The Environmental Impact of Plastic Grocery Bags and Their Alternatives

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Abstract—Plastic grocery bags can cause a variety of environmental problems. Plastic bags pollute the air through their life cycle, from raw material extraction and manufacturing process to the disposal. The raw materials to produce plastic bags are mainly crude oil and natural gas, and the extraction process of those raw materials can cause the emission of a considerable amount of air pollutants to the atmosphere. In addition, plastic bags can also cause water pollution and soil pollution. Countries around the world have issued bans and tax measures to reduce the use of plastic grocery bags. At the same time, a variety of alternative options have been created and promoted to replace the use of plastic bags, including paper bags, jute bags, and other biodegradable bags. Each alternative has its advantages and disadvantages. After analysis of the environmental impacts and the practicability of plastic bags and their alternatives, we evaluated the feasibility of the utilization of alternative grocery bags under difference occasions as well as corresponding policy measures. Finally, we proposed several suggestions to mitigate the problem of plastic bag pollution, including developing new degradable bag technologies and reusing grocery bags.

1. Introduction
Plastic grocery bags have brought great convenience to human life, but at the same time, the production and disposal of plastic bags have caused environmental problems. The analysis of the problems of plastic products requires a full life cycle method. So far, the methods of evaluating and dealing with the impact of plastic bags have been narrow and inadequate. Making a wise decision to solve the risk of plastic requires a complete life cycle approach to understand all its toxic effects on human health [1].

At each stage of the plastic life cycle, there are significant and complex human health impacts: from oil and gas field wellheads to oil refineries, from store shelves to the human body, from garbage
disposal to the continuous impact of microplastics in the air, water and soil. People all over the world are exposed to multiple stages of this life cycle. For extraction and transportation, the fossil raw materials used for plastics will release a series of toxic substances into the air and water, including those known to cause health problems such as cancer, neurotoxicity, reproductive and developmental toxicity, and immune system damage. For refining and production perspective, plastic resins and additives can release carcinogens and other highly toxic substances into the air, and their effects include neurological damage, reproductive and developmental problems, cancer, leukemia, and genetic effects such as low birth weight. Also, for consumer products and packaging, it may lead to ingestion or inhalation of microplastic particles and hundreds of toxic substances.

Plastic waste management, especially "waste-to-energy" and other forms of incineration, can release toxic substances, including heavy metals such as lead and mercury, acid gases, and particulate matter [2]. These substances can enter the air, water, and soil, and harm workers and nearby communities, causing direct and indirect health risks. Debris and microplastics can directly enter the human body and cause a series of negative health effects, including inflammation, genotoxicity, oxidative stress, apoptosis, and necrosis, which are all related to negative health results. In the process of plastic degradation, toxic chemicals added in the plastic can further leak into the environment and the human body. Julie Teel Simmonds commented that “It is worrying that the fossil fuel industry plans to increase plastic production by 40% in the next ten years [1]. Manufacturing plastic pollutes communities and plastic waste fills up our oceans. Obviously, if we don’t restrict plastic production, we will not be able to control plastic pollution and protect public health [1].”

However, it is undeniable that plastic bags provide great convenience for human production and life, so there is an urgent need to find substitutes that do less harm to the earth environment and human life through its life cycle [1]. Because plastic bags have disadvantages such as poor recycling and difficulty to be degraded, paper bags, jute bags, and other biodegradable bags have become the main alternatives. Paper bags can be recycled up to six times. Jute bags are more environmentally friendly because they are made of biodegradable materials, mainly cellulose. The production of other biodegradable plastics has also brought the use of plastics to a new stage. Scientists have developed the use of bacteria to decompose biodegradable plastics by chewing and converting them into biomass, water and carbon dioxide. Therefore, it fundamentally solves the problem of long degradation time of ordinary plastic bags for a hundred years and the serious damage to the land.

In 1845, Cybertron, a chemist living in the northwestern city of Basel, accidentally discovered the formation of nitrocellulose. In the 1850s, Parkes mixed collodion with camphor to produce a flexible, hard material called "paksim", which was the earliest plastic [3]. In the 1930s, when nylon came out, the raw material of plastic replaced coal with petroleum, and the plastic manufacturing industry also developed rapidly [4].

In the early days, with the substantial increase in the use of plastic bags and the large accumulation of pollutants, people began to study how to better dispose of these plastic bags. Many countries adopt the method of incineration, but this method still produces a large amount of harmful gas, which not only pollutes the air seriously, but also is very harmful to the human body. People began to study how to produce less harmful gases during the burning process, but the results were not very satisfactory. Though the production process of plastic bags were continuously improved, there has been no restriction on its usage. Until June 1, 2008, China implemented a plastic restriction order [5]. A large number of cloth bags became the main option to replace plastic bags, but the questions is whether the production and decomposition of these alternatives can really be more environmentally friendly than plastic bags. There has not been a lot of investigation and research on these. For this reason, a comprehensive investigation and comparison of these products is particularly important.

Previous studies only investigated the decomposition of plastic bags and the use of paper bags, cloth bags, and other biodegradable plastic bags. There are also studies covering suggestions and discussions on national policies and laws. However, there is neither a detailed comparison of the production, use, and decomposition among plastic bags and their substitutes, nor a systematic summary of the practicability of adopting each type of grocery bag under different circumstances.
Therefore, in this article, we overviewed and summarized the policies and laws of many countries regarding the use and management of grocery bags, and we made a detailed comparison among and evaluation of plastic bags and their alternatives based on previous research. In addition, we collected supporting data to strengthen our analysis of the scientific use of plastic bags and their substitutes. This article not only provides suggestions regarding the choice of grocery bags, but also shed light on the pursuit of a more effective solution to the problem of “white pollution”, contributing to China’s “net zero” goal by 2060.

2. Current Pollution Caused by Plastic Bags

Plastic bags pollute the air in three main ways: raw material extraction, manufacturing process, and end-of-life treatment. The raw materials for plastic bag production are mainly crude oil and natural gas. The extraction process of crude oil releases many air pollutants, including particulate matter (PM), benzene, toluene, ethylbenzene, xylene, methanol, formaldehyde, sulphuric acid, nitric oxide (NOx), etc [6]. Besides, well construction, well completion, liquid uploading, workovers, escaping gases from equipment, and natural gas leaks when valves are opened and closed are all causes of air pollution from natural gas extraction [7]. The primary atmospheric pollutant chemicals emitted from these processes are polycyclic aromatic hydrocarbons (PAH), methane, carbon dioxide, and nitrous oxide [7].

A data shows that the air pollutant emissions from the production process are equivalent to the emissions of 1,009,530 buses per year, of which 5,158,000 metric tons of CO2 are emitted in a year [8]. A recent study assessed the contribution of the various stages of the plastic bag production process to atmospheric pollution by quantifying the ozone layer depletion category. The results showed that the process contributing the most pollution was the extrusion process of plastic bags, followed by the printing process, which accounts for about 50% and 30% of the total contribution, respectively [9]. The extrusion process of plastic film has the most significant degree of ozone layer depletion. This is where raw materials such as natural gas and oil enter the plastic bag manufacturing process. The printing section of plastic bags is the second process that has a significant environmental impact on the ozone layer because this process uses a large number of chemicals, such as alcohol, acetic acid, and ink [9].

So far, plastic waste is disposed of mainly by landfill and incineration. A study carried out by the University of Hawaii has reported that as plastics decompose in landfills, they naturally emit CO2, methane, and ethylene into the air [10]. In addition, around 10-12% of plastic bags are incinerated for end-of-life treatment, releasing harmful gases into the environment, including carbon dioxide, dioxins, furans, mercury, and polychlorinated biphenyls [11].

Plastic bags have a huge impact on agriculture. Approximately 96% of all plastic shopping bags are discarded in landfills due to a variety of uncaring circumstances [12]. Plastic bags take a long time to degrade, if at all. Stevens (2001) claims that a plastic bag can remain 1000 years in the soil, impeding the degradation of biodegradable materials surrounding or in it [13]. This led to a decrease in soil fertility, which in turn reduced agricultural yields.

According to a 2014 research by the 5 Gyres Institute (based on a six-year investigation), 5.25 trillion plastic particles are floating in the water. Plastic waste makes up 60-80% of marine litter [14], and even 90-95 percent in some locations [15, 16, 17]. The United Nations Environment Programme raised concern in 2014 about the significant threat from plastic trash to marine life. Since the production of non-biodegradable plastics has been increasing worldwide, it is likely that levels of contamination will continue to increase and pose an escalating threat to the marine environment, and specifically to marine birds. Baltz & Victor (1976) identified largely tiny polyethylene cylinders in a survey of plastic particle pollution in the northern Pacific off central California [18]. However, they also detected Styrofoam, synthetic sponges, and fragments of flexible food wrap and stiff plastic. The majority of the plastic cylinders had rounded rather than sharp edges, indicating significant wear [19] that might have happened on the beach or in the stomachs of birds [18].
By comparison, the air pollution caused by plastic bags, such as production emissions and raw material extraction, is not the main cause of air pollution. The air pollution caused by coal combustion and automobile exhaust is more serious than that caused by the manufacture of plastic bags. Water pollution is more serious than air pollution, but not the most serious. Plastic bags is one of the major challenges to marine life. However, the pollution from plastic bags is not as high as compared to oil spills and nuclear-contaminated wastewater. The highest degree of pollution is soil pollution, because plastic bags are difficult to degrade naturally, and they will remain in the soil for 1000 years. It will have a great obstacle to the development of agriculture.

3. Current Policies on Pollution Caused by Plastic Bags

To mitigate the pollutions caused by plastic bags to the environment as mentioned above, various countries have announced corresponding policies as shown in Fig.1. These policies can be classified into two main categories: plastic ban and levy on plastic bags.

The General Office of the State Council of China issued a notice restricting the production, sale and use of plastic bags on Dec 31, 2007 [20]. The notice indicates that from June 1, 2008, the nationwide ban on the production, sale and use of plastic shopping bags with a thickness of less than 0.025 mm. In all supermarkets, shopping malls, hawker markets and other retail merchandise, plastic shopping bags cannot be provided for free.

More than 150 cities and counties in the US have banned or required fees for plastic bags. California passed its first statewide ban in 2014 [21], and a county ordinance in Hawaii has even enacted a de facto ban [22].

A product levy can be very effective in reducing the use of plastic bags by consumers. Denmark has the oldest plastic bag tax in the world. The law was implemented in 1993, and it impacted manufactures of plastic bags, who were required to pay a levy based on the bag’s weight. Shops were able to pass the charge on to customers in the form of a bag fee or by including it in the price of other items. The system's initial result was a 60 percent reduction in the use of plastic bags [23]. Another study has also shown that the effect of a tax on the use of plastic bags in retail shops is staggering. Such a policy would reduce the use of plastic shopping bags by roughly 90%, with associated benefits in the form of low waste and negative environmental impacts [24].
A survey in Britain showed that since plastic bags were no longer provided free, the number of using plastic bags had fallen from 57 percent to 21 percent, while the number of customers using reusable bags had risen from about 29 percent to 58 percent [25]. In addition, in the Japanese city of Sanan, local officials have launched a public awareness campaign encouraging residents to use reusable bags instead of plastic bags. In 1995, the programme was launched. By 2005, it was predicted that 30 percent of buyers were carrying their own plastic bags, resulting in a 30% reduction in overall plastic bag consumption [25].

Levies have been demonstrated to be a highly effective technique in decreasing the use of plastic bags in Ireland. The Irish government imposed a 15-cent levy at the point of sale on all single-use plastic bags in the country in 2002. The levy was a success in several ways: it was self-sustaining because it was supported by generation, and by 2007, the usage of plastic bags had decreased by 94% [25].

The government has strong supervision over plastic bags. In large shopping malls and developed areas of the shop, the effect is obvious. But wholesale markets in small cities are difficult to implement. The public's acceptance of new policies is frequently a key source of concern. When it came to the implementation of the English plastic bag charge, it was evident that people were ready for it. Regardless of gender, age, or income, a majority of people supported the fee before it was implemented, and support grew even more after it was implemented. People support the charge because it is considered as a highly successful strategy to encourage personal bag usage, minimise trash, and improve environmental consciousness. While there was some initial scepticism regarding how the charge earnings would be used, this swiftly faded when the charge was introduced. People may have gotten more positive about the charge as a result of the ease with which they were able to adapt to it. People quickly developed new habits, such as putting shopping bags in the trunk of their cars to remind them to carry their own bags to the grocery [26].

Overall, both bans and levies will, to a certain extent, reduce the use of plastic bags and thus the environmental pollution caused by them. The policy of charging plastic bags is one of the most effective policies. Most countries and regions advocate this measure. The effects in most developed areas are significant, but in a small number of economically underdeveloped areas are not. Levy is also a good measure. It will be more effective if combine charging on plastic bags with the tax on manufacturing plastic bags. But the feasibility of policies depends on the strength of supervision and the improvement of law and more importantly is personal consciousness.

4. Alternatives of Plastic Bags

4.1. Paper Bags

To begin with, paper bags are completely recyclable. Paper bags can be recycled up to six times, and recycled paper can be used to make a variety of paper products [25]. Also, most paper bag waste degrades in less than six months and becomes fertile vegetation waste in most cases [27]. Moreover, paper and paper bags are now made not because people cut down trees but are made with more environmentally friendly solutions, such as using the pulp waste left after sugar cane is used to make sugar. There is also a straw. Paper can also be made of straw fiber. If implemented effectively in rural India, it can encourage farmers not to burn their crops but to sell straw at a price. Even discarded coconut shells can be used to make thick paper [27]. This is conducive to reducing the harm caused by burning crops to the environment, but at the same time, it promotes economic development. Paper, unlike plastic, does not emit highly toxic and poisonous gases into the atmosphere during the recycling process. Nowadays, the majority of plastic bags are manufactured using polyethylene-based bags, which are also known as ethylene-based bags. Plastic bags are harmful to the environment because they are made from a nonrenewable petroleum resource, contain toxic compounds, and take thousands of years to disintegrate [18].

Nowadays, Paper bags are now more synonymous with fashion. Many people prefer to use paper bags because they are lightweight, easy to clean, and store items for a long time. Although plastic bags
also have these characteristics, they lack a sense of fashion. Moreover, paper bags' structural sturdiness and surface characteristics make them an ideal choice for printing high-quality images, logos, and designs better than plastic bags, making paper bags popular in the fashion, luxury, and high-end gift packaging industries. In this case, paper bags will increase brand value [27]. In contrast, paper bags that are beautiful and stylish are more worth using than plastic bags.

However, a study shows that it takes more than four times as much energy to produce a paper bag as it does a plastic bag. According to the Progressive Bag Alliance, 1000 paper bags need 1219 MJ of energy to produce, use, and dispose of, compared to 457 MJ for plastic bags. The Australian government calculated that if a person used 10 bags each week on average, 22.5 kg of paper would be required. Only 3.12 kg of polyethylene, on the other hand, would be utilised [25]. Although many other materials can be used to produce paper, paper bags cannot be avoided entirely from deforestation. As we all know, trees can absorb greenhouse gases, which is an essential factor beneficial to the ecosystem. But if the trees are cut down, and the paper is remanufactured to produce greenhouse gas emissions, it is very harmful to the environment. Most paper bags are made by heating wood chips in a chemical solution under high pressure. The use of these toxic chemicals can lead to air and water pollution and acid rain. These chemicals can pollute waterways because they are long-lastingly toxic, settle in sediments, and move up the food chain. More toxicity is released as plastic, and paper bags degrade. Paper bags emit 70% more air pollutants and 50 times more water than plastic bags. Besides, the energy consumed should also be considered in terms of transportation: It would take roughly seven lorries to transport the same number of paper bags as a single lorry full of plastic bags [28]. Compared with one truck, the carbon dioxide emissions of 7 trucks are also relatively large in the transportation process. However, current research suggests that paper bags use the same amount of energy as typical plastic bags. Paper bags, on the other hand, are expected to require three times as much water, generate 90% more greenhouse gases, 80% more nitrogen oxides and sulphur dioxide emissions, twelve times the nitrate and phosphate pollution to water, and produce 80% more solid waste than typical plastic shopping bags. Both paper and plastic bags are recyclable, and recycling each plastic bag takes 17 BTUs while recycling each paper bag takes 1444 BTUs [8, 23]. In contrast, when the energy consumption is similar, paper bags will pollute the environment: a large amount of greenhouse gas emissions, massive water consumption, and more calories that need to be consumed during recycling; paper bags are better. By collecting a pound of plastic bags, even plastic bag recyclers can make 15 to 20 cents [23]. This can also promote plastic bag recyclers to increase their enthusiasm for collecting plastic bags.

4.2. Jute Bags

Jute bags are a more environmentally friendly alternative to plastic bags since they are made of biodegradable material, mostly cellulose, obtained from a plant fibre known as jute. The raw materials for jute bags come from lush green jute plants, which help to protect the environment and maintain ecological balance by providing much-needed oxygen to the atmosphere; unlike synthetics, the jute bag manufacturing process is simple and does not involve the use of toxic chemicals and their associated harmful byproducts [29]. Jute bags come in a variety of styles and are biodegradable and compostable. They also have no detrimental environmental or agricultural implications. Jute bags are an excellent alternative to plastic bags since they are compostable and ecologically friendly. Bangladesh has enough jute to supply half of the jute used in shopping bags in the world. In addition, countries in South Asia, such as India, can offer sufficient quantities of raw jute for the production of alternative jute bags [13]. However, since 2001-02, the country's jute production has shown irregular trends. The reasons behind this contradictory growth in raw jute production in India are lack of sufficient funds, a standard deviation of seeds, and water shortages. Therefore, it lags far behind the best level that can be achieved in jute production. Rapid urbanization has also adversely affected jute cultivation in India.

When you consider the manufacturing process, you'll notice that plastic is created from billions of barrels of oil, which is a nonrenewable energy source. Each ounce of polyethylene (PET) produced
emits about 30 grams of carbon dioxide, according to the US Environmental Protection Agency. The most common form of plastic used in beverage bottles is PET [30]. Jute, on the other hand, does not necessitate a large amount of farmland, making it an environmentally beneficial option for plastics. In addition, crop rotation techniques to grow jute can improve the soil fertility of the next crop. It seems that planting jute saves space and helps improve the fertility of the next crop. It is a better choice than plastic that only uses non-renewable energy to produce and cause pollution.

In addition, if you compare prices, plastic bags are cheaper in the short term, around 50 pasas, but because of their short life span, plastic bags are usually thrown away after being used only once, which in turn means more production and natural resources. Environmental burden. On the other hand, a bag made of jute costs about 20 rupees, but they can be reused for more than a year. Therefore, to some extent, jute bags are cheaper in the long run. Although jute bags can be used repeatedly for a long time, it is worth noting that jute will lose its strength when exposed to water and turn yellow due to sunlight, and even its wrinkle resistance is meager. Compared with plastic bags, plastic bags do not need to worry about rain and can even protect the bag's contents from water, and there is no need to worry about sun exposure and wrinkle resistance. And the elasticity of the plastic bag is also excellent.

Plastics can negatively impact human health by emitting harmful gases such as nitrogen oxides, sulfur dioxide, volatile organic pollutants, and polycyclic organic compounds. Heavy metals and hazardous compounds, such as dioxins, are also released when burned plastic. On the other hand, Jute plants absorb carbon dioxide and release oxygen at a rate that is several times faster than trees. One hectare of jute plants is expected to absorb roughly 15 tons of carbon dioxide and exhale 11 tons of oxygen in one season, lessening the greenhouse effect [30].

4.3. Other Biodegradable Bags

As consumers desire environmentally friendly alternatives, biodegradable plastics are becoming more and more popular. Scientists have developed the use of bacteria to break down biodegradable plastics, chew and convert them into biomass, water and carbon dioxide, rather than remain stable for hundreds of years. This is the first time people have started to use plastics (or instead of oxygen, use methane instead of carbon dioxide). Even in the UK, the government has funded biodegradable designs and the manufacture of non-toxic plastic bags [31]. It can be seen that biodegradable plastics have become a trend of vigorous support and widespread promotion.

This type of biodegradable plastic bag, manufactured by plastic firms, is less hazardous to the land and environment. Plastic bags, both non-biodegradable and biodegradable, are toxic to the environment and contain dangerous chemicals. PLA (polylactic acid) is one of the most environmentally friendly biodegradable plastics available today. It comprises bio-based materials with various disposal alternatives (i.e., 100% recyclable and biodegradable). PLA is a high-performance material. One kilogram of PLA can be made with only 1.6 kilograms of sugar. To manufacture the same amount of final product, other bioplastics may require more natural resources. Carbon dioxide emissions are lower [32].

Compared with traditional plastics, biodegradable plastics consume less energy to manufacture. For example, corn-based polymers consume 65% less energy than petroleum-based polymers. There is no need to find, obtain and transport hydrocarbons in the production of bioplastics. This means that fewer fossil fuels will be used, thereby reducing pollution. It also reduces greenhouse gas emissions by 68% during the production process, a substantial environmental benefit. Moisture also promotes the decomposition process. They are mainly degraded under the sun's ultraviolet rays, and some only degrade at extremely high industrial temperatures. Traditional petrochemical products are used, but they are designed to decompose faster. They contain chemicals that accelerate decomposition in the presence of oxygen and light [29]. Biodegradable plastic bags are projected to decompose in a year or two, as opposed to hundreds of years for ordinary plastic bags.

Although biodegradable plastic bags are a viable alternative to non-biodegradable plastic bags, they pose environmental risks since they contain harmful compounds. As a result, alternatives to plastic bags should be thoroughly studied before being used to guarantee that they are soil and environmental
friendly [28]. The Institute of Biodegradable Plastics went on to study the plastic's chemical components and discovered that the bag's heavy metal concentration was much over permitted limits. The lead content was four times the acceptable level in the United States and twelve times the acceptable level in Japan and the European Union. It was found that the content of another heavy metal, cobalt, was seven times higher than the level accepted in Canada. Such high concentrations of toxic metals are worrying because the decomposed bags will eventually enter the groundwater or be used as fertilizers [25].

Another point is that compared with traditional plastics, biodegradable plastics are higher, and the price is two to three times that of traditional plastics. Poor plastic properties require special processing equipment, which increases manufacturing costs. Without the government's help, it will be challenging to use biodegradable plastics widely. But not every country's government may support the use of such expensive plastic bags. And the production of biodegradable plastic bags requires a lot of energy. The production of 1,000 biodegradable plastic bags requires as much as 1,380 megajoules of oil, electricity, and another point, which is more than twice the energy needed for traditional plastic bags. Biodegradable bags also require more water during production [25].

Furthermore, this biodegradable plastic can only be accelerated into microplastics or biodegraded in most items under specified conditions, such as adequate ultraviolet light or heat. As a result, this biodegradable plastic cannot decay quickly and spontaneously in all-natural situations. In the natural marine ecosystem, the most important thing is. Even though thin biodegradable plastics like purses may degrade in the ocean, they line coffee cups: cup lids, clear plastic cups, straws, and food packaging thicker and tougher PLA. However, seawater behaves like typical plastic and does not collapse [31]. Another issue will arise food waste.

Table 1. Comparative table of plastic bags, paper bags, jute bags and other biodegradable bags

| Alternatives | Key advantages | Key limitations | Key supportive data | Price |
|--------------|----------------|----------------|---------------------|-------|
| Plastic bags | 1. Cheap | 1. The use of non-renewable energy is costly | 0.457 KJ/piece (Wong, 2011) | 15 RMB/KG |
| | 2. durable | 2. Low degradability | | |
| | 3. easy to carry | 3. Many people choose one-time use | | |
| Paper bags | 1. Completely recyclable | 1. More energy consumption | 1.219 KJ/piece (Wong, 2011) | 2.8 RMB/KG |
| | 2. Reducing harm caused by burning crops to the environment | 2. the chlorine containing wastewater in the bleaching process | | |
| Other biodegradable plastics | 1. Broken down by microbes in a year or two | 1. Contain toxic materials | 20 RMB/KG | |
| | 2. Emission of carbon dioxide is less | 2. Costly | | |
| | 3. Less energy | 3. Cannot be quickly degraded naturally under all natural environmental conditions | | |
| Jute bags | 1. No negative effect on the environment and agriculture | 1. Low crease resistance | 10–15 RMB/Piece | |
| | 2. The production process of jute bag is simple | 2. If jute is wetted it lose its strength | | |
| | 3. No toxic chemicals and harmful by-products | | | |

Based on the comparisons above, the suggestions are given below:
1. If plastic bags are not replaced, plastics can be effectively controlled when the plastic restriction order is implemented. Everyone should also regard plastic bags as not a disposable product and use them multiple times, which is feasible in the long run. Technically, we should also develop new technologies, such as biodegradable plastic bags. Find a more suitable price to sell.

2. If use alternatives:
   a. Paper bags are more suitable for recycling than plastic bags. Besides, they are in line with people's fashion and are very suitable for young people. Also, it can contribute to the environment.
   b. Jute bag is less contaminative to the environment in the process of production and manufacturing, and can even make a certain contribution to the environment and soil. Its advantages are low production cost and long service time.
   c. Biodegradable plastic bags have a strong support from the government and financial guarantee, which is the main direction of future development. It is more inclined to scientific and technological research, and can protect the environment more effectively by reducing greenhouse gas emissions and reducing energy waste.

5. Conclusion
Each country has its own strategies to cope with the use of plastic bags and subsequent environmental problems, with various level of effectiveness. While policies are continuously improved, it is still indispensable to develop alternatives. Through this paper, we systematically compared plastic grocery bags with alternative grocery bags and provided insights on optimizing the use and reducing the pollution of grocery bags in the future.

In this article, we illustrated and compared several alternatives, including paper bags, jute bags and other biodegradable bags. We discussed the advantages and limitations of each feasible alternative in detail. Although plastic bags are still in use, they are limited on most occasions. The price and style of paper bags are more acceptable. Although emissions associated with paper bags are slightly higher compared with other substitutes, it is still a good choice considering that the overall damage to the ecological environment from paper bags is much less. In general, other degradable bags are a better option and therefore are the main development direction of substitutes in the future.

After comparing the price, characteristics, production and recycling, paper bags and other degradable plastic bags are the main options for replacing plastic grocery bags today. However, there is no single solution to the problem and the best choice of the grocery bag depends on many different factors. All these alternatives still involve a considerable amount of greenhouse gases emission and energy consumption through the production and recycling process, but the most important question is how often they can be used. If plastic bags can be used many times, then the associated pollution and energy consumption could be less than other substitutes. However, the feasibility of using plastic grocery bags varies in different countries or under different situations, so it is advisable to use plastic bags, paper bags and biodegradable plastic bags alternately on different occasions. For instance, plastic bags and degradable bags are the best choice for packaging soft substances and liquid. Paper bags have a flat surface and is therefore suitable for clothes shopping bags or food packaging.

Finally, we proposed several suggestions to mitigate the problem of plastic bag pollution, including, developing new degradable bag technologies. At the same time, reusing groceries bags should be highly encouraged, through policy measures or other incentives.

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