Tracing the Roots, Envisioning the Future: An Exploration of Sustainable Design Evolution

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Content

1. Abstract

The objective of this research is to investigate the origins of sustainable design, comprehend its present status, and project its future development. The thesis is structured into three main parts. Firstly, I conducted historical research into sustainable design, delving into its developmental trajectory. In the second part, I examined the contemporary Chinese and Dutch markets to analyze the current state of sustainable design. Subsequently, I formulated a taxonomy to depict the prevailing conditions of sustainable design.

In the final section, I employed inductive reasoning to derive a sustainable development model. However, due to the intricate nature of sustainable design and the multitude of factors influencing its dynamics, I refrained from providing a definitive portrayal of future sustainable design. Instead, I focused on exploring the practical application of the sustainable design development model.

2. Introduction

In contemporary discourse, the term "sustainability" has gained substantial prominence within the domain of design and various other disciplines. It is commonplace to encounter expressions such as "we value sustainability" when perusing design challenges or advertisements from companies engaged in providing products or services.

This situation started with the rise of Modern environmentalism, which emerged in the 20th century and continues to evolve in addressing environmental challenges and advocating for sustainability. It encompasses a range of activities and perspectives aimed at protecting and preserving the natural environment, promoting ecological balance, and addressing human impacts on ecosystems (Eckersley, 2004).

The starting point of modern environmentalism can be traced back to the mid-20th century, particularly to the 1960s and 1970s. During this period, there was a growing awareness and concern about the negative impacts of human activities on the environment (Carson, 1962; Dunlap & Catton Jr, 1979). Rachel Carson's book "Silent Spring" (1962) played a crucial role in this regard, as it shed light on the detrimental effects of pesticides and triggered public discourse on environmental protection (Carson, 1962). The book is widely regarded as a catalyst for the modern environmental movement.

The ascent of environmental concerns can also be observed through the establishment of notable environmental organizations, including The Nature Conservancy (1951), World Wildlife Fund (1961), Environmental Defense Fund (1967), Friends of the Earth (1969), Greenpeace (1971), Earthjustice (1971), Green Belt Movement (1977), and Rainforest Action Network (1985), among others. These organizations, renowned for their environmental endeavors, represent just a fraction of the numerous entities operating in this sphere. Simultaneously, designers have also contributed to the discourse on environmental issues, as exemplified by Jochen Gros' creation of the Tire sofa in 1974 (Bürdek, 1996).

Whether it is the work of researchers like Carson, the initiatives undertaken by environmental organizations, or the contributions made by designers like Gros, the underlying principle of sustainability revolves around minimizing environmental footprints and conserving resources. Consequently, these collective efforts by various entities have played a significant role in shaping both society and individuals of that era, while simultaneously exerting a profound influence on contemporary society.

In light of the aforementioned factors, it is comprehensible why the word sustainable engulfed our daily life. However, these factors fail to elucidate the underlying reasons behind the widespread adoption of the pursuit of a sustainable environment as a prevalent and seemingly enduring issue. This uncertainty shapes the question of our study.

2.1. Research question

From a design standpoint, it is imperative to explore the role of design in the emergence and proliferation of sustainability as a prominent social trend. In essence, how has design contributed to the widespread attention garnered by sustainability? Conversely, how has this trend influenced contemporary design practices?

A retrospective examination of design history reveals a consistent pattern wherein subsequent concepts or artistic genres react in close relation to their predecessors, often triggered by emerging events or technologies. For instance, Dadaism emerged as a reaction against traditional art styles such as Rococo and Baroque following World War I, the Arts and Crafts movement responded to the Industrial Revolution, and modernism arose in response to both the Industrial Revolution and the Arts and Crafts movement, particularly in the aftermath of World War II. Subsequently, postmodernism reacted to modernism as economies recovered from the war.

This observation leads to a thought-provoking research question: What are the origins of sustainable design, and what circumstances prompted its emergence? What is its present state? How might it progress in the future? Could this evolution spark a new trend in design?

3. Approach

The initial step of this historical research involves conducting a historical case study, serving several crucial purposes. Firstly, it aids in gaining a clear understanding of the developmental trajectory of sustainable design. By examining the timeline of sustainable design history alongside pertinent events of that era, we can roughly trace the origins and evolutionary path of sustainable design. This process helps establish a robust knowledge base, laying the groundwork for analyzing contemporary sustainable design and envisioning its future direction.

During this historical research phase, internet search engines served as the primary research tools. Google, being widely used globally, and Baidu, a prominent Chinese search engine, were utilized. Search terms such as "sustainable design," "sustainable industrial design,"

"green design," "socially responsible design," and other keywords aligned with the modern concept of sustainable industrial design were employed (Bhamra & Lofthouse, 2012). Identified sustainable design works were carefully screened, leading to the creation of a chronological timeline.

It is crucial to note that in this study, "unqualified" sustainable design refers to student works. This distinction is made because student works are more likely to contain flaws and misconceptions about the design process compared to professional designers' works, potentially disrupting our analysis of the true state of sustainable design. Additionally, for years with limited sustainable design content, keywords specific to that time period, such as "sustainable design in the 1950s," were included to ensure comprehensive coverage.

After conducting the historical research, I have selected several contemporary examples of sustainable design for in-depth case studies. These case studies will assist me in comprehending the various types of sustainable design prevalent today and in evaluating whether contemporary sustainable design continues to progress along its historical trajectory. To assess the status of this "global trend" across different nations, I have compared the markets of the two countries I am most familiar with, China and the Netherlands, in a way that I will describe in more detail in the corresponding chapters. This comparative study not only enhanced my understanding of the global sustainability process but also provided valuable insights into the principles governing the development of sustainable design.

Having completed the investigation into the history and current state of sustainable design, I am now positioned to explore its future prospects. In this section, I have chosen two representative product categories for qualitative case studies and applied the idea of inductive reasoning to derive general principles of sustainable design development from these specific cases.

4. Context

4.1. From design to industrial design

Before we look at sustainable design, we should first look into it's background and understand what is design. Design activity is a broad and multifaceted concept that encompasses the creation and planning of various objects, systems, processes, or experiences with a specific purpose in mind, it's target is everything in our life (Design Council, n.d.). It involves a combination of aesthetics, functionality, and problem-solving. Its historical roots extend deep into the annals of human existence, finding expression in activities as ancient as the crafting of stone knives, the construction of dwellings, the architectural splendor of ecclesiastical edifices, and the craftsmanship behind wooden shelving, etc.

Prior to the 19th century, these creative practices were predominantly the domain of individuals, families, or small-scale enterprises. Their impact remained constrained and primarily localized (MacKenzie, 2018). However, with the advent of the Industrial Revolution

in the 19th century, design underwent a profound metamorphosis, emerging as an autonomous and professional discipline, wielding formidable influence on a global scale, thanks to the burgeoning era of mass production. This novel iteration of design, named as "industrial design," assumed a pivotal role in shaping the contours of the contemporary world.

To facilitate a systematic discourse on these two distinct typologies of design in the context of this research, we shall henceforth refer to the traditional paradigm as "generic design" while the modern iteration stay "industrial design."

4.1.1. Industrial design

The rise of modern industrial design is often associated with the late 19th and early 20th centuries, particularly the period between the late 1800s and the mid-20th century. This era saw significant developments in design principles, materials, and manufacturing processes that laid the foundation for what we now consider modern industrial design (Fiell & Fiell, 2001).

The sudden rise of industrial design was closely related to the first Industrial Revolution, which began in the late 18th century and continued into mid-19th century, as it was the consequence of the technological and economic changes brought by this transformative period of history. The reasons are varied, for example, The Industrial Revolution introduced new technologies and manufacturing processes, such as steam power, mechanization, and mass production, that allowed for the efficient and cost-effective production of goods. These advancements created a need for design solutions to accommodate the mass production of products (Bohemia, 2000).

Nonetheless, it is imperative to note that the ascendancy of industrial design does not signify the obsolescence of generic design. In fact, even in the contemporary milieu, family-based small handicraft practices continue to flourish (Angat & Hasan, 2023). Industrial design can be better understood as an offshoot or specialized branch of generic design, with an exclusive focus on industrial applications and a profound impact on human society. Yet, it is worth contemplating the sustainability of such impact.

The inexorable pursuit of survival and profit compels companies in the industrial sphere to continually augment their production capacity (Jackson, 2009). Nevertheless, the world's populace is finite, as are the territories available for product distribution. To address this paradox, companies find themselves compelled to stimulate infinite demand among a finite consumer base. One strategy is to promote iterations of existing products that, in truth, bear minimal differentiation from their predecessors. However, these new iterations can provoke consumer proclivity, particularly by insinuating that the previous iterations have become passé (Bulow, 1986).

In effect, many facets of our daily existence are meticulously choreographed by marketing activities (Bakan, 2004). This orchestrated marketing has fomented an unprecedented yearning for material possessions, with individuals increasingly fixated on the superficial qualities of objects. Considerations such as product comfort, the social cachet they confer, and their aesthetic allure now wield considerable influence over consumer preferences.

As a result, industrial design has been closely entwined with company's profit (Seider et al., 2016). Designers' ingenuity breathes new life into products, either by keeping them current or incorporate them with added connotations, rendering commercial goods more profitable and competitive in the marketplace. This dynamic not only secures businesses' survival but also significantly enhances the material world we inhabit.

In this milieu, it is evident that designers wield considerable influence, as one of their ultimate objectives, regardless of the means employed, revolves around evoking people's materialistic desires, thereby enticing them to make purchases. However, materialistic desires are insatiable (Lee & Ahn, 2016). This implies that once awakened, these desires drive individuals to continually seek more, both in terms of quantity and quality. People perpetually yearn for objects that are more aesthetically pleasing, comfortable, technologically advanced, and, most significantly, more abundant. Much like how a lady, unburdened by financial constraints, succumbs to the temptation of acquiring yet another exquisite handbag after procuring one, or how a man, having acquired a renowned timepiece, finds his watch collection swiftly expanding to encompass an assortment of horological treasure. This overarching phenomenon, characterized by an insatiable desire for material goods and the prioritization of conspicuous consumption, has been succinctly encapsulated as "consumerism." (Papanek, 1985).

The relentless pursuit of ever-increasing demand has led to the depletion of resources across various dimensions within factories and enterprises. This resource depletion encompasses not only the consumption of raw materials extracted from the natural environment in the manufacturing of products but also the human resources, such as workers, expended in the intricate processes of product design and production (SACOM, 2011). In addition, it may also lead to social estrangement and forced use of unnecessary goods and human resources (Turkle, 2011). To illustrate, consider the quest to develop a more sensitive and seamless smartphone screen. This necessitates continual press in screen-related technology and the employment of dedicated technology researchers. Alternatively, if the goal is to reduce product costs, companies may opt to lower workers' wages or extend their working hours to enhance production output, a practice equals to squeezing labor resources. Furthermore, augmenting production levels often requires an increased demand for resources from the natural environment, manifesting as a direct squeeze on the environment itself.

Designers, as the architects of these endeavors, find themselves caught in the crossfire as soon as the relentless squeezing cycle commences. They are subjected to unending requests for novel and innovative ideas, and their creative resources are stretched to their limits. However, this squeezing process is intrinsically unsustainable. Natural resources are finite and will inevitably be depleted over time. The pace of technological advancement may fail to keep up with the relentless corporate squeezing, potentially leading to technological bottlenecks. Workers, too, may find themselves overwhelmed by the intensifying demands and working conditions, potentially leading to labor disputes and strikes.

Consequently, the material world of this era can be aptly characterized as one where the ultimate goal is profit, the means to attain it is design, and the consequence is the depletion of vital resources. This phenomenon invariably establishes the groundwork for the emergence

of sustainable design. In the following sections, **we will delve into the emergence of sustainable design during the mid-20th century,** viewed through the lens of design as a means to a more enduring and balanced end.

4.1.2. Sustainable design

The modern definition of sustainable design, also known as green design or environmentally sustainable design, refers to the practice of creating products, buildings, and systems that minimize their environmental impact and resource consumption throughout their lifecycle. In more detail, it is about controlling the environmental impact of products during their design, production, material selection, sale, use, disposal and recycling process. The goal of sustainable design is to meet present needs without compromising the ability of future generations to meet their own needs. This approach involves considering ecological, social, and economic factors to create solutions that are environmentally responsible, energy-efficient, socially equitable, and economically viable (Bhamra & Lofthouse, 2012). The delineation of sustainable design is an ongoing and dynamic process, subject to continuous evolution. Concurrently, the manner in which designers and corporations operationalize sustainable design undergoes transformations, resulting in varying perceptions of sustainable design across distinct historical stages. A comprehensive comprehension of the historical trajectory of sustainable design is instrumental in elucidating its contemporary manifestations and forecasting its prospective developments. Accordingly, this section aims to delineate and assess the historical timeline of sustainable design, thereby facilitating an elucidation of sustainability in practical application.

The dawn of sustainable design

During the late 19th and early 20th centuries, influential architects like Frank Lloyd Wright believed in translating emotions through construction and bringing self-awareness through architectural manifestations that are intricately associated with nature and our experience in nature. Although the term "sustainable design" had not yet emerged, he had a deep connection to nature and explicitly incorporated sustainable design elements such as native plants, natural ventilation, and repurposed materials into his projects (Baer & Hamilton, 2014). Earning recognition as one of the pioneering architects to integrate environmental considerations into design, he often found his bioclimatic principles and construction solutions overlooked. Nevertheless, these aspects played a crucial role in enhancing thermal comfort and energy efficiency across his designs (Beltrán-Fernández et al., 2017). This example illustrates what appears to be an initial design explicitly incorporating environmental factors into its design principles (Figure 1). However, the mere inclusion of such factors does not necessarily render it the inaugural instance of sustainable design on a global scale. It is plausible that there exist designs aligning with the principles of sustainable design without a conscious acknowledgment or advocacy of their sustainable attributes. Consequently, the identification of the foremost occurrence of sustainable design becomes an elusive task.

Figure 1 Frank Lloyd Wright–'Fallingwater'-1935

Nevertheless, our differentiation between generic design and industrial design may offer valuable insights and guide further exploration in this regard. Given that we classify design activity into two broad categories, namely generic design and industrial design, a parallel classification may be applied to sustainable design activity, yielding two distinct subcategories: sustainable generic design and sustainable industrial design. This proposition posits that sustainable generic design may have existed since the inception of generic design, whereas industrial sustainable design became apparent in the aftermath of the industrial revolution. Adopting this conceptual framework allows for a concise examination of design history, facilitating an enhanced understanding of various forms of sustainable design encountered over time.

Starting with ancient generic design (Early design stage)

Preceding the advent of industrial design, generic design had a longstanding existence, hinting at the potential prevalence of ancient sustainable design practices. It is crucial to clarify that when alluding to "sustainable design" in this context, we are not specifically referencing designs proclaiming themselves as sustainable or adhering to the contemporary conceptualization of sustainable design. Instead, we refer to designs that conform to the parameters delineated by the contemporary definition of sustainable design—possessing sustainable attributes, albeit not necessarily with an explicit intent towards sustainability.

Nevertheless, the endeavor to trace back to the initial instance of sustainable design is deemed impracticable and, moreover, unnecessary. The overarching objective of this chapter is to comprehend the evolutionary trajectory of sustainable design over time and elucidate the rationale behind this evolution, rather than to establish the definitive genesis of sustainable design.

The initial phase under examination predates the industrial revolution and is characterized by a design ethos, classified in this research as generic design. This period is distinguished by a pronounced emphasis on craftsmanship, individualized production, and a close connection to local traditions and artistic influences. Hence, we denote this phase as the early design stage. Within this context, numerous instances of generic sustainable design may be discerned.

For example, a Chinese famer, in a thousand years ago, who "designed" a toilet so that he could conveniently remove his excrement and bury it in his farmland to fertilize the land (Liu et al., 2014), the essence of this farmer's innovation aligns remarkably well with our contemporary concept of sustainable product design. Notably, the construction of such a toilet entailed minimal resource and energy consumption, yielded zero waste during production, boasted durability, and remained unaffected by shifts in aesthetics. More importantly, it effectively transformed human excrement into a reusable, organic, and environmentally friendly fertilizer. Such resource-conscious design has manifested throughout the annals of history, spanning from ancient times to the present day (Figure 2). Yet, it becomes evident that none of these instances can be neatly categorized as the catalyst for the emergence of modern sustainable design.

Figure 2 A dry pit latrine on the edge of a cornfield, a structure still used in parts of rural China.

Another illustrative case is the historical utilization of wind power by humans. The inception of Post Mills (Figure 3), an early form of windmill, can be traced back to the 11th century, with subsequent centuries witnessing the development of more sophisticated Tower and Smock mills. England and the Netherlands emerged as prominent homes for these windmills, although various other European countries also embraced and integrated windmills into their respective landscapes. These windmills played a pivotal role in powering diverse production activities, including irrigation, sawmilling, and flour production.

Figure 3 Post mill, rebuild in the open air museum Cloppenburg, Germany. The mill has presumably been build in 1683 at Essern, District of Nienburg Germany

Crucially, these windmills harnessed the power of the wind—a sustainable resource—while generating no waste, aligning seamlessly with the principles of modern sustainable design. However, it is imperative to note that, as previously mentioned, these designs are not strictly sustainable design, as their designers may not have actively considered the environmental impact and sustainability of other parts of the product's lifecycle in addition to its durability. Nonetheless, they hold significant importance in elucidating the fundamental principles of modern sustainable design and its historical trajectory (Figure 4). In this figure, the x-axis represents time, and to the right is the direction of time. y-axis shows the collection of sustainable design cases in the corresponding time at x-axis. During the case searching process, the first case retrieved is nearest to the x-axis. The brown color represents ancient times with a longer time span, while the cyan color represents a particular year or decade.

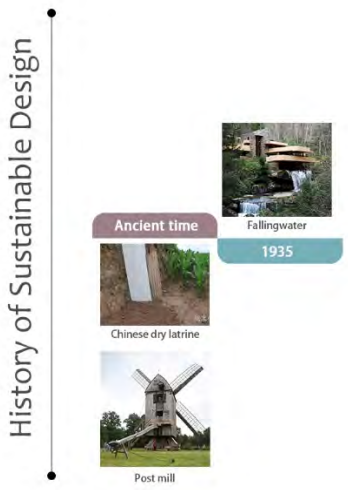


Figure 4 History of Sustainable design-part1

Early industrial stage

As previously indicated, industrial design found its genesis during the industrial revolution (Gantz, 2010). Subsequent to this revolution, humanity transitioned into the industrial age in the 19th century. In the period spanning from this transition and preceding several significant environmental and energy-related crises in the mid-20th century, there was a conspicuous absence of design initiatives incorporate sustainable factors (Figure 5). Nevertheless, a noteworthy phenomenon emerged wherein certain industrial products coincidentally adhered to sustainable design principles.

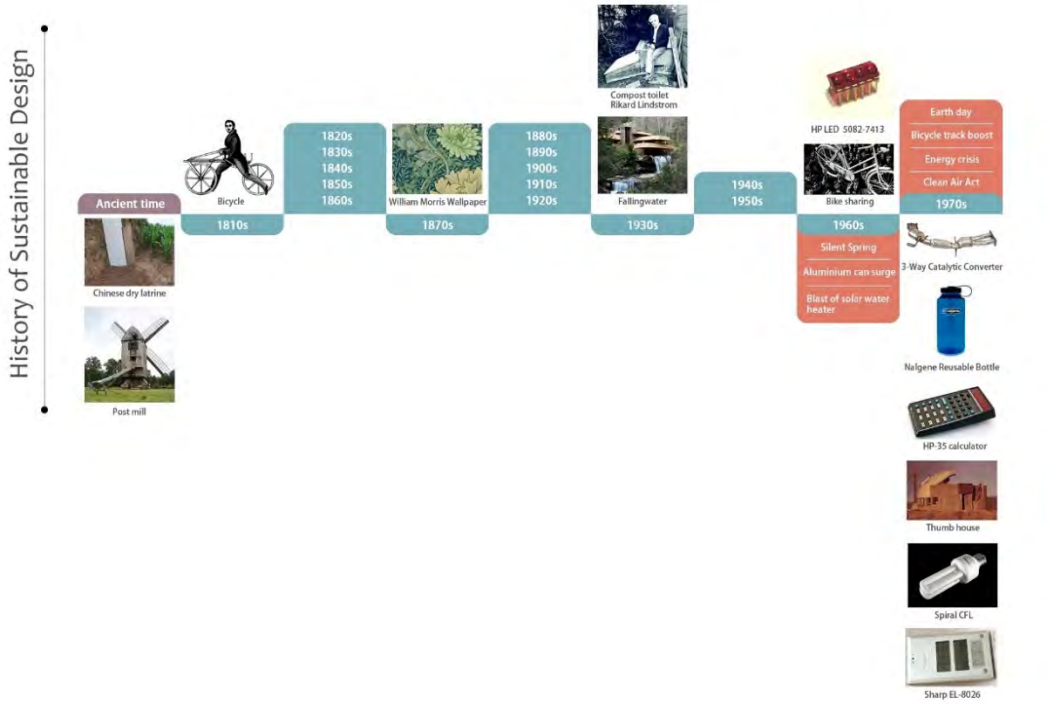


Figure 5 History of Sustainable design-part2. The orange sections show the major sustainability-related events that took place in the corresponding year.

The bicycle serves as an illustrative example. Its invention was not originally conceived with sustainability as one of the primary objectives. Instead, the bicycle was primarily developed to furnish a mode of transportation conducive to daily activities and recreation, with little consideration given to the reduction of environmental pollution (Horton & Parkin, 2012).

Conversely, examples of generic sustainable design persist, and some of them are rather modern, aligning not only with contemporary sustainable design principles but also sharing a common objective with modern sustainable design. An exemplar of such modernity is observed in the wallpaper design "Peacock and Dragon" by William Morris. In his textile designs, Morris prioritized the utilization of natural materials, including wool and linen. This deliberate choice not only enhanced the durability of the products but also adhered to an eco-friendly approach, eschewing synthetic materials prevalent in mass-produced goods.

Furthermore, Morris staunchly rejected the notion of disposable and transient design. His patterns drew inspiration from medieval and nature motifs, embodying a timeless quality that transcended prevailing trends. This enduring design philosophy contributes to sustainability by mitigating the necessity for frequent replacements. Notably, during the late 19th to the early 20th century, the Arts and Crafts Movement, championed by figures such as William Morris, actively sought to rekindle traditional craftsmanship and advocate for sustainable practices. This movement, a departure from mass production, emphasized handmade goods, the use of natural materials, and the harmonious integration of design with nature (Miller, 2011). Consequently, we encounter an early exemplification of modern sustainable design

within this historical context.

Environmental awareness stage

Moving into the 1970s, a sequence of events unfolded, including the energy crisis, the revelation of environmental side effects associated with pesticides, the publication of "Silent Spring," and the release of "The Limits to Growth" into the market, resulting a notable surge in environmental awareness unfolded, epitomized by events such as the inaugural Earth Day in 1970. This era marked the inception of a deliberate integration of environmental considerations into design practices. And this stage also witnesses a burst of modern sustainable design (Figure 5).

The first instance is the Nalgene Reusable Water Bottle designed by Marsh Hyman in 1970. The introduction of the Nalgene bottle marked a watershed moment, transcending its utilitarian function to become an emblem of an active and environmentally conscious outdoor lifestyle. Its unveiling coincided with the inaugural Earth Day celebration in 1970, a period when the notion of reusing drinking bottles was gaining traction. Nalgene provided a straightforward solution, particularly aligned with the burgeoning "Carry In/Carry Out" campground policies, discouraging campers from incinerating or burying their bottles and cans.

The second illustrative instance is the Thumb House, designed by Michael Reynolds in 1972. This structure exemplifies an Earthship house, a distinctive architectural style that emerged in the late 20th century and continued into the early 21st century under the guidance of architect Michael Reynolds. Earthships are conceived as passive solar earth shelters, constructed from a combination of natural and upcycled materials, notably earth-packed tires. These sustainable dwellings showcase a range of amenities and diverse aesthetics, designed to endure the extreme temperatures of desert environments, maintaining a comfortable interior temperature of approximately 21 °C irrespective of external weather conditions.

Originating in the desert region of northern New Mexico, near the Rio Grande, Earthship communities have proliferated globally, despite encountering legal opposition to their construction and adoption in certain instances.

Reynolds conceptualized the Earthship design subsequent to relocating to New Mexico and obtaining his degree in architecture. The primary intent behind Earthships was to fashion homes that were "off-the-grid-ready," requiring minimal reliance on public utilities and fossil fuels. These structures are meticulously crafted to harness available natural resources, particularly solar energy and rainwater. Embracing thermal mass construction and employing natural cross-ventilation mechanisms to regulate indoor temperatures, Earthships are intentionally designed with simplicity and are predominantly single-story, enabling individuals with limited building expertise to construct them. Functioning as a tangible embodiment of the utopian vision for autonomous housing and sustainable living, Earthships represent a realization of the aspiration to live independently while minimizing environmental impact.

During this phase, industrial designs that inadvertently align with sustainable design principles, although not expressly oriented towards sustainability, continue to emerge. A notable

example is the HP-35 calculator introduced by HP in 1972, recognized as the first calculator incorporating LED display technology. This calculator featured a traditional floating decimal display for numbers presented in that format but seamlessly switched to scientific notation for other numbers. The fifteen-digit LED display was adept at showcasing a ten-digit mantissa along with its sign, a decimal point, and a two-digit exponent complemented by its sign.

The LED display employed a distinctive form of multiplexing, illuminating a single LED segment at a time, a method perceived as brighter by the human eye for equivalent power, as determined by HP research. During this period, light-emitting diodes were a relatively nascent technology, and they were notably dimmer than the high-efficiency diodes developed in subsequent decades. While the design of the HP-35 calculator was primarily geared towards exploring new technology, the inadvertently sustainable aspects of the LED technology employed are noteworthy. LEDs, being efficient, durable, and requiring minimal maintenance, qualify as an ideal sustainable product. Their extended service life results in lower replacement and disposal rates, reducing the overall production demand for luminaires.

Era of sustainable design-From 1980s to today

The 1980s witnessed the crystallization of the green movement (Figure 6). This period also saw the introduction of comprehensive rating systems like LEED (Leadership in Energy and Environmental Design), signifying a more structured approach to sustainable building practices. International recognition of the significance of sustainable design expanded in the following decades, as various conferences and agreements emphasized the global imperative to address environmental issues. As well, the United Nations formally defined sustainable design in 1987 (United Nations, n.d.). These activities come with stable growth of sustainable design. For example, the Hand-cranked radio by Trevor Baylis in 1997. Baylis first got the idea for his wind-up radio in 1991 while watching a news report about the difficulty of providing education about the AIDS epidemic in rural parts of Africa. Radio tech can be expensive when you need to buy batteries or have a consistent source of electricity. Baylis was said to have been inspired by his grandmother's wind-up gramophone. "Anyone can have a good idea and turn it into something that works. It's not magic. If you find yourself trying to solve a problem, you are halfway to inventing something," Baylis told a 2007 issue of the trade journal Engineering Management.

Baylis's experiments in the '90s paired a tiny motor, a small hand-crank, and cheap radios with the casing designs of Andy Davy to produce the BayGen Freeplay radio. Baylis won the BBC's Designer of the Year Award for the device in 1997. As the 21th century unfold, sustainability has become the main consideration of almost all production industry.

Figure 6 History of Sustainable design-part3. For clarity in presentation, the figure displays the latter part of the sustainable design development timeline. The first part of this timeline is depicted in (Figure 5). The figure illustrates sustainable designs from the 1960s onward.

4.1.3. Conclusion

This historical analysis reveals that despite the emergence of designs explicitly oriented towards sustainability occurring subsequent to the late 19th century, and the formalization of the modern definition of sustainable design post-1980s (Bhamra & Hernández, 2021), humanity has historically engaged in the creation of inherently sustainable designs.

The emergence of large-scale and standardized sustainable industrial design can be traced back to the aftermath of the Industrial Revolution. This historical context provides a plausible

backdrop for the subsequent ascent of modern sustainable design. The narrative unfolds logically: the advent of large-scale globalized industrial production, integral to the Industrial Revolution, precipitated resource overexploitation and environmental degradation. In response, heightened environmental awareness among the populace catalyzed the surge in popularity of sustainable design.

However, a nuanced examination of the popularity of sustainable industrial design reveals a curious anomaly when viewed from an alternative perspective. As elucidated in our previous analysis, human nature tends to lean towards self-interest, with capital and enterprises exhibiting an even more pronounced inclination in this direction. The imperatives of constant demand expansion and the stimulation of materialistic desires to sustain production and profits align with this conventional understanding. The perplexing question arises: why, within a mere half-century, have entrepreneurs and designers seemingly undergone a collective transformation, expressing concern for the continuity of humanity and the preservation of resources? Does this shift genuinely signify a profound alteration in consciousness, an altruistic concern for the nebulous concept of the well-being of all mankind?

To unravel this intriguing puzzle, a preliminary step entails the categorization and definition of various types of sustainable design. This includes a comprehensive understanding of sustainable industrial design, as well as design approaches akin to sustainable design, as previously mentioned. This groundwork establishes a framework for expeditious reference and analysis in subsequent sections of this study.

4.2. Sustainable design and designs that are sustainable

To comprehend the intricacies of designs encapsulated within the ubiquitous term "sustainable" and to distinguish all kinds of sustainable design systematically, it is imperative to transcend the conventional confines of the "sustainable design" framework and engage in a direct examination of design itself.

4.2.1. Designs that are sustainable

Irrespective of whether it predates or postdates the articulation of the contemporary definition of modern industrial design, there exists a multitude of designs in every historical stage, encompassing industrial contexts, that are not explicitly oriented towards sustainability but inherently exhibit sustainable attributes. A closer examination of these historical cases reveals a common thread: they predominantly represent unconscious and reactive design approaches. Take, for instance, the ancient Chinese sustainable toilet in Early design stage. The driving force behind its creation was the limited availability of high-quality fertilizer during that period. The design process scarcely considered environmental impact, resource utilization, or waste generation as pivotal factors. These endeavors did not consciously seek to protect the environment or preserve resources; they were pragmatic responses aimed at maximizing the utilization of available resources, incidentally aligning with sustainability principles in terms of resource consumption and the methods employed. This design responds to its adverse and resource-scarce living environment, exhibiting an

unconsciousness of the environmental repercussions it generates.

A similar phenomenon occurred in the aftermath of the 1970s energy crisis, with a profusion of product designs centered around bioplastics, reflecting a response to the prevailing resource constraints. Nonetheless, it is crucial to recognize that the underlying motivation behind this unconscious and reactive sustainable designs remains fundamentally identical: survival. For these ancient Chinese farmers, the utilization of their excrement as fertilizer was the only way of acquiring fertilizer. Failing to do so would have jeopardized their crop yields, potentially leading to hunger and hardship for their families. Likewise, the adoption of bioplastic in design constituted a response to the scarcity of oil supply, given that traditional plastic is derived from petroleum. The development of alternative plastic materials became imperative for the sustainability of plastic companies.

These designs, though not comprehensively considering the sustainability and environmental impacts across their entire lifecycle, are predominantly concerned with self-preservation. Consequently, while possessing elements of sustainability, these designs cannot be unequivocally classified as "sustainable design." In light of this, a fitting categorization for such designs emerges, aptly termed as "passive sustainable design."

This initial categorization warrants a more nuanced refinement, as alluded to earlier in our discussion on the fundamental distinction between industrial design and generic design. These two categories diverge significantly in terms of their impact and functionality. Therefore, a similar differentiation within the realm of sustainable design becomes imperative. To illustrate, a farmer's toilet in ancient China exemplifies a Passive sustainable generic design, while the bioplastic and HP-35 aligns with a Passive sustainable industrial design. In this context, the term "Passive" denotes the overarching attitude, while "generic" or "industrial" delineates the specific attributes associated with each.

Such two-dimensional definition is a handy guidance in navigating the complex landscape of sustainable-related designs, availing a more thorough understanding. This clarity, in turn, facilitates a more in-depth exploration and clarification of our thoughts, particularly in the context of comprehensive case studies.

4.2.2. Sustainable design

Following the industrial revolution, the emergence of industrial design laid the foundation for sustainable design. Subsequently, in the latter part of the 20th century during the stage marked by “environmental awareness stage”, a proliferation of industrial designs consciously and deliberately oriented towards sustainability occurred, constituting what is commonly referred to as modern sustainable design.

Examples of such designs, as outlined in “environmental awareness stage”, serve as illustrative instances of proactive considerations toward sustainability. Take the Nalgene bottle, for instance, which meticulously factors in reusability, thereby extending the plastic bottle's lifecycle, mitigating waste generation, and contributing positively to environmental preservation. In the case of the Thumb house, the design prioritizes the energy efficiency of the dwelling, specifically addressing the house's impact on resource consumption through a

structurally informed approach aimed at reducing energy usage. The Hand-cranked radio offers a solution to the battery accessibility challenge, enabling usage in underdeveloped areas and evidencing a proactive stance toward equality—an aspect that carries significant implications for societal sustainability.

In the design process of these products, there is a discernible proactive consideration of both environmental and social sustainability, resulting in effective solutions. This research deems them as "Proactive sustainable design." Furthermore, this broad category can be further subdivided into "proactive sustainable industrial design" and "proactive sustainable generic design." For instance, the Nalgene bottle and the Hand-cranked radio fall within the former, while the Thumb house aligns more closely with the latter. The distinction arises from the limited industrial impact of the Thumb house, which operates within a smaller scope and, crucially, lacks the potential for mass production. Notably, sustainable house design, particularly, necessitates customization to harmonize with the contextual nuances of its construction site. The subsequent section will furnish more exemplary instances of proactive sustainable generic design for a comprehensive exploration of this thematic category.

4.2.3. Proactive sustainable generic design

As the environmental repercussions of the Industrial Revolution became increasingly evident, this harm and the corroborating evidence were swiftly disseminated globally through various media channels, notably through papery works such as Rachel Carson's "Silent Spring" published in 1962. These revelations catalyzed the burgeoning of the environmental movement and the advent of environmentalism as a prominent societal trend. Within this broader movement, certain designers chose to participate in this campaign, leveraging the medium of design to convey and advocate sustainability-related objectives. A notable example is the "Tire Sofa" by Des-in (Jochen Gros) in 1974 (Figure 7), which embodies this ethos.

Figure 7 Des-in (Jochen Gros) –'Tire Sofa'-1974

The sustainability dimension embedded in the design of this product manifests through the

deliberate selection of raw materials—specifically, discarded tires—a choice that resonates with the overarching concept of repurposing waste. However, it is crucial to note that the practical utility of this product leans more towards promotional ends rather than sheer practical functionality. Its primary function extends beyond mere usage; it serves as a symbolic messenger to the world, communicating the transformative idea that waste materials can find renewed purpose through reuse. The product, in essence, serves as an inspiring catalyst, prompting individuals to contemplate the possibilities of waste reutilization, and thus carries a message with broader implications beyond its immediate practical applications. This example showcasing another manifestation of Proactive Sustainable Generic Design.

4.3. The lure of sustainability

In the last section, a rather ambiguous classification system has been proposed. Before finalizing this system, it is imperative to understand the significant role that profit playing in the sustainable industrial design. So, let us now delve into addressing the inquiry posed at the end of section 4.1.3. Firstly, it is pertinent to acknowledge a lot of evidences suggesting that engaging in sustainable design indeed amplifies the overall production and manufacturing costs of a product. This encompasses augmented design expenses and escalated material costs, as indicated by Fleming (2011). This, evidently, poses a substantial drawback for profit-driven industrial products. Consequently, a pivotal question emerges: why are an increasing number of companies opting for sustainable design despite these apparent disadvantages? The answer lies in the realm of proactive sustainable industrial design discussed earlier.

While it holds true that sustainable design often incurs a cost premium, it concurrently unlocks significant profit potential. It is crucial to underscore that these profits are not solely derived from the recognition of environmentalists or eco-conscious consumers. Instead, they stem from a tangible and burgeoning demand among the broader user base.

Those illustrative cases in 4.1.2, for example, shed light on the strategies employed by companies and individuals to engage in sustainable industrial design, revealing three distinct perspectives. The case of Nalgene bottle underscores the symbiotic relationship between environmental protection trends spurred by the environmental movement and the emergence of innovative concepts such as the reusable cup. As discerned from this case, when a particular trend gains momentum, it always produces opportunities for businesses (J. Wang et al., 2013). Consequently, the development of reusable products not only aligns with sustainability objectives but also proves to be a financially rewarding endeavor.

The case of thumb house, set against the backdrop of the energy crisis of the 1970s, illuminates a different facet of sustainable industrial design. The background to this design was the energy crisis, a period marked by soaring energy prices that inflicted a considerable financial strain on households, consequently diminishing people's overall well-being. Against this backdrop, there emerged a discernible commercial potential in conceiving a house with markedly reduced energy costs. The intrinsic rationale behind such a design was twofold: firstly, to alleviate the burden of energy expenses for end-users, thereby enhancing their economic well-being, and secondly, to capitalize on the heightened demand for energy-

efficient housing, consequently bolstering orders for builders. This design, strategically aligned with the prevailing economic and environmental concerns of the time, not only addressed a pressing societal issue but also presented a commercially lucrative proposition by responding to the urgent needs and preferences of both users and builders.

In the final case of Hand-cranked radio, the designer identified a specific need in Africa, stemming from the local industries and economy's relative underdevelopment. It is worth noting that when a design effectively addresses a genuine need, the company producing it stands to reap a profitable return. Consequently, the hand-cranked radio in this case exemplifies not only sustainability but also a financially rewarding venture. Because it opens up markets in vast backward areas.

These instances epitomize modern sustainable industrial design; however, gleaned from them, it becomes evident that profit-oriented considerations play a substantial role in the evolution of sustainable designs. Indeed, nearly all instances of sustainable industrial design inherently involve discernible profit considerations. In examining these cases, it becomes evident that the true impetus behind sustainable design within companies, at least in these instances, can be distilled down to two fundamental drivers. Firstly, there is a clear drive to minimize manufacturing and energy costs, reflecting a strategic pursuit of operational efficiency and economic sustainability. Secondly, there is a compelling motivation to enhance sales, signaling the market-oriented dimension of sustainable design. Companies, it seems, are strategically embracing sustainable design not merely as an altruistic endeavor but as a pragmatic approach aimed at concurrently optimizing costs and meeting the rising demand for environmentally conscious products, thereby bolstering overall sales.

4.3.1. The profitability of sustainable design

In order to more objectively verify whether sustainable design is profitable, the profitability of sustainable design has been evaluated through literature review and research from organizations. Over the last few decades, sustainable design has emerged as a promising approach allowing a firm to both be green and competitive (Wimmer et al., 2010). Indeed, since Porter and Van der Linde (1995), numerous scholars (Pujari et al., 2003; Ambec, Lanoie, 2008) argued that by improving environmental performance the firm will increase economic performance, its profitability and, in the even longer term, its competitiveness. Empirical evidence from a recent survey also indicates that a more than 60% of respondents in the United States are willing to allocate additional expenses for products featuring sustainable packaging (Feber et al., 2020).

According to Am et al. (2023b). *"Products that made the least prevalent claims (such as "vegan" or "carbon zero") grew 8.5 percent more than peers that didn't make them. Products making medium-prevalence claims (such as "sustainable packaging" or "plant-based") had a 4.7 percent growth differential over their peers. The most prevalent claims (such as "environmentally sustainable") corresponded with the smallest growth differential. Yet even products making these widespread claims still enjoyed roughly 2 percent higher growth than products that didn't make them, suggesting that commonplace claims can be differentiating."*

These social study serves as an illustrative demonstration of the profitability of sustainable design within the current business environment.

Nonetheless, it is worth noting that products within distinct market segments may exhibit substantial disparities in their sales growth rates (Am et al., 2023c). This divergence underscores the varying responses and levels of acceptance displayed by consumers concerning the sustainability of different product categories. If this trend persists, it is conceivable that certain industries may develop a less favorable stance towards sustainability. For example, consider the tire industry, where noteworthy observations reveal that tire manufacturers prioritizing durability and economic efficiency tend to reap greater profits and achieve higher sales compared to counterparts emphasizing sustainability across all dimensions (Sarıgöl et al., 2024). This phenomenon has sparked a burgeoning debate encapsulated by the question, "Does it pay to be green?" as highlighted by Ghisetti and Rennings (2014).

4.4. Conclusion

In this chapter, we undertook a comprehensive examination of the trajectory of sustainable design, acknowledging the pivotal roles played by the Industrial Revolution, environmental degradation, and the onset of the energy crisis in shaping the evolution of modern sustainable design. It is crucial to recognize that, not all of designs spanning from ancient times to the present align with the contemporary understanding of sustainable design. While numerous historical designs exhibit sustainable characteristics, their classification as sustainable design in our modern context requires a discerning evaluation.

Therefore, it becomes important to differentiate between PSGD (Passive Sustainable Generic Design), ASGD (Proactive Sustainable Generic Design), PSID (Passive Sustainable Industrial Design), and the theoretical category of ASID (Proactive Sustainable Industrial Design). As of now, a relatively clear delineation of these four design categories has been established (Figure 8):

Figure 8 Classification of sustainable design

PSGD: Nonindustrial design which does not actively consider the sustainability and responsibility.

ASGD: Nonindustrial design which actively consider the sustainability and responsibility.

PSID: Industrial design which does not actively consider the sustainability and responsibility.

ASID: industrial design which actively consider the sustainability and responsibility.

This categorization, though effective in elucidating the specific characteristics of a given design, falls short in capturing the underlying intentions of the designer. Consider ASID, where the impetus behind a particular design remains elusive. Is the aim to align with the market allure of sustainable design? Cutting down production costs? Adhering to regulatory frameworks? Or genuinely champion social sustainability? This indeterminacy is intrinsic, given that the ascendance of sustainable design results from a complex interplay of diverse factors. Consequently, such opacity and intricacy pose potential obstacles to subsequent research endeavors, suggesting a need for further refinement in future examinations of ASID.

Additionally, our investigation reveals a pivotal role played by manufacturers' profits in propelling the trajectory of sustainable design. Profits materialize through two primary avenues: firstly, improve the energy efficiency in the manufacturing process of the product and reduce the energy expenditure of the factory or company operation; and secondly, by crafting sustainable enticements that kindle consumers' desires and boost sales, ultimately yielding higher profits. As sustainable design firmly establishes itself as a focal point in design discourse, an inquiry into the contemporary state of the sustainable design market becomes imperative. What characterizes the present landscape, and how might it evolve in the times ahead? These questions will be dissected through case studies in the ensuing chapters.

Consider that in this study, manufacturers, distributors, and designers are all part of the product providers, and it is their joint work that makes the product available to us in the marketplace. For the sake of convenience, we will refer to them collectively as Providers in the subsequent study.

4.5. Discussion – the designer’s self-awareness

Indeed, beyond the factors previously expounded in this section, the ascent of sustainability finds impetus in a diverse array of influences, including policy changes. The political landscape, both at the domestic and international levels, exerts a profound impact as governments issue environmental protection measures. Legislation like the Emissions Act targeted at the raw material processing industry places constraints on material production for goods, compelling designers to explore alternative materials or using clean energy and, consequently, steering them towards sustainable design paradigms. Another regulatory avenue involves outright bans on specific raw materials, exemplified by the EU's prohibition on plastic straws, which compels manufacturers to pivot towards sustainable alternatives such as wooden or paper straws.

Regrettably, owing to the temporal constraints of this study, a comprehensive examination of policy-related impacts remains beyond its scope. The focus here is narrowed to key

stakeholders—designers, manufacturers, and consumers. Consequently, the chapter eschews a detailed exploration of policy dynamics, opting instead for a nuanced analysis through the lens of companies and drawing pertinent conclusions.

However, a shift in perspective, one that places us in the shoes of designers, unveils a narrative wherein the surge of sustainable design appears rooted in both society's over-exploitation of the natural environment and manufacturers' profit-driven pursuits. Designers, in this light, assume a pivotal role—so crucial that it can be argued that, absent the professional contribution of designers, even amid energy crises and environmental degradation, the realization of sustainable design would remain an elusive prospect. This notion stands on the sustainable design trajectory as well. Sustainable designs have existed throughout history, but their prevalence has fluctuated in direct correlation with resource availability. This assertion is substantiated by a historical perspective that spans from the inception of humanity to the present day.

Throughout human history, the utilization of energy resources has undergone a remarkable evolution. Commencing with the use of animals, humanity transitioned through stages that encompassed wind, coal, oil, electricity, natural gas, and is presently poised on the precipice of nuclear energy. Alongside these shifts in energy sources, humankind has grappled with various energy crises. However, it is crucial to acknowledge that human technology has continually evolved to address these crises, although they might not always successful (Guarnieri, 2016). Consequently, the mere presence of an energy crisis, in and of itself, is insufficient to engender the sustainable concept and proliferation of sustainable design.

Therefore, the energy crisis alone is not necessary to cause the unprecedented explosion of sustainable design. There must be some other factor that has upset the balance between sustainable design and resource availability, so that sustainable design has gained considerable traction at a time when resource availability is rather plentiful where we are now.

The root of this phenomenon can be traced back to the very essence of design itself. Following the Industrial Revolution, the act of crafting objects evolved into a formal profession tightly tethered to corporations and factories. Those engaged in this craft became professional product designers, and it is these designers who have played an instrumental role in shaping nearly every facet of our contemporary daily existence. In essence, product designers exert a profound influence over various aspects of our lives.

Yet, as elucidated in section 4.1.1, the inherent nature of the designer’s vocation necessitates a continuous alignment with the interests of corporations and factories. This alignment invariably entails a ceaseless quest to extract and exploit resources, eventually leading to their depletion. Paradoxically, this state of affairs, which may appear to run counter to human welfare, is, in reality, a normal and natural consequence. It is driven by the survival instinct of businesses, which, absent this relentless pursuit, would likely succumb to the rigors of market competition and face extinction. This phenomenon dovetails with the premise advanced in the preceding section: that every industrial design is fundamentally designed to be sustainable. In this context, the designer assumes the role of safeguarding the business’s continuity, making their work an endeavor aimed solely at sustainability—specifically, the sustainability of profit.

In this light, designers can be regarded as mere marionettes of corporate interests, lacking a distinct sense of self. Their creative output, regardless of its unique attributes, is fundamentally an instrument for the preservation of corporate sustainability, synonymous with profitability. This labor, committed to ensuring designer's own life's continuity, draws parallels with the unconscious and reactive sustainable design exemplified by ancient Chinese farmer practices.

At this juncture, an examination of 20th-century sustainable designs reveals a notable bifurcation into two distinct categories. The first category encompasses what we may term "Sustainable industrial design" Examples of such designs include recyclable plastic bottles, solar-powered calculators, and reusable mugs. These designs are chiefly driven by the pursuit of corporate profitability. On the opposite end of the spectrum, we encounter a novel breed of "Sustainable generic design" that transcends considerations of product profitability or marketability, such as Tire Sofa. Instead, this type of design prioritizes its environmental impact and sustainability. In essence, it diverges from the inherent nature of the industrial designer's profession and operates beyond the confines of factories or corporations. In this context, it almost appears as if this type of design possesses a degree of self-awareness—a quality we may tentatively label as "Proactive Sustainable Design."

A comparative analysis of these categories underscores their distinct objectives and consequences. Industrial sustainable design primarily benefits the providers and the consumer. The company garners profits, the designer receives salary, dividends, or fame, and the consumer gains access to more material resources essential for survival or entertainment. This symbiotic relationship in turn fosters sustainability for the providers and the immediate consumer. However, it tends to sideline other stakeholders in the product lifecycle, such as workers and the natural environment, unless their interests directly impinge upon the company's survival. Consequently, this brand of sustainable design can be perceived as somewhat self-serving and shortsighted.

Conversely, some generic sustainable design operates on a fundamentally different premise. It does not center around the sustainability of the designer or producer personally, but rather, it pivots towards the sustainability of society, future generations, and the broader ecosystem.

At this point, the origin of sustainable design has been roughly clear, namely, after the industrial revolution, design became a profession, however, the essence remains the same, they began to mass produce self-interested design, which led to environmental unsustainability, however, almost immediately at the same time, altruistic behavior, a behavior embedded in human nature (Yao & Enright, 2019), collided with this new design profession, resulting in altruistic sustainable design, which named as proactive sustainable design is what we are now pursuing. The proactive sustainable design is a human inevitability. It's a necessity, not an accident.

5. Sustainable design at today

From our preceding analysis, it becomes evident that since the inception of sustainable design in the 20th century, an increasing number of designers and manufacturers have actively

engaged in sustainable design initiatives, propelling sustainability into a global discourse. Whether in design education at academic institutions, practical applications within enterprises, or avant-garde design exhibitions pushing the boundaries of creativity, sustainability has become an inescapable theme. This pervasive presence fosters the impression, particularly among designers, that contemporary products should inherently embody sustainability principles, or at the very least, earnest attempts should be made to infuse them with sustainable attributes. This ethos persists in the education of the next generation of designers.

However, the showcased examples of sustainable design, as compelling as they may be, do not necessarily mirror prevailing trends, and we lack clarity on the proportion of total industrial design dedicated to sustainability at any given juncture. Consequently, despite the palpable enthusiasm for sustainable design within contemporary design circles, and the explicit endorsement from governments and major corporations, definitive assertions about sustainable design reigning as today's predominant design paradigm remain elusive.

This prompts the critical question: does the reality align with designers' perceptions, and how does the average consumer perceive the status of sustainable design today? To answer this, a comprehensive understanding necessitates a consumer-centric viewpoint. Examining products on the market from the consumer's perspective and discerning their needs will be instrumental in unraveling the intricacies of this issue. Only through this lens can we garner a holistic comprehension of the current state of sustainable design.

Furthermore, the historical exploration of the evolution of sustainable design reveals a notable concentration of cases, particularly exemplified by ASID, originating predominantly from Europe and the United States, with scarce representation from China. The absence of robust engagement with sustainable design in China, a global powerhouse in light industry and commodity exports, raises intriguing questions. Why does China, in its role as a leading player in industrial domains, display a tepid response to sustainable design? How does this divergence manifest, and what does it unveil about the disparate values held by these two worlds? Importantly, what ramifications does this disparity hold for the future trajectory of sustainable design? As a researcher with extensive experience in both the Netherlands and China, these are inquiries that warrant thoughtful consideration.

The objectives of this chapter are therefore threefold: firstly, to refine the categorization of various sustainable designs; secondly, to explore the differences between the Chinese and Dutch markets; and thirdly, to explore the recognition of sustainable design in the consumer goods market.

5.1. ASGD at today

Since ASGD is a non-industrial product with limited diffusion, its market primarily resides in the art, luxury, or handicraft sectors. These markets typically involve high prices, cater to niche audiences, and have limited market penetration. Consequently, ASGD is not suitable for analyzing the development of sustainable design in the consumer goods market, nor is it an ideal medium for comparing the sustainable design markets of China and the Netherlands.

However, due to the absence of standardization and cost constraints in industrial production,

designers have more freedom to explore creative ideas within ASGD. This type of design allows for richer expression and facilitates the exploration of a more precise and nuanced taxonomy of sustainable design.

For example. a closer examination of ASGDs reveals a nuanced landscape where, despite falling under the same categorization, they exhibit diverse audiences and purposes. This observation underscores the limitation of the categorization system discussed previously, emphasizing that while the system adeptly captures design attributes, it falls short in elucidating the motivations driving designers.

This realization prompts a crucial refinement in our approach. Recognizing that the motivations of designers serve as reflections of the prevailing social environment, it becomes imperative to integrate the motivation parameter into the existing classification system. By doing so, we aim to enhance our analytical framework and gain deeper insights into the contemporary state of sustainable design in society. In this section, we seize the opportunity to conduct a detailed analysis of the current state of ASGD, categorizing them in a more granular manner. This refinement culminates in the formation of a three-dimensional coordinate system, incorporating parameters of (motivation)-(attitude)(attribute).

5.1.1. Approach

ASGDs (Artisanal Sustainable Goods Designs) are frequently showcased in educational institutions, art exhibitions, luxury stores, and handicraft stores. These establishments often showcase these designs on online platforms or official websites to broaden their visibility and exposure. Consequently, retrieving such designs using search engines is relatively straightforward.

For this study, I utilized Google and Baidu as search engines, employing keywords like "sustainable design," "green design," and "responsible design." I then examined the motivations of the designers behind each work in the search results. Whenever I encountered a new motivation, I selected it as an illustrative case for this study.

Research has indicated that 99% of Google users only explore the first page of search results (Fire&Spark, 2023). As a result, sustainable designs featured on the first page of search results can be considered somewhat representative of commonly encountered sustainable designs online. Thus, these designs should offer an adequate sample for our study. Therefore, I will focus on selecting content from the first page of each search result as my research sample.

5.1.2. A-ASGD

The design about waste reuse in the figure below shows us the first category of motivations.

Figure 9 Vadim Kibardin–'Paper Chair №5'-2000.

Designed by Vadim Kibardin and handmade (Figure 9) in about 5,000 hours, the chair is made from discarded cardboard. The author explains that because cardboard is made from trees, which have an important role in absorbing carbon dioxide from the atmosphere. Reusing these cardboards means that more trees will not be cut down, which further slows down the rate of global warming (Thukral & Thukral, 2020). The design is therefore not only sustainable, but also functional.

Another example is an outdoor chair designed by SMALLrevolution (Figure 10). The group believes that plastic is an excellent raw material for outdoor products, but rather than using first-hand plastic, they sought to reuse discarded plastic. Surprised by the amount of plastic waste being incinerated and landfilled, they thought this design would help to recycle waste plastic and reduce the environmental pollution caused by plastic waste disposal.

Figure 10 SMALLrevolution-'Mabel-winter'-2020

In all two cases examined, the designers employ discarded materials like recycled plastics and discarded paper, offering a novel purpose to waste that would otherwise contribute to landfills or incineration. This transformative approach renders seemingly useless materials "recyclable," alleviating environmental pressure associated with their disposal. Notably, these designs refrain from industrializing their products to amplify their environmental impact. Instead, they often find their primary showcase in design exhibitions, where numerous examples of such designs abound. While these designs propose brilliant sustainable solutions, their integration into a broader context outside these exhibitions and luxury handcraft shops remains challenging.

This apparent limitation is not a result of objective inability or a lack of subjective interest in industrialization. On the contrary, the true significance of this design category lies not in mass production but in its capacity to convey the powerful idea that through the fusion of aesthetics and sustainability, a more promising future can be crafted. It seeks to instill the belief that design using wastes can embody captivating aesthetics. This form of design tends to possess higher aesthetic value compared to typical sustainable consumer goods, making it an effective tool for conveying its message. Consequently, these designs verge on becoming works of art, where sustainability itself becomes the medium of artistic expression—a phenomenon we can term as Artistic ASGD, or A-ASGD (Art-oriented ASGD).

Remarkably, A-ASGD transcends practical roles in addressing contemporary challenges of waste disposal and environmental pollution. Instead, it captivates consumers as a blend of fashion, popularity, and artistry. While it may not directly contribute to solving environmental problems, it presents a vision of the alluring possibilities within sustainable design. It is noteworthy that this type of design can also be commercially viable; if visually striking and accompanied by a compelling story, A-ASGD can fetch premium prices in the art market. For instance, the stool featured in Figure 10 commands a price of 250 Euro (Tykky - Nordic Simplicity, 2024), significantly surpassing the cost of a typical stool and hundreds of times that of an ordinary equivalent.

5.1.3. I-ASGD

Another category is characterized by its attribution to design collectives, independent designers, and student cohorts, as opposed to being affiliated with manufacturers or distributors. Notably, these designs lack commercial availability data, precluding information regarding their retail outlets or purchase options. Instead, only a sparse selection of computer-generated renderings or sample images are accessible. Presented herein are several illustrative instances exemplifying this category.

Figure 11 Chaozhi Lin – 'KAGURA' – 2021. Source: https://www.yankodesign.com/2020/10/20/this-self-sustaining-compost-system-turns-your-food-scraps-into-a-thriving-indoor-garden/

The award winning device (Figure 11) known as KAGURA, conceptualized by designer Chaozhi Lin, facilitates users in cultivating vegetables within their residential settings while concurrently repurposing household-generated food waste as an organic fertilizer. The residual matter resulting from the growth of these vegetables can subsequently be reutilized as substrate material for the cultivation of new crops, thus exemplifying a sustainable approach to organic waste management. It is pertinent to acknowledge that notwithstanding the absence of tangible evidence substantiating the physical instantiation or prospective realization of this design, its conceptualization has garnered notable attention within various design-oriented platforms and forums.

The second instance substantiating this category as follows (Figure 12).

Figure 12 Nos – 'GIY Helmet' – 2021. Source: https://www.nos.mx/projects/giy-recyclable-organic-helmet

The studio claims that the helmet is made of fungus for breathability and safety, and is highly sustainable as it is biodegradable, avoiding the use of plastic. The company indicated back in 2021 (GIY Helmet | Type of Project: Product Design, n.d.) that it had registered the company for the concept for subsequent development, but no updates have been seen so far.
This category of sustainable design significantly dominates almost half of the Internet's search results for sustainable design. Similar to A-ASGD, this design category may not, and perhaps never will, undergo industrialization. Nevertheless, the designers behind such endeavors aim to stimulate contemplation on industrial production and industrial product design. They aspire to set a conceptual framework, serving as guiding principles for the industrial design of related products. In an ideal scenario, the designers envision their work being embraced as a standard piece of industrial design and being mass produced, despite the often elusive realization of this aspiration. It is worth acknowledging that, if successful, such concepts hold considerable potential to influence standard industrial design, offering valuable guidance for the evolution of sustainable industrial design.

While these designs are intrinsically linked to industry and can be considered a form of industrial design, they often exhibit a degree of wishful thinking on the part of the designer. Notably, they may overlook the comprehensive life cycle of the product, particularly the intricate technical details involved in the production stage. Consequently, these programs frequently remain unutilized in actual production. Given these characteristics, it is appropriate to regard this category as Industry-oriented ASGD, or I-ASGD.

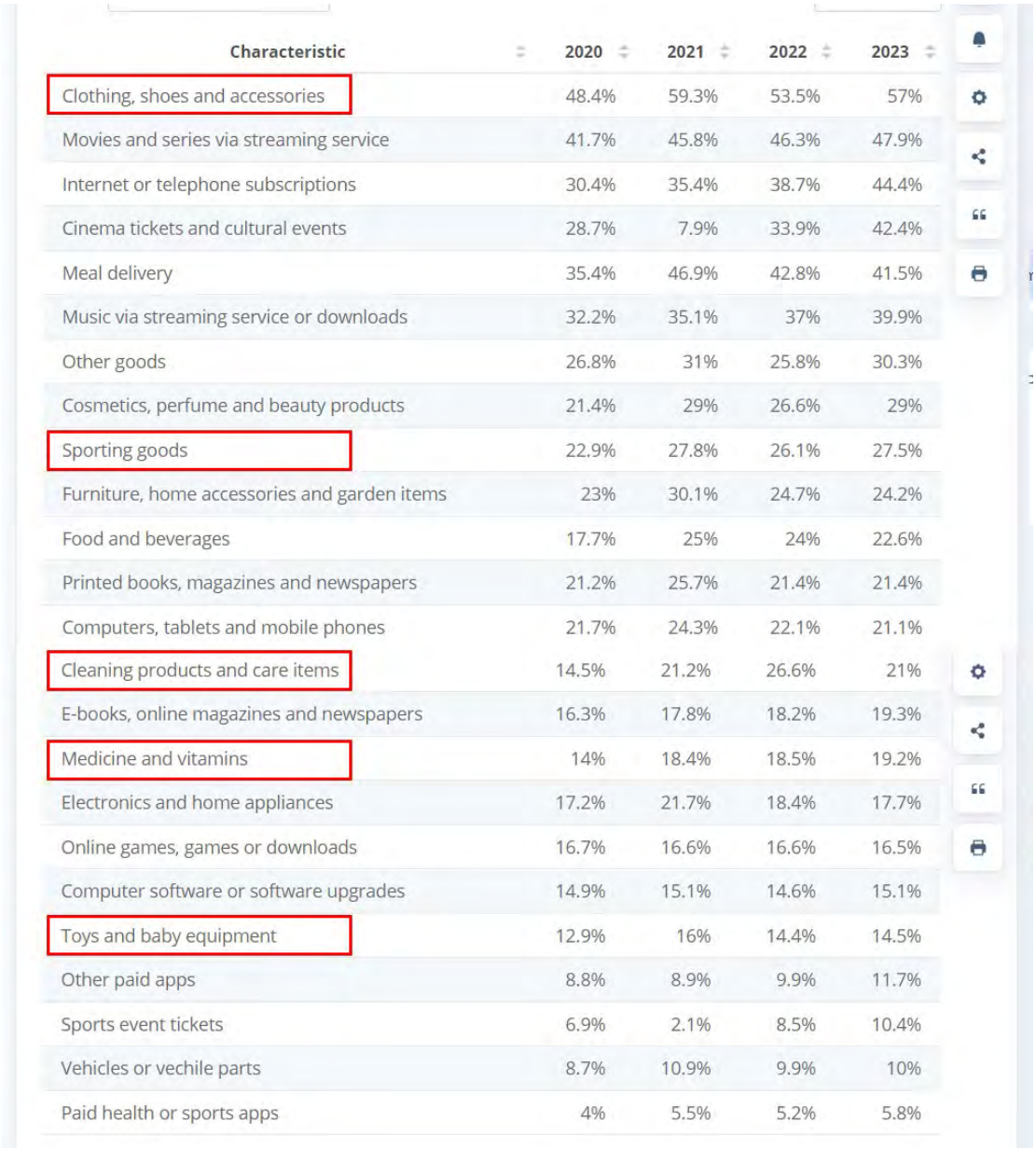
5.2. ASID at today

Following the COVID-19 pandemic, there has been a notable escalation in the global prevalence of online shopping. This mode of commerce has transitioned into a cornerstone avenue for consumer transactions, characterized by its inherent convenience and widespread accessibility. In addition to presenting a wide spectrum of products, online shopping platforms afford users the ability to engage in simultaneous exploration of multiple items, thereby augmenting the efficiency of market research endeavors, particularly within the context of ASID. Consequently, the evaluation of consumer goods and the execution of research initiatives are slated to predominantly occur via digital platforms, leveraging the internet's capabilities to effectively survey and analyze ASID offerings within the marketplace.

5.2.1. Approach

To initiate our research endeavor, it is important to delineate the categories of goods under scrutiny. This selection process draws upon a comparative analysis of the 10 highest-selling consumer goods categories in China for the fiscal year 2022 (Figure 13), juxtaposed with the top-selling products in the Netherlands in 2023 (Figure 14). Following an assessment of the breadth of product categories, a discernment of five intersecting categories has been made. These encompass shoes, sporting goods, cleaning products, vitamins, and baby products.

Figure 13 Year-on-year sales growth of major Tmall Tier 1 categories, 2022. source: https://www.36kr.com/p/2090517150684675



Characteristic	2020	2021	2022	2023
Clothing, shoes and accessories	48.4%	59.3%	53.5%	57%
Movies and series via streaming service	41.7%	45.8%	46.3%	47.9%
Internet or telephone subscriptions	30.4%	35.4%	38.7%	44.4%
Cinema tickets and cultural events	28.7%	7.9%	33.9%	42.4%
Meal delivery	35.4%	46.9%	42.8%	41.5%
Music via streaming service or downloads	32.2%	35.1%	37%	39.9%
Other goods	26.8%	31%	25.8%	30.3%
Cosmetics, perfume and beauty products	21.4%	29%	26.6%	29%
Sporting goods	22.9%	27.8%	26.1%	27.5%
Furniture, home accessories and garden items	23%	30.1%	24.7%	24.2%
Food and beverages	17.7%	25%	24%	22.6%
Printed books, magazines and newspapers	21.2%	25.7%	21.4%	21.4%
Computers, tablets and mobile phones	21.7%	24.3%	22.1%	21.1%
Cleaning products and care items	14.5%	21.2%	26.6%	21%
E-books, online magazines and newspapers	16.3%	17.8%	18.2%	19.3%
Medicine and vitamins	14%	18.4%	18.5%	19.2%
Electronics and home appliances	17.2%	21.7%	18.4%	17.7%
Online games, games or downloads	16.7%	16.6%	16.6%	16.5%
Computer software or software upgrades	14.9%	15.1%	14.6%	15.1%
Toys and baby equipment	12.9%	16%	14.4%	14.5%
Other paid apps	8.8%	8.9%	9.9%	11.7%
Sports event tickets	6.9%	2.1%	8.5%	10.4%
Vehicles or vechile parts	8.7%	10.9%	9.9%	10%
Paid health or sports apps	4%	5.5%	5.2%	5.8%

Figure 14 top-selling products in the Netherlands in 2023 (Statista, 2023)

Subsequently, it is imperative to delineate the channels employed for product searches. In light of prevailing consumption patterns in China, it is customary for individuals to conduct searches for items on prominent e-commerce platforms. Foremost among these platforms is Taobao, which registers an average of 242.7 million monthly visits (Changfa.Fu, 2023). In light of this, the strategy entails conducting searches on Taobao for each of the designated categories. The focal point will be to identify the top 10 best-selling products within each category and meticulously examine their product pages to gauge the incorporation of sustainable design elements. This methodological approach seeks to furnish an initial comprehension of the prevalence and consumer acceptance of sustainable design principles within the ambit of the most sought-after products in the Chinese online market for the year 2022.

Conversely, the online purchasing behavior of Dutch consumers leans significantly towards

search engines, with 54% of individuals relying on them as their primary avenue for product exploration. Retailer sites (46%) and brand websites (28%) also wield notable influence, whereas Amazon, with a 14% market share, assumes a less pivotal role among Dutch online consumers (ChannelEngine, 2023).

Consequently, the proposed methodology entails direct searches on a prevalent search engine favored by Dutch users for each product category. The objective is to scrutinize the sustainability attributes of the top 10 items prominently featured on the search engine results page for each category. This systematic approach endeavors to furnish a comprehensive overview of the prevalence of sustainable design within commonplace commodities showcased on the Dutch web landscape in 2023, thereby elucidating both its market penetration and consumption trends.

5.2.2. Chinese market

The procedure entails the following steps: initiate a search for the product category in the search field, subsequently opting to sort the results by sales volume, arranging them from highest to lowest. Subsequently, assess the sustainability aspects of the first 10 products in sequence. The step-by-step process is illustrated in the figure below (Figure 15):

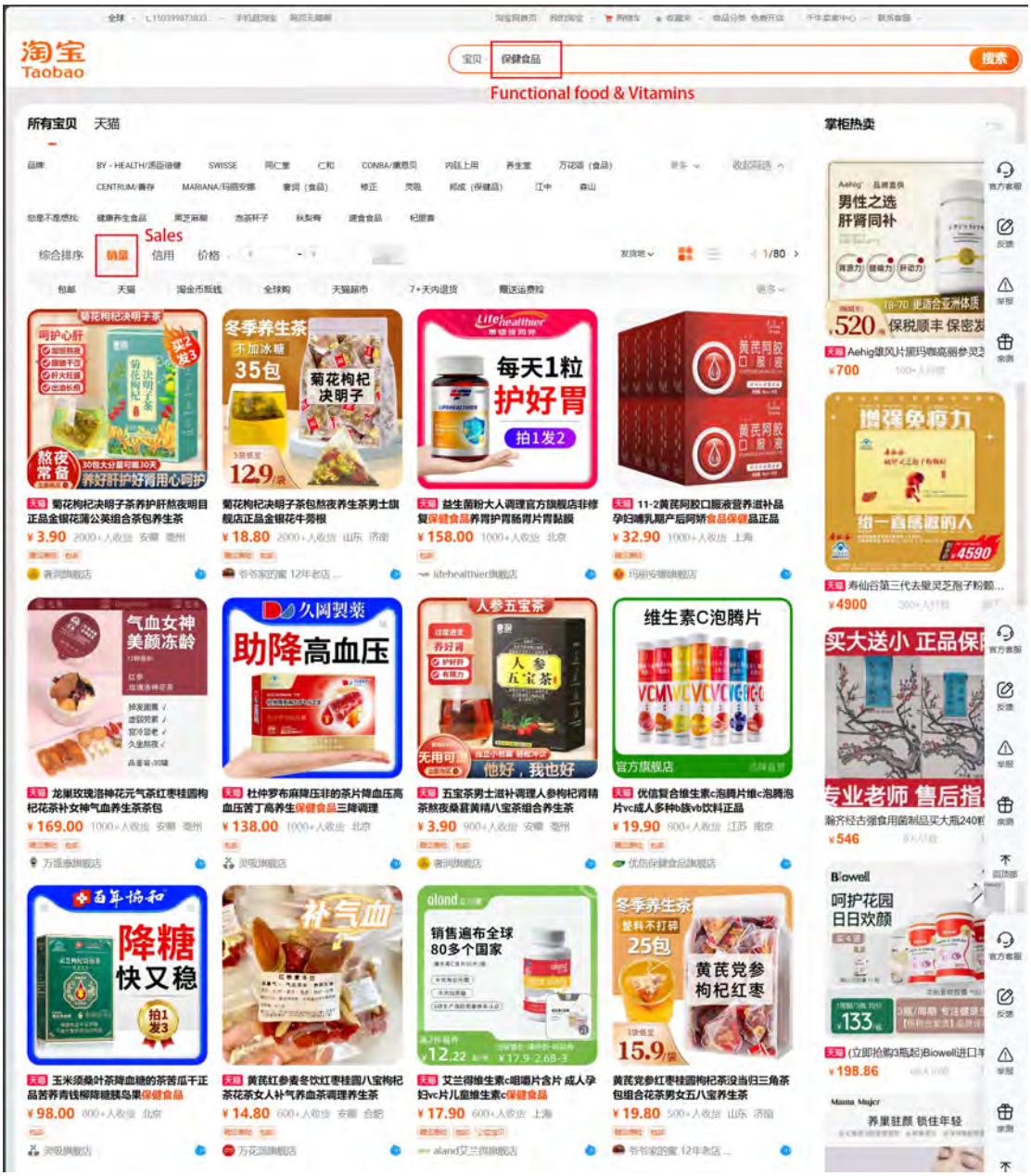


Figure 15 The searching feature of Taobao

The links of the products investigated see Appendix 1. The results of the survey on the selected product categories are as follows (Figure 16):

Figure 16 The sustainable product in Chinese market. The durability marked as brown and the eco-friendly materials marked as pink.

The main phenomena we can identify from this study are the following.

Phenomenon 1:

Different product categories exhibit varying degrees of concern for sustainability among Chinese consumers. For instance, durability takes precedence when it comes to shoes, while the material used is of greater significance for sporting goods. On the other hand, baby products, cleaning products, and vitamins demonstrate relatively lower attention to sustainability.

It's important to highlight that within these latter categories, there is a notable presence of PSID. Although products in these categories may not overtly promote their sustainability on the introduction pages, they do incorporate sustainable elements. For instance, the use of recyclable plastics like ABS, PE, and PP is common in baby products and vitamins packaging, yet their recyclability is not prominently emphasized in the product descriptions. Similarly, among cleaning products, a bamboo pot brush presents characteristics of sustainability and eco-friendly (Figure 17), but the distributor may not actively publicize its environmental friendliness.

Figure 17 The introduction page of a product called "Natural Bamboo Pot Brush"

Phenomenon 2:

In certain categories where ASID is present, the focus is not necessarily on environmental considerations. Take the example of the shoes category, where the emphasis on durability is primarily driven by consumers' practical needs, such as the desire to save money and quality requirements. It aligns more with their individual needs than with a specific environmental consciousness.

Similarly, in the sporting goods category, there is a notable presence of products utilizing environmentally friendly materials. However, the motivation behind this choice may not be driven by environmental considerations. A recurring pattern in product introduction pages is the coupling of the term "environmentally friendly" with "healthy." (Figure 18) This suggests that Chinese consumers perceive eco-friendly materials as being conducive to their own well-being, emphasizing a wrong connection between eco-friendly materials and personal health.

Figure 18 The introduction page of a sporting product

This observation suggests that Chinese consumers might associate environmentally friendly materials with their own health benefits. Consequently, the pursuit of sustainability in this product category may not be motivated by environmental concerns but rather driven by a desire to cater to consumers' perceptions of health. Such misconceptions are not uncommon and are not exclusive to Chinese consumers. In a parallel context, when examining the profitability of sustainability in Chapter 2, it was revealed that 70% of U.S. consumers are willing to pay more for sustainable food products. However, a separate study highlighted that a significant portion of U.S. consumers lack a clear understanding of what sustainability in food products entails and how it impacts the environment. Notably, 27% of U.S. consumers believe sustainable food means healthier, and 39% believe it tastes better or is of better quality. These findings underscore the prevalence of misconceptions surrounding sustainability, transcending geographical and cultural boundaries (Sustainable Brands, 2014). A similar scenario unfolds in the Netherlands, where consumers also exhibit a lack of clarity regarding the meaning of food-related sustainability. However, a key distinction emerges: unlike their counterparts in the United States, Dutch consumers don't perceive food sustainability as a significant factor influencing their purchasing decisions (Van Bussel et al., 2022).

5.2.2.1. Conclusion

The analysis of the above phenomena reveals a consumer trend where the perceived personal benefits of a product's sustainability take precedence. In essence, Chinese consumers tend to prioritize their own well-being over environmental concerns when it comes to product sustainability. On the manufacturing side, there is a notable alignment between considerations for sustainable design and consumer needs. This indicates that Chinese designers and manufacturers are inclined to directly address and fulfill existing consumer preferences, rather than actively guiding consumers towards developing new environmentally conscious demands.

5.2.3. The Netherlands market

The methodology involved first type the name of relevant product category in the search box of the chosen search engine, with a focus on localizing the results to the Dutch city of Enschede. Subsequently, from the recommended products displayed on the home page (Figure 19), the top 10 items were selected, and their sustainability was assessed based on the information provided in their respective product detail pages.

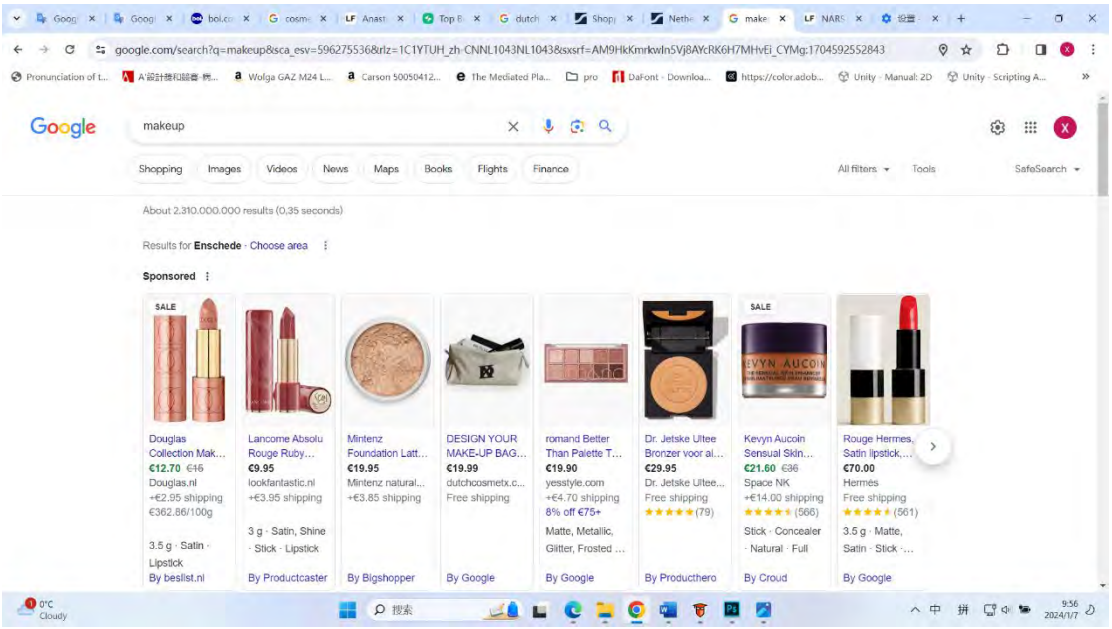


Figure 19 The searching feature of google, the most popular online shoping platform in the Netherlands

It is pertinent to acknowledge that the ranking provided is not predicated on the sales performance of the items, but rather on the positioning of advertisements by dealers. Given the absence of functionality within this search engine to sort items by sales volume, a direct comparison of the prevalence of sustainability between the Chinese and Dutch markets, as outlined in our original plan, is not feasible. Nevertheless, it is noteworthy that the absence of such sorting mechanisms does not preclude the significance of advertisement placement. Empirical studies have highlighted the substantial impact of Google ad placement on sales (Za & Tricahyadinata, 2017), underscoring the pivotal role of advertising in shaping consumer purchasing behaviors (Tritanti & Nu, 2014).

Consequently, it is reasonable to infer that heightened visibility of advertisements for a particular product correlates positively with consumer purchasing likelihood. Hence, products positioned higher on the search engine's list are presumed to exhibit greater sales volume within the respective category. Therefore, it is plausible to approximate that the search engine's ranking based on advertisement placement mirrors Taobao's ranking in terms of sales volume. The links of the products investigated see Appendix 2. The result see Figure 20:

Figure 20 Sustainable products in the Dutch market. The eco-friendly materials marked as pink, the carbon foot print marked as orange, and the biodegradable ingredient marked as green.

The main phenomena we can identify from this study are the following.

Phenomenon 1:

In the context of Dutch consumers and designers, the significance of sustainability varies across product categories. Raw materials play a crucial role in the consideration of shoes. On the other hand, the biodegradability of cleaning products emerges as a primary concern.

Conversely, sustainability appears to have less prominence in the categories of sports, vitamins, and baby products.

Phenomenon 2:

The sustainability considerations of Dutch consumers or designers appear to be less pronounced in the usage phase of a product's life cycle. This observation suggests that the sustainability discourse in the Dutch market leans more towards environmental aspects rather than consumer-centric considerations. The emphasis on environmental impact during production and disposal stages may indicate a broader societal awareness and commitment to addressing ecological concerns within the Dutch consumer and design landscape.

5.2.4. Similarities and differences

Upon juxtaposing the Dutch and Chinese markets, a salient contrast emerges, primarily concerning the locus of sustainability concerns among consumers. Chinese consumers exhibit a pronounced interest in sustainability pertaining to product utility, emphasizing attributes

such as durability that directly align with consumer interests. In contrast, Dutch consumers and designers evince a heightened focus on environmental considerations throughout the manufacturing process and post-consumer usage phase, reflecting a broader commitment to addressing ecological concerns. This distinction suggests that Dutch consumers and designers are actively contributing to fostering a sustainable societal ethos through pragmatic engagements, whereas their Chinese counterparts may exhibit comparatively lesser enthusiasm in this domain.

Furthermore, an interesting similarity between the Chinese and Dutch markets is notable: products emphasizing sustainable design exhibit almost identical perspectives on sustainability within same product categories, yet demonstrate different views on sustainability across different product categories. For instance, in the Chinese market, all sustainable sporting goods happen to utilize environmentally friendly materials. Similarly, in the Dutch market, nearly all sustainable clothing emphasizes the reclaimed materials, while other sustainability-focused products do not necessarily prioritize such materials. This curious phenomenon hints at the existence of a framework constraining the advancement of sustainable design, hindering designers from diversified realizing their sustainability goals.

It is noteworthy that the notion of "development" here pertains more to the micro-level evolution of sustainable design, delineating the progression of specific sustainability focal points from conception to integrated selling or design elements, rather than the overarching trajectory of sustainable design trends.

Although this micro-level framework delineates the incremental development of sustainable design, it offers insights into the broader panorama of sustainable design trends. Consequently, the forthcoming chapter endeavors to elucidate this framework further, unraveling its constituent elements and implications for the overarching trajectory of sustainable design evolution.

5.3. Discussion

In my exploration for instances of sustainable design, I navigated the vast expanse of the Internet, employing targeted keyword searches. It is crucial to note that the catalog of sustainable designs enumerated at each historical juncture in the trajectory of sustainable design does not purport to be exhaustive, but rather serves as an illustrative representation of what the digital archives recollect about sustainable designs from that era.

Acknowledging the inherent one-sided nature of online research, it is imperative to justify this approach in light of the consumers. The justification lies in the intrinsic relationship between design and its buyers, compelling this research to fully embrace the real market environment.

In the contemporary educational landscape, where higher education remains elusive for a substantial segment of society, the Internet and newspapers stand as the primary channel for information acquisition and thoughtful reflection. Consequently, Internet-based research holds the potential to immerse the researcher in the consumer's perspective, considering the prevalent reliance on these media for information consumption and decision making.

Furthermore, the Internet stands as a resonant platform for professional designers, serving as a pivotal channel for inspiration in their creative endeavors. Despite this, an acknowledgement of the necessity of integrating academic research into discussions involving key quantitative findings remains paramount. Therefore, this research strategically centers on the amalgamation of insights garnered from the Internet and case studies, fortified by a comprehensive review of pertinent academic literature.

During the comparative analysis between the Chinese and Dutch markets, I offered a tentative justification for employing Google's default product sorting and Taobao's product sorting based on sales volume. However, it is important to acknowledge that these two sorting mechanisms fundamentally diverge, thereby complicating their direct equivalence. Indeed, the intricate relationship between them precludes unequivocal affirmation or refutation of their parity.

At its essence, sorting by sales reflects consumers' inherent preferences, whereas Google's sorting may predominantly echo the advertising intensity of providers, signifying the subjective intent of the latter. This fundamental disparity underscores their incongruity and precludes their straightforward alignment. Nonetheless, the interplay between the two sorting methods warrants scrutiny. The advertisements consumers encounter prior to making purchasing decisions exert subtle influences on their choices, with Google's ranking itself functioning as a form of advertisement that shapes consumer behavior. Simultaneously, providers tend to allocate premium advertising resources toward products with robust sales figures, rather than expending efforts on promoting less favored items. Consequently, the sorting based on advertisements indirectly mirrors sales trends to a certain extent.

Therefore, while it remains challenging to conclusively establish the equivalence between sorting by sales and default sorting influenced by advertisements, it is plausible to infer a degree of similarity and a high correlation between them, which suffices for the purposes of this study. However, it is imperative to acknowledge a potential drawback associated with this approach. The default sorting influenced by advertisements may exhibit a lag compared to real-time sales trends due to unforeseen events precipitating abrupt shifts in consumer preferences. For instance, a company's products may face a crisis of trust leading to consumer boycotts and subsequent plummeting sales, yet the online advertisements for these products might persist or be slow to adjust. This discrepancy may result in a lag in the ranking by advertisements or a pronounced mismatch with actual sales figures. Consequently, in the event of acute changes in Dutch consumer preferences during our research period, such shifts may not be readily discernible in the rankings.

Finally, another limitation of this chapter is the limited number of products included in the study. Specifically, only 10 products were analyzed in each product category, which could have led to overlooking potential variations in sustainable approaches. The range of exhibits scrutinized in this study is also narrow, and a broader spectrum of categories might unveil similar sustainability approaches across different product types. However, I consider that such oversights would only marginally affect the study's outcomes.

For instance, if we were to increase the sample size in the apparel category from 10 to 100 products, suppose the first 20 products focus on reclaimed materials while the remaining 80

emphasize other sustainability aspects like water conservation and carbon footprint. This scenario would significantly alter our existing research outcomes. Yet, I consider the likelihood of such a scenario to be exceedingly low. The 10 products chosen are either top-selling or highly advertised and exposed, making them representative or mainstream within their respective categories. Consequently, when these representative products consistently showcase a uniform sustainability pattern, it's improbable that other products within the same category deviate significantly from this pattern.

6. The sustainable design development framework

The examination conducted in the preceding chapter has prompted a realization regarding the potential implications of sustainable selling points on the broader trajectory of sustainable trends. This realization underscores the significance of delineating a framework elucidating the development of sustainable trends as a cohesive entity. Consequently, this chapter aims to synthesize such a framework through a detailed analysis of specific cases.

As delineated in the preceding chapter, our analysis revealed distinct characteristics pertaining to sustainable design selling points within the Chinese and Dutch markets. Notably, while the sustainable design selling points prevalent in the Chinese market are inherently user-centric, they may not necessarily align with the ethos of socially responsible sustainable design. Conversely, the Dutch market exhibits the emergence of two distinct categories of sustainable selling points that are more congruent with our overarching theme. These include the utilization of recycled plastics for fabric production and the integration of biodegradable ingredients in cleaning agents.

However, user-centered sustainability in the Chinese market is not worthless; on the contrary, it provides a starting point for subsequent research. In contrast, sustainable design in the Chinese market and the Dutch market is very much like two stages of development: the Chinese market is like a human being in his infancy, who only knows how to ask for resources from the environment in order to ensure his own sustainability, while the Dutch market is like a human being in his adulthood, who has already fulfilled his own needs for survival and has started to give something back to the people around him, or to others in return. Therefore, the Chinese market is probably the past of the Dutch market, and the Dutch market is the future of the Chinese market. In the spirit of going back to the roots, The Chinese market will serve as a starting point to explore the inner law of sustainable design development.

6.1. A huge difference

First of all, it is certain that Chinese consumers are not less aware of sustainability than Dutch consumers, with a local study showing that more than 70% of Chinese consumers are aware of sustainable consumption (Li et al., n.d.). So, if there is no lack of awareness of sustainable consumption, why is it that Chinese consumers and providers are more concerned with the basic needs of the user, while Dutch consumers and providers have begun to focus on the needs of the natural environment? This point can easily remind us of Maslow's pyramid of

needs. According to Maslow (1943), the need to achieve sustainability is at least an Esteem Need, because the pursuit of sustainability allows people to feel that they are contributing to the world. This need sits above physiological, safety, and social needs. In other words, Esteem needs become a motivation for one's behavior only when these three lower needs are satisfied. The need for product durability in the Chinese market is more like a lower level safety need, because it can help users save money and thus ensure their financial security. And in today's society, money helps people fulfill most of their physiological, safety, and social needs. Then the fact that the Chinese market focuses on a lower level of consumer needs than the Dutch market means that the Dutch consumers are richer than the Chinese consumers, which we can verify through economic data.

Economists believe that PPP (GDP per capita) reflects the living and income level of a country's people (Pashchenko et al., 2022), and the latest data shows that the PPP in the Netherlands is 65,190 dollars while China's PPP is 13,160 dollars (World Economic Outlook, 2023).

The analysis suggests that a nation's standard of living exerts a significant influence on the adoption and consumption of sustainable design practices. Additionally, an approximate conclusion can be made by considering the market performance of China and the Netherlands alongside their respective PPP levels. Specifically, the PPP of $13,160 falls considerably short of establishing a foundation conducive to the widespread adoption of sustainable design initiatives. Conversely, the PPP of $65,190 observed in the Netherlands marginally surpasses the threshold required for creating an environment conducive to the popularization of sustainable design practices. Notably, the Dutch market, despite its relatively higher PPP, exhibits a concentration of sustainability efforts within a limited number of product categories.

Given that Esteem needs serve as the foundational impetus for the pursuit of sustainability needs, it is expedient to categorize physiological, safety, and social needs below Esteem needs as Basic Needs within subsequent research frameworks. Esteem needs and self-actualization needs are categorized as Advanced Needs for the sake of clarity and coherence in presentation.

6.2. Case study

In the section 6.1, we acknowledged the essential economic underpinnings requisite for the realization of sustainable design through an intuitive examination. Subsequently, we direct our focus towards a particularly enigmatic facet of this investigation, namely, the phenomenon of uniformity characterizing sustainable design attributes across products within the same category, juxtaposed against the variability observed among sustainable design attributes across products belonging to disparate categories. To elucidate this phenomenon, we endeavor to scrutinize instances exemplified by the utilization of recycled materials in the realm of apparel fabrication and the integration of biodegradable materials in the domain of cleaning products. Through such examination, we aim to delineate how they have evolved into widely recognized sustainable design points and why they stand out from the crowd of other sustainable design points in order and gain a foothold in the consumer market.

6.2.1. Recycled materials as clothing fabrics

In the absence of direct scholarly research into the historical evolution of recycled materials' utilization within the domain of clothing fabrics, the synthesis of a comprehensive historical narrative has been achieved by amalgamating insights from academic literature and reports issued by non-governmental organizations (NGOs). Commencing in the early nineteenth century, the emergence of the Napoleonic Wars precipitated a scarcity of wool, prompting a substantial adoption of secondhand wool for fabric production on a large scale, thereby constituting the inaugural documented instance of widespread, systematic utilization of recycled materials for fabric manufacturing by human societies (*Recycled Textiles | Encyclopedia.com*, n.d.). Approximately a century later, the onset of World War II, coupled with the imposition of clothing rationing measures in the United Kingdom on June 1, 1941 due to the substantial diversion of raw clothing materials towards military uniform production, catalyzed the emergence of a trend wherein recycled materials, including secondhand fabrics, were repurposed to fulfill domestic clothing needs (*The Evolution and History of Upcycling: From the 40s to Nowadays | Stain*, n.d.). This trend persisted beyond the end of the war, gaining momentum during the subsequent Great Recession of the 1990s in the United Kingdom. Concurrently, the advent and proliferation of plastics revolutionized global markets, introducing not only the ubiquitous convenience of plastic containers and bags but also polyester fabric, characterized by its affordability, durability, and ease of maintenance (*History of Polyester Fabrics - Lawrence Hunt*, n.d.). Consequently, the widespread dissemination of these products precipitated the emergence of fast fashion trends, albeit at the expense of heightened pollution and waste generation.

Today, more than 50% of fabrics are made of polyester (Smelik, 2023). However, in the decades since the popularization of plastics, there has been a growing concern that plastic waste, which is not naturally degradable, will only accumulate in the natural environment in which we live and begin to affect all aspects of the ecosystem (Rochman, 2020). 1993 saw the world's first fleece made from recycled plastic (Plastics, 2022). This initiative quickly attracted the interest of a large number of designers at the time, as they believed that the use of recycled plastics would effectively reduce plastic waste, especially from plastic bottles, and would help to improve the sustainability of the apparel industry, thereby addressing related environmental issues (Majumdar et al., 2020). Clothing made from recycled plastic was officially introduced to the market in the 2000s by clothing brands such as H&M, and skyrocketed in the 2010s as consumers became more environmentally conscious (Of Doodlage, 2023). Today, 14.8% of the world's apparel fabrics are made from recycled PET (Smelik, 2023).

Through this historical development we can see that the first few fevers for clothing made from recycled materials were caused by direct crises. For example, the first was caused by a wool shortage due to the Napoleonic wars, the second was caused by a clothing shortage due to the Second World War, and the third was caused by an economic recession, where people would have had to find ways to reuse their garments to reduce their living expenses. There is a strong causal relationship between these three waves of crisis and the wave of recycling of clothes. That is, recycling old clothes because of the lack of clothes. The fourth

wave of crisis and the wave do not have such a clear causality, in order to clarify their relationship, I tried to analyze it through the following chart (Figure 21).

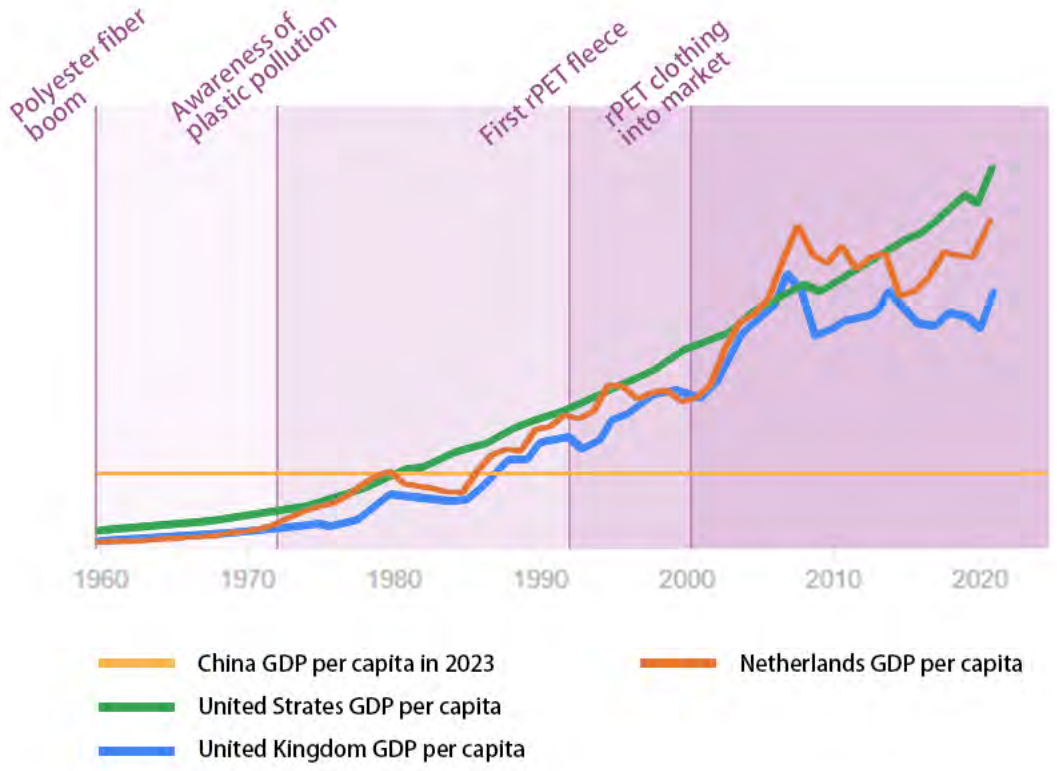


Figure 21 This chart compares the development of sustainable clothing and PPP (GDP per capita) in the countries covered in the study

The proliferation of PET-based clothing experienced a global surge during the 1960s (Smelik, 2023). Despite the initial recognition of plastic waste hazards in 1973 (Rochman, 2020), this awareness did not impede the exponential growth of the plastic industry. Presently, over half of the world's apparel is derived from plastic, with a staggering 87% of discarded textiles destined for landfill (Moazzem et al., 2021). Evidently, society has long acknowledged the damage associated with plastic waste (Moazzem et al., 2021), and consequently, the environmental ramifications engendered by the fashion industry have attained widespread recognition (Sedej & Toroš, 2023).

However, despite the acknowledgment of this environmental crisis, there has been a conspicuous absence of a discernible trend towards clothing recycling as a means of mitigating plastic pollution through the reuse of garments. Instead, a prevailing trend entails the utilization of recycled plastic to manufacture new clothing items. Regrettably, this approach serves more as a stopgap measure than as a genuine impetus for saving earth. While ostensibly addressing the production of primary plastics and mitigating certain pollution issues associated with discarded plastic bottles, it fails to address the substantial waste generated by clothing disposal or the inherent environmental detriment attributed to polyester fabrics. Notably, studies have evidenced that PET-based garments release

significant quantities of microscopic PET particles during laundering, which, being non-biodegradable, can infiltrate natural ecosystems via wastewater and accumulate within organisms across various biological chain levels (Stone et al., 2020), thereby posing an immeasurable hazard. Regrettably, the transition towards manufacturing new clothing from recycled plastics not only fails to alleviate this issue but exacerbates it, as discarded plastic bottles, which could have remained inert in landfills, are now repurposed into fabrics, thereby perpetuating the dissemination of potentially harmful debris to a broader spectrum of organisms.

Why, then, has the ostensibly more efficient practice of clothing recycling and reuse not garnered widespread prevalence? Building upon the preceding analysis, two plausible explanations can swiftly be surmised. Firstly, recycling clothing inherently entails a reduction in demand for new apparel, thereby directly impacting the profitability of clothing providers, which is fundamental to their sustainability. Consequently, clothing providers may exhibit a vested interest in impeding the proliferation of recycling initiatives. Contrarily, they possess both the incentive and the capacity to thwart such trends. As previously noted, manufacturers and brands often enlist designers to conceive novel products or concepts aimed at stimulating consumer appetites for material goods, thereby bolstering demand. In this context, designers may incorporate recycled PET into their clothing designs, thereby engendering a compelling sustainability narrative. Remarkably, this approach not only stimulates clothing demand but also caters to a consumer segment impassioned by sustainability and environmental stewardship, thereby yielding profits. Consequently, it facilitates the alignment of profit generation with public environmental concerns, ostensibly fostering a mutually beneficial relationship between consumers and providers. However, the pivotal stakeholder in this dynamic, the natural environment, does not necessarily emerge as the ultimate victor.

The second explanation revolves around the psychological dynamics at play among consumers in developed nations, where individuals, having already satisfied their basic needs, are compelled to pursue high-level needs, such as esteem need. The notion of utilizing recycled plastics for clothing not only protects their already gratified basic needs, but also satiates their esteem needs, thus epitomizing an optimal win-win situation. Consequently, consumers find themselves able to indulge in their burgeoning materialistic inclinations while concurrently fulfilling their esteem pursuits.

This analysis underscores the predominant prioritization of profitability by providers, necessitating the consideration of profit margins prior to embracing sustainability initiatives. Absent external regulatory pressures, such as governmental mandates, providers are unlikely to undertake actions that contravene their vested interests, even if such actions would significantly enhance societal and environmental sustainability. Furthermore, consumers must safeguard their basic needs while endeavoring to advance sustainability goals. In essence, successful sustainable industrial design ought to harmonize both the material and spiritual dimensions of consumer satisfaction.

Taking into account these insights, we can encapsulate the model of the development framework for the cultivation of successful sustainable design within the contemporary marketplace (Figure 22). In this diagram, the red, yellow, and blue squares labeled "Crisis,"

"Profitable provider," and "Basically satisfied consumer," respectively, form the foundation for ASID generation. The simultaneous presence of these three foundations is a prerequisite for ASID creation. However, for sustainable design to sustainably thrive in the market over time, it must successfully navigate all the cycles depicted in the diagram simultaneously. This means it must address and mitigate the crisis, be financially beneficial for the provider, and ultimately offer material and spiritual satisfaction to the consumer.

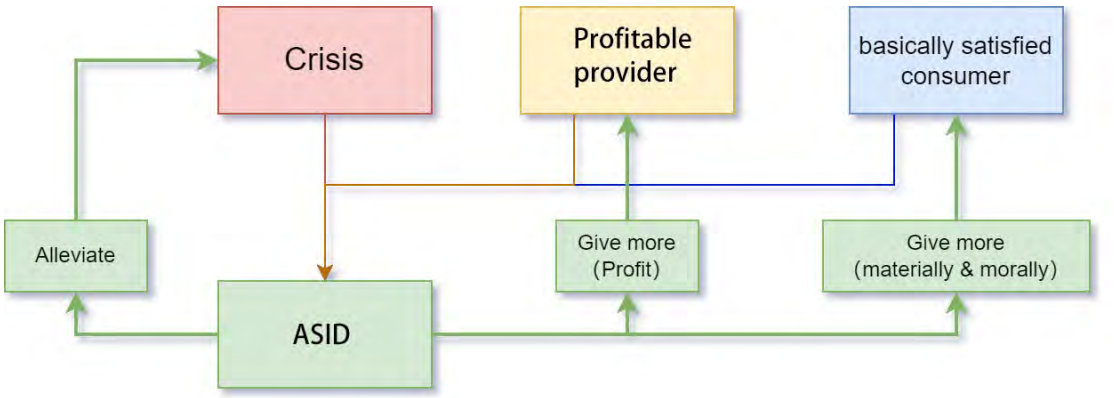


Figure 22 The initial development model of ASID

6.2.2. Biodegradable cleaning products

By analyzing this category, which is one of the two in the Dutch market that focuses on sustainability, we can on the one hand validate the model summarized earlier and on the other hand check if there are any peculiarities or omissions in the previous analysis.

In 1962, the biologist Rachel Carson published Silent Spring, whereby the environmental hazards of chemical products were recognized for the first time. Influenced by this event, in the 1970s, Tom's of Maine released the world's first phosphate-free laundry detergent in the U.S. market, but it wasn't until the 2000s that green household products became a more popular trend, when about 10% of new household products on the market took sustainability into account. sustainability. Companies like Tom's of Maine, which produced green cleaning products, began to grow in popularity (Marsh, 2022). In order to verify that this new case of sustainable design fits into the model of sustainable industrial design development that we deduced earlier, I have branched the timeline of the design's development into the following diagram for easy comparison (Figure 23).

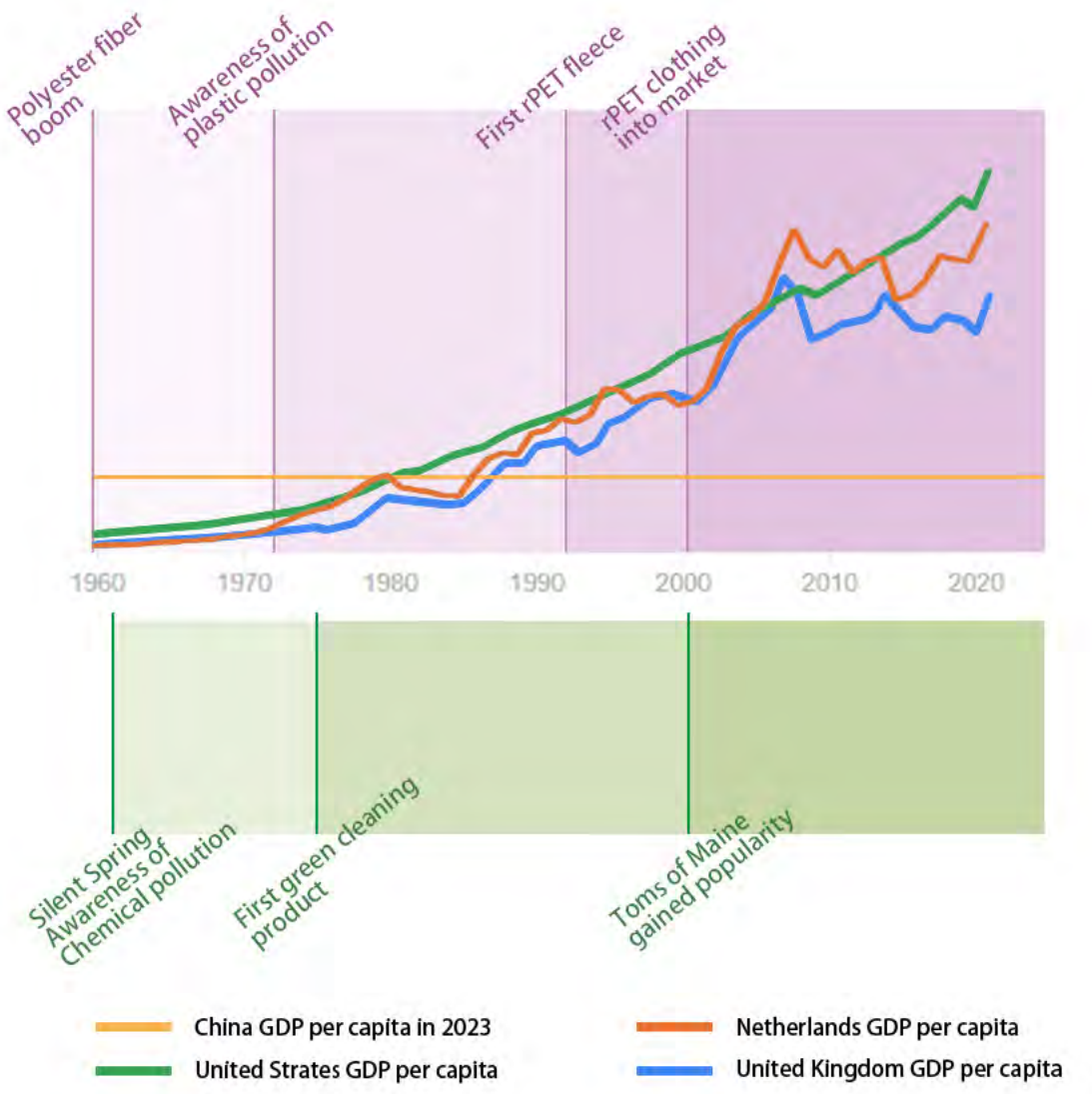


Figure 23 The comparison between economic status, development of sustainable clothing, and the development of cleaning product

As depicted in this graph, societal awareness regarding the hazards associated with chemical products preceded the recognition of risks posed by plastic products by approximately a decade. Furthermore, the inception of sustainable cleaning products preceded endeavors toward sustainable clothing by approximately two decades. Consequently, the initiation of sustainable cleaning product development commenced approximately ten years prior to sustainable clothing initiatives. However, the widespread adoption of sustainable cleaning products coincided temporally with the emergence of sustainable clothing.

This phenomenon underscores two key propositions: firstly, it reinforces the notion that economic development exerts a pivotal influence on the embrace of sustainable design within the consumer sphere. Secondly, it intimates that the economic prosperity attained by Europe and the United States during the 2000s may have constituted a threshold wherein sustainable design gained traction in the marketplace.

In addition to this, new discoveries can be observed. The damage to the natural environment caused by plastic waste from the consumption of clothing is chronic. Even today, when plastic waste has accumulated in the oceans, it is still difficult for the majority of people living on land to notice, let alone have their quality of life reduced by this pollution. Plastic particles entering the human body through the biological chain is also a long process, and there is no evidence that any kind of disease in the world today is caused by the accumulation of plastic particles in the body. On the other hand, countless studies, starting with silent spring, have pointed to the acute and direct harm caused by chemicals to the human body and the ecosystem. In short, the correlation between chemical pollution and basic needs, such as psychological needs and safety needs, is stronger than the correlation between plastic pollution and basic needs. But this greater threat to basic needs does not seem to have accelerated the development of sustainable design, but rather to have succumbed to the economic base. It is as if the level of danger to consumers or the environment from the crisis is not in itself sufficient to influence the development of sustainable industrial design.

This discovery may initially appear counterintuitive, yet upon closer examination, we can discern instances where crises have indeed directly precipitated sustainable design initiatives. For instance, when scrutinizing the historical trajectory of sustainable clothing, we observe how the initial three waves of clothing recycling were directly prompted by shortages stemming from wars or economic downturns. Within these waves, instances emerged wherein discarded garments were repurposed, such as elders' clothing being repurposed for children or curtains being transformed into new clothing. These instances underscore crises' direct role in fostering sustainable design. However, it is crucial to differentiate between ASID and ASGD, as delineated within our model.

In examining the aforementioned cases, it is discernable that crises indeed engender ASGD, not ASID, as expounded within our model. During periods of war, garment factories may be requisitioned for military uniform production, thereby precluding engagement in sustainable design endeavors due to lack of motivation or resources. Similarly, during economic downturns, factories may grapple with self-preservation, rendering the pursuit of innovative sustainable design ventures exceedingly risky, particularly when consumers face financial constraints. Consequently, amidst such circumstances, ASID may not materialize, necessitating the pursuit of ASGD. This elucidation aligns seamlessly with our ASID development model, indicating that although crises existed, sustainable design initiatives may not emerge if factories lack profitability and consumers' basic needs remain unmet.

Furthermore, an intriguing observation emerges: neither the plastics crisis nor the potentially more hazardous chemical products crisis spurred a corresponding wave of ASGD. This prompts inquiries like why did the wars and economic crises produce ASGD waves? What exactly is the difference between these crises? It is argued that crises' influence on ASGD development cannot be solely assessed based on the objective degree of danger they pose, but rather on the subjective degree of danger perceived by consumers.

For instance, plastic waste poses a threat to the distant natural environment and future generations' lives, without directly impacting one's immediate quality of life or basic needs satisfaction. Consequently, the average consumer may struggle to grasp the immediacy of

this danger. Similarly, while academic research underscores the potential for chemical products to infiltrate the human body through ecological pathways, causing direct harm or chronic health issues, users may not directly perceive this harm. Instead, these products often offer convenience and utility in daily life, making it challenging for consumers to associate subsequent illnesses with their use.

In contrast, the implementation of clothing rationing by the British government during World War II directly affected consumers' access to clothing, evoking a palpable sense of scarcity. Similarly, economic crises directly impact consumers' purchasing power, leading to a tangible inability to afford new clothing. Thus, consumers can directly feel the repercussions of these crises.

Consequently, we can delineate a model for the development of Solution-Oriented ASGD (S-ASGD), distinct from the ASGDs discussed in Chapter 2. This model prioritizes efficient resolution of current crises. Its development model is outlined as follows: When a crisis arises, it is first known, but at this stage there is not much incentive to make a change, and it is only when the crisis is felt in a tangible way that people commit to S-ASGD's development. The practice will then help to mitigate the crisis.

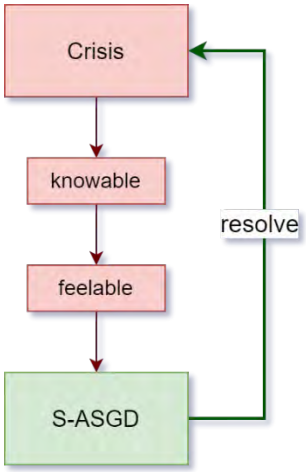


Figure 24 The development model of S-ASGD

6.3. Conclusion

This chapter initiates with a comprehensive refinement of the categorization of sustainable design, focusing on delineating the various manifestations of active sustainable design within contemporary society. Within the realm of Active Sustainable Industrial Design (ASID), a subdivision is established, comprising Art-oriented ASID (A-ASGD), Industrial Production-oriented ASID (I-ASGD), and Solution-oriented ASID (S-ASGD). Contemplating a parallel categorization for ASID, the inquiry arises: will a comparable taxonomy be applicable?

Primarily, within the Chinese market context, sustainable industrial designs retain a fundamental focus on user-centric principles. Notably, sustainability features such as durability, health considerations, and environmental protection are inherently directed towards serving the end user. Referring back to the previous conceptualization of ASID, it

denotes an industrial product wherein the designer proactively integrates sustainability considerations within at least one phase of the product lifecycle during the design process. Consequently, sustainable designs within the Chinese market are denoted as PSIDs.

Examining two illustrative cases within the Dutch market—sustainable clothing and green cleaning products—reveals a proactive integration of sustainability considerations within specific phases of their respective lifecycles. Hence, they are recognized as standard ASIDs. Nonetheless, a discernible inference from the outlined model suggests that ASIDs prioritize the interests of their providers, indicating a predisposition towards benefits superseding sustainability concerns for the provider. This discernment aligns with the analysis delineated in Chapter four concerning the inherent inclinations of providers and industrial designers.

Consequently, a sub-categorization should be proposed: Market-ASID (M-ASID), wherein the model previously proposed for ASID development was in fact describing M-ASID. Hence, the revised model is as follows:

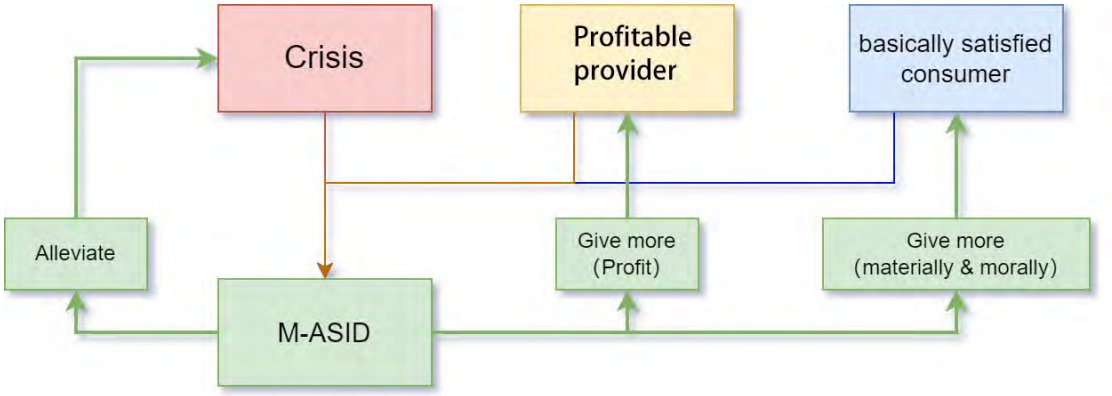


Figure 25 M-ASID development model

As per the developmental model outlined, sustainability, when viewed from the perspective of providers, assumes a subordinate position to profit imperatives. This prompts a critical inquiry: is there a conceivable paradigm of ASID that prioritizes social responsibility over profit motives? During my project, I have searched for such ASID examples but failed to find them, and despite its contravention of prevailing business paradigms, the potential existence of such a model cannot be categorically dismissed. Termed herein as Responsible-oriented ASID (R-ASID), this conceptualization underscores a departure from profit-centric orientations towards a design ethos grounded in social responsibility.
At this juncture, a relatively comprehensive classification framework for sustainable design emerges. Moreover, the development framework for two pivotal categories of sustainable design, namely S-ASGD and M-ASID, has been deduced and elucidated.

6.4. Significance of M-ASID development model

Industrial design holds significant sway over global developments and plays a pivotal role in propelling societal advancement. ASID, as a subset of industrial design, is poised to exert its positive influence worldwide alongside the broader wave of industrialization. However, this M-ASID model would expose one possible negative effect of the rapid growth of M-ASID.

This assumption stems from the perception that sustainable industrial design is increasingly being marketed to cater to the profitability of providers and the materialistic desires of consumers, while also addressing their ethical concerns. Consequently, and this: The downside of this possibility is that people may enter a vicious cycle of pursuing practical sustainable design, in which sustainable design becomes increasingly associated with profit considerations rather than responsibility, and ultimately leads society into a falsely sustainable future in which profits are made in the name of social responsibility. This could create an illusion of sustainability across all designs, masking the underlying motivation of encouraging consumer spending rather than true sustainability.

While such negative assumption is not unwarranted, it is important to acknowledge the merits of M-ASID. Given the vast reach and profound impact of the contemporary industrial design system, even minor alterations within this system can trigger substantial repercussions. Therefore, even incremental improvements, such as those facilitated by M-ASID to mitigate pollution, have the potential to significantly ameliorate the adverse effects of industrial society on the future of humanity. Cumulatively, these positive changes have the capacity to mitigate the detrimental impacts of industrialization on society.

Returning to the M-ASID model, it becomes apparent that it advocates for the development of a sustainable society without compromising existing material well-being. This vision aligns with the aspirations of achieving a future that simultaneously enhances material prosperity and fosters sustainability. Consequently, the primary role of the model is to serve as a reminder for designers to craft solutions that benefit the environment while catering to the interests of key stakeholders. Doing so is expected to increase the success of sustainable design in the marketplace and leverage the attributes of industrialization to enhance social sustainability on a larger scale.

6.5. Discussion

In analyzing the case of Applied Sustainable Industrial Design (ASID) within the Dutch market, I opted to consider not only the Dutch market but also the broader European and American markets. This decision stemmed from the lack of specific literature or information delineating the development of sustainable clothing specifically within the Netherlands. While it might have been feasible to infer the trajectory of sustainable clothing development in the Netherlands from various indirect indicators, such an approach would have significantly hampered the efficiency of my research efforts.

For instance, while it is documented that H&M introduced the world's first clothing line crafted from recycled plastic, the specific market where this line was introduced remains unspecified. While one could speculate based on H&M's operational scope at the time, such conjecture would entail a time-consuming process. Moreover, if subsequent investigation revealed that the introduced line did not debut in the Netherlands, any efforts invested in such inference would have been rendered futile, undermining the efficiency even more.

Thus, I chose to adopt a flexible interpretation of the European and American markets, enabling me to construct a rudimentary timeline of sustainable clothing development with

greater ease. This decision was not arbitrary but rooted in several factors. Firstly, the countries under consideration, including the United Kingdom, the United States, and the Netherlands, share linguistic and cultural affinities, fostering frequent and efficient academic and cultural exchanges. Moreover, sustainable design practices hold significance within each of these nations. Crucially, these countries also exhibit analogous trajectories of economic development.

These shared characteristics allowed me to confidently treat the European and American markets as a collective entity, facilitating the analysis of the Dutch market within a broader context.

However, this phenomenon also presents significant risks. In the context of sustainable clothing development, for instance, the loose "border policy" expounded in this study leads to the assumption that the introduction of H&M's sustainable clothing line to the market in the 2000s coincided across the United States, the United Kingdom, and the Netherlands. Yet, if this was not the case in reality—such as the hypothetical scenario where sustainable apparel debuts in the Dutch market two decades subsequent to its inception in the U.S., coincided with an elevated stage of economic advancement in the Netherlands—the implications for the economic underpinnings of my ASID development theory would be profound. Consequently, further investigation into the rigorous theoretical substantiation of the model's economic rationale is warranted.

7. Application

In this chapter, I will illustrate the practical application of the Sustainable Design Development Model through two cases. The first case involves utilizing the model to assess an existing design or a design in progress. The second case focuses on integrating the model into the design process to aid designers in developing sustainable designs.

7.1. Industrial design evaluation

When a design proposal is put forward, we need to assess whether it is a competent design that can bring profit to the provider and convenience to the user. Of course, there are various ways of assessment, and they may vary from company to company. Our Sustainable Industrial Design Development Model, however, can be used as a link in the assessment of sustainable industrial design solutions. If the design meets each of the needs of the model, it can be considered a potential sustainable industrial design.

Let us consider the aforementioned KAGURA, in 5.1.3, as an example to elucidate the analysis. The design is a sustainable industrial design concept presented at a design forum, where the designers indicate that the product is intended to enhance the sustainability of the user's living environment by reusing organic waste. The designers also state that users can use the design "no matter where they live". Since this is a product designed for people all over the world, let's try to determine if this is a potentially sustainable product in the context of the

Dutch market, using only the sustainable design development model.

We will first determine if organic waste is a crisis in the Netherlands.

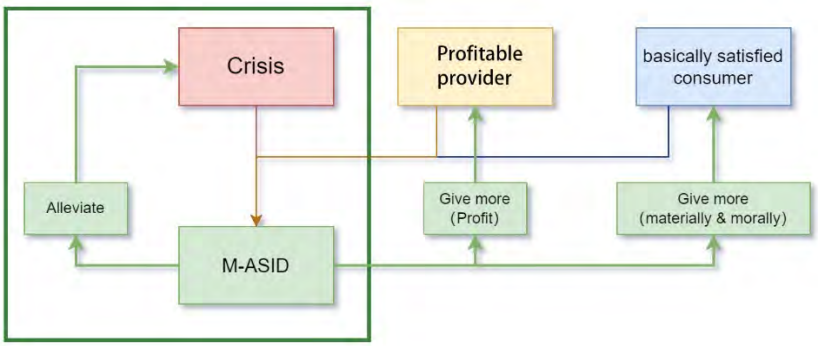


Figure 26 Checking crisis

According to the Dutch authorities concerned with waste recycling and management, most of the organic waste in the Netherlands is rationally recycled into feed or fertilizer (Dou, 2022), which is an effective and sustainable way of dealing with organic waste. Concurrently, there is no evidence of a crisis related to organic waste recycling in the Netherlands. Therefore, the design is not valid in terms of the existence of a crisis. Furthermore, since the design does not alleviate any crisis, it does not provide the user with esteem satisfaction. As a result, the design clearly fails to fulfill the 'Crisis' and the 'give more' elements on the user side of the model and therefore does not have the potential to be a successful in the Dutch market.

7.2. Engaging in sustainable product design

The product design process, particularly within the realm of human-centered design, is inherently intricate. Designers often embark on a collaborative journey with users to discern their specific needs, crafting proposals and prototypes for iterative testing. Throughout this iterative process, designers must consider not only the end-user but also various stakeholders and factors spanning the product's lifecycle.

For designers seeking to imbue their designs with sustainability while ensuring commercial viability, the Sustainable Industrial Design Development Model serves as a design tool. This model aids designers in navigating the design process and facilitates stage-by-stage evaluation, thereby enhancing the likelihood of success.

In this section, I will undertake a sustainable industrial design exercise to illustrate the model's utility. Given the comprehensive nature of product development, I will focus on delineating the process of utilizing the model rather than executing a complete design process. Consequently, for the sake of brevity and focus, the following illustrative design process will focus only on the considerations pertaining to the implementation of the model.

7.2.1. Starting point

Based on the previous analysis, sustainable clothing, which is currently sought after by society, does not necessarily alleviate the pressure on the environment due to the low efficiency of recycling and reuse. So I would like to try to address this issue by utilizing the model and some of the knowledge already gained through this research.

7.2.2. Process

Our target market is the Dutch market, characterized by a populace whose basic needs are met. This context affords us the opportunity to engage in sustainable industrial design endeavors.

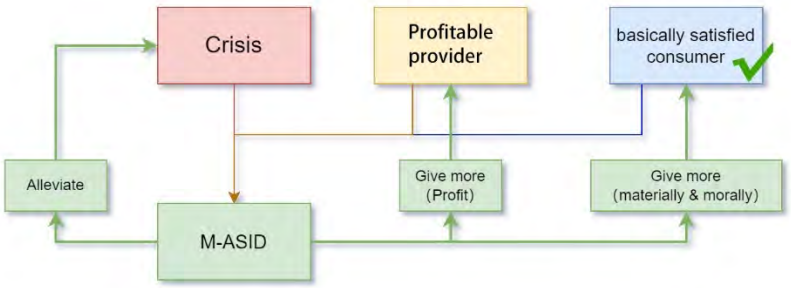


Figure 27 Checking the consumer

First, let's focus on crises and crisis resolution. Our previous research indicates that a significant amount of clothing is discarded or wasted each year, with a large portion of it being sent to landfills or incinerators due to low recycling rates, resulting in a series of environmental issues. This is the crisis we are facing.

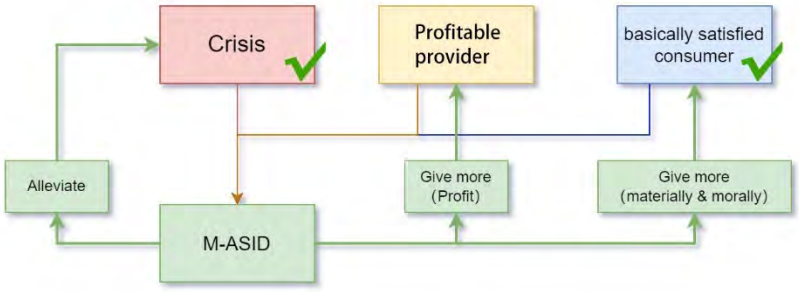


Figure 28 The foundation of sustainable design has been proved

The most efficient solution we know is to encourage consumers to reuse their old clothes instead of buying new ones, however this move would result in compromising on materialism for the users instead of giving them more, therefore it is not a promising business practice according to our model. To mitigate this challenge, an alternative method of reuse could be

pursued, a possible solution could be encouraging users to share their unwanted clothes.

By streamlining the process for users to donate their clothing and ensuring accessibility for those in need, we can probably reach the purpose of giving users more. One potential solution is the implementation of clothing sharing stations strategically placed throughout residential areas. Equipped with integrated metal coat racks, these stations offer a convenient platform for individuals to deposit their unwanted garments. Passersby can then freely browse and collect items of interest for free, fostering a culture of shared ownership and resource distribution within the community (Figure 29).

Figure 29 The idea of clothing sharing

In this manner, the reusability of clothes is expected to increase, affording those who dispose of garments the opportunity to replenish their wardrobe with new acquisitions. Moreover, this initiative imbues individuals with a sense of altruism and contribution to the sustainability of society. Concurrently addressing the material and ethical needs of users, this approach serves to mitigate crises. Furthermore, this paradigm shift mitigates the perception of dependency among those receiving donated items, fostering a sense of empowerment and dignity.

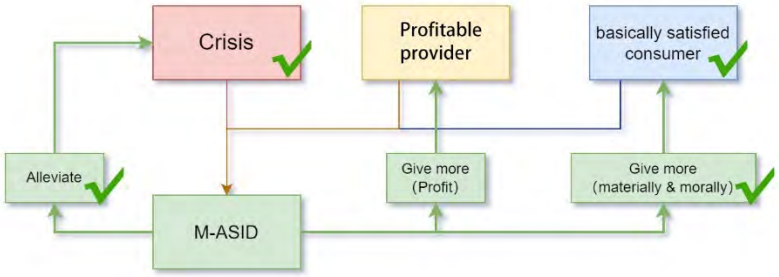


Figure 30 Checking the imperatives of the clothing sharing idea

Finally, because the result of this design is similar to a bus stop, it can bring more orders and profits to the manufacturer of the bus stop, and thus also satisfy the "give more" for the provider.

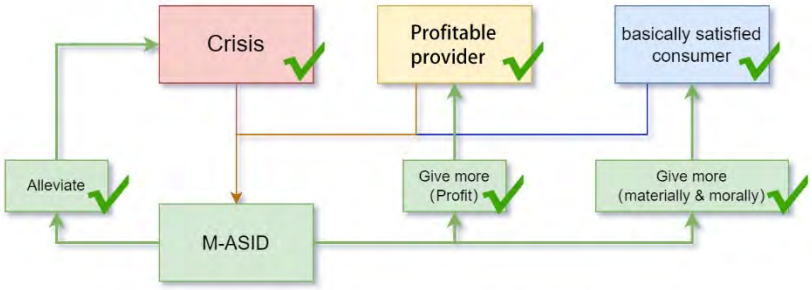


Figure 31 All factors have been checked

When all the conditions in the model are met, the design has the potential to be a successful sustainable industrial design.

7.3. Discussion

It is important to note, however, that the scenarios presented do not encapsulate the entirety of potential applications for the model. Further exploration is warranted to uncover additional use cases and expand the scope of its utilization.

In the latter part of this chapter, I demonstrated the application of the Sustainable Design Development Model within the design process. However, it's crucial to acknowledge that the design can be significantly flawed if certain essential aspects of the standard design process are overlooked. For instance, the absence of thorough user research raises doubts about whether users will be able to engage with the design as intended. Additionally, if the design is implemented by a government public service, there might be unintended negative repercussions. Also, will residents who do not directly benefit from the design support the program?

Most importantly, without practical testing, we lack evidence regarding the design's

effectiveness. This absence of real-world testing also prevents us from conclusively proving the positive impact of integrating the model into the design process based on this case alone.

8. Conclusion

This study initially addresses the origins of sustainable design. In essence, sustainable design in its modern form emerged during the mid-20th century, spurred by the industrial revolution and the resulting environmental challenges from industrial production. However, throughout history, numerous designs have shared similarities with modern sustainable design but with differing motivations, leading to the term "PSD". This insight influenced my exploration of the current state of contemporary sustainable design.

The contemporary product market is intricate, influenced by a myriad of factors such as politics, economics, culture, and the environment, among others. Consequently, a diverse range of designs exists in the market, including various forms of sustainable design. To describe the current landscape of contemporary sustainable design, I propose delineating detailed categories: A-ASGD (Art-Oriented Proactive Sustainable Generic Design), I-ASGD (Industrial-Oriented Proactive Sustainable Generic Design), S-ASGD (Solution-Oriented Proactive Sustainable Generic Design), M-ASID (Market-Oriented Proactive Sustainable Industrial Design), and R-ASID (Responsible-Oriented Proactive Sustainable Industrial Design), the latter of which currently exists primarily as an ideal.

In conclusion, I delved into contemporary developmental frameworks for sustainable design and outlined two sets of developmental models for M-ASID and S-ASGD categories. While these models could potentially contribute to design critique, the design process, or even serve as a foundation for future predictions, this study refrained from making explicit forecasts about the future evolution of sustainable design. As a result, the final research question—Could this evolution spark a new trend in design—remained unanswered within the scope of this study.

9. Discussion

In truth, we can learn about the detailed origins and evolution of modern sustainable design through desk research of existing literature. However, in this study, I took a more hands-on approach by personally organizing various sustainable design cases across historical stages and summarizing the development trajectory of sustainable design. While this method may appear complex and time-consuming for an seemingly apparent outcome, I believe that the evolution of sustainable design is a multifaceted process influenced by numerous factors.

By personally engaging in this process, I gain firsthand experience in understanding the various factors that may have shaped the development of sustainable design. This allows me to have a comprehensive understanding of the overall development of sustainable design and enables me to analyze its current state and future trajectory with greater confidence. Relying solely on existing research from others might lead to confusion when trying to

synthesize different perspectives and may hinder my ability to perceive the journey of sustainable design development from my own viewpoint. This limitation could potentially lead to more confusion in my subsequent analysis and ultimately reduce the efficiency of the study.

Analyzing the development model of sustainable design has proven to be more intricate than anticipated due to the myriad factors influencing its evolution. These factors range from local folklore to national policy-making, among others, and there are likely many more that have yet to be uncovered. As a result, many of these factors could not be fully incorporated into this research.

Consequently, the sustainable design development model I have summarized is relatively broad and may only serve as a rough guide or provide inspiration for other researchers. Its accuracy has not been validated, which is a significant limitation of this study.

In conclusion, due to the limited analysis of sustainability factors in this study, I cannot confidently predict the future of sustainable design. Therefore, the initial question posed at the beginning of this research regarding the future of sustainable design remains unanswered. However, the sustainable design development model I've presented may offer some insights.

For instance, historical trends show that many design movements eventually become socially outdated and are replaced or renewed, such as modernism superseding classicism and postmodernism succeeding modernism. One overarching message from the sustainable design development model is that people desire both sustainability and materialism concurrently. This suggests a potential future where technological advancements in human spaceflight and materials technology could lead to the ability to safely dispose of hazardous substances in distant outer space. In such a scenario, individuals wouldn't need to compromise their materialistic desires for sustainability, potentially giving rise to a wave of wasteful design. However, this remains speculative and requires further exploration.

Appendix1

This appendix includes links of the products select in the section 5.2.2. The products from China are shown as follow:

Shoe:

https://detail.tmall.com/item.htm?abbucket=9&id=645078868336&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=742460832990&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=711914973360&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=652021246583&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=539322699324&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=651335463769&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=743341634055&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=546608756847&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=634861152446&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

https://detail.tmall.com/item.htm?abbucket=9&id=733063952916&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

Sporting goods:

https://detail.tmall.com/item.htm?ali_refid=a3_430620_1006:1122455168:N:CpwecEnKDZXmElFxLxaUuA==:cf79fde9e35225eae6767e6483ac1ee8&ali_trackid=162_cf79fde9e35225eae6767e6483ac1ee8&id=706897314908&spm=a21n57.1.0.0

https://detail.tmall.com/item.htm?abbucket=9&id=744750302032&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6\

https://detail.tmall.com/item.htm?abbucket=9&id=552037974124&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

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https://item.taobao.com/item.htm?spm=a21n57.1.0.0.1e99523cUKcln6&id=662133522986&ns=1&abbucket=9#detail

https://detail.tmall.com/item.htm?abbucket=9&id=692893105430&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6

Cleaning products:

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https://chaoshi.detail.tmall.com/item.htm?abbucket=9&id=667333283600&ns=1&spm=a21n57.1.0.0.1e99523cUKcln6&skuId=4833598665458

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0.1e99523cUKcln6&sku_properties=147956252:75368623

Vitamins:

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https://item.taobao.com/item.htm?spm=a21n57.1.0.0.1e99523cUKcln6&id=620211086900&ns=1&abbucket=9#detail

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https://item.taobao.com/item.htm?spm=a21n57.1.0.0.1e99523cUKcln6&id=697195730643&ns=1&abbucket=9#detail

Baby supplies

https://item.taobao.com/item.htm?ali_refid=a3_430620_1006:1106144740:N:fqfnGfim0owomoCP9rK7qQ5KRRaVV20u:9f1ef29923ccfe9fd6801e964a0b0af4&ali_trackid=1_9f1ef29923ccfe9fd6801e964a0b0af4&id=687348955927&spm=a21n57.1.0.0

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https://detail.tmall.com/item.htm?abbucket=9&id=746110233695&ns=1&spm=a21n57.1.0.0.476d523c1rqA6q

Appendix2

Products for Dutch market analysis

Shoe:

https://www.nike.com/nl/t/dunk-low-retro-herenschoen-VMwkPQ/DD1391-100?nikemt=true&cp=76575696085_search_&Macro=--x-20409500847---c-----9103100-00194502876000&gad_source=1&gclid=Cj0KCQiAkeSsBhDUARIsAK3tiefFxUyJUk9kLhTFxGc7e2eEmeDuR4jc3ABrimJXBHanK5yq96HV9dQaApbPEALw_wcB&gclsrc=aw.ds

https://www.nike.com/nl/t/air-jordan-1-mid-damesschoenen-CR2SZ7/DV0991-101?nikemt=true&cp=76575696085_search_&Macro=--x-20409500847---c-----9103100-00196608052036&gad_source=1&gclid=Cj0KCQiAkeSsBhDUARIsAK3tieeIGBob5zZWIGm1kAExraX9ekFcf3qeHn1bOemxRaKK1Bv2TG3matAaAoYqEALw_wcB&gclsrc=aw.ds

https://www.allbirds.eu/products/womens-wool-runner-mizzles-deep-emerald?gad_source=1&gclid=Cj0KCQiAkeSsBhDUARIsAK3tiecd9LdQoOvXri7vicMams-RQsM42dLzykpVXQH0e3Qnjkv8ehqIIfAaAi2ZEALw_wcB&size=eu-39&utm_campaign=PMax%20%2F%2F%20EU%20%2F%2F%20Shoes&utm_content=&utm_medium=pmax&utm_source=google&utm_term=

https://www.nike.com/nl/t/air-force-1-07-herenschoen-HvZlfx/CW2288-111?nikemt=true&cp=76575696085_search_&Macro=--x-20409500847---c-----9103100-00194500874954&gad_source=1&gclid=Cj0KCQiAkeSsBhDUARIsAK3tiedmhLLk_1Sx3wQglyGKF1aPhmdfjqZRxwnsDTw1d0n2ib1OhyHbPF4aAnaSEALw_wcB&gclsrc=aw.ds

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Sporting goods

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