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RESEARCH ON THE CONSTRUCTION OF THE "THREE FITS" (SMA) SUSTAINABLE FASHION DESIGN MODEL FOR SPORTSWEAR, APPAREL AND EQUIPMENT BASED ON THE WHOLE INDUSTRY CHAIN

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ABSTRACT
Against the backdrop of sustained global economic development, social and environmental problems caused by the traditional growth model have become increasingly prominent, posing a threat to human survival. In order to promote harmonious coexistence between man and nature and enhance global well-being, the concept of sustainable development has emerged. In 2015, the UN proposed 17 Sustainable Development Goals (SDGs) and adopted a comprehensive strategy to address social, economic and environmental challenges under the framework of environment, society and governance (ESG). As a key area of environmental impact, the fashion industry has attracted widespread attention. Therefore, the design community has begun to incorporate sustainable concepts and explore ways to combine with SDGs. From the perspective of the whole industry chain, this paper focuses on the sportswear, apparel and equipment industry and constructs a "Three Fits" (SMA) sustainable fashion design model, aiming to promote the green transformation of the fashion industry and contribute to the Circular Economy. In the process of implementing the "Three Fits" (SMA) model, this paper analyzes the intersection and dynamics of the three dimensions of environmental, market suitability and social applicability, and verifies the scalability of the model through actual cases in the product design and development stage. This paper reveals the existing challenges of this model as well, as defining industry boundaries, quantitative assessment of carbon emissions, and emphasizes a well-thought-out design strategy which is essential to the whole life cycle of the design product.

Keywords: Whole industry chain, Sustainable fashion, Sportswear, apparel and equipment, "Three Fits" (SMA) sustainable fashion design model

1 INTRODUCTION

Globally, the improvement of environmental protection awareness has made sustainable development a common goal pursued by all walks of life. In response to environmental challenges such as climate change, China is actively promoting the realization of carbon neutrality goals and advocating a green and low-carbon lifestyle for all people[1]. Against this background, the sportswear, apparel and equipment industry is also facing transformation and upgrading, seeking new paths for sustainable development [2].

This study focuses on the role of each key link in the chain (producers, designers, consumers, etc.) from the perspective of the whole industry chain, reveals the current status and progress of sustainable fashion in the sportswear, apparel and equipment industry from the dimensions of sustainable color matching and recycled material application, identifies the challenges faced, and proposes solutions.

To this end, this study combines theoretical analysis with practical guidance to preliminarily construct a multi-module "Three Fits" (SMA) sustainable fashion design model, and explores the methods and means of effectively implementing sustainable development strategies from the aspects of design innovation, construction of recycling system, and enhancement of consumer environmental awareness, aiming to provide a solid theoretical foundation and practical guide for the sustainable development of the sportswear, apparel and equipment industry, help the industry move towards a green and sustainable future, and achieve the harmonious unity of environmental protection and economic growth [3].

2 CONSTRUCTION AND ANALYSIS OF KEY LINKS IN THE WHOLE INDUSTRY CHAIN OF SPORTSWEAR, APPAREL AND EQUIPMENT

2.1 Dividing the sustainable development responsibilities of participants in the chain by "roles"

In the grand plan of promoting the sustainable development of the sportswear, apparel and equipment industry, every part of the industry chain is crucial. To achieve this goal, all participants must assume their respective responsibilities and, through scientific and effective division of labor and cooperation, enable the industry to move towards a sustainable development path more efficiently and contribute to the future of the earth. List below shows all the participants and their respective responsibilities:

- Raw material suppliers:
  - Ensure the materials supplied are from reliable and sustainable sources;
  - Give priority to the use of environmentally friendly materials, such as organic cotton and recycled polyester;
  - Implement fair trade and responsible carbon management systems to achieve sustainable development requirements;
  - Build traceable environmental standards to enhance the sense of responsibility of the supply chain and provide strong support for sustainable design of downstream enterprises.
- Product designers:
  - Pursue the beauty and practicality of products;
  - Fully consider the environmental impact and ensure the easy dis-assemblability, maintain and recycle of the product designed;
  - Adopt sustainable and environmentally friendly dyeing processes to realize the reduction of the resource consumption, to achieve a dual balance between environmental protection and functionality [4-5].
- Manufacturers:
  - Adopt clean technology and energy-saving equipment;
  - Reduce waste and pollution;
  - Promote environmentally friendly process management such as water recycling and the application of solar and wind energy;
  - Strive to minimize production waste and effectively handle remaining materials through recycling and reuse to minimize environmental impact [6].
- Distributors and Retailers:
  - Reduce carbon emissions by optimizing logistics networks;
  - Adopt green energy vehicles and optimizing transportation routes;
  - Increase consumers' awareness and recognition of sustainable products through education and marketing activities.
- Consumers:
  - Being the key force driving market changes;
  - Support sustainable development goals by choosing environmentally friendly products;
  - Participate in recycling programs and reducing waste;
  - Make choices and provide feedback which directly influence market trends and corporate decisions, guide the industry towards a more environmentally friendly direction [1-7-8].
- Recyclers and Processors:
  - Being responsible for reprocessing old products and recycled materials;
  - Provide sustainable recycled materials;
  - Continuously improve recycling efficiency and quality through the development of new technologies;
  - Expand the application scope of recycled materials;
  - Reduce dependence on primary resources;
  - Promote the recycling of resources.
- Governments and regulatory agencies:
  - Regulate the sustainable development of the industry by formulating policies and regulations;
  - Encourage enterprises to establish strict standards and certification systems through tax incentives and subsidy incentives to ensure the sustainability of product design and production

processes.

- Non-Governmental Organizations and public interest groups:
  - Support sustainable development practices by raising public awareness, supervising corporate behavior, and providing professional advice;
  - Promote social attention to environmental issues through education, research, and publicity activities [9].

2.2 Construction and challenges of a sustainable recycling system for sportswear, apparel and equipment textiles

Building a sustainable recycling system for sportswear, apparel and equipment textiles is extremely important for the development of Circular Economy and environmental protection. Using block chain and Internet of Things technologies, we can establish an efficient carbon management of the whole supply chain traceability platform [Figure 1], achieve full-chain transparency and real-time data collection, and provide the industry with a feasible sustainable development plan. The concept of recycling should be integrated into the design and production stages, with priority given to recycled materials and easy-to-classify labels. It is necessary to mobilize manufacturers, retailers, recyclers, environmental organizations and the public to participate, and the government should introduce incentives and extended responsibility policies to ensure that companies fulfill their recycling obligations.

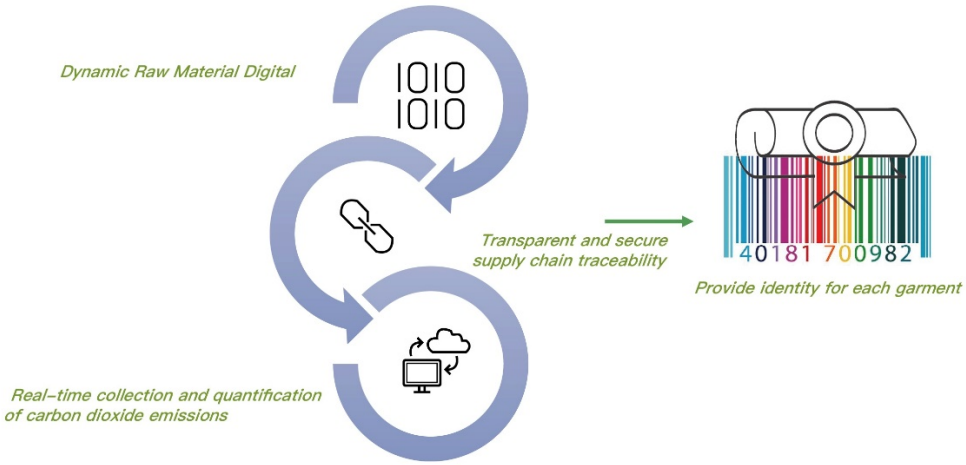

Figure 1. Carbon management whole supply chain traceability platform

Faced with challenges in the recycling system of sportswear, apparel and equipment textiles, such as material complexity and diversity of decorative materials, as well as recycling efficiency and strength of recycled materials, recycling companies need to strengthen technology research and development, reduce costs, and improve material quality. The government should improve laws and regulations, clarify responsibilities, and enhance consumer environmental awareness and participation through publicity and incentives. At the same time, a unified recycling standard and certification system should be established to ensure the standardization and transparency of the recycling and regeneration process. These measures jointly promote the sustainable recycling of sportswear, apparel and equipment textiles and achieve efficient resource utilization and environmental protection goals.

2.3 Consumer awareness and acceptance of sustainable sportswear, apparel and equipment products

Consumer attention to sustainable sportswear and equipment has increased significantly in recent years. Data shows that global online searches for sustainable products have increased by 71% [10] in the past five years. Among them, 88% of consumers said they would pay attention to the environmental protection attributes of products, and 80% of consumers aged 18 to 34 were willing to pay more for environmentally friendly products. At the same time, 66% of consumers will consider the sustainability of products when purchasing, especially among the younger generation, 75% are more inclined to choose sustainable products. However, although 78% of consumers want to buy products from companies that are more environmentally conscious, many people are still unable to tell which products

are sustainable due to low recognition, which leads to a gap between perception and actual purchasing behavior [11-12].

When choosing sustainable products, consumers tend to integrate environmental protection into their lifestyles, such as second-hand transactions and low-carbon travel, but they still face challenges such as high prices, difficulty in identification and lack of logos, which affect their purchasing decisions. In order to narrow the gap between cognition and actual behavior, analyzation of consumer consumption awareness in terms of sustainability might lead companies and marketers to improve the public's understanding of sustainable development [13-14]:

- Public education;
- Product or brand's environmental stories telling;
- Demonstration of the production transparent processes;
- Optimization the versatility and high quality of products;
- Combination added values such as teamwork and multiculturalism;
- Adoption of reasonable pricing strategies;
- Enhance customer stickiness by rewards or activities.

2.4 Establishment and optimization of chemical regeneration system in material recycling

Most of the regenerating or recycling concept products currently available to consumers are "bottle-to-fiber recycling" based on the physical method technology that began to be industrialized more than 10 years ago, which is an "Open-loop recycling". But Textile to Textile (T2T) or be called fiber-to-fiber recycling is a technology that converts waste textiles into new textile materials through chemical treatment method which is a "Closed-loop recycling". As the role of product designer, the T2T material recycling is an important aspect for considering the whole life of a product during the design process. The establishment and optimization of this system involves the following steps [Figure 2]: first, establish a collection network for waste textiles, and classify and clean them to decompose textiles, decolorize and remove impurities; second, convert fibers into renewable monomers or polymers through chemical processes, purify and recycle them, and re-spin them into fibers; at the same time, perform performance testing and certification on recycled textiles to ensure that they meet industry standards. The entire system needs to be integrated into a coherent, closed-loop system, and continuously optimize technology to improve recycling efficiency and reduce environmental impact. Economic analysis, environmental life cycle assessment, policy and regulatory support, market education and promotion, and cooperation with industry chain partners are all important strategies to promote the sustainable development of the T2T chemical recycling system. Through these measures, high-value recycling of waste textiles can be achieved, and the environmental friendliness and economic benefits of the textile industry can be promoted [15-16].

Figure 2. Textile to Textile (T2T) Chemical Regeneration Production Flow Chart

3 CONSTRUCTION AND ANALYSIS OF THE “THREE FITS” (SMA) SUSTAINABLE FASHION DESIGN MODEL FRAMEWORK

3.1 Construction of the “Three Fits” (SMA) sustainable fashion design model framework

The "Three Fits" (SMA) sustainable fashion design model framework is a comprehensive design method that integrates three key dimensions: Suitability (social aspect), Moderation (environmental aspect) and Applicability (economic aspect), aiming to achieve a perfect balance between product design in terms of sustainability, market competitiveness, and user experience. This model framework not only focuses on the entire life cycle of the product, but also emphasizes the consideration of the environmental impact, market demand, and user use of the product at the design stage by clarify industry boundaries [Table 1]. This model supports companies to meet consumers' needs for health, comfort, and functionality through innovative design, while responding to environmental trends, using sustainable materials, and enhancing brand image and market competitiveness.

In the sustainable methodology of the whole industrial chain, design plays a vital role. Design not only needs to consider the beauty and practicality of the product, but also needs to go deep into the selection of materials, optimization of the production process, and recycling and reuse of the product after use. Through the application of the SMA model, the design team can better coordinate various factors in the product development process to ensure that the final product meets the requirements of sustainable development and the needs of the market and users, thereby maximizing economic, environmental, and social value.

Table 1. Clarification of industry boundaries under the “Three Fits” (SMA) sustainable fashion design model framework

S - suitability			M - moderation			A - applicability		
Social aspect			Environmental aspect			Economic aspect		
Organization	Research	Standard	Intelligence	Materials	Manufacture	Brand	Consumer	Recycle
Policy formulation, supervision and evaluation	Entire product life cycle design and research	Standards system establish-ment	Technology empowering, emissions reduction and efficiency increase	Eco-friendly materials develop and use	Clean technology and energy-efficient equipment use	Eco-friendly products promotion and consumer awareness guidance	Recycling activities participation	Effectivity and utilization rate improve-ment

3.2 Analysis of the “Three Fits” (SMA) sustainable fashion design model framework

3.2.1 Intersectionality analysis

Intersectionality analysis explores the interrelationships between the three key dimensions of environmental Suitability, Market suitability, and social Applicability which refers to the “Three Fits” (SMA) model. The results revealed the interactions and potential synergies between them, while also pointing out possible conflicts. Based on these findings, this study strives to find a balance in design decisions, aiming to ensure that products can meet market needs and adapt to the actual usage habits of society while reducing their impact on the environment.

3.2.2 Dynamicity analysis

Dynamicity analysis conducts a comprehensive assessment of the entire life cycle of the product from the research and design stage to market decline, and focused on the impact of external environmental changes on the “Three Fits” (SMA) sustainable fashion design model. These external environmental changes include but are not limited to key factors such as technological progress, market trends, consumer behavior, and policy adjustments. The dynamicity analysis was implemented to ensure the adaptability and flexibility of the model in the face of these changes, and the design strategy was adjusted accordingly to maintain its continued effectiveness and relevance.

3.2.3 Sustainability assessment

To ensure the long-term sustainability of the design, this study adopted a systematic assessment method that aims to comprehensively quantify the environmental, social and economic impacts of the product throughout its life cycle. Quantitative analysis tools including key indicators such as carbon emissions, resource consumption rate, cost savings and user satisfaction were used. These indicators not only help to quantify the environmental impact of the product during its life cycle, but also measure its contribution to social welfare and economic growth. By using these quantitative indicators, the sustainability performance of the product can be deeply analyzed, thereby providing a scientific basis for the continuous improvement of product design to promote long-term sustainable development. List below shows steps to evaluate product carbon footprint:

1. Constitution of the process diagram which specifies each stage of the product life cycle from the raw materials to its disposal, including all material, energy and waste flows;
2. Clarification of the industry boundaries and calculate carbon emissions in order to determine actions priorities;
3. Collection of the data on material usage, activities and emission factors;
4. Evaluation of the accuracy of carbon footprint analysis.

3.2.4 Implementation challenges

During the implementation process, this study found a series of potential challenges, including technical difficulties, cost control, market acceptance and supply chain integration. In order to meet these challenges, a variety of solutions were explored and implemented, including technology research and development, partnership building, policy advocacy and market education. These comprehensive analyses and strategies ensure that the "three Fits" (SMA) model not only fully considers the needs of the environment, market and society when guiding product design, but also fully considers the various stages of the product life cycle and changes in the external environment. This approach helps promote the sustainability of design and maximize economic, environmental and social value.

3.3 “Three Fits” (SMA) sustainable fashion design standards and design grading

In the implementation of the "Three Fits" (SMA) sustainable fashion design model [Figure 3], the concepts of design standards and design grading were introduced to ensure the comprehensiveness and sustainability of product design. Design standards are a series of guidelines to be followed during the design process, covering the three dimensions of social Suitability, environmental Moderation and economic Applicability to achieve a perfect balance in product design. Design grading divides the design into different levels or categories based on the performance of the product in these three dimensions, so as to more effectively manage and optimize the design process [17].

In terms of design standards, the SMA model emphasizes the need to consider the environmental impact, market demand and actual use of the product in the design stage. The design team needs to use a series of quantitative indicators to measure the sustainable performance of the design, such as carbon emissions, resource consumption rate, cost savings and user satisfaction [18]. These indicators help ensure that the product design not only meets current needs but also has long-term sustainability.

In terms of design grading, by evaluating the performance of each design solution in the environmental, market and social dimensions, the design team can determine which solutions are more in line with the requirements of the SMA model. This hierarchical approach helps identify and prioritize those design solutions that perform best in terms of sustainability, product competitiveness and user experience [19].

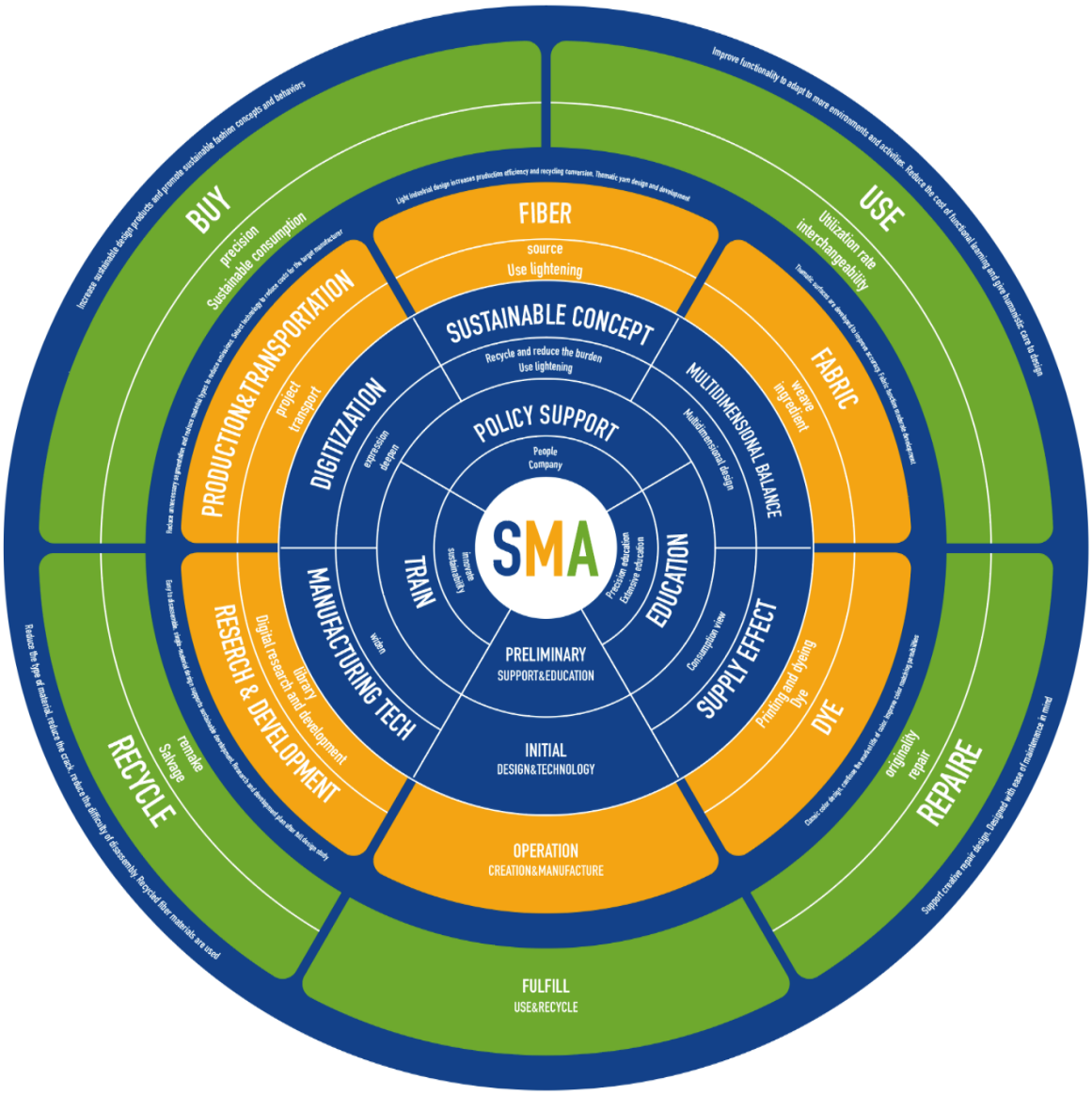

Figure 3. "Three Fits" sustainable fashion design model

3.4 Implementation of the "Three Fits" (SMA) sustainable fashion design model in ISPO Award-winning design product "Composite Structure Camping Down Jacket" and its commercialization

The winner of ISPO Award 2022 "Composite Structure Camping Down Jacket" [Figure 4] led by the authors is a sportswear design product designed and developed based on the "Three Fits" (SMA) sustainable fashion design model. The basic design concept is to integrate the sustainable concept throughout the entire processes of design, manufacturing, using, recycling and other phases, which was in the past, mainly focused only on the materials aspect. The "Three Fits" (SMA) sustainable fashion design model emphasizes minimizing waste and reducing production costs to the lowest possible level by accurately identifying functional requirements and corresponding to the most appropriate material use, abandons blindly pursuing advanced manufacturing technology and materials which will result in putting pressure on labor and consuming too many resources during the production process. The authors believe the design which comply the sustainable standards should not generate waste while meeting the multi-requirements and goals of design process.

Figure 4. Winner of ISPO Award 2022 "Composite Structure Camping Down Jacket"

The design path of this product is the practice and exploration of the "Three Fits" (SMA) Sustainable fashion design model from the perspective of social, environmental and economic aspects [Table 2]. The "Composite Structure Camping Down Jacket" is unique in its warmth-keeping function. The designer focuses on improving consumers' wearing experience and strives to make all functions easy to use, thereby increasing the frequency of use of functions, improving product practicality and reducing the burden of use. Unlike simply enhancing warmth, the designer pursues a balance of heat and moisture in static and dynamic states to ensure that the wearer remains comfortable while keeping warm and avoids discomfort caused by heat and moisture imbalance. The product's matrix dynamic adjustment system helps the wearer maintain warmth and comfort in various environments by regulating heat and moisture, reducing discomfort and heat loss caused by temperature differences and sweat. In addition, the composite style structure design supports at least 8 styling conversions, providing more matching options. Scarves and windbreaker jackets can be freely combined with other clothing to meet consumers' needs for fashion matching and functional expansion, ultimately extending the service life of the product.

Table 2. Design process based on the "Three Fits" (SMA) sustainable fashion design model

S - suitability	M - moderation	A - applicability
Social aspect	Environmental aspect	Economic aspect
Research on the multi-form and combination design style [figure. 5] to decrease purchase frequency by increasing occasions of dressing	Use of Primaloft® as inner material which is down blends and resist on humidity and animal friendly	Use of digital brand communication and marketing methods [figure. 6] to avoid the traditional photo shooting which potentially reduce the emission of CO2
	Use of a matrix dynamic adjustment system	Use of homogenous material as outer fabric to maximize the rate of recycle and regeneration

Figure 5. "Buy one, Get eight" multi-form and combination design

Figure 6. Digital brand communication and marketing methods

The sustainable design concept of this product, its enormous range of variation, functional for camping and also for urban life, easy-entry idea (If you have this “jacket”, you are equipped for everything, thus "Buy one, Get eight"), sustainable and well-thought-out design concept, easy to use, minimalistic, urban and inclusive design convinced the jury [20]. After winning the award, with the authors’ authorization, the commercialization [Figure 7] of the product by BOSIDENG, a Global Leader in Down Jackets manufacturer, is a sustainable extension attempt of the design results of the "Three Fits" (SMA) sustainable fashion design model in the fields of production, manufacturing, distribution and retail.

Figure 7. Commercialization of the “Composite Structure Camping Down Jacket” by BOSIDENG

4. CONCLUSION

This paper explores the paths of sustainable fashion of sportswear, apparel and equipment in the context of the whole industry chain, and constructs a "Three Fits" (SMA) sustainable fashion design model, which provides theoretical support and practical guidance for the sustainable development of the sportswear, apparel and equipment industry. The research results show that participants in all links of the whole industry chain should jointly assume the responsibility of sustainable development, apply sustainable technologies, improve consumers' awareness and acceptance of sustainable products, give full play to the role of color matching in conveying sustainable information, and the chemical recycling system of material recycling.

In the process of implementing the "Three Fits" (SMA) sustainable fashion design model, the author analyzes the intersection and dynamics between the three dimensions of environmental suitability, market suitability and social applicability, evaluates the sustainability of products, and verifies the scalability of the model with actual design cases in the application scenarios of the design and product development stage. Although there exist still challenges in the implementation process, such as the clarification of industry boundaries, quantitative assessment of carbon emissions, quantification and evaluation the sustainable development status of the sportswear, apparel and equipment industry, a well-thought-out design strategy which is essential to the whole life cycle of the design product should be prioritized and emphasized in order to promote the harmonious coexistence of the sportswear, apparel and equipment industry in environmental protection and Circular Economy and furthermore, to reach the Sustainable Development Goals (SDGs) from the prospective of fashion industry.

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