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A study on the integration and sustainability of landscape architecture in eco-friendly housing design

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Abstract Improving the ecological living conditions of urban populations is a very crucial livelihood issue, and the construction of eco-friendly housing projects is of great significance for improving people's livelihood and promoting sustainable development. The article analyzes the evolution trend of landscape pattern in eco-friendly housing design through the landscape pattern index, and combines the KANO model and Better-Worse coefficient to analyze the specific needs of households for eco-friendly housing landscape architecture experience. The patch density and sprawl index of eco-friendly housing landscape architecture design were 224.75 and 59.36, respectively, and the core landscape pattern was significantly negatively correlated with the abatement of PM2.5 concentration in eco-friendly housing neighborhoods at the 1% level (-0.714).The origin of the exponential matrix for the Better-Worse coefficient under the KANO model was (0.512, 0.601), the different quadrants show the different needs of users for eco-friendly housing building design. From the dimensions of sustainable landscape and three-dimensional green composition design, the sustainable development strategy of landscape architecture in eco-friendly housing design is proposed, which can help to improve users' satisfaction with eco-friendly housing landscape architecture.

Index Terms sustainable development, landscape pattern index, landscape architecture, housing design, KANO modeling

I. Introduction

Before the construction of ecological residential community, we should take the overall design of the community as the entry point, not only to ensure the smoothness of normal traffic, but also to take into account the aesthetics of the combination of roads and greenery, the landscape routes are reasonably integrated into the design of the road, and to increase the design of the pedestrian-vehicle diversion, so as to ensure the smoothness of the traffic [1]-[3]. In addition, it is also necessary to integrate the fire channel and emergency lane into the design of the road, and set up underground car parks to ensure the rationalisation of the space design of the district [4], [5]. The setting of secondary roads should be designed according to people's travelling pattern and working and resting time, strengthen the anti-skid performance of the road, and apply plastic or better performance of anti-skid material as the construction material of secondary roads to improve the safety of ecological residential communities. In addition, we should also consider the impact of wind direction on the temperature of the community, and apply a reasonable wind control strategy, so that the temperature of the community can be better controlled to provide people with a comfortable living environment [6], [7]. In the ecological residential landscape design, the vegetation landscape is the most important, the reasonable use of vegetation landscape, can enhance the overall ornamental effect, to enhance the cultural connotation to ensure the overall healthy development has a good role [8], [9].

Therefore, when carrying out ecological residential community landscape design, we need to pay attention to the application of green plants, better achieve compound three-dimensional planting, enhance the greening level of the community, and gradually improve the environment [10]. When the community is green plant collocation, as far as possible from the trees, shrubs and evergreen vegetation and other multi-angle application, as far as possible to play out the characteristics of the residential community plant diversity, a better transformation of the original design [11].

In conclusion, under the background of rapid urbanisation, the problem of urban sprawl in China has become more and more prominent, which seriously affects the development and progress of the new urbanisation process in China at this stage [12]. It is precisely for this reason that urban sprawl governance has become an important problem to be solved in the process of urbanisation in China [13]. In this process, China should build an urban sprawl governance model that meets China's national conditions based on successful international urban sprawl governance experiences and the actual national conditions of China, and only in this way can the overall improvement of China's urbanisation level be realised in a real sense [14], [15].

The process of urbanisation has changed people's living standards at the same time, but also made people put forward higher requirements for the living environment. Eco-housing design makes people's living environment become more ecological, better reflecting the ecological beauty of harmonious coexistence between man and nature. Literature [15] based on ecological architecture related books and literature research, try to argue that ecological design originates from the world re-conceptualised as a fluid and complex system, that is, there are many conflicting ideas about ecological architectural design. Literature [16] examines the current practice of eco-architecture concepts in Javanese traditional home design and the main areas of application of eco-architecture concepts, and points out that the practice of eco-architecture concepts is affected by the site conditions, location, and climatic conditions. Literature [17] examined and analysed the Kampung Tongkol community redevelopment project on the banks of the Ciliwung River in Jakarta, which was organised and designed with the participation of community residents based on the concept of sustainable development, and which not only improved the quality of the community's environment, but also contributed to the promotion of the ecological awareness of the residents. Literature [18] combined descriptive statistics, Karl Pearson product-moment correlation, and validated factor analysis to analyse the self-reports of homeowners, and found that the awareness of eco-friendly dwellings promoted the construction of eco-friendly houses, and the study verified that the Theory of Planned Behaviour can be used to explain the construction behaviour of eco-friendly buildings. Literature [19] demonstrates the successful cases and technical experiences of eco-interface design, and deeply analyses the underlying logic and common forms of eco-design, which helps readers to enhance the knowledge of eco-interface design and master the scientific methods of eco-interface. Literature [20] comprehensively analyses design with Nature, a method of combining design and ecology, including the concept of the method, and points out that the current Chinese urban design should be oriented to the combination of nature and aim at sustainable development.

The so-called ecological residential landscape design is to integrate people's daily residential design and ecology with each other, and gradually apply landscape design to it, so as to realise the quasi-convenience of residential design ideas. Literature [21] analyses the product design process of the KTU Landscape Architecture Department and distinguishes between the conceptual and design shaping process, which is used to verify the success of the design process. Literature [22] studied the development of design and creative thinking in the EDP course for landscape architecture students, including teaching methods to develop students' creativity and their use of natural inspiration, which provides an important reference for the optimisation of related courses. Literature [23] used a questionnaire survey to examine the user's preference for public space in shopping centres, and the study recommended that user centres provide public areas with sufficient space and decorate them with green elements and water features, which can provide users with a better visual experience and shopping experience. Literature [24] describes in detail the creation history and landscape technology application of Italian gardens, French conventional parks and British landscape parks, and uncovers the problems existing in these park landscapes, which contributes positively to the design optimisation of park landscapes. Literature [25] analysed the significance of interior landscape for residential houses and tried to analyse the role played by interior landscape inside interior architecture, and concluded that interior landscape adds beauty to interior architecture and improves people's living experience and quality of life. Literature [26] talks about the layout of Roissypole residential area and suggests that the renewal of public facilities should be designed around its social function, so it is argued that the Roissypole area should be designed as an attractive, living area, which can not only enhance the quality of life of the residents and tourists, but also provide a platform for the residents and tourists to share their lives.

This paper proposes an analytical method to quantify the evolutionary trend of eco-friendly housing landscape architecture through landscape pattern indexes, and combines the KANO model to explore the demand of households for eco-friendly housing landscape architecture.

In order to maximize the landscape quality of eco-friendly housing design, it is necessary to dig deeper into sustainable landscape design methods, use reasonable landscape materials, and comprehensively improve the level of landscape design. This paper analyzes the landscape architecture design process of eco-friendly housing. The eco-friendly housing data of T city is selected as the research object, and the evolution trend of eco-friendly housing landscape types is analyzed through the landscape pattern index. The KANO model and Better-Worse coefficient were introduced to analyze the specific needs of households for eco-friendly housing landscape architecture. Based on the results of the above analysis, the optimization design strategy of eco-friendly housing landscape architecture is proposed from the perspective of sustainable landscape and three-dimensional greening composition design.

II. Landscape architectural design for eco-friendly housing

Starting from the cost of landscape architectural design, landscape effect and ecological concepts, the creation of eco-friendly housing landscape design will be used as an effective means to help urban development and enhance the sense of well-being of human settlements. In the specific landscape design practice, the principle of sustainable development is taken as the principle, and the optimization of resources is reasonably allocated. Reasonable use of building materials, the status quo resources, pay attention to follow the ecological landscape design, take the ecological construction priority, scientific and reasonable traffic organization planning, economic and aesthetically pleasing and applicable and benefit supplementation, in the conditions of ecological landscape design to achieve the maximization of the comprehensive benefits.

II. A. Landscape ecology and sustainable development

II. A. 1) Landscape ecology

Landscape ecology will be the combination of geography and ecology to study the environmental impacts of different landscape elements interacting in the same territory [27]. The aim of landscape ecology is to optimize the relationship between humans and the environment and to improve the ecosystems in which humans live. The research scope of landscape ecology is mainly the influence of the spatial structure and morphology of the landscape on life activities, relying on the theory of ecology, absorbing a little bit of geography and other disciplines. The research object and content of landscape ecology can be summarized as three basic aspects:

(1) The structure of the landscape (spatial pattern), the type, diversity and spatial relationship of the landscape constituent units.

(2) Landscape function (ecological process), the interaction between landscape structure and ecological process or the interaction between landscape structure units.

(3) Landscape dynamics (spatial evolution), changes in the landscape in terms of structure and function over time. The structure, function and dynamics of the landscape are interdependent and interact with each other. Landscape ecology is a comprehensive discipline spanning both natural and social sciences.

The theoretical foundations of landscape ecology mainly include the theory of ecological evolution and ecological succession, the theory of spatial heterogeneity and biodiversity, the theory of landscape heterogeneity and heterogeneous symbiosis, the theory of island biogeography and spatial mosaics, the theory of scale effects and natural hierarchical organization, the theory of biogeochemistry and landscape geochemistry, and the theory of ecological construction and ecological location.

II. A. 2) Sustainable development

Sustainable development is defined as a three-pronged model of economic, social and environmental sustainability that meets the needs of current human beings without jeopardizing the needs of future generations themselves. Of these, the economic and social measures are macro-level issues, while the environment and ecology are micro-level issues. Based on these three measures, the scope of sustainable housing design encompasses five aspects, one of which is to ensure that residents have a suitable living environment. The three complement each other, creating a harmonious symbiotic relationship between urban and settlement environments and people, and effective natural environment building and management is crucial to the ecology of housing.

The symbiosis system of housing design under sustainable development is shown in Figure 1, which mainly emphasizes the strategy of realizing symbiosis among residents, architecture and housing ecology, and through the organic combination and collaboration among these elements, it can improve the quality of living and the quality of life, and promote the sustainable development of housing architecture with the design strategy of diversity and flexibility. In the symbiotic design of housing, the sustainable development of housing architecture and the improvement of living quality can be realized through the rational integration and layout of internal and external elements of housing, so as to promote the healthy development of the city.

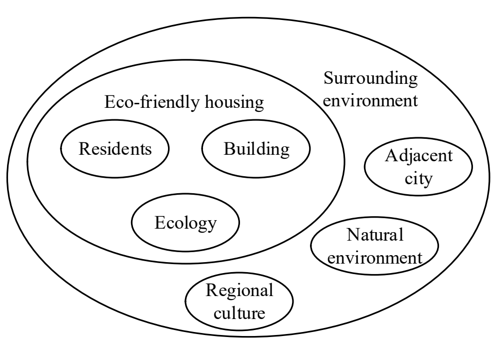

Figure 1: Schematic diagram of symbiotic system construction

II. B.Eco-friendly housing design

II. B. 1) Eco-friendly housing

Eco-friendly residential architecture is an organic combination of sustainable construction concepts and environmentally friendly lifestyles. The design style of luxury is discarded, and the principle of sustainability is taken from the selection of materials to the form of construction, with full consideration of the local climate, construction costs and other factors, and the use of the local landscape to integrate the residential building into nature, so as to bring a livable living experience to the residents [28].

Eco-friendly housing needs to adhere to the principle of sustainable development and environmentally friendly concepts, scientific means and technology, design low energy consumption, green, natural ventilation, good lighting, low energy consumption buildings, fully demonstrate the concept of humanistic architecture, to achieve a harmonious unity of science and technology and environmental friendliness. At the same time, in the process of using the building, its construction address, structural design and construction should also be based on the harmless principle of reducing energy consumption, saving resources and minimizing waste emissions. Eco-friendly housing as a whole is an all-round concept of environmentally friendly and economical construction, including saving land, water resources, energy consumption, improving the ecological environment, reducing all kinds of sound, light and other pollution, and prolonging the life of the building. Therefore, the most fundamental advantages of eco-friendly housing are energy conservation, environmental comfort and recyclability. In the process of rational allocation of resources, humanized, healthy and environmentally friendly livable buildings are designed and constructed.

II. B. 2) Landscape Architecture Design Process

Based on the concepts of landscape ecology and sustainable development, and from the perspective of eco-friendly housing design, this paper proposes an eco-friendly housing landscape architecture design process as shown in Figure 2. Eco-friendly housing landscape architecture design runs through every stage of housing design, and various specialties such as planning, architecture, landscape, structure, ventilation and air conditioning, electrical and intelligent, and economy should cooperate with each other, comprehensively consider the whole life cycle of the building, and adopt building technologies, equipment and materials that are conducive to promoting the sustainable development of the building and the environment.

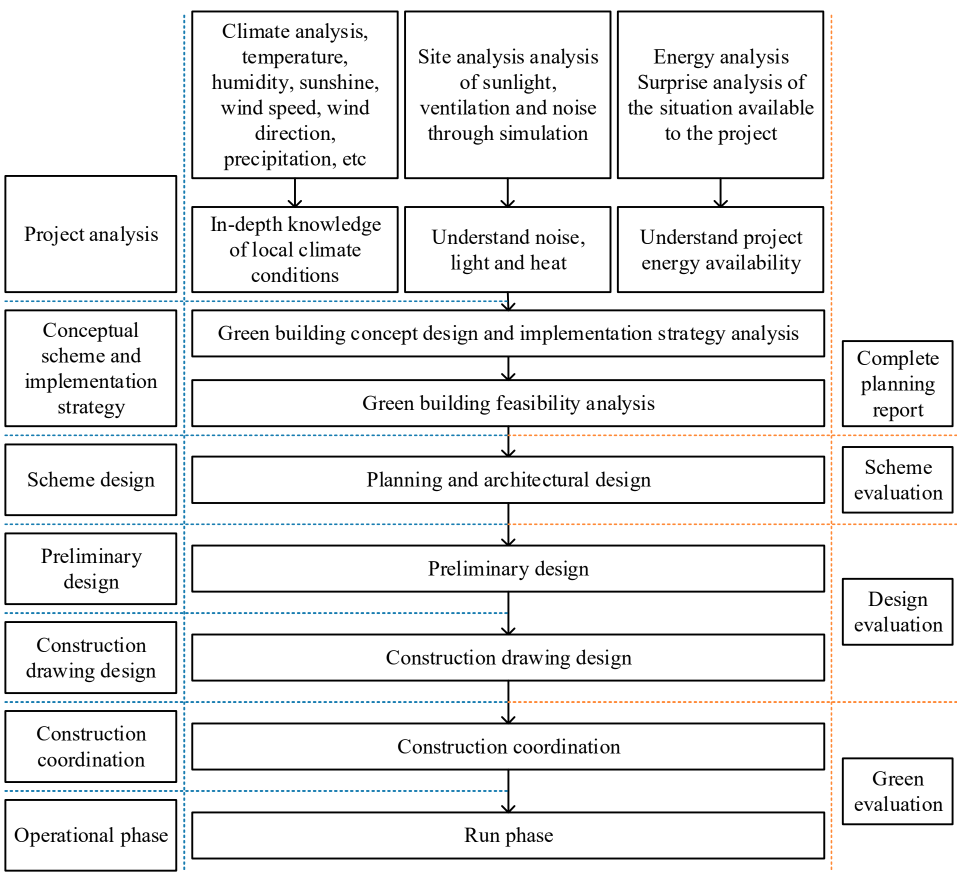

Figure 2: Eco-friendly housing landscape architecture design process

The design concepts of sustainable development and landscape ecology run through the whole life cycle of eco-friendly housing landscape architecture design, not only in the design stage, but also in every aspect of the whole process, taking into account the social and economic benefits.

III. Quantitative calculations for eco-friendly housing landscape design

Driven by the rapid development of the city, residents in housing are not simply satisfied with the building itself, and have begun to pursue higher quality outdoor landscape design. In order to create more livable eco-friendly housing, the integrated design of the site, environment and architecture is optimized through the design of ecological landscapes to achieve harmonious coexistence between people and ecological landscapes, optimize the landscape quality of the human habitat, and achieve sustainable development of eco-friendly housing landscape architecture.

III. A. Data sources and landscape pattern indices

III. A. 1) Data sources for the study area

The vector data for this study come from the fourth T city land survey change data, remote sensing images from GlolbeLand products of the Ministry of Natural Resources, and socio-economic data such as gross regional product and resident population from statistical yearbooks. The vector data is urban housing construction land coded as 201, which contains residential settlements as well as land for commercial services, residential, industrial and other enterprises and institutions in the district according to the TD/T1014 standard.

Referring to the first-level classification standard in the National Classification of Current Land Use, a number of urban housing sites in T City were grouped together to form the T City Housing Construction Land Classification. The landscape architecture construction land in the eco-friendly housing design process is mainly divided into nine categories, such as mixed forest, coniferous forest, broad-leaved forest, shrub forest, transportation land, residential land, garden land, water ponds, and idle land, which are represented by Y1~Y9, so as to facilitate the analysis process in the later section to be more convenient and quicker. Then, with the help of ArcGIS, Frag and other software, the above data were summarized and generalized to form the internal structure data of each collective construction land.

III. A. 2) Landscape pattern index selection

Landscape pattern index is a quantitative index reflecting the connection between landscape pattern structure and phenomenal processes. To characterize the spatial and temporal evolution of landscape pattern in the study area, this paper selected eight indices at the type level and landscape level to analyze the landscape pattern characteristics and evolution patterns [29]. These include number of patches (NP), patch density (PD), mean patch area (MPA), landscape shape index (LSI), aggregation index (COHESION), Shannon diversity index (SHDI), Shannon homogeneity index (SHEI), and Simpson diversity index (SIDI). Their specific calculations are as follows:

(1) The number of patches (NP) can be expressed as:

$$NP = n_i (1 \le NP) \tag{1}$$

where n_i is the number of patches of i types of landscape types, the number value of patches in the landscape, the size of which is closely related to landscape fragmentation, reflecting the heterogeneity of the landscape in the study area.

(2) Patch density (PD) can be expressed as:

$$PD = \frac{n_i}{a_i}(0 < PD) \tag{2}$$

where n_i is the number of category i patches in the landscape, and a_i is the total area of category i landscapes, which indicates the number of patches contained per square kilometer, reflecting the degree of fragmentation of different landscapes in the study area.

(3) The mean patch area (MPA) can be expressed as:

$$MPA = \frac{a_1}{n_i}10^6 (0 < MPA) \tag{3}$$

where a_i is the total patch area of i landscape types, and n_i is the total number of patches, indicating the average patch area size of a landscape type, reflecting the difference in the degree of fragmentation among landscapes in the study area.

(4) The aggregation index (COHESION) can be expressed as:

$$PCI = \left[1 - \frac{\sum P}{\sum P\sqrt{a}}\right]\left[1 - \frac{1}{\sqrt{N}}\right]^{-1} * 100 \tag{4}$$

where A, P is the area and perimeter of the patch, respectively, and N is the number of rasters in the landscape, which indicates the degree of agglomeration of different land use types, reflecting the strength of physical connectivity of different patches in the study area.

(5) The landscape shape index (LSI) can be expressed as:

$$LSI = \frac{0.25E}{\sqrt{A}}(1 \le LSI) \tag{5}$$

where E is the total length of the boundary and A is the total area of the landscape, indicating the ratio of the perimeter of a patch of a given landscape type to the perimeter of a circle of the same area, reflecting the complexity of the shape of the whole and each landscape type in the study area.

(6) Shannon diversity (SIDI) can be expressed as:

$$D = H_{Max} + \sum_{i=1}^{m} (P_i)\ln(P_i)(0 < D < 1) \tag{6}$$

where $H_{\max}$ is the diversity index of the landscape when the proportion of each landscape is the same, describing the extent to which patch types dominate the landscape in the structural composition of the landscape, reflecting the dominance of one or several types of patches in the study area.

(7) Shannon diversity (SHDI) can be expressed as:

$$H = -\sum_{i=1}^{\infty} (P_i)\ln(P_i)(0 \le SHDI) \tag{7}$$

where P_i is the size of i landscape area to the total area, and m is the number of all landscape types, which describes the diversity of landscape types and reflects the richness of land use in the study area [30].

(8) Shannon homogeneity (SHEI) can be expressed as:

$$E = \frac{H}{H_{\text{Max}}} * 100\%(0 \le SHEI \le 1) \tag{8}$$

It mainly describes the unevenness of the distribution of the patches over the area, reflecting the degree of landscape heterogeneity in the study area.

III. B. KANO model with Better-Worse coefficient

III. B. 1) KANO model fundamentals

The KANO model is essentially a satisfaction evaluation system, where data are collected through questionnaires and the corresponding data results are obtained after assigning values to different options [31]. Subsequently, with the help of different processing methods to get the type of demand and priority ranking of each test item, so that it can be transformed thinking and re-examine the traditional problems by transforming qualitative problems into semi-quantitative problems.

The KANO model suggests that the relationship between user satisfaction and quality characteristics may not always be linear, and the KANO model curve is shown in Figure 3, where the horizontal coordinate is the degree of realization of that product or service in a single function, and the vertical coordinate is the user's satisfaction with its degree of realization. Also the KANO model divides the factors affecting user satisfaction into six types, namely, Must-have needs (M), Expected needs (O), Attractive needs (A), Undifferentiated needs (I), Reversed needs (R), and Uncertain needs (Q).

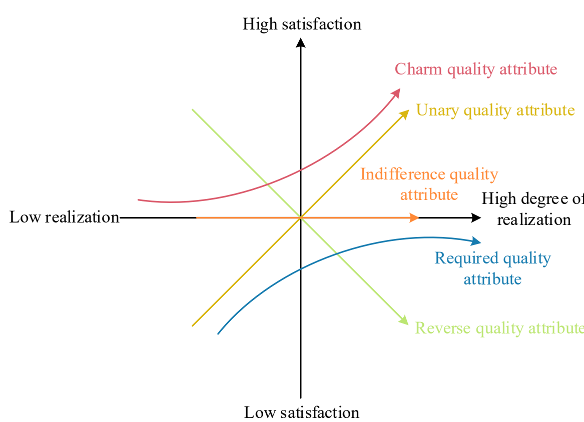

Figure 3: KANO model curve diagram

Necessary needs are the most basic needs of the target user for a product or service, i.e. the attributes that the product must have. Desired needs are needs where the user's satisfaction is positively proportional to being satisfied, and when such needs are satisfied, the user's satisfaction increases significantly. Charismatic needs represent types of needs that are not part of the user's original needs. For this type of need, as the user's expectations increase, the corresponding user satisfaction will rise sharply, even if the actual performance is average, the positive impact on the user is also very large, but if it is not met, the user will not show significant dissatisfaction. Non-differentiated needs are needs that do not affect the level of user satisfaction and do not cause significant fluctuations in user satisfaction, regardless of whether they are provided or not, and to what extent. Reversed demand refers to product or service characteristics that cause strong dissatisfaction among users. Contrary to expected demand, the existence of reversed demand causes dissatisfaction among users, and as the degree of fulfillment increases, the level of user satisfaction decreases.

III. B. 2) Better-Worse coefficients

The application of the KANO model relies on three core tools, namely a questionnaire, a quality characteristic evaluation form, and a results analysis form. These tools are used to collect and analyze the specific needs of the users, which are then categorized and prioritized. This process helps to identify key factors that can significantly enhance user satisfaction, providing an important reference and guideline for eco-friendly housing during the design and development process.

In order to better quantify the demand changes in the KANO model, existing studies have proposed a satisfaction coefficient to optimize the KANO model. The coefficient is a measure of the potential impact of service or product features and functions on increasing user satisfaction or reducing dissatisfaction. Its computational expression is:

$$\text{User satisfaction coefficient } SI=\left(A+O\right)/\left(A+O+M+I\right) \tag{9}$$

$$\text{User dissatisfaction coefficient } DSI=\left(O+M\right)/\left(-1\right)*\left(A+O+M+I\right) \tag{10}$$

With this coefficient, if the product quality fails to meet the established criteria, a negative sign is introduced in the formula showing its negative effect on user satisfaction. The coefficient of user satisfaction is defined in the range [-1,1], in the positive interval [0,1], values close to 1 have a greater positive effect on user satisfaction, values close to 0 indicate a lesser effect, and a value of zero implies that the feature does not trigger dissatisfaction. In the negative interval [-1,0], if the coefficient tends to -1, it indicates that the feature characteristic contributes significantly to user dissatisfaction.

IV. Evolution and evaluation of eco-friendly housing landscape patterns

Eco-friendly housing construction landscape design is based on traditional architectural design, according to the natural environment of the current construction area, using the basic principles of ecology, architecture and modern scientific means, reasonably arranging and organizing the distribution of functional areas in residential buildings. In the design process, the principle of overall and environmental priority, the principle of simple and efficient development, the principle of health and comfort. The effective planning of the landscape pattern is better realized, so as to give the users a more superior ecological environment and provide them with a more healthy, comfortable and safe living environment.

IV. A. Evolution of the landscape pattern of housing buildings

IV. A. 1) Overall and Landscape Component Patterns

The Geo TIFF grid(.tif) data of the overall and each landscape component type were obtained by converting to grid in ArcGIS conversion tool, and the data were imported into Fragstats to get the values of the selected indexes. Using the calculation method of landscape pattern index given in the previous section, the landscape pattern of landscape architecture-related construction land types in different eco-friendly housing design processes was obtained as shown in Table 1.

As can be seen from the table, in the process of landscape architecture design for eco-friendly housing design, the patch density of landscape architecture design for eco-friendly housing is low only 224.75, the Shannon Diversity Index (SHDI) and the Shannon Homogeneity Index (SHEI) are 4.47 and 0.75, respectively, which are at a medium level of evolution, and the Spreading Degree Index (PCI) is 59.36, which indicates that in the study area The physical connectivity between the various landscape buildings is strong, providing support for the co-creation of eco-friendly housing landscapes.

The size order of patch density (PD) was garden land (Y7) > residential land (Y6) > water pond (Y8) > idle land (Y9) > transportation land (Y5) > woodland (Y1~Y4), indicating that the degree of sporadic and scattered distribution and fragmentation of garden land, residential land, and water pond were higher than that of other landscape components. In woodland, the patch density of broadleaf forest (Y3) was 306.24, which was much higher than other component types, indicating that the distribution of broadleaf forest in the eco-friendly housing landscape design process was more fragmented than other woodland types. The edge density (ED) of transportation land has the largest edge density of 5323.18, and the size of the edge density of other landscape components except transportation land compares with the patch density.

Except for transportation land, the degree of landscape fragmentation (DIVI) of other landscape component types are close to 1, and the closer the value is to 1, the more serious the degree of landscape fragmentation. Therefore, except for transportation land, all other landscape component types have significant degree of segmentation. The mean patch area (MPA) of transportation land is the largest at 16.03, indicating that the shape of transportation land is more irregular and complex. The area index of water ponds was the smallest at 1.26, which is because the spatial shape of water ponds in the study area is close to circular, which is influenced by the landscape architectural design of eco-friendly housing. In addition, the evolutionary trends of the Spreading Index (PCI), Shannon Diversity Index (SHDI) and Shannon Homogeneity Index (SHEI) were more consistent, and the Shannon Diversity Index played a greater role in diversifying the landscape architectural design of eco-friendly housing. The highest Shannon homogeneity index of the garden (Y7) was 0.95, indicating that in the design of eco-friendly housing landscape architecture, the design of the garden for the housing building space is relatively the most uniform distribution, which better reflects the eco-friendliness of housing architecture.

Table 1: Index analysis of the overall study area and each landscape component

Type	PD	DIVI	ED	LPI	MPA	PCI	SHDI	SHEI
Y1	65.42	0.91	576.18	13.75	2.35	58.42	3.05	0.82
Y2	62.18	0.74	483.64	23.02	1.63	55.48	1.47	0.91
Y3	306.24	0.83	1151.42	19.38	2.15	58.32	2.35	0.83
Y4	129.83	0.82	816.37	23.65	1.79	55.46	2.21	0.85
Y5	165.41	0.26	5323.18	84.35	16.03	97.16	0.09	0.03
Y6	2033.94	0.95	2332.71	12.24	1.42	55.35	4.05	0.91
Y7	5841.59	0.93	4424.56	13.57	1.43	51.48	2.43	0.95
Y8	1479.78	0.84	2106.89	24.33	1.26	53.27	1.82	0.92
Y9	735.86	0.92	1849.73	16.42	2.29	56.89	3.69	0.87
Total	224.75	0.97	469.32	5.74	2.94	59.36	4.47	0.75

IV. A. 2) Analysis of the landscape pattern of settlements

After analyzing the changes in landscape patterns of eco-friendly housing landscape architecture in the study area as a whole, seven eco-friendly residential catchment areas (X1~X7) were randomly selected to carry out detailed analysis. The landscape pattern index value was calculated using the landscape pattern software Fragstats, and the results of the landscape pattern index calculation of eco-friendly housing landscape architecture in different settlement areas were obtained after finishing as shown in Table 2.

Overall, the total number of neighborhood landscape patches in the construction scale of eco-friendly housing landscape architecture is 109, the maximum patch index is 0.05, the average patch area is 0.16 hm2, the patch density is 3.52 patches/km², and the spreading index is 58.38. As for the morphology characteristics, the Shannon Diversity Index (SHDI) and Shannon Homogeneity Index (SHEI) are 1.37, 1.09. The landscape pattern characteristics of each eco-friendly housing settlement cluster differed significantly as follows:

(1) Scale characteristics: the total number of landscape patches in X1 neighborhood was 21 at most, and the number of landscape patches in X4 neighborhood was the least, only 8, but the maximum patch index and the average area of patches in this area were in the first place, 0.26hm2 and 0.34hm2, respectively, and the degree of agglomeration was higher than that in the other neighborhoods.

(2) Agglomeration characteristics. X7 plot has the largest plaque density of 7.69/km², which is related to the smaller area of the plot. X4 plot has the smallest plaque density and the largest spreading degree of prime, and the landscape patches are more sparsely distributed.

(3) Morphological characteristics. There is little difference in the morphology of landscape patches in each eco-friendly housing neighborhood, but the landscape patches in X6 neighborhood are relatively irregular and fragmented.

In general, the landscape patches in each eco-friendly housing neighborhood have obvious differences in scale and agglomeration characteristics, and smaller differences in morphological characteristics. It is mainly manifested that the landscape pattern of eco-friendly housing neighborhoods with better traffic location conditions has obvious advantages in scale and agglomeration characteristics, with more total number of patches, larger maximum patch index and average area of patches, correspondingly higher value of patch density index, and correspondingly more agglomerated patches.

Table 2: Calculation results of landscape pattern index

Index	X1	X2	X3	X4	X5	X6	X7	Total
ND	21	18	12	8	13	20	17	109
LPI (hm^2)	0.35	0.06	0.08	0.26	0.09	0.21	0.18	0.05
MPA (hm^2)	0.17	0.09	0.11	0.34	0.13	0.24	0.11	0.16
PD (km^{-2})	3.74	3.26	2.63	1.89	2.51	5.18	7.69	3.52
PCI	45.23	46.38	48.59	65.46	62.48	55.34	52.76	58.38
SHDI	1.34	1.26	1.22	1.43	1.35	1.51	1.32	1.37
SHEI	1.09	1.07	1.06	1.11	1.12	1.15	1.08	1.09

IV. A. 3) Landscape pattern pattern ecological benefits

When designing eco-friendly housing landscape architecture, different landscape pattern combinations make the landscape pattern of housing design change, and the purpose of landscape pattern combinations is to create more environmentally friendly and sustainable housing communities. In this paper, different landscape patterns are combined into six patterns: core, island, edge, ring, bridge and branch, which are represented by Q1~Q6 respectively. For the eco-efficiency of different landscape patterns, TSI DustTrak aerosol monitor was used to measure the PM2.5 concentration inside the settlement. The abatement rate and the abatement amount were selected as the evaluation indexes, and the obtained data were input into SPSS software for bivariate correlation analysis to obtain the relationship between landscape pattern morphology and PM2.5 abatement as shown in Table 3. Where *,** denotes significant at 5% and 1% level (two-tailed), respectively.

As can be seen from the table, PM2.5 concentration abatement in eco-friendly housing communities was found to be significantly negatively correlated with core landscape morphology at Sig.<0.01 (-0.714), significantly positively correlated with branching landscape morphology at $p<0.05$ (0.683), and positively correlated to some extent with insularity and bridging.The rate of PM2.5 concentration abatement was found to be significantly positively correlated with both core and branching landscape morphology at Sig. .<0.01 were significantly correlated, with Pearson's correlation coefficients of -0.701 and 0.776, respectively, indicating some degree of negative correlation with the core landscape pattern and some degree of positive correlation with the branching landscape pattern. The core represents the central area of green space for eco-friendly housing landscape architecture, which can be manifested in blocky green areas such as open lawns and grouped woodlands within the settlement. However, the core landscape pattern is negatively correlated with PM2.5 abatement, implying that the increase of concentrated green space, especially the increase of large-area blocky arboreal communities within the settlements will reduce the purification rate of PM2.5. Since the plant abatement of particulate matter has an obvious distance effect, its abatement effect decreases as the horizontal distance from the plant boundary increases as a power function. Branches are residual elements that are difficult to constitute other spatial morphology indicators, which can be manifested in the plant communities of settlements as strips of trees, shrubs, etc. that cannot be connected into a system, and are mostly distributed in the boundary area of the core. As a supplement to the spatial form of green space in eco-friendly settlements, more branching increases the complexity of its spatial form and the complexity of green space edges. And being connected to the core increases the stability of the green space system. The positive correlation effect of silos on PM2.5 abatement is basically the same principle as the reduction of core occupancy. Increasing the proportion of silos, i.e., using decentralized small green space patches in limited space within a settlement, can expand the effective adsorption area of plants and enhance the abatement of fine particulate matter.

Table 3: Landscape pattern ecological benefit

Type	Reduction rate		Reduction quantity	
	Pearson	Sig. (2-tailed)	Pearson	Sig. (2-tailed)
Q1	-0.701**	0.002	-0.714**	0.003
Q2	0.335	0.352	0.683*	0.032
Q3	-0.293	0.445	-0.616	0.087
Q4	0.151	0.749	0.325	0.428
Q5	0.345	0.372	-0.093	0.814
Q6	0.776**	0.005	0.472	0.185

IV. B. Landscaping needs for housing buildings

IV. B. 1) KANO questionnaire design

After a comprehensive analysis of the demand for eco-friendly housing architectural landscape and the evolution of landscape pattern through the research households, this study is mainly based on the theory of Donald Norman will be the user's experience, through the eco-friendly housing architectural landscape of the collection, collation and research analysis. In reference to the scholars of eco-friendly housing landscape design and related questionnaire design based on the combination of the actual situation of eco-friendly housing architectural landscape design on-site investigation, and finally designed the eco-friendly housing architectural landscape design experience needs evaluation questionnaire.

A two-way questionnaire was established through the screening of households' demand for eco-friendly housing architectural landscape design. Positive and negative questioning methods were used for households that had experienced relevant eco-friendly housing buildings to gain a deeper understanding of the design needs of households for eco-friendly housing landscape architecture. The content of the questionnaire is shown in Table 4, which mainly contains three dimensions: access service, public recreation and landscape setting. For each question, households were asked to choose one of five response options, which corresponded to don't like, barely accept, don't care, should have, and like very much, quantified on a scale of 1 to 5. This questionnaire methodology was designed to provide a more detailed understanding of the occupants' preferences for eco-friendly housing landscape architecture, with the aim of having a clear understanding of the specifics of different occupants, and to provide occupants with a comprehensive view of the experiential demand element attributes, so that they could be analyzed.

Table 4: Eco-friendly experience requirements for residents

Dimension	Explanation	Code
Passage service	Walkthrough	L1
	The takeaway parking area	L2
	Expand entertainment square	L3
Public leisure	Add a healthy walk	L4
	Additional leisure seating	L5
	Increasing lighting system	L6
	Additional monitoring equipment	L7
	Set the navigation mark	L8
Landscape Settings	Landscape ease of use	L9
	Environmental coordination	L10
	Landscape suitability	L11
	Layout rationality	L12
	Landscape features	L13

A total of 240 questionnaires were distributed and 232 valid questionnaires were finally recovered. Based on the results of the valid questionnaire research, SPSSAU was used to analyze the data, and according to the KANO evaluation table, the elements of necessary, expected and charismatic needs were screened, and the undifferentiated and reverse needs that would not have an impact on the households were eliminated.

IV. B. 2) KANO attribute segmentation results

Based on the data from the questionnaire, the KANO model was used to identify the demand elements based on the established questionnaire on user experience demands for eco-friendly housing landscape architecture. The data were processed according to the previously described method, and the frequency of the four main attributes M, O, A, and I corresponding to each pathway demand item was counted by asking the respondents' positive or negative answers to various demand items, and then this information was put into the matrix for the division of the demand types to obtain the frequency of the household's experience demand factors of ecologically friendly housing landscape architecture, as shown in Table 5.

Among the user experience demands of eco-friendly housing landscape architecture design, dredging sidewalks (L1), expanding entertainment plazas (L3), adding leisure seats (L5), increasing lighting systems (L6), installing navigation signs (L8), appropriateness of landscape scale (L11), rationality of layout (L12), and landscape modeling features (L13) belong to the essential type of demand (M). Exclusive take-out parking area (L2), health trail (L4), landscape ease of use (L9), and environmental harmony (L10) are desired requirements (O). The addition of surveillance equipment (L7) is an Attractive Demand (A). There are no undifferentiated needs, reverse needs, or uncertainty needs.

Table 5: Statistics on frequency statistics for demand factors (%)

Dimension	Code	M	O	A	I	R	Q	Type
Passage service	L1	43.27	15.76	8.42	27.65	4.24	0.66	M
	L2	18.45	50.18	10.37	18.51	2.41	0.08	O
	L3	38.53	20.24	21.59	17.44	2.08	0.12	M
Public leisure	L4	28.19	33.67	30.15	6.13	1.29	0.57	O
	L5	35.15	22.43	21.51	13.72	5.63	1.56	M
	L6	39.86	23.52	20.43	12.17	3.58	0.44	M
	L7	16.42	18.51	33.42	23.15	5.71	2.79	A
	L8	29.58	22.14	28.15	16.38	3.24	0.51	M
Landscape Settings	L9	18.79	36.75	23.27	12.83	6.52	1.84	O
	L10	20.15	33.43	26.28	13.59	4.27	2.28	O
	L11	42.59	18.52	20.95	14.71	2.98	0.25	M
	L12	38.94	23.76	33.43	3.75	0.11	0.01	M
	L13	40.27	16.52	20.79	13.48	7.25	1.69	M

IV. B. 3) Better-Worse coefficient analysis

Based on the KANO demand attribute situation given in section 4.2.2, combined with the Better-Worse coefficient calculation method in the previous section, the Better-Worse sub-coefficients of the user's experiential demand for the landscape architectural design of eco-friendly housing are obtained as shown in Figure 4. The satisfaction coefficient is taken as the horizontal axis, while the absolute value of the dissatisfaction coefficient is taken as the vertical axis, and the mean (0.512,0.601) is taken as the origin of the coordinates to construct the satisfaction Better-Worse index matrix.

The first quadrant is defined as the situation where the absolute values of both the Better coefficient value and the Worse coefficient are relatively large is the desired type of demand, whose Better coefficient and Worse coefficient are both greater than 0.55. There are 10 items in this quadrant, which include the dedicated take-out parking area (L2), the addition of a healthy walkway (L4), the ease of use of the landscape (L9), and the reasonableness of the landscape layout (L12) for the desired type of housing needs for eco-friendly housing landscape architecture design.

The second quadrant indicates that when the Better coefficient value is low and the absolute value of the Worse coefficient is high, i.e., when the Better coefficient is less than 0.55 and the Worse coefficient is higher than 0.60 as the required type of demand. The results show that among these 13 indicators, clearing sidewalks (L1), expanding recreation plazas (L3), adding recreational seating (L5), increasing lighting systems (L6), landscape scale appropriateness (L11), and landscape styling features (L13) are essential needs.

The third quadrant indicates that situations with low absolute values of both Better coefficient values and Worse coefficients are undifferentiated needs. This quadrant contains no task content, indicating that there is no undifferentiated need for occupants to experience eco-friendly housing landscape architecture.

The fourth quadrant indicates that if the Better value is higher and the absolute value of the Worse coefficient is lower, when the Better coefficient exceeds 0.55 and the Worse coefficient is lower than 0.60, it is an attractive demand. 13 demand indicators, including the installation of additional monitoring equipment (L7), the installation of navigational signage (L8), and the coordination of the environment (L10), belong to the attractive demand.

In summary, it can be seen that in the landscape architectural design of eco-friendly housing, it is necessary to give full consideration to the user's demand for landscape architecture, fully realize the ease of use of the landscape and the rationality of the layout, combined with the suitability of the landscape scale and the modeling characteristics to achieve the coordination of the eco-friendly housing environment, and to provide assistance for the enhancement of the user's ecological environment and the living experience.

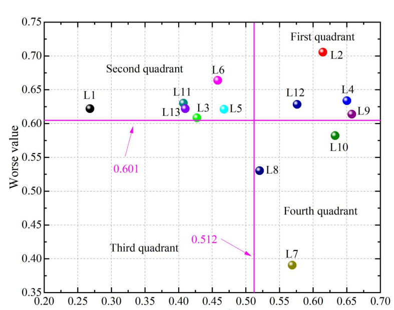

Figure 4: Analysis of the coefficient of Better-Worse

IV. C. Eco-friendly housing landscape design

Based on the results of the analysis of section 4.1 and 4.2 on the landscape pattern of eco-friendly housing and user experience needs, this paper optimizes the landscape architectural design of eco-friendly housing from the perspective of sustainable landscape design. It tries to meet the daily ecological needs of the residents and improve the quality of life of the users.

IV. C. 1) Sustainable landscape design

(1) Sustainable development of settlements. A high-quality and healthy living environment should take into account the functional layout of the building itself and the sustainable development of the wider community. Different users have different requirements for living space, and a variety of functional layouts can help meet different living requirements and improve the efficiency of living space. At the same time, low-cost sustainable housing should also pay attention to outdoor lighting, community safety, public space, sense of community belonging and potential neighborhood relations. This requires a clear positioning and accurate site selection at the beginning of the project design, considering the long-term development of the region, minimizing the pressure of new local infrastructure, and taking into account the development of interpersonal relationships among the residents.

(2) Collaborative Design. Coordinate different disciplines and technologies to promote the realization of low-cost and high-efficiency housing. By coordinating the various disciplines through design, unnecessary additional inputs can be reduced, and initial construction costs and building operation and maintenance costs can be reduced while guaranteeing performance. Relying on the synergistic construction of different landscape types to innovate eco-friendly housing landscape architecture, as a way to enhance the occupants' sense of dependence on the residential ecological environment, so that they feel happy and comfortable physically and mentally.

IV. C. 2) Three-dimensional greening composition design

Eco-friendly housing three-dimensional greening landscape form including point, linear, surface and three-dimensional landscape, landscape plant levels are rich, mostly using groundcover plants and trees, shrubs and shrubs in combination with the planting method, plant growth is good, the ecological environment is stable. Mainly from the following strategies to optimize the three-dimensional greening landscape design methods:

(1) Point composition design strategy. Three-dimensional greening in the point composition method, mainly decorative facade, the use of point composition, so that the original single facade appears more lively, but also more in line with the environmental atmosphere, highlighting the greening effect.

(2) Line composition design strategy. Flexible line elements can not only create a variety of landscape effects, but also reflect a certain spatial rhythm, the building façade to form a rhythmic three-dimensional composition from top to bottom, so that the city's streetscape is more rich. Through the line composition design method, can effectively break the original monotonous, make the neighborhood façade more rhythm and rhythm.

(3) Surface composition design strategy. Surface composition design strategy is suitable for eco-friendly housing community building walls, walls on both sides of the road, the façade of the public activity space, the surface composition of the three-dimensional green landscape effect can highlight the wholeness and completeness of the landscape, bringing a strong visual impact to the pedestrians.

V. Conclusion

The article analyzes the trend of eco-friendly housing landscape pattern evolution through the landscape pattern index, combines with the KANO model to analyze the specific needs of households for eco-friendly housing landscape architecture, and in this way puts forward the design strategy of eco-friendly housing landscape architecture.

(1) The patch density of eco-friendly housing landscape architecture design is low only 224.75, and the values of SHDI and SHEI are 4.47 and 0.75 respectively, which are at the medium evolution level. The Spreading Degree Index (SDI) was 59.36, indicating a strong physical connectivity between individual landscape buildings in the study area. Through the evolution of landscape types in landscape architectural design, the influence of landscape categories on the landscape architectural design of eco-friendly housing can be clarified to provide improvement ideas for optimizing landscape architectural design.

(2) The PM2.5 concentration abatement and abatement rate in eco-friendly housing neighborhoods are both significantly negatively correlated with the core landscape form at Sig.<0.01, and the correlation coefficients of the two are -0.714 and -0.701, respectively, and significantly positively correlated with the branching landscape form at $p<0.05$. The large-area plant particles in the core landscape combination form will significantly reduce the abatement efficiency of PM2.5 concentration, so it is necessary to adapt to the local conditions and grasp the appropriate distance of the landscape combination in order to realize the maximum ecological benefits when establishing the landscape combination form.

(3) Different needs of residents of eco-friendly housing landscape architectural design there are different expectations, in order to better meet the expectations of residents need to fully meet their needs, in order to create a more comfortable ecological living environment.

In conclusion, the design strategy of eco-friendly housing landscape architecture is proposed from the two dimensions of sustainable landscape and three-dimensional greening composition design, which provides guidance for optimizing the living experience of tenants and enhancing the ecological benefits of landscape architecture.

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