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# Research on Construction of the Green Logistics Evaluation Index System and Determination of Index Weight

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***Abstract:*** **It constructs the green logistics evaluation index system, and uses the analytic hierarchy process method and fuzzy comprehensive evaluation method to establish the weight of each index. It mainly through the questionnaire investigation and expert scoring method obtains the judgment matrix, and calculates matrix to get the weight of indicators at all levels. It establishes the theoretical basis and methods for green logistics statistical evaluation.**

***Keywords:*** Green logistics; Logistics statistics; AHP; Weight

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## 1. Introduction

Green logistics is a modern logistics theme, also should be the direction of future development of the logistics. At present, there is little accounting method of logistics in our country. Kwok Hung Lau uses composite index to evaluate the implementation of performance of green logistics [1]. He makes an overall evaluation of implementation for enterprise green logistics, which plays an important role in implementation of enterprise green logistics. Ilsuk Kim (2011) [2] through the establishment of the green logistics performance index (GLPI) and environmental performance system (EPI) to evaluate whether some countries to realize the distribution function at the expense of the environment, in order to prove the importance of green logistics. Benjamin T. Hazen [3] puts forward the quality evaluation system of green recycling logistics, and deeply studies the relationship between green supply chain management and competitive advantages. Maria Bjorklund [4] puts forward the significance of performance evaluation of green supply chain, and points out that the lack of practice and theory in this field. His article puts forward a new evaluation framework, and proves that these indicators are effective on environmental performance measurement by examples. Karin Isaksson [5] deeply studies green service performance of the logistics service provider. His article points out that in order to turn the environment problem into economic opportunities, many companies have begun to consider the green environmental protection into their service.

Nowadays，our research on green logistics is qualitative research. Green road of logistics industry also requires attention. Although there are some statistical data collected by the authorities every year, but quantitative research is not enough, also need to consider the social environment of green logistics. This paper joins the qualitative index into the index system, and combines the quantitative indicators and qualitative indicators on the current situation of the development of green logistics evaluation.

## 2. Construction the Evaluation Index System of Green Logistics

### *2.1. Construction Principle*

The evaluation index is the basis of comprehensive study on green logistics, which must be in accordance with the requirements green logistics management. It should strictly follow the scientific, comprehensive, representative, simplicity, feasibility, dynamic and static combination principle in order to establish a fair and objective evaluation index system, and assess the development of green logistics accurately.

### *2.2. The Index System Composition*

The development of green logistics involves various aspects of the logistics industry. It should consider the whole logistics process data at the time of evaluation, and it is a complex work. The index system includes target layer, criterion layer and the index layer, are divided into multiple index in the criterion layer on each inspection.

The target layer indicator is green logistics development level, which indicates the green degree of logistics industry and the sustainable development of resources and environment.

The criterion layer reflects the macro level of evaluation index based on the criteria layer, which includes environmental pollution, environmental governance, government decision making, logistics industry, enterprise management and social masses.



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The index layer is arranged under the criteria layer, a total of 27 indexes.

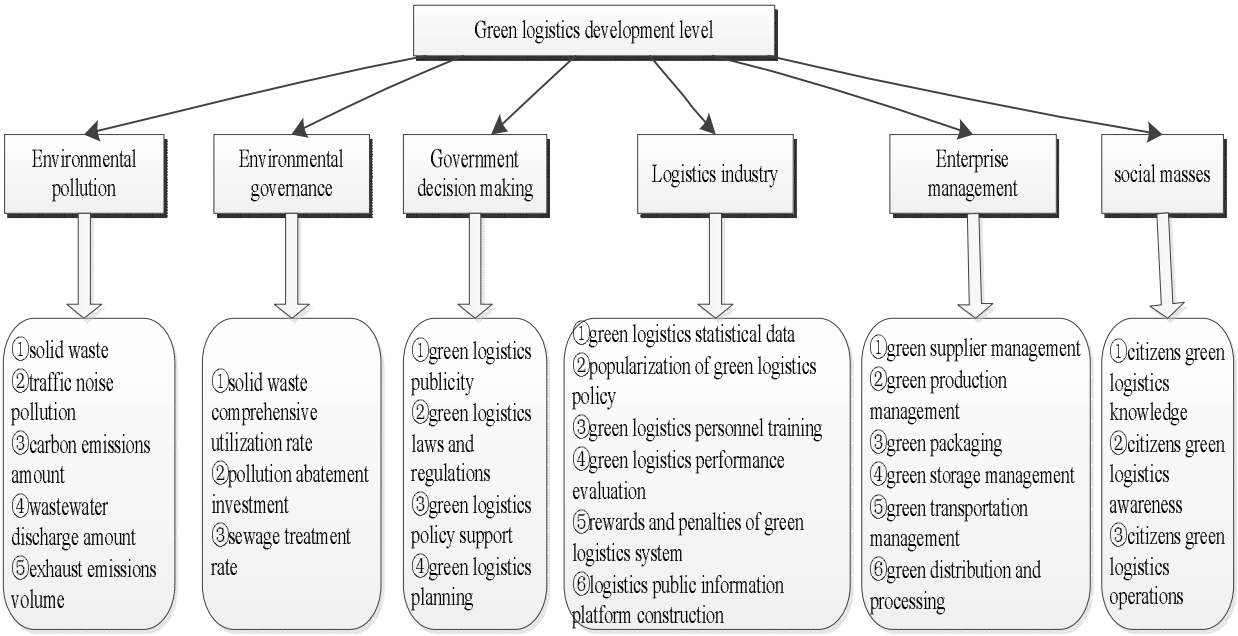


**Figure 1. Green logistics development evaluation index system.**

Analysis of the six indicators we can know, only the environmental pollution level is negative index, the index value on the development of green logistics is more and more unfavorable, the rest of the indicators are positive indicators, namely the index value is getting better and better.

## 3. Determination of the Index Weight by AHP Method

It establishes the index weight by using 1-9 scaling the relative importance of the index score, based on the collection of nearly 50 expert questionnaires for each index relative importance degree, listed a part below (Table 1).

**Table 1 Judgment matrix of criterion level**

| Relative importance of the index | Environmental pollution | Environmental governance | Government decision making | Logistics industry | Enterprise management | Social masses |
|---|---|---|---|---|---|---|
| Environmental pollution | 1 | 2 | 7 | 5 | 6 | 7 |
| Environmental governance | 1/2 | 1 | 6 | 4 | 3 | 4 |
| Government decision making | 1/7 | 1/6 | 1 | 2 | 1/3 | 3 |
| Logistics industry | 1/5 | 1/4 | 1/2 | 1 | 1/3 | 2 |
| Enterprise management | 1/6 | 1/3 | 3 | 3 | 1 | 3 |
| Social masses | 1/7 | 1/4 | 1/3 | 1/2 | 1/3 | 1 |



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When the judgment matrix is completely consistent, there is the only one non-zero eigenvalue, which is remembered as $\lambda = \lambda_{max}$. The eigenvector corresponding to the maximum eigenvalue is the relative importance of each index sorted, also is the target weight value. The premise of this conclusion is that the judgment matrix is consistency, at the same time as the one sidedness of people may develop in the subjective evaluation, it also need to check the consistency of judgment matrix. Consistency of judgment matrix $CI = (\lambda_{max} - n)/(n-1)$, where $n$ is the rank number of judgment matrix. At the same time random consistency ratio $CR = CI/RI$, where $RI$ is the average consensus standards value corresponding for each rank number of Judgment matrix. $RI$ value is listed in below (Table 2).

**Table 2 Random consistency index RI value**

| Rank number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| *RI* | 0 | 0 | 0.52 | 0.89 | 1.12 | 1.25 | 1.35 | 1.42 | 1.46 |

When $CR < 0.1$, the weight distribution is reasonable, otherwise it should redistribute weight value [6].

The eigenvectors $C$ and eigenvalues $D$ of table 1 are solved by Matlab. The results are as follows.

$$C = \begin{bmatrix} 0.8168 & 0.8163 & 0.8163 & -0.8892 & 0.8827 & 0.8827 \\ 0.4924 & 0.3520+0.3134i & 0.3520-0.3134i & 0.3921 & -0.3468-0.2322i & -0.3468+0.2322i \\ 0.1344 & -0.1691+0.0317i & -0.1691-0.0317i & 0.0870 & 0.1070+0.0203i & 0.1070-0.0203i \\ 0.1085 & -0.0543-0.0917i & -0.0543+0.0917i & -0.1693 & -0.0665-0.0869i & -0.0665+0.0869i \\ 0.2335 & -0.0445+0.2470i & -0.0445-0.2470i & -0.0796 & -0.1173+0.0746i & -0.1173-0.0746i \\ 0.0772 & 0.0246-0.0835i & 0.0246+0.0835i & 0.1140 & -0.0081+0.0587i & -0.0081-0.0587i \end{bmatrix},$$

$$D = \begin{bmatrix} 6.3980 & 0 & 0 & 0 & 0 & 0 \\ 0 & -0.0371+1.5767i & 0 & 0 & 0 & 0 \\ 0 & 0 & -0.0371-1.5767i & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.0246 & 0 & 0 \\ 0 & 0 & 0 & 0 & -0.1742+0.1151i & 0 \\ 0 & 0 & 0 & 0 & 0 & -0.1742-0.1151i \end{bmatrix}$$

We can know from the above results that $\lambda_{max}$=6.3980, and $CI = (\lambda_{max} - n)/(n-1)$ =0.0796, $CR = CI/RI$ =0.0796/1.25=0.0637<0.1, it meets the consistency test that the eigenvector corresponding to the largest eigenvalue is (0.8168, 0.4924, 0.1344, 0.1085, 0.2335, 0.0772). The weight of criterion layer after normalized is [0.4385, 0.2643, 0.0721, 0.0583, 0.1253, 0.0415].

We can get the weight distribution of all levels by this method, listed in table 3.

Namely, the index weight of criterion layer is $X$.

$X$ =[0.4385,0.2643,0.0721,0.0583,0.1253,0.0415].

Weight of six index layers respectively is $X = [X_1 \ X_2 \ X_3 \ X_4 \ X_5 \ X_6]$,

$X_1$ = [0.0890, 0.1629, 0.0552, 0.2614, 0.4315],

$X_2$ = [0.1095, 0.5815, 0.3090],

$X_3$ = [0.4399, 0.1278, 0.3287, 0.1036],

$X_4$ = [0.4095, 0.2428, 0.0947, 0.1254, 0.0736, 0.0540],

$X_5$ = [0.0378, 0.1130, 0.2422, 0.3906, 0.1082, 0.1082],

$X_6$ = [0.0936, 0.6267, 0.2797].

## 4. Conclusion

It constructs the green logistics evaluation index system, and uses the analytic hierarchy process method (AHP) and fuzzy comprehensive evaluation method to establish the weight of each index. It mainly through the questionnaire investigation and expert scoring method obtains the judgment matrix, and calculates matrix to get the weight of indicators at all levels. It establishes the theoretical basis and methods for green logistics statistical evaluation.

At present, it contains a large number of environmental pollution and energy of the data in China Statistical Yearbook, but qualitative index data listed in this paper also very scarce. However, evaluation of the development of green logistics, it should study not only the quantitative part, but also the



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qualitative part. So, how to combine the quantitative and qualitative indexes is a question worth exploring. And It need to appeal social statistics workers in the future work to take into account the impact of qualitative indicators and quantitative statistical work, so that evaluation can be more specific and comprehensive.

**Table 3 The weight distribution of all levels**

| The criterion layer | | The index layer | |
|---|---|---|---|
| Index name | Weight value | Index name | Weight value |
| Environmental pollution | 0.4385 | ①solid waste | 0.0890 |
| | | ②traffic noise pollution | 0.1629 |
| | | ③carbon emissions amount | 0.0552 |
| | | ④wastewater discharge amount | 0.2614 |
| | | ⑤exhaust emissions volume | 0.4315 |
| Environmental governance | 0.2643 | ①solid waste comprehensive utilization rate | 0.1095 |
| | | ②pollution abatement investment | 0.5815 |
| | | ③sewage treatment rate | 0.3090 |
| Government decision making | 0.0721 | ①green logistics publicity | 0.4399 |
| | | ②green logistics laws and regulations | 0.1278 |
| | | ③green logistics policy support | 0.3287 |
| | | ④green logistics planning | 0.1036 |
| Logistics industry | 0.0583 | ①green logistics statistical data | 0.4095 |
| | | ②popularization of green logistics policy | 0.2428 |
| | | ③green logistics personnel training | 0.0947 |
| | | ④green logistics performance evaluation | 0.1254 |
| | | ⑤rewards and penalties of green logistics system | 0.0736 |
| | | ⑥logistics public information platform construction | 0.0540 |
| Enterprise management | 0.1253 | ①green supplier management | 0.0378 |
| | | ②green production management | 0.1130 |
| | | ③green packaging | 0.2422 |
| | | ④green storage management | 0.3906 |
| | | ⑤green transportation management | 0.1082 |
| | | ⑥green distribution and processing | 0.1082 |
| Social masses | 0.0415 | ①citizens green logistics knowledge | 0.0936 |
| | | ②citizens green logistics awareness | 0.6267 |
| | | ③citizens green logistics operations | 0.2797 |

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