Research on the Recycling of Rural Express Packaging From the Perspective of Carbon Peaking and Carbon Neutrality

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Abstract. With the development of the economy, society now has new requirements for carbon emissions. In order to peak carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060, it is necessary to develop the use of recyclables and reduce the waste rate from now on, thereby reducing carbon emissions. This paper analyzes the influencing factors of the recycling process of rural express packaging through the PTSTLE model, analyzes the existing problems of express package packaging in combination with the current situation of rural express delivery and related data, and proposes three models: the independent recycling mode of express delivery sites, the cooperative recycling mode of farmers + express delivery sites, and the recycling mode of waste recycling stations, and then analyzes and discusses the impact of economy, society and technology on it according to the analytic hierarchy process, and selects the cooperation model of farmers + express delivery sites suitable for the current development of rural areas to improve the recycling rate of express packaging.

Keywords: rural express packaging; express packaging recycling; Analytic hierarchy process

1 The Current Situation of Express Packaging Recycling

In the process of express delivery, enterprises use outer packaging to play a protective role, but express packaging has also become a waste, and the recycling of express packaging has caused a consensus among the government, express companies and consumers[1]. With the development of the economy, China has achieved the first centenary goal of building a moderately prosperous society in an all-round way and is moving towards the second centenary goal. The living standards of farmers are improving day by day, and rural areas have become the main places to receive online purchases. A large number of express parcels are generated. Farmers throw away the packaging after receiving the parcel or take it home to sell the waste, which makes the environmental pollution problem increasingly serious and causes a serious waste of resources. Therefore, the recycling of rural express packaging is in line with the requirements of national sustainable development.

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2 Problems in Rural Express Packaging Recycling

With the development of the network, the volume of express delivery in rural areas continues to rise, and at present, about 400 million express parcels are collected every day in China, of which more than 100 million are flowing in rural areas. Express packaging is mainly cartons and plastic bags, and such a large volume of express delivery will lead to the generation of thousands of kilograms of packaging waste, such a large volume of express parcels causes serious environmental pollution and waste of resources. Among them, Li Wen [2] selected the address of the express packaging pollutant recovery node with the minimum total cost of recycling, centralized treatment of express packaging pollutants through the recycling transfer station, and then reconstructed the express packaging on the basis of cost minimization and sold it to the express delivery enterprise at a low price. Li Tianjin [3] used the extended theory of planned behavior to establish a theoretical model of the influencing factors of rural residents' express packaging waste recycling behavior, and explored the differential influence of different demographic characteristics on recycling behavior intention and recycling behavior. Boqiang Lin[4] combined principal component analysis, probability regression, conditional value evaluation and other methods to explore whether residents are willing to pay for green express packaging and participate in express packaging recycling. The results show that consumers' choice of green express packaging is mainly affected by four factors: packaging quality factors, political environment factors, other packaging factors and commodity factors. Jiahui Yang and Ruyin Long[5] constructed a theoretical framework from the perspective of network embeddedness. The results show that network density, heterogeneity and relationship quality promote the recycling behavior of urban and rural residents. Kaihan Cai [6]used the conditional value method (CVM) to evaluate the differences in attitudes towards EPW and willingness to pay among urban and rural residents in Guangdong Province. The results show that although more than 60% of respondents believe that excessive packaging is a problem, respondents have limited understanding of the recycling of express packaging, related policies and environmental impacts. There is no clear study on the recycling mode of rural express packaging, but with the development of rural logistics, the recycling of rural express packaging is also a blank space for resource recycling.

3 Analysis of Influencing Factors of Rural Express Packaging Recycling

Through the PESTLE analysis of rural express packaging recycling, it can be seen that:

Policy Aspects: In terms of policy, the state encourages the construction of a recycling system for waste materials, the development of a circular economy, and the construction of a resource-recycling society[7]. The National Development and Reform Commission, together with the Ministry of Commerce and other relevant departments, issued the "Guiding Opinions on Accelerating the Construction of the Recycling System of Waste Materials", which is of great significance for improving the recycling system of waste materials in China, improving the level of resource recycling, en-

hancing the ability to ensure resource security, and helping to achieve the goal of carbon peak and carbon neutrality.

Economic Aspects: The most important factor in the recycling process of express packaging is the economic factor, whether it is farmers or express delivery sites, the issue of efficiency and utility will be prioritized. Therefore, the costs and benefits of recycling affect the attitude of people and express delivery sites towards recyclable express packaging. Among them, because of the support of national policies and local government finances, there are also government subsidies in the economy.

Social Aspects: Because they are located in rural areas, whether they are employees at express delivery stations or villagers, their education level and recycling awareness are low, and their cultural traditions and values may be more biased towards whether they meet the expected benefits. And in the recycling process, convenience is also a major factor to consider[8].

Technical Aspects: The development of packaging recycling technology, the research and development of packaging materials, and the design of the express packaging recycling chain all affect the efficiency and effectiveness of the recycling process. Strengthening recycling is a key link and an important measure to promote technological innovation.

Legal Aspects: At present, there are only management measures for the recycling of renewable resources, but there are no other legal norms for the utilization of recycled resources.

Environmental Aspects: More focus on the impact on carbon emissions, after all, rural express packaging, if not sold to recycling stations, will be incinerated, thereby increasing carbon emissions. It also includes the number of times the express packaging can be recycled, which is not discussed in this article.

Because there are too many factors discussed in this article, environmental factors are placed in the broad category of social factors. By analyzing and finding the factors that recur in the literature, this paper selects the following important influencing factors as the intermediate indicators of the analytic hierarchy process, which are three categories: economic, social and technological.

4 Construction of Express Packaging Recycling Model

4.1 Analytic Hierarchy Process to Construct a Hierarchical Structure

Analytic hierarchy process is a qualitative and quantitative combination, systematization and hierarchical method, it relies on less quantitative information, the complex decision-making information in a mathematical way, in this paper it can be all the independent indicators in the express packaging recycling system through analysis to obtain some of the connections between them, and accordingly they through the hierarchical relationship to establish a hierarchical model[9].

According to the evaluation index system that affects the selection of express recovery mode, the graded level structure diagram is designed, as shown in the following figure 1:

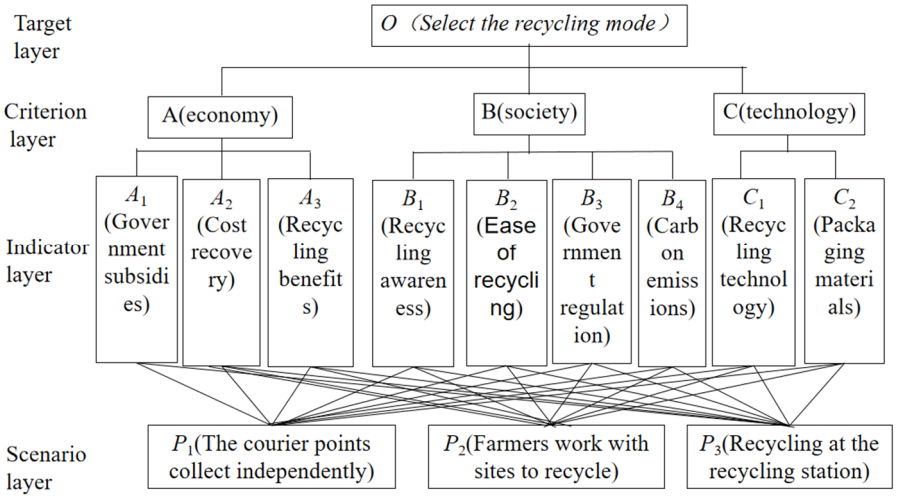

Fig. 1. The hierarchical structure of rural express packaging recycling

4.2 Determine the Judgment Matrix and Single-Level Ordering

The function of the judgment matrix is to assess the relative importance of the relevant elements in the hierarchy. Generally speaking, the values of the judgment matrix are evaluated based on the data, expert opinion and the knowledge of the analyst. The judgment matrix also needs to be tested for consistency to ensure that the conclusions reached by the AHP analysis are reasonable[10]. As shown in the table 1.

Table 1. Judgment matrix based on the overall objective criterion

O (objective)	A (economy)	B (society)	C (technology)
A (economy)	1	4	8
B (society)	1/4	1	3
C (technology)	1/8	1/3	1

Through calculation, the maximum eigenroot λmax=3.018, the corresponding eigenvector is ω=(0.717, 0.205, 0.078)T, when n=3, RI=0.58, the hierarchical total sorting random consistency ratio CR=0.016< 0.1, and the judgment matrix passes the consistency test. Next, the degree of influence of the indicator layer on the criterion layer (economic, social, technological) is obtained.

Table 2. Judgment matrix relative to economy A

A (economy)	A1 (Government subsidies)	A2 (Cost recovery)	A3 (Recycling benefits)
A1 (Government subsidies)	1	1/4	1/7
A2 (Cost recovery)	4	1	1/2
A3(Recycling benefits)	7	2	1

As shown in the table 2, The maximum eigenroot λ(1)max=3.002, the corresponding eigenvector is ω(1)=(0.083,0.315,0.602)T, when n=3, RI=0.58, the hierarchical total ranking random consistency ratio CR=0.002< 0.1, and the judgment matrix passes the consistency test.

Table 3. Judgment matrix relative to Society B

B(society)	B1 (Recycling awareness)	B2 (Ease of recycling)	B3 (Government regulation)	B4 (Carbon emissions)
B1 (Recycling awareness)	1	4	2	3
B2 (Ease of recycling)	1/4	1	1/2	2
B3 (Government regulation)	1/2	2	1	2
B4 (Carbon emissions)	1/3	1/2	1/2	1

As shown in the table 3, The maximum eigenroot λ(2)max=4.096 is calculated, and the corresponding eigenvector is $\omega(2)=(0.476,0.152,0.256,0.116)^T$, when n=4, RI=0.90, and the hierarchical total sorting random consistency ratio CR=0.036< 0.1, and the judgment matrix passes the consistency test.

Table 4. Judgment matrix relative to technology C

C (technology)	C1 (Recycling technology)	C2 (Packaging materials)
C1 (Recycling technology)	1	2
C2 (Packaging materials)	1/2	1

As shown in the table 4, The maximum eigenroot λ(3)max=2 is calculated, the corresponding eigenvector is $\omega(3)=(0.667,0.333)^T$, when n=2, RI=0, the hierarchical total sorting random consistency ratio CR=0< 0.1, and the judgment matrix is a congruent matrix.

Next, find the degree of influence of the scheme layer on the indicator layer.

Table 5. Judgment matrix relative to government subsidy A1

A1(Government subsidies)	P1	P2	P3
P1 (The courier points collect independently)	1	1/4	2
P2 (Farmers work with sites to recycle)	4	1	6
P3 (Recycling at the recycling station)	1/2	1/6	1

As shown in the table 5, The maximum eigenroot λ(11)max=3.009, the eigenvector $\omega(11)=(0.193, 0.701, 0.106)^T$ relative to the government subsidy A1 are calculated, and the RI=0.58 and the stochastic consistency index CR=0.008<0.1 of the judgment matrix are calculated to be satisfactory.

Table 6. Judgment matrix relative to recovery cost A2

A2 (Cost recovery)	P1	P2	P3
P1 (The courier points collect independently)	1	5	4
P2 (Farmers work with sites to recycle)	1/5	1	2
P3 (Recycling at the recycling station)	1/4	1/2	1

As shown in the table 6, The maximum eigenroot $\lambda(12)max=3.094$, the eigenvector $\omega(11)=(0.687, 0.186, 0.127)^T$ relative to the recovered cost A2 are calculated, the RI=0.58 is calculated when n=3, and the stochastic consistency index CR=0.081<0.1 of the judgment matrix has satisfactory consistency.

Table 7. Judgment matrix relative to recycling benefit A3

A3(Recycling benefits)	P1	P2	P3
P1(The courier points collect independently)	1	1/5	2
P2(Farmers work with sites to recycle)	5	1	6
P3(Recycling at the recycling station)	1/2	1/6	1

As shown in the table 7, The maximum eigenroot $\lambda(13)max=3.029$, the eigenvector $\omega(11)=(0.172, 0.726, 0.102)^T$ relative to the recovery benefit A3 are calculated, and the RI=0.58 and the random consistency index CR=0.025<0.1 of the judgment matrix are calculated relative to the recovery benefit A3, which has satisfactory consistency.

Table 8. Judgment matrix relative to recovery consciousness B1

B1(Recycling awareness)	P1	P2	P3
P1(The courier points collect independently)	1	1/5	1
P2(Farmers work with sites to recycle)	5	1	5
P3(Recycling at the recycling station)	1	1/5	1

As shown in the table 8, The maximum eigenroot $\lambda(21)max=3$ relative to the recovered consciousness B1 is calculated, which is a consistent matrix. The eigenvector is $\omega(11)=(0.143,0.714,0.143)^T$.

Table 9. Judgment matrix relative to B2 of recycling convenience

B2(Ease of recycling)	P1	P2	P3
P1 (The courier points collect independently)	1	1/5	1/2
P2 (Farmers work with sites to recycle)	5	1	3
P3 (Recycling at the recycling station)	2	1/3	1

As shown in the table 9, The maximum eigenroot $\lambda(22)max=3.004$, the eigenvector $\omega(22)=(0.122, 0.648, 0.230)^T$ relative to the recovery convenience B2 are calculated, and when n=3, RI=0.58, and the stochastic consistency index CR=0.003<0.1 of the judgment matrix are satisfied.

Table 10. Judgment matrix relative to government regulation B3

B3(Government regulation)	P1	P2	P3
P1 (The courier points collect independently)	1	1/5	2
P2 (Farmers work with sites to recycle)	5	1	8
P3 (Recycling at the recycling station)	1/2	1/8	1

As shown in the table 10, The maximum eigenroot $\lambda(23)max=3.006$, the eigenvector is $\omega(23)=(0.162, 0.751, 0.087)^T$, when n=3, RI=0.58, and the judgment matrix stochastic consistency index CR=0.005<0.1 is calculated, which has satisfactory consistency.

Table 11. Judgment matrix relative to carbon emissions B4

B4 (Carbon emissions)	P1	P2	P3
P1 (The courier points collect independently)	1	1	5
P2 (Farmers work with sites to recycle)	1	1	4
P3 (Recycling at the recycling station)	1/5	1/4	1

As shown in the table 11, The maximum eigenroot $\lambda(24)max=3.006$, $\omega(24)=(0.467,0.433,0.1)^T$, when n=3, RI=0.58, and the judgment matrix stochastic consistency index CR=0.005<0.1 are calculated.

Table 12. Judgment matrix relative to recycling technology C1

C1 (Recycling technology)	P1	P2	P3
P1 (The courier points collect independently)	1	3	7
P2 (Farmers work with sites to recycle)	1/3	1	4
P3 (Recycling at the recycling station)	1/7	1/4	1

As shown in the table 12, The maximum eigenroot $\lambda(31)max=3.021$, the eigenvector $\omega(31)=(0.658, 0.263, 0.079)^T$ relative to the recovery technology C1 are calculated, and the RI=0.58 and the stochastic consistency index CR=0.028<0.1 of the judgment matrix are calculated, which has satisfactory consistency.

Table 13. Judgment matrix relative to packaging material C2

C2 (Packaging materials)	P1	P2	P3
P1 (The courier points collect independently)	1	1/4	4
P2 (Farmers work with sites to recycle)	4	1	8
P3 (Recycling at the recycling station)	1/4	1/8	1

As shown in the table 13, The maximum eigenroot $\lambda(32)max=3.091$, the eigenvector $\omega(11)=(0.265, 0.669, 0.066)^T$ relative to the packaging material C2 are calculated, the RI=0.58 is 0.58 when n=3, and the random consistency index CR=0.078<0.1 of the judgment matrix has satisfactory consistency.

4.3 Hierarchical Total Sorting and Inspection.

The total ranking refers to the relative weight of each factor of each judgment matrix for the target layer. As shown in the table 14, the optimal decision-making scheme is then obtained by analyzing the results of the above total ranking.

Table 14. The ranking weights of each element in the program layer to the decision objective

element	weight
The ranking weight of the features in the first intermediate layer to the decision objective	
economy	0.717
society	0.205
technology	0.078
The ranking weight of the elements in the second intermediate layer to the goals of the decision-making layer	
Government subsidies	0.059511
Cost recovery	0.225855
Recycling benefits	0.431634
Recycling awareness	0.09758
Ease of recycling	0.03116
Government regulation	0.05248
Carbon emissions	0.02378
Recycling technology	0.052026
Packaging materials	0.025974
Alternatives	
P1(The courier points collect independently)	0.319438011
P2(Farmers work with sites to recycle)	0.567629194
P3(Recycling at the recycling station)	0.112932795

By calculation, the consistency ratio of the total ranking of the hierarchy CR=0.034<0.1 was calculated, and the total ranking of the hierarchy was considered to pass the consistency test. Decisions can be made accordingly.

5 Conclusion

Through the results of analytic hierarchy process, it can be seen that in the rural express packaging recycling mode, the mode of cooperative recycling between express stations and farmers is significantly better than the other two recycling models. This can not only take care of the farmers' income, but also reduce the cost of the site, reduce carbon

emissions, promote the recycling of materials, and contribute to the development of the economy.

Through the ranking weight of the above factors on the decision-making objectives, the two major economic indicators of recovery cost and recovery benefit are obviously in an important position. Whether it is a farmer or an express delivery site, the relative size of these two indicators in the recycling process needs to be considered, and balancing these two indicators can promote the formation and stability of the cooperation model. This requires government regulation and incentives for sites. At the same time, in the social category, farmers' awareness of recycling occupies a large proportion. Only when farmers have a strong sense of recycling, join the recycling process, and are in the closed loop of recycling, can they maximize the reuse of resources, which requires our village committee and express delivery sites to strengthen publicity, accelerate the improvement of farmers' awareness of recycling, and guide them from the perspective of thought and behavior. At the same time, the government also undertakes the important task of improving the formulation of recycling laws and regulations, and improves the legal governance system, so as to promote the stability of the rural express recycling cooperation model and strengthen "hard" supervision. In this indicator, the impact of recycling technology is greater than that of packaging materials, because the improvement of recycling technology can speed up the recycling process and improve the efficiency of the recycling chain. Therefore, the reform of the recycling technology of express packaging can also promote the stable development of the cooperation model.

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