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Investigating the Satisfaction of Residents in the Historic Center of Macau and the Characteristics of the Townscape: A Decision Tree Approach to Machine Learning

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Abstract: The historic city of Macau is China's 31st world heritage site, and its residents have actively contributed to preserving its heritage and will continue to reside there for the foreseeable future. Residents' satisfaction with the current urban environment is closely related to the landscape characteristics of the towns surrounding the historic center of Macau. This study aims to analyze the relationship between landscape characteristics and residents' satisfaction, determine the key factors affecting their satisfaction and how they are combined, and provide a scientific basis for urban planning. This study used a decision tree machine learning model to analyze 524 questionnaire survey responses that addressed five aspects of the historic town's landscape: the architectural, Largo Square, street, mountain and sea, and commercial landscapes. The data-driven approach helped find the best decision path. The results indicate that (1) the layout of Largo Square, the commercial colors and materials, the location of the former humanities and religion center, and the commercial signage system are the primary factors influencing residents' satisfaction. (2) Incorporating decision tree parameters with information entropy as the splitting criterion and a minimum sample split number of two (with no maximum depth) led to the best performance when investigating residents' satisfaction with Macau's historic town landscape characteristics. (3) A reasonable layout for Largo Square (satisfaction > 3.50), prominent and harmonious commercial colors and materials (satisfaction > 3.50), rich cultural and religious elements (satisfaction > 4.50), and an excellent commercial signage system (satisfaction > 4.00) can significantly improve residents' satisfaction. This provides important empirical support and a reference for urban planning and landscape design in Macau and other historical and cultural cities.

Keywords: world heritage; historic urban landscape; townscape characteristics; historic built environment; satisfaction questionnaire analysis; decision tree; machine learning

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1. Introduction

1.1. Research Background

As a world heritage site, the historic center of Macau exhibits historical layers [1,2]. The values and attributes of nature and culture are intertwined and gradually develop over generations to adapt to the ever-changing environment. The historic center of Macau has an extremely rich and unique historical heritage, and the landscape has extraordinary value and significance for the cultural groups living there [3,4]. These historical urban landscapes, driven by dynamic forces, continue to change in response to evolving urban development needs [5]. Together, they create urban residents' core living environments. However, the waves of urbanization and globalization have brought huge challenges to the historic center of Macau, causing problems, such as cultural discontinuity and the homogenization of urban landscapes, reducing residents' sense of identity and belonging to the city [6–8]. Furthermore, the conflict between heritage protection and rapid urban development may harm residents' quality of life in the heritage area.

Located in the Macau Peninsula area and Largos, the historic center of Macau comprises 22 buildings, with the old city serving as its central hub [9]. At the 29th UNESCO World Heritage Committee meeting on 15 July 2005, its inclusion in the "World Heritage List" was unanimously approved by 21 member states, leading to it becoming China's 31st world heritage site [10,11]. The historical center of Macau comprises many Largo spaces and buildings originally constructed in the oldest part of the city. Its specific location is in the west-central part of the Macau Peninsula, within the surrounding area of Jardim de Luis de Camões, extending southwards. To the southwest, it reaches Colina da Penha; to the west, it reaches as far as Avenida de Almeida Ribeiro, near the inner harbor pier; and in the center, it reaches as far as Colina da Guia and its surroundings. These regions constitute the historic center of Macau (Figure 1).

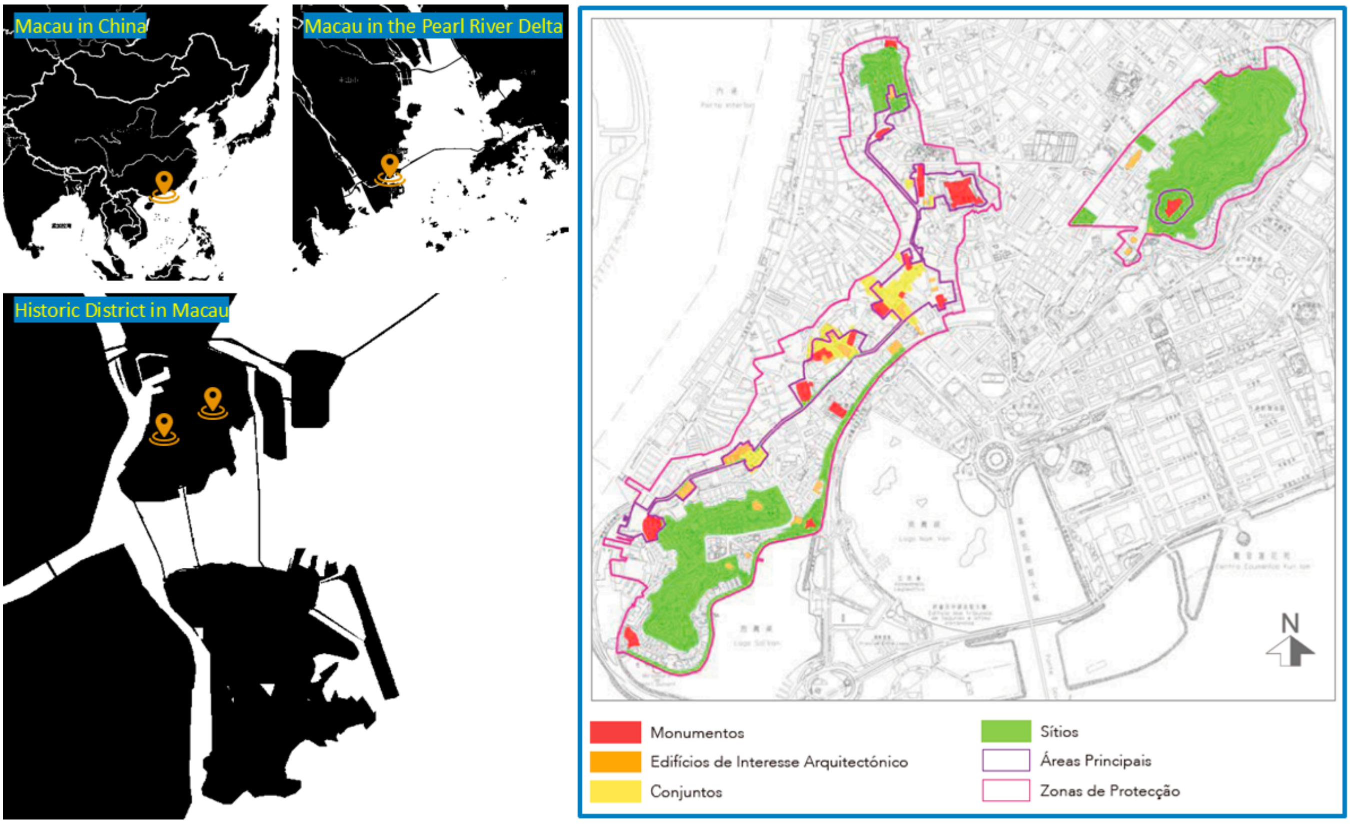

Figure 1. Location of the historic center of Macau. The word "Monumentos" in the picture means "Monuments"; "Edificios de interesse Arquitectonico" means "buildings with artistic value"; "Conjuntos" means "building complex"; "Sitios" means "mountains and other major green spaces"; "Areas Principais" means "World Heritage Area"; "Zonas de Proteccao" means "buffer protection area". The orange positioning symbol in the figure corresponds to the annotation in the upper left corner. (Image source: the authors adapted the image based on the Protection and Management Plan content for the historic center of Macau).

Historic buildings dominate the spatial layout of the historic center of Macau, with traditional streets serving as the surface and urban squares and public spaces as the core [12–14]. The buildings interconnect and disperse among themselves. Macau is China's oldest and best-protected ancient city. One of its most prominent features is that it links Chinese and Western culture, esthetics, and architecture. It integrates Chinese and Western architecture into one urban area, making them interdependent without any incompatibility.

The value of the Macau historic center is immeasurable. It preserves not only the streets, squares, buildings, etc., that we can see with the naked eye but also the cultural and spiritual witnesses of China and Western countries (mainly Portugal). According to data, many buildings in the historic center of Macau have left an important mark on Chinese history, such as the oldest church, cemetery, and Western-style forts and China's first Western-style university, Western-style hospital, and modern lighthouse [14,15]. These buildings perpetuate the exchange between China and the West. The city fosters interactions and advancements in culture, architecture, and public areas. Therefore, paying attention to residents' quality of life satisfaction in heritage areas is also important in protecting and analyzing historic districts.

1.2. Literature Review

The research on the satisfaction of world heritage sites divides the population into two major groups: residents and tourists. Currently, many studies have focused on tourist satisfaction at world heritage sites, for example, the Renaissance monumental sites of Úbeda and Baeza in Spain [16], Córdoba in Spain [17], Zanzibar Stone Town in Tanzania [18], Alhambra and Generalife in Granada, Spain [19], Malacca in Malaysia [20], and other famous world heritage sites. These studies mainly focus on tourist experience and expectations, service quality, cultural and educational value, sustainable development, tourist behavior, loyalty, management, and policy. This can assist managers of world heritage sites in better understanding tourist needs, improving tourist satisfaction, and achieving sustainable heritage development and protection. At the same time, it provides a direction for in-depth research and theoretical discussion in the tourism academic community. However, residents are important to local cultural heritage [21,22]. Understanding their satisfaction helps promote the protection and inheritance of the cultural connotation of the heritage site [23,24]. High resident satisfaction helps to create a harmonious and stable community environment. When residents are satisfied with living in a world heritage site, it can reduce contradictions and conflicts caused by development issues and enhance the community's cohesion and sense of belonging. This is also the key to achieving the long-term development of world heritage sites. Satisfied residents are more willing to support sustainable tourism development strategies, such as controlling tourist flow and protecting the environment, to ensure the ecological balance of the heritage site and sustainable use of resources [25,26].

As a result, increasingly more scholars have begun to focus on the issue of residents' satisfaction with living in world heritage sites. The current methods, from the perspective of methods and technology, mainly use questionnaire surveys [27–29], interviews [30,31], observations [32], focus group discussions [25], big data analysis, and so on. For example, some scholars will design a questionnaire containing relevant questions covering economic, social, environmental, cultural, and other aspects. Additionally, the residents should be informed about their satisfaction with the rise in economic income resulting from local tourism development and their thoughts on enhancing the community environment [33–35]. Alternatively, comprehensive, organized interviews can be conducted directly with the residents, allowing them to express their opinions and emotions [36,37]. Some scholars also directly observe residents' daily life status, behavior, and interactions at the world heritage site and record their communication with tourists and their response to environmental changes [32]. Alternatively, scholars utilize big data resources, like social media data and online comments, to investigate residents' attitudes and satisfaction with world heritage sites [38,39]. For example, using Pingyao Ancient City as an example, researchers can first use questionnaires to obtain residents' overall views on the ancient city's tourism development and then use interviews to gain an in-depth understanding of the specific opinions of some residents. At the same time, researchers can use big data analysis based on Pingyao Ancient City residents' social media comments and combine multiple methods to comprehensively evaluate residents' satisfaction [40,41]. Other scholars have employed various intersecting theoretical methods, using Sanqingshan National

Park, a world natural heritage site, as their research object. They collected 330 perception examples from residents in tourism communities, supported by social exchange theory and community participation theory, and utilized structural equation modeling as a technical method. From the perspective of tourism's social, economic, environmental, and heritage protection impacts, they have constructed a conceptual model with perceived benefits and costs, community satisfaction, and place attachment as mediating variables [42]. However, with the development of artificial intelligence technology, it has become possible to analyze residents' satisfaction by combining the decision tree method. The decision tree is presented in a tree structure with clear logic that is easy to understand and explain [43]. This makes it easier for relevant decision makers and residents to understand the factors that affect satisfaction and their relationship.

1.3. Problem Statement and Objectives

The main purpose of this study is to conduct an in-depth analysis of the life satisfaction of residents living around the historic center of Macau, a world heritage site. The historic center of Macau, with its unique historical landscape features, contains profound cultural heritage and historical value. This study uses questionnaire surveys and decision tree methods to analyze and understand the complex factors that influence residents' satisfaction with the dimensional content of Macau's urban historical landscape characteristics. Furthermore, decision tree models will help reveal potential nonlinear and hierarchical relationships among these factors. This will provide valuable insights into the causal mechanisms that shape residents' perceptions of their living conditions within this unique and treasured heritage site. Ultimately, the results of this study are expected to provide practical suggestions for policymakers, urban planners, and heritage management authorities to develop more effective strategies and policies to improve residents' life satisfaction and ensure the sustainable development of the historic center of Macau.

2. Materials and Methods

2.1. Five Dimensions of Macau's Urban Historical Landscape

The historic center of Macau and surrounding communities are the main geographical scope of this study (see Figure 1 above). This study used information from the Study on the Definition of Characteristic Elements of Macau's Urban Landscape. The author's definition and investigation of the characteristic elements of the urban landscape in their 2020 dissertation, which involved a questionnaire survey and the establishment of a confirmatory factor analysis model, served as the basis for the extraction of the above five elements. Then, the questionnaire used a five-point Likert scale to measure the respondents' agreement with the items on Macau's urban landscape characteristics. The respondents agreed with the situations mentioned in each landscape dimension, indicating that Macau's five major landscape elements are important characteristics of the city's urban landscape [44]. Due to the small area of Macau, in terms of site selection, the author extracted, screened, and sorted out the relevant books on Macau's cultural heritage, magazines on Macau research, and archival materials on the urban landscape, following the principle of full coverage. This is also the preliminary support for this study. Because there was no specific measurement scale for residents' satisfaction around the historic center of Macau, this study combined the team's existing research results [44], and a focus group consisting of five heritage protection and urban planning experts was responsible for developing and validating the measurement scale. Residents' overall satisfaction was the dependent variable (continuous variable) in this study, and 25 measurement items from Macau's urban historical landscape characteristics questionnaire were used as independent variables. We developed relevant dimensions and attributes by drawing on experience from architectural landscapes, Largo Square landscapes, street landscapes, mountain and sea landscapes, and commercial landscapes. Therefore, we selected 25 attributes from five dimensions for further research.

2.1.1. Architectural Landscape

By definition, an architectural landscape encompasses squares, parks, scenic spots, and other landscape features. The building appears to possess a certain degree of appreciation for the landscape. Most of Macau's buildings have obvious landscape attributes, such as churches and residential buildings. The Ruínas de São Paulo is a typical representation. Among them, exterior walls, roofs, chambers, multiculturalism, and ideological beliefs are crucial in enhancing their value (Figure 2). Simultaneously, the architectural heritage that surrounds Rua Direita holds significant importance.

Figure 2. Some actual photos of the architectural landscape in Macau: the pictures in the left column are Ruins of Saint Paul's (Ruínas de São Paulo), Santo António Church (Igreja de Santo António), and Guia Chapel (Capela de Nossa Senhora da Guia). The pictures in the right column are Senado Square (Largo do Senado) and Moorish Barracks (Quartel dos Mouros). (Image source: photographed by the author).

2.1.2. Largo Square Landscape

"Largo (Qian-di)" is the Chinese definition of the Portuguese "Largo", often seen in Macau (Figure 3). In Portugal, "Largo" refers to a relatively wide street space. Such a space embodies a unique aspect of Portuguese culture, while Macau's Largo exhibits regional and cultural variations, reflecting the combined influence of Portuguese culture's originality and regeneration. Largo is a regional term according to a macro-functional perspective. In a macro sense, we can understand it as a square. However, the scope of this kind of square is relatively small, which is in contrast to some large parks or sports venues in other cities. This type of square is similar to those in medieval Europe, but there are also some differences. For example, ancestral temples, churches, or buildings in public spaces are the main architectural shapes, both Chinese and Western. There are many combinations of elements, and Largo's shape is irregular. The shapes of other buildings, residential areas, and squares around it are also irregular. Narrow or short streets are used for citizens to gather and carry out public activities, such as Largo do São Domingos and Largo do Senado in Macau.

Figure 3. The distribution of some spaces with traditional Largos characteristics in Macau. The satellite image inset in the image shows the extent of the Largos space. Its Portuguese annotation is the official name. The points of different colors in the picture represent the locations of different traditional Largos in Macau, and the small pictures correspond to them. (Image source: drawn by the author. The tiles in the inset are from a Google satellite map).

In Macau, a Largo space is often synonymous with the surrounding buildings, particularly the churches. Under normal circumstances, a Largo will be in front of the church to enable people to gather together. Religious gatherings mostly take place there. A Largo space is the heart of urban religion. Around the Largo and the church, residential areas often congregate, with the homes of these residents typically located adjacent to the church. For the religious Portuguese, the church is the city's "community center", a large public space where they can regularly worship and carry out related ritual activities. The Largo around the church is often where residents gather with each other. Among the Largos established in the early days of Macau, Largo do Senado and Largo da Sé were significant to the Portuguese. This status is evident not only in the external features of the space, aligning with the "Largo" spatial pattern in Portuguese cities, but also in its spiritual significance. Later, Largo became an area for public activities. This is also a typical example of the early transition from the city's religious role to its residents' daily life role. The city's urbanization converted the requirements of a religious culture into those of a non-religious one. It represents an extension of the existing lifestyles of the residents.

2.1.3. Street Landscape

The city's historic streets and lanes serve as its residents' primary framework and pedestrian routes (Figure 4). The historical street and alley landscape embodies the traditional urban culture and material environment and serves as a platform for promoting and perpetuating urban history. The city's urban historical street and alley landscape is an important historical legacy and a manifestation of cultural characteristics. Macau's urban historic streets and alleys are important to the city's historical landscape. In addition to the street space, the buildings and grounds on both sides also form an integral part of this area. The most representative one is Rua Direita in Macau. The special urban texture confirms the characteristics of Macau's Chinese and Western cultures and carries the historical activities and living habits of Macau people. It is a comprehensive space that seamlessly integrates function and materials.

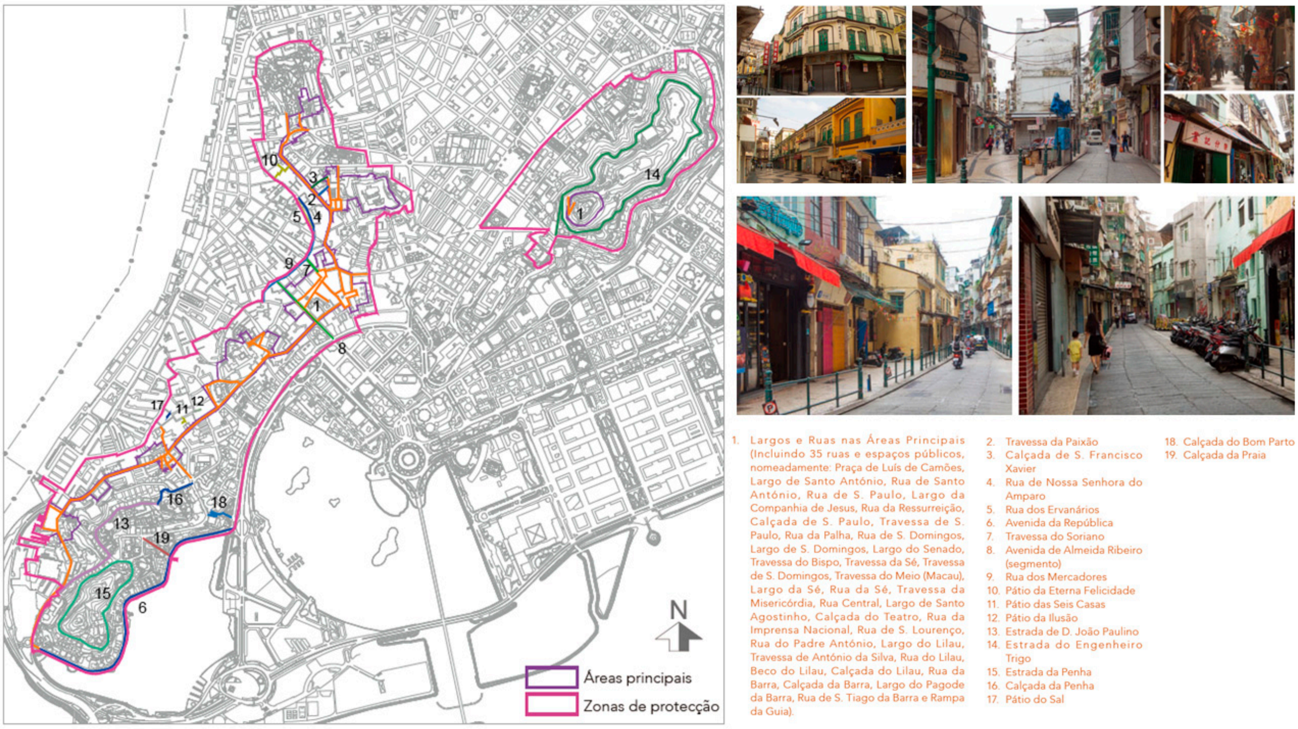

Figure 4. The streets in the historic center of Macau preserve traditional landscapes. Number 1 in the picture details and translates to "Squares and Streets in the Main Areas (Including 35 streets and public spaces, namely: Praga de Luís de Camóes, Largo de Santo António, Rua de SantoAntónio, Rua de S. Paulo, Largo da Companhia de Jesus, Rua da Ressurreição Calçada de S. Paulo, Travessa de S. Paulo, Rua da Palha, Rua de S. Domingos, Largo de S. Domingos, Largo do Senado, Travessa do Bispo, Travessa da Sé, Travessade S. Domingos, Travessa do Meio (Macau), Largo da Sé, Rua da Sé, Travessa da Misericórdia, Rua Central, Largo de Santo Agostinho, Calcada do Teatro, Rua da Imprensa Nacional, Rua de S. Lourenco Rua do Padre António, Largo do Lilau, Travessa de António da Silva, Rua do LilauBeco do Lilau, Calçada do Lilau, Rua daBarra, Calgada da Barra, Largo do Pagode da Barra, Rua de S. Tiago da Barra e Rampada Guia)". Numbers 2 to 19 are the names of the streets. (Image source: the Protection and Management Plan for the historic center of Macau).

2.1.4. Mountain and Sea Landscapes

Mountain and sea landscapes are mainly reflected in coastal cities close to mountains and seas and have favorable natural conditions. The topography of the mountain and seascape is ever-changing; the spatial vision is wide, and the ridges and coastlines interact, presenting a unique spatial vision of a coastal city (Figure 5). Macau is located on China's southeastern coast, at the intersection of the Pearl River estuary. It is a seaport city with beautiful mountain and sea landscapes, including Colina da Guia, Colina da Penha, Colina da Barra, Colina de D. Maria II, and Colina da Ilha. There are many mountains, such as Verde, Colina de Mong Há, and Taipa Grande, most of which face water (Figure 6 and Table 1). The coastline is long, and the natural landscape, which includes mountains and rivers, enriches the city's coastal urban spatial landscape. This significant urban landscape element symbolizes Macau's natural beauty.

Figure 5. Some actual photos of the mountain and sea landscape in Macau. This shows the closeness between the sea and Macau city, as well as the position of the mountains in the urban space. (Image source: Photographed by the author).

2.1.5. Commercial Landscape

The urban commercial landscape integrates the commercial area and the surrounding environment. It has both commercial functions and interactive viewing functions. Most of Macau's commercial landscapes serve a variety of comprehensive functions. These commercial areas combine more than three urban functions: business, office, residential, convention and exhibition, catering, and entertainment. These include city shopping malls and department stores, among others. The most typical representatives of Macau's commercial landscape are Macau's casinos, such as the Grand Lisboa Hotel, The Venetian, and other large casinos (Figure 7). This commercial landscape has multiple functions: entertainment, commercial and residential, convention and exhibition, catering, and shopping. It is a typical urban commercial complex. This model of commercial landscape embodies Macau's characteristics, symbolizes the new city, and is an important industry supporting Macau's economy. Therefore, it is also an integral landscape feature in the five dimensions.

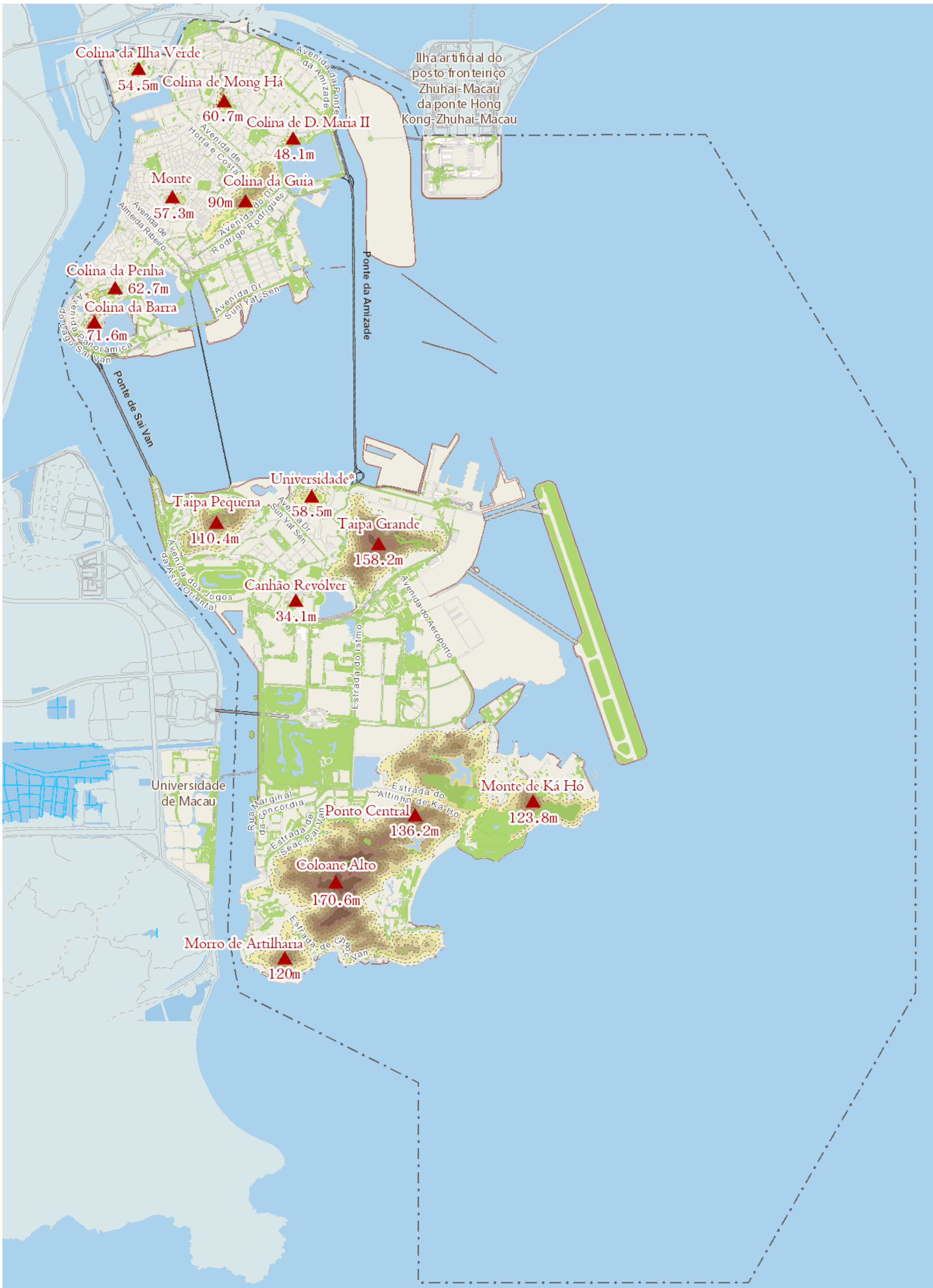

Figure 6. Distribution of major mountains in Macau. Its Portuguese annotation is the official name. "Colina" means "mountain". Its name has no specific English meaning; it is just a place name. (Image source: Macau Cartography and Cadastre Bureau).

Table 1. Elevation of hills in Macau.

Area	Hills	Elevation (Meters)
Macau Peninsula	Colina da Guia	90.0
	Colina da Penha	62.7
	Colina da Barra	71.6
	Colina de D. Maria II	48.1
	Colina da Ilha Verde	54.5
	Monte	57.3
	Colina de Mong Há	60.7
Taipa Island	Taipa Grande	158.2
	Taipa Pequena	110.4
	Universidade (Located at Avenida Padre Tomás Pereira)	58.5
	Canhão Revólver	34.1
Coloane Island	Coloane Alto	170.6
	Monte de Ká Hó	123.8
	Morro de Artilharia	120.0
	Ponto Central	136.2

Data source: Macau Cartography and Cadastre Bureau.

Figure 7. Photos of the commercial landscape in Macau. The pictures show the luxurious and colorful exterior of casino buildings. They are the traditional casino buildings on the Macau Peninsula, the Grand Lisboa Resort, the Venetian, the Parisian, the Macau Palace, and the Plaza Macau. (Image source: photographed by the author).

2.2. Data Collection and Questionnaire Distribution

As mentioned in Section 2.1, this study used information from the Study on the Definition of Characteristic Elements of Macau's Urban Landscape. Further, the authors surveyed citizens living in Macau from 5 May to 30 June 2024. The researchers selected the important features of Macau's urban historical landscape for dimensional classification, mainly based on five dimensions: architectural, Largo Square, street, mountain and sea, and commercial landscapes. We created a questionnaire using digital tools provided by wjx.cn. Please see Appendix B for the questionnaire questions. In order to ensure the randomness of the sample, in addition to the world heritage historic center of Macau and its surrounding areas, several experienced graduate students in the research team actively sought respondents at different locations in various areas of Macau, including different types of public places, shopping areas, residential buildings, and transportation facilities. The Institutional Review Board (IRB) of Hangzhou City University reviewed and approved the studies involving human subjects. The participant's legal guardian or next of kin provided written informed consent for this study before completing the questionnaire (the approval number is 2024-0501).

The researchers distributed a total of 536 questionnaires, eliminated those that were incomplete or filled in incorrectly, and collected 524 valid questionnaires, representing 97.7% of the overall questionnaire count. Regarding gender, there were 314 male respondents, accounting for 59.9% of the total, and 210 female respondents, accounting for 40.1% of the total (Table 2). In terms of the age distribution, since the research topic has no direct correlation with gender, there is no specific age limit. According to the questionnaire results, the 25–34-year-old age group had the highest participation count, with 169 individuals representing 32.25% of the total. Conversely, the 55-year-old age group had the lowest count, with 45 individuals accounting for only 8.58% of the total. Regarding occupational distribution, teachers and students comprised the largest group at 316, accounting for more than 50% or 60.30% of the total. Given the primary focus of this study on urban planning and design, professionals in architecture, planning, and design comprised approximately 20% of the total. Regarding educational background distribution, most people were undergraduates, with 238 accounting for 45.41% of the total. Researchers with an undergraduate degree or higher account for approximately 80% of the total.

Table 2. Basic information of the respondents.

Survey Items	Interval Results	Frequency	Percentage (%)
Gender	Male	314	59.9%
	female	210	40.1%
Age	15–24 years old	73	13.93%
	25–34 years old	169	32.25%
	35–44 years old	110	20.99%
	45–54 years old	127	24.23%
	>55 years old	45	8.58%
Occupation	Architects, planners, and designers	110	20.99%
	Government officials	26	4.96%
	Teachers or students	316	60.30%
	Other occupations	72	13.74%

Table 2. *Cont.*

Survey Items	Interval Results	Frequency	Percentage (%)
Education	High school (or equivalent)	39	7.44%
	College (or equivalent)	75	14.31%
	Bachelor's degree (or equivalent)	238	45.41%
	Master's degree (or equivalent)	90	17.17%
	Ph.D. degree (or equivalent)	82	15.64%
Household registration	Macau resident	154	29.38%
	Chinese Mainland resident	334	63.74%
	Other residents	36	6.87%

Data source: the author compiled the data from the questionnaire.

2.3. Research Methods and Process

This study utilized 524 questionnaire survey responses and applied the decision tree method to analyze them to identify the key factors and dividing paths that impact residents' satisfaction. The ultimate goal of this study was to determine a strategic path that maximizes residents' satisfaction and establishes a scientific foundation for urban landscape management. Simultaneously, the decision tree model's tree structure intuitively displays its decision process (please refer to Appendix A for operating environment parameters), setting it apart from other complex machine learning models, like neural networks, support vector machines, and integrated models. Each branch symbolizes a decision rule, enhancing the clarity and ease of understanding of the model's reasoning path and simplifying non-professionals' generation and use process. Therefore, an intuitive graphical display clearly explains each node and branch.

The survey covered five dimensions: architecture, Largo Square, streets, mountains and seas, and commercial landscapes. It contained a total of 25 landscape feature elements. The decision tree model required data consisting of both characteristic and target variables. This study used landscape feature elements as characteristic variables to describe and explain various indicators and information about residents' satisfaction. The model used the residents' overall satisfaction score as the target variable to predict and evaluate their feelings about their living environment. Figure 8 illustrates the research process.

(1) Data preprocessing. During the data preprocessing stage, we divided the questionnaire data into feature and target variables for model training and prediction. There were potential class imbalance problems in the residents' satisfaction data, meaning that the number of samples for some satisfaction levels was much lower than for others. Using this unbalanced data to train the model could make it more likely to predict correctly for the majority class and less likely to correctly predict for the minority class. In order to effectively solve this problem, this study used the SMOTE (Synthetic Minority Oversampling Technique) algorithm to resample the data. Specifically designed to address class imbalance problems, the SMOTE algorithm is a commonly used oversampling method. Its principle is to generate new minority class samples by interpolating between them, thereby increasing the number of minority classes and balancing the number of each class.

The steps are as follows: (a) select minority class samples: randomly select a sample from the minority class samples. (b) Calculate the k-nearest neighbors of the sample in the minority class samples, selecting $k = 1$ for this study. (c) Generate new samples: randomly select a neighbor sample from the k-nearest neighbors, randomly interpolate between the sample and the original sample, and generate a new minority class sample. Following the above steps, the SMOTE algorithm generates a new sample that falls between the original minority class sample and its neighbor sample, effectively expanding the distribution range of minority class samples and enhancing the model's robustness and prediction accuracy.

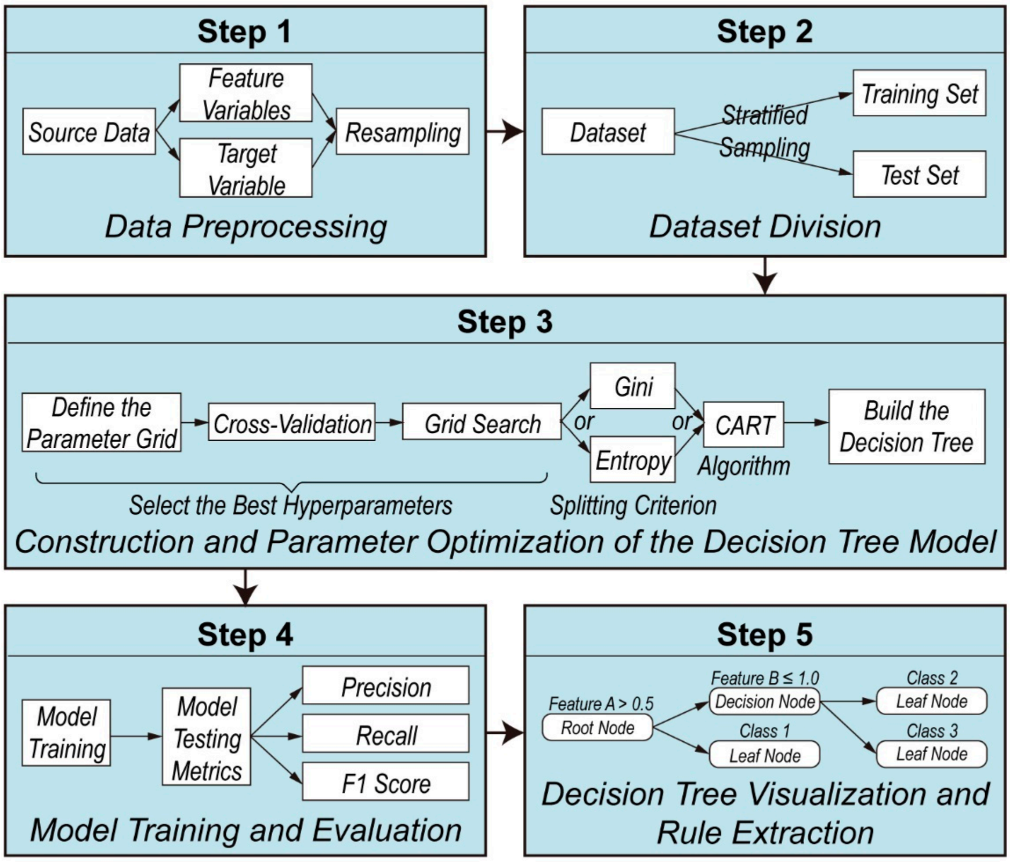

Figure 8. The research process in this study (image source: drawn by the author).

(2) Dataset division. We divided the dataset into training and test sets to build and evaluate the model. We trained the model on the training set and evaluated its performance on the test set to ensure it could perform well on unseen data. In this study, we divided the original data into a training set and a test set in a 7:3 ratio, with the training set accounting for 70% of the total data and the test set accounting for 30%. Simultaneously, we adopted the stratified sampling method during the dataset division process. This method maintained the same category proportions in the training and test sets. The "category" here refers to the target variable, i.e., the different rating levels of overall satisfaction (for example, 0 to 10 points on an 11-level scale). Stratified sampling primarily benefits from its ability to maintain the original dataset's proportion of each category, thereby mitigating model bias stemming from imbalanced categories.

The steps are as follows: (a) grouping by satisfaction score, group the dataset according to the target variable (residents' overall satisfaction rating), each representing a satisfaction level; (b) proportional sampling, sample each satisfaction level according to the specified proportion (70% training set, 30% test set in this study) to ensure that the proportion of each level in the training set and the test set is consistent; (c) merge data, merge each satisfaction level's training and test samples to form the final training and test sets. Adopting the stratified sampling method ensures consistency in the category distribution of the training and test sets, enabling the model to train fully on various samples without ignoring certain categories. Simultaneously, during the test phase, the model's prediction performance can be fairly evaluated across various categories, thereby more accurately reflecting its actual performance.

(3) Construction and parameter optimization of decision tree model. This study used a decision tree model to predict residents' satisfaction. A decision tree is a tree-structured model that divides a dataset into smaller subsets through a series of branches for classification or regression. Each node represents a feature, each branch represents a

possible value, and each leaf node represents a classification result. To improve the certainty of each split subset based on a specific target variable, the decision tree model recursively selects the optimal feature to split the dataset.

The decision tree's main splitting criteria in this study included the Gini coefficient and information entropy. We used the Gini coefficient to measure the impurity of the node. The smaller the value, the purer the node. We used information entropy to measure the information's degree of confusion or uncertainty. The larger its value, the more impure the node becomes. The splitting process persists until it reaches the preset stopping condition, which could be the maximum depth or the node's sample count falling below the minimum number of splits. The grid search (GridSearchCV) method also adjusts the model's hyperparameters to optimize the decision tree model's performance. Grid search is a method that systematically traverses multiple parameter combinations to find the optimal parameter configuration. In this study, we tuned the main parameters as follows: (a) evaluation criterion, we selected the Gini coefficient or information entropy as the criterion for node splitting; (b) maximum depth, we controlled the maximum number of tree layers to prevent model overfitting. The maximum depth limits the decision tree's complexity and makes it more interpretable. (c) Minimum sample split refers to the bare minimum of samples needed to re-split a node, thereby regulating the frequency of node splitting and avoiding excessive splitting that could lead to overfitting. At the same time, in order to prevent model overfitting, this study used 3-fold cross-validation (StratifiedKFold) to evaluate each set of parameter combinations. Cross-validation is a technique for evaluating model performance. We can more reliably estimate the model's generalization performance by dividing the dataset into several parts and training and testing it multiple times. To perform 3-fold cross-validation, divide the dataset into 3 parts, train the model with 2 each time, test the model with the remaining 1 part, and repeat 3 times to obtain the average performance index. This method prevents model overfitting and ensures the evaluation results' stability and reliability.

(4) Model training and evaluation. Once we obtained the optimal parameter combination, we retrained the decision tree model using these parameters. In the training process, the training set's characteristic variables (X train) and target variables (Y train) were fed into the decision tree algorithm. The nodes were then split recursively to eliminate as much noise as possible, and a tree structure model that can accurately classify was finally built. After the training, the model forecasted residents' overall satisfaction using the input features. The trained model made predictions on the test set. We obtained each test sample's predicted satisfaction score (Y pred) by inputting the test set's characteristic variables (X test) into the trained decision tree model. The prediction process is relatively simple; it judges each sample's characteristic value following the decision tree's structure until it reaches the leaf node and outputs the corresponding predicted category.

This study evaluated the model's performance based on the classification report and accuracy. The main indicators are as follows: (a) precision, the proportion of positive samples among all samples predicted to be positive; (b) recall, the proportion of samples correctly predicted to be positive among all positive samples; (c) F1 score, the harmonic mean of precision and recall, which comprehensively considers the accuracy and completeness of the model. Simultaneously, a confusion matrix was created during the model evaluation stage to more intuitively illustrate the model's prediction impact. The confusion matrix is a table that displays the model's classification results, with each row representing the actual category and each column representing the predicted category. Researchers can observe the model's prediction in each category using the confusion matrix, including the number of correct predictions and the distribution of incorrect predictions. We will present the color of the confusion matrix as a heat map, highlighting the size of the value and the depth of the color, ensuring a clear classification effect at a glance.

(5) This study focused on the visualization of decision trees and the rule extraction process. In order to facilitate the interpretation and display of the structure of the decision tree model, this study used the Graphviz tool to visualize the decision tree and generate

the corresponding structural diagram. The decision tree visualization diagram intuitively displayed the model's branch structure and classification rules. Each node represented a feature, each branch represented a possible value, and each leaf node represented a classification result. The steps included (a) generating the source code for Graphviz: we created a decision tree visualization graph using the Graphviz tool and saved it as an image file. This step required setting parameters, such as the feature name, category name, and node style to ensure the generated graph was clear and simple. (b) Extracting decision tree rules involved extracting decision paths and rules from the trained decision tree model. Each rule represented a path from the root node to the leaf node, which contained all the decision conditions and the final classification results.

This visualization method shows how the decision tree splits according to different features to classify the data. For example, you can see which features play an important role in early splits and which features play a fine-tuning role in later splits. In addition to aiding in the interpretation and understanding of the model, this visualization also identifies and diagnoses potential issues within the model, such as overfitting. In summary, decision tree and random forest models were used in this study to analyze and predict residents' satisfaction with the landscape characteristics of towns around the Historic District of Macau. Grid search and cross-validation methods optimized the model parameters, and various evaluation indicators and visualization tools evaluated the model performance, providing a scientific basis for relevant decision-making.

3. Results: Questionnaire Analysis Results and Machine Learning Results

3.1. Questionnaire Reliability and Validity Analysis Results

3.1.1. Questionnaire Reliability Analysis

This questionnaire survey aims to identify the landscape elements present in Macau's urban history. Based on historical documents and online survey data, we extracted five elements of Macau's landscape—architectural, Largo Square, street, mountain and sea, and commercial landscapes. The survey and analysis aim to provide public suggestions for accurately extracting Macau's urban historical landscape. The questionnaire scale has 25 items, divided into five dimensions: architectural, front square, street mountain and sea, and commercial landscape dimensions.

According to the reliability analysis in Table 3, the internal consistency coefficients (Cronbach's α coefficients) of the five dimensions are 0.895, 0.922, 0.905, 0.850, and 0.846, respectively. The Cronbach's α coefficient for the entire scale is 0.892. The Cronbach's α coefficients of the five dimensions and the entire scale are all greater than 0.8, indicating that the internal consistency and reliability of the five dimensions and the entire scale are good.

Table 3. Questionnaire reliability analysis.

Dimension Information	Number of Items	Cronbach's α Coefficient	Adjusted Cronbach's α Coefficient
Architectural landscape	5	0.895	0.917
Largo Square landscape	5	0.922	0.927
Street landscape	5	0.905	0.911
Mountain and sea landscape	5	0.850	0.891
Commercial landscape	5	0.846	0.861
Total scale	25	0.892	0.891

Data source: the author compiled the data from the questionnaire.

3.1.2. The Questionnaire's Structural Validity

The researchers conducted exploratory factor analysis based on the questionnaire using SPSS software (Version 29.0.2.0). We used the principal component analysis method for extraction and the maximum variance method for rotation. As shown in Table 4, the

KMO and Bartlett's sphericity test results show that the KMO value is equal to 0.862, greater than 0.6, and the significance of Bartlett's sphericity test is less than 0.001, indicating that the questionnaire can be used for factor analysis and factor extraction.

Table 4. KMO and Bartlett's test of sphericity.

KMO sampling suitability measure		0.862
Bartlett's test of sphericity	Approximate chi-square	4051.928
	degrees of freedom	300
	Significance	<0.001

Data source: the author compiled the data from the questionnaire.

Table 5 shows the total variance explained by the exploratory factor analysis. The results show that the factor analysis extracted five factors, with a cumulative explained variance of 73.429%, which is more than 60%, indicating that the extracted factors can explain 73.429% of the original 25 items. The first principal component's explained variance is 30.229%, less than 40% and less than half of the total explained variance of 73.429%, indicating no common method bias in the questionnaire.

Table 5. Total variance explained (extraction method: principal component analysis).

Element	Initial Eigenvalues			Extracted Sum of Squares of Loadings			Rotated Sum of Squares of Loadings		
	Total	Percentage of Variance	Cumulative (%)	Total	Percentage of Variance	Cumulative (%)	Total	Percentage of Variance	Cumulative (%)
1	7.557	30.229	30.229	7.557	30.229	30.229	3.886	15.543	15.543
2	3.833	15.332	45.561	3.833	15.332	45.561	3.859	15.437	30.980
3	3.004	12.016	57.577	3.004	12.016	57.577	3.773	15.094	46.074
4	2.670	10.682	68.259	2.670	10.682	68.259	3.568	14.270	60.344
5	1.293	5.170	73.429	1.293	5.170	73.429	3.271	13.085	73.429
6	0.756	3.024	76.453						
7	0.606	2.424	78.877						
8	0.524	2.096	80.973						
9	0.478	1.911	82.884						
10	0.449	1.796	84.680						
11	0.421	1.682	86.362						
12	0.408	1.634	87.996						
13	0.367	1.470	89.466						
14	0.351	1.406	90.872						
15	0.326	1.303	92.175						
16	0.302	1.207	93.381						
17	0.259	1.036	94.417						
18	0.242	0.970	95.386						
19	0.211	0.845	96.231						
20	0.203	0.813	97.045						
21	0.187	0.749	97.794						
22	0.164	0.656	98.450						
23	0.148	0.592	99.042						
24	0.128	0.514	99.555						
25	0.111	0.445	100.000						

Data source: the author compiled the data from the questionnaire.

Table 6 is a rotated component matrix from the exploratory factor analysis. The results show that the high loading values of the measurement items corresponding to the five dimensions all fall on the same principal component. For example, the high factor loading values of the five measurement items in Largo Square landscape dimension two all fall on the first principal component. The high factor loading values of the five dimensions of one architectural landscape measurement item all fall on the second principal component. The high factor loading values of the five measurement items of street landscape dimension three all fall on the third principal component. The five measurement items in dimension four—mountain and seascape—all have high factor loading values that fall on the fourth principal component. The high factor loading values of the five measurement items in dimension five of the commercial landscape all fall on the fifth principal component. The structure of the rotated component matrix is consistent with the structure of the questionnaire design, indicating good structural validity.

Table 6. Rotated component matrix for exploratory factor analysis (extraction method: principal component analysis; rotation method: Nishizawa normalization maximum variance method).

Measurement Item	Element				
	1	2	3	4	5
Q2_5 (Largo landscape layout)	**0.858**	0.136	0.219	0.105	−0.060
Q2_2 (Largo humanities and religion)	**0.825**	0.168	0.295	0.158	0.077
Q2_3 (Largo location layout)	**0.804**	0.109	0.307	0.189	0.036
Q2_1 (Largo ground decoration)	**0.775**	0.204	0.314	0.092	0.017
Q2_4 (Largo historical origins)	**0.722**	0.067	0.399	0.193	−0.008
Q1_4 (Architectural esthetic effect)	0.067	**0.893**	−0.026	−0.006	0.117
Q1_3 (Architectural cultural characteristics)	0.082	**0.867**	0.022	−0.054	0.079
Q1_5 (Architectural psychological feeling)	0.090	**0.849**	0.067	0.142	−0.032
Q1_1 (Architectural ecology creation)	0.161	**0.830**	0.091	0.054	0.151
Q1_2 (Architectural space feeling)	0.158	**0.810**	0.086	0.047	0.157
Q3_4 (Street and alley cultural elements)	0.188	0.017	**0.886**	0.065	0.088
Q3_5 (Street and alley building facades)	0.197	0.022	**0.872**	0.030	0.024
Q3_3 (Street and alley plant arrangement)	0.340	0.120	**0.782**	0.093	0.021
Q3_1 (Street and alley space texture)	0.318	0.077	**0.758**	0.096	0.021
Q3_2 (Street and alley space form)	0.429	0.017	**0.694**	0.141	0.007
Q4_3 (Humanities and history of mountains and seas)	−0.017	−0.104	0.068	**0.861**	−0.046
Q4_5 (Climate changes in mountains and seas)	0.106	0.000	0.126	**0.827**	0.057
Q4_1 (Natural resources of mountains and seas)	0.241	0.141	−0.019	**0.822**	0.131
Q4_4 (Geographical features of mountains and seas)	0.114	0.011	0.082	**0.810**	0.031
Q4_2 (Tourism activities in mountains and seas)	0.173	0.155	0.096	**0.780**	0.022
Q5_1 (Commercial space layout)	0.042	−0.037	0.066	0.015	**0.824**
Q5_3 (Commercial lighting design)	0.127	0.095	−0.053	0.078	**0.812**
Q5_2 (Commercial signage system)	−0.125	0.060	0.002	0.045	**0.800**
Q5_4 (Commercial color and material)	−0.065	0.136	0.042	−0.032	**0.774**
Q5_5 (Commercial, regional characteristics)	0.073	0.176	0.076	0.065	**0.761**

Data source: the authors compiled the data from the questionnaire.

3.1.3. Convergent and Discriminant Validity of the Questionnaire

The researchers conducted a confirmatory factor analysis on the questionnaire using AMOS software (Version 29) to calculate its convergent and discriminant validity. Convergent validity refers to the internal convergence of the five items in each dimension; discriminant validity refers to the discrimination between different dimensions. Figure 9 details the confirmatory factor analysis model.

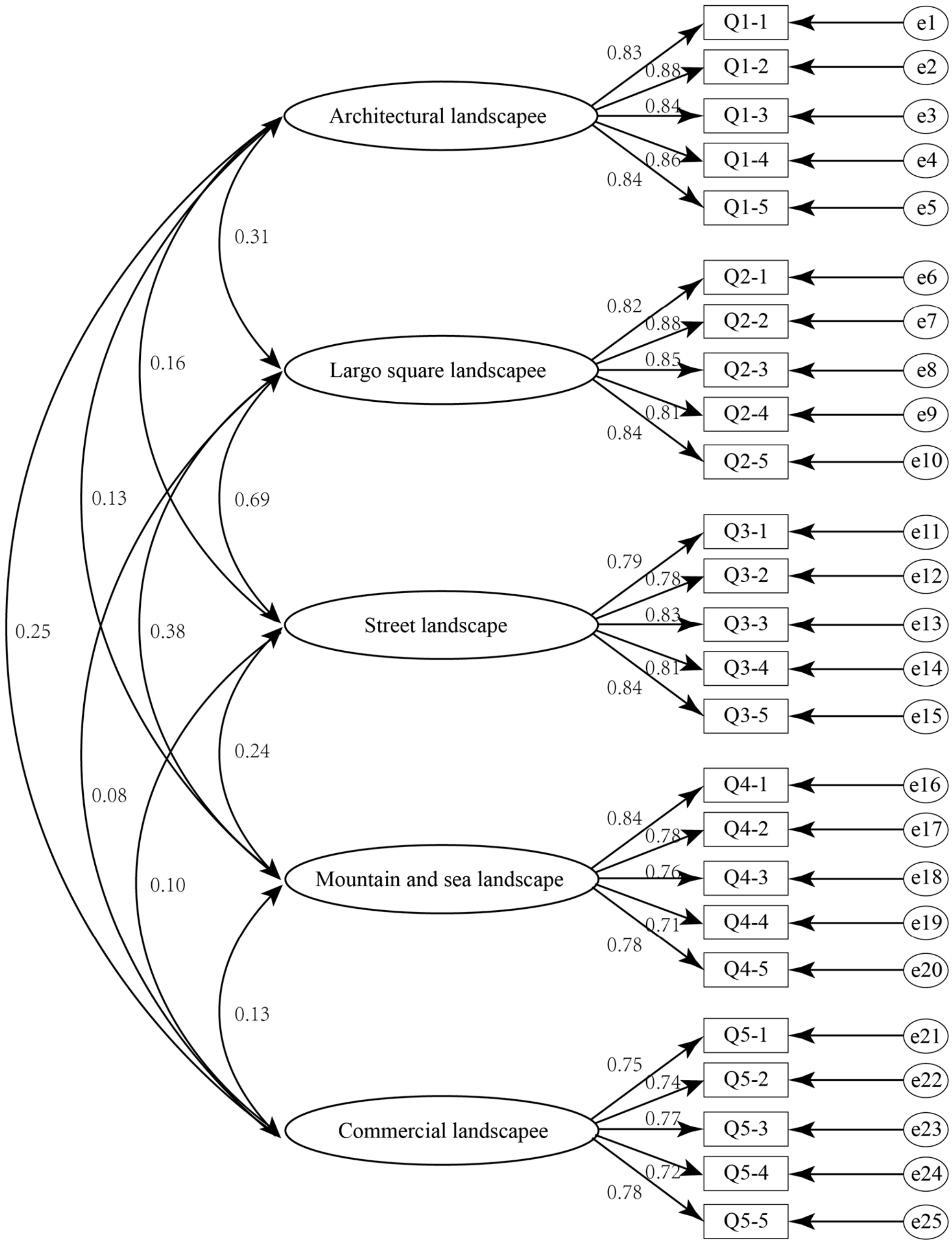

Figure 9. Confirmatory factor analysis model. (Image source: drawn by the author).

3.1.4. The Questionnaire's Convergent Validity

Convergent validity refers to the internal convergence of the five items in each dimension. As shown in Table 7, the standardized loading values of the measurement items corresponding to the five dimensions are 0.718–0.887, all greater than 0.7. The five dimensions of the architectural, Largo Square, street, mountain and sea, and commercial landscapes have a combined reliability (CR value) of 0.917, 0.928, 0.913, 0.891, and 0.861, respectively, all greater than 0.7. The five dimensions' average variance extracted (AVE value) is 0.689, 0.721, 0.677, 0.621, and 0.553, respectively, all greater than 0.5. In summary, the results of the standardized loading value, combined reliability, and average variance extracted all meet the standards, indicating that the questionnaire has excellent convergent validity.

Table 7. Results of convergent validity analysis.

Dimension Information	Item	Unstandardized Load	Standardized Load	Standard Error	t-Value	CR Value	AVE Value
Architectural landscape	Q1_1 (Architectural ecology creation)	1.000	0.833			0.917	0.689
	Q1_2 (Architectural space feeling)	1.221	0.798	0.087	13.966 ***		
	Q1_3 (Architectural cultural characteristics)	0.620	0.836	0.041	14.971 ***		
	Q1_4 (Architectural esthetic effect)	0.744	0.883	0.046	16.250 ***		
	Q1_5 (Architectural psychological feeling)	0.890	0.796	0.064	13.908 ***		
Largo Square landscape	Q2_1 (Largo ground decoration)	1.000	0.822			0.928	0.721
	Q2_2 (Largo humanities and religion)	1.487	0.887	0.091	16.339 ***		
	Q2_3 (Largo location layout)	1.277	0.863	0.082	15.665 ***		
	Q2_4 (Largo historical origins)	0.981	0.814	0.068	14.327 ***		
	Q2_5 (Largo landscape layout)	0.977	0.858	0.063	15.530 ***		
Street landscape	Q3_1 (Street and alley space texture)	1.000	0.794			0.913	0.677
	Q3_2 (Street and alley space form)	1.149	0.776	0.091	12.636 ***		
	Q3_3 (Street and alley plant arrangement)	1.101	0.835	0.079	13.897 ***		
	Q3_4 (Street and alley cultural elements)	1.010	0.868	0.069	14.616 ***		
	Q3_5 (Street and alley building facades)	0.864	0.839	0.062	13.991 ***		
Mountain and sea landscape	Q4_1 (Natural resources of mountains and seas)	1.000	0.844			0.891	0.621
	Q4_2 (Tourism activities in mountains and seas)	0.932	0.780	0.070	13.225 ***		
	Q4_3 (Humanities and history of mountains and seas)	0.335	0.761	0.026	12.803 ***		
	Q4_4 (Geographical features of mountains and seas)	0.683	0.772	0.052	13.037 ***		
	Q4_5 (Climate changes in mountains and seas)	0.395	0.780	0.030	13.237 ***		
Commercial landscape	Q5_1 (Commercial space layout)	1.000	0.755			0.861	0.553
	Q5_2 (Commercial signage system)	1.602	0.745	0.151	10.623 ***		
	Q5_3 (Commercial lighting design)	1.092	0.771	0.099	10.998 ***		
	Q5_4 (Commercial color and material)	1.180	0.718	0.115	10.244 ***		
	Q5_5 (Commercial regional characteristics)	0.908	0.728	0.087	10.381 ***		

Data source: the author compiled the data from the questionnaire. (In SPSS, an asterisk after a T-value usually indicates the level of significance. An asterisk (*) indicates significance at the 10% significance level, with a *p* value between 0.05 and 0.1. Two asterisks (**) correspond to significance at the 5% level, and the *p* value is between 0.01 and 0.05. Three asterisks (***) correspond to the 1% significance level, and the *p* value is less than 0.01.)

3.1.5. Discriminant Validity

As shown in Table 8, the values on the diagonal line represent the square root of the AVE value of each dimension, indicating the correlation strength between the items within the dimension, and the other values are the correlation coefficients between the dimensions. The table results reveal that the diagonal line values surpass the other values, demonstrating the questionnaire's strong discriminant validity.

Table 8. Results of discriminant validity analysis (the bold words on the diagonal line are the squares of the AVE values; the other values are the correlation coefficients between the dimensions).

Dimension Information	1	2	3	4	5
Architectural landscape	**0.830**				
Largo Square landscape	0.312	**0.849**			
Street landscape	0.157	0.687	**0.823**		
Mountain and sea landscape	0.132	0.378	0.244	**0.788**	
Commercial landscape	0.246	0.078	0.097	0.127	**0.744**

Data source: the author compiled the data from the questionnaire.

3.2. Descriptive Analysis of Urban Landscape Characteristics in Five Dimensions

The questionnaire uses a five-point Likert scale to measure the respondents' agreement with the items based on Macau's urban landscape characteristics. The results reveal that the average scores for the five measurement items and architectural landscape dimensions are 4.23, 4.18, 4.74, 4.71, 4.58, and 4.488, respectively (Table 9), with all average scores exceeding four points. This indicates that the respondents generally agree that the situations mentioned in the five items fully illustrate Macau's architectural landscape as important to the city's urban landscape. The respondents largely recognize the Largo Square, street, and mountain and sea landscape dimensions, as evidenced by their scores exceeding three points. Among them, the Largo Square landscape score is higher than four, second only to the architectural landscape, indicating that Macau's Largo Square landscape is one of the important characteristics of Macau's urban landscape. The average scores for the items and dimensions within the commercial landscape dimension are 2.751, 2.670, 2.73, 2.59, 2.8, and 2.708, all falling below the three-point threshold. This shows that the respondents do not agree that the commercial landscape dimension represents Macau's urban landscape characteristics. Therefore, we considered abandoning the commercial landscape dimension while researching Macau's urban historical landscape and focusing on the four aspects of Macau's architectural landscape dimension: Largo Square, street, and mountain and sea.

Table 9. Description and analysis of urban landscape characteristics.

Item or Dimension	Mean	Standard Deviation
Q1_1 (Architectural ecology creation)	4.230	0.888
Q1_2 (Architectural space feeling)	4.180	1.131
Q1_3 (Architectural cultural characteristics)	4.740	0.548
Q1_4 (Architectural esthetic effect)	4.710	0.623
Q1_5 (Architectural psychological feeling)	4.580	0.828
Architectural landscape	4.488	0.696
Q2_1 (Largo ground decoration)	4.320	0.864
Q2_2 (Largo humanities and religion)	3.290	1.190
Q2_3 (Largo location layout)	3.800	1.050
Q2_4 (Largo historical origins)	4.360	0.856
Q2_5 (Largo landscape layout)	4.460	0.808
Largo Square landscape	4.045	0.842
Q3_1 (Street and alley space texture)	3.670	0.973
Q3_2 (Street and alley space form)	3.150	1.145
Q3_3 (Street and alley plant arrangement)	3.450	1.019
Q3_4 (Street and alley cultural elements)	3.810	0.899

Table 9. *Cont.*

Item or Dimension	Mean	Standard Deviation
Q3_5 (Street and alley building facades)	3.990	0.795
Street landscape	3.607	0.825
Q4_1 (Natural resources of mountains and seas)	3.290	0.948
Q4_2 (Tourism activities in mountains and seas)	3.030	0.956
Q4_3 (Humanities and history of mountains and seas)	2.960	0.352
Q4_4 (Geographical features of mountains and seas)	2.710	0.708
Q4_5 (Climate changes in mountains and seas)	3.900	0.405
Mountain and sea landscape	3.178	0.570
Q5_1 (Commercial space layout)	2.750	0.675
Q5_2 (Commercial signage system)	2.670	1.096
Q5_3 (Commercial lighting design)	2.730	0.721
Q5_4 (Commercial color and material)	2.590	0.837
Q5_5 (Commercial regional characteristics)	2.800	0.635
Commercial landscape	2.708	0.637

Data source: the authors compiled the data from the questionnaire.

3.3. Analyzing Differences in Urban Landscape Characteristics

Considering that different attributes of respondents may affect their views on urban landscape characteristics, it is necessary to further analyze the differences in urban landscape characteristics scores based on the different attributes of respondents. The attributes of respondents considered by the researchers here include gender, age group, occupation, education level, and household registration.

3.3.1. Gender Difference Analysis

As shown in Table 10, using the independent sample t-test, there is no significant difference between the scores of men and women in the five dimensions of architectural, Largo Square, street, mountain and sea, and commercial landscapes ($p > 0.05$).

Table 10. Gender difference analysis.

Dimension Information	Gender		T-Value	*p*-Value
	Male (314 People)	Female (210 People)		
Architectural landscape	4.427 ± 0.737	4.578 ± 0.624	−1.596	0.112
Largo Square landscape	4.034 ± 0.863	4.06 ± 0.815	−0.223	0.824
Street landscape	3.663 ± 0.865	3.524 ± 0.76	1.233	0.219
Mountain and sea landscape	3.148 ± 0.585	3.222 ± 0.548	−0.958	0.339
Commercial landscape	2.787 ± 0.606	2.591 ± 0.666	2.273	0.024

Data source: the author compiled the data from the questionnaire.

3.3.2. Analysis of Differences among Age Groups

Table 11, based on a one-factor analysis of variance, reveals that the age groups of 15–24 years old, 25–34 years old, 35–44 years old, 45–54 years old, and 55 years old and older exhibit notable variations in architectural landscape, Largo Square landscape, streets, and alleys. There is no discernible disparity in the scores across the five dimensions of landscape, including mountain and sea landscapes, as well as commercial landscapes ($p > 0.05$).

Table 11. Analysis of differences in age groups.

Dimension Information	Age Groups					F-Value	*p*-Value
	15–24 Years Old	25–34 Years Old	35–44 Years Old	45–54 Years Old	>55 Years Old		
Architectural landscape	4.238 ± 0.858	4.512 ± 0.690	4.526 ± 0.731	4.623 ± 0.499	4.350 ± 0.745	1.810	0.128
Largo Square landscape	3.938 ± 0.848	4.101 ± 0.815	3.930 ± 0.863	4.008 ± 0.897	4.370 ± 0.697	1.200	0.312
Street landscape	3.619 ± 0.759	3.619 ± 0.836	3.435 ± 0.892	3.687 ± 0.801	3.730 ± 0.814	0.738	0.567
Mountain and sea landscape	3.044 ± 0.594	3.107 ± 0.590	3.252 ± 0.507	3.253 ± 0.587	3.280 ± 0.533	1.317	0.265
Commercial landscape	2.725 ± 0.714	2.674 ± 0.599	2.778 ± 0.701	2.758 ± 0.509	2.510 ± 0.796	0.761	0.552

Data source: the authors compiled the data from the questionnaire.

3.3.3. Analysis of Occupational Differences

Table 12 demonstrates that architects, planners, designers, government services, teachers, students, and other professional groups hold divergent perspectives on the five aspects of the architectural landscape: Largo Square landscape, street landscape, mountain and sea landscape, and commercial landscape, as determined by one-factor analysis of variance. A statistically significant difference between the scores is not observed ($p > 0.05$).

Table 12. Occupational difference analysis.

Dimension Information	Occupation Types				F-Value	*p*-Value
	Architects, Planners, and Designers	Government Officials	Teachers or Students	Other Occupations		
Architectural landscape	4.524 ± 0.697	4.364 ± 1.031	4.480 ± 0.662	4.509 ± 0.728	0.173	0.915
Largo Square landscape	4.027 ± 0.834	4.182 ± 1.140	4.032 ± 0.835	4.074 ± 0.807	0.128	0.944
Street landscape	3.751 ± 0.829	3.636 ± 1.196	3.564 ± 0.789	3.577 ± 0.838	0.595	0.619
Mountain and sea landscape	3.249 ± 0.561	3.000 ± 0.881	3.191 ± 0.552	3.091 ± 0.541	0.879	0.453
Commercial landscape	2.631 ± 0.641	2.582 ± 0.547	2.710 ± 0.589	2.840 ± 0.814	0.862	0.461

Data source: the authors compiled the data from the questionnaire.

3.3.4. Analysis of Differences in Academic Levels

Based on the results of a one-factor analysis of variance, Table 13 indicates that there is no statistically significant variation in the scores of high school, college, undergraduate, master's, and doctoral students across the five dimensions of architectural, Largo Square, street, mountain and sea, and commercial landscapes. Statistically significant gender differences are not observed ($p > 0.05$).

Table 13. Analysis of differences in academic levels.

Dimension Information	Academic Levels					F Value	*p*-Value
	High School	College	Bachelor's Degree	Master's Degree	Ph.D. Degree		
Architectural landscape	4.188 ± 0.859	4.494 ± 0.653	4.439 ± 0.706	4.549 ± 0.759	4.706 ± 0.473	1.847	0.121
Largo Square landscape	3.894 ± 1.040	3.775 ± 0.966	4.053 ± 0.841	4.118 ± 0.724	4.265 ± 0.698	1.631	0.167
Street landscape	3.463 ± 0.905	3.363 ± 0.886	3.596 ± 0.844	3.708 ± 0.727	3.824 ± 0.745	1.575	0.182
Mountain and sea landscape	3.000 ± 0.625	2.975 ± 0.652	3.243 ± 0.579	3.180 ± 0.584	3.259 ± 0.339	1.963	0.101
Commercial landscape	2.635 ± 0.962	2.725 ± 0.537	2.731 ± 0.690	2.626 ± 0.452	2.753 ± 0.562	0.297	0.880

Data source: the authors compiled the data from the questionnaire.

3.3.5. Analysis of Differences in Household Registration

Table 14 shows no statistically significant difference in scores among Macau household registration, Chinese mainland household registration, and other household registrations in the four specific dimensions of architectural, Largo Square, street, and mountain and sea landscapes ($p > 0.05$). There is a notable disparity in the commercial landscape dimension ($p = 0.023 < 0.05$), where respondents with Macau household registration and Chinese mainland household registration obtained significantly higher scores than respondents with other household registration categories.

Table 14. Analysis of differences in household registration.

Dimension Information	Household Registration			F-Value	*p*-Value
	Macau Household Registration	**Chinese Mainland Household Registration**	**Other Household Registration**		
Architectural landscape	4.481 ± 0.800	4.492 ± 0.648	4.480 ± 0.692	0.007	0.994
Largo Square landscape	4.087 ± 0.832	4.004 ± 0.849	4.240 ± 0.836	0.648	0.524
Street landscape	3.636 ± 0.750	3.580 ± 0.836	3.733 ± 1.065	0.289	0.749
Mountain and sea landscape	3.152 ± 0.533	3.187 ± 0.587	3.200 ± 0.609	0.098	0.907
Commercial landscape	2.666 ± 0.611 [b]	2.769 ± 0.638 [b]	2.320 ± 0.632 [a]	3.668	0.027

Data source: the authors compiled the data from the questionnaire.

The analysis of the subject's gender, age group, occupation, education level, and household registration in the questionnaire concludes that these characteristics do not affect the extraction of the dimension of the urban historical landscape, and there is no direct or necessary connection between them. However, the survey of household registrations revealed that Macau's architectural, Largo Square, street, and mountain and sea landscapes do not exhibit any differentiation among subjects of different household registrations. Conversely, the commercial landscape exhibits differentiation, as evidenced by the disparities between Chinese mainland residents, Macau residents, and those with other household registrations. Among them, Chinese mainland residents have the highest scores, and Macau residents are second only to mainland residents. This shows that Macau's commercial landscape is significant to Chinese mainland residents.

3.4. Model Training Result: Parameter Optimization and Cross-Validation

This study used parameter optimization and cross-validation to find the best combination of decision tree model parameters during training. This made the model more stable and good at making predictions. We specifically used grid search (GridSearchCV) and cross-validation (StratifiedKFold) techniques. These methods systematically traverse different parameter combinations, evaluate the performance of each set of parameters based on the training set and test set, and ultimately determine the optimal parameter configuration. In this study, the main parameters of the decision tree model include the splitting criterion, maximum depth, and minimum sample split number (min sample split). Table 15 displays the specific configuration values. The minimum sample split number refers to the minimum number of samples needed to re-divide a node, while the maximum depth controls the maximum number of layers in the tree to prevent overfitting. To ensure the generalization performance of the model, three-fold cross-validation was used; that is, the dataset was divided into three parts, two of which were used to train the model each time, and the remaining one was used to test the model, and the cycle was repeated three times to obtain the average performance index.

Table 15. Hyperparameter configuration.

The Main Parameters	Numerical value
Criterion	Gini, Entropy
Max depth	None, 5, 10, 15, 20, 25
Min samples split	2, 5, 10, 15, 20, 30

Data source: author's statistics.

Through grid search optimization, Table 16 shows the top ten parameter combinations with the highest average test scores. The best results were obtained when information entropy was used as the splitting criterion; there was no maximum depth limit, and the minimum sample split number was two. It obtained an average test score of 0.945, a training score of 1.000, and a standard deviation 0.000. This shows that the combination fully fits the data on the training set and performs well on the test set.

Table 16. Optimal parameter combination (top ten data with the highest average test scores).

Criterion	Max Depth	Min Samples Split	Mean Test Score	Std Test Score	Mean Train Score	Std Train Score
entropy	None	2	0.945	0.024	1	0
entropy	15	2	0.945	0.024	1	0
entropy	20	2	0.945	0.024	1	0
entropy	25	2	0.945	0.024	1	0
entropy	10	2	0.932	0.012	0.991	0.005
gini	None	2	0.929	0.013	1	0
gini	15	2	0.929	0.013	1	0
gini	20	2	0.929	0.013	1	0
gini	25	2	0.929	0.013	1	0
entropy	None	5	0.926	0.023	0.987	0.005

Data source: author's statistics.

Furthermore, the results shown in Table 16 demonstrate that using information entropy as the splitting criterion, the maximum depths of 15, 20, and 25 and the parameter combination with the minimum sample split number of two achieved the same average test score of 0.945. This indicates that the decision tree's performance remains relatively stable under these settings, with the change in the maximum depth having no significant impact. However, although these parameter combinations perform the same on the test set, they may differ in complexity and interpretability. Generally, a smaller maximum depth means the model is simpler, easier to interpret, and may also have better generalization ability.

In contrast, the parameter combination using the Gini coefficient as the splitting criterion (such as Gini, None, 2) also achieved a high average test score (0.929) but was slightly lower than the best combination of the information entropy criterion. This shows that information entropy is more effective as a splitting criterion for this dataset. In addition, changes in the maximum depth and minimum number of sample splits under different splitting criteria impact the model's training and test scores. Based on the information entropy criterion, the best test score and the most stable training score are achieved with no maximum depth limit and a minimum of two sample splits. It can better adapt to the test data without becoming too perfect.

Figure 10 shows the training and cross-validation scores of the model under different parameter combinations. The red line represents the training score, and the green line represents the cross-validation score. As the maximum depth increases, the training score remains high, almost reaching 1.000, indicating that the model is fully fitted to the training set. However, the cross-validation score drops significantly when the depth is small (such as five), indicating that the model is underfitting and cannot generalize well to the test data.

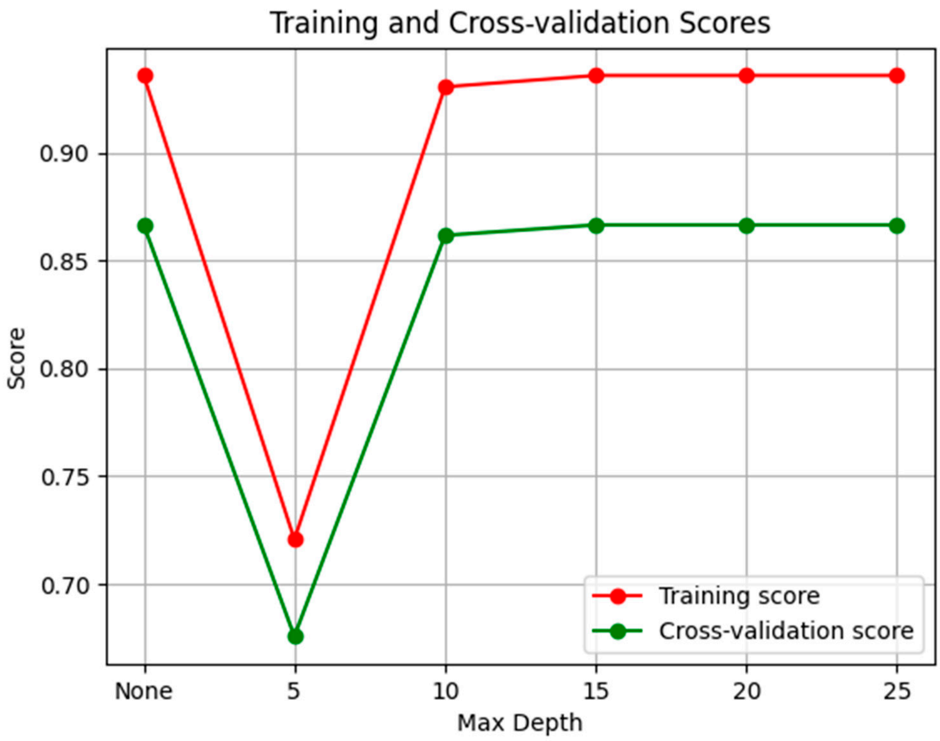

Figure 10. Model training and cross-validation scores under different parameter combinations (image source: drawn by the author).

As the maximum depth increases, the cross-validation score gradually improves until it stabilizes when the depth reaches approximately 15, indicating that the model performs well on both the training and test sets. However, when the maximum depth continues to increase to the maximum value (such as 25), the training score remains unchanged, but the cross-validation score does not improve significantly, which means that further increasing the maximum depth does not lead to performance improvement based on the current dataset.

In summary, the results show that the parameter combination using information entropy as the splitting criterion, no maximum depth limit, and a minimum sample split number of two performs best, with a test score of 0.945 and a training score of 1.000. Although other parameter combinations are slightly inferior in test scores, they still show high prediction accuracy. These results strongly support selecting appropriate decision tree parameter combinations and serve as a reference for subsequent model applications and improvements. The high performance and stability of the decision tree model is ensured through detailed parameter optimization and cross-validation analysis, which further enhances the model's reliability in practical applications.

3.5. Model Evaluation: Precision, Recall, and F1 Score

Following the completion of model training, we must assess the decision tree model's performance on the test set, concentrating on its precision, recall, and F1 score. These evaluation indicators can fully reflect the model's classification performance, help understand the model's predictive ability in different categories, and identify potential deficiencies. Table 17 displays the model evaluation report.

Table 17 demonstrates that the model's classification performance based on multiple categories is excellent, with precision, recall, and F1 score all reaching 1.000. However, for Categories 5, 6, and 7, although the model's performance is still good, there are some differences.

Table 17. Model evaluation report.

Category	Precision	Recall	F1-Score	Support
0	1	1	1	37
2	1	1	1	37
3	1	1	1	37
4	1	1	1	37
5	0.948	1	0.973	37
6	1	0.837	0.911	37
7	0.853	0.945	0.897	37
8	1	1	1	37
9	1	1	1	36
10	1	1	1	37
accuracy	0.978	0.978	0.978	0.978
macro avg	0.980	0.978	0.978	369
weighted avg	0.980	0.978	0.978	369

Data source: authors' statistics.

More precisely, the precision within Category 5 is 0.949, the recall is 1.000, and the F1 score is 0.974. Despite the high recall, the precision is somewhat suboptimal, suggesting certain false positives in Category 5 prediction. Although the model achieves a precision of 1.000, recall of 0.838, and F1 score of 0.912 in correctly identifying samples of Category 6, it still fails to detect some samples. Category 7 exhibits a precision of 0.854, a recall of 0.946, and an F1 score of 0.897, indicating a comparatively modest precision but a high recall. This suggests that the model is more thorough in delineating Category 7 but may erroneously categorize samples from other categories as Category 7.

The overall accuracy is 0.978, indicating that the model performs well. The precision, recall, and F1 scores of the macro-average and weighted average are 0.980 and 0.978, respectively, further confirming the model's overall good performance. These averages provide a comprehensive evaluation of the model's overall performance, with the macro-average emphasizing the importance of each category and the weighted average balancing the differences in the number of samples between categories.

We drew a confusion matrix diagram of the decision tree model (Figure 11) to further understand the model's performance in each category, where each element represents the relationship between the actual category and the predicted category. Figure 11 demonstrates that the model excels in classification across most categories, correctly classifying most samples. For example, samples of Categories 0, 2, 3, 4, 7, 8, 9, and 10 are correctly classified, showing a perfect classification effect. However, for Categories 5 and 6, although the overall performance is still good, there are some misclassifications. Specifically, the system correctly classifies 31 samples of Category 5 but incorrectly classifies 6 as Category 6. Thirty-five samples are correctly classified, but two are misclassified as Category 4.

The confusion matrix clearly shows the model's classification effect on different categories, further verifying the results in the classification report. Although the overall performance is very good, the misclassification in some categories still needs attention. In particular, the misclassification between Category 5 and Category 6 indicates that there may be substantial similarities in the characteristics of these two categories, making it difficult for the model to distinguish between them. This study's theme, the influence of landscape characteristics on resident satisfaction, could potentially explain the misclassification. In practical applications, Categories 5 and 6 may correspond to specific landscape types or combinations of landscape characteristics, which may have similar resident satisfaction scores.

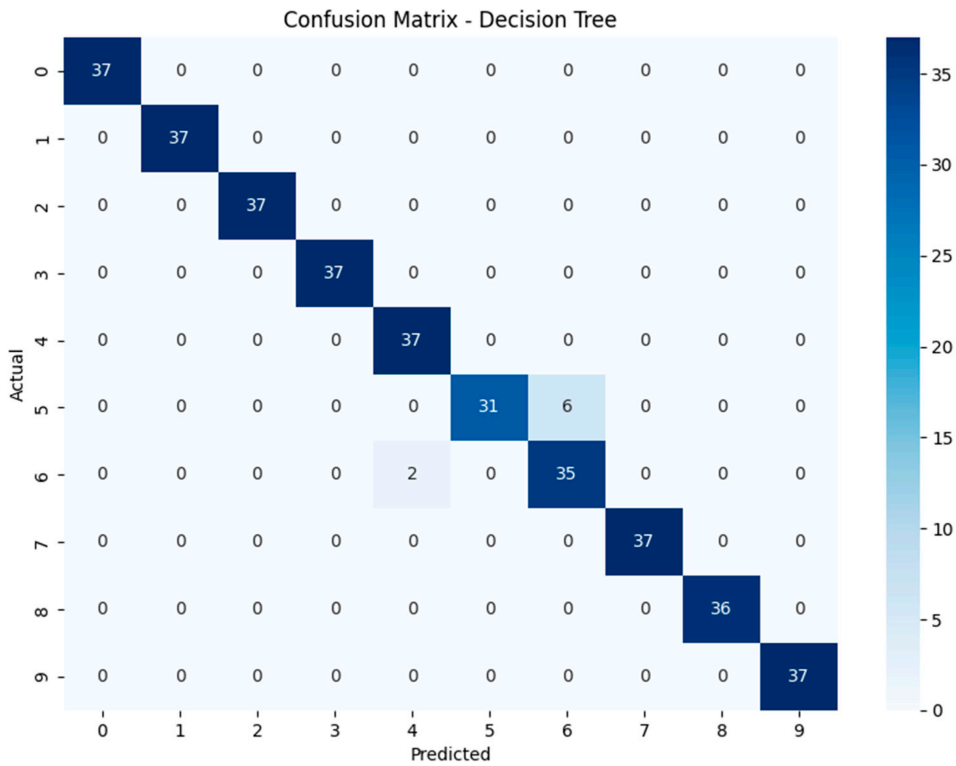

Figure 11. Confusion matrix analysis of decision tree model. (Image source: drawn by the author).

3.6. The Impact Path of Urban Landscape Characteristics on Residents' Satisfaction

A decision tree was used to build a classification model based on residents' satisfaction data about the urban landscape features around the historic center of Macau. The model showed the key landscape features and how they affect residents' satisfaction (the results of the decision tree analysis are detailed in the Supplementary Material: https://doi.org/10.6084/m9.figshare.26953633.v1, accessed on 6 September 2024). These characteristics and combinations have significant guiding implications for urban planning and landscape design. As detailed in the Supplementary Material, Largo Square's location layout is the primary node in the decision path, indicating that a reasonable layout of squares and open spaces is one of the key factors affecting residents' satisfaction. A well-planned square provides visual beauty and is an important social and leisure place for residents. This study reveals a significant improvement in residents' overall satisfaction when the current layout score exceeds 3.50. This finding underscores the importance of prioritizing square layout optimization in the vicinity of historical urban areas, particularly in residents' living areas.

People repeatedly cited the design of street and alley building facades as a split node, indicating that it plays an important role in improving the city's beauty and residents' satisfaction. The design of building facades reflects the city's historical and cultural characteristics and directly affects the visual effect and livability of street space. The results show that when the score of street and alley building facades is higher than 1.50, it can be further refined by combining other characteristics, such as the scores of the former humanities and religion, which can significantly affect the residents' satisfaction scores. This shows that high-quality building facade design is indispensable in improving residents' environmental perception and satisfaction.

Largo Square humanities and religion, among other important features, profoundly impact residents' satisfaction. This feature reflects the richness of cultural and religious elements in urban spaces. Religious buildings and cultural activities enhance the city's cultural connotation and residents' sense of belonging and identity, especially in a city with a profound historical and cultural heritage, like Macau. This study revealed a significant improvement in residents' satisfaction when the score exceeded 1.50, particularly when paired with a high score for architectural esthetics. This result underscores the importance of protecting and developing cultural and religious elements in landscape design.

Furthermore, the decision tree's split nodes frequently display geographical features, commercial space layouts, and other features, indicating their significant influence on residents' satisfaction. For instance, geographical features encompass the characteristics of mountain and sea environments. These natural landscapes not only improve the city's ecological quality but also positively impact residents' psychological feelings and satisfaction. This study shows that when the score of geographical features is high, the combination with other features, such as street and alley spatial forms, can further improve residents' satisfaction.

4. Discussion: Optimal Decision Path Analysis Based on a Decision Tree Model

In this study, the optimal decision path affecting residents' satisfaction was determined by analyzing the decision tree model (Figure 12). This path is based on the scores of different landscape features and reveals which feature combinations can maximize residents' satisfaction. The following is a detailed analysis of the optimal decision path.

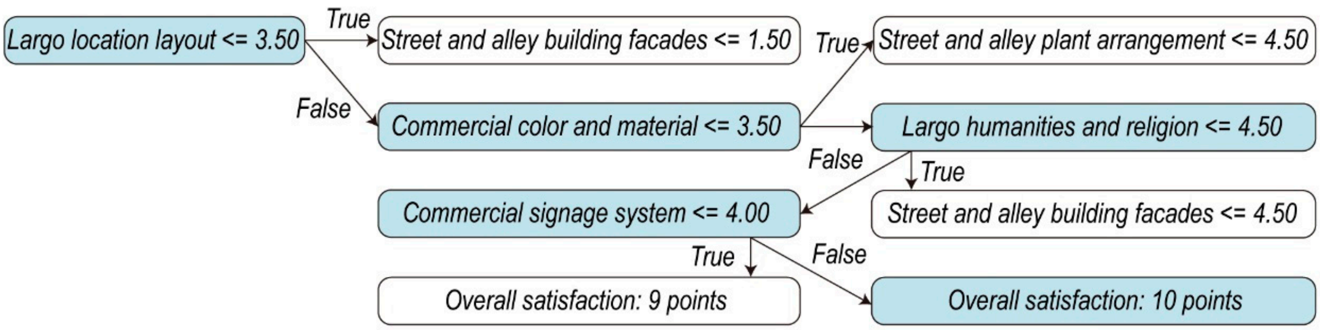

Figure 12. The optimal decision path. (Image source: drawn by the author).

(1) The Largo Square location layout score should exceed 3.50. The node with a Largo Square location layout score greater than 3.50 in the classification process is an important decision point. This score indicates the high quality of the square and open space layout, providing good visual effects and user experience. A reasonable square layout can enhance visual beauty and provide an important social and leisure place for residents. These squares are usually beautifully designed, with rich landscape elements and convenient facilities that meet the various needs of residents, thereby significantly improving residents' satisfaction.

(2) The score for commercial colors and materials should exceed 3.50. A high score for the Largo Square layout further refines the score to exceed 3.50 for commercial color and materials. This score indicates that the color and material design of the commercial area are relatively prominent, which can attract the attention of residents and produce a positive visual effect. Appropriate commercial color and material design can enhance the commercial area's attractiveness and improve the overall environment's beauty. A higher score indicates that these design elements not only highlight the characteristics of the commercial area but also coexist harmoniously with the surrounding environment, thereby improving residents' satisfaction.

(3) Largo Square's humanities and religion score should be above 4.50. Further refinement leads to a humanities and religion score greater than 4.50 in Largo Square. This score indicates that Largo Square's cultural and religious elements, including religious buildings and cultural activities, are extremely rich. Rich cultural and religious elements can enhance the city's cultural connotation and the residents' cultural identity and sense of belonging. These activities and buildings enrich urban life and provide spiritual satisfaction, significantly improving residents' satisfaction.

(4) The commercial sign system's score is greater than 4.00. The route to the commercial sign system has a score of more than 4.00. This score indicates that the sign system in the

commercial area is well designed, easy to identify, and beautiful. A reasonable commercial sign system can improve the commercial area's functionality and enhance the coordination and beauty of the overall environment. A well-designed sign system can help residents and tourists easily find their destination, enhance their shopping and travel experience, and thus increase their satisfaction.

A detailed analysis of the optimal decision path reveals that a reasonable square layout, prominent commercial color and material design, rich cultural and religious elements, and an excellent commercial sign system are the key factors affecting residents' satisfaction. The combined effects of these features have both improved residents' overall satisfaction. Urban planning and landscape design should focus on these aspects to further improve residents' quality of life and satisfaction by optimizing landscape features and improving design quality.

5. Conclusions

This study is based on five dimensions to investigate residents' satisfaction with the characteristics of the urban landscape in the vicinity of the historic center of Macau. The questionnaire survey results indicate that, except for the commercial dimension, the respondents highly recognized the situations mentioned in each landscape dimension, thereby emphasizing their significance to the urban landscape. Therefore, in studying Macau's historical landscape, we consider focusing on four aspects of the city's architectural landscape dimensions: architectural, Largo Square, street, and mountain and sea landscapes. Meanwhile, the data on residents' satisfaction with the townscape features around the historic center of Macau were analyzed, applying the decision tree model to identify the key landscape features and their combined paths influencing residents' satisfaction. The results of this study showed that residents' satisfaction was highest when the score of the Largo Square location layout in the historic center of Macau was greater than 3.50, the score of the commercial color and material was greater than 3.50, the score of the former place's humanities and religion was greater than 4.50, and the score of the commercial sign system was greater than 4.00. These data-driven findings identify specific aspects that require optimization in the planning and designing of future historic districts. (1) Square layout: a score of more than 3.50 is achieved by configuring leisure areas reasonably and incorporating green spaces and water features into the design. (2) Commercial colors and materials: the design of commercial buildings and decorations should surpass 3.50, emphasizing the importance of color coordination and material texture in enhancing visual beauty. (3) Cultural and religious elements: the cultural and religious score around Largo should exceed 4.50, reflecting rich cultural and religious activities, such as maintaining religious sites and organizing cultural festivals, and buildings. (4) Commercial sign system: the commercial area's sign system score should exceed 4.00, requiring the sign design to be clear, beautiful, and harmonious with the surrounding environment. Urban planners and designers can directly apply these specific indicators and suggestions to optimize the layout and design of urban public spaces, thereby enhancing residents' quality of life and satisfaction.

Although this study has achieved valuable results, there are still some limitations. For instance, (1) despite the high interpretability of the decision tree model in this study, its performance may deteriorate when handling complex nonlinear relationships and high-dimensional data. For example, in the decision tree model, the classification performance of Categories 5 and 6 is slightly worse than that of other categories, indicating certain limitations in dealing with complex feature combinations. (2) Resident satisfaction is affected by many factors, including socioeconomic factors, individual differences, and landscape characteristics. This study mainly focuses on landscape characteristics. Future research can introduce more influencing factors and multifactor analysis methods to comprehensively evaluate resident satisfaction.

The following paths for future research development are possible. (1) Regional expansion: similar studies should be conducted in different cities and regions to verify and expand the findings of this study. For example, researchers can conduct similar resident satisfaction studies in other historical and cultural cities, compare the impact of different cities' landscape characteristics on satisfaction, and explore the impact of regional cultural differences on resident satisfaction. (2) Multifactor analysis: multiple influencing factors should be introduced, such as socioeconomic factors and individual differences, and multifactor analysis methods should be used to provide a more comprehensive and integrated evaluation of resident satisfaction. For example, data, such as residents' income level and educational background, can be combined to construct a multidimensional satisfaction model to analyze the differences in satisfaction and their causes across different socioeconomic backgrounds. (3) Long-term effects research: long-term follow-up research should be conducted to analyze the long-term effects of landscape feature optimization measures and evaluate their continued impact on resident satisfaction. Through regular questionnaire surveys and data analysis, we can understand the changes in the effects of landscape optimization measures over different periods and provide long-term guidance for urban planning and design. (4) Participatory planning: this involves exploring mechanisms for residents to participate in urban planning and landscape design and further optimizing these processes based on residents' feedback and opinions to enhance their satisfaction. Research can collect residents' opinions and suggestions on landscape design to ensure that the design plan better meets their needs and preferences.

Through further research in these directions, we can more comprehensively understand the impact of landscape characteristics on residents' satisfaction, improve the scientificity and effectiveness of urban planning and landscape design, promote the sustainable development of cities, and improve residents' quality of life. It is worth noting that collecting questionnaires from residents and combining machine learning model analysis is not eternal and unchanging. It may change with time and with improvements to urban facilities. The regular collection of residents' opinions and public participation are also key points for future consideration. The methods used in this study, combined with a detailed analysis of actual data indicators, are also aimed at providing a scientific basis for the future optimization of historic district spaces.

Supplementary Materials: The results of the decision tree analysis are detailed in the Supplementary Material: https://doi.org/10.6084/m9.figshare.26953633.v1, accessed on 6 September 2024.

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Institutional Review Board Statement: The Institutional Review Board (IRB) of Hangzhou City University reviewed and approved the studies involving human subjects. The participant's legal guardian or next of kin has agreed to the written informed consent for this study prompted on the home page before filling out the questionnaire. The approval number is 2024-0501.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The Institutional Review Board (IRB) of Hangzhou City University that approved this study prohibits the authors from making the research dataset publicly available. Readers and all interested researchers may contact Professor Dr.Yang Shuai (Email address:

samyang@zju.edu.cn) for details. Shuai Yang could apply to the Institutional Review Board (IRB) of Hangzhou City University for the release of the data.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Computer Configuration Environment for Decision Tree Calculation

Computer configuration environment for decision tree calculation: the operating system is Windows 11 (X64), the CUDA version is 11.5, the deep learning framework is PyTorch (1.13.0), and the graphics card and processor is a GeForce GTX 3070 (16 G) and an AMD Ryzen 9 5900HX (3.30 GHz), respectively.

Appendix B. Survey Questionnaire for Exploring the Life Satisfaction of Residents around the Historic Center of Macau

Please be aware that the information provided below has been translated from the original questionnaire, which was written in Chinese.

1. Dimensions of Macau's architectural landscape [Matrix scale question] * [Single Choice] (Asterisks * indicate required questions in the questionnaire)

Question	Strongly Disagree	Disagree	Neither too Much	Agree	Strongly Agree
Are you satisfied with Macau's architectural ecology, which reflects the characteristics of its architectural landscape?	○	○	○	○	○
Are you satisfied with the architectural space experience in Macau, which reflects the characteristics of Macau's architectural landscape?	○	○	○	○	○
Are you satisfied with the architectural and cultural characteristics of Macau, which reflect the characteristics of Macau's architectural landscape?	○	○	○	○	○
Are you satisfied with the architectural esthetic effects in Macau, which reflect the characteristics of Macau's architectural landscape?	○	○	○	○	○
Are you satisfied with the architectural psychological experience in Macau, which reflects the characteristics of Macau's architectural landscape?	○	○	○	○	○

2. Dimensions of Macau's Largo Square landscape [Matrix scale question] * [Single Choice] (Asterisks * indicate required questions in the questionnaire)

Question	Strongly Disagree	Disagree	Neither too Much	Agree	Strongly Agree
Are you satisfied with Macau's Largo Square's ground decoration, which reflects its landscape characteristics?	○	○	○	○	○
Are you satisfied with how the humanities and religion of Macau's Largo Square reflect the landscape characteristics of the area?	○	○	○	○	○
Are you satisfied with Macau's Largo Square's location layout, which reflects its landscape characteristics?	○	○	○	○	○
Are you satisfied with the historical origins of Macau's Largo Square, which reflects the landscape characteristics of the area?	○	○	○	○	○
Are you satisfied with Macau's Largo Square's landscape layout, which reflects its landscape characteristics?	○	○	○	○	○

3. Dimensions of Macau's street landscape [Matrix scale question] * [Single Choice] (Asterisks * indicate required questions in the questionnaire)

Question	Strongly Disagree	Disagree	Neither too Much	Agree	Strongly Agree
Are you satisfied with the spatial texture of Macau's streets and alleys, reflecting the characteristics of Macau's street and alley landscape?	○	○	○	○	○
Are you satisfied with the spatial form of Macau's streets and alleys, reflecting the characteristics of Macau's street and alley landscape?	○	○	○	○	○
Are you satisfied with the street and alley plant arrangement in Macau, which reflects the characteristics of Macau's street and alley landscape?	○	○	○	○	○
Are you satisfied with Macau's street and alley cultural elements reflecting Macau's street and alley landscape?	○	○	○	○	○
Are you satisfied with Macau's street and alley building facades, which reflect the characteristics of Macau's street and alley landscape?	○	○	○	○	○

4. Dimensions of Macau's mountain and sea landscape [Matrix scale question] * [Single Choice] (Asterisks * indicate required questions in the questionnaire)

Question	Strongly Disagree	Disagree	Neither too Much	Agree	Strongly Agree
Are you satisfied with Macau's mountain and sea natural resources, which reflect the characteristics of the mountain and sea landscape?	○	○	○	○	○
Are you satisfied with Macau's mountain and sea natural resources, which reflect the characteristics of the mountain and sea landscape?	○	○	○	○	○
Are you satisfied with Macau's mountain and sea geographical features, which reflect the mountain and sea landscape's characteristics?	○	○	○	○	○
Are you satisfied with Macau's mountain and sea humanities and history, which reflect the characteristics of its mountain and sea landscape?	○	○	○	○	○
Are you satisfied with Macau's mountain and sea climate change, which reflects the characteristics of the mountain and sea landscape?	○	○	○	○	○

5. Dimensions of Macau's commercial landscape [Matrix scale question] * [Single Choice] (Asterisks * indicate required questions in the questionnaire)

Question	Strongly Disagree	Disagree	Neither too Much	Agree	Strongly Agree
Are you satisfied with the layout of Macau's commercial space, which reflects the characteristics of Macau's commercial landscape?	○	○	○	○	○
Are you satisfied with Macau's commercial guide system, which reflects the characteristics of Macau's commercial landscape?	○	○	○	○	○
Are you satisfied with the way Macau's regional commercial characteristics reflect the characteristics of Macau's overall commercial landscape?	○	○	○	○	○
Are you satisfied with Macau's commercial color and material, which reflect the characteristics of Macau's commercial landscape?	○	○	○	○	○
Are you satisfied with Macau's commercial lighting design, which reflects the characteristics of Macau's commercial landscape?	○	○	○	○	○

6. As a citizen, how satisfied are you with the characteristics of Macau's urban landscape? (10 points for very satisfied, and so on; tick ✔ in the box).

10	9	8	7	6	5	4	3	2	1

7. What suggestions do you have for protecting Macau's urban historical landscape? Thank you for your participation!

8. Your Gender: [Single Choice]
☐ Male
☐ Female
9. Your Age Group: [Single Choice]
☐ 15–24 years old
☐ 25–34 years old
☐ 35–44 years old
☐ 45–54 years old
☐ Over 55 years old
10. Your occupational group: [Single Choice]
☐ Architects, planners and designers
☐ Government officials
☐ Teachers or students
☐ Other occupations
11. Your Educational Level: [Single Choice] *(Asterisks* indicate required questions in the questionnaire)
☐ High school (or equivalent)
☐ College (or equivalent)
☐ Bachelor's degree (or equivalent)
☐ Master's degree (or equivalent)
☐ Ph.D. degree (or equivalent)
12. Your Household registration: [Single Choice]
☐ Macau resident
☐ Chinese Mainland resident
☐ Other resident

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