RESEARCH

Assessment of visual quality and social perception of cultural landscapes: application to Anyi traditional villages, China

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Abstract

The assessment of landscape visual quality (LVQ) holds significant importance in the preservation and advancement of traditional villages. One challenge in measuring human perception lies in establishing a connection between public preferences and landscape characteristics. This study conducted an analysis of social media data from Anyi traditional villages in China to address this issue and identified eight human perceptions: naturalness, ancientness, colorfulness, variety, uniqueness, ingenuity, vividness, and pleasantness. A total of thirty characteristic indicators with potential explanations for LVQ were determined by research group through field investigations. A questionnaire survey was developed to assess human's preferences using 82 traditional village photos, and scores for the eight perceptions were obtained. The logistic regression was employed to establish distinct perception models, with perceptions serving as the dependent variables and characteristic indicators as the independent variables. Nomograms were subsequently utilized to visualize regression results and display the correlation between these two factors. The findings suggest that nomograms facilitate intuitive determination of the weights assigned to characteristic indicators in perceptual models, as well as their influence on LVQ. This work provides a reference for decision-making related to the adaptive protection and development of traditional villages, thereby helping to enhance the competitiveness of tourist destinations.

Keywords Landscape characteristic, Perception preference, Cultural landscape, Landscape visual quality

Introduction

Traditional villages, commonly known as "ancient villages" refer to the village settlement with a long history and well preservation [1]. The productive and living activities of indigenous communities nurtured a unique cultural landscape [2]. Sauer C. O. stated in his "The Morphology of Landscape" that the cultural landscape is a synthesis of natural and human factors that shape

the features of a certain location at any specific period, and it is continually changing as a result of human activity [3]. The World Heritage Committee adopted the term "cultural landscape" for the first time in 1992, believing that it has extraordinarily rich implications of the connection between nature and humans, and that it is a shared masterpiece inextricably linked to both humans and nature [4]. The traditional villages are regarded as cultural landscapes that encompass a wealth of historical, ethnic, and regional cultural information [1], making them highly sought-after tourist destinations at present. While tourism serves as a compensatory measure for the decline of traditional village industries and fosters economic growth, it also poses challenges to landscape conservation, rendering it an indispensable factor in driving transformations within traditional

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villages [5]. With the rapid development of global urbanization, industrialization and modernization, a wide range of cultural landscape protection projects have been set off around the world [6]. The evaluation and management of traditional cultural landscape has become a research field of global concern, and has also become the focus of the United Nations Educational Scientific and the International Council on Monuments and Sites [4]. Revealingly, there has been a perceptible paradigm shift in the collective perception of landscape, transitioning from its erstwhile characterization as an objective phenomenon to its contemporary recognition as a psychological cognitive process intricately entwined with human subjects [7]. Therefore, the landscape is perceived as a cognitive process centered on vision and functions as a medium for action [8–10]. Perception-driven assessment of visual quality facilitates enhanced comprehension of landscapes, enabling stakeholders to make informed decisions pertaining to planning and management.

The assessment of LVQ serves as a crucial approach to preserving and enhancing the sustainability of traditional villages [1]. For clarification, the terms "landscape evaluation", "landscape quality" and "human perception" used in this paper are all limited to their visual attributes [10]. Previous studies have demonstrated that the assessment of landscape quality relies on the selection of visual features within a specific area [11, 12], and the presence of physical attributes significantly contributes to the promotion of visitation [13]. Daniel [12] highlighted that the LVQ originates from the interplay between landscape attributes and human perceptions. For example, Pazhouhanfar and Kamal [14] found that the coherence, complexity and mystery of landscapes have a positive impact on perception, while readability does not. Berto's findings [15] indicated that waterscapes and natural landscapes can provide users with relaxing surroundings conducive to restore attentional capacity. Furthermore, landscape evaluation also encompasses consideration of negative aspects such as excessive richness in landscapes which may lead to confusion and unfavorable perceptions [16]. Factors like cluttered streets, monotonous buildings, and jarring electronic signs can hinder individuals from having positive perceptual experiences [17]. Investigating people's preferences for LVQ and associated values is therefore essential as it offers valuable information to optimize the utilization of landscape resources within traditional villages.

To date, the correlation between landscape resources and human perceptions has been extensively studied in various fields, including urban landscapes, waterfront landscapes, road landscapes, forest landscapes, park landscapes, and rural landscapes [1, 8]. However, effectively collecting physical environment and visual perception information that influences viewers' site experience remains a challenge for assessing LVQ [18]. The popular data collection techniques such as questionnaire surveys, group interviews, and controlled experiments have long been employed by researchers to capture human preferences [19]. However, the data survey methods still possess limitations in terms of being time-consuming, potentially biased responses, and inadequate representativeness, thereby failing to encompass a broader public opinion [20]. The rapid development and widespread use of social media platforms have facilitated easy sharing of views among individuals along with information exchange and participation in discussions. The data from social media includes various types of content such as images, videos, and text that exhibit the attributes of extensive scale, diverse content, and easy accessibility. Public-driven social media enables decision makers to understand user behavior and preferences, facilitating research on human perception [21, 22]. For instance, microblog data was utilized to assess park green space usage [23] and visitor mood during COVID-19 [24]. Geotagging data from social media served as proxies of scenic spot actual visits to investigate people's preference for landscapes [25]. Twitter and Instagram data collection aims to explore the correlation between landscape features and ecosystem services [26, 27]. The aforementioned research indicates that user-generated content on social media platforms is associated with perceived preferences and significantly contributes to feature extraction and value identification.

The objective of this study is to address the following inquiries: 1. How do landscape characteristic indicators influence the visual quality of traditional village landscapes? 2. Which landscape characteristic indicators have a significant quantitative predictive impact on positive perception? What sets this study apart is the development of a quantitative and visualization method that links perceptions with characteristic indicators to evaluate LVQ for traditional villages. Unlike previous models employing complex mathematical formulas [28, 29], the nomogram was employed to illustrate the correlation between characteristic indicators and perceptions [30], with the length of each line segment representing the weight assigned to each indicator. The nomogram, being a graphical tool, can provide doctors with a quick visual diagnosis and has gained widespread popularity in prognostic assessment of diseases such as cancer. The present study contributes to the establishment of a mutually beneficial mechanism between preservation efforts and sustainable development in traditional villages. This not only ensures

the preservation of the unique cultural landscape resource but also promotes responsible tourism practices that benefit both visitors and local communities.

Materials and methods
Study area
The Anyi traditional villages (Fig. 1) are located in Nanchang, capital of Jiangxi Province, China. It covers an area of 8 square kilometers and consist of three villages known as Luotian (罗田), Shuinan (水南), and Jingtai (京台). It was first built in the Tang Dynasty (618–907) and has preserved 120 ancient buildings from the Ming (1368–1616) and Qing (1616–1911) Dynasties (www.anyigucun.com). The ancient structures encompass a variety of architectural forms, including residential buildings, academies, ancestral halls, and theaters, forming a distinctive historical cultural landscape. In 2013, the Anyi ancient villages were inscribed on China's state protection list for the preservation of their cultural relics and traditions (Ministry of Housing and Urban–Rural Development Document No.124 of 2013).

Research methodologies
Categorization of the landscape resource
Characteristic indicators have significance in numerous assessments and academic research, and their selection should follow the criteria of universality, authenticity, and feasibility in both quantitative and qualitative operations [31, 32]. Theoretically, any landscape element can be considered as a factor in LVQ.

Fig. 1 Anyi traditional villages of China

Characteristic indicators have significance in numerous assessments and academic research, and their selection should follow the criteria of universality, authenticity, and feasibility in both quantitative and qualitative operations [31]. The assessment of LVQ frequently relies on subjective criteria that have limitations regarding rational expression [1, 32]. As a result, this study utilized the classification approach suggested in the Evaluation Standards for Rural Landscape Resources of China (Group standard of Chinese Society of Landscape Architecture No T/CHSLA 50012—2022) and classifies the landscape resources of ancient villages into natural landscapes, agricultural landscapes, cultural landscapes, and living landscapes. This categorization seeks to identify indicators that are more suitable to expressing the LVQ.

The survey results are presented in Table 1, which showcases an index set of representative landscapes found in ancient villages, with a total of 12 distinct types of representative features. It reveals that cultural landscape types dominate the ancient villages in Anyi, accounting for more than half of the total, while other significant landscape kinds include natural landscapes, agricultural landscapes, and living landscapes. Some of them have comparable effects on LVQ and hence fall under the same category of characteristics [33].

Survey of human perception categories

The grounded theory approach [34] and social media data were employed to analyze tourists' perception preferences for landscapes and identify the key characteristics that have a substantial effect on their pleasant impressions [6]. The availability of social media data makes it easier to record users' impressions and differences in different types of landscapes due to its large volume and long-time span [35]. When creating public policies, management is taking public opinion into account more often than only expert advice and empirical data [36]. Citizen-driven social media content allows managements to listen to and analyze citizens' opinions and attitudes towards policies [36, 37], which is defined as a new network-based business model that utilizes creative solutions from distributed personal networks [38].

Table 1 Categories of landscape resource

Main categories	Subcategories	Basic types
A Natural landscapes	A1 Geography	A101 Terrain; A102 Landform
	A2 Natural resources	A201 Animal resources; A202 Forest resources; A203 Climatic and meteorological resources; A204 Mineral resources; A205 Water resources
B Agricultural landscapes	B1 Countryside	B101 Farmlands; B102 Orchards; B103 Economic forest; B104 Flower fields
	B2 Pasturage	B201 Grazing; B202 Captivities
	B3 Fishery	B301 Breeding; B302 Fishing
C Human landscapes	C1 Humanistic pattern	C101 Street space; C102 Landscape and horticulture
	C2 Landmarks and historical sites	C201 Landmark buildings; C202 Ancient trees; C203 Historical sites; C204 Genealogy classics
	C3 Constructions	C301 Residential architecture; C302 Administrative architecture (Yamen, drum tower, etc.)
		C303 Religious architecture (Ancestral halls, temples, pagodas, sutras, archways, etc.)
		C304 Education architecture (Museums, showrooms, academies, private schools, etc.)
		C305 Business architecture (Iron shop, medicine shop, pawn shop, restaurant, tavern, inn, etc.)
		C306 Industrial architecture (Dyehouse, brick kiln, coal kiln, mine etc.)
		C307 Agricultural architecture (Grains, oil mills, mills, threshing grounds, etc.)
		C308 Transportation architecture (Roads, walkways, piers, bridges, etc.)
		C309 Military architecture (Passes, walls, tunnels, towers, beacon towers, school yards, etc.)
		C310 Entertainment architecture (Dance towers, stages, corridors, pavilions, platforms, halls, etc.)
		C311 Auxiliary architecture (Flower houses, ditches, wells, ponds, etc.);
	C4 Folk arts	C401 Theatres and dances; C402 Weddings and funerals; C403 Temple fair; C404 Traditional skills
D Living landscapes	D1 Production and life	D101 Farm work; D102 Daily diet
	D2 Sale activities	D201 Commodity display; D202 Pedlary
	D3 Leisure activities	D301 Villagers' leisure; D302 Tourist hubs

We used the python programming language (v3.10) to gather user-generated content (UGC) information regarding perception and assessment from the six major travel network platforms in China, namely Qunar (https://www.qunar.com), Ctrip (http://www.ctrip.com), Fliggy (https://www.fliggy.com), Tuniu (https://www.tuniu.com), Travel Go (https://www.ly.com), and Mafeng-wo (http://www.mafengwo.cn). The collected UGC text data was then converted into an ANSI-encoded TXT file format and ROSTCM (v6.0) was employed to analyze the high-frequency words, co-occurrences of words, and finally construct a social semantic network diagram, shown in Fig. 2. At the time of conducting this research, these six platforms allowed searching and downloading public content. We have obtained their verbal consent to use the collected data for academic purposes. We completely adhered to the ethical guidelines established by the author's institution during the conduct of the current research. To protect personal privacy, the obtained data is only available to members of the study team and will be removed once the project is done.

Previous study found a positive relationship between image density and preferences for landscape characteristics or aesthetic appreciation [21, 39]. Similarly, we assumed that the frequency of mentioned words represents preference ratings and implies the importance of features and values. High-frequency keywords will be utilized to analyze the characteristic elements of Anyi villages that the public are concerned about, while the semantic network diagram of the comment content will assist define the overall perceived image of villages [40]. A total of 6632 travelogues, videos, photos, and comments were extracted from social media platforms by utilizing the search keyword "Anyi ancient village" to gather samples relevant to the research theme. The research team employed semantic network diagrams to eliminate isolated nodes and nodes unrelated to the image of Anyi ancient village (e.g., "economy," "politics," and "China"). The data filtering process primarily focused on subjective perception of descriptive content while considering text comprehension and contextual understanding [41]. Additionally, image or video content was used for clarification when necessary [18]. A total of 4565 eligible analysis posts were identified.

The grounded theory approach [34] was employed to systematically encode textual information for the extraction of perceptual categories related to LVQ. The authors pre-planned criteria and procedures for data encoding, wherein one author conducted the initial processing and another provided a review. Any encountered issues during evaluation were resolved through discussion. First, the original text undergoes open coding, wherein each word and sentence is meticulously examined. Phrases related to the imagery of ancient villages are conceptualized and organized into nodes [6]. For example, 'the thousand-year-old camphor tree bears witness to Anyi ancient village's historical legacy' is encoded as 'ancient trees'; 'the architectural style reflects that of the Ming and Qing dynasties' is encoded as 'ancient buildings'; 'traditional culture has
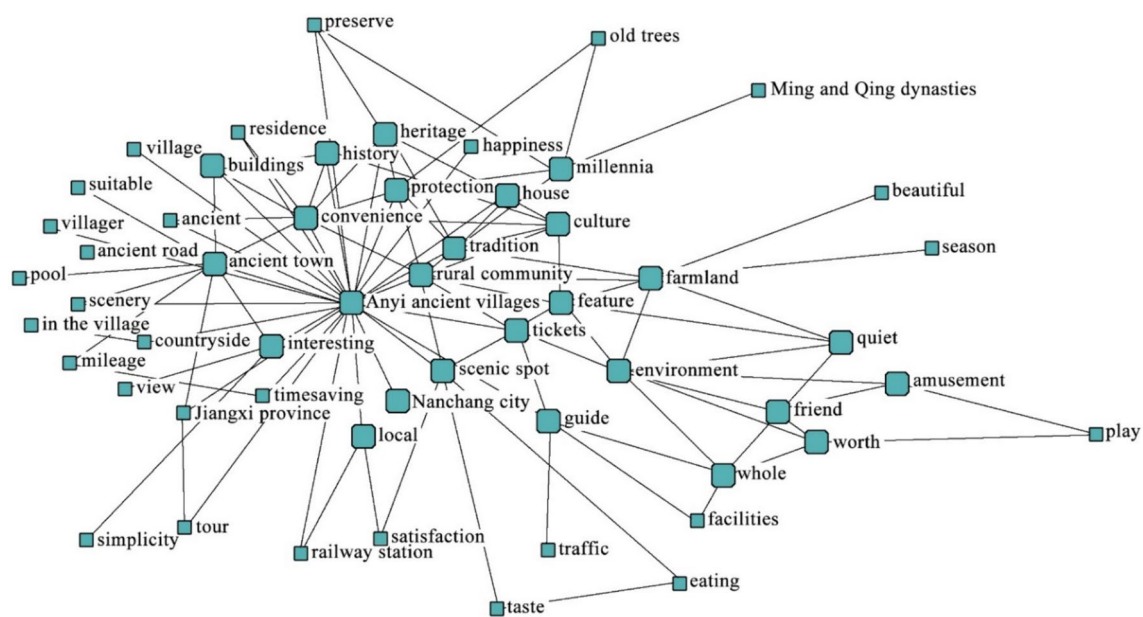

Fig. 2 Co-occurrence network of high-frequency words. (Size of the core represents word frequency, while peripheral words represent responses)

been dutifully preserved' is encoded as 'ancient culture'. Through this process, a total of 36 nodes representing village imagery are obtained. Subsequently, axial coding takes place whereby these nodes depicting village imagery are comprehensively summarized based on their reflected dimensions [34]. Nodes such as 'ancient trees', 'ancient buildings', and 'ancient culture' fall under the category of "historical relics". This results in 15 dimensions encompassing ancient village imagery. Finally, selective coding plays a pivotal role in completing the entire coding process by requiring focused consideration on envisioning dimensions of ancient villages and extracting core categories [42]. Dimensions like "historical relics", "antique charm", and "cultural heritage" are integrated into the perception image of ancientness in this stage. Ultimately, eight core categories for perceiving Anyi village images emerge: naturalness, ancientness, colorfulness, variety, uniqueness, ingenuity, vividness, and pleasantness.

Extraction of landscape characteristic indictors

The research group determined landscape characteristic indictors by assessing the physical features of the picture scene. This procedure has three steps. Firstly, identifying landscapes that interest tourists through a viewpoints analysis. We employed GPS (Global Position System) tourist tracking technology to analyze tourists' viewing routes through positioning wristbands in order to determine the locations, quantities, and visibility of landscape viewpoints [43] (Fig. 3).

In this process, we referred to the criteria proposed in reference [6] and ensured that the selection of viewpoints takes into account factors such as exposure, distance from viewpoint to landscape, prominent features of landscape and its possibility to appear in the visual field,

covering various landscape types and visual ranges existing in the research area. Secondly, conducting a viewshed analysis to determine the optimal viewing angle for taking photos [43]. the GIS (Geographic Information System) visual analysis tool was used to simulate human vision and generate the optimal viewing angle through various observations from different viewpoints [44]. Photography sampling follows Panero's principle of selecting views based on a 120° horizontal and 55° vertical range (25% top view + 35% bottom view). The cropping window is then set to 1920×880 pixels, corresponding to a 120:55 aspect ratio, after estimating the visual center (the intersection points between the horizon and vertical line in the observation direction) [45]. The camera is optimally positioned at a height of 1.5 m from the ground, which is considered as the comfortable sight height [45], and ultimately obtained 82 photo samples (Table 2). Thirdly, extracting characteristic indicators from different categories of landscape photos. The research group discussed the criteria and standards for discriminating characteristic indicators of different landscape categories in advance, and resolved differences of opinion through discussion. The physical characteristics of the natural, cultural, agricultural, and other landscapes in villages are mostly distinguishable, and there is little controversy in determining the type of landscape represented by the photos. The research team assessed the landscape features of each photo based on the evaluation criteria (Group standard of Chinese Society of Landscape Architecture No T/CHSLA 50012—2022) for rural landscape resources (detailed guidance is provided in Appendix A), and a total of 30 characteristic indicators were determined (Fig. 4).
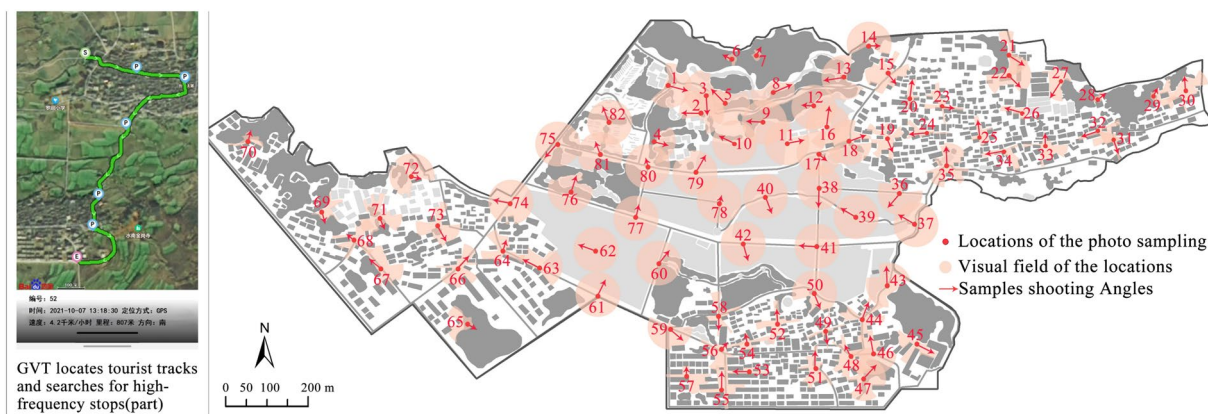

Fig. 3 Sampling sites and viewshed analysis

Table 2 Classification of photo samples

Sample label	Sample interpretation	Landscape categories	Basic types
#01	The scenic spot entrance	D3	D302
#02; #03; #82	Service Facilities	D3	D302
#46; #50; #59; #81	Small squares	C1	C102
#04	Temple (Xia Lian)	C3	C303
#05; #08; #76	Natural waters	A2	A205
#06; #07; #29; #30	Secondary forest	A2	A202
#09; #12; #65	Commercial forest	B1	B103
#10; #70	Commercial forest	B1	B102
#11	Primary school	D1	D101
#13; #69; #71	Open forest lands	A1	A101
#14	Old ginkgo tree(Symbolizing love)	C2	C202
#15	Inscription (Luotian Village)	C1	C101
#16; #40; #61; #62	Garden	B1	B104
#17	Old camphor tree (Symbolizing happiness)	C2	C202
#18; #19; #24; #64	Ancient buildings	C3	C301
#20; #26; #34; #63	Ancient streets and lanes	C1	C101
#21	Tang Zhang Restaurant	C3	C305
#22	Private residence of scholar-bureaucrat (Shi Da Fu Di)	C2	C201
		C3	C301
#23	Folk artists skills show (Carving and weaving)	C4	C404
#25	Traditional Chinese wedding scene (Bride in sedan chair)	C4	C402
#27	Tang Zhang Inn	C3	C305
#28	Thousand-year-old camphor tree (Symbolizing wealth)	C2	C202
#31	Thousand-year-old well	C3	C311
#32	Scene of residents chatting	D3	D301
#33	Scene of residents eating (sitting in the courtyard)	D1	D102
#35	Lotus pond	C3	C311
#36	Farm work	D1	D101
#37; #42; #43; #79	Cultivated land	B1	B101
#38; #66; #74; #75	Avenues	C3	C308
#39	Wooden corridor	C3	C310
#41; #77	Boardwalks	C3	C308
#44	Tan-hua-fu Inn	C3	C305
#45	Jin-gang Temple	C3	C303
#47	Green space	C1	C102
#48	Shui-nan Inn	C3	C305
#49	Xin-she Inn	C3	C305
#51	Local cuisine sales	D2	D201
#52	Boudoir Inn	C3	C305
#53	Local cuisine sales	D2	D202
#54	Boudoir Building	C2	C201
		C3	C301
#55	Ancient stage	C3	C310
#56	Huang Clan Ancestral Hall	C2	C201
		C3	C303
#57	Dyeing house	C3	C306
#58	Scene of children playing	D3	D301
#60; #80	Threshing ground	C3	C307
#67; #73	Group of vegetation, landscape stones and paving	C1	C102

Table 2 (continued)

Sample label	Sample interpretation	Landscape categories	Basic types
#68	Gan-shang Museum	C3	C304
#72	Dramatic performance	C4	C401
#78	Garden house	C3	C311

Fig. 4 Landscape characteristic indicators of Anyi villages

Statistical analysis

The LVQ of Anyi traditional villages was assessed by the subjective perception of tourists. The survey on tourists' perception preferences was conducted using a photo elicitation interview and a semi-structured questionnaire (Table 3). We recruited a total of 64 adult participants from tourists, including 28 males and 36 females during the study period. They are from diverse backgrounds, and the confidentiality of each participant is guaranteed. The permission for human subjects had been approved prior to the investigation. Participants were instructed to select the perception category that best represented the sample landscape from eight perception categories based on their perceived intensity levels. Each category

Table 3 Human perception scale for landscape assessment (select 8 out of the 30 pictures that are most likely to explain the perception model, and rank them in order of the perceptual strength)

Human perceptions	Perception value of landscape by picture viewing
Which places look natural?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look ancient?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look colorful?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look various?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look unique?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look ingenious?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look vivid?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;
Which places look pleasant?	8-; 7-; 6-; 5-; 4-; 3-; 2-; 1-;

was assigned points ranging from 8 for the strongest perception to 0 for the unchosen category. Subsequently, a computation and standardization procedure like the Scenic Beauty Estimation [12, 28] were employed to rank each landscape's value. Pearson correlation analysis [6] was performed to eliminate indicators with weak correlations, and only selected indicators were included in the subsequent creation of perception models.

Multiple linear regression is a commonly used statistical analysis approach for modeling the relationship between explanatory and response variables [30, 46].

In this section, we used logistic regression to identify indicators and constructed perceptual models. In the logistic regression analysis, eight human perceptions were used as dependent variables, while thirty characteristic indicators were used as independent predictors to examine the relationship between multiple factors and perceptions. The optimal perception model was determined using stepwise regression analysis with minimal AIC (Akaike's Information Criterion), and its performance was evaluated using the receiver operating characteristic curve (ROC) and area under the curve (AUC) [46]. This study utilized straightforward and intuitive nomograms to clarify the relationship between indicators and LVQ in the analysis of regression results. Each indicator is scored based on its degree of influence (regression coefficient size) on the perception variable, and then proportionally represented using scaled line segments on the same plane [30, 47]. It becomes feasible to quantitatively assess indicators that affect LVQ by simply accumulating their respective scores. The statistical analysis was conducted using the R program (R-4.3.2).

Framework of the study
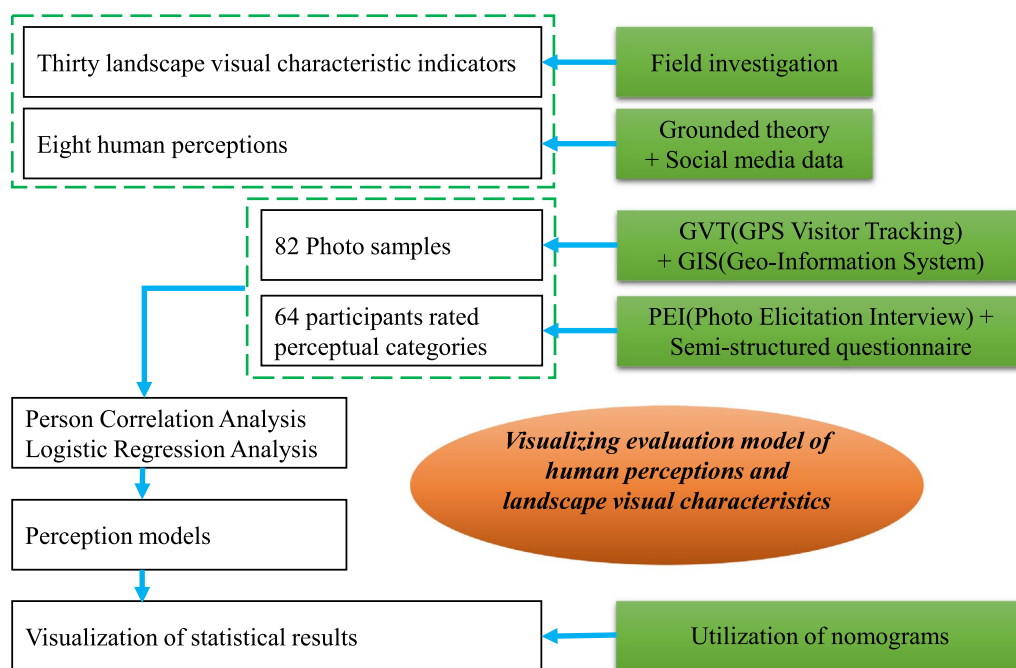Figure 5 shows the flow chart of this study, including research methods and schemes.
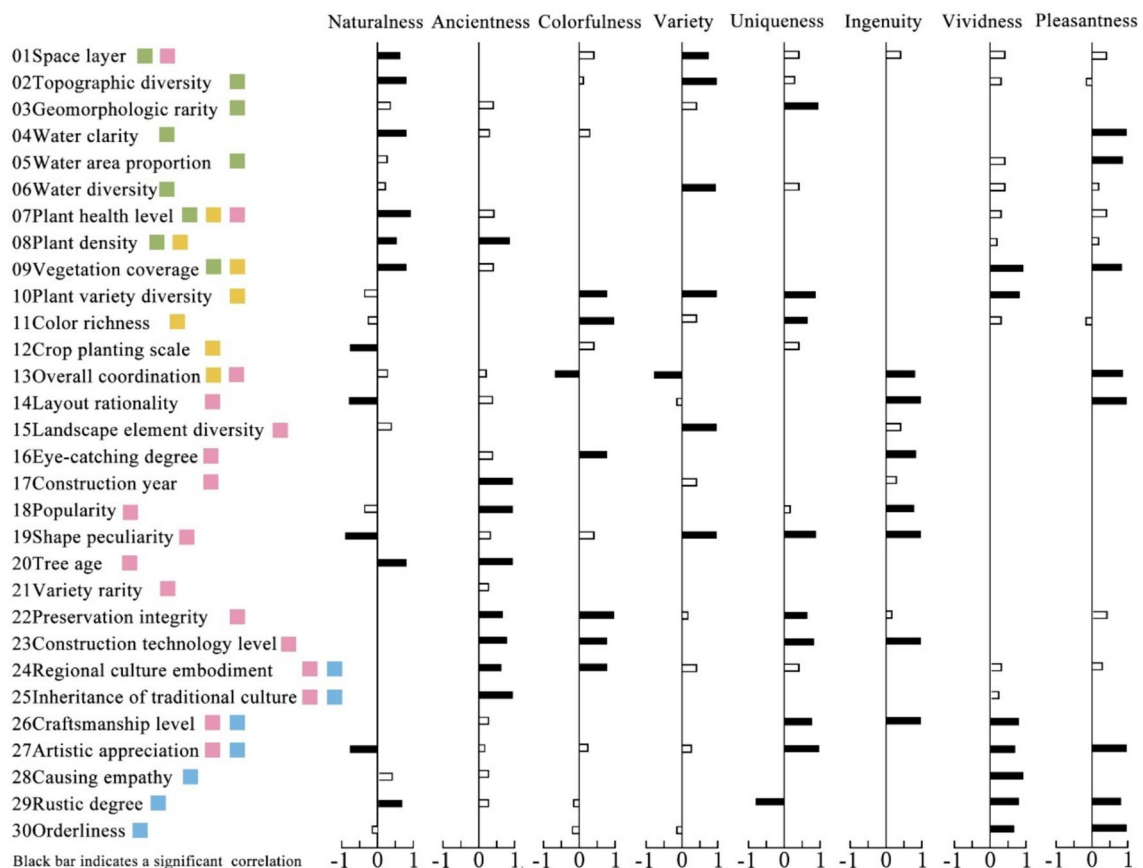

Fig. 5 Research methods and schemes

Fig. 6 Correlation between landscape visual indicators and perceptions

Results

Correlation between landscape indicators and perceptions

The findings in Fig. 6 demonstrate that some characteristic indicators can elucidate human perception across the eight perception models. However, not all characteristic indications hold significance in every model of perception. Overall, each indicator holds meaning in three or more perception models.

The indicators of terrain diversity, clean water, tree health, and vegetation coverage exhibit significantly positive correlations with naturalness perception. Notably, terms of crop plating scale, layout rationality, shape uniqueness, and artistry demonstrate a significant negative correlation with naturalness perception. There are up to eight landscape indicators that potentially account for ancientness perception involving diverse categories of landscape resources. For instance, landmark constructions, ancient facilities, and old trees constitute pivotal aspects influencing tourists' perceptions of historical relics while also serving as attractions for visitation. In terms of the perception of colorfulness and variety, UGC data frequently showcases entries related to these aspects, reflecting the diverse range of crops and ornamental plants, as well as the embodiment and transmission of regional and traditional culture. Additionally, it is noteworthy that indicator 12 demonstrates a negative correlation with both perceptions of colorfulness and variety. In the uniqueness perception model, topography of natural landscapes, diversity of planting varieties in agricultural landscapes, architectural style of cultural landscapes, and artistic elements present in living landscapes all have the potential to serve as unique descriptors of perception. In terms of ingenuity perception, human attention is wholly dedicated to encompassing cultural landscapes that include the overall design of ancient architectural ensembles, construction techniques employed in individual structures, carving methods utilized for decorative motifs, level of craftsmanship exhibited in handicrafts, and expertise possessed by artisans. As for the perceptions of vividness and pleasantness, these two types of perceptions emerge as the most frequently reported emotional experiences in UGC data, ranking second only to those of colorfulness and variety. These findings suggest that the simplicity and orderliness of rural areas evoke a strong sense of vividness, while the
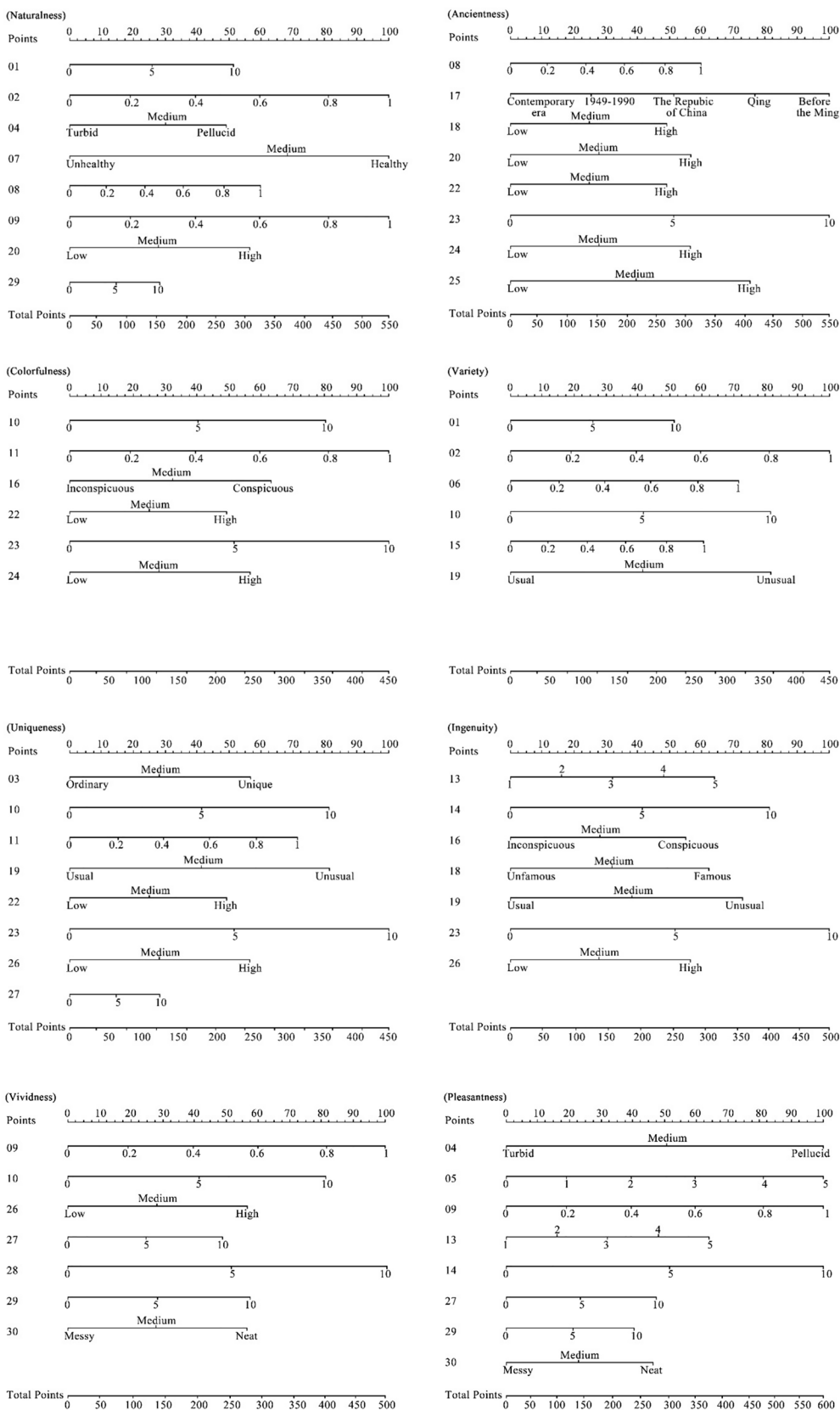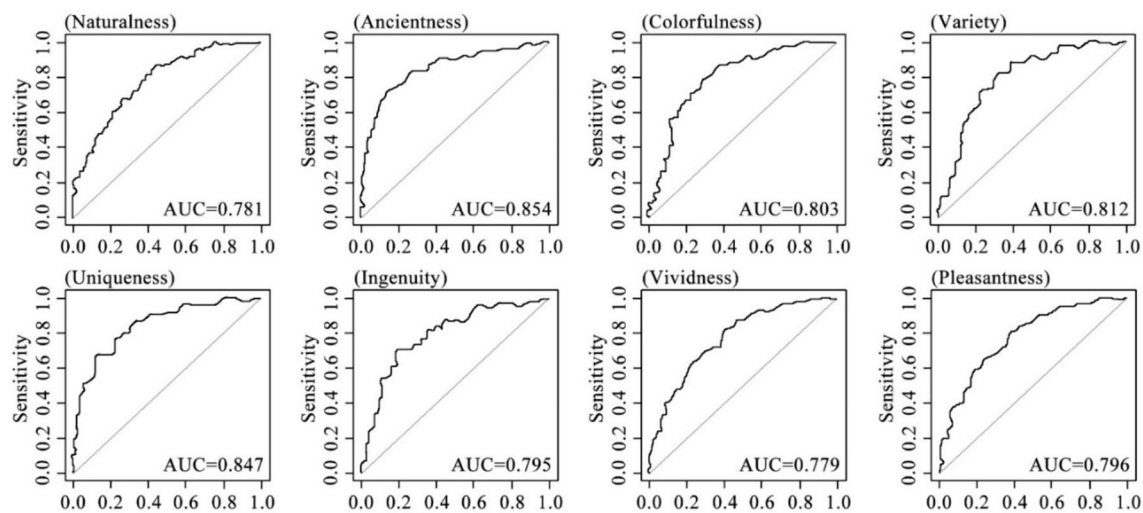
Fig. 8 Model prediction performance test

abundance of water and vegetation exhibits a significantly positive correlation with the perception of pleasantness.

Prediction and visualization of perception preferences

The logistic regression model establishes the relationship between each indicator of landscape characteristics and perception models, elucidating the impact of quantitative indicators on perceptions. Eight nomogram prediction models were developed based on significant independent components using multiple logistic stepwise regression analysis (Fig. 7). The performance test for predictive accuracy showed that all AUC values in the ROC curve exceeded 0.7 (Fig. 8), indicating a substantial discriminative capacity of the model to effectively explain diverse perceptions [46]. The strength of a prediction rule was evaluated by receiver operating characteristic curves (ROC) and area under curve (AUC) approach [46]. In general, we found that various indicators contribute differently to perceptions. The finding of this section is that various indicators contribute differently to perceptions. The nomogram of naturalness perception illustrates that topographic diversity, plant health level, and vegetation coverage are the most significant characteristic indicators, while rustic degree has the least impact on nature impression, followed by water clarity. In the ancientness perception model, plant density, construction year, popularity, tree age, preservation integrity, construction technology, regional culture embodiment and traditional cultural heritage. As demonstrated in the corresponding nomogram, construction year and construction technology have a strong explanatory power for ancientness perception which aligns with our intuition.

Furthermore, indicators such as plant variety, color richness, eye-catching degree, preservation integrity, construction technology, and regional culture embodiment have the potential to contribute to colorfulness perception. The nomogram visually demonstrates that color richness and construction technology have the strongest impact on colorfulness perception, while preservation integrity has the least significant effect. Indicators of topographic diversity, plant variety, and shape uniqueness exerted the most significant influence on variety perception. Additionally, indicators of construction technology, plant variety, and shape uniqueness demonstrated statistical significance in predicting uniqueness perception, as illustrated in Fig. 7. The results highlight that construction technology, layout rationality, and shape uniqueness significantly contribute to the perception of ingenuity. Indicators such as orderliness, eye-catching degree, popularity, and craftsmanship level also exhibit comparable relevance. The perception model of vividness incorporates landscape characteristics including vegetation coverage, plant variety, craftsmanship level, artistry, causing empathy, rusticity, and orderliness. Among these characteristics, it was found that indicators such as vegetation coverage and causing empathy exert the most significant influence on vividness perception while indicator artistry has the least impact. Furthermore, Fig. 6 shows a significant and positive correlation between water clarity, water coverage, vegetation coverage, and layout rationality in terms of pleasantness perception. Additionally, rusticity and artistry were also found to be associated with landscape pleasantness but demonstrated relatively less significance.
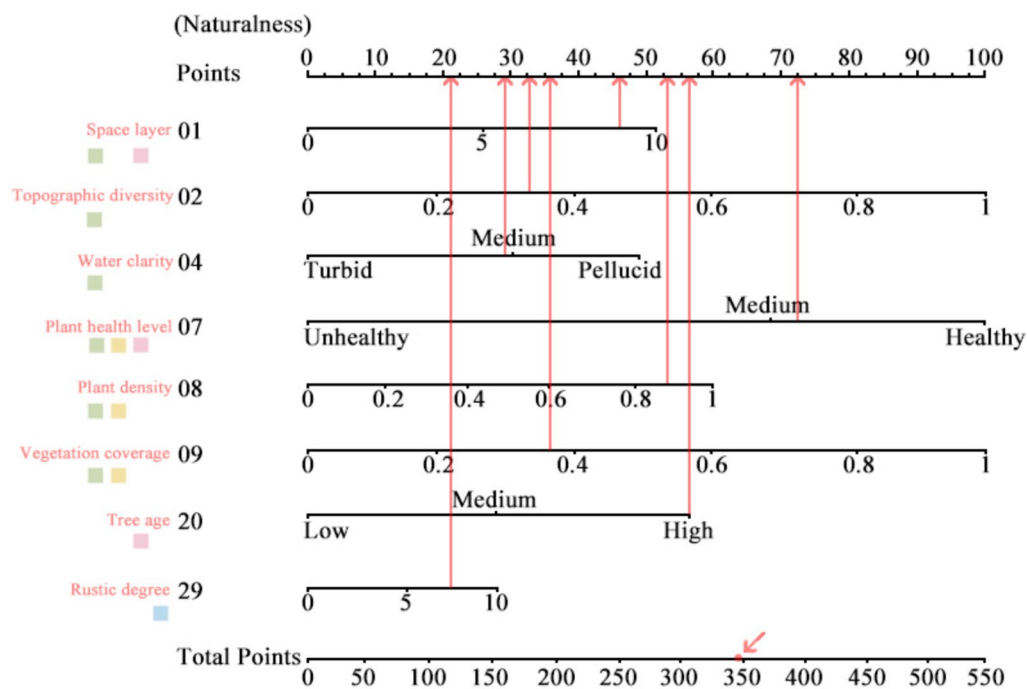
Fig. 9 The nomogram of naturalness perception

Landscape quality assessment of traditional villages in Anyi

The nomogram provides an enhanced visual representation of the perception model for landscape characteristics and human perception of LVQ. Researchers can employ a nomogram to quantify LVQ by drawing vertical lines on each characteristic indicator point (displayed on the top scale) and summing these points (Fig. 9). Each line segment in the nomogram corresponds to a specific landscape characteristic, where the length along the horizontal axis represents its contribution strength towards perceived value. For example, the regression results of the perceptual model show that naturalness perception is significantly correlated with the following indicators, and the score obtained by each indicator corresponds to its influence contribution weight, respectively: spatial level (46 points), topographic diversity (33 points), water clarity (points), plant health (72 points), plant thickness (53 points), vegetation coverage (36 points), tree age (56 points) and simplicity (21 points). Draw a vertical line for each indicator on the score line at the top of the nomogram, and then add up all the scores to obtain a total score of 346, accounting for 63% of the total score of 500, which represents the predicted probability of tourists' perception of naturalness triggered by the landscape. By way of analogy, the quantitative scores (total points; out of 100) for human perception of Anyi traditional villages in terms of eight emotions are as follows: naturalness (346; 63), ancientness (485; 88), colorfulness (257; 57.1), variety (210; 46.7), uniqueness (191; 42.4), ingenuity (384; 76.8), vividness (159; 31.8), and pleasantness (455; 75.8). It can easily be seen that the perception of ancientness is predominant among individuals, followed by ingenuity, pleasantness, and naturalness. The well-preserved ancient structures from the Ming and Qing dynasties (1368–1911), along with the superior quality and livability of the surrounding environment, likely contribute to these robust perceptions. However, feelings of colorfulness, variety, and uniqueness do not correlate with higher scores, suggesting that the heterogeneity of traditional villages in Anyi does not stand out prominently within Jiangxi Province or even nationwide [6].

Perception map of landscape

Tourism destination imagery plays a pivotal role in influencing tourist decision-making and destination marketing processes. Sensory impressions have a direct impact on the loyalty of tourism destinations, with post-tourism experience sensory impressions being more effective in stimulating tourists' desire to revisit compared to abstract destination imagery [48]. Therefore, it is crucial to comprehend the perceived value of landscapes. This
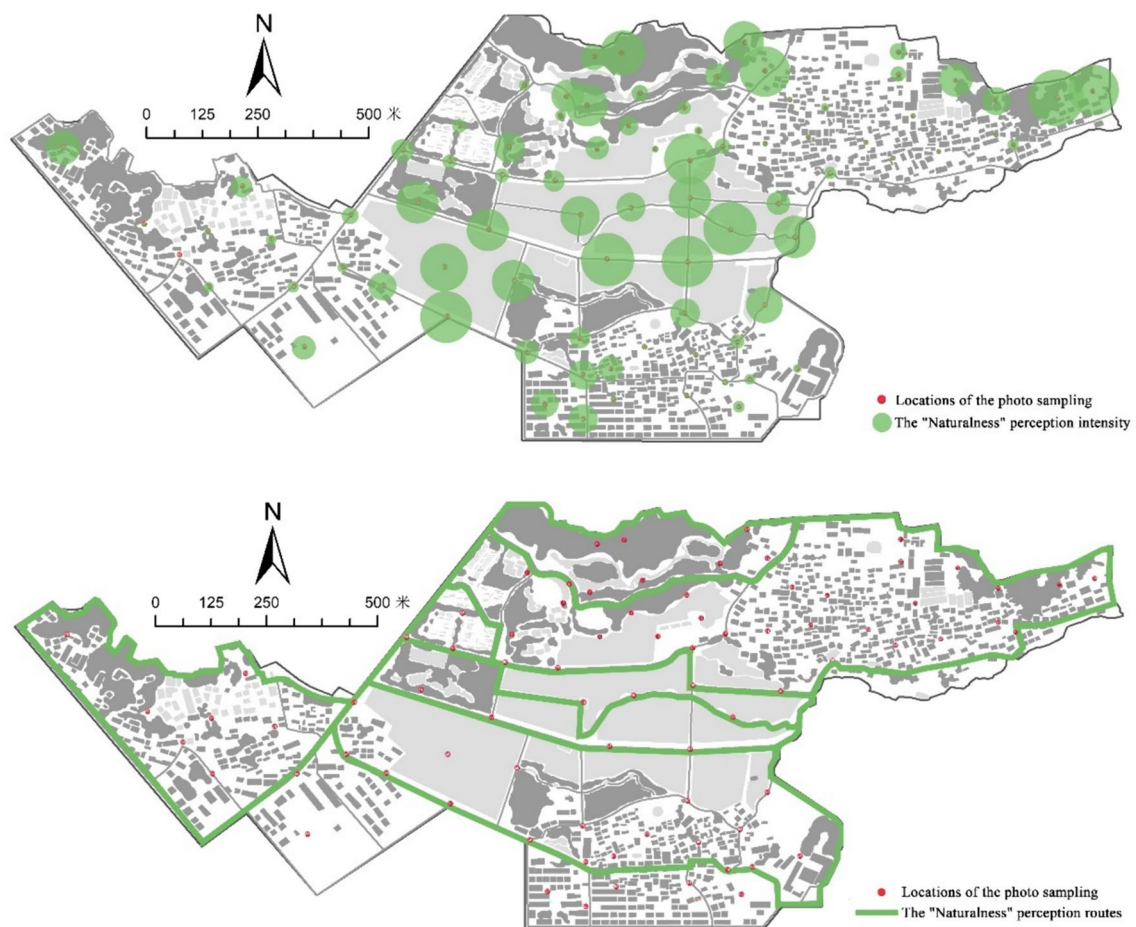
Fig. 10 The naturalness perception intensity and perception path of Anyi ancient village landscapes: the vegetation, water bodies, and overall landscape environment of traditional villages will have a positive impact on tourists' naturalness perception during the tourism process, guiding them to spend more time stopping and admiring the unique natural scenery of traditional villages

study used the visualization tool of nomogram to conduct a preliminary quantitative analysis of the perceived value for the landscape within traditional villages, and generated the perception intensity path maps. Reverse calculation of perceptual nomograms in Fig. 7 can predict which landscape visual elements may make a place perceived as a specific perceptual value. Taking naturalness and ancientness perceptions of traditional villages as examples, as shown in Figs. 10, 11, the center represents the location of the photo scenery, while the area of the circle indicates the intensity of elements perceived as naturalness and ancientness. Connecting high-intensity dots with curves generates the spatial distribution maps of naturalness and ancientness perception values, which can be regarded as perception paths. The maps show that ancient buildings, infrastructure, and relics serve as the primary carriers of the ancientness perception for tourists, while vegetation, water landscapes, and the overall setting are the representatives of naturalness perception.

Destination managers may benefit from perception maps in identifying the sources and spatial distribution of perceived value. This provides a thorough grasp of the features and advantages of the landscape, enabling decision-makers to make well-informed plans and decisions.

Discussions

Perceptions associated with key landscape indicators

Zhang [49] pointed out that the landscape context is the core of traditional village landscapes in China, encompassing both the physical and ambience aspects. This finding is further supported by the present study. Specifically, perception of the physical context relates to landscape elements such as regional characteristics, overall environment, architectural style, and street space; whereas perception of the ambient context typically relates to rural atmosphere, physical and emotional sensations, folk customs, and rural lifestyles. The results demonstrate a significant correlation between

Fig. 11 The ancientness perception intensity and perception path of Anyi ancient village landscapes: the ancient buildings, ancient infrastructure, and relics of traditional villages will have a positive impact on tourists' perception of the ancient scenery during their travels, guiding them to spend more time stopping and admiring the unique historical relics and culture of traditional villages

human perception preferences and landscape characteristics within the context of traditional villages. Specifically, individuals actively perceive an ancient perspective as the most dominant sensation, which can be attributed to the presence of historical landmarks, cultural heritage elements, and ancient constructions that offer a distinct vision and stimulate imagination [50]. Our findings corroborate the idea that rich colors enhance the visual quality of an environment and diverse visual perceptions stimulate tourists' enthusiasm [51]. Color diversity plays a crucial role in distinguishing landscape contours, depth, and shape [52], as well as capturing visual attention by providing focal points to improve visual perception [53]. The current study verifies prior research findings that naturalness perception is frequently connected with the natural states of landscapes, such as topography, water quality, and undisturbed vegetation [54, 55]. Kaplan colleagues defined complexity as a setting's richness and

discovered that planting plants of the same species near together is directly connected to landscape coherence [56]. Landscapes defined by coherence, complexity, and water setting have been shown to favorably affect human behavioral preferences, consistent with Kaplan's findings [54, 56]. Additionally, consistent with the findings of Bjerke [57], the presence of abundant tree vegetation and good health enhances the feeling of naturalness. The indicators of diversity, coverage rate, and aesthetics have significant for vividness perception. A landscape's substance and form are diverse and dynamic, increasing the likelihood that people will encounter it [58]. Piorr [59] also demonstrated a positive correlation between landscape heterogeneity, diversity, and aesthetic quality. Baddeley and Andrade [60] observed that interactive landscapes may leave people with vividness recollections. This might be the cause for the low vividness perception score in our study, namely the lack of interactive landscapes in

villages. The simplicity, orderliness, and proportion of water and plants in the countryside may explain feelings of vividness and pleasantness. This is consistent with Gao's [61] study that participants' attention is captured not by a single aspect but by a mixture of many landscape components. Both indicators' emotional qualities are consistently good since their views are intimately connected. Furthermore, history and cultural traits such as uniqueness in style, workmanship, and artistic worth are all linked to defining the uniqueness and ingeniousness perspectives found in villages. In a specific cultural context, it is critical for planning and management to identify biologically based landscape characteristics associated with stakeholders' distinctive cultural heritage values [50].

Social and cultural value of the traditional villages

Traditional villages are a distinctive rural landscape type defined by its distinct style and rich historical and cultural heritage. They incorporate the natural, geographical, and evolutionary characteristics of ordinary rural landscapes while also expressing their own unique historical-cultural interrelation and humanistic depiction. In terms of physical context, the landscape's worth of an ancient village is determined by its systematic degree, spatial scope, landscape pattern and shape, and functional characteristics [49]. The aesthetic value of traditional villages, in terms of ambience context, is dependent on the interaction climate of landscape and scene integration. This relates to the view of traditional villages' entire image, which includes diversity, regional traits, recognition, authenticity, and repute. Additionally, it also includes the attractiveness, appreciation, accessibility, experience, and friendliness of traditional cultural landscapes in human-landscape interaction [62]. The traditional village landscape space reflects the organization and operation of agricultural producing operations within human civilization. It is distinguished by particular local characteristics that provide physical evidence of long-standing social production activities and cultural accumulation [63]. Changes in agricultural production and living spaces elicit perceptual feelings from tangible components such as courtyards, clusters of houses, streets and alleyways, ancient halls, aged trees, and wells. Local lifestyles, emotional patterns, work habits, traditional customs, and folk activities are all considered psychological elements. All of these components contribute to the unique collective memories connected with traditional communities [64]. Diverging from current super-scale space, the traditional cultural landscape easily elicits emotional reactions due to its emphasis on the individual as the primary size [58]. In this light, the traditional village reflects a scene and style formed by the harmonious integration of natural and human components, resulting in a feeling of place, symbolism, and perception. It speaks to numerous visitors' homesickness while also functioning as a method of connecting and eliciting resonance among individuals. As a result, traditional villages have important local and national aesthetic value, serving as a link between people's deep depictions and memories of their "hometown's original scenery" in both current and future eras [65].

Limitations and recommendations for future research

The limitations of this study should also be discussed and addressed in future research endeavors. The survey did not take into account demographics such as gender, age, education, and other pertinent participant characteristics. Human viewing behavior is impacted by cognitive processes and emotional emotions, rather than being purely biological [51]. Additionally, human perceptual activity involves complicated subject-object interactions [6]. Future studies might possibly reveal the perceptual preferences of various communities by classifying perceived persons. Furthermore, human perception goes beyond the visual domain, demonstrating that long-term interactions with culture, history, activities, and the surrounding environment have a significant impact on perception of experience [66]. These features are difficult to portray or represent using only visual images. Future study in this area should be expanded to look at the influence of social and human aspects on perception, using points of interest, patterns of human mobility, and community demographics. Individuals are more likely to recall positive events than unfavorable ones, and various indications have diverse effects on people's viewpoints [67]. Similarly, various people's assessments of the same indication may be positive, negative, or neutral [61]. The current study focused solely on users' positive views, allowing potential for future research to investigate the influence of negative emotions on people's perceptions and behavioral choices.

Conclusions

The perception of visual stimuli plays a crucial role in psychophysical research because it enables the measurement of the public's aesthetic attitudes and perception dimension towards landscape objects. Establishing a quantifiable connection between human perception and landscape features is critical for assessing LVQ and is beneficial to the preservation and sustainable development of traditional village landscape resources. This study employed logistic regression to identify landscape visual indicators in Anyi traditional villages, as well as

nomograms to show the connection between human subjective perceptions and feature indicators.

The following conclusions can be drawn that landmark buildings, old facilities, and ancient and famous trees in traditional villages serve as a focal point for perceptions of ancientness. The attributes of ingenuity, colorfulness, variety, and uniqueness are closely intertwined with the architectural techniques employed in ancient structures, the intricacy of decorative patterns, as well as the embodiment and preservation of regional culture and traditional heritage. In the post-pandemic era, UGC data predominantly captures perceptions of naturalness, pleasantness, and vividness, reflecting their strong inclination towards engaging in village tourism encounters. The further exploration of quantifying, interpreting, and comparing village landscape resources in subsequent studies enables the classification and protection of traditional village resources based on tourist perceived preferences. It is noteworthy that the visualization framework proposed in this paper holds universal applicability and is not restricted to specific locations, rendering it useful for landscape design, planning, route mapping, and related services. In future research endeavors, scholars may refine particular indicators such as landscape aesthetics, user experience, and landscape services while optimizing them based on experimental sites.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40494-024-01326-x.

Additional file 1.

Author contributions
Conceptualization, methodology, software, investigation, writing—original draft, writing—review and editing, Ning Kang (first author). Funding acquisition, supervision, review, project administration, Chunqing Liu (corresponding author). All authors have read and agreed to the published version of the manuscript.

Data availability statement
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declarations

Competing interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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