to healthier diets or reduction in environmental impact regardless of the presence of ecolabels, while ecolabels by themselves or along with nutrition labels, helped reduce environmental impact scores [486]. The presence of explanatory sustainability claims, regardless of whether it was accompanied by a health claim, reduced sustainable purchases for those with low environmental attitudes in the Netherlands [475]. Similar labels for nutrition as well as low-carbon appearing simultaneously could be less effective than either label by itself, as it led to individuals susceptible to zero-sum bias to infer that partial resources were allocated to each aspect [487], although research also finds customers can handle different types of labels at the same time and can even cope with contradictory information regarding sustainability, such as for animal welfare and climate change [488]. At the same time labels for peripheral sustainability characteristics such as for packaging are more palatable for consumers than those for core characteristics as the former do not imply potentially decreased product functionality [470]. Studies find high correlation is observed between environmental indicators and healthy diets, especially based on portion size, although the correlation of the former with front-of-package labels for healthy food is low [489]. The placement of the BIO label and the color of the package were found to be significant using eye-tracking for Croatia and contrary to questionnaire responses, most participants missed the EU Organic logo [490]. Water footprint labels have been found to be effective in Greece, with even those with unstable jobs ready to pay more for water-sustainable products [491]. Eco-labeling may need to consider cultural heritage [492].

Finally, package design remains important towards impressions of quality and in an eye tracking experiment with four lipsticks, Urban Decay with an priced on average at £16; Dior at £25; L'Oreal at £5 and Clinique at £12, without knowing their prices respondents found the L'Oreal lipstick to be of the highest quality while Urban Decay and Dior were ranked as low-quality, although results could be subjected to the sample selection bias towards younger consumers [493]. Respondents listed material and color to be the most attractive elements and purchase intention to be triggered by package attractiveness; and plastic was the most preferred material in hairstyle, skin care as well as makeup products followed by glass, suggesting a preference for its user-friendliness and practicality [*Ibid.*].

In Italy, consumers prefer sustainable packaging to buying unpackaged products in bulk, and while slightly-familiar consumers are impacted by both communication in favor of environmental sustainability and label information towards paying more for sustainably-packaged product, consumers familiar with such issues are also impacted by health-friendly aspects of such packaging

[494]. Given the preference for plant-based biodegradable packaging materials, and the issue of waste separation, there is a need for harmonizing EU rules and improving national waste-separation infrastructures [*Ibid.*]. A panel of users for a proposed natural jenny milk cosmetic in the southern Italy suggested a low propensity with regard to expenditures, and that matte paper best conveyed the natural attribute [462]. The name, the icon and text were also found to impact the perception of potential consumers [*Ibid.*]. Awareness, behavior and expectations with regard to food packaging differed by gender, age and education level with females the most sustainable and youngest consumers being less so [495]. Given the dearth of sustainably-packaged cosmetics such as eye-shadow, using a fake product, women's environmental sustainability consciousness predicts the utility they derive from sustainable makeup packaging and thus their purchasing choice, although the explanation was only 7.2% and the significance of sustainable packaging decreased in relation to other product attributes with a greater frequency of makeup use [48]. Based on the TPB model, for Italy, perceived consumer effectiveness was found to influence environmentally conscious consumer behavior towards beauty products with eco-friendly packaging material both directly, and via pro-environmental behavior intention; attitude had a significant impact on behavior but only mediated by behavioral intention; while subjective norm did not have a significant effect [496].

For Germany, using the goal-framing approach, gain-goals in terms of positive perception of the reliability of eco-friendly packaging was found to increase the intention to use such packaging which in turn was positively related to willingness to pay; subjective norms and environmental concerns were significant factors; and personal innovativeness was a positive factor but not hedonic motivation [497]. In a study of Polish adults, knowledge regarding segragation rules for recycling was similar, and uniformly insufficient, for customers regardless of whether they had pro-environmental attitudes, were neutral, or even anti-ecological [498].

While reuse is the preferred approach for plastics, its implementation faces significant barriers related to consumer adoption [499]. The Attitude - Behavior - Context framework allows for consideration of contextual factors such as product; services and facilities in addition to attitudinal factors such as knowledge; attitude and value, allowing for structural strategies for influencing the contextual structures along with informational strategies for attitudinal factors, and for the UK, hygiene; usability; lack of clarity on benefits to consumer as well as financial issues related to payment options were primary barriers to consumer acceptance and strategies could be developed towards ameliorating such issues [*Ibid.*].

For Australia, environmental knowledge and environmental responsibility, partially mediated by attitude, were both determinants of purchase intention, guilt works better than pride for those with greater environmental knowledge and vice versa, while there was no difference in the type of messaging with regard to low or high environmental responsibility [500]. For Indonesia, adoption intentions of home-refill delivery service for fast-moving consumer goods, based on the Technology Acceptance Model, are strongly impacted by attitudes, which in turn depend on environmental concern via perceived ease of use, perceived usefulness of service which also directly enhances usage intention, green perceived value and trust in the service [501].

Package design, both visual and verbal, as well as package benefits including functional, emotional, social and environmental were tested for perfume purchase decision in the Basque region of Spain and verbal design was found to be more significant than visual due to the preference for the brand name while several additional features were more important than environmental benefits; and furthermore all aspects of package design along with age, education level, martial status and income were significant towards the purchase decision [502]. Higher income consumers would choose luxury brands, while others would be influenced by price, requiring different tactics [*Ibid.*].

Unlike countries such as Germany and Japan that regulate express packaging, customers in China feel government and industry should work towards implementation of sustainable packaging [503]. Adoption intention for reusable express packaging by consumers in Shanghai, China, is influenced by environmental concerns, personal norm which depends on environmental concerns,

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

awareness of consequences, ascription of responsibility, as well as subjective norm which depends on media influence and personal perceived policy effectiveness [504]. Chinese consumers, especially pro-environmental consumers with environmental knowledge, are willing to pay a premium for rPET bottles but are indifferent to larger-sized bottles even with environmental information as the inconvenience of carrying large bottles may offset the perceived benefits [505]. In Malaysia, environmental concern, natural packaging design and printed information were relevant to purchase intention for skincare products, the first two factors partially, and the last fully, mediated by personal attitude [506]. The willingness to pay for bio-film packaging increases with the number of children, being married and female, and with age and decreases with income [507]. For India, price and utility were important for earlier generations, and while environmental impact is a factor for the younger generation price remains a constraint [508] while other research suggests consumers value price, quality and brand over all other considerations [509]. Green packaging does not have a significant impact on consumer purchase decision in Ghana [510].

Based on an online survey of MTurk employees, with no restrictions on nationality or residency, personal norms, self-identity and self-esteem were variously found be relevant to moral satisfaction, product ownership, environmental concern and planet ownership, which were relevant to intention for eco-packaging, purchase intention, and willingness to pay [238]. For the Philippines, based conceptually on TPB and considering product pricing, quality, availability; environmental awareness and knowledge; social media influence; and environmental concerns, beliefs and values; product pricing, quality and its benefits were significant factors influencing green purchase behavior [11]. Environmental issues, interest in information about bioplastics and, at marginal statistical significance, green consumer values were found to be antecedents for attitudes towards bioplastics. Subjective norms significantly impacted attitude towards bioplastics and activity to reduce plastic use, and all three of these impacted intention to use bioplastics for Canary Islands [511].

4. Sustainability Strategies

In line with the overall intent of the work, the focus here is on the areas and directions of research, rather than technical details of specific materials or processes. Sustainable packaging for cosmetics could be related to sustainable cosmetics and sustainable packaging.

The cosmetic industry has made significant attempts towards minimizing environmental and social impacts, including for packaging. Natura and its brands have been mentioned often in literature with regard to environmental innovation such as refillable packaging based on plastic film that reduces transportation impact and waste; products 100% free of animal ingredients; use of plastic from sugercane; reduction of water and carbon footprint; and annual sustainability reporting since 2001 with a focus on achieving use of Brazil's biodiversity in a sustainable manner [512,513]. Case studies also include L'Oreal which has set a goal to have 95% biobased materials, derived from abundant minerals or from circular processes [514], and has 10 rules for eco-design including use of safe packaging in terms of environment and health; reduction in material usage and unnecessary packaging; preference to large formats; use of less impactful materials and those that come from sustainably managed sources; not shifting burdens to other parties; reusable packages; consumer guidance for appropriate disposal; and facilitating post-use management, which have been implemented in its Sustainable Product Optimization Tool [237]. The company also uses technological advancements and third-party collaborations for waste management, similar to L'Occitane [388]. The Body Shop was started expressly for ethical capitalism, and it has since been bought by L'Oreal and then by Natura, indicating the potential issues such companies can face [361,512]. DM has introduced greener packaging and inks; Frosch has introduced 100% PE-HD from post-consumer recyclables; ZAO has developed bamboo packaging; P&G is facilitating recycling through its PureCycle program while Estee Lauder's MAC cosmetics has introduced Back-to-M.A.C. to return primary packaging for recycling [285]. Certain P&G brands also have resusable, recyclable and refillable packages, while companies such as Lush (see also [512]) have at times removed all packaging and several smaller companies have adopted similar approaches to reduce, reuse and recycle [388].

4.1. Sustainable Cosmetics

A review of literature on the best practices with regard to Design and Life-Cycle Thinking (LCT) in terms of sourcing; manufacturing; packaging; distribution; consumer use and post-consumer use [515], following [87], finds most LCT in cosmetics to be related to evaluating a specific product's environmental impact rather than developing new methodologies customized for cosmetics products; and that there is a need to improve environmental performance without worsening their functionality and benefits. The importance of sustainability metrics such as carbon footprint and LCA that covers stages from raw material extraction all the way to disposal and recycling have been noted for cosmetics [323] and a planetary boundary procedure has been applied to several L'Oreal products [324]. An excel-based sustainability tool based on life-cycle thinking has been developed [516]; and an LCA-based Ecolabel criteria has been developed for the personal care and cosmetic sector in Turkey [517]. Literature has also focused on definitions of terms and allowed processes with regard to certifications (e.g., [108]).

4.1.1. Green supply chain

An environmentally-friendly platform entails not just the final product, but the overall operations of companies as well as their suppliers' practices [4]. Green supply chain management is based on the life-cycle analysis of products and includes providing design specifications to suppliers that include environmental requirements; auditing suppliers' environment management systems; cooperating with suppliers for eco-design; and handling product returns due to any reasons, including end of useful life. This could involve greater coordination efforts in a more complex environment; the need for better communication on the chain; and often training by the focal company that is facing regulations or stakeholder demands as part of joint initiatives with its suppliers [315]. Such efforts are capital intensive [518] and organizations need to include innovation in the supply chain to ensure economic, along with social and environmental, sustainability [315]. There is no comprehensive framework to facilitate the shift to sustainable business in cosmetics incorporating consumers, product lifecycle and management practices; especially for SMEs which usually cannot develop their own frameworks and models [515]. With the complexity of the issues involved in supply-chain management and sustainability, literature has emphasized the need for incorporating IE4 considerations [174]. In this context, there is no particular level of readiness or maturity that suffices, but rather SMEs need to be on par with other supply-chain actors [74]. Artificial-intelligence based supplier selection models have also been proposed for cosmetics companies (e.g., [519]). A supplier selection model specifically for cosmetics companies has been developed based on an extensive review incorporating scientific and gray literature in the field, and validated for an Italian cosmetics SME [66].

Organizations with innovation power such as Natura, a Brazilian cosmetics multinational with 5000 organizations in its supply chain, can proactively introduce innovation to further green supply chain management while companies that cannot innovate may simply be resigned to palliative social efforts and greenwashing [315]. Chinese SMEs in the field of packaging, while under significant pressure from their external markets as well as governmental regulations, are on the whole unprepared for green supply chain management due to lack of knowledge and management skills, appropriate organizational culture, financial strength, and recycling systems; and typically value quality and price over environmental characteristics with few proactively going beyond legal requirements [352]. In Ghana, where the impetus for environmental protection is not external but for firms seeking competitive advantage and market access, simply implementing internal green processes could even be counterproductive and companies need to implement a green corporate culture and ensure green supply chains [98]; and activities such as green logistics management may influence financial performance indirectly via environmental performance (e.g., [518]).

Startups can again create disruptive models, and Perpetual Product, an innovative startup located in Holland with a presence in Bologna, offers consumers both biodegradable containers as alternatives to producer packaging, and delivery via zero-impact vehicles such as electric bicycles and electric cars [520,521]. A five-step strategic planning decision framework for circular business models (SPDF-CBM) for startups, with recommend tools for each step, has been presented and applied to a Brazilian cosmetics startup [65].

4.1.2. Natural ingredients

The use of synthetics led to cheaper cosmetics with more consistent quality, and were instrumental for the growth of the industry in the 20th century [512]. Basic industrial chemicals and their mixtures, blended and shaped into structured formulated products, are both used to produce configured-consumer products such as cosmetics; often as emulsions, which are thermodynamically unstable colloidal systems where droplets of a liquid are dispersed in a second immiscible fluid, especially for skincare products [125]. The unstable nature of emulsions requires surfactants to avoid coalescence of the droplets and sensory agents such as viscosity-modifying agents, emollients or humectants can be used to provide appropriate sensory characteristics for consumers [*Ibid.*]. Other additives could include exfoliators, polymers, solvents, dyes, fragrances, UV absorbers, preservatives, pH regulators, chelating agents and antioxidants which are often sourced from petrochemical feedstock [514].

The dangers of ingredients such as lead and mercury have long been known. Several significant missteps such as the 1932 skin-cream Koremlu that contained thallium acetate, the 1933 eyelash and eyebrow colorant Lash Lure that contained a synthetic aniline dye, and the 1972 Morhange talc containing hexachlorophene were significant in raising the alarm with regard to synthetic cosmetics [512]. Ingredients such as phtalates, parabens, BHA, propylene glycol and polyethylene glycol, formaldehyde and toluenes, lead and mercury, as well as alpha-hydroxy acids have been variously found to be associated with carcinogenicity, cytotoxicity, neurotoxicity, hormone disruption, mutations, immunotoxicity and allergies [512,522]. This has led to use of natural ingredients such as aloe vera, macademia nut oil, jojoba oil, almond, babassu oil, olive oil, shea butter, vanilla, mandarin oil, corn flower, tangerine, cypress oil, herbal extracts, eucalyptus, methol, kiwi, grape seed, hazel-nut, chamomile, cucumber, rosemary, caffeine camphor, cononut oil etc. [*Ibid.*]. Sustainable replacements for traditional ingredients have been studied in literature [87].

Agricultural production, such as for palm oil, is not necessarily environmentally sustainable. A variety of methods including gene synthesis and genome sequencing as well as protein engineering have been used alongside traditional synthetic chemistry methods for bio-catalysis of ingredients including anti-aging agents, fragrances, humectants, emollients, surfactants, emulsifiers and thickeners [523]. Healthy, natural, products are especially important for cosmeceuticals and nutraceuticals and bio-nanotechnology provides a promising means to develop innovative compounds, as well as delivery systems, for active ingredients such as chitin nanofibrils and nanolignin; although some confusion in rules may remain regarding whether cosmetics cover substances that could penetrate the skin to repair minor damage [5].

Valorization of food waste as a source of ingredients is of significant benefit for the circular economy. Chestnut shell extract can be prepared using various green processes such as Subcritical Water Extraction, Ultrasound-Assisted Extraction and Supercritical Fluids Extraction and has anti-microbial as well as anti-enzyme properties [524]. It could be a promising ingredient for anti-aging formulations after its health-safety has been validated [*Ibid.*]. Supercritical fluid extraction for myrtle extracts was shown to be a green process towards its use as an active ingredient and a co-preservative for cosmetic applications [525]. Chia seed mucilage with high water-binding capacity, potential as texture modifier, and with emulsifying, gelling and encapsulating behavior was shown to be an environmentally-friendly cytocompatible and photostable biopolymer with UV photostability; with

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

potential for use as a biomaterial for controlled release of bioactive compounds [526]. Marine sources may also be available for cosmetics ingredients [527].

Typical surfactants used such as tween 80, span 80, sodium laureth sulfate, sodium laurel sulfate, sodium dodecyl sulfate, cocamidopropyl betaine, polyethelyine glycol esters and others are of increasing concern in relation to skin irritation, hemolysis and cytotoxicity and there is significant interest in particle-stabilized emulsions as an alternative to surfactants [528]. Solid stabilizers can include polymer latexes, inorganic particles, silicone particles, silica, lysosomes, chitosan, clays, starches, carbon nanotubes among others and these also impact film forming, moisturizing, exfoliating, conditioning and waterproofing characteristics [*Ibid.*]. In view of the greater susceptibility of natural ingredients to oxidation, the inability to use traditional antioxidants, and the difficulty of measuring oxidation towards useful measures of shelf-life, [529] demonstrate the feasibility of using gas chromatography to study the impact of antioxidant plant extracts on oil-water emulsions.

A mathematical model of skin-spreading behavior was developed and validated against consumer perception of the spreading behavior [122]. By predicting the behavior of sustainable alternatives to traditional emollients such as petrolatum and dimethicone, it can facilitate obtaining the desired skin-feel properties [*Ibid.*] The science of cosmetic substrates such as hair and skin, is important towards development of bio-based cleansing actives for cleansing formulations and shampoos with desirable properties such as foaming [123].

4.1.3. Biopolymers

Traditional polymers are petroleum-origin and can lead to microplastics whose degradation rate is sufficiently slow that there is still little empirical evidence as to their lifetime after several decades of use and accumulation in various environments.

One solution is to use bio-based polymers that do not require fossil fuels for their production [530]. This would include drop-in polymers similar to traditional ones [110] as well as synthetic polymers that are based on renewable biomass but require chemical processing. The organic carbon in biobased plastics, including synthetic polymers, originates in whole or in part from renewable biomass and the ratio can be assessed by radiocarbon analysis based on ASTM D6866 or ISO 16620 [22,531,532].

Another possibility is to develop biodegradable polymers, whether from natural or fossil sources, that can degrade relatively quickly in the environment. Degradation should result in lower-weight molecules that are amenable to metabolization by microorganisms, leading to complete mineralization with the final result being CO_2 or CH_4. Biodegradation may require specific conditions such as industrial composting, anarobic digestion or agricultural soil and wastewater degradation. The rate of biodegradation of a polymer under various conditions is a critical characteristic in terms of its usefulness. PLA requires industrial composting for biodegratation and there has been research into blending it with other polymers for increasing its biodegradability. Additions to PLA for this include biobased polymers like starch or chitosan, fossil-based polymers such as PCL, and also pro-oxidants [533,534] although this could also lead to the issue of micropastics. Research into various aspects of biodegradibility has covered mechanisms; rates under various environments; factors that impact the rate of biodegradation; and standards, certifications and evaluations (e.g., [22,110,533,535,536]).

Several natural polymers from animal and vegetal sources have been considered as bio-based and biodegradable replacements [531]. These include proteins such collagen, wheat gluten or soy protein; polysaccharides such as chitin from the shells of crabs, shrimp, crawfish as also from insects and from fungi, chitosan from chitin, and their derivatives as well as starch from potatoes, corn, wheat and rice; bacterial polymers including semi-synthetic polymers such as PLA from fermentation of sugars and fermentation to produce natural polyesters PHA, PHB, PHBV; and carbohydrate polymers such as xanthan, curdlan, pullulan and hyaluronic acids [*Ibid.*]. The overall mechanical and degradation properties of such polymers depend significantly on their processing and blending, as well as the environmental conditions in the end-of-life disposal system [22]. There has been significant research into specific polymers including their sourcing, processing, characterization and

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

applications, such as for biobased pullulan for body and skin contact applications [537], and lignin sourced from sugarcane-byproducts [538]. Chitosan and its nanoparticles, which can act as an emulsion stabilizer, rheology modifier, thickener and antimicrobial preservative have significant potential cosmetic applications [539,540]. Terpene-derived copolymers can be synthesized in supercritical CO_2 and can be used to replace petroleum-based polymers that are also synthesized in petroleum-based organic solvents [514]. Waste feather keratin has been mentioned as a source of ecofriendly bioplastic films [541]. With the issue of investment requirements and land requirements for plant-based polymers, marine-sourced natural ingredients could be useful [527]. Design of polymers needs to be towards managing end-of-life characteristics [22].

Biodegradable polymers from fossil-fuel include those with additives such as oxo-degradable polymers with antioxidants that can react under UV inducing photo-degradation although there is lack of consensus as to their biodegradability; and with pro-oxidant additives such as Mn^{2+}/Mn^{3+} which form hyroperoxides and can then be thermolysed or pyrolised to provide hydrophilic products with lower molecular mass that could be biodegradable [531]. Others include those with hydrolysable backbones such as aliphatic polyesters such as PGA, PLA and their copolymer PLGA, polycaprolactone (PCL), polybutylene succinate (PBS) and its copolyeseter such as PBSA, poly p-dioxanone (PPDO) and poly trimethylene carbonate (PTMC); aromatic copolyesters; polyamides and poly ester-amides; polyurethanes and polyanydrides, as well as those with carbon backbones such as vinyl polymers [531,543] . Each category has several commercial products available; a range of application areas from medical, packaging and agriculture to automotive, electronics and construction; and various biodegradable polymers can also be blended and their properties can be modified via techniques such as grafting [*Ibid.*].

Biobased, non-biodegradable polymers had a production capacity of 884.5 Ktons in 2020, expected to increase to 1070.9 Ktons by 2025, with polyamide (PA), polyethylene (PE), polytrimethylene terephthalate (PTT) and polyethylene terephthalate (PET) being the dominant polymers [544]. Poly-lactic acid (PLA), starch blends and polybutylene adipate terephthalate (PBAT) dominated the capacity for biodegradable polymers, which had a total capacity of 1226.5 Ktons in 2020 and is expected to increase to 1800.1 Ktons by 2025 [*Ibid.*].

Diversion of agricultural land and crops from food towards alternate uses can be problematic [21,545]. The need for fertilizers, deforestation and grassland conversion along with loss of biodiversity are potential problems as well [414]. Nevertheless the land requirement for biopolymers would be significantly less than land take for other purposes [110]. Additional potential problems include nanoparticles from biopolymer degradation (e,g, [213]), and degradation potentially promoting bacterial and spore infestations that could be inhaled [414].

4.1.4. Processes and Health Safety

Attempts to promote sustainable water use, including waterless life-cycles, have been considered [546]. In terms of waste management, studies have considered pre-treatments of cosmetics manufacturing waste to enhance biodegradability [547]; anaerobic digestion of cosmetic industrial waste [548]; and synthesis of value-added materials from sewage sludge of cosmetics industry effluent treatment plant [549]. Significant research has been conducted towards development of a circular bio-economy based on biomass from agricultural waste [550].

A natural product may not necessarily be safe [515]. Face preparations contain higher mercury content than body preparations, with no difference between natural and conventional preparations [551]. Even for natural ingredients that have been used traditionally, testing may be needed if the concentration proposed is beyond traditional usage [113]. Guidelines for in-vitro testing have been provided in literature [552,553], and a framework for cosmetics safety assessment is demonstrated using parabens as an example [554]. The introduction of nanoparticles in cosmetics formulations and in bionanocomposites raises several safety related issues [67], especially for smart nanomaterials due

 doi:10.20944/preprints202308.0120.v1

to their complex and dynamic behavior [411] and there is a need for a systematic and comprehensive approach that can allow for such considerations in the early design phase [*Ibid.*].

4.2. Sustainable Packaging

As use of packaging materials increases due to global supply chains moving towards singe-use products and reduced portion sizes, and for convenience [412], companies face greater consumer, shareholder and regulatory pressures for greener strategies [482] including sustainable packaging [555]. Sustainable packaging can be based on plastics, paper (see, for e.g., [556,557]), glass and metal [544,558,559], and can be minimalist, biodegradable, recyclable, refillable or otherwise reusable. It is important to consider such post-use characteristics during the design phase itself [560].

Large companies have often established ambitious goals vis-a-vis single-use packaging [561]. Such efforts take substantial investments and time; are often economically unfavorable; face technical difficulties and cross-team alignments challenges; and only a very few of the numerous award-winning solutions are commercialized or implemented, especially in the absence of a business case [60]. High costs of sustainable materials, low demand for sustainable packaging, legal incompatibilities and production and quality issues remain potential impediments [562]. Large companies often do not report how sustainable packaging efforts impact their business operations [207]. Research is ongoing towards models for sustainable packaging practices [562].

Food packaging has been of prime interest for materials and transformation processes [124] such as tools for designing and adapting food packaging; modeling mass transfer and reactions in the food/package system; and development of food packaging from food processing waste. Active packaging for control of oxygen, carbon dioxide, or ethylene levels; odors; and humidity, as well as for antimicrobial and antioxidant purposes holds promising solutions for extended shelf-life and quality [*Ibid.*].

The apparel and fashion industry has been involved with sustainable packaging such as the 7 R's of rethink, refuse, reuse, reduce, recycle, repurpose and rot [563]. With expectation of short lead times and lower costs, use of outsourcing has led to significant scrutiny in terms of sustainability of practices such as incineration of unused textiles to maintain brand exclusivity [564]. Asymmetric information, external factors outside of management control, and managing benefits and cost across opaque supply chains are barriers for change and for such industries success is particularly difficult to predict given uncertain customer demand. [*Ibid.*].

Literature provides some analyses for sustainable cosmetics packaging. Eco-design of cosmetics tubes using LCA for varying quantities of mineral fillers as well as post-consumer recycled material showed that lower environmental-impact solutions were also lower in economic costs, and that the environmental impact of different stages varies by product; not all indicators may be better for sustainable solutions, for instance freshwater eutrophication, and that the allocation scheme used for the burden of recycling can also impact results [415]. In a direct comparison of powder cases, design of durable packages was found to significantly outperform techniques such as dematerialization in terms of flimsier products and it was noted that recycling could only help if packaging materials were fully recycled, which could depend on the user and the infrastructure [561]. In a comparison of a 120 ml glass bottle with HDPE cap weighing 188.78 and 17.53 g respectively; a 150 ml PET bottle with HDPE cap weighing 25.59 and 7.55 g respectively; and a 200 ml PET bottle with HDPE cap weighing 77.1 and 21.65 g respectively, for a total volume of 1800 ml, the 150 ml PET bottle was found to be the most environmentally friendly, and the glass bottle the least, and the contributions of the various stages such as manufacturing and post-disposal, were different across the products and varied with the disposal technique used [565]. While plastic production uses 40% less electricity than cardboard, the latter is overall more sustainable as it is produced from renewable sources and can be recycled easily, and if not recycled it decomposes quickly in nature [566]. Processes such as 3-D printing can support sustainable manufacturing by reducing waste, energy use and carbon emissions and have also

 doi:10.20944/preprints202308.0120.v1

found widespread environmental applications such as for improving air quality monitors, filters and membranes [567].

Packaging is a complex field encompassing multiple disciplines. Literature has focused on materials; marketing; LCA; the three pillars of sustainability, viz., economic, environmental and social; sustainable practices such as recycle, reduce and reuse including waste valorization; supply chain; design; CE and reverse logistics with very few articles on design, especially after 1998 [124]. Several opportunities for research exist, including systemic perspective for packaging over the life cycle on a case-by-case basis; use of LCC to complement LCA; frameworks for researchers for CE studies; collaboration with third parties outside of focal company's operations; including the academic community in finding manufacturing solutions; cooperation between public and private sectors for product-service impact studies; global policies for waste disposal and consumer education; social and economic studies; biobased biodegradable materials; use of nanotechnology; cooperation between product manufacturers and bioplastic packaging producers; active packaging; comparison of new packages via LCA with prior ones; among others.

The strategies that can be employed ultimately depend in large part on the materials selected and the infrastructure available. In this sense design is the most important stage for package sustainability and comprises material selection, including considerations of reusability, recyclability or biomaterials, as well as their sources and the mechanical properties; conceptual design which considers end-of-life options based on location and issues for special applications; design development phase including specifics of the package; and design validation in terms of LCA, CE indicators and certification [413]. For plastics, the main focus has been on end-of-life considerations and early-stage interventions for the various stages of CE can be important [568]. Sixteen research areas in literature were investigated, including avoidance to reduce production and waste; use of biofeedstock alternatives to nonrenewables; design, such as for the environment or for disassembly; manufacturing; consumption and consumer behavior; reuse; repair; municipal and industrial waste collection; sorting; disposal and recycling procedures; leakage; and system-level research, with no articles on repair, presumably as it is difficult to repair plastics [*Ibid.*].

Packaging can be primary for holding the contents, secondary for information or protection of the primary packaging, and tertiary for transportation purposes. Companies can implement alternate approaches to sustainability and circularity based on their specific business models and their business environment.

All approaches have downsides. Reuse of cosmetics packages can lead to hygiene concerns and there are added issues of reverse logistics, turnaround times and return rates. Recycling can be difficult due to contamination with residual formulation in discarded products and requires separation of waste streams and appropriate infrastructure; and production of recycled plastics is currently not economically viable in many countries as primary plastics production is highly government-subsidized [195]. While it extends the lifetime of the material in terms of useful economic life, after a few cycles the material eventually needs to be discarded; and materials with indefinite recyclability along with means for their complete capture and processing remain an aspirational goal [22]. Biopolymers can be expensive, difficult to source, and use of nanomaterials for compositing biodegradable polymers to achieve desired material properties can create health concerns [67].

Different approaches can also work at cross-purposes. Large-form packaging may reduce material usage, but may be inconvenient for customers and reducing consumption would counsel smaller portion sizes [237]. Consumers typically discard packaging in trash. Reusable packaging implies durability, and if such packages are discarded in the environment they will be harder to degrade. At the same time, biodegradable packages accidentally disposed-off in areas that do not meet biodegradability conditions may break down into smaller, easily-ingestible particles causing greater environmental risks [22]. Even with awareness of recycling, consumer inability to separate waste streams in accordance with recycling requirements rather than based on visual considerations implies that biodegradable plastics may get mixed with recyclable ones, and hamper recycling [117]. Lighter packages reduce

 doi:10.20944/preprints202308.0120.v1

material usage but could lead to a reduction in the height to which pallets can be stacked, requiring additional trucks for transportation [237]. Replacing plastic with glass requires extensive transportation tests and could require secondary packaging [*Ibid.*]. The main purpose of packaging is to protect the contents and reduction in this functionality could increase wastage of contents, which could lead to a greater overall environmental impact.

The European Commission acknowledges that "*[P]roducers currently have little to no incentive to take into account recycling or reuse of plastic articles or packaging when they design their products, and that the products are often highly customized and have specific additives to meet functional and aesthetic requirements which can complicate the recycling process*" [76].

4.2.1. Plastic Packaging

Plastics comprise a significant proportion of packaging and packaging waste [569]. Several articles review the various types of plastics, the harm they cause and waste management strategies [570–572]. Figure 4 suggests several approaches towards reducing plastic waste, including remediation of waste already present [569,573], redesign of the package for reducing the quantity of packaging, creating reusable packages [412] or recyclable ones, or replacing plastic with others materials, especially biocomposites. Such biocomposite products could also be designed for reduction, reuse or recycling; or could be removed from the environment via biodegradation.

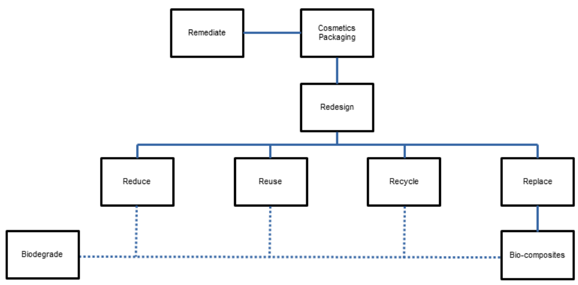

Figure 4. Options for Plastic Waste.

Academic literature and media both envisage a future for plastics and the former emphasizes alternatives such as biobased and biodegradable materials while the latter focuses on recycling of traditional plastics [574]. Literature provides 44 business models related to plastic waste management strategies, although more probably exist, and tradeoffs exist between financial, environmental and social issues with less focus on social [63]. Consistent with general observations startups attempted strong sustainability optimizing for environmental impact; as opposed to weakly sustainable firms that were motivated by competition, competivie advantage and financial motivations and optimized on economic factors while incorporating environmental variables. Startups occupied niche markets with limited scope for growth and were at a disadvantage in terms of access to technical expertise and financing. In the plastic waste management hierarchy, prevention of waste generation is the most preferable and with the greatest financial opportunities along with minimum environmental externalities; followed by reuse; recycle; energy recovery; disposal; and finally capture and removal respectively [*Ibid.*]. There may be some overlap in terminology and, for instance, tertiary recycling or quaternary recycling may refer to recovery of chemicals including fuels and energy recovery by combustion [575]. A higher perceived functional risk for remanufactured products or products with reused or recycled content can negatively affect willingness to pay a premium price [75].

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

Techniques such as fungi-based bioremediation for plastic pollution are being researched, but there is a need to promote biodegradability of petroleum-based polymers by eliminating biocides and antioxidant stabilizers while incorporating pro-oxidants [569,573]. Factors that can affect plastic degradation via pathways such as biodegradation, photodegradation, chemical degradation and thermal degradation are complex and may interact and interfere with each other [576], and degradation can result in release of atmospheric microplastics and nanoplastics as well as harmful chemicals. Microplastics, once introduced, are difficult to remove in wastewater treatment plants; cannot be collected centrally; and with their large specific area and strong adsorption characteristics, can collect a large number of toxic and harmful substances which make degradation more challenging. While degradation methods have been studied for specific cases an environmentally-friendly and efficient method that can be widely used in practice has not been identified as of yet [*Ibid.*]. Reducing microplastics may require a combination of strategies involving minimizing the loss of pre-production plastic pellets via initiatives such as Operation Clean Sweep®; extending producer responsibility; banning certain types of single-use plastics; supporting the recycling market via taxes on use of unrecycled material or incentivizing the production of recycled plastics and initiating educational campaigns; development of bioplastics and biodegradable plastics as well as improving wastewater treatment technology [12].

Recycling

Plastic recycling can be primary, or closed-loop, which is often pre- or post-consumer mono-stream recycling involving use of waste during manufacturing or from products returned to the manufacturer to produce the same products [577]. Open-loop recycling, which is the largest part of post-consumer plastic recycling typically involves sorting of the waste, reduction of waste size, and extrusion is usually associated with downcycling for lower-quality products [*Ibid.*], which after one or more recycles could end up in a landfill [570]. Recycling can also cause release of harmful chemicals, especially during the heating phase, and can contribute to acid rain and greenhouse gases [*Ibid.*]. Not all recycling processes are beneficial for all materials. For instance chemical recycling may not be useful for PET, HDPE, LDPE, PP and PS as the processes themselves have high environmental impact [578], although there have been several technological innovations in this regard [575,577]. For packaging of organic cosmetics the amount of packaging material should be reduced to the minimum necessary, and the amount of packaging material that can be reused or recycled should be increased while the use of plastic materials (PVC, polystyrene, etc.), which are not biodegradable is forbidden [579]. PVC is normally considered harmful to the environment, however with only 43% of its mass from petrochemical raw materials, PVC could be useful in the circular economy with the development of appropriate recycling technologies [580]. Finally, 3-D printing is another potential means for reuse of plastic waste, especially for PLA and acrylonitrile butadiene styrene (ABS), although price reduction is required as the cost of commercial filaments is up to 200 times higher than raw plastic; and properties start to degrade after a few cycles which could require compositing [581].

Traditional recycling plants can only handle a limited category of plastics and can be sensitive to even trace amounts of additives and may also not be able to handle multilayer packaging, mixed plastics or fiber-reinforced composites [577]. Several techniques including optical, density-separation, flotation, electrostatic [404,571] and magnetic levitation [582] have been considered. Bioplastics can cause a rebound effect when mixed with other plastics, and it may not be possible to prevent consumers from mixing inappropriate waste streams [117]. Techniques such as near-infrared spectroscopy and hyperspectral imaging in the near-infrared region can be used to separate PLA [404]. Differential calorimetry and isotope-ratio mass spectrometry can analyze various biodegradable and non-degradable plastics and can achieve high PLA discriminant accuracy, which can help with identification for bioplastics to detect counterfeited and mislabeled products and avoid sustainability fraud, and can also help improve plastic waste recycling [583].

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

Several new techniques are under active development for recycling of challenging plastic wastes, and these have been compared in terms of their environmental impacts and their technological rediness levels (TRL) [577]. Chemical recycling can be used to break down polymers into monomers via solvalysis or depolymerziation; or using pyrolysis with a catalyst to obtain petrochemicals such as gasoline and diesel, or if this is not feasible, gasification to convert waste to fuel gas or hydrocracking although setup costs can be high and research is still ongoing to optimize the procedures with regard to costs and operations (see also, [570]). Additional physical methods include dissolution/precipitation which can be slow and expensive, and the promising area of supercritical fluid extraction for which efforts towards operating parameter optimization and validation of efficiencies, and process scale-up, are still underway. Energy recovery via thermochemical routes or via combustion are not necessarily aligned with CE but combustion is often used for waste-to-energy for cases where traditional recycling is infeasible and can also help concentrate and immobilize inorganic pollutants for reuse or safe disposal [*Ibid.*]. An intelligent recycling system taking into consideration the various contradictory needs of cosmetics has been outlined [584]. Use of 3-D printing can also help reuse plastics, such as on the space station.

Reuse

Reusable packaging retains more value than recycling [412]. The concept is not new and is still found in B2B for transport packaging in the form of crates and pallets; and in B2C for primary packaging such as beer bottles, although bottles in general have been replaced by single-use packaging due to greater restaurant takeouts. Reusable packages can be in the form of refillable packages where the primary package is refilled at selected locations by bulk dispensers, which can include food stores that have no packaging and depend on consumers to bring their containers; refillable parent package which can be used in conjunction with refill packages that require significantly less packaging material; returnable packaging that requires return to the manufacturer; transit packaging which can be returned by door delivery; commercial crates and pallets for which industry-wide standardization can help; and wrappers which can be reused multiple times [*Ibid.*] [585]. While the number of such attempts is growing, the economics of the approach is not clear. Bulk dispensers entail hygiene requirements and are at times outsourced to third parties; returnable packaging needs reverse logistics and cost considerations include the distances involved, the rate of return and turnaround time. Issues such as rejection rates due to improper use can also arise. Strict hygiene, and removal of all prior materials, is required for food and cosmetics and the packaging must also inhibit leaching [559]. Sorting procedures are needed to ensure manufacturers all get their own products for reuse.

Many attempts are by small firms, although Loop is a circular shipping platform that works with major brands. Experience with returnable packages has been mixed, such as for the Body Shop that discontinued such packages, but is reintroducing them after 15 years under its new owner, Natura. Some companies use Aluminum packages, such as Plaine Products [*Ibid.*] or We are Paradoxx [388]. On the other hand Lush has announced it will move from reusable aluminum containers to sustainably-harvested biodegradable cork containers [285]. Kjaer Weiss has refillable makeup cases, such as a resuable compact that can be filled by the consumer, making them 30% cheaper than a new product and also refillable versions of mascara, lip gloss and eyeliners [561]. Natura was the first company in Brazil to offer products for continuous use in a refill version, with 54% lower weight than regular packaging, and its Natural Sou brand is positioned as an intermediate price range based on savings generated from efficiency gains in production processes [513]. It's packaging is not ready-to-use but on a roll of plastic film which results in lower transportation impact and use of fewer vehicles. It occupies significantly less space and also generates much less waste at the time of disposal [*Ibid.*].

Biocomposites

In spite of technological improvements in terms of recycling, plastic waste is often not managed properly in several regions such as Africa; the Middle East; Asia including India and China; and Latin America [586]. Littering and landfilling constitute the majority of the destination for waste with only 9% being recycled globally [*Ibid.*]. Bio-based, biodegradable and compostable plastics constitute a relatively small but fast-growing proportion of plastics that are desirable from sustainability considerations and for design for life, although the challenges of higher costs by a factor of two, and lower durability, remain [55,543]. Biocomposites are also being considered for use in marine environments [587].

Their use could be critical towards long-term resolution of the environmental issues, in conjunction with reuse and recycling which requires products with easily separable and reusable materials and appropriate waste handling procedures [22]. It must be emphasized that not all bioplastics are biodegradable; some bioplastics can be recyclable and can be designed to improve their recyclability, such as PLA-blends with chain extension [588]; degradation for a particular product is a strong function of environmental factors such temperature, humidity and the type of microorganisms present; biopolymers can have widely varying rates of degradation; and it is not feasible at this time to create a biocomposite that is degradable under all possible conditions. Household waste has been explored as a cheap source for bioplastics [589]. Seaweed polysaccharides have also been considered as a healthy and environmentally friendly source for biodegradable packaging, including for food and pharmaceuticals [590]. Comparison of mechanical, water-permeability, and degradation properties of PLA, PGA, PC and PHA are available in literature [591].

Literature has discussed processing techniques for biopolymers [592], and for food packaging, production techniques and parameters [593]. In applications involving replacement of traditional plastics, natural or synthetic fibers are typically added to the matrix for reinforcement, load-bearing and improving rheological and thermomechanical properties [543]. Natural fibers are preferable from an environmental viewpoint such as use of renewable sources and biodegradability, along with their high strength, low density, and low cost [*Ibid.*]. Natural fibers can be plant-based; bast fibers extracted from the outer bark of plant stems, such as flax, jute, kenaf and hemp consisting mainly of cellulose or hemicellulose; leaf fibers from leaf tissues such as sisal and pineapple; seed and fruit fibers such as cotton, loofah, kapok, coir and oil palm and coconut; or those extracted from wood, stalk and grass [543,591,594]. A comparison of the properties of fibers, of certain biocomposites based on these, their areas of applications and case studies are available [543,591,595], and for individual fibers such as sweet palm [594], or banana fiber [596]. Recycled fibers may also be used for molded fiber products [597]. Animal-origin fibers such as wool are also being researched [598]. Cork-polymer composites with chitosan and PE-graft-maleic anhydride has been studied for improved mechanical and thermal characteristics, as well as antibacterial and antifouling properties [599]. Biomass such as coffee grounds, nanocellulose and date stones can be used to develop smart reinforcing agents in biopolymers, and research is underway towards production of high performance lignocellulosic reinforced materials that can overcome the issues of high humidity absorption, poor wettability and incompatibility associated with these [600]. Organoclay could also be used for compatibilizing and reinforcing different, incompatible biopolymers such as chitosan, carboxy methyl cellulose and PLA [*Ibid.*]. Rice and wheat bran platelets, treated with beeswax, along with talc and calcium carbonate have been considered for PLA/PBSA matrix [601]. Metals and metal oxides based on nanofillers are also used [602].

Production processes for green composites [603], parameters for sustainability assessment of biocomposite-based rigid packaging [464], and considerations for multilayer packaging which are traditionally particularly difficult to recycle; use of biodegradable coatings and biobased adhesives based on PLA, PHA, bioPE and bioPET; upcycling involving controlled degradation along with a modification step to create a second-generation material that can provide new performance aimed at higher-value applications [404]; and LCA for bioplastic production, as well as life-cycle cost (LCC) and social life cycle assessment (S-LCA) [73,604] have been covered in literature. Biodegradable plastics from fossil fuels as well as biobased non-biodegradable plastics can be processed similar to conventional plastics while caution is warranted for biobased, biodegradable material that is susceptible to hygroscopic characteristics that can induce loss of viscosity, foaming, thermal degradation or hydrolysis which requires pre-drying to optimal levels while also avoiding overdrying; flow anomalies and wall slipping, especially for biocomposites based on natural fibers which may exhibit heterogeneity; degradation at higher temperatures; and the need for modifications to avoid high shear rates as well as potential for flow hesitancy [414].

PLA has been investigated as a potential biodegradable replacement for traditional plastics for more than two decades [605,606] and has been studied extensively for extrusion, injection and blow molding among other processes, given its unique properties [607]. Various fibers have been incorporated as microfibers or nanofibers over the past decade to improve its properties, especially agricultural fibers such as jute, hemp, flax, lyocell, sisal, oil-palm and wood flour, as also microcellulose nanochitin and nanolignin to provide fully biobased and biodegradable materials (e.g., [608–613]). Research has been directed towards the composition, additives, and production conditions to attain appropriate product characteristics, shelf-life and degradation, as well as special requirements such as UV absorption; flame retardancy and antibacterial protection (e.g., [614–618]). Research has also been directed towards optimization of injection processes and surface finish [619–622], and more recently towards additive manufacturing techniques and comparative analyses vis-a-vis injection molding [623,624]. Finally, studies have focused on degradation [625,626], product life [627], as well the potential for reusability via re-extrusion [628–630]. Reusability is important not just for environmental benefits, but also due to the cost of the materials. PLA recycling is feasible, but the decrease in molecular weight suggests a limit to the number of cycles [404].

Research shows the promise of such materials for a wide range of applications, from biomaterials to automotive, based on composition in terms of fiber type and content as well as any additives, material-production process conditions and manufacturing conditions. Suitable materials have not been available for the cosmetics packaging industry up to this point. However the cosmetics industry has gained significant experience in nanomaterials [631]. Recently developed novel PLA-based nanofiber composites hold significant potential for cosmetics applications, based on bio-inspired processes and products from renewable feedstocks, by which technological innovations have been fostered to produce innovative non-woven tissues based on the use of chitin nanofibers and nanolignin complexes [542]. Efforts towards modulating the viscosity of PBDA and PBAT melts have been reported to facilitate industrial extrusion of biobased beauty masks have been reported in literature and properties of PLA-based bionanocompsoites incorporating chitin nanofibers, using polyethyline glocol as a biobased plasticizer, have been investigated to remediate their mechanical characteristics related to ductility and stiffness [632,633]. Efforts towards flexible films and active molecular compounds in biomedical, cosmetics and sanitary industry; as well as in related areas such as food packaging have also been reported (e.g., [67,634,635]. Active food packaging, such as based on biopolymeric nanocarriers containing essential oils (e.g., [603]) is a significant development as packaging must be able to protect food, and reducing its effectiveness in an effort to reduce its environmental impact could lead to wastage of the contents which could have a greater negative impact on the environment. Multilayer antibacterial food packaging based on PLA, chitosan, and cellulose nanocrystals has been investigated [636]. Intelligent food packaging based on green materials can provide information about the history of the package as well as the quality of the contents, such as via time-temperature history monitoring to indicate unsafe food [600].

Potential issues with biodegradable polymers include lack of sufficient knowledge as to their marine impact such as PLA not degrading significantly for 6 months in seawater although use of natural fibers could help speed up the degradation process; PLA being potentially ecotoxic in marine environments [637] and with potentially problematic nanoparticles in freshwater [213]; their acting as contaminants in traditional plastic recycling schemes requiring adequate separability [22]; use of potentially harmful chemicals during manufacturing [586]; insufficient industry experience relative

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

to traditional plastics for various applications as well as for design of biocomposites incorporating the various sustainability considerations; and higher cost. In spite of the disadvantges, biodegradable plastics may provide a partial offset for littering and waste mismanagement and have fewer negative effects on the environment than traditional ones even in cases of partial bioderadation, especially when created from waste biomass [110].

5. Discussion and Conclusions

The review considered 639 sources from across a myriad of subject areas. Clearly it is nowhere close to being an exhaustive review in any of these areas, nor could it have been intended for such a purpose. The approach, aimed towards discerning a possible way forward for sustainable cosmetics packaging, was adopted for demonstrating a few basic issues.

There is a vast range of considerations, and a large number of factors, that may be relevant to an issue such as whether a company should consider sustainable packging for its cosmetics products. Real-life problems present multi-disciplinary challenges where a single oversimplification in an assumption can potentially unravel long and carefully-constructed chains of reasoning upon which we might wish to predicate some action. Assuming that consumers who claimed they would pay extra for green products would actually purchase whatever products companies claimed were sustainable resulted in a significant number of failures, and much research has since been directed towards understanding what actually constitutes sustainability and why a consumer might or might not wish to purchase a particular sustainably-packaged lipstick.

The complexity of the issues involved implies that greater research into a topic does not necessarily lead to greater consensus or even a clearer understanding of the problem. There has been an exponential increase in the number of papers in sustainability-related areas in recent years. In almost every topic considered, as is essential in scientific work, literature cites prior works that are in line with its findings, as also those which find results contrary to its own. There are more definitions of sustainability now than there were when the concept started to become popular. Lack of consensus persists in areas that have been researched for decades, such as the impact of entrepreneurship on society or even the efficacy of free-market systems versus those with some state control. "Obvious" strategies such as having investors favor firms with higher ESG rankings to promote good corporate behavior have now been shown to be potentially counterproductive in that they can increase environmental damage. Increased research in an area, especially if it provides results contrary to prior work, can provide invaluable information as to what is not known for certain anymore, forcing a revaluation of implicit assumptions.

Finally, results from any chain of models encompassing multiple areas, particularly quantitative and computerized models, must especially be treated with significant caution. There is no substitute for empirical validation.

5.1. Potential Pitfalls

For identifying potential pitfalls, the findings in literature regarding implementing sustainable products could be summarized for the worst-case scenario as

- attempting to sell products that may not necessarily help the environment
  - depending on local post-use handling and infrastructure
  - the sustainability criteria applied
  - and may also underperform and be overpriced
- introduced in response to unreliable demand estimates
  - that may or may not materialize
  - based on models that may not be accurate
  - for consumers who may not trust or even understand the claims
- potentially without complete knowledge of sustainability

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

  - of the manufacturing processes
  - or the economics of the business model
- for compliance with policies not necessarily fully-informed
- in conjunction with heterogeneous supply-chain partners
  - each with their own values, expertise and business models
  - subject to different stakeholder demands and regulations

5.2. Desirable Characteristics

The aim is to determine potential pathways towards enhancing sustainability-related characteristics of cosmetics packaging in spite of the lack of consensus in literature with respect to almost every aspect of the numerous issues involved with sustainable products. In this sense the uncertainties inherent in the various aspects of environmental protection efforts help delineate the constraints within which the effort towards sustainable cosmetics packaging must operate. While the attempt is to discern such issues from literature, the wide range of results in literature make the task somewhat subjective. Reviews of the same literature can reach differing conclusions, and it should be possible to make a case against one, more, or all of the suggestions below.

Consumer uptake is indispensable for a product to succeed. Given the myriad of individual, social and product factors that can impact consumer reaction to green products, the safest a priori assumption would be that ceteris paribus consumers would choose a product with less environmental impact. Literature has often emphasized the need for maintaining performance and price for green products. Companies already have significant knowledge with regard to the characteristics and functionality that consumers desire for their traditional products, and adding the constraint of sustainability will not improve upon an optimum design sans the constraint. This is especially important for mass-manufactured products which must satisfy the needs of a range of consumers. For such products, instead of experimenting with novel designs that may or may not appeal to particular segments of the customer base, it may be easier to simply adopt the constraint that *sustainable packaging must provide the same product characteristics and functionality as the corresponding traditional products, and at the same price*. This transforms consumer-related issues into a technical problem with regard to product characteristics as well as a financial problem related to pricing. It does not mean the problem has been solved. Rather, it provides a specific goal for technical development, and subsequently, for cost analysis and policy support.

The true impact of a new material may only become apparent after it is incorporated into full-fledged production, and at times new knowledge or technological developments may also require companies to shift to alternate sustainability strategies. Significant up-front investment requirements for material-specific production machines can impede attempts to explore and employ new, sustainable, materials all the way to commercialization. To reduce the upfront investment-related risk associated with initiating mass-production of a particular product, the second constraint would be that *the new materials must be processable on existing machines, with modifications in tooling and process parameters if needed*.

New fossil-based plastic materials are entering the waste stream faster than they can be recycled and the amount of plastic waste is growing [25]. Regions with relatively developed infrastructure and greater recycling capacity continue to export waste to countries where dumping, landfilling and incineration constitute the most popular disposal techniques by far [110,586]. Plastic waste will not be decreased by the addition of more recyclable material to the waste stream if there is no capacity to recycle it. If bioplastics were to be designed to be primarily recyclable, it is not entirely clear how replacing traditional plastics by recyclable bioplastics would help either, unless the relevant locations had sufficient infrastructure for recycling the new material. Absent proper separating procedures, it could in fact interfere with the recycling of traditional plastics [117]. Any benefits of recycling for bioplastics, such as retaining some of the energy and resources used towards creation of the material, while reducing the impact of the production processes, are only obtained if the material is actually

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

recycled [561]. Globally, only 9% of the plastics produced are recycled [25]. A total of eight plastics manufacturers have targets of 20% of their plastics production to be based on recycled material by 2030, and this could potentially turn into greenwashing if it is not implemented [*Ibid.*].

On the other hand even partial biodegradability in soil and water would directly help reduce plastic waste and ameliorate the burden on landfills [110]. Prevention of waste generation is the most preferable means, and one with the greatest financial opportunities as well as the least environmental externalities as compared to other strategies such as reuse, recycling or recovery of energy or other chemicals [63]. Use of bio-based plastics is increasing to avoid fossil-fueld dependence. Use of biodegradale plastics is controversial in this hierarchy but its use can help with the reduction in waste. While recycling of all bioplastics, including biodegradable ones, has been recommended for recovery of materials [638], the issue of capacity remains. In areas where waste handling is carried out in a systematic and comprehensive manner with traditional plastics being recycled to a significant extent, facilities for separation of bioplastic waste would be needed anyway even for recyclable bioplastics and adding them for those that will not enter the recycling stream may not be overly burdensome. In areas with no such facilities, appropriate biodegradable plastics could help reduce the waste where recyclable ones would not help. Research is ongoing into biopolymer blends that show improved biodegradation under less demanding environmental conditions than industrial composting. Thus, the next constraint proposed is that *the proposed sustainable material must be designed for maximizing biodegradability under specified environmental conditions and minimizing the production of microplastics*.

Lab testing and shop-floor production can be quite different and results from the former cannot be the basis for final validation towards implementation in the latter. In the absence of models that could provide reasonable predictions, such validations need to be empirical. This makes implementation attempts expensive, time-consuming and risky. It also necessitates participation from across the supply chain, which adds to the complexity and difficulty of coordinating such attempts, although it could also be beneficial as the greatest level of environmental, social and governance performance is achieved via collaborative projects; followed by in-house efforts; and finally via outsourced projects [639].

In this regard, design of materials that provide biodegradable products with similar characteristics to traditional ones is not a novel aim but it requires emphasis at the outset so as to narrow down design choices and avoid a plethora of potential sustainability strategies and corresponding designs, each with its own acceptability issues and post-use infrastructure requirements. The focus can then be on development of the product and validating its feasibility from various relevant perspectives starting from raw material sourcing to their post-disposal characteristics under field conditions.

Finally, the risky nature of such efforts along with potential benefits for the population at large, *such efforts could be funded by governmental agencies to the extent that participants do not make a profit out of the funding*.

5.3. Research Program

Figure 5 shows the possible constituents of a group to help implement sustainable packaging. Unlike horizontal alliances that are needed for cooperation on tasks such as standardization, validation of a particular sustainable packaging for cosmetics will involve vertical alliances, extending beyond the traditional supply chain.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

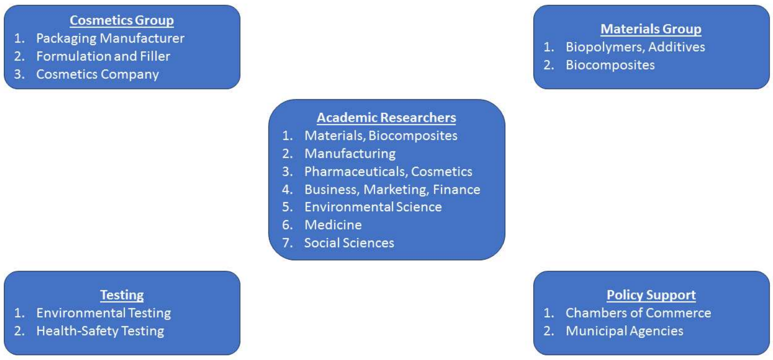

Figure 5. Participants Required for Development of Commercially-Applicable Sustainable Packaging.

The cosmetics component would include a packaging manufacturer interested in implementing sustainable packaging, along with a company that produces formulations and fills the packages, and a company that sells cosmetics under its brands. Given the necessity of experience in production processes to be able to implement change, these companies need to be highly experienced and proficient. Information sharing concerns could be exacerbated with new and unknown partners while long-standing business relationships may already have generated trust and familiarity with each others' pricing structures and business practices. Additionally, large companies typically do not experiment with new technology but rather prefer to partner with third parties for development and scale up successful ones. This suggests that experienced and proficient SMEs who have built long-term business relationships with each other could be considered for the cosmetics group.

The materials group would consist of companies, potentially startups, that produce biopolymers and additives, and also novel biocomposites. Testing would comprise of companies or research facilities that can carry out environmental testing; health-safety testing; as well as market testing but the last one can probably be the cosmetics company itself. The policy support group would be comprised of chambers of commerce and municipal agencies involved in waste handling or environmental protection. Material development is still often in the research phase and academic researchers would have a significant role from multiple perspectives. The supply chain components could be spread over different countries, with cosmetics companies in a region with relatively lower costs, research-oriented SMEs related to materials could be in countries with a greater emphasis on research. Universities in proximity to such groups can also act as key facilitators in the process, while helping guide the development and testing based on scientific literature, along with broader research into social considerations.

The overall steps of the procedure are in Figure 6.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

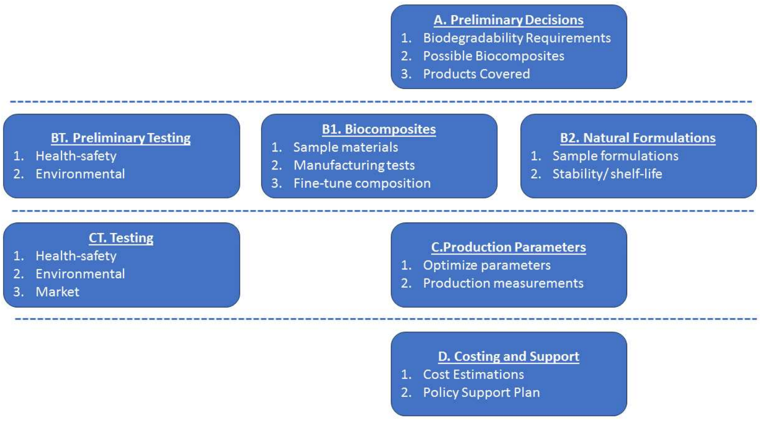

Figure 6. Steps towards Development of Commercially-Applicable Sustainable Packaging.

With the focus on achieving the greatest possible biodegradability and the same functionality as the traditional product, the preliminary decisions would relate to potential blends that could be employed for each of the different types of products sought to be replaced, including considerations such as the potential for scale up and the environmental conditions expected under post-use disposal.

The second phase would include samples of proposed packaging materials and formulation ingredients being produced and being sent for environmental and health-safety testing as well as for production tests, and for formulation and filling. Production tests would evaluate the usability of the materials on existing equipment, as well as their compatibility with different finishing processes. Manufacturing companies would provide feedback to the materials companies for fine-tuning the composition of the materials based on preliminary testing, and materials not meeting health-safety requirements or those potentially toxic to the environment would need to be removed from consideration.

The third phase would be optimization of process parameters for the fine-tuned materials and determining their production-related measures such as cycle-times, defect rates and power consumption. Filled samples would also undergo stability and shelf-life evaluations, and optimal production parameters would be determined for these as well. Material resources, energy, water-usage and similar comparisons can be conducted for the new product at each stage of production using the actual production data, and the corresponding values for the prior product. Finally, samples could be sent for overall product health-safety and environmental testing; and could also be provided to other downstream companies and consumers for their evaluation, both with and without knowledge of their sustainable characteristics.

Successful completion of the technical phase of testing would be followed by costing, and attempting to determine the required costs of the parts at various stages that would allow the final price of the product to remain the same. For this, policy support could initially be sought in the form of tax subsidies or other financial incentives. Once scale-up has been achieved for the group and it has been determined that additional raw material capacity can be brought online, other companies can be incentivized to shift to the new materials by removing any subsidies on traditional fossil-based raw material suppliers. Finally, once companies in the market gain experience with such materials, the policy can be changed to one mandating the new materials.

As such materials get established and are adopted for widespread use, equipment manufacturers would be able to produce machines that may be better suited to such materials and companies could replace existing equipment with such machines, potentially for improving production efficiency and quality, if it made business sense to do so.

As noted, different researchers may come to differing conclusions based on the issues presented in literature. The approach presented here is not exclusive and researchers and companies can certainly come up with alternate strategies; based on issues such as the potential problems with biodegradable plastics and their high costs, as well as the loss of all the inputs for the production process; which may be more in line with their business strategy. Comparing across such approaches to obtain the best path for a company is outside the scope of this work.

Author Contributions: Conceptualization, M.D. and S.D.; writing—original draft preparation, M.D. and S.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not applicable

Conflicts of Interest: The authors declare no conflict of interest

References

1. The short history of global living conditions and why it matters that we know it. Available online: https://ourworldindata.org/a-history-of-global-living-conditions-in-5-charts (accessed on 31 May 2023).
2. Kannan, S. Impact of Industrialization on Social Mobility in Puducherry. *Man in India* **2016**, *96(4)*, 55–68.
3. Kumar, S. Exploratory analysis of global cosmetics industry: major players, technology and market trends. *Technovation* **2005**, *25*, 1263–1272.
4. Prothero, A.; McDonagh, P. Producing Environmentally Acceptable Cosmetics? The Impact of Environmentalism on the United Kingdom Cosmetics and Toiletries Industry. *Journal of Marketing Management* **1992**, *8*, 147–166.
5. Morganti, P.; Lohani, A.; Gagliardini, A.; Morganti, G.; Coltelli, M.-B. Active Ingredients and Carriers in Nutritional Eco-Cosmetics. *Compounds* **2023**, *3*, 122–141.
6. Cubas, A.L.V.; Bianchet, R.T.; dos Reis, I.M.A.S.; Gouveia, I.C. Plastics and Microplastic in the Cosmetic Industry: Aggregating Sustainable Actions Aimed at Alignment and Interaction with UN Sustainable Development Goals. *Polymers* **2022**, *14*, 4576.
7. Earth Overshoot Day is Coming Sooner and Sooner. Available online: https://www.statista.com/chart/15026/earth-overshoot-day-comes-sooner-every-year/ (accessed on 31 May 2023).
8. Mandelik, Y.; Dayan, T.; Feitelson, E. Issues and dilemmas in ecological scoping: scientific, procedural and economic perspectives *Impact Assessment and Project Appraisal* **2005**, *23(1)*, 55–63.
9. Past and future decline and extinction of species. Available online: https://royalsociety.org/topics-policy/projects/biodiversity/decline-and-extinction/ (accessed on 31 May 2023).
10. Calculating Deforestation Figures for the Amazon. Available online: https://rainforests.mongabay.com/amazon/deforestation_calculations.html (accessed on 31 May 2023).
11. Montes, R.M.A.; Delapaz, G.V.; Oliquiano, J.I.D.R.; Pascasio, H.K.A.; Lugay, C.I.J.R.P. A Study on the Impact of Green Cosmetic, Personal Care Products, and their Packaging on Consumers' Purchasing Behavior in Luzon, Philippines. In Proceedings of the 7th North American International Conference on Industrial Engineering and Operations Management, Orlando, Florida, USA, June 12-14, 2022; 119–128.
12. Calero, C.; Godoy, V.; Queseda, L.; Martin-Lara, M.A. Green strategies for microplastics reduction. *Current Opinion in Green and Sustainable Chemistry* **2021**, *28*, 100442.
13. Shaikh, I.V.; Shaikh, V.A.E. A comprehensive review on assessment of plastic debris in aquatic environment and its prevalence in fishes and other aquatic animals in India. *Science of the Total Environment* **2021**, *779*, 146421.
14. Ansari, M.; Farzadkia, M. Beach debris quantity and composition around the world: A bibliometric and systematic review. *Marine Pollution Bulletin* **2022**, *178*, 113637.
15. Karthik, R; Robin, R.S.; Purvaja, R.; Karthikeyan, V.; Subbareddy, B.; Balachandar, K.; Hariharan, G.; Ganguly, D.; Samuel, V.D.; Jinoj, T.P.S.; Ramesh, R. Microplastic pollution in fragile coastal ecosystems with special reference to the X-Press Pearl maritime disaster, southeast coast of India. *Environmental Pollution* **2022**, *178*, 119297.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

16. Khaleel, R.; Valsan, G.; Rangel-Buitrago, N.; Warrier, A.K. Hidden problems in geological heritage sites: The microplastic issue on Saint Mary's Island, India, Southeast Arabian Sea. *Marine Pollution Bulletin* **2022**, *182*, 114043.
17. Kurniawan, T.A.; Haider, A.; Ahmad, H.M.; Mohyuddin, A; Aslam, H.M.U.; Nadeem, S.; Javed, M.; Othman, M.H.D.; Hog, H.H.; Chew, K.W. Source, occurrence, distribution, fate, and implications of microplastic pollutants in freshwater on environment: A critical review and way forward. *Chemosphere* **2023**, *325*, 138367.
18. Kye, H.; Kim, J.; Ju, S; Lee, J.; Lim, C.; Yoon, Y. Microplastics in water systems: A review of their impacts on the environment and their potential hazards. *Heliyon* **2023**, *9*, e14359.
19. Mugilarasan, M.; Karthik, R.; Subbareddy, B.; Hariharan, G.; Anandavelu, I.; Jinoj, T.P.S.; Purvaja, R.; Ramesh, R. Anthropogenic marine litter: An approach to environmental quality for India's southeastern Arabian Sea coast. *Science of the Total Environment* **2023**, *866*, 161363.
20. Xu, Q.; Xiang, J.; Ko, J.H. Municipal plastic recycling at two areas in China and heavy metal leachability of plastic in municipal solid waste. *Environmental Pollution* **2020**, *260*, 114074.
21. Rhodes, C.J. Plastic pollution and potential solutions *Science Progress* **2018**, *101(3)*, 207–260.
22. Law, K.L.; Narayan, R. Reducing environmental plastic pollution by designing polymer materials for managed end-of-life. *Nature Reviews Materials* **2022**, *7(2)*, 104:116.
23. Eriksen, M.; Lebreton, L.C.M.; Carson, H.S.; Thiel, M.; Moore, C.J.; Borerro, J.C.; Galgani, F.; Ryan, P.G.; Reisser, J. Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. *PlosOne* **2014**, 0111913.
24. Where the EU exports its waste. Available online: https://www.statista.com/chart/24716/main-destinations-for-eu-waste/ (accessed on 31 May 2023).
25. Plastic Waste Makers Index 2023. Available online: https://cdn.minderoo.org/content/uploads/2023/02/04205527/Plastic-Waste-Makers-Index-2023.pdf (accessed on 31 May 2023).
26. Stumpf, L.; Schoggl, J.-P.; Baumgartner, R.J. Circular plastics packaging – Prioritizing resources and capabilities along the supply chain*Technological Forecasting & Social Change* **2023**, *188*, 122261.
27. Explainer: Toxic Substances Control Act. Available online: https://www.chemistryworld.com/news/explainer-toxic-substances-control-act/1010187.article (accessed on 31 May 2023).
28. Bridges, J.W.; Greim, H.; van Leeuwen, K.; Stegmann, R.; Vermeire, T.; den Haan, K. Is the EU chemicals strategy for sustainability a green deal? *Regulatory Toxicology and Pharmacology* **2023**, *139*, 105356.
29. Gaber, N.; Bero, L.; Woodruff, T.J. The Devil they Knew: Chemical Documents Analysis of Industry Influence on PFAS Science. *Annals of Global Health* **2023**, *89(1)*, 37.
30. 3M Resolves Claims by Public Water Suppliers, Supports Drinking Water Solutions for Vast Majority of Americans. Available online: https://investors.3m.com/news-events/press-releases/detail/1784/3m-resolves-claims-by-public-water-suppliers-supports (accessed on June 26 2023).
31. Press Releases Related to PFAS. Available online: https://www.epa.gov/pfas/press-releases-related-pfas (accessed on June 26 2023).
32. Cingano, F. Trends in Income Inequality and its Impact on Economic Growth *OECD Social, Employment and Migration Working Papers No. 163* OECD Publishing, 2014.
33. Dabla-Norris, E.; Kochhar, K.; Suphaphiphat, N., Ricka, F., Tsounta, E. Causes and Consequences of Income Inequality: A Global Perspective. *IMF Staff Discussion Notes 15/13*, International Monetary Fund, 2015.
34. For most U.S. workers, real wages have barely budged in decades. Available online: https://www.pewresearch.org/short-reads/2018/08/07/for-most-us-workers-real-wages-have-barely-budged-for-decades/ (accessed on 31 May 2023).
35. Bruton, G.; Sutter, C.; Lenz, A.-K. Economic inequality - Is entrepreneursihp the cause or the solution? A review and research agenda for emerging economies *Journal of Business Venturing* **2021**, *36*, 106095.
36. Gao, P.; Lei, T.; Jia L.; Yury, B.; Zhang, Z.; Du., Y.; Fang, Y.; and Xing, B., Bioaccessible trace metals in lip cosmetics and their health risks to female consumers *Environmental Pollution* **2018**, *238*, 554–561.
37. Bilal, M.; Mehmood, S.; Iqbal H.M.N., The Beast of Beauty: Environmental and Health Concerns of Toxic Compounds in Cosmetics *Cosmetics* **2020**, *7*, 13.
38. Teo, T.L.L.; Coleman, H.M.; Khan S.J. Chemical contaminants in swimming pools: Occurrence, implications and control *Environment International* **2015**, *76*, 16–31.
39. Jurado, A.; Gago-Ferrero, P.; Vazquez-Sune, E.; Carrera, J.; Pujades, E.; Diaz-Cruz, M.S.; Barcelo, D. Urban groundwater contamination by residues of UV filters *Journal of Hazardous Materials* **2014**, *271*, 141–149.

40. Tang, Z.; Han, X.; Li, G.; Tian, S.; Yang, Y.; Zhong, F.; Han, Y.; Yang, J. Occurrence, distribution and ecological risk of ultraviolet absorbents in water and sediment from Lake Chaohu and its inflowing rivers, China *Ecotoxicology and Environmental Safety* **2018**, *164*, 540–547.
41. Juliano, C.; Magrini, G.A. Cosmetic Ingredients as Emerging Pollutants of Environmental and Health Concern. A Mini-Review *Cosmetics* **2017**, *4*, 11.
42. Giokas, D.L.; Salvador, A.; Chisvert, A. UV filters: From sunscreens to human body and the environment *Trends in Analytical Chemistry* **2007**, *26(5)*, 360–374.
43. Sanchez-Quilez, D.; Tovar-Sanchez, A. Are sunscreens a new environmental risk associated with coastal tourism *Environment International* **2017**, *83*, 158–150.
44. Jaini, A.; Quoquab, F.; Mohammad, J.; Hussin, N. I buy green products, do you. . .? The moderating effect of eWOM on green purchase behavior in Malaysian cosmetics industry *International Journal of Pharmaceutical and Healthcare Marketing* **2020**, *14(1)*, 89–112.
45. Taylor, K.; Rego-Alvarez, L. Regulatory drivers in the last 20 years towards the use of in silico techniques as replacements to animal testing for cosmetic-related substances *Computational Toxicology* **2020**, *142*, 100112.
46. Zhou, Y.; Ashokkumar, V.; Amobonye. A.; Bhattacharjee, G.; Sirohi, R.; Singh, V.; Flora, G.; Kumar, V.; Pillai, S.; Zhang, Z.; Awasthi, M. K. Current research trends on cosmetic microplastic pollution and its impacts on the ecosystem: A review *Environmental Pollution* **2023**, *320*, 121106.
47. Anagnosti, L.; Varvaresou, A.; Pavlou, P.; Protopapa, E.; Carayanni, V. Worldwide actions against plastic pollution from microbeads and microplastics in cosmetics focusing on European policies. Has the issue been handled effectively? *Marine Pollution Bulletin* **2021**, *162*, 111883.
48. Caruana, P. Ethical Consumerism in The Cosmetics Industry: Measuring how Important Sustainability is to The Female Consumer. Bachelors Thesis, University of Twente, The Netherlands, 26 June 2020.
49. Grappe, C.G.; Lombart, C.; Louis, D.; Durif, F. Clean labeling: Is it about the presence of benefits or the absence of detriments? Consumer response to personal care claims *Journal of Retailing and Consumer Services* **2022**, *65*, 102893.
50. Kim, Y.; Choi, S.M. Antecedents of Green Purchase Behavior: an Examination of Collectivism, Environmental Concern, and Pce. In *NA - Advances in Consumer Research Volume 32*; Menon, G., Rao, A.R. , Eds.; Association for Consumer Research, 2005; 592–599.
51. Lin, Y.; Yang, S.; Hanifah, H.; Iqbal, Q. An Exploratory Study of Consumer Attitudes toward Green Cosmetics in the UK Market *Administrative Sciences* **2018**, *8*, 71.
52. Orzan, G.; Cruceru, A.F.; Balaceanu, C.T.; Chivu, R.-G. Consumers' Behavior Concerning Sustainable Packaging: An Exploratory Study on Romanian Consumers *Sustainability* **2018**, *10*, 1787.
53. Bioplastics innovation 'particularly poorly covered' in cosmetics: Report. Available online: https://www.cosmeticsdesign-europe.com/Article/2020/04/27/Bioplastics-packaging-innovation-poor-in-cosmetics-finds-Clarivate-Analytics (accessed on 31 May 2023).
54. When to Choose Biobased Packaging for Cosmetics - An Interview with Caroli Buitenhuis. Available online: https://formulabotanica.com/biobased-packaging-cosmetics/ (accessed on 31 May 2023).
55. Wandosell, G.; Parra-Merono, M.C.; Alcayde, A.; Banos, R. Green Packaging from Consumer and Business Perspectives. *Sustainability* **2021**, *13*, 1356.
56. Chang, T.-W. Double-edged sword effect of packaging: Antecedents and consumer consequences of a company's green packaging design. *Journal of Cleaner Production* **2023**, *406*, 137037.
57. Baumann, H.; Boons, F.; Bragd, A. Mapping the green product development field: engineering, policy and business perspectives *Journal of Cleaner Production* **2002**, *10*, 409-425.
58. Bluher, T.; Riedelsheimer, T.; Gogineni, D.; Klemichen, A.; Stark, R. Systematic Literature Review—Effects of PSS on Sustainability Based on Use Case Assessments. *Sustainability* **2020**, *12*, 6989.
59. Visser, W. The future of CSR: Towards transformative CSR, or CSR 2.0. In *Research handbook on corporate social responsibility in context*; Ortenblad, A., Ed.; Edward Elgar Publishing, 2016; pp. 339–367.
60. Boz, Z.; Kothonen, V.; Sand, C.K. Consumer Considerations for the Implementation of Sustainable Packaging: A Review. *Sustainability* **2020**, *12*, 2192.
61. Buntin, M.B.; Burke, M. F.; Hoaglin, M.C.; Blumenthal, D. The Benefits of Health Information Technology: A Review Of The Recent Literature Shows Predominantly Positive Results. *Health Affairs* **2011**, *30(3)*, 464–471.
62. Dube, S.; Dube, M. *SomPack: If You Can't Beat Them, Join Them?*; Ivey Publishing/ Harvard Business Case Collection, 2010.

63. Dijkstra, H.; van Beukering, P.; Broiwer, R. Business models and sustainable plastic management: A systematic review of the literature. *Journal of Cleaner Production* **2020**, *258*, 120967.
64. Alejandrino, C.; Mercante, I.T.; Bovea, M.D. Combining O-LCA and O-LCC to support circular economy strategies in organizations: Methodology and case study. *Journal of Cleaner Production* **2022**, *336*, 130365.
65. Puglieri, F.N.; Salvador, R.; Romero-Hernandez, O.; Filho, E.E.; Piekarksi, C.M.; de Francisco, A.C.; Ometto, A.R. Strategic planning oriented to circular business models: A decision framework to promote sustainable development. *Business Strategy and the Environment* **2022**, *31*, 3254–3273.
66. Acerbi, F.; Rocca, R.; Fumagalli, L.; Taisch, M. Enhancing the cosmetics industry sustainability through a renewed sustainable supplier selection model. *Production & Manufacturing Research* **2023**, *11(1)*, 2161021.
67. Cinelli, P.; Coltelli, M.B.; Signori, F.; Morganti, P.; Lazzeri, A. Cosmetic Packaging to Save the Environment: Future Perspectives. *Cosmetics* **2019**, *6*, 26.
68. Rosenow, P.; Destler, E.; Springer, A. The Search for Suitable Packaging for Cosmetics – a Case Study. *SOFW Journal* **2022**, *148*, 56-59.
69. Klitkou, A.; Bolwig, S.; Hansen, T.; Wessberg, N. The role of lock-in mechanisms in transition processes: The case of energy for road transport. *Environmental Innovation and Societal Transitions* **2015**, *16*, 22-37.
70. Poma, L.; Al Shawwa, H.; Nicolli, F.; Quaglietti, V. Towards sustainability: The Impact of Environmental Sustainability of Consumer Goods in the Italian Packaging Sector. *Transnational Marketing Journal* **2022**, *10(2)*, 443–457.
71. Jager-Roschko, M.; Petersen, M. Advancing the circular economy through information sharing: A systematic literature review. *Journal of Cleaner Production* **2022**, *369*, 133210.
72. Dube, M.; Dube, S. SomPack: succession planning gone wrong. *Emerald Emerging Markets Case Studies* **2021**, *11(2)*.
73. Ali, S.S.; Abdelkarim, E.A.; Elsamahy, T.; Al-Tohamy, R.; Li, F.; Kornaros, M.; Zuorro, A.; Zhu, D.; Sun, J. Bioplastic production in terms of life cycle assessment: A state-of-the-art review. *Environmental Science and Ecotechnology* **2023**.
74. Kayicki, Y.; Kazanoglu, Y.; Gozacan-Chase, N.; Lafci, C.; Batista, L. Assessing smart circular supply chain readiness and maturity level of small and medium-sized enterprises. *Journal of Business Research* **2022**, *149*, 375–392.
75. Dangelico, R.M.; Volcalelli, D. Green Marketing: An analysis of definitions, strategy steps, and tools through a systematic review of the literature. *Journal of Cleaner Production* **2017**, *165*, 1263–1279.
76. A European Strategy for Plastics in a Circular Economy - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, . Available online: https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF (accessed on 31 May 2023).
77. Henchion, H.M.; Shirsath, A.P. Developing and implementing a transdisciplinary framework for future pathways in the circular bioeconomy: The case of the red meat industry. *Journal of Cleaner Production* **2022**, *380*, 134845.
78. Carmona-Lavado, A.; Gimenez-Fernandez, E.M.; Vlaisavljevic, V.; Cabello-Medina, C. Cross-industry innovation: A systematic literature review. *Technovation* **2023**, *124*, 102743.
79. Johnston, P.; Everard, M.; Santillo, D.; Robert, H.-K. Reclaiming the Definition of Sustainability. *Environmental Science and Pollution Research International* **2007**, *13(1)*, 60–66.
80. Geissdoerfer, M.; Savaget, P.; Bocken, N.M.P.; Hultink, E. The Circular Economy - A new sustainability paradigm? *Journal of Cleaner Production* **2017**, *143*, 757–768.
81. Pollman, F. Corporate Social Responsibility, ESG, and Compliance. In *The Cambridge Handbook of Compliance*; van Rooij, B., Sokol, D.D., Eds.; Cambridge University Press: Cambridge, England, 2021; pp. 662–672.
82. Saidani, M.; Yannou, B.; Leroy, Y.; Cluzel, F.; Kendall, A. A taxonomy of circular economy indicators. *Journal of Cleaner Production* **2019**, *207*, 542–559.
83. Bjorn, A.; Lloyd, S.M.; Brander, M.; Matthews, H.D. Renewable energy certificates threaten the integrity of corporate science-based targets. *Nature Climate Change* **2022**, *12*, 539–546.
84. Schiano, A.N.; Drake, M.A. Sustainability: Different perspectives, inherent conflict. *Journal of Dairy Science* **2021**, *103(11)*, 11386–11400.
85. Chan, R.B.Y. Drivers of divergent industry and consumer food waste behaviors: The case of reclosable and resealable packaging. *Journal of Cleaner Production* **2023**, *412*, 137417.

86. Kasza, G.; Veflen, N.; Scohlderer, J.; Munter, L.; Fekete, L.; Csenki, E.Z.; Dorko, A.; Szakos, D.; Iszo, T. Conflicting Issues of Sustainable Consumption and Food Safety: Risky Consumer Behaviors in Reducing Food Waste and Plastic Packaging. *Foods* **2022**, *11*, 3520.
87. Bom, S.; Jorge, J.; Ribeiro, H.M.; Marto, J. A step forward on sustainability in the cosmetics industry: A review *Journal of Cleaner Production* **2019**, *225*, 270–290.
88. Damanpour, F.; Wischnevsky, J.D. Research on innovation in organizations: Distinguishing innovation-generating from innovation-adopting organizations *Journal of Engineering and Technology Management* **2006**, *23*, 269–291.
89. Moldaschl, M. Why Innovation Theories Make no Sense. *Papers and Preprints of the Department of Innovation Research and Sustainable Resource Management, Chemnitz University of Technology* **2010**, 9/2010.
90. Suchek, N.; Fernandes, C.I.; Kraus, S.; Filser, M.' Sjorgren, H. Innovation and the circular economy: A systematic literature review. *Business Strategy and the Environment* **2021**, 1–17.
91. Intezari, A.; Taskin, N.; Pauleen, D.J. Looking beyond knowledge sharing: an integrative approach to knowledge management culture. *Journal of Knowledge Management* **2017**, *21(2)*, 492–515.
92. Lopez-Torres, G.C.; Garza-Reyes, J.A.; Maldonado-Guzman, G.; Kumar, V.; Rocha-Lona, L.; Cherrafi, A. Knowledge management for sustainability in operations. *Production Planning & Control* **2019**, *30(10-12)*, 813–826.
93. Martins, V.W.B.; Rampasso, I.S.; Anholon, R.; Quelhas, O.L.G.; Leal Filho, W. Knowledge management in the context of sustainability: Literature review and opportunities for future research. *Journal of Cleaner Production* **2019**, *229*, 489–500.
94. Sanguankaew, P.; Ractham, V.V. Bibliometric Review of Research on Knowledge Management and Sustainability, 1994–2018. *Sustainability* **2019**, *11(16)*, 4388.
95. Chang, C.L.-H.; Lin, T.-C. The role of organizational culture in the knowledge management process *Journal of Knowledge Management* **2015**, *19(3)*, 433–455.
96. Matic, D.; Cabrilo, S.; Grubic-Nesic, L.; Milic, B. Investigating the impact of organizational climate, motivationaldrivers, and empowering leadership on knowledge sharing *Knowledge Management Research and Practice* **2017**, *15*, 431–446.
97. Chang, Y.-C.; Chang, H.-T.; Chi, H.-R.; Chen, M.-H.; Agnikpe, C.; Deng, L.-L. How do established firms improve radical innovation performance? The organizational capabilities view *Technovation* **2012**, *32*, 441–451.
98. Agyabeng-Mensah, Y.; Ahenkorah, E.; Afum, E.; Agyemang, A.N.; Agnikpe, C.; Rogers, F. Examining the influence of internal green supply chain practices, green human resource management and supply chain environmental cooperation on firm performance *Supply Chain Management: An International Journal* **2020**, *25(5)*, 585–599.
99. Holzer, D.; Rauter, R.; Fleib, E.; Stern, T. Mind the gap: Towards a systematic circular economy encouragement of small and medium-sized companies *Journal of Cleaner Production* **2021**, *98*, 126696.
100. Chen, Y.-Y.; Huang, H.-L. Knowledge management fit and its implications for business performance: A profile deviation analysis*Knowledge-Based Systems* **2012**, *27*, 262–270.
101. Pee, L.G.; Min, J. Employees' online knowledge sharing: the effects of person-environment fit *Journal of Knowledge Management* **2017**, *21(2)*, 432–453.
102. Wehn, U.; Montalvo, C. Knowledge transfer dynamics and innovation: Behaviour, interactions and aggregated outcomes *Journal of Cleaner Production* **2018**, *171, Supplement*, S56–S68.
103. Aydin, S.; Dube, M. Knowledge management, innovation, and competitive advantage: is the relationship in the eye of the beholder? *Knowledge Management Research and Practice* **2018**, *16(3)*, 402–413.
104. Martins, S.; Carvalho, M.; Pinto, C. The Preservation of Memory and the Management of Information as a Step towards Sustainable Development. *WSEAS Transactions on Environment and Development* **2023**, *19*, 341–349.
105. Cooper, T. Product Development Implications of Sustainable Consumption *The Design Journal* **2000**, *3:2*, 46–57.
106. Peattie, K.; Crane, A. Green marketing: legend, myth, farce or prophesy? *Qualitative Market Research: An International Journal* **2005**, *8(4)*, 357–370.
107. Laroche, M.; Bergeron, J.; Barbaro-Forleo, G. Targeting consumers who are willing to pay more for environmentally friendly products *Journal of Consumer Marketing* **2001**, *18(6)*, 503–520.

 doi:10.20944/preprints202308.0120.v1

108. Barros, C.; Barros, R.B.G. Natural and Organic Cosmetics: Definition and Concepts *Journal of Cosmetology & Tribology* **2020**, *6:2*, 503–520.
109. Bozza, A.; Campi, C.;Garelli, S; Ugazio, E.; Battagila, L. Current regulatory and market frameworks in green cosmetics: The role of certification *Sustainable Chemistry and Pharmacy* **2022**, *30*, 100851.
110. Filiciotto, L.; Rothenberg, G. Biodegradable Plastics: Standards, Policies, and Impacts. *ChemSusChem* **2021**, *14*, 56–72.
111. Guntzburger, Y.; Peignier, I.; de Marcellis-Warin, N. The consumers' (mis)perceptions of ecolabels' regulatory schemes for food products: insights from Canada. *British Food Journal* **2021**, *124(11)*, 3497–3521.
112. Morone, P.; Caferra, R.; D'Adamo, I.; Falcone, P.M.; Imerbt,E.; Morone, A. Consumer willingness to pay for bio-based products: Do certifications matter? *International Journal of Production Economics* **2021**, *240*, 108248.
113. Amberg, N.; Fogarassy, C. Green Consumer Behavior in the Cosmetics Market *Resources* **2019**, *8*, 137. *Sustainable Chemistry and Pharmacy* **2019**, *30*, 100851.
114. Ferreira, M.; Matos, A.; Couras, A; Marto, J.; Ribeiro, H. Overview of Cosmetic Regulatory Frameworks around the World *Cosmetics* **2022**, *9*, 72.
115. Kassaye, W.W. Green Dilemma *Marketing Intelligence and Planning* **2001**, *19/6*, 444–455.
116. Nakatani, J.; Aramaki, T.; Hanaki, K. Evaluating source separation of plastic waste using conjoint analysis *Waste Management* **2008**, *28*, 2393–2402.
117. Ansink, E.; Wijk, L.; Zuidemeer, F. No clue about bioplastics *Ecological Economics* **2022**, *191*, 107245.
118. Dijkgraaf, E.; Gradus, R. Post-collection Separation of Plastic Waste: Better for the Environment and Lower Collection Costs? *Environmental and Resource Economics* **2020**, *77*, 127–142.
119. Aubin, S.; Beaugrand, J.; Berteloot, M.; Boutrou, R.; Buche, P.; Gontard, N.; Guillard, V. Plastics in a circular economy: Mitigating the ambiguity of widely-used terms from stakeholders consultation. *Environmental Science and Policy* **2022**, *134*, 119–126.
120. Grant, R.M. Toward a Knowledge-based Theory of the Firm. *Strategic Management Journal* **1996**, *17*, 109–122.
121. Spender, J.-C. Making Knowledge the Basis of a Dynamic Theory of the Firm. *Strategic Management Journal* **1996**, *17*, 45–62.
122. Bom, S.; Gouveia, L.P.; Pinto, P.; Martins, A.M.; Ribeiro, H.M.; Marto, J. A mathematical modeling strategy to predict the spreading behavior on skin of sustainable alternatives to personal care emollients. *Colloids and Surfaces B: Biointerfaces* **2021**, *205*, 111865.
123. Luengo, G.S.; Fameau, A.-L.; Leonforte, F.; Greaves, A.J. Surface science of cosmetic substrates, cleansing actives and formulations *Advances in Colloids and Interface Science* **2021**, *290*, 102383.
124. Sastre, R.M.; de Paula, I.C.; Echeveste, M.E.S.; Greaves, A.J. A Systematic Literature Review on Packaging Sustainability: Contents, Opportunities, and Guidelines. *Sustainability* **2022**, *14*, 6727.
125. Calvo, F.; Gomez, J.M.; Ricardez-Sandoval, L.; Alvarez, O. Integrated design of emulsified cosmetic products: A review. *Impact Assessment* **1982**, *1:4*, 30–43.
126. Leistritz, F.L.; Murdock, S.H.; Chase, A.R. Socioeconomic Impact Assessment Models: Review and Evaluation. *Chemical Engineering Research and Design* **2020**, *1:4*, 30–43.
127. van Elk, R.; Mot, E.; Franses, P.H. Modeling healthcare expenditures: overview of the literature and evidence from a panel time-series model. *Expert Review of Pharmacoeconomics & Outcomes Research* **2010**, *10(1)*, 25–35.
128. Brown Jr., G. Some Remarks on Impact Assessment. *Impact Assessment* **1982**, *1:3*, 15–26.
129. Dube, S.; Dube, M. *Basics First*, 1st ed.; Publisher: Iff Books Winchester, UK, 2017; pp. 3–10.
130. Goodkin, M. *The Wrong Answer Faster: The Inside Story of Making the Machine that Trades Trillions*, 1st ed.; Publisher: Wiley New Jersey, US, 2012.
131. Fama, E.F.; French, K.R. Choosing Factors. *Journal of Financial Economics* **2018**, *128*, 234–252.
132. Hartzmark, S.M.; Shue, K. Counterproductive sustainable investing: The impact elasticity of brown and green firms. *Working Paper*, Boston College, 2023.
133. Groening, C.; Sarkis, J.; Zhu, Q. Green marketing consumer-level theory review: A compendium of applied theories and further research directions. *Journal of Cleaner Production* **2018**, *172*, 1848–1866.
134. Testa, F.; Cosic, A.; Iraldo, F. Determining factors of curtailment and purchasing energy related behaviours. *Journal of Cleaner Production* **2018**, *112*, 3810–3819.
135. Yuriev, A.; Dahmen, M.; Paille, P.; Boiral, O.; Guillaumie, L. Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources, Conservation & Recycling* **2020**, *155*, 104660.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2023 doi:10.20944/preprints202308.0120.v1

136. Zhang, X.; Dong, F. Why Do Consumers Make Green Purchase Decisions? Insights from a Systematic Review. *International Journal of Environmental Research and Public Health* **2020**, *17*, 6607.
137. Giant Wind Turbines Keep Mysteriously Falling Over. This Shouldn't Be Happening. Available online: https://www.popularmechanics.com/technology/infrastructure/a42622565/wind-turbines-falling-over/ (accessed on 31 May 2023).
138. Andersen, I.; Guven, I.; Madenci, E.; Gustaffson, G. The Necessity of Reexamining Previous Life Prediction Analyses of Solder Joints in Electronic Packages. *IEEE Transactions on Components and Packaging Technology* **2000**, *23(3)*, 516–520.
139. Dube, M.; Kundu, T. Yield Function for Elastoviscoplastic Solder Modeling. *ASME Journal of Electronic Packaging* **2005**, *127(2)*, 147–156.
140. Dube, M.; Kundu, T. Closure to Discussion of Yield Function for Elastoviscoplastic Solder Modeling. *ASME Journal of Electronic Packaging* **2011**, *133(4)*.
141. Dube, M.; Dube, S. Criticality of Robustness Checks for Complex Simulations and Modeling. *Information - An International Interdisciplinary Journal* **2013**, *16(11)*, 7917–7940.
142. Riley, F.J. *Assembly Automation: A Management Handbook*, 2nd ed.; Industrial Press Inc., NY, New York, US, 1996.
143. Nettleton, D. F.; Fernandez-Avila, C.; Sanchez-Esteva, S.; Verstichel. S.; Coltelli, M.B.; Marti-Soler, H.; Aliotta, L.; Gigante, V. Biodegradation Prediction and Modelling for Decision Support. In Proceedings of the 12th International Conference on Simulation and Modeling Methodologies, Technologies and Applications, Lisbon, Portugal, Date of Conference July 2022; 26-35.
144. Berliner, L.M. Uncertainty and Climate Change. *Statistical Science* **2003**, *18(4)*, 430–435.
145. Shepherd, T.G. Atmospheric circulation as a source of uncertainty in climate change projections. *Nature Geoscience* **2014**, *7*, 703–708.
146. Alizadeh, O. Advances and challenges in climate modeling. *Climatic Change* **2022**, *170*, 18.
147. Noto, L.V.; Cipolla, G.; Pumo, D.; Francipane, A. Climate Change in the Mediterranean Basin (Part II): A Review of Challenges and Uncertainties in Climate Change Modeling and Impact Analyses*Water Resources Management* **2023**, *37*, 2307–2323.
148. Wasti, A.; Ray, P.; Wi, S.; Folch, C.; Ubierna, M.; Karki, P. Climate change and the hydropower sector: A global review. *Wiley Interdisciplinary Reviews: Climate Change* **2022**, *13(2)*, e757.
149. Rogers, A.; Serbin, S.P.; Way, D.A. Reducing model uncertainty of climate change impacts on high latitude carbon assimilation. *Global Change Biology* **2022**, *28*, 1222–1247.
150. Legates, D.R.; Davis, R.E. The continuing search for an anthropogenic climate change signal: Limitations of correlation-based approaches. *Geophysical Research Letters* **1997**, *24(18)*, 2319–2322.
151. Beer, J.; van Geel, B. Holocene Climate Change and the Evidence for Solar and other Forcings. In *Natural Climate Variability and Global Warming: A Holocene Perspective*; Battarbee, R.W., Binney, H.A., Eds.; Blackwell Publishing Ltd, 2008; pp. 138–162.
152. Herndon, J.M. Evidence of Variable Earth-heat Production, Global Non-anthropogenic Climate Change, and Geoengineered Global Warming and Polar Melting. *Journal of Geography, Environment and Earth Science International* **2017**, *10(1)*, JGEESI.32220.
153. Stefani, F. Solar and Anthropogenic Influences on Climate: Regression Analysis and Tentative Predictions. *Climate* **2021**, *9*, 163.
154. Skrable, K.; Chabot, G.; French, C. World Atmospheric CO_2, Its ^{14}C Specific Activity, Non-fossil Component, Anthropogenic Fossil Component, and Emissions (1750–2018). *Health Physics* **2022**, *122(2)*, 391–305.
155. Van Kleef, E.; Dagevos, H. The Growing Role of Front-of-Pack Nutrition Profile Labeling: A Consumer Perspective on Key Issues and Controversies. *Food Science and Nutrition* **2015**, *55:3*, 291–303.
156. Donini, L.M.; Berry, E.M.; Folkvord, F.; Jansen, L.; Leroy F.; Simsek, O.; Fava, F.; Gobetti, M.; Lenzi, A. Front-of-pack labels: "Directive" versus "informative" approaches. *Nutrition* **2023**, *105*, 111861.
157. Aguenaou, H.; Babio, N.; Deschasaux-Tanguy, M.; Galan, P.; Hercberg, S.; Julia, C.; Jones, A.; Karpetas, G.; Kelly, B.; Kesse-Guyot, E.; et al. Comment on Muzzioli et al. Are Front-of-Pack Labels a Health Policy Tool? *Nutrients* **2022**, *14*, 2165.
158. Muzzioli, L.; Penzavecchia, C.; Donini, L.M.; Pinto, A. Reply to Aguenaou et al. Comment on "Muzzioli et al. Are Front-of-Pack Labels a Health Policy Tool? Nutrients 2022, 14, 771". *Nutrients* **2022**, *14*, 2167.

 doi:10.20944/preprints202308.0120.v1

159. Thiene, M.; Scarpa, R.; Longo, A.; Hutchinson, G. Types of front of pack food labels: Do obese consumers care? Evidence from Northern Ireland. *Food Policy* **2018**, *80*, 84–102.
160. Russell, C. G.; Burke, P.F.; Waller, D.S.; Wei, E. The impact of front-of-pack marketing attributes versus nutrition and health information on parents' food choices. *Appetite* **2017**, *116*, 323–338.
161. Kuhne, S.J.; Reijnen, E.; Granja, G.; Hansen, R.S. Labels Affect Food Choices, but in What Ways? *Nutrients* **2022**, *14*, 3204.
162. Muzzioli, L.; Penzavecchia, C.; Donini, L.M.; Pinto, A. Are Front-of-Pack Labels a Health Policy Tool? *Nutrients* **2022**, *14*, 771.
163. Ducrat, P.; Mejean, C.; Julia, C.; Kesse-Guyot, E.; Touvier, M.; Fezeu, L.; Hercberg, S.; Peneau, S. Effectiveness of Front-Of-Pack Nutrition Labels in French Adults: Results from the NutriNet-Santé Cohort Study. *PloS ONE* **2015**, *10(10)*, e0140898.
164. Strazzullo, P.; Cairella, G.; Sofi, F.; Erba, D.; Campanozzi, A. et al. "Front-of-pack" nutrition labeling. *Nutrition, Metabolism & Cardiovascular Diseases* **2021**, *31*, 2989–2992.
165. Todd, M.; Guetterman, T.; Volschenk, J.; Kidd, M.; Joubert, E. Healthy or Not Healthy? A Mixed-Methods Approach to Evaluate Front-of-Pack Nutrition Labels as a Tool to Guide Consumers. *Nutrients* **2022**, *14*, 2801.
166. Meijer, L.J.J.; van Emmerik, T.; van der Ent, R.; Schmidt, C.; Lebreton, L. More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. *Science Advances* **2021**, *7*, eaaz5803.
167. Kash, D.E. Impact Assessment Premises - Right and Wrong. *Impact Assessment* **1982**, *1:3*, 5–14.
168. Lawless, E.W. Anticipating Technologically-Derived Risk. *Impact Assessment* **1982**, *1:3*, 54–66.
169. Beltrami, M.; Orzes, G.; Sarkis, J.; Sartor, M. Industry 4.0 and sustainability: Towards conceptualization and theory. *Journal of Cleaner Production* **2021**, *312*, 127733.
170. da Rocha, A.B.T.; de Oliveira, K.B.; Espuny, M.; da Motta Reis, J.S.; Oliveira, O.J. Business transformation through sustainability based on Industry 4.0. *Heliyon* **2022**, *8*, e10015.
171. de Sousa Jabbour, A.B.L.; Jabbour, C.J.C.; Choi, T.-M.; Latan, J. 'Better together': Evidence on the joint adoption of circular economy and industry 4.0 technologies. *International Journal of Production Economics* **2022**, *252*, 108581.
172. Khan, I.S.; Ahmad, M.O.; Majava, J. Industry 4.0 and sustainable development: A systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. *Journal of Cleaner Production* **2021**, *297*, 126655.
173. Esmaeilian, B.; Sarkis, J.; Lewis, K.; Behdad, S. Blockchain for the future of sustainable supply chain management in Industry 4.0. *Journal of Cleaner Production* **2020**, *163*, 105064.
174. Taddei, E.; Sassanelli, C.; Rosa, P.; Terzi, S. Circular supply chains in the era of industry 4.0: A systematic literature review. *Computer & Industrial Engineering* **2022**, *170*, 108268.
175. Behl, A.; Singh, R.; Pereira, V.; Laker, B. Analysis of Industry 4.0 and circular economy enablers: A step towards resilient sustainable operations management. *Technological Forecasting & Social Change* **2023**, *189*, 122363.
176. Touriki, F.E.; Benkhati, I.; Kample, S.S.; Belhadi, A.; El fezazi, S. An integrated smart, green, resilient, and lean manufacturing framework: A literature review and future research directions. *Journal of Cleaner Production* **2021**, *319*, 128691.
177. Aniza, R.; Chen, W.-H.; Petrissans, A.; Hoang, A.T.; Ashokkumar, V.; Petrissans, M. A review of biowaste remediation and valorization for environmental sustainability: Artificial intelligence approach. *Environmental Pollution* **2023**, *324*, 121363.
178. Ding, B. Pharma Industry 4.0: Literature review and research opportunities in sustainable pharmaceutical supply chains. *Process Safety and Environmental Protection* **2018**, *119*, 115–130.
179. Haba, H.F.; Bredillet, C.; Dastane, O. Pharma Green consumer research: Trends and way forward based on bibliometric analysis. *Cleaner and Responsible Consumption* **2023**, *8*, 100089.
180. Hughes, A.; Urban, M.A.; Wojcik, D. Alternative ESG Ratings: How Technological Innovation Is Reshaping Sustainable Investment. *Sustainability* **2021**, *13*, 3551.
181. Huntingford, C.; Jeffers, E.S.; Bonsall, M.B.; Christensen, H.M.; Lees, T.; Yang, H. Machine learning and artificial intelligence to aid climate change research and preparedness. *Environmental Research Letters* **2010**, *14*, 124007.
182. Al-Dahoud, A.; Fezari, M.; Aldahoud, A. Machine Learning in Renewable Energy Application: Intelligence System for Solar Panel Cleaning. *WSEAS Transactions on Environment and Development* **2023**, *19*, 472–478.

183. Tschang, F.T.; Almirall, E. Artificial intelligence as augmenting automation: Implications for employment. *Academy of Management Perspectives* **2021**, *35(4)*, 642–659.
184. Yang, Y. Analysis of the Impact of Artificial Intelligence Development on Employment. In Proceedings of the 2020 International Conference on Computer Engineering and Application IEEE (2020); Pagination 324-327.
185. Padilla-Rivera, A.; Russo-Garido, S.; Merveille, N. Addressing the Social Aspects of a Circular Economy: A Systematic Literature Review. *Sustainability* **2020**, *12*, 7912.
186. Dube, S.; Dube, M.; Turan, A. Information technology in Turkey: Creating high-skill jobs along with more unemployed highly-educated workers? *Telecommunications Policy* **2015**, *38(10)*, 811–829.
187. Williams, J.H; Jones, R.A.; Haley, B.; Kwok, G.; Hargreaves, J.; Farbes, J.; Torn, M. S. Carbon-Neutral Pathways for the United States. *AGU Advances* **2021**, *2*, e2020AV000284.
188. Renne, D. S. Progress, opportunities and challenges of achieving net-zero emissions and 100% renewables. *Solar Compass* **2022**, *1*, 100007.
189. Gottesfeld, P.; Cherry, C.R. Lead emissions from solar photovoltaic energy systems in China and India. *Energy Policy* **2011**, *39(9)*, 4939–4946.
190. Liu, C.; Zhang, Q.; Wang, H. Cost-benefit analysis of waste photovoltaic module recycling in China. *Waste Management* **2020**, *118*, 491–500.
191. Goe, M.; Gaustad, G. Strengthening the case for recycling photovoltaics: An energy payback analysis. *Applied Energy* **2014**, *120*, 41–48.
192. Dominguez, A.; Geyer, R. Photovoltaic waste assessment in Mexico. *Resources, Conservation and Recycling* **2017**, *127*, 29–41.
193. California went big on rooftop solar. Now that's a problem for landfills, Available online: https://news.yahoo.com/california-went-big-rooftop-solar-120043034.html (accessed on 1 July 2023).
194. Bassi, S.A.; Boldrin, A.; Faraca, G.; Astrup, T.F. Extended producer responsibility: How to unlock the environmental and economic potential of plastic packaging waste? *Resources, Conservation & Recycling* **2020**, *162*, 105030.
195. Diggle, A.; Walker, T.R. Implementation of harmonized Extended Producer Responsibility strategies to incentivize recovery of single-use plastic packaging waste in Canada. *Waste Management* **2020**, *110*, 20–23.
196. The Inadequacy of Wind Power, Available online: https://www.thegwpf.org/content/uploads/2023/03/Allison-Wind-energy.pdf (accessed on 31 May 2023).
197. Michaelides, E.E. Primary Energy Use and Environmental Effects of Electric Vehicles. *World Electric Vehicle Journal* **2021**, *12(3)*, 138.
198. Schapper, A.; Unrau, C.; Killoh, S. Social mobilization against large hydroelectric dams: A comparison of Ethiopia, Brazil and Panama. *Sustainable Development* **2020**, *28*, 413–423.
199. Andersson, B.A.; Rade, I. Metal resource constraints for electric-vehicle batteries. *Transportation Research Part D* **2001**, *6*, 297–324.
200. Kaunda, R.B. Potential environmental impacts of lithium mining. *Journal of Energy & Natural Resources Law* **2020**, *38(3)*, 237–244.
201. Zaimes, G.G.; Hubler, B.J.; Wang, S.; Khanna, V. Environmental Life Cycle Perspective on Rare Earth Oxide Production. *ACS Sustainable Chemistry and Engineering* **2015**, *3(2)*, 237–244.
202. Billionaires are funding a massive treasure hunt in Greenland as ice vanishes, Available online: https://edition.cnn.com/2022/08/08/world/greenland-melting-mineral-mining-climate/index.html (accessed on 1 July 2023).
203. Rabaia, M.K.H.; Abdelkareem, M.A.; Sayed, E.T.; Elsaid, K.; Chae, K.-J.; Wilberforce, T.; Olabi, A.G. Environmental impacts of solar energy systems: A review. *Science of the Total Environment* **2021**, *754*, 141989.
204. Lander, L., Cleaver, T., Rajaeifar, M. A., Nguyen-Tien, V., Elliott, R. J. R.; Heidrich, O.; Kendrick, E.; Edge, J.S.; Offer, G. Financial viability of electric vehicle lithium-ion battery recycling. *iScience* **2021**, *24(7)*, 102787.
205. Despiesse, M.; Kishita, Y.; Nakano, M.; Barwood, M. Towards a circular economy for end-of-life vehicles: A comparative study UK - Japan. *Procedia CIRP 29, the 22nd CIRP conference on Life Cycle Engineering* **2015**, 668–673.
206. Skeete, J.-P.; Wells, P.; Dong, X.; Heidrich, O.; Harper, G. Beyond the EVent horizon: Battery waste, recycling and substainability in the United Kingdom electric vehicle transition. *Energy Research & Social Science* **2020**, *69*, 101581.

207. Amberg, N.; Magda, R.; Environmental Pollution and Sustainability or the Impact of the Environmentally Conscious Measures of International Cosmetic Companies on Purchashing Organic Cosmetics. *Visegrad Journal of Bioeconomy and Sustainable Development* **2018**, *7(1)*, 23–30.
208. Amato, F.; Dimitropoulos, A.; Farrow,K.; Queslati, W. *Non-exhaust Particulate Emissions from Road Transport.*; Publisher: OECD, 2020.
209. Feng, K.; Lin, N.; Xian, S.; Chester, M. V. Can we evacuate from hurricanes with electric vehicles? *Transportation Research Part D* **2020**, *86*, 102458.
210. Peterson, R.; Awwad, M. A. The Use of Electric Cars in Short-Notice Evacuations: A Case Study of California's Natural Disasters. In Proceedings of the International Conference on Industrial Engineering and Operations Management, Monterrey, Mexico, 3-5 Nov 2021.
211. Zhang, H.; Zhan, F.; Hao, H.; Liu, Z. Effect of Chinese Corporate Average Fuel Consumption and New Energy Vehicle Dual-Credit Regulation on Passenger Cars Average Fuel Consumption Analysis. *International Journal of Environmental Research and Public Health* **2021**, *18*, 7218.
212. UNEP. *Biodegradable Plastics and Marine Litter. Misconceptions, concerns and impacts on marine environments.*; Publisher: United Nations Environment Program, Nairobi Kenya, 2015.
213. Kardgar, A.K; Ghosh, D.; Sturve, J.; Agarwal, S.; Almroth, B.C. Chronic poly(L-lactide) (PLA)- microplastic ingestion affects social behavior of juvenile European perch (Perca fluviatilis). *Science of the Total Environment* **2023**, *88*, 163425.
214. Lab-Grown Meat's Carbon Footprint Potentially Worse Than Retail Beef, Available online: https://www.ucdavis.edu/food/news/lab-grown-meat-carbon-footprint-worse-beef (accessed on July 15 2023).
215. Herrmann, C.; Rhein, S.; Srater, K.F. Consumers' sustainability-related perception of and willingness-to-pay for food packaging alternatives. *Resources, Conservation & Recycling* **2022**, *181*, 106216.
216. The future of gas in Europe: Review of recent studies on the future of Gas, CEPS Research Report No. 2019/03, Available online: https://www.ceps.eu/wp-content/uploads/2019/08/RR2019-03_Future-of-gas-in-Europe.pdf (accessed on 31 May 2023).
217. Global oil and gas investment will be 30% below pre-Covid level: ONGC, Available online: https://www.business-standard.com/article/companies/global-oil-and-gas-investment-will-be-30-below-pre-covid-level-ongc-121092400690_1.html (accessed on 31 May 2023).
218. The Role of Natural Gas in Europe Towards 2050, NTNU Energy Transition Policy Report, 2021. Available online: https://www.ntnu.edu/documents/1276062818/1283878281/Natural+Gas+in+Europe.pdf (accessed on 31 May 2023).
219. Coal power's sharp rebound is taking it to a new record in 2021, threatening net zero goals, Coal 2021 Press Release, International Energy Agency. Available online: https://www.iea.org/news/coal-power-s-sharp-rebound-is-taking-it-to-a-new-record-in-2021-threatening-net-zero-goals (accessed on 31 May 2023).
220. German Emissions From Electricity Rose 25% In First Half Of 2021 Due To The Lack Of Wind Power, Not Willpower. Available online: https://www.forbes.com/sites/michaelshellenberger/2021/07/28/german-emissions-from-electricity-rose-25-in-first-half-of-2021-due-to-the-lack-of-wind-power-not-willpower/ (accessed on 31 May 2023).
221. Taylor, R.L.C. Bag leakage: The effect of disposable carryout bag regulations on unregulated bags. *Journal of Environmental Economics and Management* **2019**, *93*, 254–271.
222. Huang, Y.K.; Woodward, R.T. Spillover Effects of Grocery Bag Legislation: Evidence of Bag Bans and Bag Fees. *Environmental and Resource Economics* **2022**, *81*, 711–741.
223. 2023 Reports 1 to 5 of the Commissioner of the Environment and Sustainable Development to the Parliament of Canada, Available online: https://www.oag-bvg.gc.ca/internet/English/parl_cesd_202304_05_e_44243.html (accessed on 31 May 2023).
224. Williams, R.; Banner, J.; Knowles, I.; Dube, M.; Natishan, M.; Pecht, M. An Investigation of 'Cannot Duplicate' Failures. *Quality and Reliability Engineering International* **1998**, *14(5)*, 331–337.
225. Dishongh, T.J.; Dube, M.; Pecht, M.; Wyler, J. Failure Analysis of Liquid Crystal Displays Due to Indium Tin Oxide Breakdown. *ASME Journal of Electronic Packaging* **1999**, *121(2)*, 126–127.

226. Pecht, M.; Dube, M.; Natishan, M.; Williams, J.; Banner, J.; Knowles, I. Evaluation of Built-In Test. *IEEE Transactions on Aerospace and Electronics Systems* **2001**, *37(1)*, 266–271.
227. The Elusive Green Consumer, Available online: https://hbr.org/2019/07/the-elusive-green-consumer (accessed on 31 May 2023).
228. Bratt, C. Consumers' Environmental Behavior Generalized, Sector-Based, or Compensatory?. *Environment and Behavior* **1999**, *31(1)*, 28–44.
229. Are oxo-biodegradable plastics bad for the environment?, Available online: https://www.packaging-gateway.com/features/are-oxo-biodegradable-plastics-bad-for-the-environment/ (accessed on 31 May 2023).
230. Roy, S. Development, Environment and Poverty: Some Issues for Discussion. *Economic & Political Weekly* **1996**, *31(4)*, PE29–PE41.
231. COP26: Did India betray vulnerable nations?, Available online: https://www.bbc.com/news/world-asia-india-59286790 (accessed on 31 May 2023).
232. What it will cost to get to net-zero, Available online: https://www.mckinsey.com/mgi/overview/in-the-news/what-it-will-cost-to-get-to-net-zero (accessed on 31 May 2023).
233. Stopping Global Warming Will Cost $50 Trillion: Morgan Stanley Report, Available online: https://www.forbes.com/sites/sergeiklebnikov/2019/10/24/stopping-global-warming-will-cost-50-trillion-morgan-stanley-report/ (accessed on 31 May 2023).
234. What's the cost of net zero?, Available online: https://obr.uk/frs/fiscal-risks-report-july-2021/ (accessed on 31 May 2023).
235. Fiscal risks report – July 2021, Available online: https://climatechampions.unfccc.int/whats-the-cost-of-net-zero-2/ (accessed on 31 May 2023).
236. Claydon, J. A new direction for CSR: the shortcomings of previous CSR models and the rationale for a new model. *Social Responsibility Journal* **2011**, *7(3)*, 405–420.
237. Aguirre, A. Sustainability improvement in luxury packaging: a case study in Giorgio Armani and Helena Rubinstein brands. Masters Thesis, Aalto University, Bordeaux, France, 20 June 2020.
238. Baptista, J.R.D. Thoughtful Packaging: How Inner Motivations Can Influence the Purchase Intention for Green Packaged Cosmetics. Masters Thesis, Universidade Nova de Lisboa, Lisboa, Portugal, November 2021.
239. Rai, H.B.; Broekaert, C.; Verline, S.; Macharis, S. Sharing is caring: How non-financial incentives drive sustainable e-commerce delivery. *Transportation Research Part D* **2021**, *93*, 102794.
240. Escursell, S.; Llorach-Massana, P.; Roncero, M. B. Sustainability in e-commerce packaging: A review. *Journal of Cleaner Production* **2021**, *280*, 124314.
241. Helmi, A.; Komaladewi, R.; Sarasi, V.; Yolanda, L. Characterizing Young Consumer Online Shopping Style: Indonesian Evidence. *Sustainability* **2023**, *15*, 3998.
242. Kopot, K.; Reed, J. Shopping for beauty: The influence of the pandemic on body appreciation, conceptions of beauty, and online shopping behaviour. *Journal of Global Fashion Marketing* **2023**, *14:1*, 20–34.
243. Muralidhar, S.; Naresh, N.R.; Sharmila, A.; Shwetha, B.V.; Ramesh, S. Consumer Consideration for Herbal Cosmetic Products with respect to Present Scenario. *Journal of Pharmaceutical Negative Results* **2023**, *14(2)*, 2594–2601.
244. Jung, J.C.; Sharon, E. The Volkswagen emissions scandal and its aftermath. *GBOE* **2019**, *38(4)*, 6–15.
245. Dabla-Norris, E.; Helbling, T.; Khalid, S., Khan; H., Magistretti; G.; Sollaci, A.; Srinivasan, S. Public Perceptions of Climate Mitigation Policies: Evidence from Cross-Country Surveys. *IMF Staff Discussion Note SDN2023/002*, International Monetary Fund, 2023.
246. Bago, B.; Rand, D.G.; Pennycook, G. Reasoning about climate change. *PNAS Nexus* **2023**, *2*, pgad100.
247. Frases, B.C.; Harman, R.; Nunn, P.D.; Associations of locus of control, information processing style and anti-reflexivity with climate change scepticism in an Australian sample. *Public Understanding of Science* **2023**, *32(3)*, 322–339.
248. Guenther, L.; Jorges, S.; Mahl, D.; Bruggemann, M. Framing as a Bridging Concept for Climate Change Communication: A Systematic Review Based on 25 Years of Literature. *Communication Research* **2023**, 009365022211371.

 doi:10.20944/preprints202308.0120.v1

249. Chirani, M.R.; Kowsari, E.; Termourian, T.; Ramakrishna, S. Environmental impact of increased soap consumption during COVID-19 pandemic: Biodegradable soap production and sustainable packaging. *Science of the Total Environment* **2021**, *796*, 149013.
250. Sayeed, A.; Rahman, M.H; Bundschuh, J.; Herath, I.; Ahmed, F.; Bhattacharya, P.; Tariz, M. R.; Rahman, F.; Joy, M.T.I.; Abid, M.T.; Saha, N.; Hasan, M. T. Handwashing with soap: A concern for overuse of water amidst the COVID-19 pandemic in Bangladesh. *Groundwater for Sustainable Development* **2021**, *13*, 100561.
251. Teymoorian, T.; Teymourian, T.; Kowsari, E.; Ramakrishna, S. Direct and indirect effects of SARS-CoV-2 on wastewater treatment. *Journal of Water Process Engineering* **2021**, *42*, 102193.
252. Shams, M.; Alam, I.; Mahbub, M.S. Plastic pollution during COVID-19: Plastic waste directives and its long-term impact on the environment. *Environmental Advances* **2021**, *5*, 100119.
253. Neumeyer, X.; Ashton, W.S.; Dentchey, N. Addressing resources and waste management challenges imposed by COVID-19: An entrepreneurship perspective. *Resources, Conservation & Recycling* **2020**, *162m*, 105058.
254. Tetlow, M.F.; Hanusch, M. Strategic Environmental Assessment: The State of the Art. *Impact Assessment and Project Appraisal* **2012**, *30(1)*, 15–24.
255. Sri Lanka faces 'man-made' food crisis as farmers stop planting, Available online: https://www.aljazeera.com/news/2022/5/18/a-food-crisis-looms-in-sri-lanka-as-farmers-give-up-on-planting (accessed on 31 May 2023).
256. Emotion and pain' as Dutch farmers fight back against huge cuts to livestock, Available online: https://www.theguardian.com/environment/2022/jul/21/emotion-and-pain-as-dutch-farmers-fight-back-against-huge-cuts-to-livestock (accessed on 31 May 2023).
257. Don't Pay UK: Campaign to boycott payment of energy bills gathers pace, Available online: https://www.euronews.com/2022/08/04/dont-pay-uk-campaign-to-boycott-payment-of-energy-bills-gathers-pace (accessed on 31 May 2023).
258. The Tricky Politics of Anti-ESG Investing, Available online: https://www.crainscleveland.com/opinion/opinion-tricky-politics-anti-esg-investing (accessed on 31 May 2023).
259. BlackRock, Vanguard and State Street Update Corporate Governance and ESG Policies and Priorities for 2022, Available online: https://www.gibsondunn.com/blackrock-vanguard-and-state-street-update-corporate-governance-and-esg-policies-and-priorities-for-2022/ (accessed on 31 May 2023).
260. BlackRock ditches green activism over Russia fears, Available online: https://www.telegraph.co.uk/business/2022/05/11/blackrock-ditches-green-activism-russia-energy-fears/ (accessed on 31 May 2023).
261. An update on Vanguard's engagement with the Net Zero Asset Managers initiative, https://corporate.vanguard.com/content/corporatesite/us/en/corp/articles/update-on-nzam-engagement.html (accessed on 31 May 2023).
262. A resolution directing an update to the investment policy statement and proxy voting policies for the Florida retirement system defined benefit pension plan, and directing the organization and execution of an internal review, Available online: https://www.flgov.com/wp-content/uploads/2022/08/ESG-Resolution-Final.pdf (accessed on 31 May 2023).
263. Purchasing: Divestment Stature List, Available online: https://comptroller.texas.gov/purchasing/publications/divestment.php (accessed on 31 May 2023).
264. Sweden abandons 100% renewable energy goal, Availableonline:https://scandasia.com/sweden-abandons-100-renewable-energy-goal/ (accessed on 29 June 2023)
265. ESG Not Making Waves with American Public, Available online: https://news.gallup.com/poll/506171/esg-not-making-waves-american-public.aspx (accessed on 31 May 2023).
266. Exxon Mobil Corporation Proxy Statement Pursuant to Section 14(a) of the Securities Exchange Act of 1934, Available online: https://ir.exxonmobil.com/static-files/da018d10-fb85-4eb9-9251-d2e04f1923d5 (accessed on 31 May 2023).
267. Lloyd's becomes the 10th major player to mark its exit from NZIA, Available online: https://www.reinsurancene.ws/lloyds-becomes-the-10th-major-player-to-mark-its-exit-from-nzia/ (accessed on 31 May 2023).
268. Arnold, D. Market Democracy: Land of Opportunity? *Critical Review: A Journal of Politics and Society* **2014**, *26(3-4)*, 239–258.
269. Bird, C. Why not Marx? *Critical Review: A Journal of Politics and Society* **2014**, *26(3-4)*, 259–282.

270. Gourevitch, A. Welcome to the Dark Side: A Classical-Liberal Argument for Economic Democracy. *Critical Review: A Journal of Politics and Society* **2014**, *26(3-4)*, 290–305.
271. Morganti, P.; Morganti, G.; Memic, A.; Coltelli, M.B.; Chen, H.-D. The New Renaissance of Beauty and Wellness Through the Green Economy. *Latest Trends in Textile and Fashion Design* **2021**, *4(2)*, 290–305.
272. Ali, A.; Audi, M. The Impact of Income Inequality, Environmental Degradation and Globalization on Life Expectancy in Pakistan: An Empirical Analysis. *International Journal of Economics and Empirical Research* **2016**, *4(4)*, 182–193.
273. Wang, Z.; Asghar, M.M.; Zaidi, S.A.H.; Wang, B. Dynamic linkages among CO2 emissions, health expenditures, and economic growth: empirical evidence from Pakistan. *Environmental Science and Pollution Research* **2019**, *26*, 15285–15299.
274. Alimi, O.Y.; Ajide, K.B.; Isola, W.A. Environmental quality and health expenditure in ECOWAS. *Environment, Development and Sustainability* **2020**, *22*, 5105–5127.
275. DDMA allows standing passengers in Delhi Metro trains, buses to tackle air pollution, Available online: https://www.business-standard.com/article/current-affairs/ddma-allows-standing-passengers-in-delhi-metro-buses-to-tackle-pollution-121112000908_1.html (accessed on 31 May 2023).
276. Soaring pollution has Delhi considering full weekend lockdown, Available online: https://www.theguardian.com/world/2021/nov/16/soaring-pollution-has-delhi-considering-full-weekend-lockdown (accessed on 31 May 2023).
277. Indian officials order Coca-Cola plant to close for using too much water, Available online: http://www.theguardian.com/environment/2014/jun/18/indian-officals-coca-cola-plant-water-mehdiganj (accessed on 31 May 2023).
278. Kahuthu, A. Economic growth and environmental degradation in a global context. *Environment, Development, and Sustainability* **2006**, *8(1)*, 55–68.
279. Ahmed, F.; Ali, I.; Kousar, S.; Ahmed, S. The environmental impact of industrialization and foreign direct investment: empirical evidence from Asia-Pacific region. *Environmental Science and Pollution Research* **2022**, *29*, 29778–29792.
280. Sala-i-Martin, X. The disturbing 'rise' of global inequality, *Working Paper 8904*, National Bureau of Economic Research, 2002.
281. Kharas, H.; Kohli, H. What is the Middle Income Trap, Why do Countries Fall into It, and How Can It Be Avoided? *Global Journal of Emerging Market Economies* **2011**, *3(3)*, 281–289.
282. Bhattacharya, P. India in the Rise of Britain and Europe: A Contribution to the Convergence and Great Divergence Debates. *Journal of Interdisciplinary Economics* **2021**, *33(1)*, 24–53.
283. The World is Not Enough, Available online: https://www.statista.com/chart/10569/number-of-earths-needed-if-the-worlds-population-lived-like-following-countries/ (accessed on 31 May 2023).
284. Morgan, R.K. Environmental impact assessment: the state of the art. *Impact Assessment and Project Appraisal* **2012**, *30(1)*, 5–14.
285. Drobac, J.; Alivojvodic, F.; Maksic, P.; Stamenovic, M. Green Face of Packaging - Sustainability Issues of the Cosmetic Industry Packaging. In MATEC Web of Conferences 318, 2020; 01022.
286. Canter, L.W. Lessons for impact monitoring. *Impact Assessment* **1982**, *1(2)*, 6–40.
287. Estevas, A.M.; Franks, D.; Vanclay, F. Social impact assessment: the state of the art. *Impact Assessment and Project Appraisal* **2012**, *30(1)*, 34–42.
288. Vanclay, F. Reflections on Social Impact Assessment in the 21 st century. *Impact Assessment and Project Appraisal* **2020**, *38(2)*, 126–131.
289. Hitchcock, H.H.; Anthony, R.W.; Filderman, L.D. Public concerns method: a means for assessing alternative policies. *Impact Assessment* **1982**, *1(3)*, 67–85.
290. Vlachos, E. Cumulative Impact Analysis. *Impact Assessment* **2020**, *1(4)*, 60–70.
291. Rajaram, T.; Das, A. Screening for EIA in India: Enhancing effectiveness through ecological carrying capacity approach. *Journal of Environmental Management* **2011**, *92*, 140–148.
292. Weston, J. Screening for environmental impact assessment projects in England: what screening? *Impact Assessment and Project Appraisal* **2006**, *29(2)*, 90–98.
293. Geneletti, D.; Biasiolli, A.; Morrison-Saunders, A. Land take and the effectiveness of project screening in Environmental Impact Assessment: Findings from an empirical study. *Environmental Impact Assessment Review* **2017**, *67*, 117–123.

294. Tenney, A.; Kvaerner, J.; Gjerstad, K.I. Uncertainty in environmental impact assessment predictions: the need for better communication with more transparency. *Impact Assessment and Project Appraisal* **2006**, *24(1)*, 45–56.
295. Keken, Z.; Hanusova, T.; Kulendik, J.; Wimmerova, L.; Zitkova, J.; Zdrazil, V. Environmental impact assessment – The range of activities covered and the potential of linking to post-project auditing. *Environmental Impact Assessment Review* **2022**, *93*, 106726.
296. Halla, P.; Merino-Saum, A.; Binder, C.R. How to link sustainability assessments with local governance? – Connecting indicators to institutions and controversies. *Environmental Impact Assessment Review* **2022**, *93*, 106741.
297. Neumann, V.A.; Hack, J. Revealing and assessing the costs and benefits of nature-based solutions within a real-world laboratory in Costa Rica. *Environmental Impact Assessment Review* **2022**, *93*, 106737.
298. Gazzola, P. The bad, the abnormal and the inadequate. A new institutionalist perspective for exploring environmental assessment's evolutionary direction. *Environmental Impact Assessment Review* **2022**, *95*, 106786.
299. Bailey, J.; Renton, S. Redesigning EIA to fit the future: SEA and the policy process. *Impact Assessment* **1997**, *15(4)*, 319–334.
300. Bina, O. Strategic Environmental Assessment. In *Innovation in Environmental Policy? Integrating environment for sustainability*; Jordan, A., Lenschow, A., Eds.; Edward Elgar Publishing Ltd.: Cheltenham, UK, 2008, pp.134–156.
301. Gonzalez, A.; Therivel, R. Raising the game in environmental assessment: Insights from tiering practice. *Environmental Impact Assessment Review* **2022**, *92*, 106695.
302. Wolf, C.P. Social Impact Analysis. *Impact Assessment* **1982**, *1(1)*, 9–19.
303. Finsterbusch, K. Psychological impact theory and social impacts. *Impact Assessment* **1982**, *1(4)*, 71–89.
304. Berg, M.R. Increasing the utility and utilization of assessment studies. *Impact Assessment* **1982**, *1(2)*, 41–49.
305. Reynolds Jr., R.R.; Wilkinson, K.P.; Thompson, J.G.; Ostresh, L.M. Problems in the social impact assessment literature base for western energy development communities. *Impact Assessment* **1982**, *1(4)*, 44–59.
306. Flynn, C.B.; Flynn, J.H. The group ecology method: a new conceptual design for social impact assessment. *Impact Assessment* **1982**, *1(4)*, 11–19.
307. Turkey repeals plastic import ban, Available online: https://waste-management-world.com/artikel/turkey-repeals-plastic-import-ban/ (accessed on 31 May 2023).
308. Exxon Mobil CEO: No fracking near my backyard, Available online: https://www.usatoday.com/story/money/business/2014/02/22/exxon-mobil-tillerson-ceo-fracking/5726603/ (accessed on 31 May 2023).
309. Five ways that ESG creates value, Available online: https://www.mckinsey.com/~{}/media/McKinsey/Business%20Functions/Strategy%20and%20Corporate%20Finance/Our%20Insights/Five%20ways%20that%20ESG%20creates%20value/Five-ways-that-ESG-creates-value.ashx (accessed on 31 May 2023).
310. Karwowsky, M.; Raulinajtys-Grzybek, M. The application of corporate social responsibility (CSR) actions for mitigation of environmental, social, corporate governance (ESG) and reputational risk in integrated reports. *Corporate Social Responsibility and Environmental Management* **2021**, *28*, 1270–1284.
311. Bhattacharyya, S.S. Development of international corporate social responsibility framework and typology. *Social Responsibility Journal* **2020**, *16(5)*, 719–744.
312. Fatima, T.; Elbanna, S. Corporate Social Responsibility (CSR) Implementation: A Review and a Research Agenda Towards an Integrative Framework. *Journal of Business Ethics* **2023**, *183*, 105–121.
313. Kim, E.-H.; Lyon, T.P. Greenwash vs. Brownwash: Exaggeration and Undue Modesty in Corporate Sustainability Disclosure. *Organization Science* **2015**, *26(3)*, 705–723.
314. Bhattacharyya, S.S.; Sahay, A.; Arora, A.P.; Chaturvedi, A. A toolkit for designing firm level strategic corporate social responsibility (CSR) initiatives. *Social Responsibility Journal* **2008**, *4(3)*, 265–282.
315. de Carvalho, A.P.; Barbieri, J.C. Innovation and Sustainability in the Supply Chain of a Cosmetics Company: a Case Study. *Journal of Technology Management & Innovation* **2012**, *7(2)*, 144–156.
316. Laursen, K.; Salter, A. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal* **2005**, *27*, 131–150.
317. Baumann-Pauly, D.; Scherer, A.G.; Palazzo, G. Organizational Implications of Managing Corporate Legitimacy in Complex Environments – A Longitudinal Case Study of Puma *Working Paper No. 321*, University of Zurich, 2012.
318. Soytas, M.A.; Atik, A. Does being international make companies more sustainable? Evidence based on corporate sustainability indices. *Central Bank Review* **2018**, *18*, 61–68.

319. Iliev, P.; Roth, L. Director Expertise and Corporate Sustainability. *Review of Finance* **2023**, rfad012.
320. Morea, D.; Fortunati, S.; Martiniello, L. Circular economy and corporate social responsibility: Towards an integrated strategic approach in the multinational cosmetics industry. *Journal of Cleaner Production* **2021**, *315*, 128232.
321. Andrae, A.S.G. From an Environmental Viewpoint Large ICT Networks Infrastructure Equipment must not be Reused. *WSEAS Transactions on Environment and Development* **2023**, *19*, 375–382.
322. Pena, C.; Civit, B.; Gallego-Schmid, A.; Druckman, A.; Caldeira-Pires, A.; Widema, B. et al. Using life cycle assessment to achieve a circular economy. *The International Journal of Life Cycle Assessment* **2021**, *26*, 215–220.
323. Vital, X. Environmental Impacts of Cosmetic Products. In *Sustainability: How the Cosmetics Industry is Greening up*; Sahota, A., Ed.; John Wiley & Sons, 2014; pp. 17–46.
324. Vargas-Gonzalez, M.; Witte, F.; Martz, P.; Gilbert, L.; Humbert, S.; Jolliet, O. et al. Operational Life Cycle Impact Assessment weighting factors based on Planetary Boundaries: Applied to cosmetic products. *Ecological Indicators* **2019**, *107*, 105498.
325. Castillo-Gonzalez, E.; Giraldi-Diaz, M. R.; De Medina-Salas, L.; Velasquez-De la Cruz, R. Environmental Impacts Associated to Different Stages Spanning from Harvesting to Industrialization of Pineapple though Life Cycle Assessment. *Applied Sciences* **2020**, *10*, 7007.
326. Peiris, R.L.; Kulatunga, A.K.; Jinadasa, K.B.S.N. Conceptual model of Life Cycle Assessment based generic computer tool towards Eco-Design in manufacturing sector. *Procedia Manufacturing* **2019**, *33*, 83–90.
327. Santi, R.; Elegir, G.; Del Curto, B. Designing for Sustainable Behavior Practices in Consumers: A Case Study on Compostable Materials for Packaging. In Proceedings of the International Design Society: DESIGN Conference, 1, 2020; 1647–1656.
328. Landi, G.; Sciarelli, M. Towards a more ethical market: the impact of ESG rating on corporate financial performance. *Social Responsibility Journal* **2019**, *15(1)*, 11–27.
329. Gillan, S.L.; Koch, A.; Starks, L.T. Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance* **2021**, *66*, 101889.
330. Das, N.; Ruf, B.; Chatterjee, S.; Sunder, A. Fund Characteristics and Performances of Socially Responsible Mutual Funds: Do ESG Ratings Play a Role? *Journal of Accounting and Finance* **2018**, *18(6)*, 57–69.
331. Rathner, S. The Influence of Primary Study Characteristics on the Performance Differential between Socially Responsible and Conventional Investment Funds: A Meta Analysis. *Journal of Business Ethics* **2013**, *118*, 349–363.
332. Halbritter, G.; Dorfleitner, G. The wages of social responsibility — where are they? A critical review of ESG investing. *Review of Financial Economics* **2015**, *26*, 25–35.
333. Henke, H.-M. The effect of social screening on bond mutual fund performance. *Journal of Banking and Finance* **2016**, *67*, 69–84.
334. Aslan, A.; Poppe, L.; Posch, P. Are Sustainable Companies More Likely to Default? Evidence from the Dynamics between Credit and ESG Ratings. *Sustainability* **2021**, *13*, 8568.
335. Zhang, J.; Se Speigeleer, J.; Schoutens, W. Implied Tail Risk and ESG Ratings. *Mathematics* **2021**, *9*, 1611.
336. Denuwara, N.; Kim, A.; Newenhisen, P.; Gibson, C.; Schork, D.; Hakovirta, M. Corporate economic performance and sustainability indices: a study based on the Dow Jones Sustainability Index. *Springer Nature Business & Economics* **2022**, *2*, 77.
337. Naumer, H.-J.; Yurtoglu, B. It is not only what you say, but how you say it: ESG, corporate news, and the impact on CDS spreads. *Global Finance Journal* **2022**, *52*, 100571.
338. Keisel, F.; Lucke, F. ESG in credit ratings and the impact on financial markets. *Financial Markets, Institutions and Instruments* **2019**, *28*, 263–290.
339. Hubel, B.; Scholz, H. Integrating sustainability risks in asset management: the role of ESG exposures and ESG ratings. *Journal of Asset Management* **2020**, *21*, 52–69.
340. Stellner, C.; Klein, C.; Zwergel, B. Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability. *Journal of Banking and Finance* **2015**, *59*, 538–549.
341. Crespi, F.; Migliavacca, M. The Determinants of ESG Rating in the Financial Industry: The Same Old Story or a Different Tale? *Sustainability* **2020**, *12*, 6398.
342. Ates, S. Corporate Social Performance Scores of the Firms in Sustainability Index. *Muhasebe Bilim Dunyasi Dergisi* **2021**, *23(1)*, 48–60.

343. Ece, N. A Comparative Analysis of Socially Responsible Investing for Borsa Istanbul Stock Market. *Maliye ve Finans Yazilari* **2018**, *110*, 199–216.
344. Levent, C.E. Sustainability Indices in the Financial Markets, Performance and Intraday Volatility Analysis: The Case of Turkey. *Journal of Business Research - Turk* **2019**, *11(4)*, 3190–3203.
345. Feng, M.; Wang, X.; Kreuze, J.G. Corporate social responsibility and firm financial performance: Comparison analyses across industries and CSR categories. *American Journal of Business* **2017**, *32(3/4)*, 106–133.
346. Rogers, T.; Casey, K.M. Bank Dividend Policy: Does ESG Rating Matter. *Journal of Leadership Accountability and Ethics* **2020**, *17(6)*, 66–72.
347. Casey Jr., K.M.; Casey, K.M.; Griffin, K. Does Good Stewardship Reduce Agency Costs in the IT Sector? Evidence from Dividend Policies and ESG Ratings. *Global Journal of Accounting and Finance* **2020**, *4(1)*, 6–15.
348. Brounen, D.; Mercato, G.; Op 't Veld, H. Pricing ESG Equity Ratings and Underlying Data in Listed Real Estate Securities. *Sustainability* **2021**, *13*, 2037.
349. Drempatick, S.; Klein, C.; Zwergel, B. The Influence of Firm Size on the ESG Score: Corporate Sustainability Ratings Under Review. *Journal of Business Ethics* **2020**, *167*, 333–360.
350. Parker, C.M.; Redmond, J.; Simpson, M. A review of interventions to encourage SMEs to make environmental improvements. *Environment and Planning C: Government and Policy* **2009**, *27*, 1150–1190.
351. Rao, P. Greening of the Supply Chain: An Empirical Study for SMEs in The Philippine Context. *Journal of Asia Business Studies* **2007**, *Spring*, 55–66.
352. Kumar, N.; Brint, A.; Shi, E.; Upadhyay, A.; Ruan, X. Integrating sustainable supply chain practices with operational performance: An exploratory study of Chinese SMEs. *Production Planning and Control: The Management of Operations* **2019**, *30(5-6)*, 464–478.
353. Turkey's Best Practices on Sustainable Development and Green Economy 2012, Available online: https://www.skdturkiye.org/userfiles/file/documents/044ve7kyaettlwt9jjyb0q4e8pcdh5.pdf (accessed on 31 May 2023).
354. Baumann-Pauly,D.; Wickert, C.; Spence, L.J.; Scherer, A.G. Organizing Corporate Social Responsibility in Small and Large Firms: Size Matters. *Journal of Business Ethics* **2013**, *115*, 693–705.
355. Dey, P.K.; Malesios, C.; Chowdhury, S.; Saha, K.; Budhwar, P.; De D. Adoption of circular economy practices in small and medium-sized enterprises: Evidence from Europe. *International Journal of Production Economics* **2022**, *248*, 108496.
356. Austin, A.; Ur Rahman, I. A triple helix of market failures: Financing the 3Rs of the circular economy in European SMEs. *Journal of Cleaner Production* **2022**, *361*, 132284.
357. Fortunati, S.; Martiniello, L.; Morea, D. The Strategic Role of the Corporate Social Responsibility and Circular Economy in the Cosmetic Industry. *Sustainability* **2020**, *12*, 5120.
358. Tiscini, R.; Martiniello, L.; Lombardi, R. Circular economy and environmental disclosure in sustainability reports: Empirical evidence in cosmetic companies. *Business Strategy and the Environment* **2022**, *31*, 892–907.
359. Kolling, C.; Ribeiro, J.L.D.; de Medeiros, J.F. Performance of the cosmetics industry from the perspective of Corporate Social Responsibility and Design for Sustainability. *Sustainable Production and Consumption* **2022**, *30*, 171–185.
360. Todd, A.M. The aesthetic turn in green marketing: Environmental consumer ethics of natural personal care products. *Ethics and the Environment* **2004**, 86–102.
361. The Body Shop Case Analysis. The Challenges of Managing Business as Holistic Configuration, Available online: https://www.researchgate.net/profile/Vladimir-Korovkin-2/publication/341255107_The_Body_Shop_Case_Analysis_The_Challenges_of_Managing_Business_As_Holistic_Configuration/links/5eb9469e92851cd50da8d7b8/The-Body-Shop-Case-Analysis-The-Challenges-of-Managing-Business-As-Holistic-Configuration.pdf (accessed on 31 May 2023).
362. Bergman, M.S.; Curran, D.; Deckelbaum, A.J.; Karp, B.S.; Martos, S.D. ESG Ratings and Data: How to Make Sense of Disagreement. *The Corporate Governance Advisor* **2021**, *May/Jube*, 14–18.
363. Escrig-Olmedo, E.; Fernandez-Izquierdo, M.A.; Ferrero-Ferrero, I.; Rivera-Lirio, J.M.; Munoz-Torres, M.J. Rating the Raters: Evaluating how ESG Rating Agencies Integrate Sustainability Principles. *Sustainability* **2019**, *11*, 915.
364. MacMahon, S. The Challenge of Rating ESG Performance. *Harvard Business Review* **2020**, *September/October*, 52–54.

365. Polonsky, M. J.; Bailey, J.; Baker, H.; Basche, C.; Jepson, C.; Neath, L. Communicating Environmental Information: Are Marketing Claims on Packages Misleading? *Journal of Business Ethics* **1998**, *17*, 281–294.
366. Delmas, M.A.; Burbano, V.C. The Drivers of Greenwashing. *California Management Review* **2011**, *54(1)*, 64–87.
367. de Freitas Netto, S. V.; Sobral, M. F. F.; Ribeiro, A. R. B.; and da Lyz Soares, G. R. Concepts and forms of greenwashing: a systematic review. *Environmental Sciences Europe* **2020**, *32(1)*,19.
368. Avetisyan , E.; Hockerts, K. The Consolidation of the ESG Rating Industry as an Enactment of Institutional Regression. *Business Strategy and the Environment* **2017**, *26*, 316–330.
369. Pathak, S.; Muralidharan, E. Economic Inequality and Social Entrepreneurship. *Business & Society* **2018**, *57(6)*, 1150–1190.
370. Anderson, A.R. Cultivating the Garden of Eden: environmental entrepreneuring. *Journal of Organizational Change* **1998**, *11(2)*, 135–144.
371. Volery, T. Ecopreneurship: Rationale, current issues and future challenges. In Rencontres de St-Gall 2002: Radical change in the world: Will SMEs soar or crash?, Hergiswil, Switzerland, 2002; 531–553.
372. Evertsen, P.H.; Rasmussen, E.; Nenadic, O. Commercializing circular economy innovations: A taxonomy of academic spin-offs. *Technological Forecasting & Social Change* **2022**, *185*, 122102.
373. Frishammar, J.; Panda, V. Circular Business Model Transformation: A Roadmap for Incumbent Firms. *California Management Review* **2019**, *61(2)*, 5–29.
374. Veleva, V. Reflections on Social Impact Assessment in the 21^st century. *Journal of Cleaner Production* **2021**, *283*, 124685.
375. Bauwens, T.; Mees, R.; Gerardts, M.; Van Dune, J.; Friedl, H.; Von Daniels, C. et al. Disruptors: How Circular Start-ups Can Accelerate the Circular Economy Transition. *White Paper*, Utrecht University, 2019.
376. Huang, Y.; An, L.; Wang, J.; Chen, Y.; Wang, S.; Wang, P. The Role of Entrepreneurship Policy in College Students' Entrepreneurial Intention: The Intermediary Role of Entrepreneurial Practice and Entrepreneurial Spirit. *Frontiers in Psychology* **2021**, *12*, 585698.
377. Gawel, A. Does Entrepreneurship Affect Income Inequality within Countries? Direct and Indirect Effects in European Countries. *Entrepreneurial Business and Economics Review* **2020**, *8(2)*, 93–110.
378. Corporate sustainability reporting, Available online: https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en (accessed on July 1 2023).
379. Deloitte Survey: 70% of Companies Unprepared for EU CSRD Disclosures, Available online: https://www.enterpriseengagement.org/articles/content/8635140/deloitte-survey-70-of-companies-unprepared-for-eu-csrd-disclosures/ (accessed on July 1 2023).
380. Callao, C.; Latorre, M.P.; Martinez-Nunez, M. Understanding Hazardous Waste Exports for Disposal in Europe: A Contribution to Sustainable Development. *Sustainability* **2021**, *13*, 8905.
381. Plastics - the Facts 2017, Available online: https://plasticseurope.org/knowledge-hub/plastics-the-facts-2017-2/ (accessed on July 1 2023).
382. Plastics - the Facts 2019, Available online: file:///home/sylkittomhon/Downloads/2019-Plastics-the-facts.pdf (accessed on July 1 2023).
383. Wen, Z.; Xie, Y.; Chen, M.; Dinga, C.D. China's plastic import ban increases prospects of environmental impact mitigation of plastic waste trade flow worldwide. *Nature Communications* **2021**, *12*, 425.
384. Vormedal, I.; Skjaerseth, J.B. The good, the bad, or the ugly? Corporate strategies, size, and environmental regulation in the fish-farming industry. *Business and Politics* **2020**, *22(3)*, 510–538.
385. Boring, P. The relationship between firm productivity, firm size and CSR objectives for innovations. *Eurasian Business Review* **2019**, *9*, 269–297.
386. Wang, F.; Sun, Z. Does the Environmental Regulation Intensity and ESG Performance Have a Substitution Effect on the Impact of Enterprise Green Innovation: Evidence from China. *International Journal of Environmental Research and Public Health* **2022**, *19*, 8558.
387. Luo, X.; Du, S. "Good" Companies Launch More New Products. *Harvard Business Review* **2012**, *April*.
388. De, S.K.; Kawda, P.; Gupta, D.; Pragya, N. Packaging plastic waste management in the cosmetic industry. *Management of Environmental Quality: An International Journal* **2023**, *34(3)*, 820–942.
389. Berard, C.; Szostak, B.; Abdesselam, R. Corporate Social Responsibility: A Driving Force for Exploration and Exploitation in SMEs? *Journal of Innovation Economics & Management* **2022**, *38(2)*, 119–146.

390. Bocquet, R.; Mothe, C.D. Exploring the relationship between CSR and innovation: A comparison between small and largesized French companies. *Revue Sciences de Gestion* **2011**, *80*, 101–119.
391. EU Policy framework on SMEs: state of play and challenges, Available online: https://cor.europa.eu/en/engage/studies/Documents/EU-SMEs/EU-policy-SMEs.pdf (accessed on July 1 2023).
392. Ozcelik, F.; Ozturk, B.A.; Gursakal, S. Corporate Sustainability: A Research on Firms That Issue Sustainability Reports in Turkey. *Business and Economics Research Journal* **2015**, *6(3)*, 33–49.
393. Lippmann, S.; Davis, A.; Aldrich, H.E., Entrepreneurship and Inequality. In *Research in Sociology of Work, v. 15, Entrepreneurship*; Keister, L.A., Ed.; Elsevier, 2005; pp. 3–31.
394. Kimhi, A. Entrepreneurship and income inequality in southern Ethiopia. *Small Business Economics* **2010**, *34*, 81–91.
395. Means, B. Wealth Inequality and Family Businesses. *Emory Law Journal* **2016**, *65*, 937–986.
396. Atems, B.; Shand, G. An empirical analysis of the relationship between entrepreneurship and income inequality. *Small Business Economics* **2018**, *51*, 905–922.
397. Halvarsson, D.; Korpi, M.; Wennberger, K. Entrepreneurship and income inequality. *Economic Research - Ekonomska Istraživanja* **2019**, *33:1*, 2269–2285.
398. Ragoubi, H.; El Harbi, S. Entrepreneurship and income inequality: a spatial panel data analysis. *International Review of Applied Economics* **2018**, *32(3)*, 374–422.
399. Lecuna, A. Income inequality and entrepreneurship. *Journal of Economic Behavior & Organization* **2018**, *145*, 275–293.
400. Mohamad, N.M.; Masrson, T.A.; Ibrahim, H. The Role of Entrepreneurship on Income Inequality in Developing Countries. *Journal of Poverty* **2021**, *25(6)*, 520–542.
401. Packard, M.D.; Bylund, P.L. On the relationship between inequality and entrepreneurship. *Strategic Entrepreneurship Journal* **2018**, *12(1)*, 3–22.
402. Li, D.; Zhu, J. The Role of Environmental Regulation and Technological Innovation in the Employment of Manufacturing Enterprises: Evidence from China. *Sustainability* **2019**, *11*, 2982.
403. Sheng, J.; Zhou, W.; Zhang, S. The role of the intensity of environmental regulation and corruption in the employment of manufacturing enterprises: Evidence from China. *Journal of Cleaner Production* **2019**, *219*, 244–257.
404. Eissenberger, K.; Ballesteros, A.; De Bisschop, R.; Bugnicourt, E.; Cinelli, P.; Defoin, M. Approaches in Sustainable, Biobased Multilayer Packaging Solutions. *Polymers* **2023**, *15*, 1184.
405. Sreedhar, D.; Manjula, N.; Pise, A.; Pise, S.; Ligade, V.S. Ban of Cosmetic Testing on Animals: A Brief Overview. *International Journal of Current Research and Review* **2020**, *12(14)*, 113–116.
406. Suphasomboon, T.; Vassanadumrongdee, S. Toward sustainable consumption of green cosmetics and personal care products: The role of perceived value and ethical concern. *Sustainable Production and Consumption* **2022**, *33*, 230–243.
407. Fonseca-Santos, B.; Correa, M.A.; Chorilli, M. Sustainability, natural and organic cosmetics: consumer, products, efficacy, toxicological and regulatory considerations. *Brazilian Journal of Pharmaceutical Sciences* **2015**, *51(1)*, 17–26.
408. Mattar,J.B.; Candido, A.C.; de Souza Vilela, D.L.; de Paula, V.L.; Castro, L.C.V. Information displayed on Brazilian food bar labels points to the need to reformulate the current food labelling legislation. *Food Chemistry* **2022**, *370*, 131318.
409. Kattstrom, D.; Beronius, A.; Ruden, C.; Agerstrand, M. Stricter regulation applies to antimicrobial substances when used as biocides compared to cosmetics under current EU legislation. *Emerging Contaminants* **2022**, *8*, 229–242.
410. Bellasen, V.; Drut, M.; Hilal, M.; Bodini, A.; Donati, M.; de Labarre, M.D. et al. The economic, environmental and social performance of European certified food. *Ecological Economics* **2022**, *191*, 107244.
411. Gottardo, S.; Mech, A.; Drbohlavova, J.; Malyska, A.; Bowadt, S.; Sintes, J.R.; Rauscher, H. Towards safe and sustainable innovation in nanotechnology: State-of-play for smart nanomaterials. *NanoImpact* **2021**, *21*, 100297.
412. Coelho, P.M.; Corona, B.; ten Klooster, R.; Worrell, E. Sustainability of reusable packaging–Current situation and trends. *Resources, Conservation & Recycling: X* **2020**, *6*, 100037.

413. Zhu, Z.; Liu, W.; Ye, S.; Batista, L. Packaging design for the circular economy: A systematic review. *Sustainable Production and Consumption* **2022**, *32*, 817–832.
414. Rujnic-Sokele, M.; Pilipovic, A. Challenges and opportunities of biodegradable plastics: A mini review. *Waste Management & Research* **2017**, *35(2)*, 132–140.
415. Civancik-Uslu, D.; Puig, R.; Voigt, S.; Walter, D.; Fullana-i-Palmer, P. Improving the production chain with LCA and eco-design: application to cosmetic packaging. *Resources, Conservation & Recycling* **2019**, *151*, 104475.
416. Lessons from the Green Graveyard, Available online: http://www.greenmarketing.com/articles/complete/lessons-from-the-green-graveyard/ (accessed on July 1 2023).
417. Lal. B.S. Green Marketing: Opportunities and Issues. *International Journal of Multidisciplinary Research and Modern Education* **2015**, *1(1)*, 2454–6119.
418. Silva, C.S. Are Consumers Willing to Adhere to Companies' Environmentally Friendly Packaging? Masters Thesis. Universidade Catolica Protuguesa, Portugal, May 2018.
419. Ernesto, M.C. The Unnecessity of Advertising as a Promotional Tool to Build Brand Awareness and Brand Image: A Case of Lush Cosmetics. Doctoral Thesis, Universidade Europeia, Lisbon, Portugal, 2022.
420. Hartman, C.L.; Beck-Dudley, C. L. Marketing Strategies and the Search for Virtue: A Case Analysis of the Body Shop International. *Journal of Business Ethics* **1999**, *20(3)*, 249–263.
421. Wycherley, I. Greening Supply Chains: The case of the Body Shop International. *Business, Strategy and the Environment* **1999**, *8*, 120–127.
422. Is Lush Guilty of Greenwashing? We Take a Closer Look, Available online: https://bettergoods.org/lush/ (accessed on July 1 2023).
423. Heredia-Colaco, V. Pro-environmental messages have more effect when they come from less familiar brands. *Journal of Product & Brand Management* **2023**, *32(3)*, 436–453.
424. Morin, C. Neuromarketing: the new science of consumer behavior. *Society* **2011**, *48(2)*, 131–135.
425. Stokes, P. Brain Power. *Acuity* **2015**, *2(7)*, 44–47.
426. Adhami, M. Using Neuromarketing to Discover How We Really Feel About Apps. *International Journal of Mobile Marketing* **2013**, *8(1)*, 95–103.
427. Chun. R. What Holds Ethical Consumers to a Cosmetics Brand: The Body Shop Case. *Business & Society* **2016**, *55(4)*, 528–549.
428. Yenipazarli, A.; Vakharia, A. Pricing, market coverage and capacity: Can green and brown products co-exist? *European Journal of Operational Research* **2015**, *242*, 304–315.
429. Mansor, A. A. B.; Isa, S. M. The Impact of Eye Tracking on Neuromarketing for Genuine Value-Added Applications. *Global Business and Management Research: An International Journal* **2018**, *10(1)*, 1–11.
430. del Carmen Aguilar-Luzon, M.; Garcia-Martinez, J.M.A.; Calvo-Salguero, A.; Salinas, J.M. Comparative Study Between the Theory of Planned Behavior and the Value–Belief–Norm Model Regarding the Environment, on Spanish Housewives' Recycling Behavior. *Journal of Applied Social Psychology* **2012**, *42(11)*, 2797–2833.
431. Page, G. Scientific realism: what 'neuromarketing' can and can't tell us about consumers. *International Journal of Market Research* **2012**, *54(2)*, 287–290.
432. Klincekova, S. Neuromarketing – research and prediction of the future. *International Journal of Management Science and Business Administration* **2016**, *2(2)*, 53–57.
433. Glova, B.; Mudryk, I. Application of Deep Learning in Neuromarketing Studies of the Effects of Unconscious Reactions on Consumer Behavior. In Proceedings of the IEEE Third International Conference on Data Stream Mining & Processing, Lviv, Ukraine, 21-25 August 2020; 337–340.
434. Venkatraman, V.; Dimoka, A.; Pavlou, P. A.; Vo, K.; Hampton, W.; Bollinger, B.; Hershfield, H. E.; Ishihara, M.; Winer, R. S. Predicting Advertising Success Beyond Traditional Measures: New Insights from Neurophysical Methods and Market Response Modeling. *Journal of Marketing Research* **2015**, *LII*, 436–452.
435. Lee, N.; Brandes, L.; Chamberlain, L.; Senior. C. This is your brain on neuromarketing: reflections on a decade of research. *Journal of Marketing Management* **2021**, *15(1)*, 54–83.
436. Ciprian-Marcel, P.; Radomir, L.; Ioana, M.A.; Maria, Z. M. Neuromarketing - getting inside the customer's mind. *Annals of the University of Oradea, Economic Science Series*, The University of Oradea, 2019.
437. Varan, D.; Lang, A.; Barwise, P.; Weber, R.; Bellman, S. How Reliable Are Neuromarketers' Measures of Advertising Effectiveness? *Journal of Advertising Research* **2015**, *55(2)*, 176–191.

 doi:10.20944/preprints202308.0120.v1

438. Ramsoy, T.Z. Building a Foundation for Neuromarketing And Consumer Neuroscience Research. *Journal of Advertising Research* **2019**, *59(3)*, 281–294.
439. Spence, C. Neuroscience-Inspired Design: From Academic Neuromarketing to Commercially Relevant Research. *Organizational Research Methods* **2019**, *22(1)*, 275–298.
440. Clark, N.; Trimingham, R.; Wilson, G.T. A remote ethnography methodology to gain packaging behaviour insights. *Packaging Technology and Science* **2022**, *35*, 373–382.
441. Findrik, E.; Meixner, O. Drivers and barriers for consumers purchasing bioplastics – A systematic literature review. *Journal of Cleaner Production* **2023**, *410*, 137311.
442. Branca, G.; Resciniti, R.; Loureiro, S.M.C. Virtual is so real! Consumers' evaluation of product packaging in virtual reality. *Psychology & Marketing* **2023**, *40*, 596–609.
443. Teng, Y.-M.; Wu, K.-S.; Huang, D.-M. The Influence of Green Restaurant Decision Formation Using the VAB Model: The Effect of Environmental Concerns upon Intent to Visit. *Sustainability* **2014**, *6*, 8737.
444. Chen, K.; Deng, T. Research on the Green Purchase Intentions from the Perspective of Product Knowledge. *Sustainability* **2016**, *8*, 943.
445. Lal, M.; Sharma, C.S.; Sharma, N. Trust in Green Purchase intentions: A Study of Antecedents and Consequents. In Proeedings of the 2017 Annual Conference of the Emerging Markets Conference Board, 5-7 Jan 2017, 711–716.
446. Ates, H. Merging Theory of Planned Behavior and Value Identity Personal Norm Model to Explain Pro-Environmental Behaviors. *Sustainable Production and Consumption* **2020**, *24* 169–180.
447. De Abreu Duarte, M.M. Green Marketing as an Atecedent of Willingess to Pay: The Mediating Role of Brand Coolness and Pro-environmental Behavior, Masters, Instituto Universitario de Lisboa, Lisbon, Portugal, October 2021.
448. Govaerts F.; Olsen S.O. Consumers' values, attitudes and behaviours towards consuming seaweed food products: The effects of perceived naturalness, uniqueness, and behavioural control. *Food Research International*. **2023**, *165*, 112417.
449. Lopez-Nicolas, C.; Merono-Cerdan, A. L. Strategic knowledge management, innovation and performance. *International Journal of Information Management* **2011**, *31*, 502–509.
450. Jiminez-Jiminez, D., and Sanz-Valle, R., (2011). "Innovation, organizational learning, and performance", Journal of Business Research, 64, 409-417.
451. Magnier-Watanabe, R., and Benton, C., (2017). "Management innovation and firm performance: the mediating effects of tacit and explicit knowledge", Knowledge Management Research and Practice, (forthcoming).
452. Gomes GM, Moreira N, Ometto AR. Role of consumer mindsets, behaviour, and influencing factors in circular consumption systems: A systematic review. Sustainable Production and Consumption. 2022 Jul 1;32:1-4.
453. Wijaya A, Chandra E, Julyanthry J, Candra V, Simarmata SM. Purchase Intention of Grooming Products: The Value-Attitude-Behaviour (VAB) Model. International Journal of Entrepreneurship and Sustainability Studies. 2021 Dec 31;1(2):10-21.
454. Askadilla WL, Krisjanti MN. Understanding indonesian green consumer behavior on cosmetic products: Theory of planned behavior model. Polish Journal of Management Studies. 2017;15(2):7-15.
455. Chin J, Jiang BC, Mufidah I, Persada SF, Noer BA. The investigation of consumers' behavior intention in using green skincare products: a pro-environmental behavior model approach. Sustainability. 2018 Oct 28;10(11):3922.
456. Lestari DD. Green Cosmetic Purchase Intention: Impact Of Green Brand Positioning, Attitude, And Knowledge. Bachelors Thesis. Universitas Islam Indonesia. Yogyakarta, 2020.
457. Dewi CS, Annas M. Consumption Value dimension of green purchase intention with green trust as mediating variable. Dinasti International Journal of Economics, Finance & Accounting. 2022 Aug 26;3(3):315-25.
458. Patnaik A, Tripathy S, Dash A. Identifying the features influencing sustainable products: A study on green cosmetics. InAdvances in Mechanical Processing and Design: Select Proceedings of ICAMPD 2019 2021 (pp. 631-640). Springer Singapore.
459. Acharya S, Bali S, Bhatia BS. Exploring consumer behavior towards sustainability of green cosmetics. In2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT) 2021 Feb 19 (pp. 1-6). IEEE.

460. Grădinaru C, Obadă DR, Grădinaru IA, Dabija DC. Enhancing Sustainable Cosmetics Brand Purchase: A Comprehensive Approach Based on the SOR Model and the Triple Bottom Line. Sustainability. 2022 Oct 29;14(21):14118.
461. Grappe CG, Lombart C, Louis D, Durif F. "Not tested on animals": how consumers react to cruelty-free cosmetics proposed by manufacturers and retailers?. International Journal of Retail & Distribution Management. 2021 Oct 6;49(11):1532-53.
462. Cosentino C, Freschi P, Paolino R, Valentini V. Market sustainability analysis of jenny milk cosmetics. Emirates Journal of Food and Agriculture. 2013:635-340.
463. Sundar A, Cao ES, Machleit KA. How product aesthetics cues efficacy beliefs of product performance. Psychology & Marketing. 2020 Sep;37(9):1246-62.
464. Srivastava P, Ramakanth D, Akhila K, Gaikwad KK. Package design as a branding tool in the cosmetic industry: consumers' perception vs. reality. SN Business & Economics. 2022 May 21;2(6):58.
465. Ikkyung SUNG. Interdisciplinary Literaure Analysis between Cosmetic Container Design and Customer Purchasing Intention. Journal of Industrial Distribution & Business. 2021;12(3):21-9.
466. Heller MC, Selke SE, Keoleian GA. Mapping the influence of food waste in food packaging environmental performance assessments. Journal of Industrial Ecology. 2019 Apr;23(2):480-95.
467. Alam, M.Z.; Abunar, S. A. Appraising the Buyers Approach Towards Sustainable Development with Special Reference to Buying Habits and Knowledge Source of Green Packaging: A Cross-Sectional Study. *WSEAS Transactions on Environment and Development* **2023**, *19*, 400–411.
468. Veerabhadrappa, NBB, Fernandes S, Panda R. A review of green purchase with reference to individual consumers and organizational consumers: A TCCM approach. Cleaner and Responsible Consumption. 2022 Dec 24:100097.
469. Wang C, Liu J, Fan R, Xiao L. Promotion strategies for environmentally friendly packaging: a stochastic differential game perspective. International Journal of Environmental Science and Technology. 2022 Sep 3:1-0.
470. Murtas G, Pedeliento G, Andreini D. To Pack Sustainably or Not to Pack Sustainably? A Review of the Relationship between Consumer Behaviour and Sustainable Packaging. Managing Sustainability: Perspectives From Retailing and Services. 2022 Sep 15:147-68.
471. Mugobo VV, Ntuli H, Iwu CG. Consumer Perceptions of the Use of Nondegradable Plastic Packaging and Environmental Pollution: A Review of Theories and Empirical Literature. Journal of Risk and Financial Management. 2022 May 30;15(6):244.
472. Tarabashkina L, Devine A, Quester PG. Encouraging product reuse and upcycling via creativity priming, imagination and inspiration. European Journal of Marketing. 2022 Jul 15;56(7):1956-84.
473. Zeng T. Impacts of consumers' perceived risks in eco-design packaging on food wastage behaviors. British Food Journal. 2022 Jul 22;124(8):2512-32.
474. Testa F, Iovino R, Iraldo F. The circular economy and consumer behaviour: The mediating role of information seeking in buying circular packaging. Business Strategy and the Environment. 2020 Dec;29(8):3435-48.
475. van der Waal NE, Folkvord F, Azrout R, Meppelink CS. Can product information steer towards sustainable and healthy food choices? A pilot study in an online supermarket. International Journal of Environmental Research and Public Health. 2022 Jan 19;19(3):1107.
476. Ruf J, Emberger-Klein A, Menrad K. Consumer response to bio-based products–A systematic review. Sustainable Production and Consumption. 2022 Sep 28.
477. Siddiqui SA, Zannou O, Bahmid NA, Fidan H, Alamou AF, Nagdalian AA, Hassoun A, Fernando I, Ibrahim SA, Arsyad M. Consumer behavior toward nanopackaging-a new trend in the food industry. Future Foods. 2022 Sep 22:100191.
478. Boncinelli F, Gerini F, Piracci G, Bellia R, Casini L. Effect of executional greenwashing on market share of food products: An empirical study on green-coloured packaging. Journal of Cleaner Production. 2023 Mar 10;391:136258.
479. da Fonseca C, Sá AG, Ribeiro Gagliardi T, dos Santos Alves MJ, Ayala Valencia G. Understanding the packaging colour on consumer perception of plant-based hamburgers: A preliminary study. Packaging Technology and Science. 2023 Jun;36(6):495-503.
480. Califano G, Furno M, Caracciolo F. Beyond one-size-fits-all: Consumers react differently to packaging colors and names of cultured meat in Italy. Appetite. 2023 Mar 1;182:106434.

481. Hallez L, Vansteenbeeck H, Boen F, Smits T. Persuasive packaging? The impact of packaging color and claims on young consumers' perceptions of product healthiness, sustainability and tastiness. Appetite. 2023 Mar 1;182:106433.
482. Steenis ND, Van Herpen E, Van Der Lans IA, Ligthart TN, Van Trijp HC. Consumer response to packaging design: The role of packaging materials and graphics in sustainability perceptions and product evaluations. Journal of cleaner production. 2017 Sep 20;162:286-98.
483. Granato G, Fischer AR, van Trijp HC. A meaningful reminder on sustainability: When explicit and implicit packaging cues meet. Journal of environmental psychology. 2022 Feb 1;79:101724.
484. Chacon L, Lavoine N, Venditti RA. Valorization of mixed office waste as macro-, micro-, and nano-sized particles in recycled paper containerboards for enhanced performance and improved environmental perception. Resources, Conservation and Recycling. 2022 May 1;180:106125.
485. Arrazat L, Chambaron S, Arvisenet G, Goisbault I, Charrier JC, Nicklaus S, Marty L. Traffic-light front-of-pack environmental labelling across food categories triggers more environmentally friendly food choices: a randomised controlled trial in virtual reality supermarket. International Journal of Behavioral Nutrition and Physical Activity. 2023 Dec;20(1):1-3.
486. Potter C, Pechey R, Cook B, Bateman P, Stewart C, Frie K, Clark M, Piernas C, Rayner M, Jebb SA. Effects of environmental impact and nutrition labelling on food purchasing: An experimental online supermarket study. Appetite. 2023 Jan 1;180:106312.
487. Huang Y, Yang X, Li X, Chen Q. Less is better: how nutrition and low-carbon labels jointly backfire on the evaluation of food products. Nutrients. 2021 Mar 26;13(4):1088.
488. Sonntag WI, Lemken D, Spiller A, Schulze M. Welcome to the (label) jungle? Analyzing how consumers deal with intra-sustainability label trade-offs on food. Food Quality and Preference. 2023 Mar 1;104:104746.
489. Muzzioli L, Donini LM, Mazziotta M, Iosa M, Frigerio F, Poggiogalle E, Lenzi A, Pinto A. How Much Do Front-Of-Pack Labels Correlate with Food Environmental Impacts?. Nutrients. 2023 Feb 26;15(5):1176.
490. Šola HM, Gajdoš Kljusurić J, Rončević I. The impact of bio-label on the decision-making behavior. Frontiers in Sustainable Food Systems. 2022 Sep 1;6:1002521.
491. Nydrioti I, Grigoropoulou H. Using the water footprint concept for water use efficiency labelling of consumer products: the Greek experience. Environmental Science and Pollution Research. 2023 Feb;30(8):19918-30.
492. Manta F, Campobasso F, Tarulli A, Morrone D. Showcasing green: how culture influences sustainable behavior in food eco-labeling. British Food Journal. 2022 Nov 1;124(11):3582-94.
493. Mohammed NB, Medina IG, Romo ZG. The effect of cosmetics packaging design on consumers' purchase decisions. Indian Journal of Marketing. 2018 Dec;48(12):50-61.
494. De Canio F. Consumer willingness to pay more for pro-environmental packages: The moderating role of familiarity. Journal of Environmental Management. 2023 Aug 1;339:117828.
495. Chirilli C, Molino M, Torri L. Consumers' awareness, behavior and expectations for food packaging environmental sustainability: Influence of socio-demographic characteristics. Foods. 2022 Aug 9;11(16):2388.
496. Bellomo M, Pleyers G. Sustainable cosmetics: the impact of packaging materials, environmental concern and subjective norm on green consumer behaviour. Louvain School of Management, Université catholique de Louvain. 2021.
497. Koch J, Frommeyer B, Schewe G. Managing the transition to eco-friendly packaging–An investigation of consumers' motives in online retail. Journal of Cleaner Production. 2022 Jun 1;351:131504.
498. Wojciechowska P, Wiszumirska K. Sustainable Communication in the B2C Market—The Impact of Packaging. Sustainability. 2022 Feb 28;14(5):2824.
499. Long Y, Ceschin F, Harrison D, Terzioğlu N. Exploring and Addressing the User Acceptance Issues Embedded in the Adoption of Reusable Packaging Systems. Sustainability. 2022 May 18;14(10):6146.
500. Shimul AS, Cheah I. Consumers' preference for eco-friendly packaged products: pride vs guilt appeal. Marketing Intelligence & Planning. 2023 Mar 13;41(2):186-98.
501. Vincent FY, Aloina G, Eccarius T. Adoption intentions of home-refill delivery service for fast-moving consumer goods. Transportation Research Part E: Logistics and Transportation Review. 2023 Mar 1;171:103041.
502. Salem MZ. Effects of perfume packaging on Basque female consumers purchase decision in Spain. Management Decision. 2018 Apr 10;56(8):1748-68.

503. Wu S, Gong X, Wang Y, Cao J. Consumer cognition and management perspective on express packaging pollution. International Journal of Environmental Research and Public Health. 2022 Apr 18;19(8):4895.
504. Song J, Cai L, Yuen KF, Wang X. Exploring consumers' usage intention of reusable express packaging: An extended norm activation model. Journal of Retailing and Consumer Services. 2023 May 1;72:103265.
505. Xu, Y.; Ward,P.S. Environmental Attitutdes and Consumer Preference for Environmentally-Friendly Beverage Packaging: The Role of Information Provision and Identity Labeling in Influencing Consumer Behavior. *Frontiers of Agricultural Science and Engineering* **2023**, *10(1)*, 95–108.
506. Najm AA, Salih SA, Fazry S, Law D, Azfaralariff A. Moderated mediation approach to determine the effect of natural packaging factors on intention to purchase natural skincare products among the population of Klang Valley, Malaysia. Journal of Sensory Studies. 2023 Apr;38(2):e12811.
507. Muhammad NH, Yusoff AM, Nawi NM, Razak NF, Simpong DB. Pro-environmental Behaviour Impacts on the Willingness to Pay for Bio-based Sustainable Food Packaging. InThe Implementation of Smart Technologies for Business Success and Sustainability: During COVID-19 Crises in Developing Countries 2022 Sep 25 (pp. 325-334). Cham: Springer International Publishing.
508. Jain P, Hudnurkar M. Sustainable packaging in the FMCG industry. Cleaner and Responsible Consumption. 2022 Dec 1;7:100075.
509. Kapse U, Mahajan Y, Hudnurkar M, Ambekar S, Hiremath R. The Effect of Sustainable Packaging Aesthetic on Consumer Behavior: A Case Study from India. Australasian Accounting, Business and Finance Journal. 2023;17(1):236-46.
510. Mahmoud MA, Tsetse EK, Tulasi EE, Muddey DK. Green Packaging, Environmental Awareness, Willingness to Pay and Consumers' Purchase Decisions. Sustainability. 2022 Dec 1;14(23):16091.
511. Gutierrez Tano D, Hernandez Mendez J, Díaz-Armas R. An extended theory of planned behaviour model to predict intention to use bioplastic. Journal of Social Marketing. 2022 Jan 3;12(1):5-28.
512. Girotto, G. Sustainability and Green Strategies in the Cosmetic Industry: Analysis of Natural and Organic Cosmetic Products from the value chain to final certification. Masters Thesis, Universita Ca' Foscari Di Venezia, Italy, 2012.
513. De Abreu Sofiatti Dalmarco D, Hamza KM, Aoqui C. The implementation of product development strategies focused on sustainability: From Brazil—The case of Natura Sou Cosmetics brand. Environmental Quality Management. 2015 Mar;24(3):1-5.
514. Bennett TM, Portal J, Jeanne-Rose V, Taupin S, Ilchev A, Irvine DJ, Howdle SM. Synthesis of model terpene-derived copolymers in supercritical carbon dioxide for cosmetic applications. European Polymer Journal. 2021 Aug 15;157:110621.
515. Rocca R, Acerbi F, Fumagalli L, Taisch M. Sustainability paradigm in the cosmetics industry: State of the art. Cleaner Waste Systems. 2022 Nov 21:100057.
516. Bom S, Ribeiro HM, Marto J. Sustainability calculator: a tool to assess sustainability in cosmetic products. Sustainability. 2020 Feb 14;12(4):1437.
517. Cılız NK, Değirmen C, Uzun M, Kalıpçıoğlu C, Ahmed IA, Birpınar ME, Ecer M, Moralı EK, Atay S, Ulutaş Ö, Aki Z. The Contribution of LCA Applications to the Development of National Ecolabel Criteria for the Personal Care and Cosmetic Sector. International Journal of Innovation Engineering and Science Research.
518. Agyabeng-Mensah Y, Afum E, Ahenkorah E. Exploring financial performance and green logistics management practices: examining the mediating influences of market, environmental and social performances. Journal of cleaner production. 2020 Jun 10;258:120613.
519. Vahdani B, Iranmanesh SH, Mousavi SM, Abdollahzade M. A locally linear neuro-fuzzy model for supplier selection in cosmetics industry. Applied Mathematical Modelling. 2012 Oct 1;36(10):4714-27.
520. Vizzini L, Ragaglia F, Dugo G, Leonardi V, Pulvirenti E. Economic and environmental assessments of cosmetic packaging. Case study of an innovative startup. Procedia Environmental Science, Engineering and Management. 2019;6(2):275-81
521. Matarazzo A, Vizzini L, Arfo S. Bioplastics for packaging in cosmetic sector towards a circular bioeconomy model. Archives of Business Review–Vol. 2020 Jul 25;8(7).
522. Csorba LM, Boglea VA. Sustainable cosmetics: a major instrument in protecting the consumer's interest. Regional and Business Studies. 2011 Feb 15;3(1 Suppl.):167-76.
523. Heath RS, Ruscoe RE, Turner NJ. The beauty of biocatalysis: sustainable synthesis of ingredients in cosmetics. Natural Product Reports. 2022;39(2):335-88.

524. Pinto D, de la Luz Cádiz-Gurrea M, Garcia J, Saavedra MJ, Freitas V, Costa P, Sarmento B, Delerue-Matos C, Rodrigues F. From soil to cosmetic industry: Validation of a new cosmetic ingredient extracted from chestnut shells. Sustainable Materials and Technologies. 2021 Sep 1;29:e00309.
525. Pereira P, Mauricio EM, Duarte MP, Lima K, Fernandes AS, Bernardo-Gil G, Cebola MJ. Potential of supercritical fluid myrtle extracts as an active ingredient and co-preservative for cosmetic and topical pharmaceutical applications. Sustainable Chemistry and Pharmacy. 2022 Sep 1;28:100739.
526. da Silveira Ramos IF, Magalhaes LM, do O Pessoa C, Ferreira PM, dos Santos Rizzo M, Osajima JA, Silva-Filho EC, Nunes C, Raposo F, Coimbra MA, Ribeiro AB. New properties of chia seed mucilage (Salvia hispanica L.) and potential application in cosmetic and pharmaceutical products. Industrial Crops and Products. 2021 Nov 1;171:113981.
527. Fonseca S, Amaral MN, Reis CP, Custódio L. Marine Natural Products as Innovative Cosmetic Ingredients. Marine Drugs. 2023 Mar 8;21(3):170.
528. Venkataramani D, Tsulaia A, Amin S. Fundamentals and applications of particle stabilized emulsions in cosmetic formulations. Advances in Colloid and Interface Science. 2020 Sep 1;283:102234.
529. Springer A, Ziegler H, Bach K. The Influence of Antioxidant Plant Extracts on the Oxidation of O/W Emulsions. Cosmetics. 2023 Feb 24;10(2):40.
530. Gupta S, Sharma S, Nadda AK, Husain MS, Gupta A. Biopolymers from waste biomass and its applications in the cosmetic industry: A review. Materials Today: Proceedings. 2022 Jan 1;68:873-9.
531. Vroman I, Tighzert L. Biodegradable polymers. Materials. 2009 Apr 1;2(2):307-44.
532. Joseph TM, Unni AB, Joshy KS, Kar Mahapatra D, Haponiuk J, Thomas S. Emerging Bio-Based Polymers from Lab to Market: Current Strategies, Market Dynamics and Research Trends. C. 2023 Mar 7;9(1):30.
533. Tyagi P, Agate S, Velev OD, Lucia L, Pal L. A critical review of the performance and soil biodegradability profiles of biobased natural and chemically synthesized polymers in industrial applications. Environmental Science & Technology. 2022 Jan 25;56(4):2071-95.
534. Aliotta L, Gigante V, Geerinck R, Coltelli MB, Lazzeri A. Micromechanical analysis and fracture mechanics of Poly (lactic acid)(PLA)/Polycaprolactone (PCL) binary blends. Polymer Testing. 2023 Apr 1;121:107984.
535. Fernandes M, Salvador A, Alves MM, Vicente AA. Factors affecting polyhydroxyalkanoates biodegradation in soil. Polymer Degradation and Stability. 2020 Dec 1;182:109408.
536. Idris SN, Amelia TS, Bhubalan K, Lazim AM, Zakwan NA, Jamaluddin MI, Santhanam R, Abdullah AA, Vigneswari S, Ramakrishna S. The degradation of single-use plastics and commercially viable bioplastics in the environment: A review. Environmental Research. 2023 Apr 25:115988.
537. Coltelli MB, Danti S, De Clerck K, Lazzeri A, Morganti P. Pullulan for advanced sustainable body-and skin-contact applications. Journal of Functional Biomaterials. 2020 Mar 18;11(1):20.
538. Antunes F, Mota IF, da Silva Burgal J, Pintado M, Costa PS. A review on the valorization of lignin from sugarcane by-products: From extraction to application. Biomass and Bioenergy. 2022 Nov 1;166:106603.
539. Kulka K, Sionkowska A. Chitosan Based Materials in Cosmetic Applications: A Review. Molecules. 2023 Feb 15;28(4):1817.
540. Thambiliyagodage C, Jayanetti M, Mendis A, Ekanayake G, Liyanaarachchi H, Vigneswaran S. Recent Advances in Chitosan-Based Applications—A Review. Materials. 2023 Mar 3;16(5):2073.
541. Sharma S, Gupta A, Kumar A, Kee CG, Kamyab H, Saufi SM. An efficient conversion of waste feather keratin into ecofriendly bioplastic film. Clean Technologies and Environmental Policy. 2018 Dec;20:2157-67.
542. Morganti, P., (Ed.), Bionanotechnology to Save the Environment, MDPI, Basel, Switzerland, 2019.
543. Fouad D, Farag M. Design for sustainability with biodegradable composites. InDesign and Manufacturing 2019 Sep 4 (pp. 39-55). London, UK: IntechOpen.
544. Stark NM, Matuana LM. Trends in sustainable biobased packaging materials: A mini review. Materials Today Sustainability. 2021 Nov 1;15:100084.
545. Baker A, Zahniser S. Ethanol Reshapes the Corn Market—Updated. Amber Waves 2016 5 66–71
546. Aguiar JB, Martins AM, Almeida C, Ribeiro HM, Marto J. Water sustainability: A waterless life cycle for cosmetic products. Sustainable Production and Consumption. 2022 Jul 1;32:35-51.
547. Demichelis F, Fiore S, Onofrio M. Pre-treatments aimed at increasing the biodegradability of cosmetic industrial waste. Process Safety and Environmental Protection. 2018 Aug 1;118:245-53
548. Fiore S, Demichelis F, Chiappero M, Onofrio M. Investigation of the anaerobic digestion of cosmetic industrial wastes: Feasibility and perspectives. Journal of Environmental Management. 2021 Dec 1;299:113678.

549. Ribeiro MR, de Moraes Guimarães Y, Silva IF, Almeida CA, Silva MS, Nascimento MA, da Silva UP, Varejao EV, dos Santos Renato N, de Carvalho Teixeira AP, Lopes RP. Synthesis of value-added materials from the sewage sludge of cosmetics industry effluent treatment plant. Journal of Environmental Chemical Engineering. 2021 Aug 1;9(4):105367.
550. Brandao, A.S.; Goncalves, A.; Santos, J.M.R.C.A. Circular bioeconomy strategies: From scientific research to commercially viable products. Jounral of Cleaner Production. 2021; 295; 126407.
551. Podgórska A, Puścion-Jakubik A, Grodzka A, Naliwajko SK, Markiewicz-Żukowska R, Socha K. Natural and conventional cosmetics—mercury exposure assessment. Molecules. 2021 Jul 5;26(13):4088.
552. OECD (2018), Guidance Document on Good In Vitro Method Practices (GIVIMP), OECD Series on Testing and Assessment, No. 286, OECD Publishing, Paris.
553. Barthe M, Bavoux C, Finot F, Mouche I, Cuceu-Petrenci C, Forreryd A, Chérouvrier Hansson A, Johansson H, Lemkine GF, Thénot JP, Osman-Ponchet H. Safety testing of cosmetic products: overview of established methods and new approach methodologies (NAMs). Cosmetics. 2021 Jun 11;8(2):50.
554. Ouedraogo G, Alexander-White C, Bury D, Clewell III HJ, Cronin M, Cull T, Dent M, Desprez B, Detroyer A, Ellison C, Giammanco S. Read-across and new approach methodologies applied in a 10-step framework for cosmetics safety assessment–A case study with Parabens. Regulatory Toxicology and Pharmacology. 2022 Jul 1;132:105161.
555. Magnier L, Schoormans J. Consumer reactions to sustainable packaging: The interplay of visual appearance, verbal claim and environmental concern. Journal of Environmental Psychology. 2015 Dec 1;44:53-62.
556. Huang J. Sustainable development of green paper packaging. Environment and Pollution. 2017;6(2):1-7
557. Dos Santos JW, Garcia VA, Venturini AC, Carvalho RA, da Silva CF, Yoshida CM. Sustainable Coating Paperboard Packaging Material Based on Chitosan, Palmitic Acid, and Activated Carbon: Water Vapor and Fat Barrier Performance. Foods. 2022 Dec 14;11(24):4037.
558. Kozik N. Sustainable packaging as a tool for global sustainable development. InSHS web of conferences 2020 (Vol. 74, p. 04012). EDP Sciences.
559. Ibrahim ID, Hamam Y, Sadiku ER, Ndambuki JM, Kupolati WK, Jamiru T, Eze AA, Snyman J. Need for Sustainable Packaging: An Overview. Polymers. 2022 Oct 20;14(20):4430.
560. Cappelletti, F.; Rossi, M.; Germani, M. How de-manufacturing supports circular economy linking design and EoL - a literature review. Journal of Manufacturing Systems. 2022; 63: 118–133.
561. Gatt IJ, Refalo P. Reusability and recyclability of plastic cosmetic packaging: A life cycle assessment. Resources, Conservation & Recycling Advances. 2022 Nov 1;15:200098.
562. Lekesiztürk D, Oflaç BS. Investigating sustainable packaging practices: a framework approach. Present Environment & Sustainable Development. 2022 Jan 1;16(1).
563. Jestratijevic I, Maystorovich I, Vrabič-Brodnjak U. The 7 Rs sustainable packaging framework: Systematic review of sustainable packaging solutions in the apparel and footwear industry. Sustainable Production and Consumption. 2022 Mar 1;30:331-40.
564. Bhandari N, Garza-Reyes JA, Rocha-Lona L, Kumar A, Naz F, Joshi R. Barriers to sustainable sourcing in the apparel and fashion luxury industry. Sustainable Production and Consumption. 2022 May 1;31:220-35.
565. Ren Z, Zhang D, Gao Z. Sustainable design strategy of cosmetic packaging in China based on life cycle assessment. Sustainability. 2022 Jul 4;14(13):8155.
566. Resimović L, Brozović M, Kovačević D. Design of sustainable packaging for natural cosmetics. Journal of Applied Packaging Research. 2022;14(1):2.
567. Nadagouda MN, Ginn M, Rastogi V. A review of 3D printing techniques for environmental applications. Current opinion in chemical engineering. 2020 Jun 1;28:173-8.
568. King S, Locock KE. A circular economy framework for plastics: A semi-systematic review. Journal of Cleaner Production. 2022 Sep 1;364:132503.
569. Sánchez C. Fungal potential for the degradation of petroleum-based polymers: An overview of macro-and microplastics biodegradation. Biotechnology advances. 2020 May 1;40:107501.
570. Evode N, Qamar SA, Bilal M, Barceló D, Iqbal HM. Plastic waste and its management strategies for environmental sustainability. Case Studies in Chemical and Environmental Engineering. 2021 Dec 1;4:100142.
571. Damayanti D, Saputri DR, Marpaung DS, Yusupandi F, Sanjaya A, Simbolon YM, Asmarani W, Ulfa M, Wu HS. Current prospects for plastic waste treatment. Polymers. 2022 Jul 31;14(15):3133.

572. Tiwari R, Azad N, Dutta D, Yadav BR, Kumar S. A critical review and future perspective of plastic waste recycling. Science of The Total Environment. 2023 Apr 13:163433.
573. Jaiswal S, Sharma B, Shukla P. Integrated approaches in microbial degradation of plastics. Environmental Technology & Innovation. 2020 Feb 1;17:100567.
574. Colijn I, Fraiture F, Gommeh E, Schroën K, Metze T. Science and media framing of the future of plastics in relation to transitioning to a circular economy. Journal of Cleaner Production. 2022 Oct 10;370:133472.
575. Dugo G, Mancuso T, Massa C, Zerbo A, Gatto S. Recycling of plastic materials obtaining second raw materials in a circular economy perspective. Procedia Environ Sci Eng Manag. 2020;7:167-74.
576. Liu L, Xu M, Ye Y, Zhang B. On the degradation of (micro) plastics: Degradation methods, influencing factors, environmental impacts. Science of the Total Environment. 2022 Feb 1;806:151312.
577. Arena U, Ardolino F. Technical and environmental performances of alternative treatments for challenging plastics waste. Resources, Conservation and Recycling. 2022 Aug 1;183:106379.
578. Meys, R., Frick, F., Westhues, S., Sternberg, A., Klankermayer, J., and Bardow, A., "Towards a circular economy for plastic packaging waste - the environmental potential of chemical recycling", Resouces, Conservation and Recycling, v. 163, 2020, 105101.
579. Vasiljević D. Organic and natural cosmetic products-who benefits the most?. Arhiv za farmaciju. 2021;71(5 suplement):S26-7.
580. Lewandowski K, Skórczewska K. A brief review of poly (vinyl chloride)(PVC) recycling. Polymers. 2022 Jul 27;14(15):3035.
581. Mikula K, Skrzypczak D, Izydorczyk G, Warchoł J, Moustakas K, Chojnacka K, Witek-Krowiak A. 3D printing filament as a second life of waste plastics—a review. Environmental Science and Pollution Research. 2021 Mar;28:12321-33
582. Zhao P, Xie J, Gu F, Sharmin N, Hall P, Fu J. Separation of mixed waste plastics via magnetic levitation. Waste Management. 2018 Jun 1;76:46-54.
583. Zhang M, Zhang Y, Li C, Jing N, Shao S, Wang F, Mei H, Rogers KM, Kong X, Yuan Y. Identification of biodegradable plastics using differential scanning calorimetry and carbon composition with chemometrics. Journal of Hazardous Materials Advances. 2023 May 1;10:100260.
584. Wang J, Tang M, Wang H. Research on the Design of Intelligent Recycling System for Cosmetics Based on Extenics. Procedia Computer Science. 2022 Jan 1;199:937-45.
585. Beitzen-Heineke EF, Balta-Ozkan N, Reefke H. The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain. Journal of Cleaner Production. 2017 Jan 1;140:1528-41.
586. Babaremu K, Oladijo OP, Akinlabi E. Biopolymers: A suitable replacement for plastics in product packaging. Advanced Industrial and Engineering Polymer Research. 2023 Jan 13.
587. Crupi, V.; Epasto, G.; Napolitano, F.; Palomba, G.; Papa, I.; Russo, P. Green Composites for Maritime Engineering: A Review. J. Mar. Sci. Eng. 2023, 11, 599
588. Coltelli MB, Bertolini A, Aliotta L, Gigante V, Vannozzi A, Lazzeri A. Chain extension of poly (Lactic acid)(pla)–based blends and composites containing bran with biobased compounds for controlling their processability and recyclability. Polymers. 2021 Sep 9;13(18):3050.
589. Pratap JK, Krishnan K. Microbial Production of Polyhydroxyalkonates (Bioplastic) using Cheap Household Waste Resources and Their Biomedical Applications: A Systematic Review. Letters in Applied NanoBioScience 2023 12(4) 174.
590. Lomartire S, Marques JC, Gonçalves AM. An overview of the alternative use of seaweeds to produce safe and sustainable bio-packaging. Applied Sciences. 2022 Mar 18;12(6):3123.
591. Shrivastava A, Dondapati S. Biodegradable composites based on biopolymers and natural bast fibres: A review. Materials Today: Proceedings. 2021 Jan 1;46:1420-8.
592. Reichert CL, Bugnicourt E, Coltelli MB, Cinelli P, Lazzeri A, Canesi I, Braca F, Martínez BM, Alonso R, Agostinis L, Verstichel S. Bio-based packaging: Materials, modifications, industrial applications and sustainability. Polymers. 2020 Jul 14;12(7):1558.
593. Ahari H, Golestan L, Anvar SA, Cacciotti I, Garavand F, Rezaei A, Sani MA, Jafari SM. Bio-nanocomposites as food packaging materials; the main production techniques and analytical parameters. Advances in Colloid and Interface Science. 2022 Dec 1;310:102806.

594. Mukhtar I, Leman Z, Ishak MR, Zainudin ES. Sugar palm fibre and its composites: A review of recent developments. BioResources. 2016 Nov 1;11(4):10756-82.
595. Arif ZU, Khalid MY, Sheikh MF, Zolfagharian A, Bodaghi M. Biopolymeric sustainable materials and their emerging applications. Journal of Environmental Chemical Engineering. 2022 Aug 1;10(4):108159.
596. Singh S, Naik N, Sooriyaperakasam N, Iyer T, Agarwal C, Tirupathi J, Al Abdali M. A Comprehensive Review of Banana Fiber-Reinforced Composites: Properties, Processing and Applications. Journal of Computers, Mechanical and Management. 2022 Dec 31;1(2):36-49.
597. Zhang Y, Duan C, Bokka SK, He Z, Ni Y. Molded fiber and pulp products as green and sustainable alternatives to plastics: A mini review. Journal of Bioresources and Bioproducts. 2022 Feb 1;7(1):14-25.
598. Løvbak Berg L, Klepp IG, Sigaard AS, Broda J, Rom M, Kobiela-Mendrek K. Reducing Plastic in Consumer Goods: Opportunities for Coarser Wool. Fibers. 2023 Jan 28;11(2):15.
599. Fernandes EM, Lobo FC, Faria SI, Gomes LC, Silva TH, Mergulhão FJ, Reis RL. Development of Cork Biocomposites Enriched with Chitosan Targeting Antibacterial and Antifouling Properties. Molecules. 2023 Jan 18;28(3):990.
600. Moustafa H, Youssef AM, Darwish NA, Abou-Kandil AI. Eco-friendly polymer composites for green packaging: Future vision and challenges. Composites Part B: Engineering. 2019 Sep 1;172:16-25.
601. Gigante, V.; Aliotta, L.; Canesi, I.; Sandroni, M.; Lazzeri, A.; Coltelli, M.-B.; Cinelli, P. Improvement of Interfacial Adhesion and Thermomechanical Properties of PLA Based Composites with Wheat/Rice Bran. Polymers 2022, 14, 3389.
602. Udayakumar GP, Muthusamy S, Selvaganesh B, Sivarajasekar N, Rambabu K, Banat F, Sivamani S, Sivakumar N, Hosseini-Bandegharaei A, Show PL. Biopolymers and composites: Properties, characterization and their applications in food, medical and pharmaceutical industries. Journal of Environmental Chemical Engineering. 2021 Aug 1;9(4):105322.
603. Abdur Rahman M, Haque S, Athikesavan MM, Kamaludeen MB. A review of environmental friendly green composites: production methods, current progresses, and challenges. Environmental Science and Pollution Research. 2023 Feb;30(7):16905-29.
604. Briassoulis D, Pikasi A, Hiskakis M, Arias A, Moreira MT, Ioannidou SM, Ladakis D, Koutinas A. Life-cycle sustainability assessment for the production of bio-based polymers and their post-consumer materials recirculation through industrial symbiosis. Current Opinion in Green and Sustainable Chemistry. 2023 Apr 10:100818.
605. Lunt, J., "Large-scale production, properties and commercial applications of polylactic acid polymers", Polymer Degradation and Stability, v. 59, 1998, pp. 145-153.
606. "Plastic compost produced from corn", USA Today Magazine, v. 126 Is. 2637, Jun 1998, p. 10.
607. Lim, L.-T., Auras, R., and Rubino, M., "Processing technologies for poly(lactic acid)", Progress in Polymer Science, v. 33, 2009, pp. 820-852.
608. Yang, Y., Murakami, M., and Hamada, H., "Molding Method, Thermal and Mechanical Properties of Jute/PLA Injection Molding", Journal of Polymers and the Environment, v. 20, 2012, pp. 1124-1133. DOI 10.1007/s10924-012- 0565-8.
609. Xia, X., Liu, W., Zhou, L., Liu, H., He, S., and Zhu, C., "Study on flax fiber toughened poly (lactic acid) composites", Journal of Applied Polymer Science, 2015. DOI: 10.1002/APP.42573.
610. Chaitanya, S., and Singh, I., "Processing of PLA/sisal fiber biocomposites using direct- and extrusion-injection molding", Materials and Manufacturing Processes, v. 32, no. 5, 2017, pp. 468-474. http://dx.doi.org/10.1080/10426914.2016.1198034.
611. Akindoyo, J. O., and Beg, M. D. H., "Effects of poly(dimethyl siloxane) on the water absoption and natural degradation of poly(lactic acid)/oil-palm empty-fruit-bunch fiber bicomposites", Journal of Applied Polymer Science, v. 132, Is. 45, 2015, 42784.
612. Suryenegara, L., Okumura, H., Nakagaito, A. N., and Yano, H., "The synergistic effect of phelylphosphonic acid zinc and microfibrillated celluloe on the injection molding cycle time of PLA composites", Cellulose, v. 18, 2011, pp. 689- 698. DOI 10.1007/s10570-011-9515-1.
613. Herrera N., Roch, H., Salaberria, A. M., Pino-Orellana, M. A., Labidi, J., Fernandes, S. C. M., Radic, D., Leiva, A., and Oksman, K., "Functionalized blown films of plasticized polyactic acid/chitin nanocomposite: Preparation and characterization", Materials and Design, v. 92, 2016, pp. 846-852.

614. Gunning, M. A., Geever, L. M., Killion, J. A., Lyons, J. G., and Higginbotham, C. L., "The effect of processing conditions for polylactic acid based fibre composites via twin-screw extrusion", Journal of Reinforced Plastics and Composites, v. 33 no. 7, 2014, pp. 648-662. DOI: 10.1177/0731684413512225
615. Leistriz, C. M., "Compounding PLA on Twin-Screws: What Testing Reveals", Plastics Technology, April 2014, pp. 50- 52.
616. Dhar, P., Gaur, S. S, Soundararajan, N., Gupta, A., Bhasney, S. M., Milli, M., Kumar, A., and Katiyar, V., "Reactive Extrusion of Polylactic Acid/Cellulose Nanocrystal Films for Food Packaging Applications: Influence of Filler Type on Thermomechanical, Rheological and Barrier Properties", Industrial and Engineering Chemistry Research, v. 56, Is. 16, 2017, pp. 44718-4735. DOI: 10.1021/acs.iecr.6b04699
617. Murariu, M., Bonnaud, L., Paint, Y., Fontaine, G., Bourbigot, S., and Dubois, P., 'New trends in polylactic (PLA)- based materials: "Green" PLA-Calcium sulfate (nano)composites tailored with flame retardant properties", Polymer Degradation and Stability, v. 95, 2010 pp. 374-381.
618. Murariu, M., Paint, Y., Murariu, O., Raquez, J.-M., Bonnaud, L., Dubois, P., "Current Progress in the production of PLA-ZnO nanocomposites: Beneficial effects of chain extender addition on key properties", Journal of Applied Polymer Science, 2015, DOI: 10.1002/APP.42480.
619. Heidari, B. S., Oliaei, R., Shayesteh, H., Davachi, S. M., Hejazi, I., Seyfi, J., Bahrami, M., and Rashedi, H., "Simulation of mechanical behavior and optimization of simulated injection molding process for PLA based antibacterial composite and nanocomposite bone screws using central composite design", Journal of the Mechanical Behavior of Biomedical Materials, v. 65, 2017, pp. 160-176.
620. Wang, M.-W., Fu, G.-L., and Jeng, J.-H., "Optimal Molding Parameter Design of PLA Micro Lancet Needles using Taguchi Method", IEEE International Conference on Service Operations and Logistics, and Informatics, 12-15 October, 2008.
621. Schafer, H., Preschuh, C., and Bruggemann, O., "Reduction of cycle times ininjection molding of PLA through bio- based nucleating agents", European Polymer Journal, v. 115, 2019, pp. 6-11.
622. Liparoti, S., Speranza, V., and Pantani, R., "Replication of Micro- and Nanofeatures in Injection Molding of Two PLA Grades with Rapid Surface-Temperature Modulation", Materials, v. 11, 2018m 1442. doi:10.3390/ma11081442.
623. Aumnate, C., Soatthiyanon, N., Makmoon, T., and Potiyaraj, P., "Polylactic acid/kenaf cellulose biocomposite filaments for melt extrusion based-3D printing", Cellulose, 2021. https://doi.org/10.1007/s10570-021-04069-1
624. Komal, U. K., Kasaudhan, B. K., and Singh, I., "Comparative Performance Analysis of Polylactic Acid Parts Fabricated by 3D Printing and Injection Molding", Journal of Materials Engineering and Performance, 2021. https://doi.org/10.1007/s11665-021-05889-9
625. Cervantes-Uc, J. M., Cauich-Rodriguez, J. V., Vazques-Torres, H., Garias-Mesias, L. F., and Paul, D., R., "Thermal degradation of commercially available organoclays studied by TGA-FTIR", Thermochimica Acta, v. 457, 2007, pp. 92-102.
626. Brdlik, P., Boruvka, M., Behalek, L., and Lenfeld, P., "Biodegradation of Poly(Lactic Acid) Biocomposites under Controlled Composting Conditions and Freshwater Biotopes", Polymers, v. 13, 2021, 594. https://doi.org/10.3390/polym13040594
627. Jiang, N., Yu, T., and Li, Y., "Effect of Hydrothermal Aging on Injection Molded Short Jute Fiber Reinforced Poly(Lactic Acid) (PLA) Composites", Journal of Polymers and the Environment, v. 26, 2018, pp. 3176-3186. https://doi.org/10.1007/s10924-018-1205-8
628. Aguero, A., del Camern Morcillo, M., Quiles-Carrillo, L., Balrart, R., Boronat, T., Lascano, D., Torres-Giner, S., and Fenollar, O., "Study of the Influence of the Reprocessing Cycles on the Final Properties of Polylactide Pieces Obtained by Injection Molding", Polymers, v. 11, 2019, 1908. doi:10.3390/polym11121908.
629. Akesson, D., Fazelinejad, S., Skrifvars, V.-V., and Skrifvars, M., "Mechanical reclying of polylactic acid composites reinforced with wood fibres by multiple exrusion and hydrothermal aging", Journal of Reinforced Plastics and Composites, v. 35 no. 16, 2016, pp. 1248-1259.
630. Peinado, V., Castell, P., Garcia, L., and Fernandez, A., "Effect of Extrusion on the Mechanical and Rheological Properties of a Reinforced Poly(Lactic Acid): Reprocessing and Recycling of Biobased Materials", Materials, v. 8, 2015, pp. 7106-7117.
631. Fytinos, G., Rahdar, A., and Kyzas, G. Z., "Nanomaterials in Cosmetics: Recent Updates", Nanomaterials, v. 10, 2020, 979.

632. Coltelli, M.-B., Panariello, L., Morganti, P., Danti, S., Baroni, A., Lazzeri, A., Fusco, A., and Donnarumma, G., "Skin- Compatible Biobased Beauty Masks Prepared by Extrusion", Journal of Functional Biomaterials, v. 11, 2020, 23.
633. Coltelli, M.-B., Aliotta, L., Vannozzi, A., Morganti, P., Panariello, L., Dani, S., Neri, S., Fernandez-Avila, C., Fusco, A., Donnarumma, G., and Lazzeri, A., "Properties and Skin Compatibility of Films Based on Poly(Lactic Acid) (PLA) Bionanocomposites Incorporating Chitin Nanofibrils (CN)", Journal of Functional Biomaterials, v. 11, 2020, 21
634. Coltelli, M.-B., Cinelli, P., Gigante, V., Aliotta, L., Morganti, P., Panariello, L., and Lazzeri, A., "Chitin Nanofibrils in Poly(Lactic Acid)(PLA) Nanocomposites: Disperion and Thermo-Mechanical Properties", International Journal of Molecular Sciences, v. 20, 2019, 504.
635. Morganti, P., Yudin, V. E., Morganti, G., and Coltelli, M.-B., "Trends in Surgical and Beauty Masks for a Cleaner Environment", Cosmetics, v. 7, 2020, 68.
636. Vidal CP, Luzi F, Puglia D, López-Carballo G, Rojas A, Galotto MJ, de Dicastillo CL. Development of a sustainable and antibacterial food packaging material based in a biopolymeric multilayer system composed by polylactic acid, chitosan, cellulose nanocrystals and ethyl lauroyl arginate. Food Packaging and Shelf Life. 2023 Apr 1;36:101050.
637. Manfra L, Marengo V, Libralato G, Costantini M, De Falco F, Cocca M. Biodegradable polymers: A real opportunity to solve marine plastic pollution?. Journal of Hazardous Materials. 2021 Aug 15;416:125763.
638. Fredi G, Dorigato A. Recycling of bioplastic waste: A review. Advanced Industrial and Engineering Polymer Research. 2021 Jul 1;4(3):159-77.
639. Husted, B. W.; de Sousa-Filho, J. M. The impact of sustainability governance, country stakeholder orientation, and country risk on environmental, social, and governance performance. Journal of Cleaner Production, 2017, 155, 93–102.