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Comprehensive Evaluation and Quantitative Research on the Living Protection of Traditional Villages from the Perspective of "Production–Living–Ecology"

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Abstract: Aiming at the current isolated, static protection method of traditional villages, a comprehensive evaluation system for the living protection of traditional villages has been constructed based on the land use function integration concept in "Production–Living–Ecology" (PLE). By combining the "horizontal" PLE coupling coordination analysis with the "vertical" correlation analysis of the elements at each layer, the comprehensive evaluation and quantitative analysis of six traditional villages of different types and grades in the Taihu Lake area are carried out to quantitatively reflect the interactive relationship and integration mechanism of PLE in traditional villages. The results show that: (1) The PLE development of traditional villages is a dynamic process. Even if the villages are close in the PLE score, they may be in different stages of PLE development and coupling coordination type. (2) The "living" function has the highest correlation with the coupling coordination degree of PLE, and it acts as the engine and bridge of benign interaction between the PLE. (3) Even if the national traditional villages have a favorable ecology background, they may not get high scores, or even fail in the PLE score. (4) Among the sub-indicators, the natural environmental characteristics, the ecological vitality of political organizations, and the level of human settlement facilities show a significant linear correlation with the PLE score. Additionally, the ecological vitality of political organizations is the strongest. It can be therefore concluded that a positive policy organization is an important guarantee for realizing the PLE integration of traditional villages.

Keywords: production–living–ecology integration; traditional villages; living protection; coupling coordination degree; Taihu Lake area

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1. Introduction

Both the countryside and the city are the formal manifestations of human activities of production, living, and ecology, and the two have an isomorphic relationship; traditional Chinese cities dominate rural areas politically, but rely on them economically for survival [1,2]. Villages vastly outnumber cities. Countless villages are scattered on the vast land of China, where hundreds of millions of people live, giving birth to a world-famous agricultural civilization [3]. Traditional villages are one type of village. In the past, it used to be called "ancient village", which means that the village formed earlier. It has rich cultural and natural resources, and has certain historical, cultural, scientific, artistic, economic, and social values. Compared with general villages, they reflect the wisdom of the overall spatial pattern and engineering construction, and the harmonious state of integration and symbiosis between humankind and the original ecological environment during the farming period. They are of high artistic and scientific value, and are the living fossils of China's thousand-year agricultural civilization. With rapid urbanization, a large amount of intangible rural cultural heritage has failed to be handed down from past generations, so the intangible culture in traditional villages is endangered and lacks vitality [4]. Doubts and reflections have been aroused on the conventional way of preserving traditional villages by making them into "museums", which is only a preservation of the lifeless remains. At present, the previous research on the protection and utilization of traditional villages is mostly based on a one-sided, static protection, which has encountered many difficulties and resistance in practice, and the effect is not ideal [5,6]. It is therefore urgent to carry out research on the living protection of traditional villages.

The concept of Production–Living–Ecology (PLE) was first put forward in "Our Common Future" by the World Commission on environment and development in 1987. Under the promotion of the report, countries (regions) worldwide have reached a consensus on "sustainable development". After that, the "Rio Declaration on environment and development" and "Convention on biological diversity" signed in the 1990s and "transforming our world: the 2030 agenda for sustainable development" was signed in the 21st century, and they all expressed their continuous concern for sustainable development. As rural agricultural production is a part of rural life and ecological environment, and the food, energy, and resources of rural life come from agricultural production and ecological environment, respectively, the sustainable development of rural areas is considered as the integrated development of PLE [7]. It is an inexorable trend to integrate the development concept of PLE into the living protection of traditional villages.

Rural policies in Europe all show concern for PLE, with the introduction of the Agenda 2000 reforms, rural development was established in the European Union as the so-called second pillar of the Common Agricultural Policy (CAP), aiming at sustainably developing the rural area as a whole [8]. Based on Council Regulations 1257/1999 and 1698/2005, rural development plans (RDP) require Member States to pay more attention to maintaining the diversity of the ecosystem and ensuring the vitality of the village and the quality of the village's living environment in addition to strengthening the development of rural economy. In terms of funding, more funds are invested in sustainable ecological economic development, improvement of rural living quality, characteristic economy, and rural tourism [9]. In addition, many countries have their own unique plans, such as Poland's "Rural Renewal Programs" in the Warmia and Mazury Region, promoting the quality of production, living and ecology of the village systematically through "small grants", which then stimulate the comprehensive vitality of the village [10]. As for Germany, according to the German Territorial Order Act, the primary principle of territorial planning includes the construction of high-quality and healthy living and working environments throughout the country. Starting from the important significance of agriculture to production, living, and ecology, the principle of saving cultivated land resources and making better use of cultivated land resources is emphasized [11]. In addition, in the Weyarn Municipality, a rural area of upper Bavaria in southern Germany, village renewal under the framework of the Federal Land Consolidation Act provided a broad range of instruments: the local government makes full use of the land resources, actively develops the village economy, and, at the same time, takes into account the sustainable ecological development and the improvement of people's living quality, so that the village can be revitalized [12]. In China, 2017, the rural revitalization strategy emphasized the new requirements of thriving industries, a pleasant living environment, and a prosperous life in its overall development route, pushing the development concept of PLE to a new height. The living protection of traditional villages characterized by the development concept of PLE integration is a new practice. The basic connotation of PLE integration covers the material and spiritual achievements from the harmonious coexistence of humankind and nature, and from the construction of better human settlements. For traditional villages, ecological space is their natural foundation, while living space and production space are products derived from the environment where human beings live. In the long-term process of human activities, they react on the ecological space, thus forming a relatively stable overall pattern.

Domestic and foreign research on evaluation methods of traditional villages in related fields has yielded certain results, and the quantitative methods are increasingly concerned. For example, Yang et al. constructed an evaluation system and comprehensive evaluation function of cultural inheritance from the aspects of preservation and acceptance, and put forward corresponding protection strategies and suggestions [13]. Zou et al. constructed an index system for evaluating the vitality level of traditional villages from the three aspects of material heritage, intangible heritage, and village residents. They obtained data through field surveys, literature review, questionnaires, and other methods, and then quantitatively evaluated the vitality level of three types of traditional villages in West Hunan, China [14]. Ipekoglu proposed a grading system-based approach to evaluate the external and internal characteristics of traditional buildings in Odunpazari, Turkey, by their architectural, historical, environmental, visual, and aesthetic features, and divided these buildings into four groups of different values, A, B, C, and D, which would help make better decisions on cultural heritage [15]. Hu et al. constructed a multi-dimensional framework to understand the spatial reconstruction of traditional villages from the three levels of material space, social space, and cultural space. They preliminarily analyzed the spatial reconstruction mechanism of traditional villages under the interaction of social, political, and capital forces [16]. Guo et al. analyzed the Dang Village, a traditional village in Shaanxi Province, by combining qualitative and quantitative methods from social, economic, and environmental perspectives [17].

The current research results have the following shortcomings: First, the evaluation framework is relatively one-sided. Due to different research perspectives and evaluation objectives, the organic integrity of the village and the complexity of its internal system are ignored. To explore the influence mechanism of internal factors, a more comprehensive evaluation system is needed. Second, the quantitative evaluation research is relatively weak, and the reliability judgment of parameter compound operation lacks a systematic approach and accuracy of data processing. Third, the biggest feature of traditional villages is that the boundaries of PLE spaces are indistinct, and the degree of coupling coordination is high. During the integrative development of PLE in traditional villages, their interaction and integration mechanism is still vague [18].

In view of this, this paper attempts to construct a PLE comprehensive evaluation system of traditional villages. Taking the traditional villages around Taihu Lake as the research object, this paper quantitatively evaluates the PLE development levels of various traditional villages. By combining the horizontal PLE coupling coordination analysis with the vertical correlation analysis of indicators at different layers, the internal mechanism between PLE during the living protection of traditional villages is thoroughly analyzed, and appropriate multiple paths and strategies are proposed.

2. Materials and Methods

2.1. Study Area

The research team selected six traditional villages with typical characteristics in the Taihu Lake area for case study, covering different grades (national grade and provincial grade) and different types (mountainous, urban-suburbs, and water-network intensive). The basic information of these villages is shown in Figure 1 and Table 1.

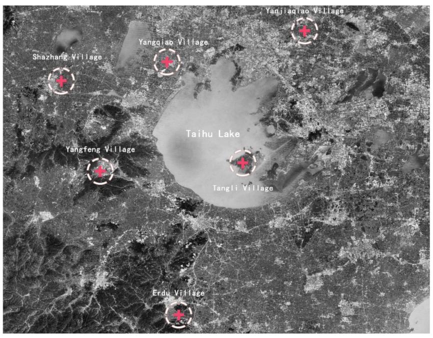

Figure 1. Distribution of typical traditional villages around Taihu Lake.

Table 1. Basic information of villages.

Village Name	Geographical Position	Type	Grade	Basic Information and Characteristics
Yangfeng	Huaikan Township, Changxing County	mountainous type	national grade	A population of 1453 (2019); the main industries are forestry, mining resources development, and tourism; a forest coverage rate of more than 80%. Yangfeng village has a large number of historical sites of the Communist Party, known as "little Yanan in the south of the Yangtze River".
Erdu	Xiazhuhu street, Deqing County	water-network intensive type	provincial grade	A population of 1775 (2019), the main industries are ecological agriculture, aquaculture, and tourism services. It is known as the most beautiful wetland in China and an important part of Xiazhu Lake National Wetland Park.
Shazhang	Kunlun Street, Liyang City	urban-suburbs type	national grade	A population of 1014 (most of which have moved to the New Village), the main industry is concentrated aquaculture. Shazhang Village Lane presents a structure of two horizontal and six vertical, which is famous for its features of "ancient village, ancient water, ancient tomb and ancient trees".
Yanjiaqiao	Yangjian Town, Xishan District	urban-suburbs type	national grade	A population of 5770 (2019), the main industries are ecological agriculture, processing and manufacturing, and eco-tourism. In the 1920s and 1930s, the village was a famous trading dock for rice, books, cloth, and medicine in Wuxi, and also a famous birthplace of Xi opera.
Yangqiao	Qianhuang Town, Wujin District	water-network intensive type	national grade	A population of 5211 (2019), the main industries are traditional cultivation, aquaculture, and tourism services. There are about 13,000 square meters of ancient buildings from the Ming and Qing Dynasties and the Republic of China. About 1000 square meters of stone revetments have been well preserved.
Tangli	Jinting Town, Wuzhong District	mountainous type	national grade	A population of 2991 (2019); the main industries are traditional planting and tourism. There are more than 30 single buildings and cultural relics, among which Diaohua hall, Rongde hall, and Qinyuan hall are typical.

The research data was obtained mainly through field surveys, on-site surveys, questionnaires, and a literature review. In August 2020, the research team conducted field surveys, on-site interviews, and questionnaire surveys for more than 20 days. Indicators D8–18 were from field surveys; D22, D30, and D38 from questionnaire surveys; and D1–2, D5–7, D19–20, and D23–25 from the literature review. Some indicators came from multiple sources. For example, D3–4, D26–30, and D36–37 were obtained through on-site interviews supplemented by literature review, whereas D21 and D32–35 were obtained through a questionnaire survey and field survey.

2.2. Methods

A comprehensive evaluation system was constructed based on the PLE integration with the principles of high feasibility and strong operability. The major steps were as follows: preliminary screening of indicators, expert consultation, determination of weights, determination of scoring standards, distribution of survey questionnaires, fuzzy comprehensive evaluation, correlation analysis of internal factors, etc. In terms of quantitative methods, the statistical method of "reliability analysis and Z-score unified standardization" was adopted to ensure the objectivity of scale analysis. By combining the horizontal PLE coupling coordination analysis with the vertical correlation analysis of the indicators at different layers, the interaction and integration of PLE of traditional villages are quantitatively reflected.

2.2.1. Construction of the Proposed Comprehensive Evaluation System

The specific evaluation process is shown in Figure 2 below.

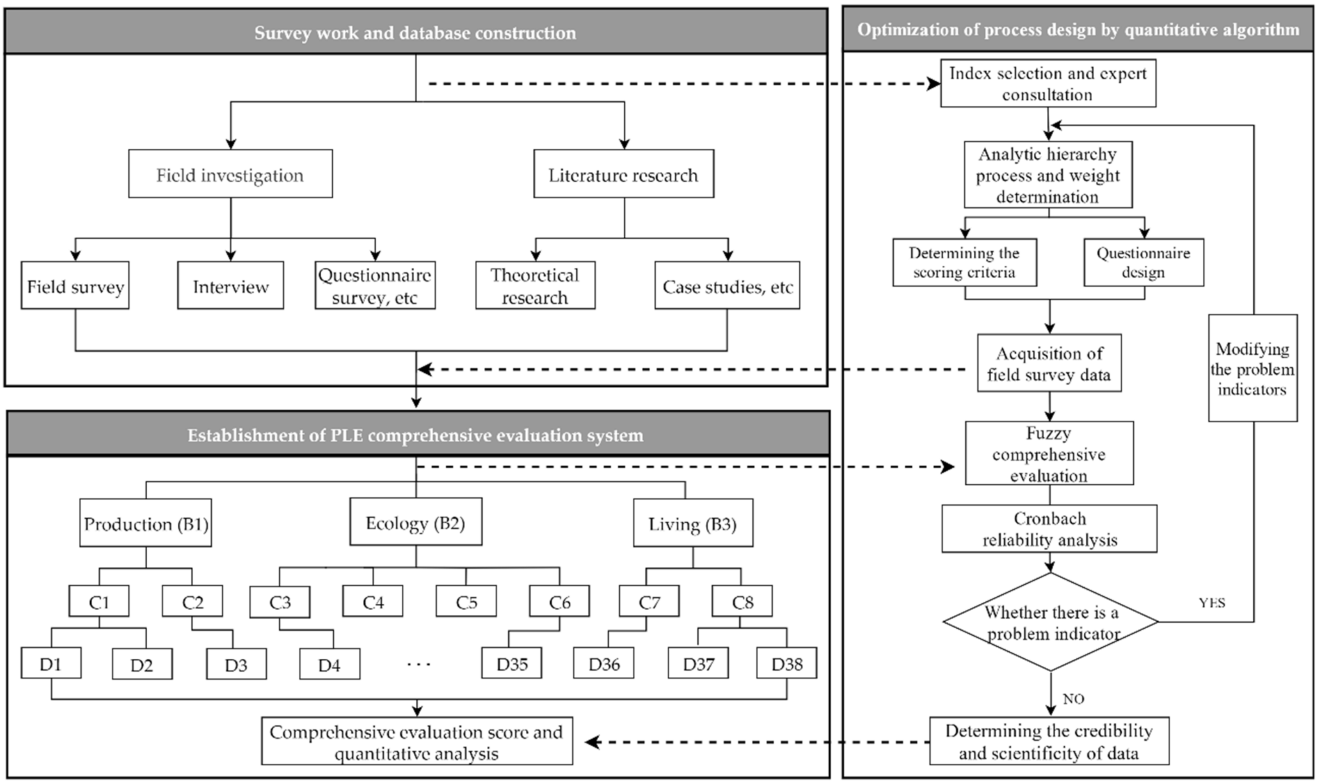

Figure 2. Flowchart for the comprehensive evaluation system.

2.2.2. Index Screening and Expert Consultation

Preliminary screening of indicators: Analyze and sort out relevant evaluation indicators for village economic production [19–23], human settlement environment [15,24–27], village ecological and cultural value [28–30], diversity of traditional village [31–34], policy efficiency index [35,36], and adaptability of rural tourism [17,32,37–39] from available literature. Finally, a total of 52 evaluation indicators were selected according to the objectives and principles mentioned above.

Expert consultation: The consulting experts were composed of four parts: experts in the field of traditional village protection, representatives of villagers, managers of village-related administrative organizations, and tourists, at a proportion of 4:3:2:1. By distributing the index consultation forms after the preliminary screening and analyzing the collected consultation forms and questionnaires [40], 38 key indicators were singled out (see Table A1 in Appendix A). These indicators were from 3 major categories (layer B), 8 medium categories (layer C), and 38 small categories (layer D).

1. Production B1

Comprehensive economic vitality C1 can roughly reflect the overall economic development level of the village [41]. A higher villagers' annual income per capital D1 and village collective annual average income D2 means better economic development. A strong industry means an economy of scale but not necessarily with distinctive features. As a result, the landscape and cultural characteristics of the village have not been fully explored. Therefore, the indexes D3 and D4 in the characteristic industry vitality C2 need to be treated differently. The deeper the future industrial development of the village integrates with the local characteristics [42], the higher the vitality level of its production field. Generally, the number of tourists reflects the real vitality of the tourism industry in the village. D6 and D7 reflect the talent leadership in the field of village production; the larger the number of leaders and the higher their income, the better the economic production vitality of the village [43].

2. Ecology B2

The products of the interaction between human beings and the environment include material ecology as well as spiritual ecology, such as society and humanities. Ecological civilization is the sum of material and spiritual results produced in the process of long-term coexistence and mutual influence between humans and the environment [44]. Academics have put forward the "pan-ecology" viewpoint which refers to the generalization of ecology in a broader sense. It is the sum of the material and spiritual achievements made by human beings in the interaction with the original ecological environment. Thus, the ecology B2 includes two major parts: material ecology and spiritual ecology [45].

Specifically, material ecology herein consists of the characteristics of natural environment C3 and the spatial characteristics of the village C4; the higher the scores of D8, D9, and D10, the better the natural environment of the village [46]. The material heritage features can be divided into three layers: overall layout, public space, and single building. The indexes in each layer are evaluated according to their quantity and quality. The larger the quantity of material heritages and the more distinctive and the more diversified the village, the higher the score for the ecology of the village [47].

The spiritual ecology is composed of political organization ecology C5 and cultural ecology C6 [48]. In addition to the evaluation of system management, the former index also includes the government's execution power and villagers' participation in protection work, thus forming a systematic evaluation system from top-level management to personnel implementation to villagers' cooperation and participation. The more complete the system, the higher the degree of implementation and the better the villagers' awareness and participation, the more effective the political organization ecology of the village. The latter is selected according to principle of "quantity + quality". The score of cultural ecology C6 is higher if the sub-indexes—history (D23–24), influence of historic figures and events (D25), cultural features (D26), villagers' participation in cultural activities (D27), and cultural inheritance—have higher scores.

3. Living B3

As for the layer of human settlement facilities (C7) [31], the higher the scores of such sub-indexes such as traffic (D32), living facilities (D33), and service facilities (D34), the better the living environment of the village, the stronger its attraction, and the more conducive it is to the living protection of the village. Meanwhile, it is necessary to pay more attention to the actual returned population and talent attraction of the village [49], especially the returned young population (D36), the attractiveness to foreign entrepreneurs (D37), and social inclusiveness (D38).

2.2.3. Analytic Hierarchy Process and Weight Determination

The weights are determined by the classical Analytic Hierarchy Process (AHP) [50]. That is, a tree hierarchical structure is constructed according to the comprehensive evaluation framework of PLE integration, and then Yaahp program distributes the score questionnaire to experts and scholars in the field. After experts determine the weight scores, the software will generate a judgment matrix to obtain the weight of each index in the comprehensive evaluation index system (see Table A1 in Appendix A).

2.2.4. Determination of Scoring Standards and Survey Questionnaire Design

Comprehensive evaluation includes qualitative and quantitative indicators. The graded scoring method for qualitative indicators [51]. There are five grades of evaluation scores (I, II, III, IV, and V), and each grade is assigned 20 points, that is, the scores of the grades are in the interval of 0–20, 21–40, 41–60, 61–80, and 81–100, respectively [52]. For quantitative indicators, a five-grade centesimal system similar to the above method is developed in combination with relevant standards for scoring. For the types of questionnaire and interview indicators, the majority opinion results of questionnaire interview are the final evaluation results. Copies of the survey questionnaire formulated by experts were distributed to local villagers. The collected valid questionnaires for each village were ensured to be more than 50.

2.2.5. Fuzzy Comprehensive Evaluation

Experts in the field were invited to score according to the above criteria. In the evaluation layer domain U, in order to obtain the index membership degree, it was necessary to uniformly sort and analyze the indexes of each layer to form a fuzzy evaluation matrix R.

Then, compound operation was carried out for the fuzzy matrix. According to the weight of each index w = ($\mathrm{w_1}$, $\mathrm{w_2}$, . . . , $\mathrm{w_n}$) [53] and fuzzy evaluation matrix R obtained in the above steps by AHP [54], the following operations are started:

$$B = W \cdot R = [\mathrm{w_1}, \mathrm{w_2}, \cdots, \mathrm{w_n}] \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (B_1, B_2, \cdots, B_n) \tag{1}$$

Similarly, a complete resulting score scale for groups A, B, C, and D of the comprehensive evaluation index system for traditional village living protection can be obtained.

2.2.6. Reliability Analysis

The reliability analysis—Cronbach reliability analysis—was performed on the PLE comprehensive score scale to estimate the internal consistency of the test.

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum S_i^2}{S_x^2}\right) \tag{2}$$

α is the reliability coefficient, K is the number of test items, S_i^2 is the score variation of all subjects on the i-th question, and S_x^2 is the variance of the total scores obtained by all subjects.

In the above analysis, if the reliability coefficient is less than 0.35, it is considered to be low reliability, indicating the unreliability of the scale data. A reliability coefficient larger than 0.8 is acceptable. If the value is above 0.9, the scale is of high reliability. If the comprehensive evaluation scale fails to have high reliability, adjustments should be made on the related indexes according to the modification suggestions of experts.

2.2.7. Weight Calculation Based on Entropy Weighting Method and PLE Coupling Coordination Model

The process of the horizontal PLE coupling coordination model is shown in Figure 3.

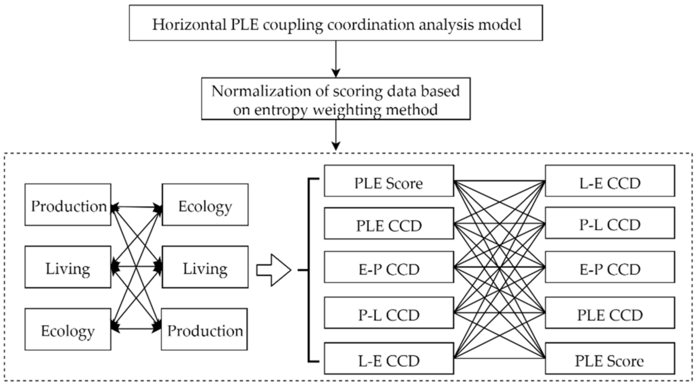

Figure 3. Process of the horizontal PLE coupling coordination model.

The range method is adopted in this paper normalize the dimensionless data:

$$x = \frac{x - x_{\text{min}}}{x_{\text{max}} - x_i} \quad (3)$$

where x_i=x_1,x_2, ... ,x_{n}; x_{max} and x_{min} respectively are the maximum and minimum of the index i.

The index weight is determined by calculating information entropy and information entropy redundancy. After the weights are determined, the comprehensive scores of PLE system can be calculated [55].

$$\text{f}(x) = \sum_{i=1}^{m} a_i x_i \quad (4)$$

$$g(y) = \sum_{i=1}^{n} b_i y_i \quad (5)$$

$$h(z) = \sum_{i=1}^{k} c_i z_i \quad (6)$$

Here, $\text{f}(x)$, $g(y)$, and $h(z)$ are the comprehensive scores of production, living, and ecology, respectively. a_i, b_i, and c_i are the weights of the production, living, and ecology system, respectively, and they are dimensionless values.

$$C = \left\{ \frac{\text{f(x)} \times \text{g(y)} \times \text{h(z)}}{\left[\frac{\text{f(x)}+\text{g(y)}+\text{h(z)}}{3}\right]^3} \right\}^{\frac{1}{3}} \quad (7)$$

The value of the coupling degree C ranges within (0, 1). The closer C is to 1, the greater the coupling degree between the systems; the closer C is to 0, the smaller the coupling degree between systems, and the order parameters are in a state of independent and disorderly development.

$$D = \sqrt{C \times T} \quad (8)$$

$$T = \partial f(x) + \beta g(y) + \delta h(z) \quad (9)$$

D is the coordination degree of the interaction coupling between the PLE functions, C is the coupling degree, and T is the comprehensive evaluation index of the coupling coordination degree. ∂, β, and δ are the weights of the PLE systems, which are assigned to 1/3, 1/3, and 1/3, respectively. Similarly, the pairwise mutual influence between production, living, and ecology can be calculated, respectively, such as ecology–production (E–P), living–ecology (L–E) and production–living (P–L) [56–59].

The lower the coordination (D value), the weaker the interaction among the three functions, and the greater the conflict among them. With reference to relevant research results and the actual development stage of the village, the results are divided into 4 categories and 10 subcategories [56] (see Table 2).

Table 2. Classification of PLE coupling coordination degree.

PLE Development Stage	Coupling Coordination Type	Coupling Coordination Degree
Coordination and integration period	Type I integration Type II integration Type IIIintegration	0.9~1.0 0.8~0.9 0.7~0.8
Running-in and adjustment period	Type I adjustment Type II adjustment	0.6~0.7 0.5~0.6
Antagonistic and contradictory period	Type I contradiction Type II contradiction	0.4~0.5 0.3~0.4
Declining and maladjusted period	Type I maladjustment Type II maladjustment Type IIImaladjustment	0.2~0.3 0.1~0.2 0~0.1

2.2.8. Z-Score Normalization and the Vertical Correlation Analysis Model

The process of the vertical correlation analysis model is shown in Figure 4.

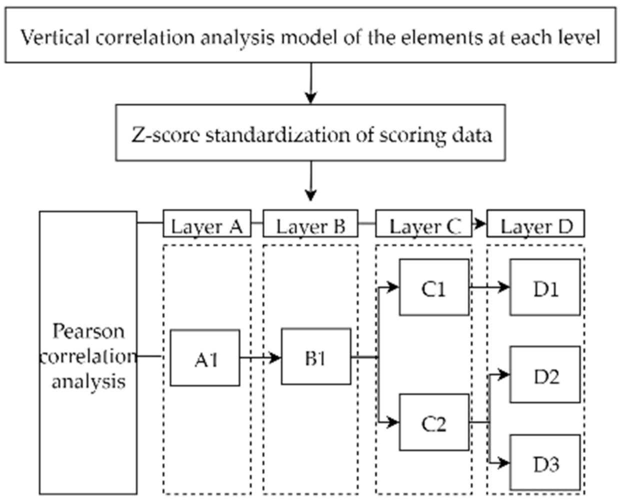

Figure 4. Process of the vertical correlation analysis model.

To ensure the results of different dimensions or layers of the fuzzy comprehensive evaluation [60] are comparable, it is necessary to normalize the evaluation vector results in the SPSS software. Z-score processing method is used to convert the data so that they have a mean value of 0 and a standard deviation of 1. The conversion formula is:

$$x^* = \frac{x - \overline{x}}{\sigma} \quad (10)$$

where x^* is the Z-score, x is the score of the indicator, $\overline{x}$ is the mean of the original data, and σ is the standard deviation of the original data.

Finally, the Pearson correlation analysis is adopted to measure the closeness of two or more variables in the PLE systems, so as to explore the mutual influence mechanism of the internal factors [61].

The Pearson's correlation coefficient is defined as:

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}\sqrt{\sum_{i=1}^{n}\left(Y_i - \overline{Y}\right)^2}} \quad (11)$$

Obviously, $-1 \leq r \leq 1$. When $r < 0$, the two variables are negatively correlated; when $r \geq 0.8$, the two variables are highly correlated; when $0.8 > r \geq 0.5$, they are moderately correlated; when $0.5 > r \geq 0.3$, they are slightly correlated; and when $r < 0.3$, they are roughly independent. The significance test results show that when the significance is less than 0.05, the samples have a relatively significant linear correlation; when the significance is below 0.01, the samples have an extreme significant linear correlation [62].

3. Results

3.1. Evaluation Results

According to the operation process of the comprehensive evaluation index system constructed above, the fuzzy evaluation is carried out, and the scores are shown in Table 3. In this table, village names are abbreviated, such as Yangfeng (YF), Erdu (ED), Shazhang (SZ), Yanjiaqiao (YJQ), Yangqiao (YQ), Tangli (TL).

Table 3. Comprehensive evaluation index result.

Layer C	Score						Average Score	Layer D	Score						Average Score
	YF	ED	SZ	YJQ	YQ	TL			YF	ED	SZ	YJQ	YQ	TL	
C1	3.75	4.66	0.66	4.35	4.63	4.71	3.78	D1	1.53	1.55	0.22	1.11	1.52	1.59	1.24
								D2	2.22	3.10	0.44	3.24	3.11	3.12	2.53
C2	9.31	11.73	2.77	10.39	8.01	10.11	8.72	D3	1.93	2.48	0.82	2.48	1.38	1.94	1.84
								D4	3.15	4.02	1.35	4.05	3.15	4.05	3.29
								D5	1.29	1.66	0.18	0.92	0.55	1.29	0.98
								D6	0.96	0.96	0.13	0.96	0.96	0.96	0.82
								D7	1.99	2.56	0.28	1.99	1.99	1.99	1.81
C3	3.89	4.27	1.89	3.51	3.62	4.51	3.62	D8	0.53	0.29	0.29	0.41	0.53	0.53	0.43
								D9	1.21	1.20	0.67	0.93	0.93	1.22	1.02
								D10	2.14	2.76	0.92	2.14	2.12	2.76	2.14
C4	9.72	5.46	9.03	10.86	10.44	11.76	9.55	D11	1.11	0.61	1.11	0.86	0.86	0.86	0.90
								D12	1.28	1.00	1.13	1.28	1.00	1.56	1.09
								D13	1.48	1.06	1.47	1.48	1.90	1.92	1.55
								D14	0.72	0.52	0.72	0.75	0.72	0.52	0.66
								D15	0.66	0.37	0.07	0.37	0.66	0.51	0.44
								D16	0.61	0.61	1.44	1.03	1.44	1.85	1.16
								D17	0.95	0.95	2.21	2.27	2.23	2.23	1.80
								D18	2.86	0.31	0.95	2.86	1.59	2.86	1.90
C5	4.12	4.51	1.47	4.12	3.73	4.51	3.74	D19	0.60	0.61	0.21	0.61	0.63	0.66	0.53
								D20	0.79	0.79	0.61	0.79	0.79	0.79	0.76
								D21	1.39	1.34	0.45	1.33	1.31	1.37	1.21
								D22	1.34	1.72	0.19	1.34	0.96	1.72	1.21
C6	9.86	9.32	4.87	10.34	7.44	9.89	8.62	D23	0.83	0.83	0.59	0.83	0.59	0.59	0.71
								D24	0.62	0.37	0.86	0.62	0.62	0.62	0.62
								D25	1.27	0.91	0.91	1.27	0.54	0.91	0.97
								D26	0.22	0.38	0.38	0.22	0.38	0.53	0.35
								D27	1.14	1.14	0.49	1.47	0.49	1.14	0.98
								D28	0.24	0.14	0.04	0.24	0.24	0.24	0.19
								D29	0.39	0.39	0.07	0.07	0.23	0.71	0.31
								D30	3.56	3.51	1.18	2.77	2.77	3.56	2.89
								D31	1.56	1.56	0.31	2.81	1.56	1.55	1.55
C7	12.11	11.65	1.31	11.71	8.23	11.73	9.46	D32	2.01	2.01	0.22	2.01	2.01	2.01	1.71
								D33	3.94	3.94	0.43	3.94	3.06	3.94	3.21
								D34	4.59	4.59	0.51	4.59	2.55	4.59	3.57
								D35	1.44	1.12	0.16	1.44	0.82	1.46	1.07
C8	9.12	10.75	7.37	7.42	7.98	15.99	9.77	D36	1.31	1.31	3.94	1.31	1.31	6.58	2.63
								D37	4.14	5.80	0.82	2.48	2.48	5.82	3.59
								D38	3.21	3.65	2.61	3.85	3.67	3.59	3.43
Amount	61.88	62.35	29.37	62.71	54.08	73.21	57.26		61.88	62.35	29.37	62.71	54.08	73.21	57.26

3.2. Reliability Analysis

The Cronbach reliability analysis results show that the average value of the Alpha index of the evaluation scale for the above-mentioned villages reach 0.952, and the Alpha index of each indicator is above 0.94, indicating that the scale has high consistency and strong reliability (Table 4).

Table 4. Comprehensive evaluation index result.

Layer D	Cronbach's Alpha	Layer D	Cronbach's Alpha
D1	0.949	D20	0.951
D2	0.949	D21	0.954
D3	0.950	D22	0.953
D4	0.948	D23	0.952
D5	0.950	D24	0.952
D6	0.949	D25	0.949
D7	0.949	D26	0.951
D8	0.953	D27	0.949
D9	0.953	D28	0.949
D10	0.950	D29	0.952
D11	0.950	D30	0.955
D12	0.949	D31	0.953
D13	0.955	D32	0.953
D14	0.952	D33	0.951
D15	0.952	D34	0.949
D16	0.954	D35	0.951
D17	0.949	D36	0.949
D18	0.955	D37	0.949
D19	0.955	D38	0.950

3.3. Horizontal Analysis: PLE Score and Coupling Coordination Analysis Results

Through the comparison of the PLE score and coupling coordination degree (CCD) scores, the CCD contain PLE CCD and pairwise mutual CCDs of production, living and ecology, respectively, Pearson correlation analysis method is adopted to explore the evaluation content such as the integration and correlation of PLE, so as to quantitatively express the interaction and integration mechanism of PLE of traditional villages.

As shown in Table 5 and Figure 5, the PLE score and the PLE CCD are not strongly correlated. Yangfeng Village (61.88), Erdu Village (62.35) and Yanjiaqiao Village (62.71) have similar PLE scores. Among them, Yangfeng Village is the lowest, but it has reached coordination and integration period in PLE development stage (0.76), higher than the other two villages' 0.63 and 0.68 (Running-in and adjustment period).

Table 5. The score of PLE, coupling coordination degree scores and Z-score processing results.

Village Name	PLE Score	PLE CCD	L–E CCD	P–L CCD	E–P CCD	Z-Score PLE Score	Z-Score PLE CCD	Z-Score L–E CCD	Z-Score P–L CCD	Z-Score E–P CCD
Yangfeng	61.88	0.76	0.74	0.71	0.77	0.30833	0.65011	0.37047	0.69616	0.32223
Erdu	62.35	0.63	0.82	0.84	0.56	0.33975	0.07989	0.28871	−0.40151	0.91481
Shazhang	29.37	0.28	0.31	0.29	0.19	−1.86449	−1.52665	−1.38747	−1.45669	−1.61181
Yanjiaqiao	62.71	0.68	0.82	0.51	0.76	0.36381	0.29119	0.68375	0.65367	−0.56392
Yangqiao	54.08	0.45	0.39	0.61	0.42	−0.21298	−0.75418	−1.06993	−0.66116	0.12344
Tangli	73.21	0.89	0.92	0.87	0.89	1.06558	1.25965	1.11448	1.16953	1.06212

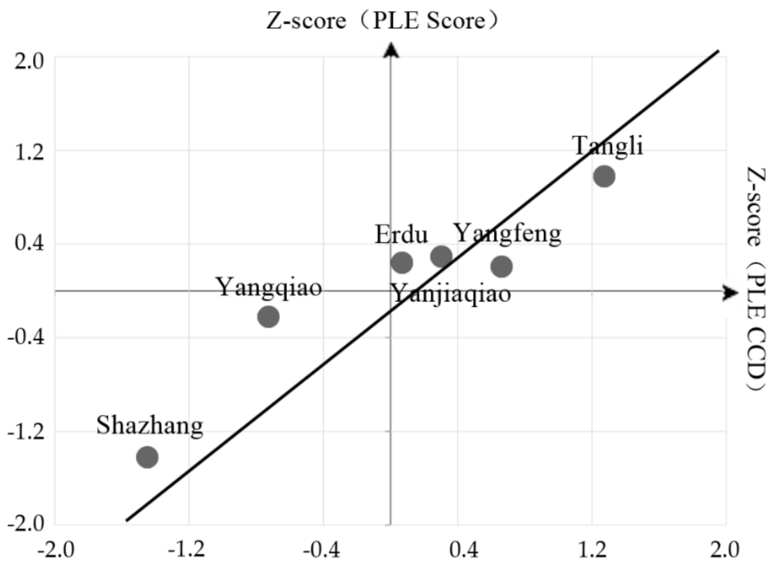

Figure 5. The relationship between PLE score with PLE CCD.

The internal mechanism reason for that scoring performance can be found from the pairwise mutual CCDs, as shown in Figure 6. Erdu village and Yanjiaqiao village show Type II adjustment performance, respectively in the pairwise mutual CCDs on L–E (0.56) and P–L (0.51). Even though they show a relatively high score on other CCDs, their scores of PLE coordination will be affected by the buckets effect. It thus can be concluded that the PLE development of village is a dynamic process, the coordination among PLE functions constrain and contribute each other. In Yangfeng Village, the three functions of space begin to balance and cooperate with each other, which shows the characteristics of benign coupling coordination. Different from Yangfeng Village, Erdu village and Yanjiaqiao village face the problem of antagonism at CCD in L–E and P–L. Their dominant function become stronger and occupy the space for the development of disadvantaged functions. Consequently, these disadvantaged functions would become weaker and weaker.

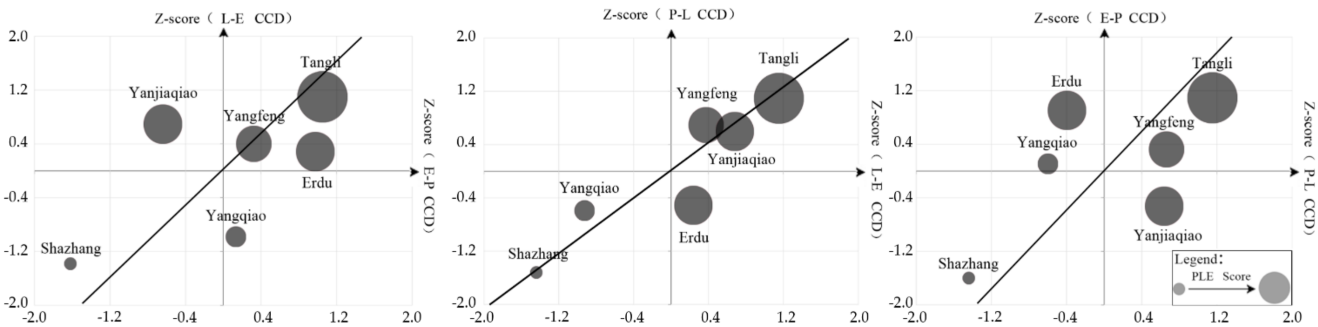

Figure 6. The relationship among pairwise mutual CCDs.

After Z-score processing, the relationships among the CCDs of PLE, L–E, P–L, and E–P can be seen more intuitively (Figure 7). Figure 8 shows the significance of Pearson results between the PLE score, PLE CCD, and pairwise mutual CCDs. When the significance is less than 0.05, the samples have a relatively significant linear correlation (light red); when the significance is below 0.01, the samples have an extreme significant linear correlation (bright red). Specifically, the PLE CCD shows a strong linear relationship with P–L (0.002) and L–E (0.003), respectively, as shown in Table A2 of Appendix A. Moreover, P–L shows a strong correlation of 0.005 with L–E. It can be seen that the living function acts as a bridge for the interaction between the production and ecology functions. It has demonstrated that the living protection for traditional villages is a key link to realize the coordinated development of PLE, which is inconsistent with the general belief that the better the production or ecology, the better the PLE development of village. In addition, PLE CCD shows a strong correlation of 0.006 with PLE score, demonstrating that the comprehensive development of three aspects is an effective way to realize the living development trend of "seeing people, things, and living" in traditional villages.

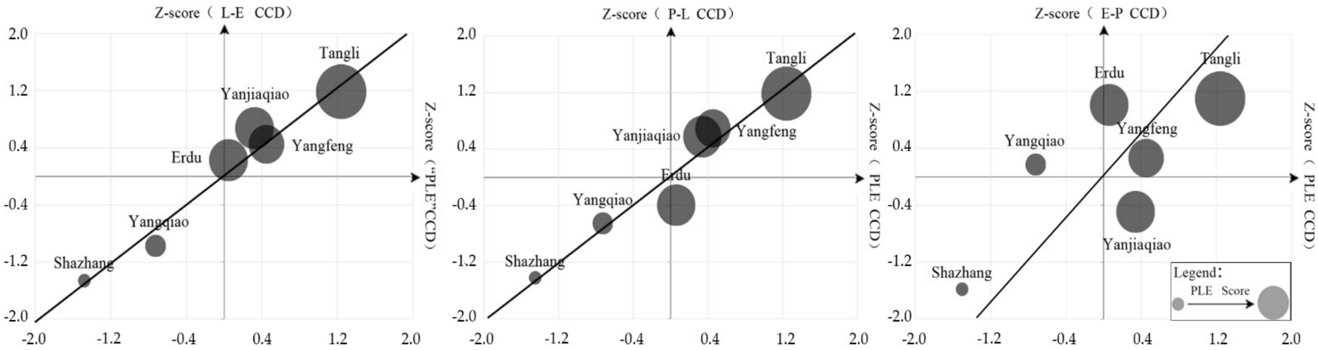

Figure 7. The relationship of PLE CCD with pairwise mutual CCDs.

	PLE Score	PLE CCD	E–P CCD	P–L CCD	L–E CCD
PLE Score		0.006	0.026	0.019	0.017
PLE CCD	0.006		0.076	0.002	0.003
E–P CCD	0.026	0.076		0.208	0.156
P–L CCD	0.019	0.002	0.208		0.005
L–E CCD	0.017	0.003	0.156	0.005	

Legend: 0.300, 0.100, 0.050, 0.020, 0.010, 0.005, 0.000

Figure 8. The significance of Pearson results between the PLE score, PLE CCD, and pairwise mutual CCDs.

3.4. Vertical Analysis: PLE Score (Layer A) and Analysis Results of PLE Dimensions (Layer B)

Overall, the average score of the six studied villages only reached 57.26. This indicates that although they are located around the Taihu Lake, a developed region covering Zhejiang and Jiangsu provinces, their PLE development is not ideal. Among them, only Tangli Village scores over 70, and three villages (Yangfeng, Erdu, and Yanjiaqiao) score a little over 60. Furthermore, among the villages with scores below 60 points, Yangqiao only achieves 54.08, while Shazhang shows the lowest score of 29.37. In addition to Erdu, which is a provincial grade traditional village, the others are all at the national grade. This shows that the villages may score low even if they have a fine ecology, and that their development strategy should be adapted to the concept of PLE integration.

The difference among the studied villages in terms of production, living, and ecology can be directly seen after Z-score normalization (Table 6). To better show the difference, the villages' Z-scores of production, living, and ecology at layer B can be transformed and put into a coordinate system (Figure 9). The larger the circular area in the figure, the higher the village's Z-score in the production.

Table 6. Z-score normalization results of production, living, and ecology.

Village Name	Production	Living	Ecology	Z-Score (Production)	Z-Score (Living)	Z-Score (Ecology)
Yangfeng	13.1	27.6	21.1	0.12263	0.44273	0.28009
Erdu	16.4	23.5	22.4	0.83674	−0.41484	0.47871
Shazhang	3.5	17.2	8.7	−1.95480	−1.73256	−1.61436
Yanjiaqiao	14.6	28.8	18.4	0.44722	0.69372	0.02037
Yangqiao	12.7	25.2	15.9	0.03607	−0.05926	−0.51435
Tangli	14.9	30.6	28.1	0.51214	1.07022	1.34954

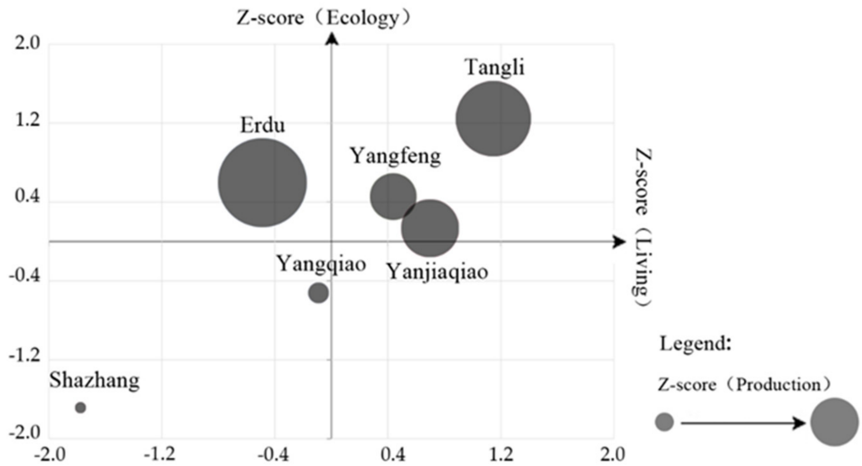

Figure 9. Z-scores of production, living, and ecology after normalization.

1. Production dimension

In terms of production, provincial grade traditional village Erdu has the highest score (16.4 points), followed by the national grade traditional villages, Yanjiaqiao, Tangli and Yangfeng, ranking 2nd, 3rd, and 4th, respectively. There are not many historical sites and features in Erdu Village, and its score for spatial and environmental characteristics (C4) are not high. However, Erdu has benefited greatly from large projects and events nearby, such as the Xiazhu Lake Wetland Park completed in 2013 and the pastoral expo held in 2019. Yanjiaqiao is a traditional suburban village, 4 km away from Yangjian Industrial Park in Wuxi City, 12 km from East Railway Station, and 20 km from the downtown. In recent years, it has developed an economy through suburban tourism and urban industry, so the villagers' income and the collective income of the village are both high. In addition, Tangli Village is located in the Xishan Island Scenic Spot, with high artificial and natural ecological values. The development of tourism helps the village score relatively high in the production dimension. Moreover, Yangfeng is a mountainous type of village with a forest coverage rate of more than 80%. This village develops forestry and mining industries based on its own superior natural conditions and sees a sound economic boost. It shows that the rational use of their own and surrounding environmental resources is the key to maintaining the economic vitality of traditional villages.

The villages with lower scores are Yangqiao and Shazhang. Yangqiao Village has a favorable material ecology (C3 and C4), yet the lack of large-scale development projects in its surrounding area and the poor planning and management of the political organization ecology (C5) have resulted in a low production score. In contrast, the economy of Shazhang is more sluggish, and the low score of political organization is one of the main reasons for the decline in its production. According to the on-site interview, the local government organized the aborigines to move out for the protection of historic sites. There were more than 200 households, more than 180 of which have moved out. Those still live there are mostly the elderly. Shazhang village is almost an empty village where only some lonely elderly villagers visit each other during the day. As most of the residents have moved out, many century-old houses in the village are worn down by the years without repair, and even collapsed, showing a dilapidated scene.

2. Living dimension

As can be seen in Figure 9, Shazhang, Yangqiao, and Erdu have relatively low scores for the living dimension. Although Erdu sees an outstanding economic increase, as well as a trend of labor returning (a subindicator at layer D), its social amenities are insufficient. As a result, the livability is poor, which partly affects the progress in its living protection. For Shazhang and Yangqiao, as mentioned above, in addition to regional differences, the quality of policy organization plays a crucial role in their development. Despite a large number of material ecological remains and various historical sites, Yangqiao is poor in livability and living protection owing to the lagged policy and organization.

The villages with relatively high scores in the living dimension, such as Yangfeng, Yanjiaqiao, and Tangli, also face the same issues. The living facilities are relatively complete, and a certain number of migrants come to the village to start businesses, such as opening homestays, restaurants, and studios. However, the indicator D36 shows that only a small proportion of young people in Tangli have returned to the village. Additionally, this figure for the other two villages is almost zero.

3. Ecology dimension

In this dimension, except for the relatively weak Shazhang and Yangqiao, the remaining four villages all show high scores. Comparison between Yangqiao and Yanjiaqiao shows that, under the same material ecology (natural environment and material heritage), the villages with better spiritual ecology (political organization ecology and cultural ecology) have a higher level in production and living dimensions.

It can also be found that the material ecology and cultural ecology of Erdu (a provincial grade traditional village) are significantly inferior to Yangqiao (a national grade traditional village), whereas Erdu's scores for the production dimension are significantly higher. This further confirms the importance of organizational ecology mentioned above in Pearson correlation analysis. Thus, the local government should appropriately develop and utilize the resources of the village and those nearby, which is a necessary guarantee for the village to achieve a sustainable development of PLE integration. The production, living and ecology are closely related and complement each other, the absence of any of which will impact the sound, sustainable development of the whole system.

3.5. Vertical Analysis: Analysis Results of Sub-Indicators (Layer C and Layer D)

The indicators of layer C are standardized by Z-score processing mentioned above, and the results are shown in Table 7. The data are visualized to analyze the differences between specific indicators, as shown in Figure 10.

Table 7. Normalized results of Z-scores for sub-indicators at layer C.

Layer C	Z-Score (Yangfeng)	Z-Score (Erdu)	Z-Score (Shazhang)	Z-Score (Yanjiaqiao)	Z-Score (Yangqiao)	Z-Score (Tangli)
C1	−0.02749	0.54987	−1.98799	0.35319	0.53084	0.58159
C2	0.18651	0.95150	−1.88088	0.52791	−0.22444	0.43940
C3	0.29680	0.70693	−1.86177	−0.11333	0.00540	0.96596
C4	0.07919	−1.84845	−0.23304	0.59503	0.40499	1.00228
C5	0.32716	0.66591	−1.97457	0.32716	−0.01158	0.66591
C6	0.59043	0.33330	−1.78556	0.81898	−0.56186	0.60471
C7	0.62550	0.51706	−1.92051	0.53121	−0.28918	0.53592
C8	−0.19728	0.29617	−0.72706	−0.71192	−0.54239	1.88248

Figure 10. The Z-score of each index in C layer.

From the score of indicator C1 (overall economic vitality), it can be observed that all the other villages are at or above the mean, except for Shazhang. This shows that the traditional villages in the affluent area around Taihu Lake in Jiangsu and Zhejiang provinces have excellent economic performance.

The indicators C2 (characteristic industrial vitality), C5 (ecological vitality of political organizations), C6 (cultural ecological vitality), and C7 (the level of human settlement facilities) exhibit consistent characteristics in their standardized images That is, except Yangqiao and Shazhang, the scores of other villages are close to each other. These indicators are closely related to the administration level of government.

Shazhang Village has been unmanaged in recent years, so the surrounding environment is overgrown with weeds, and its natural features have been seriously damaged. Consequently, this village scores low at the natural environment features C3 and spatial environment features C4. Erdu Village, a provincial grade traditional village, is not comparable to the other five national grade traditional villages in terms of material heritage characteristics due to fewer historical sites and cultural relics. Nevertheless, the outstanding characteristic industries, political organizations, and the human settlement environment have contributed to Erdu's PLE score above the average level.

Through the standardization of Z-score and Pearson analysis, the correlation results between the PLE scores and the C-layer indicators are obtained (Table A3 in Appendix A). In order to make the data more intuitive, the significance of correlation results between the PLE scores and the C-layer indicators table is drawn (Figure 11). When the significance is less than 0.05, the samples have a relatively significant linear correlation (light red); when the significance is below 0.01, the samples have an extreme significant linear correlation (bright red).

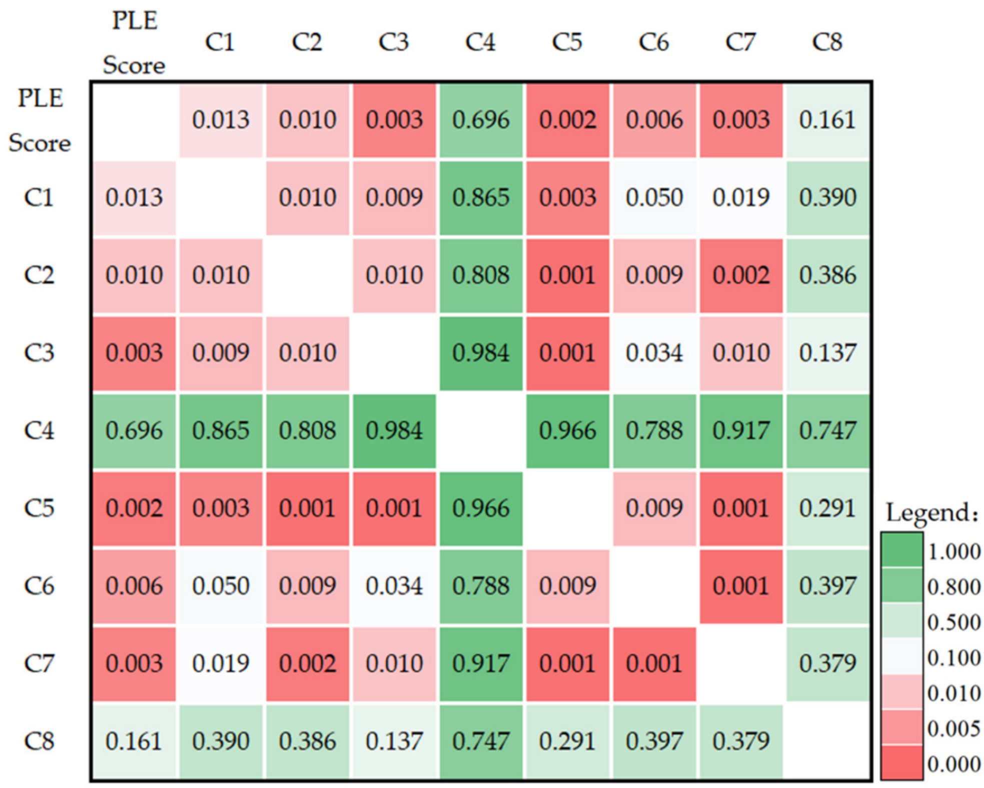

Figure 11. The significance of Pearson results between the PLE scores and the C-layer indicators.

Natural environment features, ecological vitality of political organizations, and the level of human settlement facilities show a linear correlation with the PLE score. Among them, the significance between the ecological vitality of political organizations and the score is 0.002, indicating the strongest correlation. This indicates that positive policy organization is the key factor a key factor in realizing the PLE integration of villages. In addition, in C5 column, the number of bright red color blocks is the most, indicating that the index has the strongest correlation with other elements.

In addition, the correlation value of the PLE score with spatial environmental features and population vitality of the village is 0.696 and 0.161, respectively, showing a weak linear correlation. It is thus can be concluded that the village can still find a suitable path for PLE integration based on its own strengths even if its spatial environment is not excellent. Moreover, there is a certain correlation between spatial environment and population vitality (0.137). This indicates that a favorable natural environment is the foundation of the village's development and population increase.

4. Discussions

Figure 12 shows the visualization results of the indicators at layer C. Then, each quadrant in the z-score coordinate system (Figure 9) of each village is classified and summarized, and the influence mechanism and related issues of the village are explored from the perspective of PLE, so that the suitable strategy can be proposed.

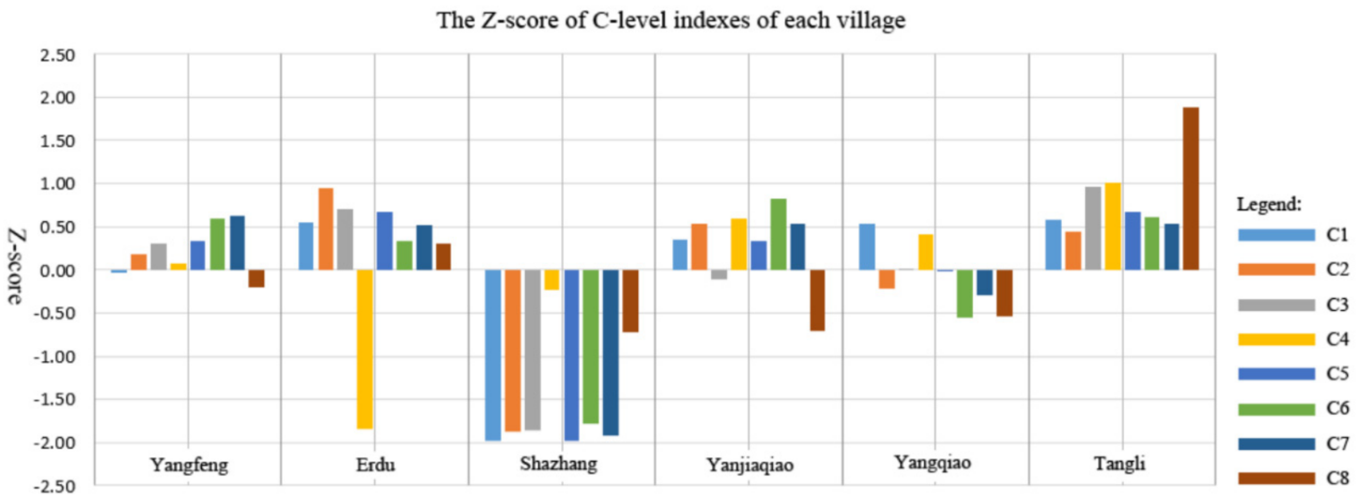

Figure 12. Normalized Z-scores of villages' indicators at layer C.

(1) The villages in the first quadrant are Yangfeng, Yanjiaqiao, and Tangli, all national grade villages. They score above the average in the PLE dimensions and have achieved all-around progress in PLE integration. These villages all make full use of natural and cultural resources, forming unique village characteristics, and providing a high-class ecological and cultural foundation for further living protection (Figure 9).

For such traditional villages, we should adhere to the strategy of "inheritance first". Moreover, they should actively promote local culture and characteristic industries, and develop tourism, which can in turn contribute to heritage preservation. Furthermore, it is necessary to guide villagers to participate in the village protection, ensure they are the masters of the village, and expand the cultural heritage team to achieve internal improvement. It is suggested to attract young people to return and inject vitality into the sustainable development of the village by creating more employment opportunities. In addition, it is also suggested to adhere to continuous protection plan of villages and unify the historic style of traditional villages from the overall spatial environment, individual buildings, and interior space. At the same time, multiple functional spaces for photography, painting, and cultural experience can be constructed.

(2) The villages in the second (fourth) quadrant are those with above-average scores in one of the ecology and living functions and below-average scores in the other. These villages have a single characteristic. Only Erdu is in this quadrant, and it is a provincial grade traditional village. Thanks to the major projects nearby, this village boosts its economy by developing corresponding service industry. However, Erdu is weak in preservation of historical characteristics. Many of the traditional features are not well conserved, and there are few traditional buildings left (Figure 9).

Such traditional villages should adopt the strategy of "development first". They should promote the construction of "one village and one featured product", explore the diversified value of traditional villages according to local conditions, clarify the major characteristics, establish their own brands, and actively develop tourism and its surrounding industries. They need to improve infrastructure and enhance the overall livability and tourism service quality in the village, so as to attract talents to return. Furthermore, they also need to restore the traditional buildings and unify the traditional style. To ensure the living protection of traditional villages does not deviate from the masses, the government should play a leading role in establishing a long-term preservation mechanism. Meanwhile, the government should provide more opportunities for villagers to fully express their opinions so that they can better participate in the development of villages.

(3) In the third quadrant, there are Shazhang and Yangqiao. Their scores of ecology and living dimensions are lower than the average, so they belong to the villages with lagged PLE development. The common problems these villages face are as follows: First, the

village characteristics are not distinct, the exploration of connotative values is limited, and the economy is sluggish. Second, a large number of villagers go out to work, which makes it more difficult to protect and inherit the culture and building technology of traditional villages. Additionally, the architectural heritage with cultural and historical value have not received enough attention (Figure 9).

Therefore, such traditional villages should adhere to the strategy of "protection first". With low productivity and serious population loss, these villages should not take tourism as their leading industry. Instead, they should preserve the main historical remains of traditional villages and meanwhile develop agriculture as a basic industry while protecting the heritage. In addition, they should actively expand their diversified and compound functions, and integrate them with industries such as culture, tourism, and education. Furthermore, they are suggested to extend the industrial chain and develop related service industries based on the natural and cultural resources and historic remains of traditional villages. In general, the key to a virtuous revival of traditional villages lies in enhancing infrastructure construction and retaining villagers. In terms of material ecology, the priority should be given to its protection, and the heritages at different spatial levels should be properly preserved. As for political ecology, the social capital should play a leading role in the development of rural tourism based on government guidance and public participation.

5. Conclusions

Based on the development concept of PL integration, this paper conducts a comprehensive evaluation and quantitative study of the living protection of traditional villages. The case study is based on a number of traditional villages of different grades and types in the Taihu Lake area. The evaluation research in this paper is based on quantitative evaluation and supplemented by qualitative evaluation. In data processing, the reliability analysis is combined with Z-score normalization to ensure that the evaluation indicators are comparable. Through the horizontal PLE coupling coordination analysis with the vertical correlation analysis of the elements at each layer, the relationship between the internal factors of the living protection of traditional villages and the mutual influence mechanism are thoroughly analyzed. The major preliminary conclusions can be drawn as follows:

(1) The PLE development of traditional villages is a dynamic process. Even if the villages are close in the PLE score, they may be in different stages of PLE development and coupling coordination type. For example, in the coupling coordination stage, the villages' production, living, and ecology functions restrict and contribute to each other, showing a benign coupling. However, the villages in the adjustment stage would have confrontation between different dimensions. The stronger the predominant function of traditional villages, the less space for the development of other functions. As a result, these disadvantaged functions would be weakened.

(2) The living function serves as a bridge between production and ecology functions. This is inconsistent with the general belief that the better the production or ecology, the better the PLE development of villages. It has also demonstrated that the living protection of traditional villages is a key link to realizing the coordinated development of PLE. The PLE integration development is an effective way to practice the living protection of traditional villages.

(3) Villages may score low even if they are national grade traditional villages with a high-quality ecological environment. Thus, their development strategy should be adapted to the concept of PLE integration. By contrast, even if the spatial and environmental characteristics of the villages are not distinct, they can still pursue suitable PLE integration according to the local conditions.

(4) There is a significant linear correlation between the ecological vitality of political organizations and PLE score. This shows that a positive policy organization is the fundamental guarantee for the PLE integration of traditional villages.

The evaluation results can clarify the interaction mechanism of the internal factors of the village, pinpoint problems, and provide a research reference for formulating targeted optimization measures. The comprehensive evaluation system established based on the PLE perspectives breaks through the traditional isolated, static protection method. For China and other countries and regions, it is of positive significance to discuss the quantitative evaluation of traditional villages' living protection in terms of methods. In theory, it can broaden the ideas of traditional villages' activation and protection, and in practice, it can provide basis and reference for the activation of traditional villages.

As it is still exploratory research, the interaction mechanism between the internal elements of traditional villages may be more complex network structure or composite structure, and even need more than two multi factor correlation comparative study. Follow up studies need to continue to optimize the traditional mechanism analysis methods. For example, the way of AHP, Pearson correlation analysis of paired comparison, the construction of evaluation index system and the selection of case villages need to be further improved.

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

Appendix A

Table A1. The comprehensive evaluation system for the living protection of traditional villages.

Layer A	Layer B	Weight	Order	Layer C	Weight	Order	Layer C	Weight	Order
The comprehensive evaluation system for the living protection of traditional villages	Production B1	0.2000	2	Comprehensive economic vitality C1	0.0667	2	Villagers' annual income per capital D1	0.0222	2
							Village collective annual average income D2	0.0444	1
				Characteristic industry vitality C2	0.1333	1	Development of strong industries D3	0.0276	3
							Development of characteristic industries D4	0.0450	1
							Daily average number of tourists in Tourism D5	0.0185	4
							Number of rich leaders D6	0.0138	5
							Annual output value of rich leaders D7	0.0285	2

Table A1. *Cont.*

Layer A	Layer B	Weight	Order		Layer C	Weight	Order	Layer C	Weight	Order
	Ecology B2	0.4000	1	Material ecology	Characteristics of landscape and natural environment C3	0.0500	1	Water green area coverage D8	0.0059	3
								Landscape environmental quality and overall continuity D9	0.0134	2
								Uniqueness of ecological environment D10	0.0307	1
					Characteristics of village space environment C4	0.1500	2	characteristics of traditional village pattern D11	0.0123	6
								Landform adaptability D12	0.0143	5
								Overall features of the village D13	0.0212	3
								Public space and the number of important nodes D14	0.0104	7
								Public space and quality of important nodes D15	0.0074	8
								Types of ancient buildings and cultural relics D16	0.0206	4
								Number of ancient buildings and cultural relics D17	0.0319	1
								Characteristics of ancient buildings and cultural relics D18	0.0318	2
				Spiritual ecology	Ecological vitality of political organizations C5	0.0500	1	Integrity of village management system D19	0.0067	4
								Integrity of traditional village protection system D20	0.0088	3
								Implementation of traditional village protection measures D21	0.0153	2
								Villagers' participation in protection work D22	0.0192	1
					Cultural ecological vitality C6	0.1500	2	Historical value and importance of villages D23	0.0119	6
								Number of important historical events and figures D24	0.0124	5
								Important historical events and influence of figures D25	0.0182	3
								Quantity of traditional intangible culture D26	0.0076	7
								Characteristics of traditional intangible culture D27	0.0164	4
								Quantity of traditional products D28	0.0048	9
								Characteristics of traditional products D29	0.0079	8
								Participation in Villagers' cultural life D30	0.0396	1
								Number of cultural inheritors D31	0.0312	2

Table A1. *Cont.*

Layer A	Layer B	Weight	Order	Layer C	Weight	Order	Layer C	Weight	Order
				The level of human settlement facilities C7	0.1333	2	Traffic convenience in the village D32	0.0224	3
							Living infrastructure D33	0.0438	2
							Integrated service facilities D34	0.0511	1
	Living B3	0.4000	1				Recreational facilities D35	0.0160	4
				Village popularity and vitality C8	0.2667	1	The number of young people returning to villages D36	0.1316	1
							Number of foreign talents D37	0.0829	2
							Social Inclusiveness D38	0.0522	3

Table A2. Pearson correlation analysis Z-score results between PLE score, PLE CCD and pairwise mutual CCDs.

		Z-Score (PLE Score)	Z-Score (PLE CCD)	Z-Score (E–P CCD)	Z-Score (P–L CCD)	Z-Score (L–E CCD)
Z-score (PLE Score)	Pearson correlation	1	0.937 **	0.864 *	0.884 *	0.893 *
	Significance (2- tailed)		0.006	0.026	0.019	0.017
	Number of cases	6	6	6	6	6
Z-score (PLE CCD)	Pearson correlation	0.937 **	1	0.766	0.961 **	0.958 **
	Significance (2- tailed)	0.006		0.076	0.002	0.003
	Number of cases	6	6	6	6	6
Z-score (E–P CCD)	Pearson correlation	0.864 *	0.776	1	0.600	0.658
	Significance (2- tailed)	0.026	0.076		0.208	0.156
	Number of cases	6	6	6	6	6
Z-score (P–L CCD)	Pearson correlation	0.884 *	0.961 **	0.600	1	0.924 **
	Significance (2- tailed)	0.019	0.002	0.208		0.005
	Number of cases	6	6	6	6	6
Z-score (L–E CCD)	Pearson correlation	0.893 *	0.958 *	0.658	0.924 **	1
	Significance (2- tailed)	0.017	0.003	0.156	0.005	
	Number of cases	6	6	6	6	6

Note: **, at 0.01 level (2-tailed), the correlation is strong significant; *, at 0.05 level (2-tailed), the correlation is significant.

Table A3. Pearson correlation analysis Z-score results between PLE scores and the C-layer indicators.

		Z-Score (PLE Score)	Z-Score (C1)	Z-Score (C2)	Z-Score (C3)	Z-Score (C4)	Z-Score (C5)	Z-Score (C6)	Z-Score (C7)	Z-Score (C8)
Z-score ("PLE" Score)	Pearson correlation	1	0.904 *	0.919 *	0.958 **	0.206	0.968 **	0.937 **	0.955 **	0.652
	Significance (2- tailed)		0.013	0.010	0.003	0.696	0.002	0.006	0.003	0.161
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C1)	Pearson correlation	0.904 *	1	0.916 *	0.921 **	0.091	0.956 **	0.812 *	0.886 *	0.434
	Significance(2- tailed)	0.013		0.010	0.009	0.865	0.003	0.050	0.019	0.390
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C2)	Pearson correlation	0.919 **	0.916 *	1	0.919 **	−0.128	0.975 **	0.922 **	0.960 **	0.437
	Significance(2- tailed)	0.010	0.010		0.010	0.808	0.001	0.009	0.002	0.386
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C3)	Pearson correlation	0.958 **	0.921 **	0.919 **	1	0.011	0.970 **	0.845 *	0.917 *	0.680
	Significance(2- tailed)	0.003	0.009	0.010		0.984	0.001	0.034	0.010	0.137
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C4)	Pearson correlation	0.206	0.091	−0.128	0.011	1	0.023	0.143	0.055	0.170
	Significance(2- tailed)	0.696	0.865	0.808	0.984		0.966	0.788	0.917	0.747
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C5)	Pearson correlation	0.968 **	0.956 **	0.975 **	0.970 **	0.023	1	0.924 **	0.975 **	0.519
	Significance(2- tailed)	0.002	0.003	0.001	0.001	0.966		0.009	0.001	0.291
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C6)	Pearson correlation	0.937 **	0.812 *	0.922 **	0.845 *	0.143	0.924 **	1	0.978 **	0.428
	Significance(2- tailed)	0.006	0.050	0.009	0.034	0.788	0.009		0.001	0.397
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C7)	Pearson correlation	0.955 **	0.886 *	0.960 **	0.917 *	0.055	0.975 **	0.978 **	1	0.443
	Significance(2- tailed)	0.003	0.019	0.002	0.010	0.917	0.001	0.001		0.379
	Number of cases	6	6	6	6	6	6	6	6	6
Z-score (C8)	Pearson correlation	0.652	0.434	0.437	0.680	0.170	0.519	0.428	0.443	1
	Significance(2- tailed)	0.161	0.390	0.386	0.137	0.747	0.291	0.397	0.379	
	Number of cases	6	6	6	6	6	6	6	6	6

Note: **, at 0.01 level (2-tailed), the correlation is strong significant; *, at 0.05 level (2-tailed), the correlation is significant.

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