Research on zero waste garment engineering design in sustainable environment

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Abstract. With life becoming more convenient and rich, the pollution caused by human beings is far beyond our imagination. This study focuses on the clothing industry, which is closely related to human life, and its ecological pollution and waste of resources. It attempts to combine environmental issues to create clothing that can convey the concept of a sustainable environment and a more friendly Earth 2050: The Future of Energy. Different from the previous green environmental protection design, the current fashion trend is not only to promote environmental protection, but also to emphasize blue economy. In environmental protection, find out the industrial and economic values that meet various costs to achieve sustainable operation. In this study, the concept of environmental sustainability is brought into the clothing project. The goal is that the manufacturing process will not produce cloth waste. All cloth will go through the life course of clothing. The clothing project of “zero waste” will be built. The consumed resources will be fully utilized. In this research design, water resources, which is the most threatening issue of human sustainable environment, are used as the main design axis with blue as the image. Pollution and optimization issues faced by water resources are applied to clothing design thinking, presenting a series of clothing with zero waste structure, and implementing good behaviors of “sustainable” environment in life.

1. Introduction
This research aims at the progress of science and technology, which not only accelerates the economic growth, but also changes the pattern of human life.

While people enjoy the comfort and convenience brought by economic development, our natural environment has been destroyed bit by bit, such as the hole in the ozone layer, the disappearance of rainforest, the greenhouse effect etc. ecosystem imbalances [1]. In the face of environmental crisis, as a fashion designer, how to reduce and slow down the impact of clothing on the environment, and hope to remind consumers to pay attention to the related issues of sustainable and friendly environment. Timo Rissanen, an assistant professor of fashion design and sustainability at parson School of design, pointed out that about 15% of the fabrics were left behind in the process of clothing cutting and were discarded before entering the market, causing environmental problems and wasting resources.

Therefore, this study hopes to explore the relevant importance of clothing design and production in a sustainable environment, to understand the environmental impact factors caused by the production and consumption patterns of the clothing industry up to now. And more importantly, from the thinking of the design before clothing forming, bring the concept of environmental protection and sustainability into the actual act of fashion engineering, through the use of materials and fabrics, style design, and layout structure.
It is not only necessary to reduce the waste of resources and harm to the environment, but also to design clothing with the function of fashion and the concept of environmental sustainability.

2. Literature review
Understand the development of clothing industry, the general situation of environmental changes and the environmental problems faced by today, and summarize the causes of environmental problems caused by clothing industry.

2.1. Development of clothing industry
Clothing consumes a lot of natural resources in the process of production, and discharges many pollutants into the natural environment.

By understanding how designers lead the trend after the industrial revolution, the development of synthetic fiber cloth, the rise of fashion democratization in the clothing industry, and the development process of clothing industry in the era of transnational cooperation, especially in the middle of the 20th century, the invention of material science Human engineering research, mechanical automation etc. The results of the scientific and technological revolution have been widely used in the clothing industry, which makes the development of ready-made clothing leap forward rapidly. In a short period of 200 years, it has overthrown the previous all manual production mode [2]. With the popularization of information, multi-media make fashion information spread more rapidly, through newspapers, the Internet, press conferences and so on. For the promotion of fashion to the extreme, the popularity of ready-made clothing has become faster and faster, and its rise and rapid development almost dominated the clothing industry since the late 20th century, so it is called “the era of ready-made clothing”. It became the beginning of rapid fashion in the 21st century [3].

2.2. Environmental situation

![Diagram of the relationship between human behavior and environmental deterioration](image)

**Figure 1.** Diagram of the relationship between human behavior and environmental deterioration

Photo source: editing group of environmental education course, 2008
After the industrial revolution, due to the high development of machinery and the large-scale development of energy, it provides a huge power for production and life. Then many countries, in order to increase the output value, are desperate to tap natural resources. Due to the population growth, human demand promotes the continuous improvement of science and technology. After the industrial revolution, human damage to the environment is far more than any previous era. At present, the main environmental problems come from a large number of resource consumption, artificial waste and accumulation of chemical compounds, which exceed the capacity of natural decomposition and regeneration. Under the condition that nature cannot bear, human pollution accelerates the impact on the environment, and the threat to human living space gradually changes from a single region to a regional, or even expands to a global environmental problem, such as global warming. The pollution and depletion of water resources, and the relationship between human behavior and environmental degradation is shown in Figure 1.

2.3. Sustainable development of environment
The United Nations General Assembly first proposed the concept of “sustainable development” in 1980. It called on the world to study the interrelationship among nature, society, ecology, economy and natural resources, so as to ensure the sustainable development of the earth. Nowadays' sustainable development covers four aspects [4]

2.3.1. The concept of natural ecology
Sustainable development was first put forward by ecologists. The sustainable development of ecology is to protect and strengthen the production and rebirth of environmental ecosystem.

2.3.2. Economic development
According to the World Resources Research Institute in 1992, the sustainability of economy should be based on not damaging natural resources and without compromising the quality of the environment.

2.3.3. Social Development
The Sustainable Survival Strategy of protecting the Earth in 1991 states that the sustainability of society is to survive without exceeding the capacity of the system for survival, and to improve the quality of life, emphasizing that “life form and production scale must balance the earth's carrying capacity”.

2.3.4. Science and technology
In 1992, the World Resources Institute proposed that sustainable science and technology is based on the production of minimal waste and pollution.

2.4. Fast Fashion and Environment
The word (Fast Fashion) originates from the rapid development of ready-to-wear in Europe in the 20th century, while the United States calls it “Speed to Market”. The British Guardian has also created a new word “McFashion”. "Mc" is taken from MacDonald's, to express the rapid sale of fashion like McDonald's. Traditional clothing brands usually take several months from design release to circulation and sale, while fast fashion brands can go through the production cycle in about 50 days at first. With the development of Internet information and transportation, they can even be quickly circulated in a week; they are close to the fashion; they are more affordable and less expensive, so they can complete the product development, production to circulation and sale.

The life cycle of clothing, from raw material planting, adoption, fiber production, manufacturing to the use of final consumers, uses a lot of natural resources: the global textile industry uses about 37.8 billion liters of water every year. The World Bank estimates that textile dyeing, finishing and treatment account for 17% - 20% of the total industrial water pollution, and there are nearly 8000 kinds of synthetic chemicals used in the process of converting raw materials into textiles. Most of
them will be discharged to the fresh water system after use. Fashion and textile industry is one of the most energy consuming industries in the world. Fast fashion design is closely related to fashion, and the price is low, so that the public can enjoy fashion in a timely and easy manner. However, due to the low price, manufacturers reduce the production process, and make fabrics with unqualified formaldehyde content, color fastness and fiber content. The cost control of fast fashion causes product quality problems. The main reason for this problem is that poor quality has almost become a feature of fast fashion brands, which makes the life cycle of clothing extremely short. Because fast fashion brands launch new clothing almost every week, huge amount of textile waste will be generated under the condition of mass production, consumption and discarding. In 2005, Timo Rissanen, an assistant professor of fashion design and sustainability at parson School of design, pointed out that about 15% of the fabrics were left behind in the process of clothing cutting and were discarded before entering the market, causing environmental problems and wasting resources.

2.5. Green action of clothing industry
More and more people realize that environmental protection requires everyone to take practical actions. Fashion has always been in the controversy of environmental protection, which has promoted the development of green fashion. The concept of environmental protection is really popular with consumers. With the trend of environmental protection, many brands have launched green fashion products. Because of the promotion of many folk forces, green fashion is brought to the world, which makes consumption bring not only the beauty of appearance, but also a brand-new and healthy outlook on life, and environmental sustainability will become the future trend [5]. In the fashion industry, sustainable development is a mere discussion, but there are few actions to be taken, said Christina Dean, a non-profit charity founded in Hong Kong in 2007. There is not enough action to reduce waste. Therefore, Redress is committed to education to reduce textile waste and save energy, and cooperates with many organizations to promote the sustainable development of the fashion industry in Asia, and hopes to inspire fashion designers and students through its annual “Eco Chic Regeneration Fashion Design Competition” held every year from 2011, so as to change the fashion landscape by creating a market that is in line with the public and change the fashion pattern with the least waste [5].

3. Research methods
Starting from the treatment of raw materials, a piece of clothing is bleached and dyed to become yarn and fabric.

After garment production and logistics, it is recycled and even burned to decompose. There is carbon emission in every link. What can a garment designer do in the face of environmental crisis? In the tailoring of ready to wear fabric, about 15% of the fabric is wasted. If the designer can pay attention to the wasted part as well as the material in the design, it will not only increase the value but also reduce the waste. Through the literature to find out the direction for discussion, to reduce the waste of cloth, or even to create fashion with zero waste as the goal, using the literature analysis method, to analyze the contemporary popular trend, to explore the clothing case with “zero waste cutting” structure, and the design method that can be applied to no waste, and to use its characteristics as a reference for subsequent clothing design.

3.1. Contemporary trends
WGSN, the international popular trend prediction website, has put forward “ecological awakening” in its dominant trend in recent years (as shown in Figure 2). Through the awakening of human awareness of the environment, it explores how the whole society can solve the adverse impact on the ecology. Then put forward the “The Great Reset reset” in autumn and winter (as shown in Figure 3) - we will press the restart button to reverse our life, design and work. Consumers will reduce their pursuit of brand and turn to environmental protection life. The future values will focus on the product life cycle and human characteristics rather than only economic benefits. It is mentioned in the seasonal theme “mentality” released by spring and summer trend (as shown in Figure 4) [6].
make many industries progress, expand new business opportunities, and the importance of connectivity is beyond doubt, but at the same time, it promotes reverse movement - hand in hand with nature again to create a healthy body, mind and environment.

From the analysis of ongoing and future trends in recent quarters, environmental sustainability has become an important and necessary trend. Through various technologies, we must enable us to treat the environment in a new way, regard nature as a partner, integrate environmental care into the design process, and promote us to protect the world we live in and create a sustainable industry [7].

3.2. Sustainable clothing design method

The basic elements of clothing design are the application and combination changes of body structure, color matching and materials and fabrics. According to the two techniques of “reconstruction” and “upgrade and reconstruction” put forward by Redress and the design of “zero waste structure clothing”, by prolonging the life cycle of textile fabric, the accumulation of textile waste can be reduced.

“Restructure” is to decompose the existing and no longer worn clothes, reconstruct them and combine them into new clothes; “upgrade” is to recycle the unused fabrics and transform them into products of higher value. “Zero waste structure clothing” is through the design of clothing molding structure, that is, the design of the so-called “clothing version”, in order to avoid 15% to 21% of the leftovers cut by the garment industry in the production of cut clothing fabrics, so as to achieve the goal of zero waste (as shown in Figure 5 and Figure 6). Timo Rissanen, an assistant professor in the Department of fashion design and sustainability at Parsons School of design, and one of the members of Redress, studied a group of designers between the 19th and 20th century. For example, from the bias cut (oblique cutting method) invented by Madeleine Vionnet, it was found that the drape of fabric twill was used to fit the human body, and the characteristics of different weave directions between fabrics were used to increase zero waste clothing The feasibility of its creation mainly uses the “jigsaw puzzle” and “cutting method” [8].
4. Results and Discussion
Through the literature discussion, it is understood that the environmental problems caused by the clothing industry are mainly three major crises. “global warming”, “water shortage” and “textile waste”. From these three crises, it is necessary to think about the sustainable environmental direction that the theme design should aim at, analyze the fashion style and issues of the contemporary popular trend, and the basic elements of the clothing design, production and shaping, which will be friendly to the environment, positive and not a waste of resources. And the designer has a high autonomy of “zero waste tailoring” design method, develop this research design theme, and specifically create fashionable clothing with the concept of sustainable environment.

4.1. Creative theme
Different from the green used to convey environmental protection in the past, in addition to environmental protection, blue pays more attention to the regeneration and non-waste of the environment, and according to the literature, the water resources crisis is a major element of contemporary environmental sustainability. Therefore, the creation of this study echoes the sustainability of blue with the theme of water resources - “optimization” (Figure 7), hoping to highlight the anaerobic asphyxiation of organisms due to the destruction of water resources. Communicating sustainable environmental behavior requires immediate vigilance.

The application of zero waste cutting clothing structure is full of uncertainty in the design process, so the design must be completed in the process of production, rather than the traditional pattern of clothing drawing construction. This feature and challenge is that it can't be completely conceived in the first draft of design. It is necessary to design the contour of clothing first, and roughly cut distribution, and then think about how unused fabric can not be wasted, except for configuration In detail design, it can be used as the design change of clothing function adjustment to make the fabric used up without waste. The preliminary design of the clothing style (as shown in Figure 8) is based on the loose straight version and umbrella shaped silhouette, responding to the static and flowing water, which can be worn with different upper and lower clothing items to present a variety of faces.

4.2. Zero waste theme and Fashion Design
After conceiving the costume's outline, the design must be completed in a zero waste configuration. This study divides various methods into three major modes. The first one is “After conceiving the outline, the subsequent overall style design is completed in the way of Stereo Cutting” which is shown in Figure 9. The second one is “After positioning the main large section of the fabric, then arrange the details setting of the redundant cloth” shown in Figure 10.

The third is “according to the size of the fabric and the tailoring line adjust the pattern of the existing clothing”. As shown in Figure 11. The above three modes are used to modulate the structure of the clothing version.
Subsequently, according to the design theme, arrange the matchability within the fabrics, details and the single product (Figure 12), thereby meeting the needs of wearing in various life situations and providing practical convenience for achieving sustainable wearing.

**Figure 9.** After conceiving the outline, the subsequent overall style design is completed in the way of Stereo Cutting
Picture source: Shooting in this study

**Figure 10.** After positioning the main large section of the fabric, then arrange the details setting of the redundant cloth
Picture source: Shooting in this study

**Figure 11.** According to the size of the fabric and the tailoring line adjust the pattern of the existing clothing
Picture source: Drawing in this study

**Figure 12.** Design drawing of “NO2” series
Picture source: Drawing in this study

4.3. Series clothing design finished products

**Figure 13.** Finished clothing designed with zero waste version in “NO2” series
Picture source: Shooting in this study

In this study, a series of clothing styles (Figure 13) are all designed with zero waste version to echo the sustainable behavior of the environment, not only actually reduce textile waste, but also no waste of resources after many samples, finalization, production and other procedures, after the completion of
the work, models are invited to wear, with appropriate makeup and hair style, to create an atmosphere consistent with the concept of creation. With the combination of the pieces, it will present a variety of wearing styles.

5. Another section of your paper

The environmental damage caused by fast fashion has been overloaded. Many clothing brands will incorporate sustainable development into their business strategies, and put forward many recycling programs to remanufacture waste products into new products.

But among these waste fabrics, about 15% to 21% of the rags are cut in the manufacturing process, consuming a lot of resources, but they are scrapped without entering the life process of clothing. This study implements the goal of environmental protection and fashion with a zero-waste layout structure. The complete application of cloth in the production of clothing not only reduces the production of textile waste, but also does not waste the resources consumed in the fabric production process.

This series of creative design will be able to form a zero waste fabric clothing structure method, combined with the water source crisis image of water quality optimization, and finally present 13 complete clothing items. The combination of the items can create many ways to wear, and successfully enable the wearer to wear a variety of clothes according to different occasions of life. In the implementation of this research and design, it is found that because of the zero waste structure, it is not conducive to the use of different fabric splicing design in the material of a single garment, so the use of fabric length and short, transparent and opaque to show the sense of hierarchy of the garment, and also to show the clarity and pollution of the water quality. As this series of clothing is made of existing fabrics in the market, the effect of the cloth table is difficult to directly associate with the picture of the improvement of water quality. Although the overall effect can show the flow and stillness of water, it lacks the heavy sense of warning after water quality optimization. The theme emphasizes that the “anaerobic suffocation” of water resources is expressed by using color and text symbols, and the image of endangered water resources is also weak. In the follow-up, if digital printed fabrics and fabric surface texture processing designed for the theme can be added, it will be better able to show the optimal image of human destruction of water quality. The outline and structure of each style completed in this series are mostly the whole loose or the whole fit. If able to show a comparison of fit in the clothing style, it will be more able to strengthen the sense of tightness that can not be breathed due to lack of oxygen, and even the tense atmosphere that will suffocate.

The creation of this study uses zero-waste version of clothing design to echo the sustainable behavior of the environment, which not only actually reduces textile waste, but also does not waste resources. It is suggested that if the follow-up development can use functional fabric as the main fabric, the use of clothing to adjust human body temperature, reduce the use of electric energy, with recycled material fabrics or natural organic fabrics, will be more actively in line with the main idea of environmental sustainability.

In this study, the pattern of garment single products recorded in the creation can provide a basis for subsequent design to modify, and self expect the sustainable design and development of fashionable clothing more in line with the sustainable environment. It also provide a reference for garment designers who want to carry out environmental protection issues in the future to have zero waste pattern structure of garment forming, which not only expect more designers to join in creating popular products with the concept of sustainability, but also hope that human beings will implement the good behavior of the “sustainable”environment in their lives.

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