

Sustainable Gift Packaging Design Based on KANO-AHP-QFD

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As global environmental problems become increasingly severe and consumers' environmental awareness grows, traditional gift packaging is facing heavy criticism due to its excessive luxury orientation, high material consumption, and recycling difficulties. To address these challenges, this study proposed an innovative sustainable gift-packaging design methodology driven by user requirements and integrating the KANO model, Analytic Hierarchy Process (AHP), and Quality Function Deployment (QFD), aiming to enhance consumers' willingness to adopt green practices and improve overall user experience. First, the KANO model was employed to identify and classify consumers' packaging requirements, resulting in twenty user needs categorized by attribute. Second, AHP was used to construct a judgment matrix and calculate the composite weight of each requirement, thereby establishing the prioritization of design elements. Finally, QFD translated these user requirements into concrete design parameters, which were then ranked according to their importance. The resulting sustainable gift-packaging solution not only met users' functional and aesthetic demands but also significantly elevated their environmental awareness. This research offers a scientifically grounded and practically applicable reference for the sustainable development of the packaging industry, while pointing to future research directions and potential applications in sustainable packaging design.

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INTRODUCTION

Gift packaging is a significant value-added component of products, enhancing product image and facilitating emotional communication (Pogačar and Gregor-Sveteč 2025). As of 2025, the global gift-packaging market is projected to reach approximately USD 43.99 billion by 2034, with a compound annual growth rate of 4.81 percent from 2025 to 2034 (Wang *et al.* 2022). This growth is fueled by e-commerce expansion and demand for durable, reusable corrugated-cardboard boxes. However, traditional gift packaging faces mounting criticism on account of its excessive luxury, high material consumption, and poor recyclability, exacerbating environmental strain. The packaging industry generates a large volume of waste annually, causing serious environmental contamination and resource depletion (Wang *et al.* 2022). Packaging waste in the U.S. amounted to 82.2 million tons in 2018, representing 28 percent of the total waste stream (US EPA 2017). Consequently, the concepts of “green packaging” or “sustainable

packaging” have gained increasing attention. Design approaches are being advocated throughout the entire packaging lifecycle—from material procurement and manufacturing to use and recycling—to minimize environmental impact (Jin *et al.* 2024). Governments worldwide have begun implementing regulations to limit and reduce packaging waste and to improve waste reprocessing (Islam *et al.* 2020). Packaged-goods retailers are likewise striving to cut packaging waste and avoid overpackaging—for example, by light-weighting and downsizing packages and limiting plastic content (Boz *et al.* 2020) or by replacing conventional plastics with recyclable packaging materials (Cinelli *et al.* 2019).

Yet, developing sustainable solutions remains challenging, balancing environmental goals with functionality, economy, aesthetics, and consumer acceptance (Cao *et al.* 2021). Though 4 to 7% of consumers pay a 10%+ premium for sustainable products (‘NIQ Report Highlights Top Trends Shaping Tech and Durables Spending in 2025’ 2024), traditional design processes often overlook environmental integration and evolving consumer needs (Lindh *et al.* 2016). Moreover, simply introducing ecofriendly materials or features does not guarantee customer satisfaction or market success if they fail to meet user expectations or provide tangible benefits (Raluy and Dias 2021; Mudgal *et al.* 2024). This reveals a critical research gap: the lack of systematic methods to harmonize gift packaging’s functional, aesthetic, and emotional demands with sustainability.

This study focused on the sustainable design of gift packaging, aiming to establish a scientific, systematic, and operable design process through the integration of multiple design tools and methodologies. The KANO model was employed to gain an in-depth understanding of consumer demands regarding the attributes of gift packaging, categorizing these needs into basic, performance, and excitement requirements, thereby providing a clear direction for subsequent design stages. Following this, the Analytic Hierarchy Process (AHP) was utilized to determine the priority of various design elements. Finally, the Quality Function Deployment (QFD) method was applied to translate consumer requirements into specific design specifications, serving as the foundation for optimizing design solutions. This ensures that the final design not only maximally satisfies consumer expectations but also aligns with environmental sustainability. Such an integrated approach can assist enterprises in more effectively designing and promoting green packaging, enhancing consumer acceptance and willingness to use, thereby advancing the development of sustainable packaging.

EXPERIMENTAL

Theoretical Model

The Kano model, developed by Professor Noriaki Kano of the Tokyo Institute of Technology, is a widely used framework for categorizing customer needs based on their attributes and priorities, dividing them into five distinct categories: Must-be requirements (M), One-dimensional requirements (O), Attractive requirements (A), Indifferent requirements (I), and Reverse requirements (R) (Shahin *et al.* 2013). This model helps identify different levels of user needs, providing clear guidance for product design and enhancing customer satisfaction and competitiveness (Wang and Zhou 2020). For instance, Wang *et al.* (2023) extracted design elements of children’s interactive products and combined the Kano model to analyze user needs and consumer preference attributes, providing a systematic decision-making basis for designers (Wang *et al.* 2023). Similarly,

Luo and Young (2022) analyzed the health protection needs of the elderly based on the Kano model and proposed interface design strategies covering usability, user experience, and appearance.

The Analytic Hierarchy Process (AHP), developed by Professor Thomas L. Saaty of the University of Pennsylvania, is a multi-criteria decision-making method designed to determine the relative importance of various factors (Saaty 1977). AHP addresses complex decision problems by decomposing them into a hierarchical structure consisting of multiple levels. It involves pairwise comparisons among elements within the same level to construct a judgment matrix, from which eigenvectors are calculated to derive the weight of each factor (Luo *et al.* 2017). AHP is widely applied in product design to prioritize different design elements and optimize design solutions accordingly. For example, Ariff *et al.* (2008) proposed a method based on AHP for evaluating and selecting the most appropriate design concepts during the conceptual design phase. Similarly, Zhu *et al.* (2022) applied AHP to obtain the priority ranking of design elements, significantly improving both the rationality and user experience of surgical support equipment design.

Quality Function Deployment (QFD) was proposed in 1966 by Japanese scholar Yoji Akao as a systematic methodology for translating customer needs into specific product design specifications (Wu *et al.* 2020). QFD employs the construction of a “House of Quality” to establish a structured relationship between consumer requirements and design elements, thereby identifying the priority of design features and formulating targeted design strategies and objectives (Li *et al.* 2022). The strength of QFD lies in its ability to clarify product features and quality from the outset by mapping user needs to design attributes, which in turn enhances customer satisfaction (Li and Zhang 2021). For instance, Liu *et al.* (2024) transformed the demands of the mother-and-baby group into quantifiable design features through QFD, and they combined the Kano model with AHP priority ranking to enhance the user satisfaction of the optimized breastfeeding chair. Similarly, Miao *et al.* (2025) utilized the QFD house of quality model to convert demands into design elements and quantify their importance, thereby obtaining a feasible design plan for parent-child interactive toys.

Research Framework

In the traditional Kano model, limited quantitative analysis is conducted, and its qualitative categorization of customer needs does not accurately reflect the degree of customer satisfaction. These limitations reduce its effectiveness as a decision-making tool in product innovation and service management (Violante and Vezzetti 2017). To address this, many scholars have integrated the Kano model with the Analytic Hierarchy Process (AHP), using Kano to classify user requirements and AHP to assign scientific weights, thus optimizing the design process. For example, Xiao (2025) applied the Kano model to categorize the needs of potential users and used AHP to calculate the weight coefficients across different hierarchical levels, ultimately designing a healing-oriented spatial installation. Similarly, Liu *et al.* (2024) developed a design process for outdoor leisure chairs by combining the Kano model and AHP: the Kano model was used to extract requirement attributes and their impact coefficients, AHP determined their relative weights, and the final design was evaluated based on harmonious design theory.

While the Kano–AHP model is effective for uncovering user needs, it still struggles to translate these needs into actionable design elements. The Quality Function Deployment (QFD) model, on the other hand, excels at mapping user needs to specific design features. Therefore, the integration of Kano, AHP, and QFD combines the strengths of all three models: Kano enables comprehensive identification and classification of user needs, AHP provides a rigorous quantitative prioritization, and QFD ensures the effective translation of prioritized needs into concrete design parameters. Recent studies have integrated Kano–AHP with QFD for more comprehensive design solutions (Cao 2024; Li *et al.* 2024).

However, most existing research on sustainable packaging remains at the qualitative level, lacking systematic quantitative analysis and prioritization of user needs. This makes it difficult to accurately measure user satisfaction or translate needs into concrete design elements, limiting the effectiveness of design decisions. To date, few scholars have applied this integrated approach to the study of sustainable packaging design. Therefore, this study adopted the Kano–AHP–QFD theoretical model to conduct research on the sustainable design of gift packaging, aiming to ensure scientific rigor and comprehensiveness throughout the product development process. The detailed design research framework is illustrated in Fig. 1.

User Demand Analysis of Sustainable Gift Packaging Based on Kano Model

Acquisition of user requirements

Several studies (Zhao *et al.* 2014; Čater and Serafimova 2019; Brennan *et al.* 2021) have revealed a positive correlation between age, environmental concern, and recycling behavior. Conversely, other research indicates that younger consumers possess a strong awareness of the necessity of environmental protection and are more actively engaged with sustainability issues (Jaderná and Volfová 2022). This study identifies the primary target users as environmentally conscious young consumers aged 18 to 35 with purchasing power, while users from other age groups are considered secondary target groups.

This research combines a literature review with empirical investigation to systematically extract user requirements. A mixed-methods approach was employed, including multi-scenario field observations and semi-structured interviews, to deeply explore consumer needs. User behavior was observed in large retail environments such as Walmart and Costco, with a focus on identifying pain points encountered by consumers during the selection, usage, and disposal of gift packaging.

Additionally, random sampling interviews were conducted with 50 consumers aged 18 to 35 (28 female, 22 male), using open-ended questions to explore their expectations regarding the functionality, aesthetics, and environmental value of gift packaging. By integrating observational data and interview transcripts, the research team applied the card sorting method to preliminarily categorize user needs into three dimensions: aesthetic needs, functional needs, and psychological needs. Subsequently, based on the classification logic of the Kano model, the identified needs were filtered, merged, and categorized, resulting in a list of 20 key requirement items. These serve as a foundation for subsequent priority analysis and design optimization, as presented in Table 1.

Classification of emotional needs

To gain a deeper understanding of users' genuine needs regarding a product or service and to translate these needs into quantifiable quality attributes, a five-point Likert scale was developed. Users were asked to evaluate their level of satisfaction with each requirement from both positive and negative perspectives, as shown in Table 2. The scale options included: "Very Dissatisfied (1)", "Dissatisfied (2)", "Neutral (3)", "Satisfied (4)", and "Very Satisfied (5)". The questionnaire used bidirectional stimulus statements—both positively and negatively framed—to guide participants in comprehensively assessing their satisfaction with each requirement attribute. This approach not only captured users' functional expectations but also revealed variations in the fulfillment of latent needs.

Table 1. User Demand Index System

Experience Elements	User Needs
Appearance Needs	Simple and modern design
	Natural elements integrated
	Conspicuous eco-friendly labels
	Harmonious and soft color coordination for comfort
	Visualized brand story
	Personalized customization options
Function Needs	Durable and wear-resistant
	Safe and eco-friendly materials
	Lightweight and portable
	Easy-to-clean structure
	Sealed and leak-proof performance
	Multi-functional adaptability
	Space-saving storage
	Quick opening and closing design
Mental Needs	Good storage stability
	Satisfaction of environmental responsibility
	Strengthened social recognition
	Pleasure of reducing waste
	Trust and security
	Optimized perception of cost performance

A total of 130 questionnaires were distributed, with Question 11 designed as an attention check item to identify random or inattentive responses. After screening, 102 valid responses were obtained, resulting in an effective response rate of 78.5%. Prior to analyzing the questionnaire data, a reliability analysis was conducted. The Cronbach's α coefficient for the positively worded items was 0.868, while for the negatively worded items it was 0.825. Both values exceed the threshold of 0.8, indicating a high level of internal consistency and suggesting that the data are suitable for further analysis.

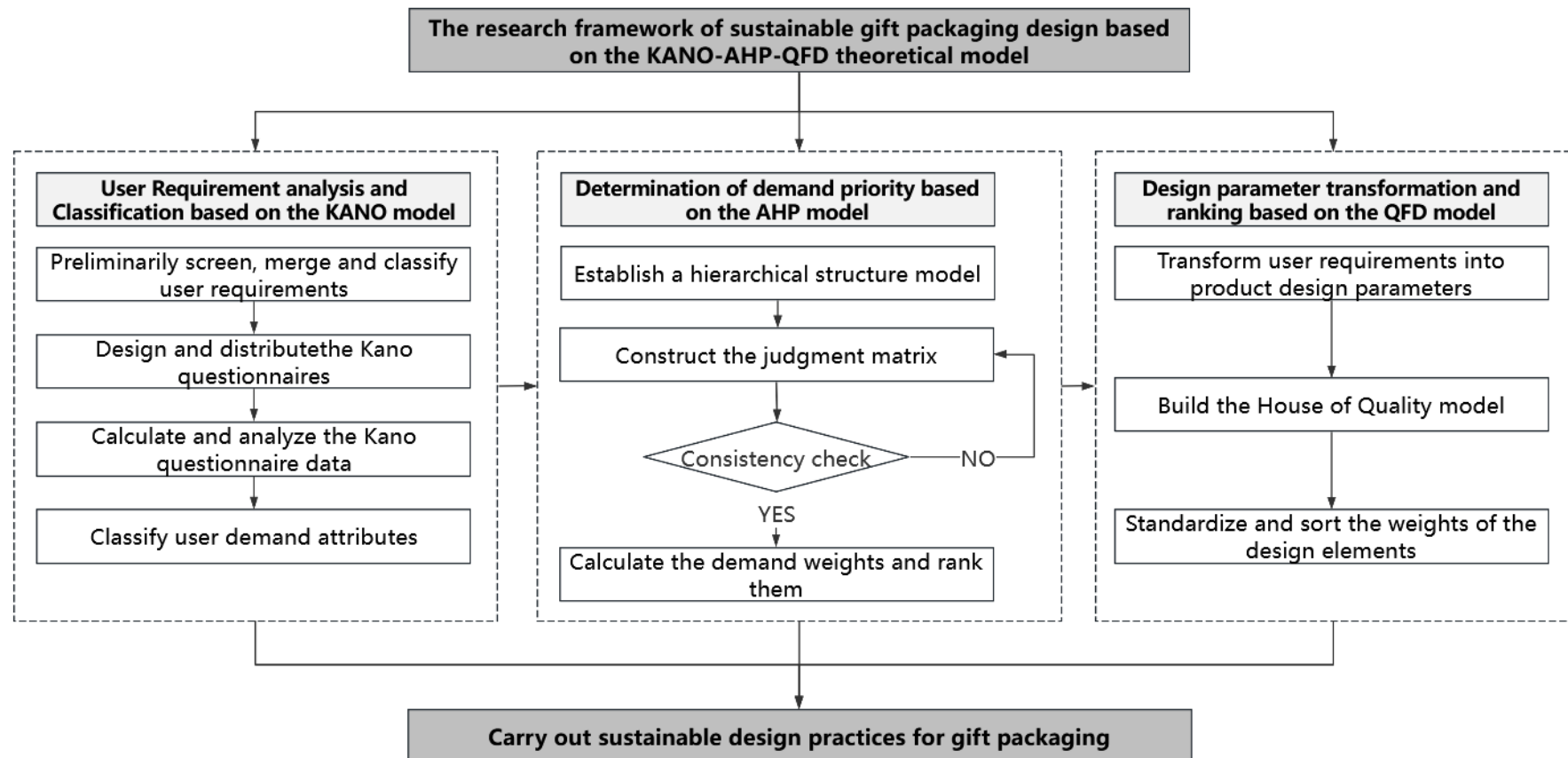


Fig. 1. The research framework of sustainable gift packaging design

Subsequently, SPSS 26.0 was used to assess the construct validity of the questionnaire. To ensure the accuracy and comprehensiveness of the analysis, factor analysis was conducted using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity as key indicators of sampling adequacy. Separate KMO and Bartlett tests were performed for the positively and negatively worded items to verify the validity of the data. For the positively worded items, the KMO value was 0.788, and Bartlett's Test of Sphericity yielded a chi-square value of 2636.331 with 136 degrees of freedom and a significance level of $p < 0.05$. For the negatively worded items, the KMO value was 0.863, and the chi-square value for Bartlett's test was 3540.854, also with 136 degrees of freedom and a significance level of $p < 0.05$. These results confirm that the questionnaire data passed the significance tests, indicating that the dataset is appropriate for factor analysis (Cortina 1993).

Based on the KANO evaluation matrix (Table 3), the questionnaire responses were classified into five categories: K_M , K_O , K_A , K_I , and K_R . The classification of each user requirement was determined by the category with the highest proportion of responses. The KANO categorizations were calculated using SPSSPRO 2024.

Table 2. KANO Two-factor Five-order Likert Questionnaire

If available, what is your attitude? (Positive Question)					Requirements for Designers	If available, what is your attitude? (Negative Question)				
1	2	3	4	5		1	2	3	4	5
					Simple and modern design					
					Natural elements integrated					
					Conspicuous eco-friendly labels					
					Harmonious and soft colors					
					Visualized brand story					
					Personalized customization options					
					Durable and wear-resistant					
					Safe and eco-friendly materials					
					Lightweight and portable					
					Easy to clean and maintain					
					Sealed and leak-proof performance					
					Multi-functional adaptability					
					Space-saving storage					
					Quick opening and closing design					
					Good storage stability					
					Satisfaction of environmental responsibility					
					Strengthened social recognition					
					Pleasure of reducing waste					
					Trust and security					
					Optimized perception of cost performance					

$$K_M = \frac{M}{A+O+M+I+R}, K_A = \frac{A}{A+O+M+I+R'} \quad (1)$$

$$K_R = \frac{R}{A+O+M+I+R}, K_O = \frac{O}{A+O+M+I+R'}$$

$$K_I = \frac{I}{A+O+M+I+R'}$$

In the equation, M represents the proportion of Must-be requirements, A denotes the proportion of Attractive requirements, R stands for the proportion of Reverse requirements, O indicates the proportion of One-dimensional requirements, and I reflects the proportion of Indifferent requirements.

Table 3. KANO Evaluation Criteria

User Demand		Negative Question				
		Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
Positive Question	Very Dissatisfied (1)	Q	A	A	A	O
	Dissatisfied (2)	R	I	I	I	M
	Neutral (3)	R	I	I	I	M
	Satisfied (4)	R	I	I	I	M
	Very Satisfied (5)	R	R	R	R	Q

Based on the equation and the results of the calculation and classification, 20 preliminary user requirement attributes were identified, as shown in Table 4.

As shown in Table 4, among the 20 identified user requirements, 5 were classified as Must-be requirements (M), 5 as Attractive requirements (A), 8 as One-dimensional requirements (O), and 2 as Indifferent requirements (I). No Reverse requirements (R) or Questionable requirements (Q) were identified.

Table 4. Analysis Table of KANO Questionnaire For Reusable Packaging

Needs Elements	K_A	K_O	K_M	K_I	K_R	Need Attributes
Simple and modern design	32.76%	0%	3.45%	60.34%	1.72%	I
Natural elements integrated	70.69%	10.34%	0.00%	15.52%	0.00%	A
Conspicuous eco-friendly labels	36.21%	15.52%	8.62%	32.76%	0.00%	A
Harmonious and soft colors	6.90%	8.62%	63.79%	18.97%	0.00%	M
Visualized brand story	67.24%	8.62%	0.00%	20.69%	0.00%	A
Personalized customization options	63.79%	6.90%	0.00%	24.14%	0.00%	A
Durable and wear-resistant	3.45%	15.52%	62.07%	18.97%	0.00%	M
Safe and eco-friendly materials	3.45%	18.97%	70.69%	6.90%	0.00%	M
Lightweight and portable	8.62%	13.79%	60.34%	17.24%	0.00%	M
Easy to clean and maintain	13.79%	63.79%	6.90%	13.79%	0.00%	O
Sealed and leak-proof performance	8.62%	62.07%	20.69%	8.62%	0.00%	O
Multi-functional adaptability	1.72%	74.14%	6.90%	17.24%	0.00%	O
Space-saving storage	24.14%	6.90%	12.07%	55.17%	0.00%	I
Quick opening and closing design	70.69%	3.45%	0.00%	25.86%	0.00%	A
Good storage stability	5.17%	3.45%	72.41%	18.97%	0.00%	M
Satisfaction of environmental responsibility	5.17%	67.24%	8.62%	18.97%	0.00%	O
Strengthened social recognition	1.72%	63.79%	5.17%	29.31%	0.00%	O
Pleasure of reducing waste	6.90%	67.24%	5.17%	20.69%	0.00%	O
Trust and security	31.03%	43.10%	6.90%	17.24%	0.00%	O
Optimized perception of cost performance	6.90%	68.97%	6.90%	17.24%	0.00%	O

The Must-be requirements (M) include: harmonious and comfortable color coordination, durability and abrasion resistance, safe and eco-friendly materials, lightweight and portability, and good storage stability. These are fundamental design elements for sustainable gift packaging. Failure to meet these requirements would significantly reduce user satisfaction. While fulfilling them may not substantially enhance satisfaction, they remain essential and must be addressed in future design practices without excessive enhancement.

The One-dimensional requirements (O) include: easy-to-clean structure, sealing and leak-proof performance, multifunctional adaptability, fulfillment of environmental responsibility, reinforcement of social identity, the pleasure of waste reduction, a sense of trust and safety, and perceived cost-effectiveness. Meeting these requirements effectively in sustainable gift packaging design will enhance user satisfaction; therefore, the quality of these attributes should be maximized.

The Attractive requirements (A) include: integration of natural elements, prominent eco-labeling, visualization of brand storytelling, quick-opening and closing design, and options for personalized customization. Optimizing these features can provide users with unexpected satisfaction and significantly increase their overall experience. As such, these aspects should receive considerable attention in design practice.

The Indifferent requirements (I) include minimalist modern design and space-saving storage. These requirements have no significant impact on user satisfaction and, therefore, are not prioritized for optimization in this design process.

RESULTS AND DISCUSSION

User Requirement Weight Analysis for Sustainable Gift Packaging Based on Analytic Hierarchy Process (AHP)

While the Kano model is effective in classifying user requirements for sustainable gift packaging, it does not provide a means to calculate the relative importance of each requirement. To better prioritize design elements in subsequent design practices, this study incorporated the Analytic Hierarchy Process (AHP)—a method known for its strong logical decision-making capabilities—following the KANO model analysis, in order to accurately determine the overall weights of design factors (Khorsandi and Li 2022). Based on the results of the Kano questionnaire, the 20 user requirements were categorized into Must-be requirements (M), One-dimensional requirements (O), Attractive requirements (A), and Indifferent requirements (I). The two indifferent requirements (I), which do not directly influence user satisfaction, were excluded from further analysis. The remaining 18 user requirements were designated as design objectives for the development and evaluation of sustainable gift packaging.

As shown in Fig. 2, a hierarchical structure model for sustainable gift packaging design was constructed, consisting of three levels: the goal level, the criteria level, and the sub-criteria level. The goal level represents the overall design solution for sustainable gift packaging. The criteria level includes Must-be requirements (M) and Attractive requirements (A). The sub-criteria level comprises the 18 user requirements, specifically: Harmonious and comfortable colors M1, Durable and wear-resistant M2, Safe and eco-friendly materials M3, Light-weight and portable M4, Good storage stability M5, Easy to clean and maintain O1, Sealed and leak-proof performance O2, Multi-functional

adaptability O3, Satisfaction of environmental responsibility O4, Strengthen social recognition O5, Pleasure of reducing waste O6, Trust and security O7, Optimized perception of cost performance O8, Natural elements integrated A1, Conspicuous eco-friendly labels A2, Visualized brand story A3, Quick opening and closing design A4 and Personalized customization options A5.

To ensure the professionalism and scientific rigor of the weighting results for user requirements in sustainable gift packaging, this study adopted the Analytic Hierarchy Process (AHP) proposed by Thomas L. Saaty. A 9-point scale, ranging from “extremely important” to “not important at all,” was used to systematically construct an evaluation framework that ensures the precision and consistency of expert judgments (Saaty 1977).

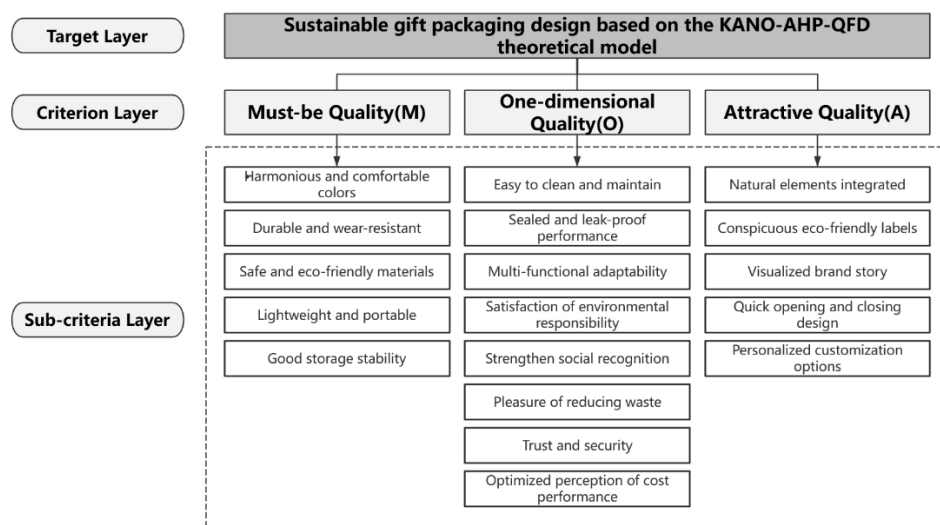


Fig. 2. The hierarchical structure model of sustainable gift packaging design

A panel of 15 experts was invited to participate in the evaluation, representing a diverse range of backgrounds: five environmental engineers (three of whom hold IBEC certification and have led waste treatment projects exceeding 100,000 tons), four packaging designers (with an average of 12.5 years of professional experience, including two recipients of the Gold Award in the China Packaging Creative Design Competition), three sustainability researchers (all of whom have led projects supported by the National Social Science Foundation), three consumer behavior scholars (members of leading teams applying neuroscience to study green consumer behavior), and two industrial engineers (specialists in intelligent manufacturing system integration).

This expert panel covers the four key stages of the product life cycle: technological research and development (environmental engineers), aesthetic and structural design (packaging designers), social impact assessment (sustainability researchers), market demand analysis (consumer behavior scholars), and production process optimization (industrial engineers), forming a comprehensive, closed-loop evaluation system. The diversity of the expert group—spanning technology, design, management, and user perspectives—ensures the comprehensiveness of the assessment. Within this methodology, a judgment matrix was constructed to determine the weight of the criteria-level indicators. The geometric mean method was employed to calculate the weight values of user requirements in sustainable gift packaging, followed by a

consistency check of the matrix scores. An overview of the calculation process is presented below, and the results are shown in Tables 5 and 6.

A judgement matrix S was constructed as follows.

$$S = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{bmatrix} \quad (2)$$

$$a_{ij} \cdot a_{ji} = 1, \quad i, j = 1, 2, \dots, n.$$

The maximum eigenvalue $\lambda_{\max}$ was calculated as follows,

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{S_{wi}}{W_i} \quad (3)$$

where n denotes the order of the judgment matrix, and S_{wi} represents the i component of the eigenvector S_w .

The consistency of $\lambda_{\max}$ was tested as follows,

$$I_{CR} = \frac{I_{CI}}{I_{RI}} \quad (4)$$

$$I_{CI} = \frac{\lambda_{\max} - n}{n - 1} \quad (5)$$

$$I_{CR} = \frac{\lambda_{\max} - n}{(n - 1) \times I_{RI}} \quad (6)$$

where n is the order corresponding to the evaluation scale of the judgement matrix, I_{RI} is the average stochastic consistency index, and I_{CR} is the consistency ratio.

The maximum eigenvalue V_i was calculated as follows,

$$V_i = \sqrt[n]{\prod_{j=1}^n S_{ij}} \quad (7)$$

where S_{ij} is the demand indicator in row i , column j , and n is the quantity of the demand indicator.

The geometric mean method was used as the basis for weight calculation to calculate the geometric mean values of each level a_i .

$$a_i = \sqrt[n]{M_i} \quad (i = 1, 2, \dots, n) \quad (8)$$

The relative weight W_i was calculated using Eq. 9.

$$W_i = \frac{a_i}{\sum_{i=1}^n a_i} \quad (9)$$

Table 5. Criterion Level Judgment Matrix

Index	The Must-Be Needs (M)	The One-Dimensional Needs (O)	The Attractive Needs (A)	Weighted Value	I_{CR}
The must-be needs (M)	1	3	5	0.6334	0.0371
The one-dimensional needs (O)	1/3	1	3	0.2605	
The attractive needs (A)	1/5	1/3	1	0.1062	

Table 6. Sub-Criterion Level Judgment Matrix

Primary Index	Secondary Index	Judgment Matrix								Weight	Relative Weight	I_{CR}
The must-be needs(M)	Harmonious and comfortable colors(M1)	1	1/5	1/2	3	4	×	×	×	1.080	0.171	0.073
	Durable and wear-resistant(M2)	5	1	1/4	2	5	×	×	×	1.778	0.282	
	Safe and eco-friendly materials(M3)	2	4	1	5	5	×	×	×	2.605	0.412	
	Lightweight and portable(M4)	1/3	1/2	1/5	1	2	×	×	×	0.553	0.088	
	Good storage stability(M5)	1/4	1/5	1/5	1/2	1	×	×	×	0.301	0.048	
The one-dimensional needs(O)	Easy to clean and maintain(O1)	1	1/3	3	1/3	1/2	1/3	1/5	1/4	0.592	0.049	0.051
	Sealed and leak-proof performance(O2)	3	1	3	2	2	3	1/3	1/2	1.861	0.146	
	Multi-functional adaptability(O3)	1/3	1/3	1	1/3	2	1/2	1/4	2	0.745	0.062	
	Satisfaction of environmental responsibility(O4)	3	1/2	3	1	1/2	1/5	1/5	3	1.043	0.086	
	Strengthen social recognition(O5)	2	1/2	1/2	2	1	1/3	1/5	2	0.941	0.079	
	Pleasure of reducing waste(O6)	3	1/3	2	5	3	1	1/4	3	1.861	0.150	
	Trust and security(O7)	5	3	4	5	5	4	1	4	4.237	0.358	
	Optimized perception of cost performance(O8)	4	2	1/2	1/3	1/2	1/3	1/4	1	0.841	0.071	
The attractive needs(A)	Natural elements integrated(A1)	1	1/3	1/4	1/2	1/3	×	×	×	0.485	0.077	0.045
	Conspicuous eco-friendly labels(A2)	3	1	3	1/4	1/3	×	×	×	1.106	0.172	
	Visualized brand story(A3)	4	1/3	1	2	1/2	×	×	×	1.245	0.192	
	Quick opening and closing design(A4)	2	4	1/2	1	3	×	×	×	1.964	0.299	
	Personalized customization options(A5)	3	3	2	1/3	1	×	×	×	1.677	0.260	

To ensure the reliability of the data, it is essential to test the consistency of the judgment matrix. When $I_{CR} \leq 0.1$, the matrix is considered to meet the requirements of the consistency test, and the resulting weights are deemed valid. Otherwise, the data must be revised and the judgment matrix reconstructed.

Finally, a consistency check was performed on the calculation results. The value of the criterion layer I_{CR} was 0.0371, and the values for the sub-criteria layer were 0.073, 0.051, and 0.045 respectively, all of which were less than 0.1, and conformed to the consistency test standard.

The relative weight ranking results presented in Table 7 indicate that, in addition to fulfilling the Must-be requirements (M), certain One-dimensional requirements (O)—such as Sense of Trust and Safety (O7) and Pleasure from Waste Reduction (O6)—as well as Attractive requirements (A)—such as Quick-opening and Closing Design (A4) and Options for Personalized Customization (A5)—achieved relatively high rankings. Therefore, in practical design implementation, it is essential to give full consideration to the top-ranked user requirements within both the One-dimensional (O) and Attractive (A) categories. Doing so will significantly enhance user satisfaction with the sustainable design of gift packaging.

Table 7. Relative Weight Calculation Ranking Table

Sub-Criterion Level Indicator	Relative Weight	Rank
Safe and eco-friendly materials(M3)	0.412	1
Trust and security(O7)	0.358	2
Quick opening and closing design(A4)	0.299	3
Durable and wear-resistant(M2)	0.282	4
Personalized customization options(A5)	0.260	5
Visualized brand story(A3)	0.192	6
Conspicuous eco-friendly labels(A2)	0.172	7
Harmonious and comfortable colors(M1)	0.171	8
Pleasure of reducing waste(O6)	0.150	9
Sealed and leak-proof performance(O2)	0.146	10
Lightweight and portable(M4)	0.088	11
Satisfaction of environmental responsibility(O4)	0.086	12
Strengthen social recognition(O5)	0.079	13
Natural elements integrated(A1)	0.077	14
Optimized perception of cost performance(O8)	0.071	15
Multi-functional adaptability(O3)	0.062	16
Easy to clean and maintain(O1)	0.049	17
Good storage stability(M5)	0.048	18

Design Element Analysis Based on the Quality Function Deployment (QFD) Method

After determining the weight and overall priority of various user requirements for sustainable gift packaging using the Analytic Hierarchy Process (AHP), it is essential to apply the Quality Function Deployment (QFD) method to translate these user requirements into specific product design parameters. As shown in Table 8, QFD enables the transformation of customer expectations into actionable design elements, ultimately allowing for the calculation of the weight of each design element in the sustainable packaging solution.

The construction of the House of Quality (HOQ) model is the core of the entire Quality Function Deployment (QFD) process. Based on the KANO model and the Analytic Hierarchy Process (AHP), user requirement elements and design parameters were identified and used to build the HOQ. The user requirement weights were incorporated into the left wall of the HOQ, while the design elements formed the roof of the structure.

To assess the relationships between user requirements and design elements, a panel of experts was invited. This panel consisted of two professors specializing in product design, two professional product designers, and one experienced user. They conducted pairwise comparisons between user requirements and design elements in the context of sustainable gift packaging. The symbols ★, ▲, and ● were used to represent the degree of correlation between user requirements and design elements, with assigned values of ★ = 1.5, represents a strong correlation; ▲ = 1.2, represents a moderate correlation; and ● = 1, represents a weak correlation. Blank spaces indicate no correlation. The final weight of each design element was calculated as the sum of the products of its correlation values with each user requirement and the corresponding user requirement weights, forming the basement of the House of Quality (Zheng *et al.* 2024). These computed weights were then normalized according to their relative importance and subsequently ranked, as illustrated in Fig. 3.

Table 8. User Requirements-Conversion Table of Elements for Sustainable Gift Packaging Design

User Requirement	Design Parameter
Safe and eco-friendly materials(M3)	Environmental-friendly material selection(D1)
Trust and security(O7)	Reliability design(D2)
Quick opening and closing design(A4)	Structural convenience(D3)
Durable and wear-resistant(M2)	Material durability(D4)
Personalized customization options(A5)	Customizability(D5)
Visualized brand story(A3)	Brand symbol design(D6)
Conspicuous eco-friendly labels(A2)	Information visualization(D7)
Harmonious and comfortable colors(M1)	Color coordination(D8)
Pleasure of reducing waste(O6)	Sustainable interaction design(D9)
Sealed and leak-proof performance(O2)	Sealing structure(D10)
Lightweight and portable(M4)	Material lightweighting(D11)
Satisfaction of environmental responsibility(O4)	Environmental behavior guidance(D12)
Strengthen social recognition(O5)	Community value communication(D13)
Natural elements integrated(A1)	Ecological aesthetic design(D14)
Optimized perception of cost performance(O8)	Cost control design(D15)
Multi-functional adaptability(O3)	Modular design(D16)
Easy to clean and maintain(O1)	Surface treatment process(D17)
Good storage stability(M5)	Material weather resistance(D18)

User Need	Composite Weight	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18
M3	0.412	★														▲			
O7	0.358	★	★		▲						▲								★
A4	0.299			★							●					★	★		
M2	0.282	▲	★		★							▲				★		★	▲
A5	0.260					★			★	▲					▲	★	★		
A3	0.192					▲	★			★			★						
A2	0.172							★					★						
M1	0.171					●	▲		★						★				
O6	0.150				●					★									▲
O2	0.146	●	▲		●						★	●							
M4	0.088	▲		▲								★							
O4	0.086	●			▲					▲			★	▲					
O5	0.079						●	●		▲			▲	★				▲	
A1	0.077					●			▲						★			●	
O8	0.071			●	▲					▲	★		▲	▲		★			
O3	0.062										●					●	★		
O1	0.049	★																★	
M5	0.048	▲	●									▲				●			★
	SUM	1.962	1.183	0.625	1.337	0.868	0.572	0.337	0.739	1.108	1.116	0.674	0.855	0.307	0.684	1.972	0.932	0.668	1.127

Fig. 3. Quality house

Based on the Kano–AHP–QFD methodology, the priority weights of design requirements for sustainable gift packaging were determined, as shown in Fig. 4. The analysis reveals a clear hierarchy of importance among the identified design requirements.

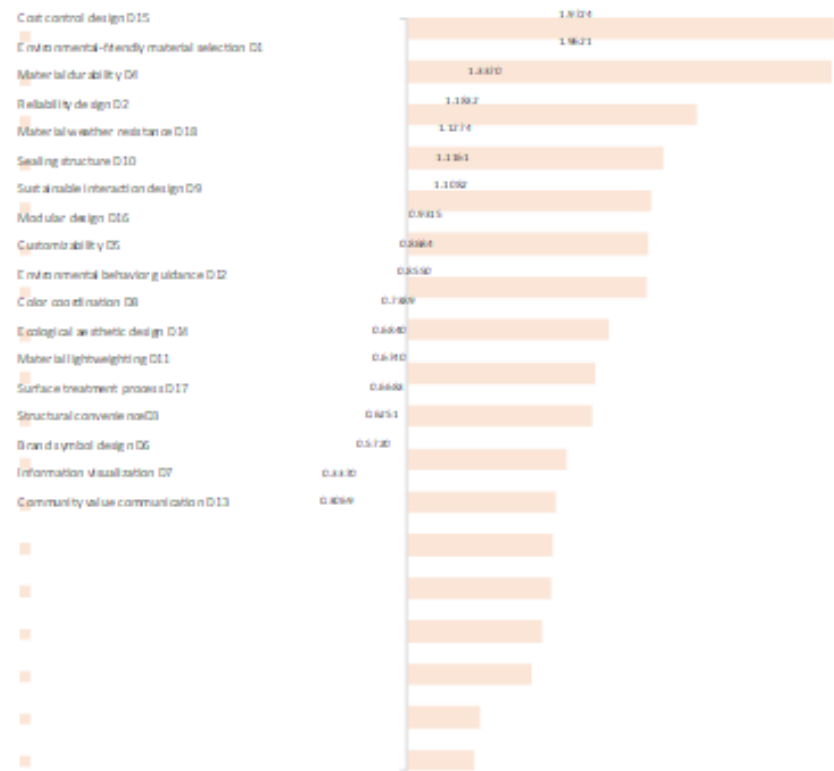


Fig. 4. Relative weight calculation ranking chart

The results indicate that cost control design (D15) and eco-friendly material selection (D1) are the most critical factors, possessing the highest priority weights of 1.9724 and 1.9621, respectively. This suggests that economic feasibility and the choice of environmentally sustainable materials are the most important considerations in the

sustainable design of gift packaging. These are followed by several performance-related requirements. Material durability (D4) holds a weight of 1.3370, while reliability design (D2), material weather resistance (D18), and sealing structure (D10) are also assigned high priority weights of 1.1832, 1.1274, and 1.1161, respectively. Sustainable interaction design (D9) also shows a relatively high weight (1.1082), indicating that user interaction and sustainability features are regarded as important design considerations. Requirements such as modular design (D16), customizability (D5), guidance for environmentally friendly behavior (D12), color scheme (D8), and eco-aesthetic design (D14) fall within the medium priority range, with weights varying from 0.9315 to 0.6251. Compared to cost, material performance, and essential functional requirements, these aspects appear to be less critical but still relevant.

Finally, material lightweighting (D11) and surface treatment technology (D17) are identified as having the lowest priority weights, 0.3370 and 0.3069, respectively. This finding may suggest that, while these factors contribute to sustainability, they are perceived as less decisive or having a smaller impact relative to other design parameters within the context of this study.

In summary, the KANO–AHP–QFD analysis prioritizes cost-effectiveness and eco-friendly material selection as the foundational elements of sustainable gift packaging design, followed closely by key performance attributes such as durability, reliability, weather resistance, and seal integrity. Interaction design also emerges as an important design priority. Other factors—including modularity, customization, aesthetics, and lightweighting—occupy a relatively lower but still meaningful level of importance within the derived priority framework. These findings offer valuable insights for advancing the design of sustainable and environmentally responsible packaging solutions.

Sustainable Gift Packaging Design Based on the KANO, AHP, and QFD Models

Based on the ranking of design elements presented in Table 9, a sustainable gift packaging solution was developed, with design renderings shown in Figs. 5 and 6.



Fig. 5. Sustainable gift packaging design display board



- The gift box is composed of 6 pieces of recycled cardboard parts, which are joined together through mortise and tenon joints and slots without the need for glue or metal nails. Users can assemble it quickly by hand. The mortise and tenon interfaces have been optimized mechanically to ensure a stable structure after assembly and can bear the weight of items within 2kg. The edges of the components are rounded to prevent finger injuries during disassembly, taking into account both safety and ease of use.

Fig. 6. Sustainable gift packaging design renderings

The design centers on the core principles of sustainability, multifunctionality, and user engagement, aiming to overcome the limitations of traditional single-use packaging. Through innovative choices in materials, structure, and functionality, the gift box is endowed with long-term practical value. It not only serves as a vessel for conveying festive sentiments but also transforms into a functional item in users' daily lives and a medium for promoting environmental awareness. The design embodies the concept of "green consumption as a path to a better life," encouraging sustainable behavior through thoughtful design.

Top surface design

The top surface features a galloping horse rendered using a water-based, eco-friendly hot stamping foil. In traditional Chinese Zodiac culture, the horse symbolizes perseverance and self-improvement. Above the golden horse motif, the Chinese characters "賀新年" (Happy New Year) are printed in cinnabar red, enhancing the festive atmosphere. The color scheme includes three options: natural tones, red, and blue, catering to various holiday preferences.

Eco-friendly material selection

The packaging is made from 100% post-consumer recycled fiberboard, processed without surface lamination to ensure natural biodegradability and efficient recyclability. SGS testing reports a cross-directional tensile strength of ≥ 4.5 kN/m and a bursting strength of ≥ 550 kPa. Compared to conventional white cardboard, this material reduces the carbon footprint by 23%, based on life cycle assessment (LCA) under GB/T 20862-2007. Surface graphics are printed using soy-based inks certified under ISO 24276:2021,

achieving a colorfastness rating of 4–5 (ISO 105-B02) and a color difference $\Delta E < 1.2$ after 200 Taber abrasion cycles (CIE Lab* system). The absence of lamination shortens the degradation period to 60–90 days under anaerobic conditions (ASTM D5511-21), while the recycling rate increases to 92%, compared to 41% for traditional PET-laminated paperboard.

Structural design

The gift box consists of six components made from recycled paperboard, assembled using interlocking mortise-and-tenon joints and slots—without the need for adhesives or metal fasteners. Users can quickly assemble the box manually. The joint structure is mechanically optimized to ensure stability and can support up to 2 kg of contents. Rounded corners are adopted on all edges to prevent finger injuries during disassembly, enhancing both safety and usability.

Multifunctional design

A side opening allows users to insert paper currency or coins, enabling the box to function as a piggy bank. Alternatively, the lid can be opened for use as a storage box. The outer surfaces feature a printed 2026 calendar, allowing the box to also serve as a desktop calendar throughout the year.

Eco-labeling and user interaction

The side of the box displays several eco-labels, including FSC certification, recycling symbols, and the PAP21 recyclable material mark. The bottom panel includes an environmental slogan and a QR code. Upon scanning, users can access a detailed carbon footprint data chain of the packaging, covering emissions from material sourcing, transportation, and production stages. Additionally, users receive a digital “Environmental Achievement Card,” which visually presents their contribution to carbon reduction and enhances the positive emotional response to waste reduction. In a pilot study, users spent an average of 82 seconds on the achievement card interface, and 73% followed the subsequent recycling guidance. The FSC-COC certification ensures full traceability from raw materials to finished products. The recycling symbol is produced using intaglio embossing (depth: 0.3 mm), with a tactile recognition accuracy rate of 91% in a blind test ($n = 150$).

This design leverages the cultural relevance of the Year of the Horse (2026) to deeply integrate Chinese zodiac symbolism with sustainability concepts, creating a festive gift box that is aesthetically pleasing, functionally practical, and emotionally expressive. It transforms gift packaging into not only a vessel of New Year greetings but also a cultural artifact that conveys Eastern wisdom and environmental responsibility.

CONCLUSIONS

1. This study classified user requirements using the Kano model and employed the Analytic Hierarchy Process (AHP) to construct a requirement prioritisation matrix. By integrating Quality Function Deployment (QFD), the study translated these requirements into design elements, ultimately forming a “requirement-function-design” mapping framework. Based on this framework, the study proposes reasonable sustainable design solutions for gift packaging, providing new insights and references

for the development of other sustainable products.

2. However, several limitations should be acknowledged. First, the sample data used in this study were primarily collected from a specific geographic region, which may limit the generalizability of the findings. Second, cultural differences that could influence user preferences and perceptions of sustainable packaging were not fully considered, potentially affecting the applicability of the results in a broader context.
3. Future research could address these limitations by expanding the sample to include more diverse regions and by incorporating cross-cultural analyses. Additionally, the transferability and adaptability of the proposed framework to other product categories beyond gift packaging warrant further exploration. Such studies would help validate and refine the framework, enhancing its value for sustainable product design across various industries.

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