Problem Chosen	2020 MCM/ICM Summary Sheet	Team Control Number
E		2012076

Disposable and single-use plastic wastes are closely related to the ecological environment and human health. It is very urgent to study the relationship between them. This paper divides the problem into the following five tasks and solves them.

Task 1: In order to establish the corresponding relationship between disposable and single-use plastic waste and environmental pressure, the environmental pressure evaluation model is established in this chapter. The maximum level of disposable and single-use plastic waste is transformed into the worst level of environmental pressure under the influence of disposable and single-use plastic waste. Firstly, the evaluation index system of environmental pressure is established, including 4 first level indexes and 23 second level indexes. Then, AHP-NBM fuzzy comprehensive evaluation model is used to solve the two evaluation models (ANFCE), and MATLAB software is used to solve the relevant values, and the plastic waste output corresponding to each environmental pressure index is obtained. In order to get the maximum level of plastic waste, we describe the time-varying of the model and give the flow chart under the time-varying condition. Then the neural network method is used to predict the time series, and MATLAB software is used to get the prediction data. When the growth rate of plastic waste output is equal to the reduction rate of environmental pressure, it is the worst level of environmental pressure, that is, the maximum level of plastic waste. Therefore, when the minimum environmental pressure index is 53, the output of plastic waste can be reduced without further damage to the environment, and the corresponding maximum output of plastic waste is 662mt per year. Finally, the time variability of the model can be verified by replacing the data back into the model.

Task 2: This task discusses the extent to which plastic waste can be reduced to achieve environmental safety. Based on the cost-benefit analysis, the measures and means to reduce plastic waste are set as cost, and the possible benefits to reduce plastic waste are set as revenue. Firstly, the composition of cost-benefit of reducing plastic waste is analyzed, and then four cost-benefit indexes are introduced to determine the calculation method of cost-benefit economic indexes. Then, the cost and benefit are analyzed in detail, and the cost and benefit are respectively corresponding to the model indicators in task 1. Using the residual analysis method, combined with the analysis results and actual data, the effectiveness index of the cost-benefit analysis model is calculated, and the effectiveness of the cost-benefit analysis model is obtained.

Task 3: Using the model established in task 1, the lowest level of environmental pressure is calculated, that is, the lowest environmental pressure index, which is set as the lowest attainable level of global disposable or disposable plastic products. And use the model established in task 2, and discuss the impact of reaching this level. That is to say, in order to reach the lowest level of plastic products, we will pay for the costs and benefits, and analyze various indicators, including the impact on human life style, environment and plastic industry.

Task 4: Based on the unequal distribution of the causes and impacts of plastic waste among countries or regions, we discussed the equity issues caused by the global crisis and provided the expected solutions.

Task 5: We wrote a two page memo to ICM. Based on the above models and solutions, we show the global minimum achievable level of disposable or disposable plastic waste, the time line to achieve this level, and any situation that may accelerate or hinder the achievement of the goals and time line.

Finally, the advantages and disadvantages of the article are analyzed and summarized.

Key words: AHP-NBM- fuzzy comprehensive evaluation, time-varying, cost-benefit analysis.

Contents

Analysis of the Level of Plastic Waste and Environmental Pressure

I. Introduction

1.1 Backgrounds

Since the 1950s, the plastic manufacturing industry has grown exponentially. While there are significant benefits, the negative impact associated with increased plastic production is worrying. The rise of disposable and disposable plastic products has led to the industry's commitment to manufacturing plastic waste. Plastic products are difficult to decompose and handle, only about 9% of them are recycled. Therefore, to solve the problem of plastic waste, we must slow down the plastic production process and improve the management level of plastic waste.

1.2 What do we need to do？

Our team needs to deal with this escalating environmental crisis. We must make a plan to greatly reduce the waste of disposable products and disposable plastic products.

Task 1: We need to develop a model to estimate the maximum level of disposable or disposable plastic product waste, that is, safe waste can be safely reduced without further environmental damage. Among many factors, we need to consider the sources of these wastes, the severity of the current waste problem, and the availability of the resources needed to dispose of them.

Task 2: We need to discuss the extent to which plastic waste can be reduced to reach the level of environmental safety. This may involve consideration of factors affecting the level of plastic waste, including, but not limited to, the source and use of disposable or disposable plastics, the availability of plastic substitutes, the impact on citizens' lives, or urban, regional, national policies, as well as the reduction of the use of disposable or primary plastics on all continents and the effectiveness of such policies. These factors may vary from region to region, so taking into account the specific constraints of the region may make some policies more effective than others.

Task 3: Using our models and discussions, set goals for the lowest attainable level of global disposable or disposable plastic products and discuss the impact of reaching that level. We need to think about changing the way people live, the environmental impact, or the impact on the trillions of dollars worth of plastic industry.

Task 4: Although this is a global problem, its causes and effects are not evenly distributed among countries or regions. Discuss the equity issues caused by the global crisis and our expected solutions. We need to make suggestions to ICM to solve these problems.

Task 5: We need to write a two page memo to ICM about the actual minimum achievable level of global disposable or disposable plastic product waste, the schedule to achieve this level, and any circumstances that may accelerate or hinder the achievement of the goals and schedule.

II. Assumptions

- The selected indicators can represent the situation of plastic waste in different regions.
- The collected data can represent the basic status of plastic waste in the area and be used for further analysis.
- The model does not include the interaction between plastic waste level indicators.

III. Symbol Specification

Too many symbols are used, which will be explained in detail in the chapters.

IV. Model Preparation

First of all, we explain disposable plastic products and single-use plastic products, and analyze their advantages and disadvantages, harmfulness, and the social background of disposable consumption.

4.1 Definition

With the rapid development of social reform and opening up, disposable plastic products are also used by more and more people. People have a new understanding of its quality and role, which makes the disposable plastic products management emerging industry.[1] People have a new understanding of disposable plastic products, promote the development of disposable plastic products industry, and further arouse people's attention to disposable plastic products. [2] In order to better analyze and solve the model, we first define the following main terms.

1. Disposable Plastic Products

Disposable plastic products are plastic materials or products that are not recyclable and become trash. Excessive use of these disposable products can damage the environment. [3]

2. Plastic Waste

Plastic waste is plastic objects that have not been recycled properly or cannot be recycled, also known as plastic debris.

3. Single-Use Plastic Products

Single-use plastic products are products made of plastic intended for one time use before being discarded.

4.2 Relative merits

What are the advantages, disadvantages and harms of the three plastic products mentioned above? We will explain here.

1. Advantages

1) Most plastics have strong corrosion resistance and do not react with acid or alkali.
2) Low cost of plastic manufacturing.
3) Durable, waterproof and light.
4) It is easy to be molded into different shapes.
5) It is a good insulator.
6) Plastics can be used to prepare fuel oil and fuel gas, which can reduce crude oil consumption.

2. Disadvantages

1) Plastic is easy to burn, and toxic gas will be produced when burning. For example, when

polystyrene is burned, toluene will be produced. A small amount of this substance will cause blindness, vomiting and other symptoms when inhaled. In addition to combustion, that is, high temperature environment, plastic will decompose toxic components, such as benzene ring. [4]

2) Plastics are made of petroleum products, and petroleum resources are limited.

3) Plastic cannot be naturally decomposed.

3. Damage

1) Environmental pollution. Disposable plastic products cause serious environmental pollution. Because of the difficulty of degradation, the disposable plastic products bring heavy burden to the environment.

2) Waste of resources. One time consumption leads to the crazy plunder of natural resources. Behind the convenience and rapidity brought by one-off is the shocking consumption of resources. [5]

3) Health problems. As a kind of fast-moving consumer goods, the low price of disposable plastic products often goes with the poor quality. The chaotic market situation is difficult to guarantee the product quality. [6]

4.3 Social context--- One-off consumption

The formation and popularity of one-off consumption has a complex social background, which is gestated by the comprehensive effect of many factors such as economy, science and technology, culture, religion and so on.

1. Consumerism and one-off consumption. With the development of society and the progress of modern science and technology, people get rid of the shackles of extreme lack of material, thus entering the era of abundant food and clothing. In this context, hedonism and consumerism have replaced the thrifty (frugality) which emphasizes thrift and abandons luxury. One-time consumption also emerged in this tide. [7]

2. Social pressure and one-off consumption. Disposable plastic products have become an indispensable part of people's daily life because they are easy to use, convenient and fast without much follow-up work. Therefore, in the fast-paced modern social life, disposable consumption is more and more popular.

3. Science and technology and one-off consumption. Science and technology and one-off consumption. As mentioned before, without the revolution of science and technology, there would be no emancipation from nature and great material enrichment, and there would be no one-off consumption. It can be said that the progress of science and technology is the basic condition of one-off consumption.

V. Task 1: Model for Maximum Level Estimation of Plastic Waste

In order to analyze the maximum level of disposable plastic products without further impact on the environment, we try to convert this problem into the analysis of the maximum environmental pressure. We have established the environmental pressure evaluation model affected by waste. When the environmental pressure score is the lowest, it is the maximum level of disposable plastic products. First of all, we need to establish a comprehensive evaluation index system of environmental pressure.

5.1 Evaluation index of environmental pressure affected by plastic waste

In this part, we put forward four main indicators of environmental pressure, and give the important role they play and the secondary indicators they contain.

- **Types of the waste**

Plastic packaging as a necessary way of packaging in today's society, suitable for a wide range of goods. Because of its excellent performance, plastic packaging materials are widely used in the field of packaging. The biggest advantage of plastic packaging material is that it can easily adjust the material properties through various methods to meet different needs, and can also be made into composite film and multi-layer plastic bottles, which are light, not easy to be damaged, and convenient for transportation and carrying. The plastic packaging material is transparent, smooth and smooth, easy to print and shape, which can beautify the appearance of goods and improve the performance of goods display. Most plastics can be used for beverage and food packaging, and the most expensive polyolefin is used. The commonly used plastics are polyethylene, polyvinyl chloride, polypropylene, polyester, polyvinylidene chloride and polycarbonate. The types of waste systems for single-use and disposable plastics products include eight secondary indicators. [8]

1) Packaging film.
2) Woven bag plastic.
3) Plastic hollow container.
4) Plastic turnover boxes.
5) Foam plastic packaging materials.
6) Plastic rope and belt.
7) Packaging sheet.
8) Plastic pallet.

- **Source of the waste**

The source of waste for single-use and disposable plastics products includes seven secondary indicators.

1) Transportation.
2) Packaging.
3) Building and Construction.
4) Electrical.
5) Consumer & Institutional Products.
6) Industrial Machinery.
7) Other waste.

The disposable plastic waste mainly includes domestic waste, cleaning waste, commercial waste, institutional waste, medical and health waste, transportation waste, construction and decoration waste, industrial enterprise waste and other waste, of which the proportion of domestic waste is the largest, accounting for about half of the total amount of urban waste, followed by commercial waste and administrative institution waste. The industrial unit waste is mainly composed of the proportion of cities with different levels of industrial development changes greatly, and the proportion of waste from different sources in urban waste also changes with different stages of urban development. [9]

- **Extent of the current waste problem**

Due to poor management and insufficient investment, a large number of urban domestic waste is directly transported to the outskirts of the city without treatment or simply landfilled, resulting in a large number of farmland being occupied, forming a situation of "garbage surrounding the city". At the same time, due to the imperfect environmental protection measures in the disposal process, the air, surface water, groundwater and soil environment around the landfill site are seriously polluted. [10]At present, the extent of waste problems mainly includes six secondary indicators.

1) Impact on city appearance.
2) Destroy the ecological environment.
3) Soil and water pollution.
4) Air pollution.
5) Global environment.
6) Special waste.

- **Manner of the Waste-disposal**

There are two main ways to deal with the waste-disposal.

1) Security Landfill

Sanitary landfill is not only a treatment method, but also the final disposal method of solid residues which cannot be treated by other treatment methods. The sanitary landfill method is to use low-level anti-seepage, layered landfill of garbage, after compaction, the top layer is covered with soil layer, so that the waste can be fermented under the condition of anoxia, so as to achieve harmless treatment.

At present, sanitary landfill technology has been widely used in the world. Compared with other treatment methods, landfill method has the characteristics of less construction investment, no dependence on other methods, and low operating cost. But the biggest problem of sanitary landfill method is the difficulty of site selection, not all the suburbs can find suitable landfill sites. The landfill far away from the city will increase the transportation cost. [10]

At the same time, with the improvement of landfill disposal standard, the disposal cost of sanitary landfill method will be higher and higher. No matter what process technology is used to treat municipal solid waste, there will be a certain amount of residues, including inorganic and non-combustible materials, which need to be finally landfilled. [11]

2) Incineration and pyrolysis

European countries and Japan take the leading position in the world in incineration technology. Incineration is a process that the combustible components sorted out from the garbage are fully burned at high temperature (800°- 1000°) [11], and finally become stable ash. The incineration of garbage has become a widely used garbage treatment method in many countries because of its large capacity, good reduction, thorough harmless and heat recovery.[12] The application of incineration technology is limited by many factors.

First of all, because of the complex composition and poor stability of MSW, the incineration is unstable. Secondly, the composition of the waste gas produced by incineration of municipal solid waste is complex, so it is difficult to control, especially the dioxin produced by incineration, which has strong pollution toxicity. Finally, the cost of incineration treatment equipment and operation costs are very high, and the technical level of operation and management of the treatment system is also very high.

5.2 Evaluation index system of environmental pressure affected by plastic waste

We will continue to improve the comprehensive evaluation index system of environmental pressure. It includes 4 first-level indicators, 23 second-level indicators. They are shown in table 1.

Table 1: Comprehensive Evaluation Index System of Ecological Services

Primary index	Secondary index
Types of the waste	P1: Packaging film
	P2: Woven bag plastic
	P3: Plastic hollow container
	P4: Plastic turnover boxes
	P5: Foam plastic packaging materials
	P6: Plastic rope
	P7: Packaging sheet
	P8: Plastic pallet
Source of the waste	P9: Transportation
	P10: Packaging
	P11: Building and Construction
	P12: Electrical
	P13: Consumer & Institutional Products
	P14: Industrial Machinery
	P15: Other waste
Extent of the current waste problem	P16: Impact on city appearance
	P17: Destroy the ecological environment
	P18: Soil and water pollution
	P19: Air pollution
	P20: Global environment
	P21: Special waste
Availability of resources to process the waste	P22: Security Landfill
	P23: Incineration and pyrolysis

Based on the results of single environmental pressure evaluation, the comprehensive index of environmental pressure is evaluated. That is to say, the project adopts the method of weighted analysis, and the weights of each index are assigned by the analytic hierarchy process (AHP). At the same time, it refers to the analysis of the importance of indicators. With the same sub-indicators, the natural breakpoint method (NBM) is used to divide into five grades. [13] The fuzzy comprehensive evaluation method is used to get the final score of environmental pressure affected by plastic waste.

In Section 5.3, we will introduce the AHP-NBM-Fuzzy Comprehensive Evaluation Method.

5.3 The Establishment of AHP-NBM- Fuzzy Comprehensive Evaluation Model (ANFCE)

Because of the complexity of the index system, the weight and classification of each index is particularly important when establishing the evaluation model. The fuzzy comprehensive evaluation model (ANFCE) consists of three parts. The first part is analytic hierarchy process. The second part: natural breakpoint method to determine the level of environmental pressure. [14] The third part is fuzzy comprehensive evaluation. Fuzzy comprehensive evaluation is based on AHP and natural breakpoint method. They complement each other and improve the reliability and validity of evaluation.

Next, we will introduce how to use the ANFCE model to assess the environmental pressure affected by plastic waste.

5.3.1 Analytic hierarchy process (AHP) - scientifically determining the weight of evaluation index

The analytic hierarchy process of mathematical thinking of complex system, human subjective judgment based qualitative quantitative analysis, the differences between the various factors determine the numerical value, help people to maintain the consistency of the thinking process is suitable for fuzzy comprehensive evaluation of complex system, is currently one of the most widely used to determine weight method. The use of analytic hierarchy process (AHP) to determine the weight of the index can be carried out according to the following steps. [14]

Step 1：Establishing hierarchical structure of vulnerability assessment system

A clear classification index system is established to analyze the N indexes in the established index system. The index set is represented as the first class index set $V=\{V_1,V_2,\cdots,V_N\}$ and sub-index set $V_i=\{V_{i1},V_{i2},\cdots,V_{ik}\}$, V_i represents the first level index, N is the number of indexes, and the set of these indexes is a simple sort by numbered.

Step 2：Determine the comparison matrix between the two

The 1-9 proportions scale method is used to qualitatively describe the relative importance of each level's evaluation index, and quantify it with accurate numbers, and then determine the discriminant matrix [6].

Table 2: The meaning table of discriminant matrix and scale

Scale	Meaning
1	It is of the same importance that the two elements are compared.
3	One element is slightly more important than the other.
5	One element is more important than the other.
7	One element is intensely more important than the other.
9	One element is extremely more important than the other.

2, 4, 6, 8 are the median of the adjacent judgments, and if the index a and B are compared to a_{ij}, then the index B and a are compared to $1/a_{ij}$. The first level index concentrates each index relative to the total evaluation goal. The comparison matrix between the two is as follows.

$$A=\begin{bmatrix} 1 & V_{12} & \cdots & V_{1N} \\ V_{21} & 1 & \cdots & V_{2N} \\ \cdots & \cdots & \cdots & \cdots \\ V_{N1} & V_{N2} & \cdots & 1 \end{bmatrix}=(V_{ij})_{N\times N} \qquad (V_{ij}=\frac{1}{V_{ji}}) \tag{6}$$

Among them, for the total evaluation target, the value of the relative importance of elements is characterized by the diagonal elements of 1, that is, the importance of each index relative to itself is 1. In terms of the indexes of the sub index concentration, the comparison matrix between the two is follows.

$$B_i=\left\{\begin{array}{l} v_{i1} \\ v_{i2} \\ \cdots \\ v_{ik} \end{array}\right.\begin{bmatrix} 1 & f_{12}^i & \cdots & f_{1k}^i \\ f_{21}^i & 1 & \cdots & f_{2k}^i \\ \cdots & f_{12}^i & \cdots & \cdots \\ f_{k1}^i & f_{k2}^i & \cdots & 1 \end{bmatrix}=f_{k\times k}^i \quad (i=1,2,\cdots N)\ (f_{lj}^i=\frac{1}{f_{jl}^i}) \tag{7}$$

Step 3: The application and product method are used to solve the discriminant matrix, and the relative weight of the index one by one is obtained under a single criterion.

First, the elements in the matrix are normalized by column normalization. Then the matrices that are processed are added in line respectively. Then the row vectors are normalized to get the weight vectors of each comparison element under a single criterion. Finally, the unique maximum eigenvalue is calculated according to the following formula. $\lambda_{\max}$, $\lambda_{\max} = \sum_{i=1}^{n} \frac{(A\omega)_i}{n\omega_i}$ (The other discriminant matrix is equal to the same.)

Step 4: Hierarchy - a matrix that calculates the combination weight of the same level index $(H_1, H_2, \cdots, H_m)$

Step 5: Consistency test

First, the consistency index $C.I$ is calculated, $C.I = \lambda_{\max} - n / n - 1$ .N is the order of the discriminant matrix [6]. Finding the average random consistency index $R.I$ .Computing conformance ratio $C.R = C.I / R.I$. When $C.R < 0.1$, it is generally accepted that the consistency of discriminant matrix is acceptable. The smaller the value of $C.R$ is, the smaller the value of discriminant matrix deviates from the actual situation, the closer it is to the reality. Therefore, from the above we can see that the weight using the analytic hierarchy process to solve the various evaluation index, a qualitative evaluation is given only to the relative importance of each evaluation personnel elements 22 description, and then through the AHP method can accurately calculate the weight of each evaluation element, which are based on strict scientific theory as a basis, greatly enhance the scientific and effective evaluation process.

5.3.2 Weight calculation results

Analytic hierarchy process (AHP) is used to calculate the weights of the primary and secondary indicators in the index system, which are sorted out in Table 3 below.

Table 3: Weight Table of Indicators

Primary index	Weight	Secondary index	Weight
Types of the waste	0.2	P1: Packaging film	0.250
		P2: Woven bag plastic	0.125
		P3: Plastic hollow container	0.125
		P4: Plastic turnover boxes	0.075
		P5: Foam plastic packaging materials	0.050
		P6: Plastic rope	0.125
		P7: Packaging sheet	0.125
		P8: Plastic pallet	0.125
Source of the waste	0.3	P9: Transportation	0.1428
		P10: Packaging	0.0714
		P11: Building and Construction	0.1428
		P12: Electrical	0.2856
		P13: Consumer & Institutional Products	0.1428
		P14: Industrial Machinery	0.1432
		P15: Other waste	0.0714
Extent of the current	0.3	P16: Impact on city appearance	0.1667

waste problem		P17：Destroy the ecological environment	0.1667
		P18：Soil and water pollution	0.2499
		P19：Air pollution	0.1667
		P20：Global environment	0.0833
		P21：Special waste	0.1667
Availability of resources to process the waste	0.2	P22：Security Landfill	0.4
		P23：Incineration and pyrolysis	0.6

5.3.3 Natural breakpoint method (NBM) ——reasonable formulation of evaluation grade classification

The natural breakpoint method is a statistical method based on the statistical distribution law of numerical statistics. It considers that the data itself has breakpoints, which can be classified by the characteristics of data. The principle of the algorithm is a small clustering, and the end of the cluster is the maximum variance between groups and the minimum variance within the group. [15]

There are some natural turning points and characteristic points in any statistical sequence [16]. These points can be used to divide the research objects into groups of similar nature. Therefore, the split point itself is a good boundary of classification. Statistics can be measured by variance. By calculating the variance of each class, the sum of the variance is calculated and the quality of the classification is compared with the variance and the size of the variance. Therefore, it is necessary to calculate the variance of various classifications, and the minimum value is the optimal classification result.

ArcGIS software can be used to classify data. Applying it to the evaluation of fuzzy comprehensive evaluation.

The natural breakpoint method is used to get the classification of ecological service assessment. The assessment results are divided into four levels, which are arranged in Table 4 and Table 5 below.

Table 4: Level of environmental pressure degree

Grade	Scoring interval
Excellent	[300,400]
Good	[200,300]
Qualified	[200,100]
Unqualified	[0,100]

Table 5: Classification of environmental pressure degree

Grade	Meaning	Scoring interval
Excellent	According to the principles of ecology, each index is in the leading position, and its implementation technology is slightly ahead of the existing appropriate technology.	[300,400]
Good	Designed in accordance with ecological principles, all of them have reached the benchmark targets, but they are still within the scope of realizable suitable technologies at present.	[200,300]
Qualified	Indicators can not only meet the requirements of the benchmark level of the corresponding norms or local standards, but also improve the benchmark level to a certain extent.	[200,100]
Unqualified	Only meeting or failing to meet the benchmark level requirements of the corresponding norms or local standards.	[0,100]

5.3.4 Fuzzy comprehensive evaluation

The fuzzy set A in the domain U is a set characterized by the membership function μ_A. [8]

$\forall \mu_A : U \rightarrow [0,1]$, $u \in \mu_A(u)$， $\mu_A(u) \in [0,1]$. $\mu_A(u)$ is called the membership degree of the element u to the A, which indicates the degree of u belonging to the A. The fuzzy set can be quantified by the membership function, and the fuzzy information can be analyzed and processed by the exact mathematical method. The fuzzy comprehensive evaluation can effectively deal with the subjectivity of the people in the process of evaluation and the fuzziness of the objective. Fuzzy comprehensive evaluation is usually carried out according to the following steps.

Step1： The judgment set is set to $U = \{\text{excellent, good, qualified, unqualified}\}$ by natural breakpoint method. So $U = \{400，300，200，100\}$.

Step2： The degree of subordination of each sub factor to the evaluation set U was described with the degree of membership. The membership degree of this paper refers to the degree of conformity of regional land development projects to the evaluation set, and obtains a fuzzy evaluation matrix of land development projects.

$$D_i = \begin{cases} v_{i1} \\ v_{i2} \\ \cdots \\ v_{ik} \end{cases} \begin{bmatrix} S_{11}^i & S_{12}^i & \cdots & S_{1n}^i \\ S_{21}^i & S_{22}^i & \cdots & S_{2n}^i \\ \cdots & S_{11}^i & \cdots & \cdots \\ S_{k1}^i & S_{k2}^i & \cdots & S_{kn}^i \end{bmatrix} \qquad (i = 1, 2, \cdots m) \tag{8}$$

Step3： First order fuzzy comprehensive evaluation - fuzzy relation matrix is determined by fuzzy operator $R = (R_1, R_2, \cdots\cdots, R_n)^T$.Where

$$R_i = (w_1^i, w_2^i, \cdots\cdots, w_k^i) \begin{bmatrix} S_{11}^i & S_{12}^i & \cdots & S_{1n}^i \\ S_{21}^i & S_{22}^i & \cdots & S_{2n}^i \\ \cdots & S_{11}^i & \cdots & \cdots \\ S_{k1}^i & S_{k2}^i & \cdots & S_{kn}^i \end{bmatrix} = (r_{i1}, r_{i2}, \cdots\cdots, r_{in}) \tag{9}$$

$(w_1^i, w_2^i, \cdots\cdots, w_k^i)$ The ranking weight vector for the two level index belonging to the first level index of i is the allocation weight of each index.

1) Secondary fuzzy comprehensive evaluation - determine the final evaluation result of the evaluated object,

$$E = H \circ R = (H_1, H_2, \cdots, H_m) \times \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (e_1, e_2, \cdots e_k, \cdots e_n) \tag{10}$$

Where, $(H_1, H_2, \cdots, H_m)$ is the ranking weight vector of all the first level indexes under the total target, that is, the weight vector obtained by the analytic hierarchy process (AHP).

2) According to the principle of maximum membership degree, the evaluation grade of the evaluated object is determined. If $e_k = \max(e_1, e_2, \cdots e_k, \cdots e_n)$.That is, e_k is the K component of the vector. According to the principle of maximum membership degree of fuzzy mathematics, the evaluation result of the evaluated object belongs to the K grade.

3) If class P is the subject of evaluation, the results of their comprehensive evaluation are vector $E_1, E_2, \cdots, E_P$, and the weights of all kinds of evaluation subjects are respectively $T_1, T_2, \cdots, T_k$. The overall evaluation result is $E' = (T_1, T_2, \cdots, T_k)(E_1, E_2, \cdots, E_P)^T$

Finally, the comprehensive evaluation results and scores of environmental pressure under different degrees of plastic waste pollution can be obtained by using the above methods.

5.3.5 Result of ANFCE model

Analyze the data in 2018, we determine the fuzzy comprehensive evaluation vector and evaluate each factor. According to table 3, get the judgment matrix respectively:

$$x = [0.6, 0.5, 1.0, 0.4] \tag{11}$$

Fuzzy comprehensive evaluation. Do vector synthesis:

$$\begin{aligned} r &= A \cdot x = [0.3, 0.2, 0.2, 0.3] \cdot [0.2, 0.3, 0.5, 0.8]^T = 0.46 \\ R &= 400 \cdot r = 400 \times 0.46 = 184 \end{aligned} \tag{12}$$

The environmental pressure index in 2018 is 184, and the corresponding plastic output is 413Mt.

5.3.6 Result of maximum levels of plastic product waste and Time-varying model

1. Result of maximum levels of plastic product waste

In order to verify the time variability of the model, a set of real data can be selected and fitted by using the neural network method. Time series prediction is carried out by using MATLAB software. The environmental pressure index in different years and the corresponding plastic waste output can be obtained. The results are shown in the Table 6 below.

Table 6: The environmental pressure index and the corresponding plastic waste output.

Year	Environmental pressure degree	Plastic waste output (Mt)
2018	184	413
2019	180	424
2020	173	438
2021	164	451
2022	159	459
2023	147	472
2024	142	485
2025	138	496

Use Excel software to draw the two curves, and put the two curves in the same chart for comparison.

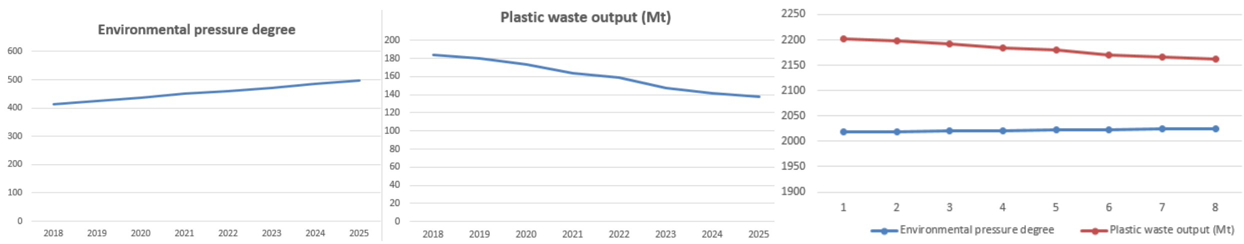

Figure 1: Environmental pressure curve and plastic waste output curve.

By analyzing the change rate of the two curves, it can be concluded that when the environmental pressure score is 53, the maximum level of plastic waste is 662mt per year.

2. Time-varying model

Because the evaluation model established in Task 1 is closely related to the actual data. Therefore, when the input data of the model changes with time, the results of the model can be obtained. The flow chart is as follows.

Figure 2: Flow chart

By substituting the obtained data sequence into the model for verification, it can be found that the model changes with time and still has validity. See Appendix II for the procedure. The results are as follows:

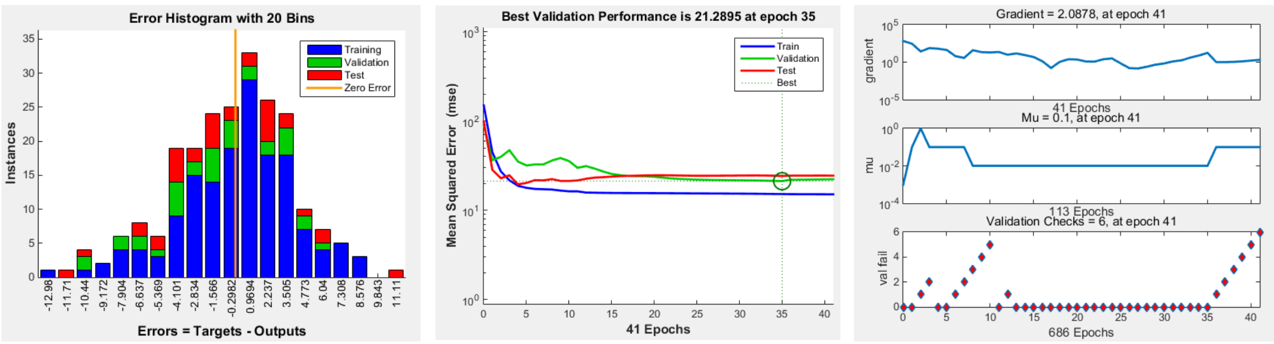

Figure 3: Results of Analysis

The results show that the fitting results are good. The predicted sequence data are substituted into the model. The time variability of the model can be verified.

VI. Task 2: Reduction of plastic waste and its influence

The task discusses the extent to which plastic waste can be reduced to achieve environmental safety. On the basis of cost-benefit analysis, the measures and means of reducing plastic waste are determined as cost, and the possible benefits of reducing plastic waste are determined as income.

We need to determine the calculation method of cost-benefit economic indicators. Then, the cost and benefit of plastic waste reduction are analyzed in detail. Then the residual analysis method is used to calculate the effectiveness index, and the effectiveness of plastic waste treatment is obtained.

6.1 Cost-Benefit Analysis

Cost benefit analysis method is also called cost benefit analysis method. Cost benefit analysis is to estimate the cost of reducing plastic waste from many aspects. And what are the benefits of these measures? Measure and compare with specific data. Finally, the feasibility of the project is evaluated by scientific calculation. [16]

In this problem, the cost-benefit method is used to analyze the implementation of each measure in detail, and according to these measures, the corresponding reduction degree of plastic waste is analyzed.

6.1.1 Cost-benefit Indicators

- Complete life cycle——Plastic waste treatment cycle

The complete life cycle refers to the period from the beginning of plastic waste treatment to the target level. The whole period is the whole life cycle of plastic waste treatment. Based on the whole life cycle of plastic waste treatment, this paper calculates and evaluates the cost-benefit of plastic waste treatment. From the perspective of sustainable development, the cost and benefit of plastic waste treatment are calculated, so that the final evaluation can directly reflect the value of the whole life cycle of plastic waste treatment. [16]

- Net present value——Commercial net present value of plastics industry

Net present value (NPV). It refers to the sum of all cash flows of a project or investment plan discounted to the initial point of the calculation period by the benchmark discount rate. The popular understanding is how much the future earnings are now worth. Set the benefit as CI and the cost as CO. The formula is: [16]

$$NPV = \sum_{t=0}^{n} \left(CI - CO\right)_t \left(1 + i_0\right)^{-t} \tag{13}$$

Where, NPV represents net present value, i_0 represents the benchmark discount rate; n represents the life of the project (in this paper, the life of the project is set at 50 years). The application of NPV is conditional on the known cash flow (CI-CO) and its distribution and benchmark return during the calculation period.

When NPV = 0, according to the given rate of return, the project just recovers its investment in its lifetime, which does not mean that the project's income is zero, but just meets the minimum profit requirement of capital; the popular understanding is just to insure the capital. When NPV > 0 indicates that the profitability of the project is higher than the profitability requirement for capital. Since the profitability requirement for capital investment is met, it can also be higher than the profitability requirement, which means that the project is feasible. When NPV < 0, it shows that the profitability of the project is lower than the profitability requirement of the capital, and that the project whose profitability is lower than the profitability requirement of the capital is not feasible.

- Internal Return Rate——Internal return rate of plastic industry business

IRR is the internal rate of return. Essentially, the discount rate at zero net present value of a project is the rate of return on investment in the year in which the project is able to recover its investment. Because this index is only determined by the inherent cash flow system of the project, the exogenous variables of the project are not involved, so it is called internal rate of return. The IRR satisfies the following formula:[16]

$$\sum_{t=0}^{n} \left(CI - CO\right)_t \left(1 + IRR\right)^{-t} = 0 \tag{14}$$

The IRR calculates the net cash flow of each period at the end of the project life cycle, while the net present value and net annual value as well as the present value of cost and annual value of cost need to set a basic discount rate in advance to calculate and compare. Therefore, the internal rate of return index is more scientific than other indicators.

- Net Present Value Index——NPV index of plastics industry business

Net present value index (NPVI). [17] Net present value index, also known as net present value ratio, refers to the ratio of the net present value of a scheme calculated with a set discount rate to the present value of all its investments. The NPV index reflects the excess of the scheme relative to the benchmark rate of return, but because it does not take into account the differences in the amount of investment of each scheme, it cannot well reflect the differences in the efficiency of capital utilization of each project.

Therefore, the NPV of a plastic waste treatment project can be related to the NPV of the total investment of the corresponding project, so as to obtain the NPV index. Let p be the present value of all investments, and NPV index is calculated as follows:

$$NPVI = \frac{NPV}{P} \tag{15}$$

Through the NPV index, we can see more intuitively the proportion of incremental cost in total investment.

6.1.2 Cost composition of the Reduction of Plastic Waste

Combined with task 1, the environmental pressure evaluation model can reduce the cost of plastic waste reduction. Each cost comes from the analysis of sub indicators of the evaluation model. The weight of each item in the large and small items is given in the table, and the final result is obtained by weighted average method.

Table 7: Cost Composition of the Reduction of Plastic Waste

Cost		Weights in Small-scale Projects	Weights in Large-scale Projects
Design cost	Planning cost	0.0769	0.0769
Authentication cost	Production cost	0.0769	0.1538
Technology cost	Energy cost	0.1538	0.1538
	Production cost	0.0385	0.0385
	Water environment cost	0.1538	0.1538
	Air environment cost	0.1538	0.0769
	Acoustic environment cost	0.0769	0.0385
	Light environmental cost	0.0385	0.0385
	Thermal environment cost	0.0385	0.0385
	Afforest cost	0.0385	0.0769
	Health cost	0.0385	0.0769
	Habitat Security cost	0.0385	0.0385
	Information cost	0.0769	0.0385

6.1.3 Income Composition of the Reduction of Plastic Waste

Combined with task 1, the environmental pressure evaluation model can reduce the income of plastic waste reduction. Each income comes from the analysis of sub indicators of the evaluation model. The weight of each item in the large and small items is given in the table, and the final result is obtained by weighted average method.

Table 8: Income Composition of the Reduction of Plastic Waste

Income		Weights in Small-scale Projects	Weights in Large-scale Projects
Technology income	Energy income	0.0909	0.1212
	Production income	0.1818	0.1818
	Water environment income	0.1212	0.0909
	Air environment income	0.0303	0.0303

	Acoustic environment income	0.0303	0.0303
	Light environmental income	0.0303	0.0303
	Thermal environment income	0.0909	0.0606
	Afforest income	0.0909	0.1212
	Health income	0.0606	0.0606
	Habitat Security income	0.0909	0.1818
	Information income	0.1818	0.0909

By calculating the specific data of these cost-benefit indexes, the cost-benefit analysis results of plastic waste reduction can be obtained.

6.2 Model Validity Analysis—Effectiveness Index Calculation Based on Residual Analysis

Residual analysis is to subtract the simulated data from the measured data and obtain the residual sequence. Then, an appropriate mathematical model is established for the residual sequence, and the corresponding numerical indicators are given to reflect the proximity of the two sequences [10].Set the reference data as $X = \{x_i | i = 1, 2, \ldots, N\}$. The corresponding simulation data is $Y = \{y_i | i = 1, 2, \ldots, N\}$.

Then the numerical similarity calculation steps of the two sequences are as follows.

1) If the sequence is divided into n segments, then $X = \{x_k | k = 1, 2, \ldots, n\}$.

Where, $x_k = \{x_{ki} | i = 1, 2, \ldots, N_k\}$ and $\sum_{k=1}^{n} N_k = N$. The Y sequence is the same as that [11].

2) Calculate the similarity element value Q_{ki} of each point signal in the selected time interval K and its influence weight β_{ki} on the similarity degree.

$$Q_{ki} = 1 - \frac{|x_{ki} - y_{ki}|}{2\max\left(|x_{ki}|, |y_{ki}|\right)} \tag{16}$$

$$\beta_{ki} = \frac{|x_{ki}|}{\sum_{i=1}^{N_k} |x_{ki}|} \tag{17}$$

3) By synthesizing the similarity element values of each time point, the similarity Q_k of x_k and y_k is obtained, that is, the similarity of time interval k:

$$Q_k = \sum_{i=1}^{N_k} \beta_{ki} Q_{ki} \tag{18}$$

4) Analytic Hierarchy Process (AHP) is used to calculate the influence weight of the k-th time-period similarity on the similarity of the whole time series.

5) The numerical similarity of sequence X and Y in the total time period is as follows:

$$Q(X, Y) = \sum_{k=1}^{n} \beta_k Q_k \tag{19}$$

The final Q is the validity index of the model.

6.3 Result

By integrating the above cost-benefit model, we can get the cost and possible benefits of plastic waste treatment, and give the weight of each index in the above analysis. The specific indicators are integrated as follows.

Table 9: Cost and income of plastic waste treatment

<table>
<tr><th colspan="2">Cost</th><th colspan="2">Income</th></tr>
<tr><td>Design cost</td><td>Planning cost</td><td rowspan="13">Technology income</td><td>Energy income</td></tr>
<tr><td>Authentication cost</td><td>Production cost</td><td>Production income</td></tr>
<tr><td rowspan="11">Technology cost</td><td>Energy cost</td><td>Water environment income</td></tr>
<tr><td>Production cost</td><td>Air environment income</td></tr>
<tr><td>Water environment cost</td><td>Acoustic environment income</td></tr>
<tr><td>Air environment cost</td><td>Light environmental income</td></tr>
<tr><td>Acoustic environment cost</td><td>Thermal environment income</td></tr>
<tr><td>Light environmental cost</td><td>Afforest income</td></tr>
<tr><td>Thermal environment cost</td><td>Health income</td></tr>
<tr><td>Afforest cost</td><td>Habitat Security income</td></tr>
<tr><td>Health cost</td><td>Information income</td></tr>
<tr><td>Habitat Security cost</td><td></td></tr>
<tr><td>Information cost</td><td></td></tr>
</table>

The weight of each index is the impact factor of the cost or benefit. By substituting it into the ANFCE model in task 1, the impact degree of each index on plastic waste treatment and the affected level of plastic waste can be obtained.

VI. Task 3: The Minimal Achievable Level of Global Waste of Plastic Products

Using our models and discussions, set goals for the lowest attainable level of global disposable or disposable plastic products and discuss the impact of reaching that level. We need to consider the impact on lifestyle, environment, or the plastics industry.

7.1 The Minimal Achievable Level

The data in Schedule 1 is substituted into the ANFCE model in Task1 for calculation. It is known that the total amount of plastic waste in the world in 2018 is 413Mt, and it can be calculated that the environmental pressure score in 2018 is 184.

When the environmental pressure score is 400, the environmental pressure is the minimum, i.e. the amount of plastic waste is the minimum, and the total amount of plastic waste should be 104Mt per year.

Because plastic products are difficult to decompose and handle, only about 9% of them are recycled. Therefore, plastic waste accounts for 81% of the total plastic products. Therefore, the minimum level of plastic products shall be calculated as follows:

$$\begin{aligned} \textit{the minimum level of plastic products} &= \frac{\textit{plastic waste}}{0.81} \\ &= \frac{104Mt}{0.81} = 128.39Mt \end{aligned} \tag{20}$$

Thus, the minimum level of plastic products shall be 128.39Mt per year.

7.3 Impact of minimum level of plastic products

According to the analysis of each indicator in task 1 and task 2, we can summarize the impact of each indicator to the following table 8. The impact degree of each index is recorded in the table.

Table 8: The impact of each index

Index	Degree of impact
Energy	0.1818
Production	0.0909
Water environment	0.1212
Air environment	0.0303
Acoustic environment	0.0303
Light environmental	0.0303
Thermal environment	0.1818
Afforest	0.0909
Health	0.0606
Habitat Security	0.0909
Information	0.0909

The weight of each index is the impact factor of the cost or benefit. By substituting it into the anfce model in task 1, the impact degree of each index on plastic waste treatment and the affected level of plastic waste can be obtained.

VIII. Task 4: Equity problems caused by global crisis and expected solutions

Although this is a global problem, its causes and effects are not evenly distributed among countries or regions. Discuss the equity issues caused by the global crisis and our expected solutions. We need to make suggestions to ICM to solve these problems.

8.1 Equity problems caused by global crisis

1. The cost input of plastic waste treatment is different.

2. Regional division of plastic waste treatment.

3. The establishment of plastic waste treatment facilities

8.2 Expected solutions

1. Cost input of plastic waste treatment. Using the cost-benefit analysis model of plastic waste treatment established in task 2, the corresponding costs and benefits of each country and region are obtained, and the allocation is based on the results of the model.

2. Regional division of plastic waste treatment. By using the ANFCE model established in task 1 and substituting the index values, the annual output of plastic waste under different environmental pressures can be obtained. Each country and region should control its scope to make the annual output of plastic waste reach the standard level.

3. Setting of plastic waste treatment facilities. By using the ANFCE model established in task 1 and substituting the index values, the annual output of plastic waste under different environmental pressures can be obtained. Countries and regions should control the setting of treatment facilities within their jurisdiction, so that the annual output of plastic waste in China can reach the standard level.

IX. Task 5: Memo to ICM

Our team integrated the above model analysis and got that when the environmental pressure score is 360, the environmental pressure is the lowest, that is, the plastic waste is the smallest, and the total plastic waste is 104mt / per year.

Because plastic products are difficult to decompose and process, only about 9% of them are recycled. Therefore, plastic waste accounts for 81% of the total amount of plastic products. Therefore, the minimum content of plastic products is calculated as follows:

$$\begin{aligned} \textit{the minimum level of plastic products} &= \frac{\textit{plastic waste}}{0.81} \\ &= \frac{104Mt}{0.81} = 128.39Mt \end{aligned}$$

Thus, the minimum level of plastic products shall be 128.39Mt per year, and the minimum level of plastic products waste shall be 104Mt.

We have also arranged the schedule for the global plastic waste to reach the target level, as shown in the table below.

Table 9: The schedule for the global plastic waste to reach the target level.

Year	Environmental pressure degree	Plastic waste output (Mt)
2018	184	413
2019	193	407
2020	201	390
2021	209	381
2022	215	372
2023	223	364
2024	237	359
2025	241	346
2026	246	334
2027	253	325
2028	268	312
2029	279	304
2030	292	296
2031	297	282
2032	306	274
2033	312	260
2034	324	251
2035	335	243
2036	346	230
2037	351	217
2038	358	209
2039	362	201
2040	367	192
2041	395	181
2042	374	164
2043	379	158
2044	382	149

2045	386	141
2046	391	132
2047	393	123
2048	396	118
2049	398	110
2050	400	104

We also list any situations that may accelerate or hinder the achievement of goals and timelines, as shown in the table below.

Table 10: Situations that may accelerate or hinder the achievement of goals and timelines.

Accelerate situations	Hinder situations
Research and development of plastic substitutes	Failed to find plastic substitutes
Development of new energy	Energy waste
Productivity improvement	Reduction of productivity
Renewal of water cycle mode	Slow down of water cycle
Conserve energy, reduce emissions	Increased emissions
Reduce noise pollution	Increase noise pollution
Reduce light pollution	Increase light pollution
Improve vegetation greening	Vegetation degradation
Improvement of residents' health level	Decrease of residents' health level
Improvement of cultural quality of residents	Decrease in cultural quality of residents
Perfect medical conditions	Reduced medical conditions

Hope our research results can provide help for the treatment of disposable plastic waste!

X. Conclusion

We established an environmental pressure assessment model affected by plastic waste. According to the problem of waste reduction and environmental pressure, the cost-benefit relationship is established, and the cost-benefit analysis and stability analysis of the model are carried out. Then, we set a goal for the lowest attainable level of global disposable or disposable plastic products, discuss the impact of reaching this level, and establish a time change model. Finally, it analyzes the equity issues caused by the global crisis and our expected solutions. The advantages and disadvantages of the model are summarized as follows.

9.1 Advantages of the model

1. Establish a comprehensive evaluation model with a complete evaluation index system.
2. The evaluation model has flexible requirements for data sources.
3. The cost-benefit analysis model consists of four cost-benefit indexes, cost index system and benefit index system. The model not only combines traditional economic knowledge with mathematical knowledge, but also combines the cost-benefit analysis of plastic waste reduction with environmental pressure.
4. The effectiveness analysis method of cost-benefit model is simple, which can verify the effectiveness of the model.
5. The time variability of the model is good, and it can be flexibly applied to the reduction of plastic waste of different scales.

9.2 Disadvantages of the model

6. The evaluation index system contains 23 sub-indicators, which requires a high level of data collection.
7. Data computation is large and complex.
8. The generalization of the model can be further studied, and there is still room for improvement.

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