

## Assessment and Optimization of Sustainable Tourism Planning for Suburban Rural Areas of Metropolitan Fringe Areas Based on Ecological Landscape Unit Division: Evidence from Huanglongxian, Nanjing

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### Abstract

The rapid acceleration of urbanisation in China has led to the emergence of many big cities, which has greatly affected the development of tourism in the surrounding areas. As Metropolitan Fringe Areas increasingly serve as popular short-term travel destinations, the adjacent villages confront unprecedented developmental opportunities and challenges. This study examines the Paifang community in Jiangning District, Nanjing, China to investigate ecological landscape assessment and strategic tourism planning within the context of a sustainable tourism framework in Metropolitan Fringe Areas. First, this research delineates the landscape ecological units of the Paifang community and assesses ecological sensitivity. Through a combination of technical research, field surveys, and in-depth interviews, this study analyses the expectations of both residents and tourists, proposing targeted tourism planning strategies.

**Keywords:** Urban suburbs; Landscape ecological units; Sustainable rural tourism; Machine learning

### 1. Introduction

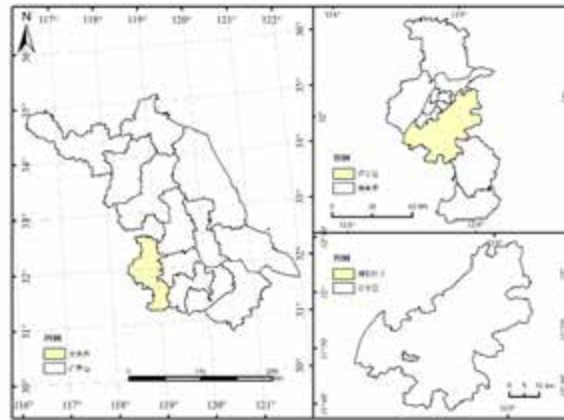
Urban areas worldwide have been steadily expanding, often at the expense of natural and semi-natural land (Martellozzo et al., 2018). The current "Rural Revitalization" strategy is continuously advancing across China, and a consensus has been reached: to rationally plan the spatial layout of urban and rural construction with holistic thinking and promote integrated urban-rural development. This implies that the models and experiences of urban construction cannot be directly applied to rural construction. As a special ecological-production-living space, rural areas need to build a harmonious relationship between humans and nature, organically integrating ecological and social systems (Central Committee of the Communist Party of China & State Council, 2018). However, as metropolitan fringe areas increasingly serve as popular short-term travel destinations, villages face unprecedented developmental opportunities and challenges. This involves the interaction and contrasting relationship between human activities and natural landscapes in rural areas. The penetration of tourism consumption culture has precipitated spatial alienation, manifesting through phenomena such as village relocations and population displacement (He et al., 2022). If the natural, historical, and cultural environment cannot be protected, there can be no expectations for sustainability in destination areas (Khizar et al., 2023). To mitigate both positive and negative impacts on residents' quality of life (QOL) arising from unsustainable over-tourism, it is essential to implement effective control measures (Mihalic et al., 2021). As a model for sustainable tourism development, alternative tourism emphasises the necessity of harmonious coexistence between tourism initiatives and rural communities based on ecological protection and cultural respect. Localised analysis of existing ecological and cultural resources is a prerequisite for the effective implementation of alternative tourism. The rural landscape is a spatial representation of the composite ecosystem comprising the social, humanistic, economic, and natural environments of the countryside, possessing dual characteristics of humanity and nature (Wang & Liu, 2003). On the one hand, the organisation and assessment of the current situation are crucial, and the scientific delineation of landscape ecological units is a fundamental prerequisite for regional research and environmental development. On the other hand, against the backdrop of accelerated urbanisation nationwide, how to maintain the diversity of regional characteristics in rural areas and carry out sustainable tourism development is a common issue faced by urban-rural planning and sociology (Zhang, 2021).

### 2. Development History and Current Situation of Huanglongxian

#### 2.1 Overview of the Study Area

This study focuses on the Paifang Community, situated in the Jiangning District of Nanjing City, Jiangsu Province, China (Figure 1). The research aims to explore methodological approaches for delineating landscape ecological

units within rural environments, thereby contributing to strategies for sustainable rural development.



**Figure 1.** Location map of the study area.

Jiangning District of Nanjing belongs to subtropical monsoon climate, which is rich in plant resources and forms various types of landscape ecological environment. Paifang Community is located in the southeast of Jiangning Street, Jiangning District, Nanjing, with a total area of 8.2 square kilometers. It belongs to hilly and mountainous villages, and the western tourist corridor line passes through the territory. With beautiful scenery, beautiful environment and rich resources, the community is the location of beautiful countryside-Huanglongxian Tea Culture Eco-tourism Village. With the deepening of rural tourism development, the natural scenery and human activities in this area have more overlap, so it has high research value and reference significance.

## 2.2 Development History of Rural Tourism in Huanglongxian

The evolution of rural tourism in Huanglongxian can be divided into four distinct phases:

**Initial Stage (Pre-2013):** At this early juncture, Huanglongxian was a relatively impoverished mountainous village whose primary economic activity centred on tea cultivation. Its development was hindered by limited transportation infrastructure and weak public services.

**Transformation and Enhancement Phase (2013–2016):** Leveraging its unique landscape resources, the area underwent infrastructure and environmental improvements driven by coordinated efforts at district, street, and village levels. During this phase, the tea industry and tourism began to develop simultaneously, initiating what has been termed the “beauty economy.”

**Upgrading and Expansion Phase (2017–2020):** This period was marked by efforts to deepen the integration of cultural elements. Key strategies included the construction of the “Rural +” industrial chain, the establishment of an ecological tea industry system, and the development of clustered guesthouses. Organised cultural events contributed to tourism brand-building and furthered the integration of various sectors.

**Consolidation and Innovation Phase (2021–present):** Since 2021, ongoing efforts have aimed to improve the ecological environment further. Initiatives such as the “toilet revolution” and “waste revolution” were implemented, alongside the development of sewage treatment infrastructure. Concurrently, traditional cultural practices, including tea culture, have been revitalised and incorporated into the tourism offering, enriching its cultural dimensions.

Community engagement has played a pivotal role in this development process. For instance, the spontaneous signing of the “Villagers’ Environmental Protection Pact” has demonstrated enhanced local participation, contributing to co-creation and shared benefits. The historical trajectory of rural tourism in Huanglongxian highlights the critical importance of governmental guidance, ecological prioritisation, cultural revitalisation, industrial in-

tegration, and community participation. These elements collectively offer valuable insights for the sustainable development of rural tourism within the broader framework of China's rural revitalisation strategy.

### 3 Ecological Landscape Unit Delineation

#### 3.1 Necessity of Delineating Rural Landscape Ecological Units

As previously mentioned, rural areas, as places with dual attributes of "space" and "resources," closely link human activities with the natural environment, while also possessing unique ecological conservation functions and potential for sustainable development. Consequently, there is a relatively rich variety of ecologically functional land use types within the rural landscape environment. However, changes in the land use structure of villages and towns have led to landscape fragmentation, resulting in a decline in the "sense of place" and "sense of belonging" in rural areas (Guo et al., 2013), loss of regional characteristics, and homogenisation of landscape features (Chen, 2012). The scientific protection and moderate development of rural landscapes are the developmental direction for rural construction. On the other hand, in rural areas, even the same type of land use can exhibit differences in ecological characteristics due to variations in area, hydrological climate, elevation, and vegetation cover. Therefore, to conduct a classified analysis of the landscape ecology of different regions within the study site, considering natural geographical conditions, climatic factors, locational environment, and the current vegetation conditions of different areas, the study area should be divided into different ecological units. This paper explores the integration of Python programming language with traditional landscape unit delineation techniques, aiming to obtain more objective results for landscape ecological unit delineation.

#### 3.2 Existing Methods for Delineating Landscape Ecological Units

The concept of a "unit" originates from a fundamental concept in the modern scientific and technological system, representing a self-contained system with relative independence and function. It possesses basic characteristics such as systematism and self-containment, and when applied, the research object is considered as a whole or system (Wang et al., 2020). Ecological spatial units are landscape constituent units that must be recognised in the landscape design process and are also the most commonly used and studied scale types in landscape planning and design (Wang, 2018). Ecological unit mapping has become a fundamental method and tool for various planning and evaluation studies (Zhao, 2012). A landscape unit usually refers to the smallest unit expressed in landscape mapping, i.e., the spatial extent enclosed by baselines representing landscape characteristic types. In image maps, a landscape unit refers to the smallest homogeneous polygon that can be distinguished at a specific spatial resolution (Lou, 2016). A landscape ecological unit is a research unit generated by combining the resource base of geographical space with scale characteristics.

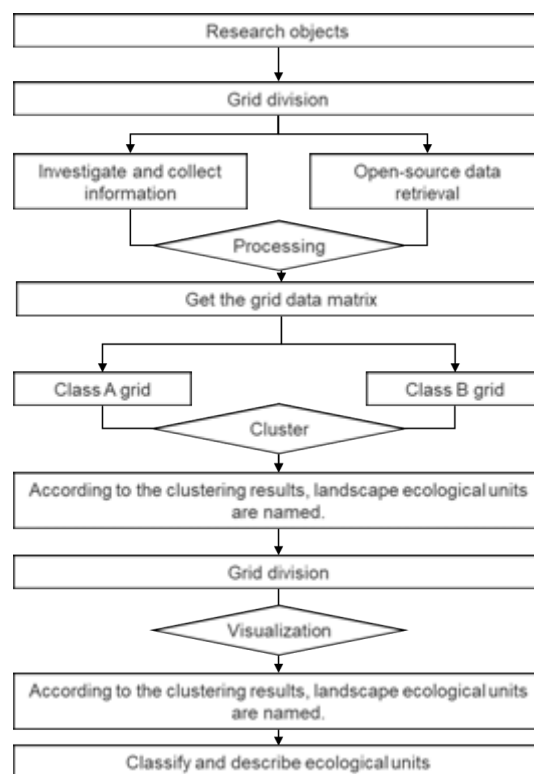
The application of research methods based on landscape ecological units is more common in urban landscapes and natural landscapes. With the vigorous progress of rural construction, landscape ecological units have emerged as a research perspective and entry point in rural landscape studies. Unlike landscape patches in purely natural environments, a village ecological unit is a composite ecosystem integrating natural, artificial, and social elements (Kang & Wang, 2019). Therefore, the method for delineating rural landscape ecological units lays the foundation for further research.

Currently, there are few existing methods for delineating landscape ecological units, and most focus on purely natural landscapes and urban landscapes. Research on rural landscapes is relatively preliminary. For instance, Gao Tian et al. (2010) summarised the history and methods of ecological unit mapping (Gao et al., 2010), including selective ecological unit mapping and comprehensive ecological unit mapping. Kang Yuan et al., in their study of Xiuri Village on the Qinghai-Tibet Plateau, mentioned the wisdom of constructing village ecological units, building the concept of village ecological units from an ecological perspective, and dividing them into residential landscapes, production landscapes, and cultural landscapes. They considered the village ecological unit as a multi-functional complex with humans as the main theme, with the research primarily focusing on local production and living areas with higher human congregation. Similarly, in the research on rural settlement ecological units by Wei Yanyan et al., while dividing them into geographical, landscape ecological, and human settlement units, they also combined macro-, meso-, and micro-perspectives (Wei et al., 2018). However, this approach faced

issues such as irregular boundaries when spatial lines overlapped and insufficient research precision. Another example is the Wusheng County unit delineation method conducted by Wang Zhifang et al. in 2020 (Wang et al., 2020), which utilised SPSS for data processing. However, due to limitations in computing power and data volume, it only studied three aspects: elevation, slope, and land use. The delineated grids were also relatively large, leading to problems such as irregular regional shapes, inconsistent areas, or unclear boundaries, which increased the workload for subsequent tasks.

### 3.3 Innovative Method for Delineating Landscape Ecological Units

The delineation of landscape ecological units requires the establishment of evaluation criteria. The same piece of land is often influenced by multiple factors; therefore, a single evaluation criterion is not suitable for delineating rural landscape ecological units. Referring to the characteristic evaluation factor system for rural landscape sensitivity assessment (Wang et al., 2021), standards for landscape unit delineation are established (Figure 2).



**Figure 2.** Technical route.

According to the definition and properties of landscape ecological units, the evaluation factors and data types generally considered for the study area include nine items: land use type, presence of surface runoff, flow rate, average temperature, annual precipitation, average elevation, slope, soil sensitivity, and vegetation cover. When there is no surface runoff or no significant surface runoff within the study area, the number of items actually considered for data clustering is six.

### 3.4 Grid Division and Data Linking

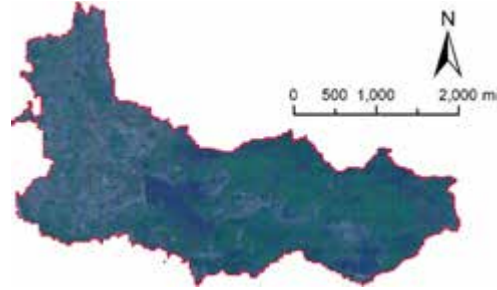
#### 3.4.1 Fishnet Tool

For the study area of Paifang Community, based on the formulae: unit side length  $x = \frac{L}{n}$ , and total number of units  $y = \frac{H}{x}$ , it can be deduced that a 10m10m grid precision is suitable for this research object. According to the grid standard, the fishnet tool in ArcGIS was used to divide the bounding rectangle of Paifang Community into a grid (Yang et al., 2019), forming a total of 3530\*5640 cells, establishing a system with individual cells of 10m\*10m

(Figure 3). Fishnet labels corresponding to the geometric centre of each cell were created and designated as the sampling points for the cells. Finally, empty cells within the bounding rectangle were removed (Figure 4).



**Figure 3.** Matrix grid.



**Figure 4.** Study area grid.

### 3.4.2 Data Collection and Determining Factors

The data sources for this study include locally provided materials, field surveys, and satellite open-source data obtained from relevant public data websites. The finally collected effective geographical data include seven categories: elevation, slope, vegetation, temperature, precipitation, land use type, and soil sensitivity. Among these, the temperature data had poor precision and could not form regional differences, so it was excluded. Therefore, a total of six data items were studied.

Multi-band image maps of satellite remote sensing data were obtained from the Geospatial Data Cloud. The data were imported into ENVI. According to the formula in the research method of Li (Li et al., 2003):

$$NDVI = \frac{\text{float}(b4) - \text{float}(b3)}{\text{float}(b4) + \text{float}(b3)}$$

data such as NDVI vegetation cover (FVC) were calculated. The obtained raster data were imported into ArcGIS and converted to vector data under the WGS\_1984 coordinate system.

Where b1, b2, b3, and b4 represent four bands respectively (Figure 5):

**Figure 5.** Band Correspondence Table

| Band   | Colour  | Wavelength (µm) | Application                                                              |
|--------|---------|-----------------|--------------------------------------------------------------------------|
| Band-1 | Blue    | 0.45-0.52       | Water bodies, shallow water underwater features                          |
| Band-2 | Green   | 0.52-0.60       | Green reflectance of healthy vegetation, distinguishing vegetation types |
| Band-3 | Red     | 0.63-0.69       | Plant classification, distinguishing artificial land feature types       |
| Band-4 | Near IR | 0.76-0.90       | Distinguishing vegetation types, delineating water body boundaries       |

Taking Paifang Community as the research object, the main determining factors to be considered are six categories (Figure 6 -11): The terrain of Paifang Community is low in the west and high in the east, with the lowest elevation at 13.7m and the highest at 197m. The study area includes small reservoirs and mountainous landforms, with significant topographical variations. Therefore, elevation and slope are considered influencing factors. The

location experiences abundant rainfall and distinct seasons, with good soil conditions; thus, precipitation and vegetation cover are also influencing factors. Among the determining factors obtained from field surveys and literature review, the above four categories are continuous data, while land use type and soil sensitivity are discrete data. Clustering is based on continuous data. Therefore, discrete data need to be stratified and named 1, 2, 3... where the order does not represent priority but is only used for calculating Euclidean distances in the subsequent computational procedures. This method is flexible in determining factor weights, which are often determined based on the current situation and development needs of the study area. For simplicity, this paper sets all weights to  $\Phi_i=1$ .

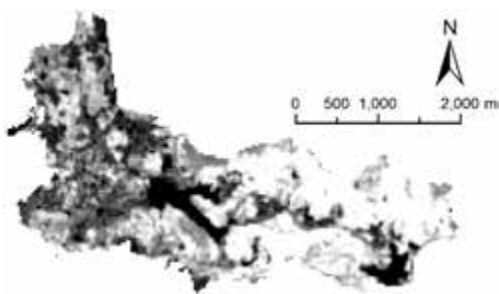


Figure 6. Vegetation cover.

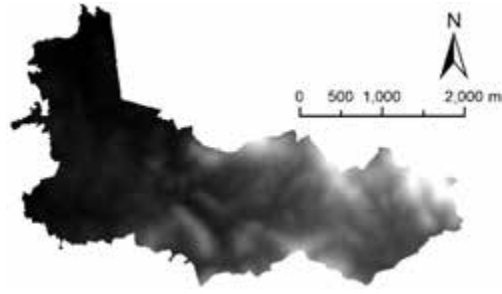


Figure 7. Elevation.

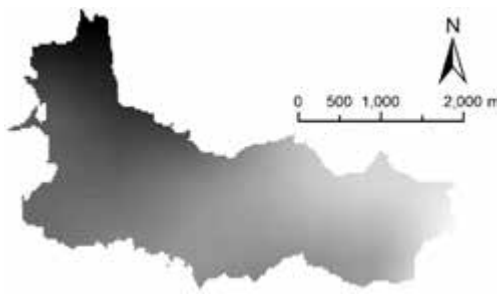


Figure 8. Precipitation.

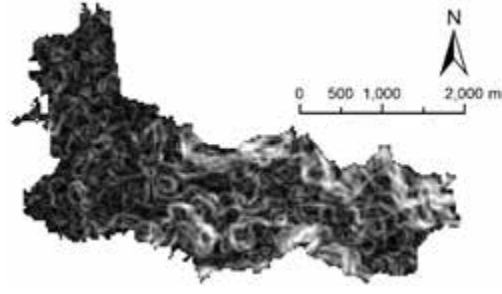


Figure 9. Slope.

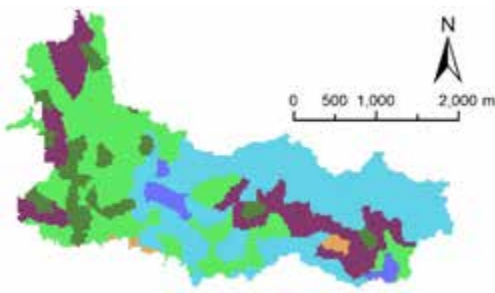


Figure 10. Land use.

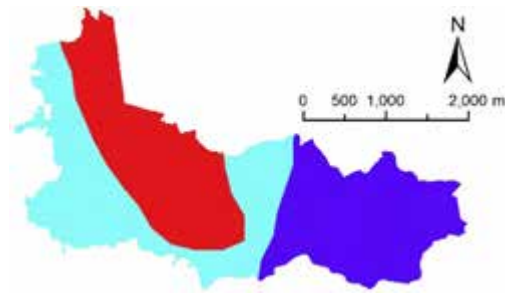


Figure 11. Soil sensitivity.

### 3.4.3 Grid Classification

As mentioned earlier, the size of the divided grid cells is 10m\*10m. To make the delineation of ecological units more precise, this study primarily identifies and classifies two types of grid cells during the division phase: Type A grid cells, where the internal functions, composition, and morphology are relatively consistent; and Type B grid cells, where these aspects show significant differences. In this ecological unit delineation, the bound-

any lines of different land uses were first identified to distinguish Type B grid cells. Since grid cells located on boundary lines contain two or more types of land use and exhibit high complexity, these cells were classified as Type B grid cells using GIS. The remaining grid cells within the area, containing only a single land use type, were classified as Type A grid cells.

#### 3.4.4 Clustering Process

Taking the geometric centre of each 10m\*10m grid cell as a sampling point, the spatial join tool in GIS was used to obtain various data for each sampling part. On the one hand, the data were standardised and outliers filtered to verify data integrity. On the other hand, discrete data were integrated, ultimately yielding the corresponding determining factor data for each grid cell.

In this process: first, randomly select an arbitrary number  $k$  (representing the final number of rural landscape unit types for the research object), and denote the  $k$  centres as  $\mu_1, \mu_2, \dots, \mu_k$ . Second, the mean of each cluster object is substituted into the group formula as

$$Dis_j = \sqrt{\sum_{i=1}^n \varphi_i (x_i - \mu_j)^2} ,$$

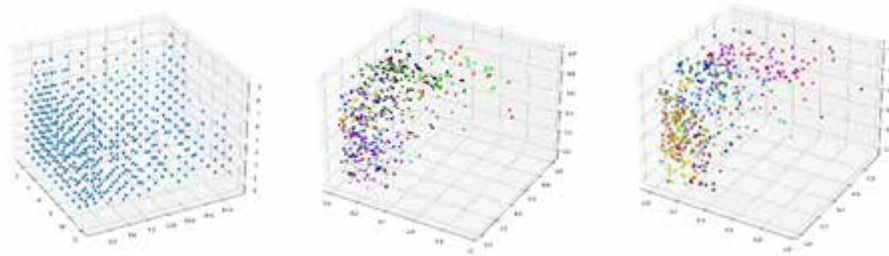
$$D = \min Dis_j.$$

Calculate the Euclidean distance (Dis) of each object to these central objects, and reclassify the corresponding objects based on the minimum distance  $D$ . Then, calculate the cluster centre  $\mu_k^m$  (the mean of all objects in that cluster) for each newly formed cluster. This process is repeated until the sum of squared errors (SSE) standard measure function begins to converge (Figure 12). The calculation formula is as follows:

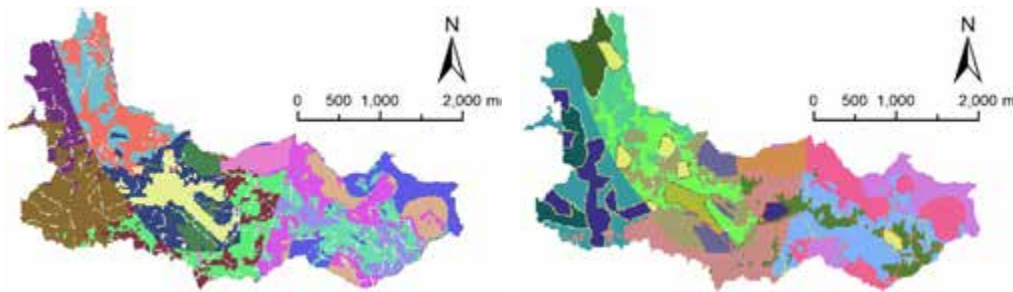
$$E = \sum_{i=1}^k \sum_{p=x_i} |p - \mu_i|^2$$

Where:  $E$  is the sum of squared errors for all objects in the database;  $p$  is a point in the space of the object;  $\mu_i$  is the mean of cluster  $x_i$  (both  $p$  and  $\mu_i$  are multidimensional) (Chen et al., 2017).

Clustering was performed on the 6 types of data for Type A grid cells, and obtaining the results (Figure 13). After multi-point verification and troubleshooting, the clustering determining factors were improved. Finally, geographical information (longitude, latitude) was listed separately as a division factor to avoid a scattered distribution of results, thereby obtaining the final clustering result for Type A grid cells. On this basis, for the clustering of Type B grid cells, the item "included land use types" was added, resulting in a unit division result characterised by linear and point-like patterns. The clustering results for Type A and Type B were combined according to geographical information to obtain the final ecological unit delineation result (Figure 14). This includes 16 types of Type A landscape ecological units and 10 representative Type B ecological units.



**Figure 12.** 3D model of the clustering process.



**Figure 13.** Type A clustering results without latitude and longitude.

**Figure 14.** Final clustering results incorporating latitude and longitude.

The division of ecological units in nature reserves can be classified according to the natural zoning method and the kilometre grid method (Zhou, 2006). Considering the complexity of rural areas, this paper, based on the kilometre grid, divides the rural research object into several unit grids, and then conducts ecological resource investigation, data registration, and comprehensive evaluation for each one.

During the process of equally dividing the study area, issues related to grid scale, number of grids, grid shape, and differentiated processing between grids are involved. For grid shape, considering the universality of the research object, the grid is defined as a regular quadrilateral. Simultaneously, the grid scale is defined as

$$x = \frac{L}{n}, y = \frac{H}{x} \cdot n$$

Where  $x$  is the side length of a single grid,  $y$  is the total number of grids,  $L$  is the length of the long side of the bounding rectangle of the study area,  $H$  is the length of the short side of the study area, and  $n$  is the number of grids in the direction of the long side. In the division phase, two types of grids are identified: Type A grids, where the internal functions, composition, and morphology are relatively consistent, and Type B grids, where the internal functions, composition, and morphology show significant differences, thereby reflecting the differentiated processing between grids. Among these, Type B grid data, due to the complexity of the plots, include two or more types of land use and are all located on irregular boundaries. Therefore, data collection for Type B grids, in addition to the aforementioned conventional 9 data items, should also include the number of land use types

contained within a single grid range. For example, if a grid plot includes cultivated land, water bodies, and forest land (three types of land use), then the number of land use types is 3.

Finally, a matrix is initialised to store the data for each grid, including the grid's serial number and corresponding item data. According to the different types of items, the delineated landscape grids are divided into two parts for clustering.

#### 4. Delineation and Evaluation of Ecological Units

##### 4.1 Description of Ecological Unit Delineation Results

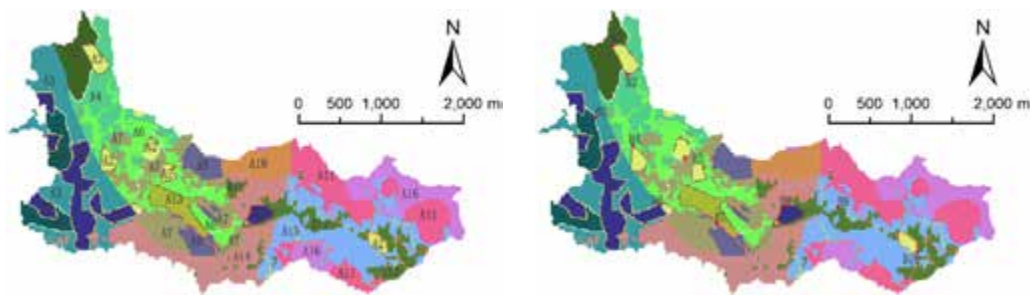
###### 4.1.1 Naming and Description of Type A Landscape Ecological Units

The ecological unit delineation results are shown in Figure 16. Combining the type and position of the units, they are named sequentially from top to bottom, left to right as A1, A2, A3... As a relatively large-scale comprehensive evaluation result, the ability to accurately describe each ecological unit becomes an important criterion for judging the accuracy of the ecological unit delineation. After summarising the characteristic descriptions in the table (Figure 15), it can be found that various types of landscape ecological units have certain differences but often exhibit internal correlations, following the laws of land use type transformation and the spatial-temporal dynamic evolution mechanism of rural landscapes constituted by the functional transformation of "production-living-ecological spaces" (Fan et al., 2022). According to the complex intersecting conditions of different landscape ecological units, it reflects that natural conditions endow landscape ecological units with uniqueness and regionality, and also reflects the multi-functionality and inclusive uses of rural landscapes.

**Figure 15.** Description of Type A Units

| Unit No. | Characteristics                                                                                                                                             |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1       | Paddy field with low elevation, gentle terrain, low soil sensitivity, and low precipitation.                                                                |
| A2       | Villager residential area with low elevation, gentle terrain, low soil sensitivity, and low vegetation cover.                                               |
| A3       | Mixed area of dry land and residential land with low elevation, gentle terrain, high soil sensitivity, low precipitation, and low vegetation cover.         |
| A4       | Dry land area with low elevation, gentle terrain, low soil sensitivity, low precipitation, and high vegetation cover.                                       |
| A5       | Villager residential area with low elevation, gentle terrain, high soil sensitivity, low precipitation, and low vegetation cover.                           |
| A6       | Mixed area of dry land and residential land with low elevation, gentle terrain, low soil sensitivity, low precipitation, and low vegetation cover.          |
| A7       | Dry land area with low elevation, distinct topographical undulation, low soil sensitivity, high precipitation, and high vegetation cover.                   |
| A8       | Paddy field area with low elevation, gentle terrain, high soil sensitivity, low precipitation, and low vegetation cover.                                    |
| A9       | Forested land with high elevation, distinct topographical changes including slopes, high soil sensitivity, high precipitation, and high vegetation cover.   |
| A10      | Forested land with high elevation, distinct topographical changes including slopes, low soil sensitivity, high precipitation, and high vegetation cover.    |
| A11      | Forested land with high elevation, distinct topographical changes including slopes, medium soil sensitivity, high precipitation, and high vegetation cover. |

|     |                                                                                                                                                          |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| A12 | Paddy field with low elevation, gentle terrain, low soil sensitivity, and high precipitation.                                                            |
| A13 | Paifang Reservoir, with strong topographical and landform characteristics.                                                                               |
| A14 | Area dominated by forested land with low elevation, gentle terrain, high soil sensitivity, and relatively high vegetation cover.                         |
| A15 | Vegetation cover area with relatively high elevation, gentle terrain, medium-high soil sensitivity, and low precipitation.                               |
| A16 | Forested land area with very high elevation, distinct topographical changes, medium soil sensitivity, abundant precipitation, and high vegetation cover. |

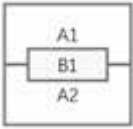
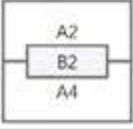
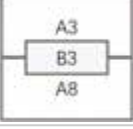


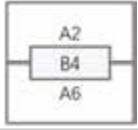
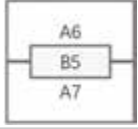
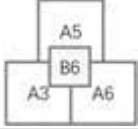
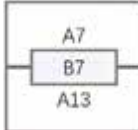
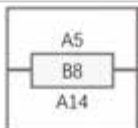
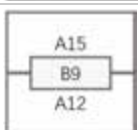
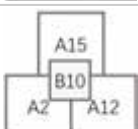
**Figure 16.** Type A unit numbering and selected points. **Figure 17.** Type B unit numbering and selected points.

#### 4.1.2 Naming and Description of Type B Landscape Ecological Units

The ecological unit delineation results are shown in Figure 17. Combining the features and position of the units, they are named sequentially from top to bottom, left to right as B1, B2, B3... Due to the generation method of Type B grids, these grids are small in area, elongated in shape, and diverse in type. In reality, various types of Type B ecological units share certain commonalities. They are classified and refined into ten representative units, and the table (Figure 18) below explains their characteristics and positional relationships. Type B units often exhibit characteristics of linear continuity and overall fragmented distribution. Typically, Type B landscape ecological units located at boundaries have greater landscape richness, biodiversity, and spatial diversity compared to Type A units. Their geographical location and environmental attributes often show strong similarity and dependence on adjacent Type A landscape ecological units. For example, Type B units adjacent to both village residential areas and natural environments usually exhibit significant internal variation.

**Figure 18.** Description of Type B Units

| Unit No. | Figure                                                                              | Characteristics                                                                                                                                                                                                |
|----------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B1       |  | Interface between paddy fields and villager residential areas; low soil sensitivity, gentle terrain, low annual precipitation within the study area.                                                           |
| B2       |  | Mixed land use of dry land and villager residential areas; at the boundary of high and low soil sensitivity, gentle terrain, distinct variation in vegetation cover within the unit, low annual precipitation. |
| B3       |  | Interface between paddy fields and dry land; significant variation in soil sensitivity within the unit, but overall low sensitivity. Low vegetation cover, low annual precipitation.                           |

|     |                                                                                     |                                                                                                                                                                                                                                             |
|-----|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B4  |    | Mixed land use of dry land and residential areas; no significant changes in climatic and topographical conditions. Minimal variation in vegetation cover within the unit, low annual precipitation.                                         |
| B5  |    | Mixed land use of dry land and residential areas; low soil sensitivity, low elevation, distinct topographical undulation, distinct variation in vegetation cover within the unit, relatively drastic changes in precipitation.              |
| B6  |    | Mixed land use of dry land and residential areas; drastic changes in soil sensitivity, including high, medium, and low categories; no significant changes in climatic and topographical conditions.                                         |
| B7  |    | Interface between dry land and reservoir/ponds; strong landform characteristics, distinct topographical undulation, high vegetation cover, high annual precipitation.                                                                       |
| B8  |    | Boundary land use between residential areas and forested land; located in an area with high soil sensitivity, gentle terrain, distinct variation in vegetation cover within the unit, high annual precipitation, distinct landform changes. |
| B9  |  | Boundary land use between paddy fields and forested land; high elevation, drastic changes in soil sensitivity, located in mountainous terrain, high vegetation cover, high annual precipitation.                                            |
| B10 |  | Interface land use among forested land, sparse woodland, and residential areas; distinct topographical changes, distinct variation in vegetation cover within the unit, diverse soil sensitivity, high annual precipitation.                |

## 4.2 Landscape Unit Evaluation

### 4.2.1 Ecological Gene Evaluation

This ecological unit delineation covers Type A and Type B landscape ecological units. Type A units are larger and relatively complete in form, with varying natural element characteristics such as elevation, terrain, soil sensitivity, precipitation, and vegetation cover. For example, A1 is a paddy field with low elevation, gentle terrain, low soil sensitivity, and low precipitation, reflecting the uniqueness and regionality of natural conditions, and follows the laws of land use type transformation and the spatio-temporal dynamic evolution mechanism of rural landscapes constituted by the functional transformation of "production-living-ecological spaces." Type B landscape ecological units are small, elongated, and fragmented in distribution. Typically, Type B units located at boundaries exhibit more complex landscape richness, biodiversity, and spatial diversity. Their geographical location and environmental attributes show strong similarity and dependence on adjacent Type A units. For instance, B1, at the interface of paddy fields and villager residential areas, has low soil sensitivity, gentle terrain, and low precipitation, demonstrating the multi-functionality and inclusive uses of rural landscapes. Overall, this reflects the complex intersecting conditions of the regional ecosystem.

### 4.2.2 Village Layout Gene Evaluation

The layout of Huanglongxian Village changes dynamically with the terrain, conforming to the traditional layout principle of "concealing wind and gathering qi" (Xiong et al., 2023). The village site selection exhibits a strong affinity for water, belonging to a dispersed layout, built along the foot of hillsides. The building layout is primarily guided by water systems and road orientations, generally presenting a strip-like pattern. The internal road network structure of the village is dendritic, with residences distributed along the main road. As the residential distribution changes, the main road further branches into many vine-like subsidiary roads, and residences in ad-

jacent areas are interconnected. Alleyways are often formed spontaneously by the passage between residences, without fixed planning traces. It is precisely because of this characteristic of alleyways that they embody ingenious spatial planning and human-oriented design concepts.

#### 4.2.3 Architectural Gene Evaluation



**Figure 19.** Pedestrian Street.



**Figure 20.** Waterside residences.

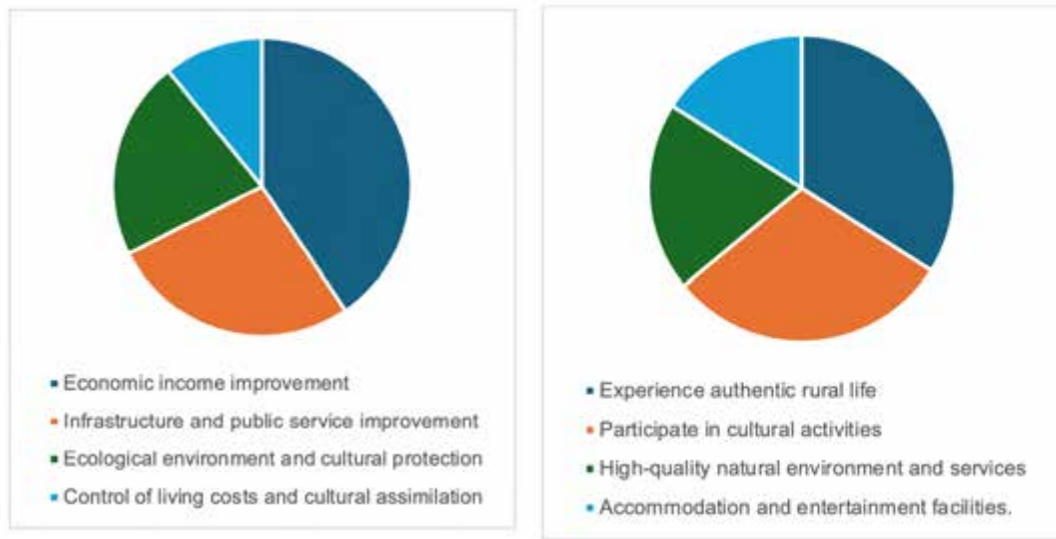
The residential architecture of Huanglongxian Village, influenced by traditional culture and hilly terrain (Figure 19), exhibits a style that is robust and simple, with a composed and introverted temperament. It possesses both the dignified grandeur of northern architecture and the delicate finesse of southern architecture. In terms of overall layout, the village's residential buildings demonstrate characteristics of adapting to the terrain and respecting nature (Figure 20). In terms of planar layout, they feature flexibility in scale and adaptation to local conditions. In terms of spatial structure, they highlight diverse forms and rigorous construction.

### 5. Sustainable Tourism Planning Strategies

Finally, based on the classification and evaluation of landscape ecological units, this study combines field surveys and in-depth interviews to thoroughly analyse the needs and expectations of residents and tourists in Huanglongxian Village. On this basis, the following targeted tourism planning strategies are proposed, aiming to construct a tourism model adapted to diverse tourist experiences while promoting local economic development, ecological protection, and cultural preservation.

#### 5.1 Analysis of Resident and Tourist Needs

Through in-depth interviews and field surveys, pie charts illustrating the distribution of resident and tourist expectations were compiled (Figure 21-22).



**Figure 21.** Distribution of resident expectations. **Figure 22.** Distribution of tourist expectations.

Residents of Huanglongxian Village generally expect tourism development to bring about an increase in economic income, while also hoping for improvements in infrastructure and public services, such as healthcare and education. Furthermore, residents show a strong sense of identification with protecting the local ecological environment and cultural traditions, but also express concerns that excessive tourism development may lead to rising living costs and cultural assimilation. On the tourist side, the main demands are concentrated on experiencing authentic rural life, participating in rich cultural activities, and enjoying a high-quality natural environment and tourism services. The needs of different types of tourists also vary; for example, leisure-oriented tourists pay more attention to the comfort of accommodation and entertainment facilities, while cultural experience-oriented tourists show strong interest in local historical buildings and tea culture.

## 5.2 Tourism Planning Strategies

From a sustainable development perspective, the linear and fragmented development of tourism spaces should be replaced by a cohesive strategy that integrates ecological protection and cultural revitalisation. In Huanglongxian, where rural tourism has developed for over five years, it is essential to re-examine the excavation of local culture and encourage greater public engagement. Based on this, five strategic directions are proposed: establishing ecological buffer zone standards, diversifying tourism products, enhancing community participation, developing a sustainable development assessment system, and strengthening brand identity.

It is essential to clearly define the ecological core zones of Huanglongxian according to the result of ecological units, such as the Paifang Reservoir and its surrounding forests, designating them as ecological protection areas. Designate these as ecological protection zones, restrict development and construction activities, and formulate strict environmental management measures to ensure the stability of the ecosystem and biodiversity. By setting up ecological trails, viewing platforms, etc., allow tourists to appreciate the natural beauty without disturbing the ecology, thereby enhancing ecological protection awareness. Simultaneously, conduct ecological education activities to popularise ecological protection knowledge among tourists and residents, promoting harmonious coexistence between humans and nature. Research has shown that the participatory management of eco-cultural trails enhances conservation outcomes while educating visitors (Lukoseviciute et al., 2024).

To maintain appeal and competitiveness, explore the connotations of Huanglongxian's tea culture and She eth-

nic culture to develop diversified tourism offerings. In addition to existing tea picking and processing experiences, in-depth tea culture-themed tour routes can be introduced, including visits to ancient tea gardens, learning about tea history, and studying tea art. Combined with the historical buildings and folk customs of the She ethnic village, create culturally distinctive experience projects, such as She ethnic song and dance performances and traditional handicraft making. Furthermore, develop rural leisure and holiday products, construct high-quality guesthouses and resorts, and provide services such as hot spring therapy and agricultural experiences to meet the needs of different tourist groups. Product diversification and culturally embedded experiences have proven effective in revitalising rural tourism destinations (Garau, 2015; Costantino et al., 2022).

Engaging local residents in tourism planning and operations enhances ownership and sustainability. Establishing a local tourism association, providing skills training, and implementing benefit-sharing mechanisms ensure fair economic returns and cultural continuity. Scholars argue that participatory frameworks are essential for the long-term management of cultural landscapes (Selman, 2004) and for achieving inclusive heritage tourism (Li and Hunter, 2015). At the same time, establish a reasonable benefit distribution mechanism to ensure that residents can obtain fair economic returns from tourism development, thereby enhancing their sense of belonging and satisfaction.

A sustainable tourism development assessment framework should evaluate environmental quality, economic benefits, social equity, and cultural preservation. The indicator system should include aspects such as tourism economic income, residents' quality of life, ecological environment quality, and cultural inheritance status. Based on the assessment results, timely adjust tourism planning and policy measures to ensure that tourism development is coordinated with ecological protection, cultural preservation, and social progress. Simultaneously, publicly disclose the assessment results to accept public supervision, improving the transparency and credibility of tourism development.

To establish a strong tourism identity, Huanglongxian should develop a distinct brand that integrates its tea heritage, She architecture, and local values. Branding elements such as logos, slogans, and cultural events reinforce recognition and pride. Sustainable tourism branding fosters long-term loyalty and encourages resident participation in cultural protection (Su et al., 2016; Landorf, 2009). When residents recognise the unique value of their local culture, they will more actively participate in cultural inheritance and protection, forming a virtuous cycle.

## 6. Conclusion

By employing a scientific ecological landscape unit division method combined with post - research surveys and interviews to comprehend diverse expectations, we aim for these strategies to enhance understanding of alternative tourism in rural development and boost Huanglongxian's sustainable tourism.

However, the research has limitations. The article's judgment factors, though broadly covering influential ones, lack detailed clarification due to data limits. The studied area's limited natural features result in an under - detailed determination factor system, like vegetation types and water conditions. Future regional analyses should adjust to local conditions, selecting suitable variable evaluation factors for more targeted outcomes. As China's rural construction evolves, there's a need for more theoretical reflection. Future large - scale machine learning could help create digital platforms for this research method.

In summary, these strategic tourism plans can help Huanglongxian Village achieve sustainable tourism development that meets residents' and tourists' needs, offering useful experience for metropolitan fringe area rural revitalisation.

### Declaration of competing interest

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.

### Annotate:

Source of charts: The charts in this paper are all compiled and drawn by the author, and the satellite remote sensing image is from the sky map (January 14, 2021).

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