International Journal for Housing Science and Its Applications
Publish August 4, 2025. Volume 46, Issue 3 Pages 2343-2359

https://doi.org/10.70517/ijhsa463196

Exploring the development of large flat projects in Hangzhou based on the perspective of living quality

Yu Liu[1,*]
[1] School of Art and Design, Zhejiang Tongji Vocational College of Science and Technology, Hangzhou, Zhejiang, 311231, China
Corresponding authors: (e-mail: liuyu@zjtongji.edu.cn).

Abstract Promoting the high-quality construction and high-quality development of housing has become the urgent demand of the housing industry, and providing quality housing that effectively meets the needs of users has also become the trend of the housing market. Based on the perspective of residential quality, this paper obtains 6 first-level evaluation indexes and 24 second-level indexes through the theory of the principle of construction of evaluation index system, thus composing the evaluation index system of residential quality of Hangzhou large flat project. Before constructing the evaluation model, we use hierarchical analysis method and entropy weighting method to calculate the comprehensive weights of evaluation indexes, and then combine the weights, topology method and cloud model to design the evaluation model of the living quality of Hangzhou large flat projects. Taking Hangzhou large flat project C as a research case, the model in this paper is used to evaluate and analyze it. After calculation, 24 secondary indicators show high living quality, with values ranging from 0.8 to 0.95, which concludes that the development direction of Hangzhou Grand Flat Project C is very suitable for the users' living quality needs.

Index Terms hierarchical analysis method, entropy weight method, topable method, living quality

I. Introduction

In recent years, large flat luxury houses have been rapidly rising in major cities because of their both commercial housing characteristics and high-end temperament [1], [2]. Hangzhou, as a city with a very high level of modernization and construction, the emergence of the large flat opened another door for both urban life and landscape resources [3], [4]. This kind of large openings, large-scale, one-staircase, one-family high-end products are no longer just the behavior of one or two enterprises, but finally become the industry's “key words” [5], [6].

Large flat floor, refers to the flat-floor residence with large area [7]. From the product point of view, large flat belongs to a kind of high-end apartment, often distributed in the whole building or part of the floor of high-rise or multi-storey residential buildings, with large area and perfect function as the main characteristics [8]-[10]. It breaks through the design concept of ordinary apartment products and realizes the spatial layout of one floor, one family, large width and full landscape [11]. As the volume ratio and building density of multi-storey houses are relatively low, to a certain extent, they have a villa-style living experience, which is also called “flat villa” or “flat villa” in the industry [12], [13]. As a new form of high-end products, the large flat is expected to gradually expand into an emerging development mode in the high-end market from both the differentiation advantage of the product itself and the perspective of market demand [14], [15]. Large flat projects have resource advantages, and most of them are in the main city, and its development reflects the return of the elite class [16]. Many of these people can't leave the main city, can't leave the main city's resource support and living experience, after experiencing the journey of fleeing to the outside looking for, there are a group of people back to the city [17]-[19]. In the main city, as a kind of high-quality products, the large flat has the scale of villa, but also has a good living atmosphere, undoubtedly loved by this part of the people [20]-[22].

This paper first defines the concept of living quality and summarizes the characteristics of living quality, which are material and spiritual. Under the constraints of the principle of construction of evaluation index system, 6 first-level indicators and 24 second-level indicators are selected to finalize the construction of evaluation index system. Adopting the combination of hierarchical analysis method and entropy weight method, the evaluation index weights are calculated, and under the joint effect of index weights, topology method and cloud model, the topology cloud evaluation model is designed. Finally, take Hangzhou Grand Flat Project C as this research building project, and use the model of this paper to evaluate and analyze the project.

II. Exploring the living quality of large flat projects in Hangzhou

II. A. Definition of the concept of housing quality

The quality of living is also a reflection of the quality of living life, which is the concept of evaluating the degree of the advantages and disadvantages of living life [23], [24]. According to the concept and content of the quality of life, we can understand the quality of living in this way, the quality of living based on the level of living, but its connotation has a greater complexity and breadth, which focuses more on the degree of fulfillment of people's living life in the spirit of culture and other high-level needs and the evaluation of the state of the environment of living life. As a reflection of the quality of living life, living quality also consists of two parts: one is the objective conditions of people's living life, i.e. the material space environment. The other part is people's subjective feeling of living life. The two do not exist independently, but influence each other and work together.

II. B. Housing quality characteristics

As a reflection of the quality of residential life. The quality of living naturally takes on two characteristics, material and spiritual. They are expressed as follows:

II. B. 1) Materiality

Life is real, not imaginary. The daily life of the residents requires a certain material space as a carrier in order to produce and carry out. The material space environment in a residential area plays this role and becomes the background and stage for residents to enrich their lives. This materiality becomes an important characteristic of the quality of living. Differences in the physical and spatial environment are directly or indirectly reflected in the quality of living. Although the physical environment does not completely determine the quality of living, many studies have shown that the physical environment as a container of life has a significant impact on people's lives.

II. B. 2) Spirituality

Life itself is extremely complex. Any thing or phenomenon, once someone is involved in it, takes on the character of spirituality. It supports the development of things together with materiality. The spirituality of the quality of living is firstly manifested in the fact that it is influenced by the social and cultural conditions of the whole society at that time. Each era has its own cultural characteristics, which influence people's concept of living, lifestyle, values and so on. For example, the arrival of the network era has changed many people's lifestyles, and the emergence of virtual interactions has affected the frequency of traditional public interactions, and the public activities in the settlements have been affected in some ways, and the residential life has shown a tendency of individualization. Secondly, different income classes, different age groups, different occupations, different interest groups and so on will have different needs for living life, and will have different satisfaction. Therefore, the evaluation system of living quality becomes very diversified and cannot be defined by uniform standards. Again, the frequent contact between the residents and the physical space environment of the settlement makes the interaction relationship obvious. The environment has a certain impact on human behavior, and human behavior in turn shapes the environment, leading to changes in the original environment or the creation of a new environment. The interaction between the two changes people's lives, and the quality of living is constantly changing in the process.

II. C. Principles for the construction of the evaluation index system

Residential quality is a measure of the degree of matching between the residential environment and the residential needs and expectations of individuals or family units, and its indicator system is established with multi-level and comprehensive influencing factors, so the housing quality evaluation indicator system should be able to scientifically, objectively, and comprehensively reflect the psychological expectations of the residents' demand for residential housing, and follow the principles of people-oriented, scientific, hierarchical, and independent.

II. C. 1) People-centered principle

As the material carrier of “home”, large flat building should not only meet the material needs of human habitation, but also meet the spiritual needs of the occupants, so the selection of evaluation indexes should not only be able to reflect the comfort and safety elements related to people's living life, but also fully and accurately reflect their psychological needs for a pleasant and healthy living environment.

II. C. 2) Scientific principles

The living quality evaluation index system of Hangzhou large flat project must be able to scientifically and systematically reflect the connotation of living quality, reflect the macro and micro elements that constitute the requirements of living quality in an all-round way, and the index system constructed not only contains the physical quality of the building, but also embodies the humanities, nature, ecology and other elements of the city, so as to make the evaluation indexes and the evaluation objectives complement each other.

II. C. 3) Principle of Hierarchy

The evaluation of living quality involves the internal and external environments of the residence, and the influencing factors on both are diversified and multilevel, and the indexes of evaluation should be determined by designing the overall quality of the large flat building as the target layer, and the internal and external environments of the large flat building as the criterion layer, and designing the corresponding quality element layer according to the criterion layer, so that the evaluation system will be distinctly hierarchical, structurally clear, well organized, and easy to be understood by the respondents. The evaluation system is hierarchical, clearly structured and easy to be understood by the respondents.

II. C. 4) Principle of independence

Indicators in the system of evaluation indicators must be relatively independent, not highly correlated with each other, and have a high degree of differentiation, so that each indicator can independently reflect the requirements of the population for a certain aspect or a different level of housing quality.

Table 1: Evaluation index system

First-level indicator	Symbol	Secondary indicators	Symbol
Residential architectural design	A1	Architectural style	A11
		Residential area	A12
		Overall layout	A13
		Lighting	A14
Intelligent technical equipment	A2	Public security system	A21
		Supporting equipment management system	A22
		Home intelligent system	A23
		Monitoring system	A24
The environment of residential communities	A3	Convenience of transportation	A31
		Community culture	A32
		Residents' quality and Neighborhood relations	A33
		Property service	A34
The elderly-friendly nature of residences	A4	Public service facilities for the elderly	A41
		Elderly-friendly medical service facilities	A42
		Elderly-friendly living service facilities	A43
		Outdoor activities	A44
Residential market environment	A5	The reputation and services of developers and real estate agencies	A51
		The quality of bank mortgage services	A52
		Housing security system	A53
		And the economic burden of the previous housing	A54
Living environment	A6	Air quality	A61
		Leisure cultural atmosphere	A62
		Educational supporting facilities	A63
		Medical support	A64

II. D.System of evaluation indicators

Living quality is an indispensable part of the development of Hangzhou large flat project, with the residents of the quality of life requirements continue to improve, the standard of living quality not only examines the objective quality of the building entity, the residents of Hangzhou large flat project of the overall subjective psychological feeling of the living environment has also become an important factor in the consideration of a variety of standards, the evaluation of the index system as shown in Table 1. Therefore, in the design of the evaluation index system, according to the construction principle of the index system, and fully adopting the experts' suggestions, not only considering the residents' requirements on the physical sense of the single body of the Hangzhou large flat project, i.e., the quality of the building (safety, practicability, functionality, etc.), but also including the psychological needs of the guests with different age groups, educational backgrounds, occupational backgrounds, etc., and putting the conventional architectural design, neighborhood environment, urban environment As well as education, medical care, living services and leisure and entertainment facilities and other factors into the scope of the examination, a comprehensive examination of the practicality, comfort, safety, economy and environmental protection of Hangzhou large flat projects, and the use of the Keto cloud model, and ultimately formed from the architectural design, intelligent technology and equipment, community environment, residential suitability for the elderly, the market environment, the residential environment of the Hangzhou large flat projects of the six main indicators Each indicator is further decomposed one by one and subdivided into a number of specific indicators, which lays the foundation for subsequent research.

II. E. Calculation of combined weights of evaluation indicators

II. E. 1) Calculation of subjective weights based on hierarchical analysis method (AHP)

The core of the hierarchical analysis method is to be analyzed by experts by comparing and analyzing the indicators of each different level, using the scale method from 1 to 9 levels, comparing the criterion level of the target user's needs and the indicator level with each other, and calculating the indicators by constructing the two-by-two comparative judgment matrix formula [25]. See equation (1):

$$C=(C_{ij})_{n\times n}=\begin{pmatrix} C_{11} & \cdots & C_{1n} \\ \vdots & \ddots & \vdots \\ C_{n1} & \cdots & C_{nn} \end{pmatrix} \tag{1}$$

where C_{ij} denotes the relative importance value of C_i over C_j, or $1/C_{ij}$ if the result is opposite.

Each column in the matrix C is normalized and the result is denoted as b_{ij}. See equation (2):

$$b_{ij}=\frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} \tag{2}$$

The approximate method of finding the eigenvectors of the judgment matrix is used by summing the normalized matrices by rows, denoted a_i. See equation (3):

$$a_i=\sum_{j=1}^{n} b_{ij} \tag{3}$$

The vectors are normalized to find the subjective weight of each indicator, denoted ω_i see equation (4):

$$\omega_i=\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{4}$$

Before performing a one-time test of the results, the maximum characteristic root $\lambda_{\max}$ must be calculated, see equation (5):

$$\lambda_{\max}=\frac{1}{n}\sum_{i=1}^{n}\frac{(a\omega)_i}{\omega_i}\left(i=1,2,\cdots\cdots,n\right) \tag{5}$$

And the results were tested for consistency (CI), see equation (6):

$$CI=\frac{\lambda_{\max}-n}{n-1} \tag{6}$$

The value of the stochastic consistency index RI of the judgment matrix is introduced. When $CR=\frac{CI}{RI}<0.1$, the judgment matrix is consistent and the weighting results are reasonable.

II. E. 2) Objective weight calculation based on entropy weight method (EWM)

The entropy weighting method can minimize the subjective influence of the weights of the factors on the evaluation results and make them more in line with the objective reality [26]. The basic principle of entropy weighting method is to determine the objective weight value according to the size of the indicator variation, and this method is more objective compared to AHP expert scoring. In the definition of entropy weight method, if the information entropy of an indicator is smaller, the more information the indicator provides, the higher the degree of variation (variance) of the indicator, and the greater the weight in the result. First, construct n evaluation objects and m evaluation indicators, the judgment matrix based on entropy weighting method is $A=(a_{ij})_{n\times m}$, a_{ij} indicates the probability value that the i evaluation indicator belongs to the j evaluation level. The judgment matrix A is normalized to obtain the normalization matrix, denoted q, and the elements of the normalization matrix q are shown in equation (7). That is:

$$q_{ij}=\frac{a_{ij}-a_{\min}}{a_{\max}-a_{\min}} \tag{7}$$

Normalizing the normalized matrix q gives the characteristic weight as, see equation (8). For:

$$f_{ij}=\frac{q_{ij}}{\sum_{i=m}^{n} q_{ij}} \tag{8}$$

Calculate the entropy value of the evaluation index, noting e_j see equation (9). For:

$$e_j=-\frac{1}{\ln m}\sum_{j=1}^{m} f_{ij}\ln f_{ij} \tag{9}$$

The objective weight of each indicator is denoted ω_j see equation (10). For:

$$\omega_j=\frac{1-e_j}{\sum_{j=1}^{m}\left(1-e_j\right)} \tag{10}$$

II. E. 3) Combined weights

In order to ensure the accuracy of the indicators, the combination of subjective weights and objective weights to get a more reasonable and scientific comprehensive weights, this method can weaken the influence of some subjective factors on the empowerment of the hierarchical analysis method, but also able to weaken the bias that exists in the objective empowerment of the weights of the indicators for the combination of the calculation, see formula (11). For:

$$\omega_j^{*}=\frac{\omega_i\omega_j}{\sum \omega_i\omega_j} \tag{11}$$

where ω_i is the subjective weight and ω_j is the objective weight.

II. F. Topological Cloud Evaluation Model

II. F. 1) Topology

The theoretical basis of topology is the combination of topological set theory and object element theory, which can well express the correlation and law in the middle of quantitative and qualitative changes of the research object [27]. Topology mainly completes the qualitative through the object element, the characteristics of the object element itself, equations, etc., and uses the correlation function and the topable set method for quantitative treatment. In topology, if the object to be evaluated has a total of m metrics to be evaluated, then each metric is denoted as c_1, c_2, $\cdots$, c_m, R - (name of the thing, feature of the thing, metric of the thing about the feature) - (N,C,V). Then the comprehensive evaluation object meta-model of the object to be evaluated is as follows:

$$R=\left(N_j,C,V_{jk}\right)=\begin{bmatrix} N_j & c_1 & V_{j1} \\ & c_2 & V_{j2} \\ & \vdots & \vdots \\ & c_m & V_{jm} \end{bmatrix}=\begin{bmatrix} N_j & c_1 & (a_{j1},b_{j1}) \\ & c_2 & (a_{j2},b_{j2}) \\ & \vdots & \vdots \\ & c_m & (a_{jm},b_{jm}) \end{bmatrix} \tag{12}$$

Let each evaluation index can be divided into n evaluation levels, determine the eigenvalues and characteristic information of each evaluation index in the comprehensive evaluation object, and obtain the object to be evaluated R_0:

$$R_0=\left(N_0,C,V\right)=\begin{bmatrix} N & N_1 & \cdots & N_n \\ c_1 & (a_{11},b_{11}) & \cdots & (a_{n1},b_{n1}) \\ \vdots & \vdots & \ddots & \vdots \\ c_m & (a_{1m},b_{1m}) & \cdots & (a_{nm},b_{nm}) \end{bmatrix} \tag{13}$$

Comprehensive evaluation results can be obtained by calculating the corresponding evaluation level intervals for each indicator in the section domain of the object meta-model:

$$R_p=\left(N_p,C,V_p\right)=\begin{bmatrix} N_p & c_1 & V_{p1} \\ & c_2 & V_{p2} \\ & \vdots & \vdots \\ & c_n & V_{pk} \end{bmatrix}_{n\times 2}=\begin{bmatrix} N_p & c_1 & (a_{p1},b_{p1}) \\ & c_2 & (a_{p2},b_{p2}) \\ & \vdots & \vdots \\ & c_n & (a_{pk},b_{pk}) \end{bmatrix} \tag{14}$$

The principle of comprehensive evaluation of the object to be evaluated is to calculate the correlation between the evaluation indexes of the object to be evaluated and each evaluation level, and the evaluation level interval with the highest correlation is the final evaluation level. However, when applied to the real engineering evaluation process, each evaluation index has different values, characteristic information and corresponding grade intervals, therefore, it is necessary to calculate the correlation between each index and each evaluation grade by using the corresponding grade intervals to which it belongs. The correlation function of indicator features V_K and intervals V_{jk},V_{pk} is:

$$P\left(V_k,V_{jk}\right)=\left|V_k-\frac{a_{jk}+b_{jk}}{2}\right|-\frac{b_{jk}-a_{jk}}{2} \tag{15}$$

$$P\left(V_k,V_{pk}\right)=\left|V_k-\frac{a_{pk}+b_{pk}}{2}\right|-\frac{b_{pk}-a_{pk}}{2} \tag{16}$$

where $j=1,2,\cdots,n$. $k=1,2,\cdots,m$. When $P\left(V_k,V_{jk}\right)$ is calculated to be less than 0, then V_k belongs to the interval V_{jk} . Equal to 0, then V_k is on the boundary of the interval V_{jk} . Greater than 0, then V_k does not belong to the interval V_{jk} . The calculated value of $P\left(V_k,V_{jk}\right)$ can indirectly reflect the approximate distribution of V_k in the interval V_{jk} .

The indicator c_K corresponds to the correlation of each evaluation level:

When $V_k\in\left(a_{jk},b_{jk}\right)$:

$$k_j(V_k)=-\frac{P\left(V_k,V_{jk}\right)}{\left|V_{jk}\right|} \tag{17}$$

When $V_k\notin\left(a_{jk},b_{jk}\right)$:

$$k_j(V_k)=\frac{P(V_k,V_{jk})}{P(V_k,V_{pk})-P(V_k,V_{jk})} \tag{18}$$

where $k_j(V_k)$ - the degree of correlation between the evaluation index k of the object to be evaluated and the evaluation level j .

When the value of the correlation function is positive, then V_k is within the interval V_{jk} , and the larger the value of the resulting correlation means that the characteristics exhibited by V_k overlap with the interval V_{jk} . Conversely, when the correlation function value is negative, then V_k is not in the interval V_{jk} , and the larger the negative value is, the larger the difference between the characteristics exhibited by V_k and the interval V_{jk} .

Multiply each indicator to be evaluated by the corresponding weight to get the correlation between the object element to be evaluated and each evaluation level:

$$K_j(p)=\sum_{i=1}^{m} w_i k_j(V_i)\left(j=1,2,\cdots,n\right) \tag{19}$$

When $K_j(p)=\max K_j(p)$, it means that the object element to be evaluated has the highest degree of correlation with the evaluation level j, so the comprehensive evaluation result of the object element to be evaluated is j level. If no matter j take any evaluation level calculated $K_j(p)$ is always less than 0, for this case, it means that the characteristics of indicators to be evaluated as well as the weights of some indicators may not be appropriate enough, it can be adjusted appropriately, and then recalculated using the above described correlation calculation method to get the correlation of the corresponding evaluation level. Calculation of comprehensive evaluation eigenvalues by the topology method:

$$k_j(p)=\frac{K_j(p)-\min K_j(p)}{\max K_j(p)-\min K_j(p)} \tag{20}$$

II. F. 2) Cloud Modeling Theory

Cloud model theory is a theory that represents the vagueness and randomness of things based on the traditional fuzzy theory and probability theory. The cloud model integrates the fuzziness, discrete and randomness of the research object and expresses them mathematically, so as to show the law of double uncertainty of the research object. After a long period of research and development, the cloud model has been derived from a variety of morphological types such as normal cloud, rectangular cloud, trapezoidal cloud, triangular cloud, etc. In terms of the current research and application in various engineering fields, the mathematical characteristics of normal cloud are better and show a normal distribution model, which has strong applicability in a number of fields, and therefore the normal cloud model is most widely used.

Figure 1 shows the schematic diagram of three numerical features of the normal cloud model, which is composed of three feature values together, namely, the expected value E_x, entropy E_n, and hyperentropy H_e. All ambiguities as a whole have a distribution center, and the characteristic expectation value E_x represents the average value of this whole class interval, which is the center value of the cloud. The characteristic entropy E_n indicates the size of the interval span of the cloud, which reflects the ambiguity, and the size of its value is proportional to the randomness of the evaluation index and the ambiguity of the grading boundary. The superentropy H_e reflects the thickness of the cloud.

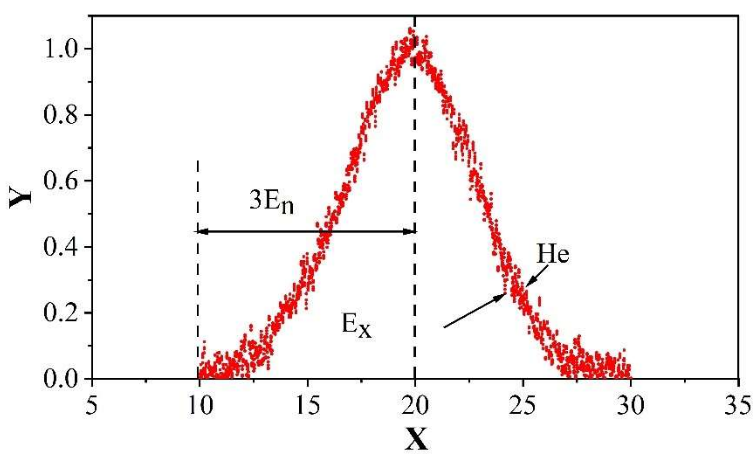

Figure 1: Three digital characteristics of the normal cloud model

The cloud model well represents the intertransformation relationship between qualitative and quantitative attributes of the research object, and its model calculation is accomplished with the help of the cloud model generator, which is shown in Fig. 2. The main types of cloud model generators are forward cloud generator, inverse cloud generator and conditional cloud generator, among which the forward cloud generator can make the fuzzy and random nature of the characteristics of the evaluation object transformed to the exact numerical expression, which is an important algorithm that is widely used in the cloud computing model.

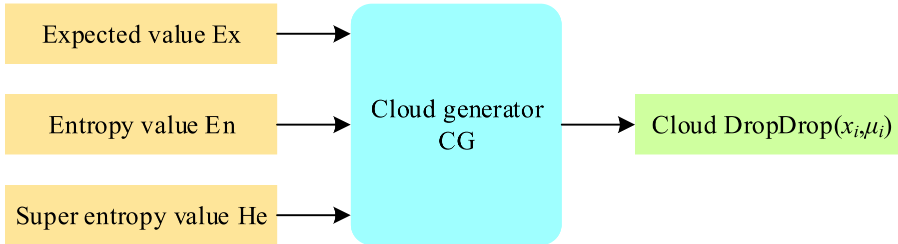

Figure 2: Forward cloud generator

To the forward cloud generator input three numerical features of the cloud model (expected value E_x, entropy E_n, hyperentropy H_e), through the generator can be calculated to obtain a two-dimensional point cloud $drop(x_i, \mu_i)$, repeat the calculation many times can be generated to generate a number of cloud droplets, the collection of cloud droplets is called the cloud, which after the The output of the generator calculation can get the correlation between the cloud droplets and the interval after quantitative transformation in the numerical space and the distribution position of the cloud droplets in the interval.

Forward cloud generator algorithm:

Input: three numerical features of the cloud model (expected value E_x, entropy E_n, hyperentropy H_e) and the number of N cloud droplets

Output: get N cloud droplet values i.e. $drop(x_1, \mu_k(x_1))$, $drop(x_2, \mu_k(x_2))$, ... , $drop(x_N, \mu_k(x_N))$, and the cloud droplet affiliation:

$$\mu_k(x_i) = \exp\left[-\frac{(x_i - E_x)^2}{2E_{ni}'^2}\right] \tag{21}$$

III. Evaluation analysis of large flat projects under the concept of living quality

III. A. Overview of the Hangzhou Grand Flat Project

Located in the vicinity of a business district in Hangzhou, the large flat project J is the fifth project of a brand developer in Hangzhou. The project is positioned as a low-density improved residence and the developer has always been known for the quality of its residences, which is in line with the object of this paper. The project covers an area of about 46,530,000 square meters, with a building area of about 165,300 square meters. There are 12 38-story high-rise buildings and 10 15-story small high-rise buildings, with two- and three-bedroom large apartments, with the main area of high-rise buildings being 89.33m², 111.52m² and 148.55m², and the main area of townhomes being 126-148m². The overall architectural style of the project adopts the neoclassical style, which portrays the towering sense of vision and noble experience through the shaping of the vertical lines of the building, and the overall use of the "three-section" composition method in accordance with the golden ratio, which adds the neoclassical charm. A 7200m² mountain park is built in the residential area, with different leisure spaces designed for users of different ages, an artificial ecological lake combined with a large number of ground cover plants planted to build a natural ecological lake, and a musical fountain in the area relying on the resources of the ecological lake.

III. B. Calculation of evaluation indicator weights

III. B. 1) Analysis of subjective weighting results

(1) Establishment of hierarchical model

Based on the hierarchical rules of hierarchical analysis method to construct the hierarchical model of the living quality of Hangzhou large flat project, to get the scores of each evaluation index of living quality, and the scores of the hierarchical model of evaluation indexes are grouped as shown in Table 2. Based on the scores in the table, it can be seen that the scores of each index are distributed in the interval of 6~8.

(2) Construction, weighting and consistency test of judgment matrix

Three experienced architects were selected to construct a judgment matrix comparing each factor two by two, and the relative weight calculation and consistency test of each indicator were carried out according to the following steps, as shown in Tables 3~9. Based on the formula of the hierarchical analysis algorithm mentioned above, the weight of each indicator was derived, and the weights of the indicators passed the consistency test (CR<0.01) with the values of 0.067, 0.053, 0.071, 0.044, 0.081, 0.092, 0.069.

Table 2: Evaluation index hierarchical model and score

First-level indicator	Symbol	Secondary indicators	Symbol	Score
Residential architectural design	A1	Architectural style	A11	7.844
		Residential area	A12	6.386
		Overall layout	A13	7.241
		Lighting	A14	7.55
Intelligent technical equipment	A2	Public security system	A21	6.836
		Supporting equipment management system	A22	7.284
		Home intelligent system	A23	7.792
		Monitoring system	A24	6.127
The environment of residential communities	A3	Convenience of transportation	A31	7.866
		Community culture	A32	6.196
		Residents' quality and Neighborhood relations	A33	6.221
		Property service	A34	7.232
The elderly-friendly nature of residences	A4	Public service facilities for the elderly	A41	6.769
		Elderly-friendly medical service facilities	A42	7.451
		Elderly-friendly living service facilities	A43	6.298
		Outdoor activities	A44	7.688
Residential market environment	A5	The reputation and services of developers and real estate agencies	A51	7.072
		The quality of bank mortgage services	A52	7.636
		Housing security system	A53	6.824
		And the economic burden of the previous housing	A54	7.011
Living environment	A6	Air quality	A61	6.069
		Leisure cultural atmosphere	A62	7.731
		Educational supporting facilities	A63	6.759
		Medical support	A64	7.074

Table 3: Judgment matrix and weights of the residential building design scheme layer

A1	A11	A12	A13	A14	Weight	CR
A11	1	1	3	3	0.4869	0.067
A12	1	1	0.5	0.25	0.1671	
A13	0.333	3	1	0.2	0.1879	
A14	0.5	0.2	1	1	0.1581	

Table 4: Judgment matrix and weights of the intelligent technology solution layer

A2	A21	A22	A23	A24	Weight	CR
A21	1	1	1	0.2	0.2667	0.053
A22	1	1	0.5	0.5	0.2820	
A23	0.333	0.25	1	1	0.2142	
A24	0.25	0.25	2	1	0.2371	

Table 5: Judgment matrix and weights of the residential environment scheme layer

A3	A31	A32	A33	A34	Weight	CR
A31	1	2	0.2	0.2	0.2664	0.071
A32	0.25	1	0.333	0.25	0.1889	
A33	0.5	0.5	1	0.333	0.2671	
A34	0.2	2	0.25	1	0.2796	

Similarly, calculate the relative weights of the indicators obtained under a single factor, and carry out consistency tests, and ultimately arrive at the value of the subjective weights of the evaluation indicators, and the results of the subjective weights of the evaluation indicators are shown in Table 10. For example, A11=0.1832*0.4869=0.0892, other indicators are the same, and will not repeat the expression.

III. B. 2) Analysis of objective weighting results

(1) Through on-site field survey, on-site visits and expert consultation and other methods to develop on-site questionnaires in the form of mail issued to the relevant business personnel and experts, technicians, etc. for scoring, and summary processing of the results of the returned scoring, the summary of the scores of the various indicators is shown in Table 11. It can be seen that the scores of the various indicators to maintain the range of 60 ~ 100.

Table 6: Judgment matrix and weights of the elderly-friendly residential scheme layer

A4	A41	A42	A43	A44	Weight	CR
A41	1	0.333	0.5	0.25	0.1943	0.044
A42	2	1	0.2	0.25	0.2418	
A43	0.5	0.5	1	1	0.3041	
A44	2	0.333	0.2	1	0.2598	

Table 7: Judgment matrix and weights of the market environment solution layer

A5	A51	A52	A53	A54	Weight	CR
A51	1	0.2	0.2	0.333	0.2064	0.081
A52	0.25	1	0.25	0.5	0.2555	
A53	1	0.2	1	0.2	0.2717	
A54	0.333	0.333	0.333	1	0.2664	

Table 8: Judgment matrix and weights of the residential environment scheme layer

A6	A61	A62	A63	A64	Weight	CR
A61	1	0.25	0.333	0.25	0.1992	0.092
A62	0.5	1	0.5	0.333	0.2817	
A63	0.2	1	1	0.5	0.2950	
A64	0.5	0.333	0.2	1	0.2241	

Table 9: The criterion layer judgment matrix and weights

Index	A1	A2	A3	A4	A5	A6	Weight	CR
A1	1	0.333	0.333	0.5	0.5	0.333	0.1832	0.069
A2	0.333	1	0.333	0.2	1	0.2	0.1621	
A3	0.125	0.5	1	0.333	1	0.2	0.1604	
A4	0.5	0.333	0.25	1	0.5	0.333	0.1746	
A5	1	0.2	0.2	0.2	1	0.5	0.1593	
A6	0.2	0.25	0.333	0.5	0.5	1	0.1604	

(2) Process the raw data summarized by the questionnaire, and use the formula to calculate the proportion of j experts to i indicators f_{ij}, you can find out f_{ij}, and the results obtained are shown in Table 12. After the calculation and processing, so that the results of f_{ij} to meet the requirements of entropy weighting method for objective weighting Lay the theoretical foundation.

(3) According to the formula in the previous chapter to calculate the information entropy of the evaluation indicators e_j, the coefficient of variation of the evaluation indicators as well as the entropy weights of the evaluation indicators, the results obtained are shown in Table 13, where the coefficients $k = \frac{1}{\ln m} = \frac{1}{\ln 10} = 0.4343$. The objective weight of each individual indicator is finally calculated to provide data support for the comprehensive weight calculation below.

Table 10: The results of subjective weights of evaluation indicators

First-level indicator	Weight	Secondary indicators	Weight	Relative weight
A1	0.1832	A11	0.4869	0.0892
		A12	0.1671	0.0306
		A13	0.1879	0.0344
		A14	0.1581	0.0290
A2	0.1621	A21	0.2667	0.0432
		A22	0.2820	0.0457
		A23	0.2142	0.0347
		A24	0.2371	0.0384
A3	0.1604	A31	0.2664	0.0427
		A32	0.1889	0.0303
		A33	0.2671	0.0428
		A34	0.2796	0.0448
A4	0.1746	A41	0.1943	0.0338
		A42	0.2418	0.0422
		A43	0.3041	0.0531
		A44	0.2598	0.0454
A5	0.1593	A51	0.2064	0.0329
		A52	0.2555	0.0407
		A53	0.2717	0.0433
		A54	0.2664	0.0424
A6	0.1604	A61	0.1992	0.0320
		A62	0.2817	0.0452
		A63	0.2950	0.0473
		A64	0.2241	0.0359

Table 11: Entropy weight method expert scoring

Index	1	2	3	4	5	6	7	8	9	10	Mean
A11	75	80	89	86	68	72	68	63	84	79	76.4
A12	99	68	78	64	72	80	73	67	84	64	74.9
A13	60	83	76	71	70	72	85	91	96	96	80
A14	64	73	64	72	93	79	76	86	96	98	80.1
A21	99	96	90	95	69	92	62	78	74	99	85.4
A22	66	77	64	67	89	79	76	99	99	68	78.4
A23	70	63	86	78	81	86	92	72	83	84	79.5
A24	99	97	78	95	87	61	78	97	67	79	83.8
A31	79	86	90	92	85	64	100	61	84	67	80.8
A32	84	80	83	97	99	82	79	80	86	70	84
A33	65	67	90	75	75	90	82	92	99	65	80
A34	80	88	80	60	66	84	62	97	64	64	74.5
A41	92	87	78	90	98	80	95	96	78	68	86.2
A42	60	88	98	90	92	80	69	77	93	69	81.6
A43	64	85	94	78	65	67	69	89	78	90	77.9
A44	84	89	60	83	93	71	73	89	75	76	79.3
A51	83	96	91	75	74	79	63	70	75	93	79.9
A52	91	80	84	99	92	88	90	97	67	71	85.9
A53	70	86	68	76	60	95	97	99	79	83	81.3
A54	90	75	86	68	87	79	84	89	98	62	81.8
A61	77	63	99	97	91	74	100	91	94	94	88
A62	73	61	94	85	87	87	67	71	94	82	80.1
A63	67	98	92	60	80	92	71	90	87	64	80.1
A64	99	63	84	95	69	71	70	98	74	81	80.4

Table 12: The proportion of expert scoring by the entropy weight method

Index	1	2	3	4	5	6	7	8	9	10
A11	0.0896	0.1269	0.1940	0.1716	0.0373	0.0672	0.0373	0.0000	0.1567	0.1194
A12	0.3211	0.0367	0.1284	0.0000	0.0734	0.1468	0.0826	0.0275	0.1835	0.0000
A13	0.0000	0.1150	0.0800	0.0550	0.0500	0.0600	0.1250	0.1550	0.1800	0.1800
A14	0.0000	0.0559	0.0000	0.0497	0.1801	0.0932	0.0745	0.1366	0.1988	0.2112
A21	0.1581	0.1453	0.1197	0.1410	0.0299	0.1282	0.0000	0.0684	0.0513	0.1581
A22	0.0139	0.0903	0.0000	0.0208	0.1736	0.1042	0.0833	0.2431	0.2431	0.0278
A23	0.0424	0.0000	0.1394	0.0909	0.1091	0.1394	0.1758	0.0545	0.1212	0.1273
A24	0.1667	0.1579	0.0746	0.1491	0.1140	0.0000	0.0746	0.1579	0.0263	0.0789
A31	0.0909	0.1263	0.1465	0.1566	0.1212	0.0152	0.1970	0.0000	0.1162	0.0303
A32	0.1000	0.0714	0.0929	0.1929	0.2071	0.0857	0.0643	0.0714	0.1143	0.0000
A33	0.0000	0.0133	0.1667	0.0667	0.0667	0.1667	0.1133	0.1800	0.2267	0.0000
A34	0.1379	0.1931	0.1379	0.0000	0.0414	0.1655	0.0138	0.2552	0.0276	0.0276
A41	0.1319	0.1044	0.0549	0.1209	0.1648	0.0659	0.1484	0.1538	0.0549	0.0000
A42	0.0000	0.1296	0.1759	0.1389	0.1481	0.0926	0.0417	0.0787	0.1528	0.0417
A43	0.0000	0.1511	0.2158	0.1007	0.0072	0.0216	0.0360	0.1799	0.1007	0.1871
A44	0.1244	0.1503	0.0000	0.1192	0.1710	0.0570	0.0674	0.1503	0.0777	0.0829
A51	0.1183	0.1953	0.1657	0.0710	0.0651	0.0947	0.0000	0.0414	0.0710	0.1775
A52	0.1270	0.0688	0.0899	0.1693	0.1323	0.1111	0.1217	0.1587	0.0000	0.0212
A53	0.0469	0.1221	0.0376	0.0751	0.0000	0.1643	0.1737	0.1831	0.0892	0.1080
A54	0.1414	0.0657	0.1212	0.0303	0.1263	0.0859	0.1111	0.1364	0.1818	0.0000
A61	0.0560	0.0000	0.1440	0.1360	0.1120	0.0440	0.1480	0.1120	0.1240	0.1240
A62	0.0628	0.0000	0.1728	0.1257	0.1361	0.1361	0.0314	0.0524	0.1728	0.1099
A63	0.0348	0.1891	0.1592	0.0000	0.0995	0.1592	0.0547	0.1493	0.1343	0.0199
A64	0.2069	0.0000	0.1207	0.1839	0.0345	0.0460	0.0402	0.2011	0.0632	0.1034

Table 13: Entropy weight

First-level indicator	Weight	Secondary indicators	Information annoyance	Difference coefficient	Entropy weight
A1	0.1776	A11	0.7107	0.00289	0.0407
		A12	0.6315	0.0048	0.0516
		A13	0.7195	0.00316	0.0393
		A14	0.6714	0.00256	0.0460
A2	0.1653	A21	0.7204	0.00199	0.0392
		A22	0.6494	0.00112	0.0491
		A23	0.7299	0.0033	0.0378
		A24	0.7198	0.00327	0.0392
A3	0.1774	A31	0.7028	0.00141	0.0416
		A32	0.7233	0.00304	0.0387
		A33	0.6551	0.00221	0.0483
		A34	0.6522	0.00436	0.0487
A4	0.1661	A41	0.7296	0.00123	0.0379
		A42	0.7211	0.00488	0.0391
		A43	0.6659	0.00369	0.0468
		A44	0.7330	4.3E-5	0.0374
A5	0.1566	A51	0.7159	0.00116	0.0398
		A52	0.7230	8.86E-4	0.0388
		A53	0.7162	0.00296	0.0397
		A54	0.7263	0.00253	0.0383
A6	0.1620	A61	0.7349	0.00481	0.0371
		A62	0.7177	0.00448	0.0395
		A63	0.6995	0.00164	0.0421
		A64	0.6907	0.0047	0.0433

III. B. 3) Analysis of combined weighting results

Under the premise of knowing the subjective weights and objective weights of the evaluation indexes, the comprehensive weights of the evaluation indexes are calculated based on the formula for calculating the comprehensive weights in the previous section, and the comprehensive weights of the evaluation indexes are shown in Table 14. Taking A11 as an example, the calculation process is as follows:

$$\omega_{A11}^{*}=\frac{0.0892*0.0407}{0.0892*0.0407+0.306*0.0516+\cdots+0.0359*0.0433}=0.0871$$

The remaining evaluation indicators are the same and will not be double-counted.

Table 14: Comprehensive weight of evaluation indicators

First-level indicator	Weight	Secondary indicators	Relative weight	Entropy weight	Comprehensive weight
A1	0.1893	A11	0.0892	0.0407	0.0871
		A12	0.0306	0.0516	0.0378
		A13	0.0344	0.0393	0.0324
		A14	0.0290	0.046	0.032
A2	0.1619	A21	0.0432	0.0392	0.0406
		A22	0.0457	0.0491	0.0537
		A23	0.0347	0.0378	0.0315
		A24	0.0384	0.0392	0.0361
A3	0.1725	A31	0.0427	0.0416	0.0426
		A32	0.0303	0.0387	0.0281
		A33	0.0428	0.0483	0.0495
		A34	0.0448	0.0487	0.0523
A4	0.1706	A41	0.0338	0.0379	0.0307
		A42	0.0422	0.0391	0.0396
		A43	0.0531	0.0468	0.0596
		A44	0.0454	0.0374	0.0407
A5	0.1493	A51	0.0329	0.0398	0.0314
		A52	0.0407	0.0388	0.0378
		A53	0.0433	0.0397	0.0412
		A54	0.0424	0.0383	0.0389
A6	0.1564	A61	0.0320	0.0371	0.0285
		A62	0.0452	0.0395	0.0428
		A63	0.0473	0.0421	0.0478
		A64	0.0359	0.0433	0.0373

III. C. Analysis of the application of topable cloud evaluation models

III. C. 1) Determination of object elements to be evaluated

The residential quality level of Hangzhou large flat project C is selected as the object element to be evaluated, and the value of each index is determined by expert scoring. The evaluation process is to invite 5 experts familiar with the project and 5 engineers engaged in residential development to form a group of 10 experts to jointly score the evaluation indicators for the residential quality of Project C. Although the evaluation process is not consistent, the experts' understanding of the evaluation issue is not uniform. Although the evaluation process of the experts on the evaluation object is not consistent, the principle of scientificity and consistency exists under the premise of ensuring that the experts have a deep understanding of the evaluation issues, are clear about the scoring rules, and that the experts are fair and impartial. In order to ensure the objectivity of the evaluation results and the authenticity of the evaluation data, and to take its average value to get the final evaluation value of each indicator, the initial expert scoring value of each evaluation indicator and the final indicator value are shown in Table 15. It can be clearly seen that the range of each indicator value is 86.4 to 92.5.

III. C. 2) Determination of residential quality assessment levels

The determination of the evaluation grade is based on the determination of the value of each indicator and its weight, according to the evaluation of the value of the meta-indicator and the weight of the indicator obtained in the previous section, to determine the evaluation grade of the quality of the residence, which is “high, medium, basically satisfied, do not satisfy” four levels of describing the quality of the residence. Applying MATLAB program operation, the cloud diagram of residential quality level is obtained, as shown in Figure 3-6. This subsection takes A11, A12, A13 and A14 as examples of the standardized grade cloud diagrams, and the standardized grade cloud diagrams of other indexes are established in the same way. Table 16 shows the finally obtained comprehensive evaluation matrix (correlation matrix), the comprehensive evaluation vector as well as the fuzzy eigen-expectation value (E_{rx}) and entropy value (E_m). The results show that the fuzzy grade characteristic expectation value calculated for this project-level evaluation $E_{rx} = 1.024$, which corresponds to level 1 of the evaluation scale, i.e., it meets the evaluation standard of high-quality residential housing. The credibility factors of the evaluation calculated according to the formula are 0.00004 respectively, which are much smaller than 0.01, indicating that the dispersion of the evaluation results is small, the degree of credibility is high, and the results are credible.

Table 15: The initial expert score value and the final indicator value

Index	1	2	3	4	5	6	7	8	9	10	Indicator value
A11	81	85	99	90	96	87	95	95	85	91	90.4
A12	82	98	82	91	94	81	96	92	82	96	89.4
A13	88	96	82	97	80	85	99	95	95	83	90
A14	96	86	98	97	88	85	87	98	81	91	90.7
A21	93	88	90	91	96	93	80	87	99	82	89.9
A22	86	94	97	89	81	91	84	83	84	86	87.5
A23	97	89	90	90	96	81	88	96	80	82	88.9
A24	95	87	99	83	94	92	98	86	89	100	92.3
A31	84	97	82	85	85	97	89	84	92	99	89.4
A32	89	95	84	98	96	84	90	93	86	89	90.4
A33	81	99	87	90	99	96	90	87	95	84	90.8
A34	87	86	91	86	99	94	87	98	95	98	92.1
A41	98	81	92	94	94	87	99	80	95	98	91.8
A42	86	92	100	83	92	94	85	82	93	99	90.6
A43	89	92	81	86	95	85	88	94	88	90	88.8
A44	93	81	87	93	81	94	96	96	84	90	89.5
A51	84	90	90	96	84	97	99	99	84	95	91.8
A52	87	99	86	82	98	85	97	94	96	90	91.4
A53	93	85	83	87	86	84	94	97	96	99	90.4
A54	84	85	100	93	91	96	91	87	100	98	92.5
A61	89	96	94	81	90	87	86	90	99	80	89.2
A62	85	81	89	98	83	81	96	85	86	80	86.4
A63	97	88	85	85	97	93	98	81	87	87	89.8
A64	96	89	84	84	96	87	93	94	86	80	88.9

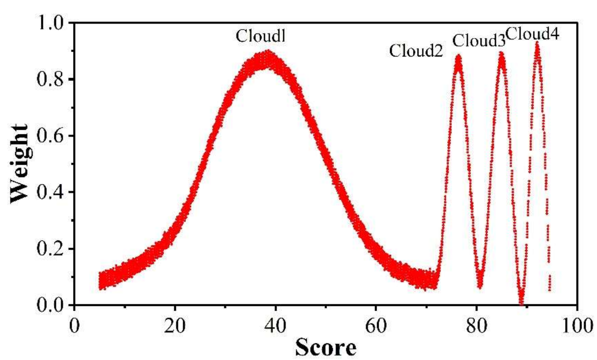

Figure 3: A11 Standard grade cloud map

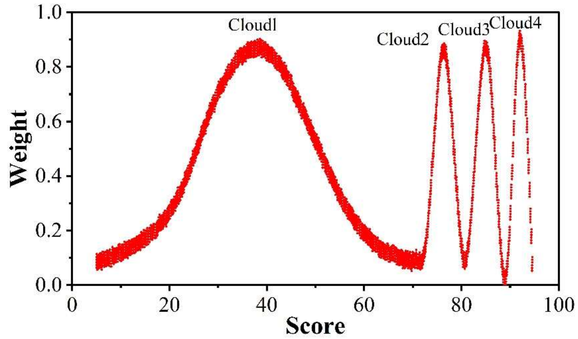

Figure 4: A12 Standard grade cloud map

Table 16: The evaluation result of the residential quality of Project C

Index	Cloud1	Cloud2	Cloud3	Cloud4
A11	0.937	0.0247	0.0195	0.02
A12	0.8085	0.0114	0.0211	0.0188
A13	0.8417	0.0195	0.0226	0.0291
A14	0.9385	0.0222	0.0194	0.0106
A21	0.8425	0.0109	0.0281	0.029
A22	0.8315	0.0161	0.0273	0.0107
A23	0.8213	0.0295	0.0173	0.0261
A24	0.8967	0.0285	0.0148	0.0139
A31	0.9263	0.0114	0.0249	0.0252
A32	0.8589	0.0149	0.0177	0.0167
A33	0.9343	0.0126	0.0137	0.0174
A34	0.9465	0.0216	0.0286	0.0203
A41	0.9153	0.0216	0.0203	0.015
A42	0.8883	0.0193	0.0182	0.0296
A43	0.876	0.0263	0.0233	0.0281
A44	0.8321	0.0131	0.0162	0.0188
A51	0.8086	0.0137	0.0202	0.0122
A52	0.8553	0.0202	0.0231	0.0157
A53	0.9427	0.0166	0.014	0.0268
A54	0.9129	0.0288	0.027	0.0114
A61	0.9015	0.0204	0.0255	0.0286
A62	0.8986	0.0152	0.0194	0.0217
A63	0.9408	0.0255	0.0116	0.0183
A64	0.8889	0.0264	0.0243	0.0236
Comprehensive evaluation vector	0.8852	0.0196	0.0208	0.0203

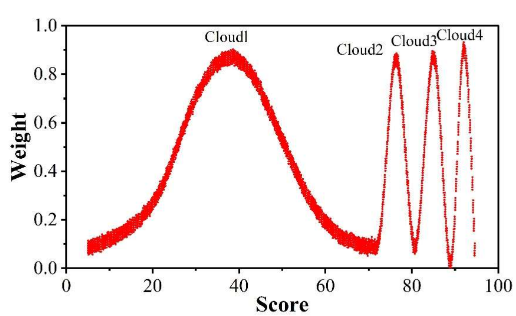

Figure 5: A13 Standard grade cloud map

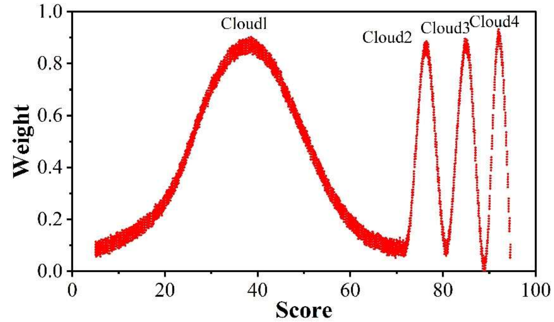

Figure 6: A14 Standard grade cloud map

III. C. 3) Analysis of the results of the evaluation of the living quality of large flat projects

From the above analysis, it can be seen that the final residential quality evaluation grade of Project C is to get, according to the principle of large affiliation, the correlation matrix of each index item and its maximum cloud correlation attributed to the quality grade are listed separately, as shown in Table 17. It can be concluded that Hangzhou large flat project C evaluation indicators, its quality grade are reached high, indicating that the project's indicators of performance is excellent, no quality items to be improved under the current level, has a very good living experience.

Table 17: Project C housing quality evaluation grade of each index

Index	High	Medium	Basically satisfy	Not satisfied	Quality grade
A11	0.937	0.0247	0.0195	0.02	High
A12	0.8085	0.0114	0.0211	0.0188	High
A13	0.8417	0.0195	0.0226	0.0291	High
A14	0.9385	0.0222	0.0194	0.0106	High
A21	0.8425	0.0109	0.0281	0.029	High
A22	0.8315	0.0161	0.0273	0.0107	High
A23	0.8213	0.0295	0.0173	0.0261	High
A24	0.8967	0.0285	0.0148	0.0139	High
A31	0.9263	0.0114	0.0249	0.0252	High
A32	0.8589	0.0149	0.0177	0.0167	High
A33	0.9343	0.0126	0.0137	0.0174	High
A34	0.9465	0.0216	0.0286	0.0203	High
A41	0.9153	0.0216	0.0203	0.015	High
A42	0.8883	0.0193	0.0182	0.0296	High
A43	0.876	0.0263	0.0233	0.0281	High
A44	0.8321	0.0131	0.0162	0.0188	High
A51	0.8086	0.0137	0.0202	0.0122	High
A52	0.8553	0.0202	0.0231	0.0157	High
A53	0.9427	0.0166	0.014	0.0268	High
A54	0.9129	0.0288	0.027	0.0114	High
A61	0.9015	0.0204	0.0255	0.0286	High
A62	0.8986	0.0152	0.0194	0.0217	High
A63	0.9408	0.0255	0.0116	0.0183	High
A64	0.8889	0.0264	0.0243	0.0236	High

IV. Conclusion

Standing on the perspective of living quality, this paper selects 6 first-level indicators and 24 second-level indicators, which together form the evaluation index system of Hangzhou large flat projects. Since the calculation of evaluation index weights by hierarchical analysis alone will have great subjectivity, for this reason, the combination of hierarchical analysis algorithm and entropy weighting method is used to calculate the comprehensive weights of evaluation indexes, and based on the index weights, topology method, and cloud model, it completes the evaluation model of Hangzhou large flat project's living quality, and evaluates and analyzes the project C by using the evaluation model in this paper. It is concluded that the evaluation grade of the living quality of Hangzhou large flat project C is high, and the values of various indicators are distributed in the range of 0.8~0.95, which indicates that Hangzhou large flat project C is very adaptable to the users' living and brings the users' living experience, and also reflects that the development of this project is very close to the users' residential needs.

Funding

This work was supported by Zhejiang Provincial Department of Housing and Urban-Rural Development (Project No: 2020K202).

References

[1] Botti, G. (2023). Dwelling: new forms of housing, new forms of city. In Designing Emerging Markets: A Quantitative History of Architectural Globalisation (pp. 331-382). Singapore: Springer Nature Singapore.

[2] Hung, C. H., Chen, M. C., Tzang, S. W., & Cheng, C. C. (2023). Does high-end housing always have a premium luxury value? A theoretical and numerical study. International Journal of Strategic Property Management, 27(4), 246-260.

[3] Freimane, S. (2022, July). Quality of Apartment Layouts in Contemporary Urban Housing: The Study of Riga. In SPACE International Journal of Conference Proceedings (Vol. 2, No. 1, pp. 19-27).

[4] Soub, N. M. H., & Memikoğlu, İ. (2020). Exploring the Preferences for Micro-Apartments. Online Journal of Art & Design, 8(2).

[5] Mahmoud Mohammed Ahmed, O. (2022). Modern Design for Studio Spaces and Unique Residential Architecture . Journal of Design Sciences and Applied Arts, 3(2), 47-73.

[6] Pham, P. P., Pham, G. N. Q., & Oh, G. S. (2021). Spatial configuration of traditional houses and apartment unit plans in Ho Chi Minh City, Vietnam: A comparative study. Spatium, 34-45.

[7] Yoon, C., Kim, M., Park, J., & Lee, J. (2022). A case study on a flexible floor plan design for South Korean apartments using two types of margins. Open House International, 47(2), 207-217.

[8] Andersson, M., Granath, K., & Nylander, O. (2021). Aging-in-place: Residents' attitudes and floor plan potential in apartment buildings from 1990 to 2015. HERD: Health Environments Research & Design Journal, 14(4), 211-226.

[9] McMurtrie, R. J. (2020). Aesthetics in the high-rise apartment complex: a social semiotic perspective. Social Semiotics, 30(1), 65-88.

[10] Larcombe, D. L., van Etten, E., Logan, A., Prescott, S. L., & Horwitz, P. (2019). High-Rise apartments and urban mental health—historical and contemporary views. Challenges, 10(2), 34.

[11] Andersen, M. A. (2021). Affordable Housing Reimagined: In search of the neighbourly, spacious and rebuildable. Architectural research in Finland, 5(1), 117-129.

[12] Choi, I. Y., Cho, S. H., & Kim, J. T. (2012). Energy consumption characteristics of high-rise apartment buildings according to building shape and mixed-use development. Energy and Buildings, 46, 123-131.

[13] Gong, K., & Nam, J. (2022). Diachronic Changes and Factors Influencing the Exterior Design of High-Rise Apartment Buildings. Buildings, 12(7), 892.

[14] Dohnke, J., & Hölzl, C. (2015). „The Boom of High-rise Apartment Buildings in Buenos Aires ". Housing and Belonging in Latin America, New York: Berghahn, 164-180.

[15] Easthope, H., Palmer, J., Sharam, A., Nethercote, M., Pignatta, G., & Crommelin, L. (2023). Delivering sustainable apartment housing: new build and retrofit. AHURI Final Report, (400).

[16] Ngoc, N. M., Tien, N. H., & Hieu, V. M. (2023). Factors affecting the selling price of luxury apartments in Vietnam. A quantitative analysis. International journal of business and globalisation, 10(Y), 1-19.

[17] Generalova, E., & Generalov, V. (2015, October). Apartments in skyscrapers: innovations and perspectives of their typology development. In Proceedings of the CTBUH 2015 International Conference «Global Interchanges: Resurgence of the Skyscraper City». New York, USA. 26th (pp. 355-362).

[18] Kleeman, A., Giles-Corti, B., Gunn, L., Hooper, P., & Foster, S. (2022). Exploring the design, quality and use of communal areas in apartment developments. Cities & health, 6(3), 480-494.

[19] Whang, S. W., Park, K. S., & Kwon, C. (2024). Influence of aesthetic design elements on residential satisfaction in apartment Based on Seoul apartment complex. Journal of Asian Architecture and Building Engineering, 23(4), 1381-1392.

[20] Schnure, C., & Thompson, A. (2018). Apartment Markets and the Cascade of Demand. Available at SSRN 3153116.

[21] Phong, N. T., & Thu, N. A. (2021). High-class apartment selection factors in Ho Chi Minh City. HO CHI MINH CITY OPEN UNIVERSITY JOURNAL OF SCIENCE-ENGINEERING AND TECHNOLOGY, 11(1), 69-78.

[22] Jayantha, W. M., & Lau, J. M. (2016). Buyers' property asset purchase decisions: an empirical study on the high-end residential property market in Hong Kong. International Journal of Strategic Property Management, 20(1), 1-16.

[23] Dongxiao Chen,Chunqing Li,Rulong Gong & Enlin Jin. (2025). Elevator Selection Methodology for Existing Residential Buildings Oriented Toward Living Quality Improvement. Sustainability,17(7),3225-3225.

[24] Huang Qixin & Gan Huacheng. (2023). Intervention effect of innovation and entrepreneurship education on employment anxiety and living quality of undergraduates. CNS Spectrums,28(S2),S10-S10.

[25] Ghada A. Ragheb & Amany Ragheb. (2021). A Multi-Criteria Decision for Touristic Revitalization of Historic Waterfront Based on AHP Analysis: A Case Study of Ezbet El-Borg City, Damietta, Egypt. IJSDP,16(8),1437-1448.

[26] Guoi Lei,Wangl Linyu,Wang Yongli,Zhang Yuanyuan,Dong Huanran & Zhang Danyang. (2019). Comprehensive Energy Efficiency Assessment of Energy Internet Based on Entropy Weight Method. IOP Conference Series: Earth and Environmental Science,358,032051-032051.

[27] Wenhao Zhu,Yiting Liu,Guannan Hu,Jianyue Ni & Zhiguo Lu. (2018). A Sample Extension Method Based on Wikipedia and Its Application in Text Classification. Wireless Personal Communications,102(4),3851-3867.