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Analysis of Regulations and Systems of Packaging Waste Management under Circular Economy in Africa

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Abstract: With the development of economy, the packaging industry has become a relatively complete industry. Packaging can not only protect commodities, facilitate circulation, and promote market sales, but it also brings resource and environmental problems to the society. Cities and rural areas generate tons of waste every year, most of which is packaging waste, and it is increasing year by year. With the needs of economic development, the current shortage of resources and the environment are becoming more and more severe. It is urgent to strengthen the management of packaging waste. Based on this, this paper analyzed the regulations and systems of packaging waste management under circular economy. First, at the beginning of the introduction, the background of circular economy was expounded, and academic research on circular economy and packaging waste management was carried out and summarized finally; various algorithms were proposed to provide theoretical basis for packaging waste management. The third part analyzed the regulatory and institutional factors related to packaging waste management under circular economy. Finally, the experimental analysis of the regulations and systems of packaging waste management under the circular economy was carried out, and the experiments were summarized and discussed. The research results showed that the legal system of packaging waste management under the circular economy constructed in this paper increased the effectiveness of sustainable economic development by 7.81%.

1. Introduction

Circular economy plays a pivotal role in resources and environmental protection. It is necessary to adhere to the goal of sustainable development and to achieve the goal of beautiful cities. Circular economy is the concept of "reduce, reuse, recycle", which focuses on recycling and reuse to maximize the utilization of resources. With the closed loop of material flow and value flow as the main feature, it breaks the traditional single-line economic growth model and forms a circular and feedback economic development model of "resources-products-renewable resources", so that enterprises can achieve low emissions or even zero emissions at the end of production. Due to the

recycling of waste, the use of enterprises in the circular economy requires financial personnel to provide information on environmental costs, such as the cost of waste, the recycling value of waste, etc., so as to evaluate the efficiency and effectiveness of its use.

According to the current severe situation and current situation of solid waste pollution control in China, the particularity of solid waste pollution control is discussed, and a comparative analysis is made at the level of relevant laws and regulations. Based on this, many scholars have carried out research on the laws and regulations of waste management. ManekaKaur's research showed that due to the rapid growth of waste emissions and the limited use of resources, it was particularly urgent to develop an effective urban solid waste treatment plan [1]. Cesaro A believed that proper waste disposal was the key to preventing public health and environmental pollution, so some countries implemented special laws to regulate the classification, collection, treatment and disposal of medical waste [2]. Kouloughli S conducted research on the collection and delivery of urban managed solid waste with little private sector involvement. More than 90% of municipal solid waste was carried out in an environmentally friendly way [3]. Carmen conducted an environmental survey of different waste treatment operations in 32 European countries using new input/output environmental parameters and data envelopment analysis [4]. Wang L M conducted in-depth research and discussion on the current legal system for soil solid waste pollution control, and discussed the current status of the current legal system for soil solid waste pollution control [5]. Fu H started from the legal system of the whole process control of packaging, and continuously improved the relevant legal system by establishing the basic legal system to achieve the goal of green packaging [6]. Lee J was committed to understanding the mechanism of carbon dioxide in the pyrolysis reaction of agricultural waste for waste management, energy recovery and production [7]. The legal system of waste management has been heatedly discussed in daily life, and it has also attracted attention in academia.

At present, serious environmental pollution, ecological imbalance, lack of energy and other problems are faced. It is necessary to adhere to the guidance of the scientific concept of development, coordinate the coordinated development of man and nature, and establish a development model of circular economy. Kilkis S proposed a three-stage approach to integrate circular economy principles into the curriculum of energy policy [8]. Wang Q believed that the integrated circular economy model of agriculture and animal husbandry has attracted more and more attention as an effective model to solve the unfair allocation of industrial resources and realize the value-added of the agricultural industry chain [9]. Tsai Chi Kuo pointed out that with the importance of environmental awareness education, people gradually realized that environmental issues became more complex [10]. The aim of Singh M P was to develop a generalizable theoretical model of planning behavior to explore how small businesses could respond to a circular economy [11]. James M believed that the circular economy model was an important strategy to improve the sustainable development of products, which included extending the service life of products and closing the circulation of materials during the cycle [12]. Hopkinson P focused on the successes, difficulties and conflicts of implementing the circular economy model by summarizing the history, experience, wider practical experience and policy experience of the 30-year circular economy model [13]. Saleem U illustrated the vision to replace the "classical" linear business model with a circular economy model using the chosen classification of technical approaches as an example [14]. Based on the circular economy, this paper studied the legal system analysis of packaging waste management.

In this paper, a model of waste management was established first, and the theoretical basis for the simulation model of waste management was passed. This paper discussed the factor analysis of the simulation model construction, and finally carried out the simulation experiment of the regulatory relationship of packaging waste management under the circular economy through the

method and analysis.

2. Algorithmic Model of Related Packaging Waste Management

The Vehicle Routing Problem (VRP) problem of packaging waste recycling can be summarized as: The recycling station dispatches a certain number of cars to recycle the packaging waste of customers [15]. The location of the recycling center, the location of the customer, the quality of the recycled packaging materials, and the weight of the vehicle: The driving path of the vehicle should be reasonably arranged according to the following conditions, so that the vehicle starts from a recycling center and returns to the recycling center under the limitation of the recycling center; unique access: All customers can access and only once; vehicle loading limit: The overloading is strictly prohibited.

It is assumed that V represents the set of recycling network nodes and V={0,1…n}. Among them, 0 represents the recycling center, and the remaining nodes represent customers; K represents the vehicle set and K={1,2…m}. Among them, m is the completion recovery value of the task; Q is the maximum load mass of the vehicle; d_{nm} is the mass of packaging waste that customer n needs to recycle.

2 decision variables are set:

$$x_{nmk} = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} (1)$$

$$y_{nk} = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} (2)$$

The mathematical model of the packaging waste recycling VRP problem is:

$$\min Z = \sum_{k\in K}\sum_{i\in V}\sum_{j\in V} d_{nm} x_{nmk} \quad (3)$$

The constraints are:

$$\sum_{i\in V/\{0\}} qi \sum_{j\in V} x_{nmk} \le Q, \forall k \in K \quad (4)$$

$$\sum_{k\in K}\sum_{n\in V} x_{nmk} = 1, \forall m \in V/\{0\} \quad (5)$$

$$\sum_{k\in K}\sum_{m\in V} x_{nmk} = 1, \forall n \in V/\{0\} \quad (6)$$

$$\sum_{n\in V/\{0\}} x_{n0k} = \sum_{m\in V/\{0\}} x_{0mk} = 1, \forall k \in K \quad (7)$$

$$\sum_{k\in K}\sum_{n\in V/\{0\}} x_n 0k = \sum_{k\in L}\sum_{m\in V/\{0\}} x_0 mk = m \quad (8)$$

$$\sum_{k\in K}\sum_{n\in S}\sum_{m\in S} x_{nmk} \ge 1, \forall S \subseteq V/\{0\}, |S| \ge 1 \quad (9)$$

$$\sum_{j\in V} x_{nmk} = \sum_{j\in V} x_{nmk}, \forall k \in K, \forall i \in V/\{0\} \quad (10)$$

$$x_{nmk}(x_{nmk} - 1) = 0, \forall k \in K, \forall i \in K \quad (11)$$

Among them, Formula (1) is the objective function, which is the shortest travel route; Formula (2) is the vehicle load limit; Formulas (3) and (4) are the only restrictions on customer access; Formulas (5) and (6) are the recycling center limits; Formula (7) is the sub-loop limit; Formula (8) represents the conservation limit for customer traffic flow; Formulas (9) and (10) are 0 to 1 variable limits.

3. Regulatory Factors Related to Packaging Waste Management under Circular Economy

(1) Analysis of circular economy factors

Circular economy is an economy generated by the recycling of resources [16]. It emphasizes the organization of economic activities according to the cycle process of "resources-products-recyclable". It is characterized by low mining volume, high utilization efficiency and low emission. In this continuous economic cycle, all materials and energy can be used rationally and continuously to minimize the impact of economic activities on the natural environment, as shown in Figure 1:

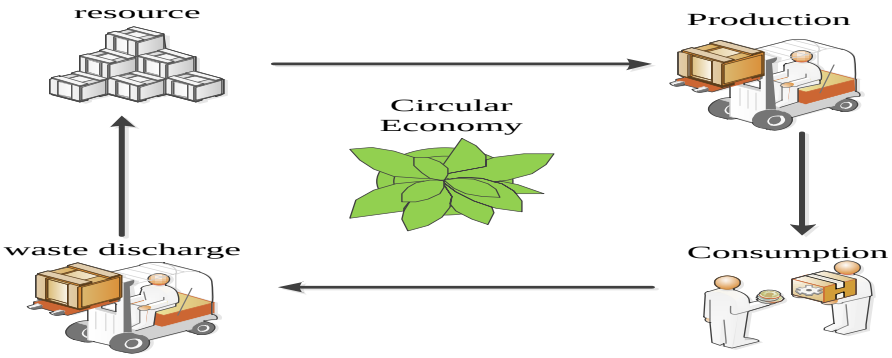

Figure 1. Analysis of circular economy factors

In theory, "reduction, reuse and recycling" can include the following three levels of content, as shown in Figure 2:

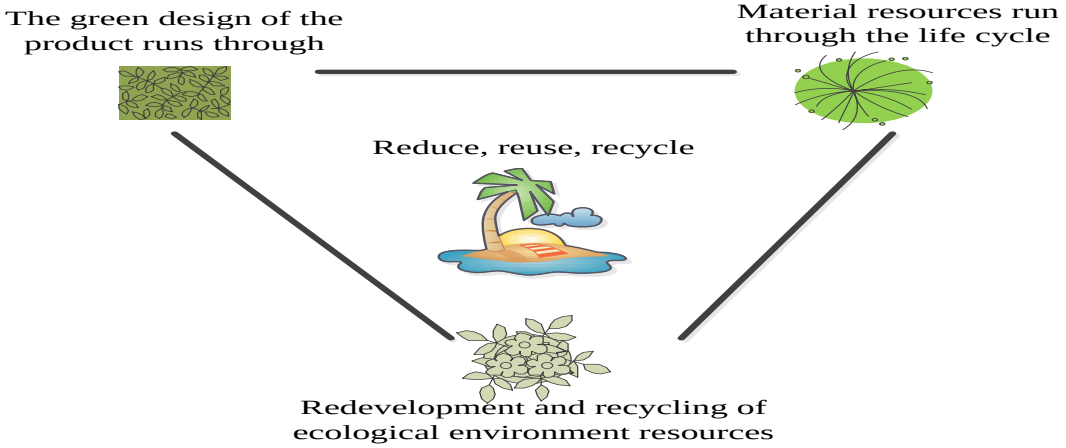

Figure 2. Subreduction, reuse and recycling model

1) The concept of "reduction, reuse and recycling" runs through the green design of products

Green design includes all designs based on environmental protection, and any design that is beneficial to society, human beings and the human living environment belongs to "green design".

Green design refers to the design of all links from the creativity, conception, raw materials and processes of the product to the non-polluting and non-toxic selection of the product, to the production, use, recycling after disposal, and recycling of the product, that is, the life cycle of the product [17].

2) The concept of "reduction, reuse and recycling" runs through the entire life cycle of material resources development and utilization

In the development of resources, attention should be paid to rational utilization and multi-level reuse; in the design and production process, full attention should be paid to the design idea of product recycling [18]; in the design of the process system, the multi-level utilization of resources is fully considered, and the integrated and standardized process design idea is adopted; in all aspects such as production, transportation, and sales, attention must be paid to the integration of the process and the recycling of waste; in the stage of circulation and consumption, the extension of the service life of the product should be emphasized to realize the reuse of resources; after the expiration of the product life cycle, the reuse and recycling of resources should be emphasized.

3) Redevelopment and recycling of ecological environment resources

Between recovery and recycling, the limitations of waste recycling must be recognized: First, recycling is inherently an afterthought rather than a preventive measure [19]. Although waste recycling can reduce the final disposal volume of waste products, it would not reduce the circulation speed of materials in economic activities and the utilization rate of materials. Second, recycling cannot guarantee the safety of the environment. The use of recycling technology to treat waste not only consumes many energy sources such as fossil energy, water, and electricity, but also generates new pollutants, causing secondary pollution. Third, the recovery rate of resources is too low, the cost is too high, and there is no economic value.

(2) Packaging waste management factors

Packaging waste refers to various types of packaging that are discarded after consumption in the packaging industry [20]. According to the source of packaging waste, it can be divided into two types:

One is the packaging that is recycled by the packaging industry, that is, the residues, wastes, and wastes generated in the production of packaging products;

The other is all kinds of waste packaging such as metal barrels, cans, etc., which are used in production and life; plastic boxes, barrels, bottles, film bags; cartons, glass bottles, etc., as shown in Figure 3:

Figure 3. Packaging waste management factors

1) The management of packaging waste needs to be strengthened to promote the sustainable development of the packaging industry. With the continuous development of the world economy and society, the packaging industry must adhere to sustainable development. Sustainable development needs of packaging industry: In order to meet the needs of society, economy, culture and spirituality, it must be carried out in a sustainable way. This requires a design concept and production method that reduces or reduces pollution as much as possible while rationally utilizing and recycling packaging resources and raw materials. It is necessary to strengthen the management of packaging waste and enhance the public's awareness of waste recycling, so as to let the packaging industry take the road of sustainable development as soon as possible.

2) The need to strengthen the treatment of packaging waste is a major event to protect the environment and benefit future generations. The socialist market economy is the need for the development of social productive forces and also for the development of the socialist market economy. The development of production is to make people's lives better. People's living, learning and working environments are polluted, air pollution, water quality deterioration, and garbage everywhere would cause various diseases and seriously endanger people's body and spirit, which goes against the socialist production goals.

3) By strengthening the management of packaging waste, the healthy development of the packaging industry can be promoted. At present, economic development is facing many old and new environmental problems, such as the destruction of the ozone layer, the sharp decline of biodiversity, the atmosphere, acid precipitation, water pollution, freshwater resource crisis, environmental pollution of toxic waste and so on. These problems are eroding nature, economy, and human beings from the three levels of nature, economy and human beings, which destroy the foundation of human economic and social survival and become the bottleneck of economic development. On the other hand, the development of the packaging industry is also coordinated with environmental protection. The raw materials, fuels and other production factors required by the packaging industry ultimately come from the environment. All kinds of waste generated during the production and utilization of packaged products in the packaging industry would eventually return to the environment. If the packaging resources are not properly developed and utilized and the effective management and comprehensive utilization of packaging resources are not paid attention to, a vicious circle would be created. If people start paying attention to this issue from today, formulate resource development policies that are conducive to environmental protection, and adopt product design ideas and processes that are conducive to environmental protection and circulate, reuse and recycle them, the awareness of resource utilization of packaging waste can be minimized, and at the same time it can effectively alleviate the contradiction between resource shortage and social demand, thereby promoting the healthy development of the packaging industry.

(3) Establishment of an enterprise-led packaging waste recycling model

As a direct user enterprise, enterprises should make full use of their professional knowledge and use their own logistics network to realize the recycling of product packaging. There are two ways to reuse packaging. One is to set up a special packaging box at the self-service station. Customers can disassemble the packaging bag on the spot and put the packaging bag in the packaging box to achieve the purpose of recycling. For responsive customers, certain rewards would be given to increase the recovery rate of the product. The second method is mainly to send the package back to the recycling station by the deliveryman, which can not only reduce the express cost, but also provide a convenient recycling method for customers, as shown in Figure 4:

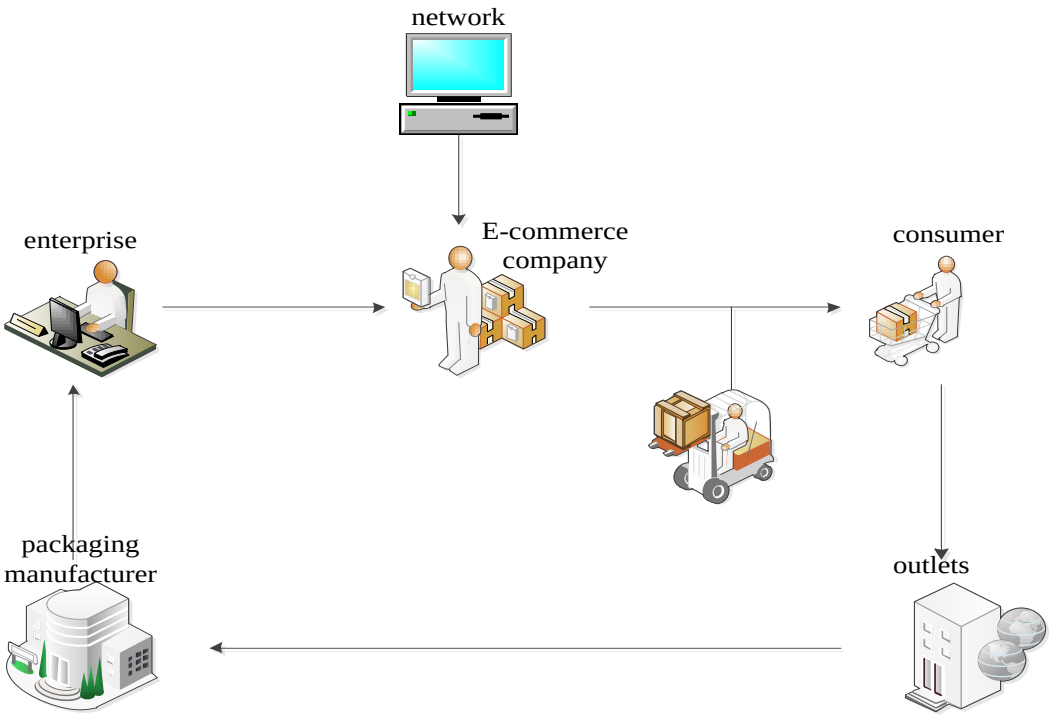

Figure 4. Enterprise-led packaging waste recycling mode

However, this way of operating would also increase the operating and operating costs of the enterprise. It is difficult to find a balance between cost recovery and profit, and the risks are high. At the same time, at present, there are still many problems in the packaging renewable resources that Chinese enterprises only rely on themselves. Therefore, enterprises must work together with other relevant units and the government.

4. Experimental Evaluation of Regulations and Systems for Packaging Waste Management Under Circular Economy

The reasonable recycling methods can not only effectively improve the recycling rate of products, but also save social resources. This paper conducts field research on the current packaging recycling methods, and summarizes three categories: garbage recycling stations, packaging manufacturers and the dominant packaging recycling modes of enterprises, all of which have their own advantages and disadvantages.

This paper compares the three models from the perspectives of economic factors, management factors and social factors. The main consideration is the investment amount, cost and the size of the relevant company; management elements mainly include equipment management, personnel expertise, personnel management and information management capabilities; social elements mainly include social reverse logistics ability and risk tolerance, as shown in Table 1.

Through the comparative analysis of Table 1, it is found that the circular economy mode with enterprises as the main body can effectively use the existing resources, reduce the investment amount and the related expenses, and save a lot of manpower and material resources, thus solving the problem of environmental pollution.

Table 1. Pattern comparative analysis

factor	Recycle bin dominates	Packaging Manufacturers Dominate	Enterprise-led
Investment amount	Small	Big	smaller
cost	Low	high	lower
Related company size	smaller	very big	larger
Facility and equipment management capabilities	very weak	larger	Big
Personnel management	difficult to manage	Easier	good management

(1) Drawing on the legislation of other countries, formulate laws and regulations to promote the recycling of packaging waste

In order to prevent, restrain and strengthen recycling, European and American countries have formulated recycling lists, recycling procedures, recycling goals, responsibility systems, and support and incentive mechanisms. Japan has developed three legal systems from basic law to comprehensive law to specialized law. Now in the primary and middle stages of industrialization, energy, material consumption, and resource waste are serious, and its potential for reduction is great. Therefore, it is necessary to save resources from the source of resources. At the same time of development, it is also necessary to make use of various aspects in order to achieve the overall benefits of development. At present, relevant regulations should be formulated as soon as possible to improve the circular economy evaluation index system, packaging recycling management methods, and promote resource conservation. Environmental protection pricing mechanism and other relevant regulations should be established, and economic laws should be circulated. Figure 5 shows the implementation rates of developing and developed countries in four aspects: recycling, comprehensive utilization, packaging materials, and packaging classification.

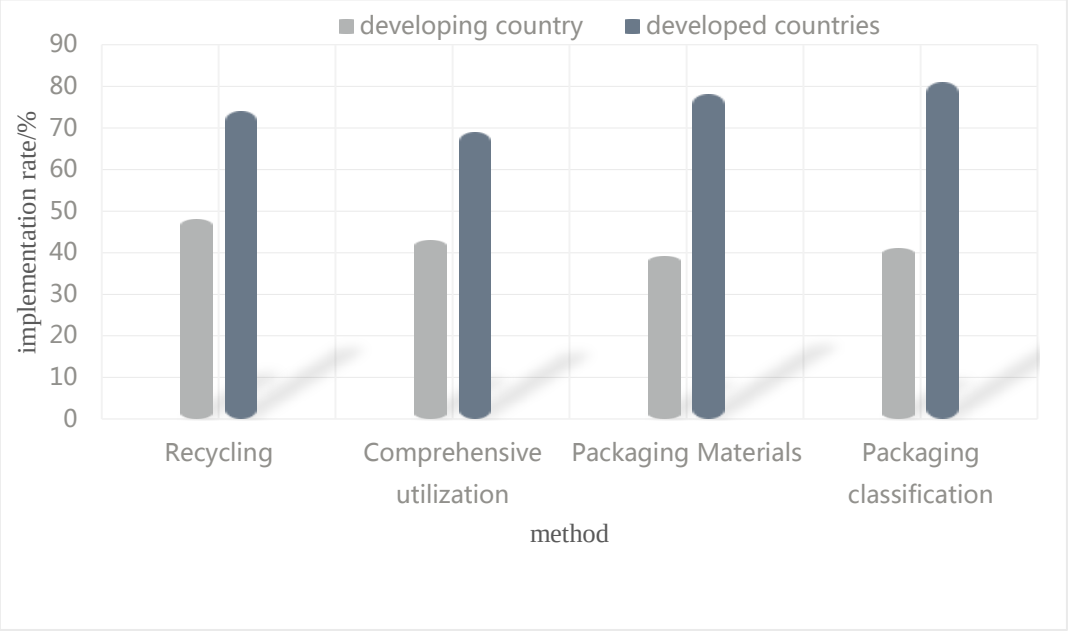

Figure 5. The implementation rate of packaging waste regulations in developing countries and developed countries

As can be seen from Figure 5, the implementation rate of developing countries in the four

aspects of recycling, comprehensive utilization, packaging materials, and packaging classification is generally lower than 50%. In developed countries, the implementation rate of recycling, comprehensive utilization, packaging materials, and packaging classification is generally around 70%; in developing countries, the implementation rate of recycling is higher than other areas, reaching 48%, while the implementation rate of waste packaging materials is lower at 39%. Therefore, it is also necessary to strengthen the laws and regulations on the recycling of packaging waste; developed countries have the highest implementation rate of packaging classification at 81%. Good sorting can minimize the environmental damage caused by packaging waste.

(2) Formulate packaging laws to clarify the responsibilities of enterprises, consumers and governments

For enterprises, it is necessary to strengthen energy conservation, emission reduction and clean production. At the same time, an Extended Producer Responsibility (EPR) system should be established. In addition to product performance, manufacturers are responsible for the product's entire life cycle from design to production and to waste disposal. Production needs to be controlled from the source to achieve "zero emissions" and make products more environmentally friendly. In the packaging law, clean energy and raw materials should be used for the production of packaging products, and the use of packaging materials containing lead, mercury, pickaxes, etc. should be prohibited; the contaminated and non-recyclable packaging cannot be reused.

From the perspective of consumers, relevant policies should be adopted to guide green consumption. The green consumption system refers to regulating the consumption object, consumption process and consumption behavior of packaged products. When consumers buy green packaged goods, it is far from enough to rely on their own awareness, and they must rely on the system to restrict them.

At the government level, it is necessary to strengthen constraints and incentives. The relevant government departments should seize this opportunity to adjust the industrial structure and speed up the merger and reorganization of enterprises, so as to optimize the allocation of resources and promote the development of the green packaging industry. Special funds for circular economy are established; key scientific research projects are to be financially supported; various circular economy activities should be actively carried out, preferential tax policies should be implemented; relevant circular economy construction projects should be supported; relevant policies such as prices and charges to promote the development of circular economy should be implemented. Fiscal, credit, taxation and other supporting policies should be formulated to promote the development of green packaging. At the same time, high tax rates, polluting product tax, ecological compensation tax, garbage tax, packaging tax, etc. are levied on the traditional packaging industry to reduce the external effects of packaging enterprises. Figure 6 shows the effect of the two areas A and B in the four quarters after the formulation of the packaging law.

For both areas A and B, the effect of the four quarters after the formulation of the packaging method has become better visible to the naked eye. By comparing areas A and B, companies, consumers and the government in area B have better implementation results. Area A has a 29% effect in the first quarter and a 7% increase in the second quarter compared to the first quarter. The third quarter is up 3% from the second quarter. The fourth quarter is the end of the quarter, which receives the best results and increases by 12% compared to the third quarter; area B has a 31% effect in the first quarter and a 6% increase in the second quarter compared to the first quarter. The third quarter is up 5% from the second quarter. The fourth quarter is the end of the quarter, which receives the best results and increases 12% from the third quarter.

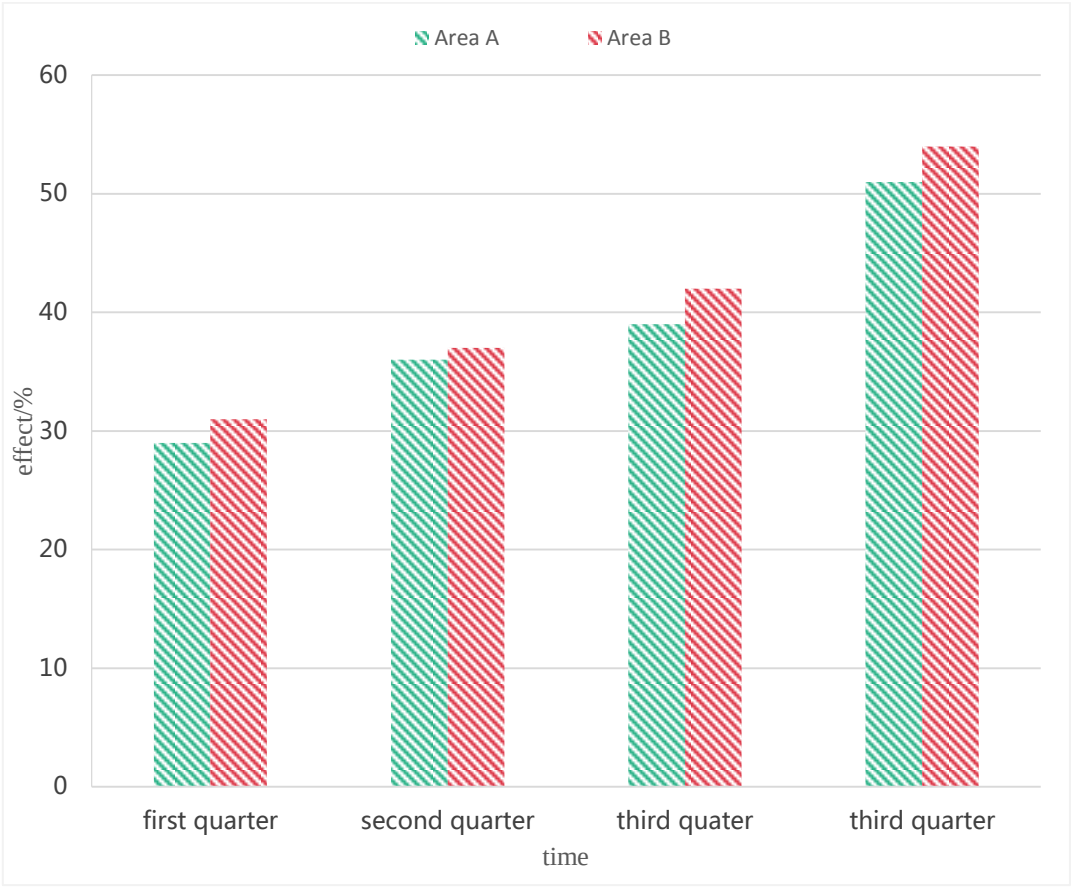

Figure 6. Effect of areas A and B in the four quarters after the formulation of the packaging method

(3) Improve the packaging waste recycling network

The recycling of renewable resources has become an important industry in countries all over the world. Most of the current waste disposal work relies on migrant workers. If it is not classified at the source, it would inevitably be polluted by other garbage and lead to a decline in resource utilization. To this end, it is necessary to improve the packaging waste recycling network as soon as possible. First, it is necessary to build a waste recycling system such as roadside recycling, scattered recycling, and decentralized recycling; the second is to encourage relevant manufacturers, retailers and importers to gradually set up recycling systems and household sorting and packaging centers to promote green packaging signs; the third is to encourage various intermediaries and associations to set up packaging recycling institutions, which are specialized in the collection, classification and reuse of packaging waste. Figure 7 shows the comparison of the growth rate of packaging waste recycling between the three schemes in areas A and B.

For the implementation of the three schemes, it should be treated from the perspective of stable development and wait-and-see in the process of improving the packaging waste recycling network. In plan 1, the growth rates of areas A and B are 33% and 33.5%; in plan 2, the growth rates of areas A and B are both 34%; in plan 3, the growth rates of areas A and B are 33% and 32.5%. Therefore, in accelerating the improvement of the packaging waste recycling network, it is not necessary to rush for quick success and it needs to follow the steps without ignoring the role of any scheme.

To sum up, the regulations and system of packaging waste management under the circular economy constructed in this paper improve the effectiveness of sustainable economic development by 7.81%.

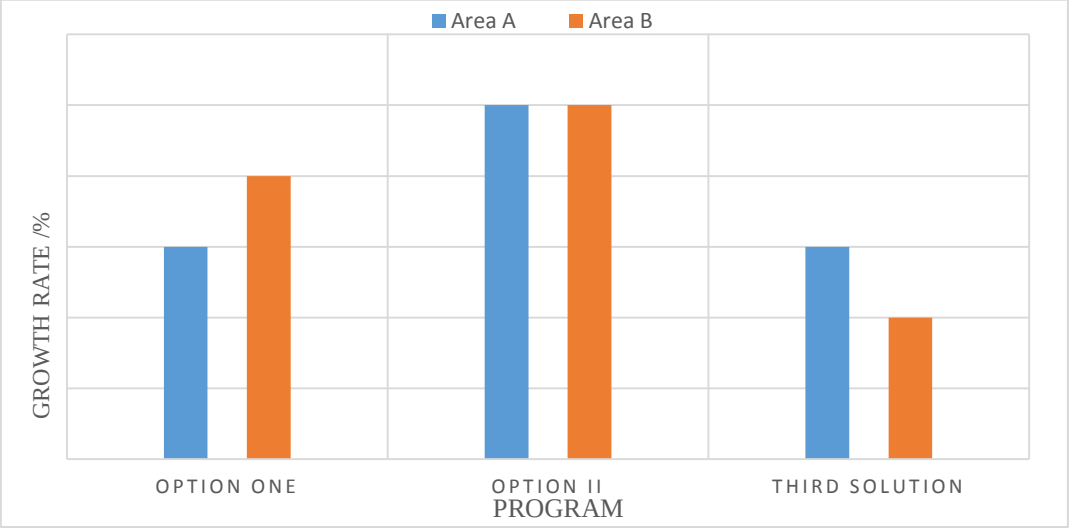

Figure 7. Comparison of the growth rate of packaging waste recycling in the three schemes in areas A and B

5. Conclusions

This paper established a regulatory system analysis and application research model of packaging waste management under circular economy. In this experiment, the comparison results of improving the packaging waste recycling network, formulating packaging laws, clarifying the responsibilities of enterprises, consumers and the government, drawing on the legislation of other countries, and formulating laws and regulations to promote the recycling of packaging waste were obtained. The experimental results showed that the legal system for the management of packaging waste under the circular economy improved the effectiveness of sustainable economic development.

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If any, should be placed before the references section without numbering.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] ManekaKaur. Municipal Solid Waste Management in India: Why Judicial Activism and Legislative Interventions Have Failed to Effectively Address This Issue?.Waste management, 2019,1007(10):978-981.

[2] Cesaro A, Belgiorno V. Sustainability of Medical Waste Management in Different Sized Health Care Facilities. Waste & Biomass Valorization, 2017, 8(5):1819-1827.

[3] Kouloughli S, Kanfoud S. Municipal Solid Waste Management in Constantine, Algeria. Journal of Earth Science and Environmental Protection (English), 2017, 5(1):9-10.

[4] Carmen, Callao, Margarita. Data envelopment analysis%Disposal%Europe%Hazardous waste management%Incineration%Recovery. Waste management, 2019,84(1):147-157.

[5] Wang L M. Research on the legal system for the prevention and control of soil solid waste pollution . High Quality, 2020,21(9):227-229.

[6] Fu H. Research on the legal system of the whole process control of express packaging waste . Journal of Hunan Institute of Engineering: Social Science Edition, 2020, 30(4):5-6.

[7] Lee J, Yang X, Cho S H. Pyrolysis process of agricultural waste using CO2 for waste management, energy recovery, and biochar fabrication. Applied Energy, 2017, 185(1):214-222.

[8] Kilkis S, Kilkis B. Integrated circular economy and education model to address aspects of an energy-water-food nexus in a dairy facility and local contexts. Journal of Cleaner Production, 2017, 167(11):1084-1098.

[9] Wang Q, Liu M, Tang Y. Evaluation and advancement of the integrated circular economy model of farming and stock raising. China's Population, Resources and Environment: English Edition, 2020, 18(4):11-12.

[10] Tsai Chi Kuo, Hsiao Ming Chen. Toward Circular Economy: Cost Effectiveness of Design for Recycling - A mathematical model of two level optimization.Resources Conservation & Recycling, 2017, 12(3):127-132.

[11] Singh M P, Chakraborty A, Roy M. Developing an extended theory of planned behavior model to explore circular economy readiness in manufacturing MSMEs, India. Resources Conservation & Recycling, 2018,135(8):313-322.

[12] James M, Eliberto M. Development of Sustainability Indicators for Product Lines Based on Circular Economy Model . Journal of Cleaner Production, 2018, 196 (9): 1429-1442.

[13] Hopkinson P, Zils M, Hawkins P. Managing a Complex Global Circular Economy Business Model: Opportunities and Challenges. California Management Review, 2018, 60(3):71-94.

[14] Saleem U, Kamierczak J. Building a Circular Economy Model for Managing Exploitation of Household Used Devices on the Example of Washing Machine Driven by DC Motor Along with Components. Multidisciplinary Aspects of Production Engineering, 2021, 4(1):309-316.

[15] Antonopoulos I, Faraca G, Tonini D. Recycling of post-consumer plastic packaging waste in the EU: Recovery rates, material flows, and barriers - ScienceDirect. Waste Management, 2021, 126(5):694-705.

[16] Krupanek J. Sustainable management of hazardous wastes in the electroplating sector according to Circular Economy rules. OCHRONA PRZED KOROZJĄ, 2021, 1(2):8-14.

[17] Larrain M, Passel S V, Thomassen G. Corrigendum to techno-economic assessment of mechanical recycling of low value post-consumer plastic packaging waste. Resources, Conservation and Recycling, 2022, 177(1):106004-106005.

[18] Diao Yuyu, Guo Zhida. Research on Incentive Model of Express Packaging Waste Recycling Based on Tripartite Game Model . Environmental Science, 2021, 47(5):16-19.

[19] Yang J, Long R, Chen H. A comparative analysis of express packaging waste recycling models based on the differential game theory. Resources Conservation and Recycling, 2021, 168(4):105-449.

[20] Guo D, Liu H, Fang B. Visual Affordance Guided Tactile Material Recognition for Waste Recycling. IEEE Transactions on Automation Science and Engineering, 2021, 10(99):1-9.