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CONSTRUCTION OF GREEN VILLAGES/ TOWNSHIPS EVALUATION MODEL FOR ECONOMIC METROPOLITAN CIRCLE*

Deyong ZHANG
Tian TIAN

Deyong ZHANG (corresponding author)
Professor, College of Biology and Environmental Engineering,
Zhejiang Shuren University, Hangzhou, Zhejiang, China
E-mail: danex2487@163.com

Tian TIAN
Assistant professor, College of Management,
Zhejiang Shuren University, Hangzhou, Zhejiang, China

Abstract

In recent years, the Chinese government has proposed the concept of 'green villages/townships', but the lack of implementation standards is hindering the achievement of this goal. The Northern Zhejiang region was selected as a case study to address this issue. The region's overall traits were examined to formulate the basic evaluation framework and establish the hierarchical structure of the evaluation model. An indicator library was subsequently compiled, and through expert scoring and the importance matrix method, six primary indicators and 30 secondary indicators were selected. Each indicator was assigned ideal values, and scoring methods were then determined, resulting in a grey-AHP evaluation model. This model generates a comprehensive score by calculating the total correlation between the tested sample and the idealized green village/township. Furthermore, the scores for each component provide insights into the strengths and weaknesses of the sample, offering guidance for its future development. To validate the model, 10 sample townships were assessed, yielding R values ranging from 0.5827 to 0.8891, which effectively distinguished differences between them. The comprehensiveness and flexibility of this model address various challenges commonly encountered in conducting research in rural areas in China. The model is instrumental in achieving sustainable development in these regions.

Keywords: Northern Zhejiang Province, green villages/townships, evaluation model, grey model, analytic hierarchy process.

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1. Introduction

The sustainable development of rural areas is a critical issue for many countries. However, the challenges faced by different regions vary significantly. For example, in Europe, key concerns include greenhouse gas emissions, the economic impact of agriculture, renewable energy, employment, education, and digitization (Memo and Pienkowski, 2023; Upreti, 2004; Jończy *et al.*, 2021). In contrast, with the rapid industrialization and urbanization in China, environmental degradation, farmland pollution, social conflicts, and other issues have emerged as the primary challenges in rural areas. To address these challenges, the Chinese government has proposed the plan of building a 'new countryside' based on the concept of sustainable development, with the fundamental goal of achieving 'developed production, affluent living, civilized rural customs, clean village appearance, and democratic management'. Subsequently, scholars have conceptualized these rural areas as 'green villages/townships', and have conducted extensive research on their connotations and construction methods.

Currently, three prevailing theories within the academic community elucidate the essence of 'green villages/townships'. The first theory broadens the concept to encompass a green environment, green buildings, green production, and a green lifestyle, collectively referred to as the 'four greens' (Ning, 2015, p. 25). The second theory expands this framework further to include green products, green planning, and green technology, resulting in the 'six greens' (Bao, 2015). The third approach extends the concept to eight dimensions: village and township planning, housing, transportation, energy usage, environmental protection, landscape greening, water resource utilization, and economic development, referred to as the 'Eight Greens' (Bao, 2015). The evaluation criteria for 'green villages/townships' have also garnered attention. For instance, Bao studied the evaluation system for green villages/townships in the cold Northeast China of high-latitude (Bao, 2015). Additionally, Wang and Hua conducted research on the construction of over 100 green village/township demonstration projects in China and authored a monograph titled China's Green Villages/Townships Construction (Wang and Hua, 2021, pp. 33–35). As research deepens, it has become evident that significant differences in environmental, economic, cultural, and other factors across different regions of China present distinct challenges for the evaluation of green villages/townships. Consequently, a fixed standard for their evaluation is difficult to establish (Zhang, Huang and Li, 2023). For example, Northeast China, studied by Bao, is a major grain-producing area in China, characterized by vast land and a sparse population. Therefore, the evaluation system developed for this region places great emphasis on indicators related to agriculture and agricultural products. However, this standard proves inadequate for the Northern Zhejiang region. Northern Zhejiang, influenced by nearby developed cities such as Hangzhou, Shanghai, and Ningbo, exhibits distinct characteristics, including high population density, robust economic activity, rapid urbanization, and limited arable land. Consequently, evaluation frameworks for green villages/townships in this area must be tailored to their unique regional characteristics. Furthermore, as China's economy and urbanization continue to develop, many rural areas around major cities are likely to experience a developmental stage similar to that of Northern Zhejiang. Therefore, case studies based on Northern Zhejiang are not only applicable to this region but also hold reference value for many rural areas near urban centers with increasingly active economies. Due to the lack of detailed construction plans provided by senior officials of the Chinese government when proposing the 'new countryside' plan, provincial governments generally support local scholars in conducting research on green villages/townships through soliciting proposals or funding scientific research projects. As to Zhejiang provincial government, in recent years, several announcements including 'a letter on soliciting opinions on the implementation plan for green communities in Zhejiang Province', 'a letter on soliciting opinions on the implementation plan for green construction in Zhejiang Province', and 'announcement on publicly soliciting suggestions on the modern and beautiful township construction plan of Evergreen Town' have been released. The officials from Zhejiang Province are eager for scholars to propose specific plans for the construction and evaluation of green villages and towns in Zhejiang Province. Based on such a background, this study intends to establish a comprehensive evaluation model based on field data collection, specifically for evaluating the green villages/townships projects in Northern Zhejiang. The framework of the model will be based on scholars' concepts of green villages/townships, and the selection of evaluation indicators will be guided by the 'new countryside' goal proposed by the Chinese government.

There are numerous methods for evaluating construction projects, primarily categorized into three types: qualitative evaluation methods, quantitative evaluation methods, and comprehensive evaluation methods. The qualitative evaluation method is straightforward to implement but is limited to basic assessments and lacks the precision to effectively differentiate between multiple samples. For complex projects like green villages/townships, suitable models are predominantly drawn from quantitative or comprehensive evaluation methods. Currently, techniques such as the analytic hierarchy process (AHP) and grey model in comprehensive evaluation, as well as composite models that integrate both, are increasingly utilized in assessing various complex projects due to their advantages, including objectivity and comprehensiveness. AHP involves organizing complex indicators into hierarchical layers and objectively quantifying the relative importance of each indicator to minimize subjective bias (Vaidya and Kumar, 2006). The construction of green villages/townships encompasses a multitude of intricate issues that lend themselves well to hierarchical evaluation. However, these issues often contain a degree of ambiguity. Consequently, employing a hybrid evaluation model that combines both methods is expected to be more effective in addressing these challenges (Chen *et al.*, 2019; Fan and Zhong, 2022; Irfan *et al.*, 2022; Mishra, Mishra and Jayswal, 2022). This study, therefore, aims to explore the establishment of a grey-AHP composite model for evaluating the performance of green village/township construction in Northern Zhejiang. The key challenge in creating a specialized evaluation model tailored to a specific region lies in the selection of evaluation indicators and methods grounded in region-specific research. By correlating with the Green Village/Township Project, the selection of indicators can draw significantly from existing academic literature and various government documents pertaining to green development (Du *et al.*, 2016; Su, 2018, pp. 51–83; Xiong *et al.*, 2013). Thus, based on prior research and supplemented by necessary investigations, the establishment of the proposed model is highly feasible.

2. Literature review

Various methods are available for evaluating government-implemented projects and plans, which can broadly be categorized into three types: qualitative evaluation, quantitative evaluation, and comprehensive evaluation (combining both qualitative and quantitative methods). Simple qualitative evaluation techniques — such as rating, survey inquiry, observation, comparison, and ranking methods — are limited by their subjectivity and lack of precision. These methods are increasingly inadequate for meeting the rising demands for objectivity and accuracy in project evaluation. Consequently, recent years have witnessed a shift towards adopting quantitative and comprehensive evaluation approaches.

Common quantitative evaluation techniques include cost-benefit analysis and impact analysis. The cost-benefit analysis method assesses the pros and cons of a given scheme by calculating its costs against its benefits, and it is frequently applied to public utility projects requiring quantifiable social benefits. Managers in the private sector also use this approach to gauge the intangible benefits of large projects. In this method, all costs and benefits associated with a project or decision are itemized and quantified. Since economists Kaldor and Hicks introduced the Kaldor-Hicks Principle in 1940, cost-benefit analysis has become a widely accepted tool for evaluating government-led projects, including landmark cases like the 1939 Flood Control Act and the Great Dam budget in Tennessee (Jiang and Marggraf, 2021). Nowadays, with the increasing prevalence of government-led investment projects, cost-benefit analysis has been widely adopted by governments globally. However, while this method offers a clear comparison of costs and benefits, it struggles to quantify aspects not easily measured in monetary terms, such as environmental quality and social benefits, potentially overlooking critical non-economic impacts. Furthermore, government action plans often merely guide lower-level departments to strive towards specific improvement goals without directly assigning funds. Departments vary in their foundational resources and approaches; hence, in such cases, higher-level government agencies typically focus on assessing the construction results, rather than the construction process, of local governments or subordinate departments, making the cost-benefit analysis method less applicable. Impact analysis is another commonly used method in quantitative evaluation, mainly designed to explore the influence and effectiveness of specific factors or variables on a system or research target. This method seeks to quantify the relationship between an independent variable and a studied indicator, identifying its effectiveness and potential mechanisms of influence based on experimental results. Although impact analysis provides objectivity and strong methodological rigor, it is suitable only for a narrow range of specific scenarios, such as principal component analysis, and is less effective for comprehensive evaluations involving numerous indicators and complex interactions.

The comprehensive analysis method, represented by AHP and grey model analysis, combines qualitative and quantitative evaluation techniques. The concept of AHP was initially proposed by the American operations researcher Saaty in the early 1970s. AHP decomposes decision-making elements into hierarchical levels — such as goals, criteria, and alternatives — transforming qualitative human judgments into structured comparisons of relative importance, thereby allowing for both qualitative and quantitative analyses. The AHP approach is characterized by its ability to integrate both subjective and objective factors, using psychological and cognitive laws to structure and quantify decision-making processes. This method is well-suited for complex problems involving multiple objectives, criteria, elements, and levels and has found wide applications in evaluation, management, decision-making, and other fields. Particularly in recent years, scholars have increasingly applied AHP to solve a variety of issues related to sustainable development. According to Dos Santos *et al.* (2019), between 2014 and 2018, over 173 studies in the major databases of Web of Science, Scopus, and ScienceDirect focused on the use of AHP for sustainable development, primarily in areas like product development, sustainability decision-making, life-cycle management, end-of-life design, valuation analysis, implementation of sustainability concepts, and sustainable assessments (Dos Santos *et al.*, 2019). Recent studies showcase AHP's growing versatility. For example, Kolotzek *et al.* (2018) used a company-oriented AHP model to evaluate raw material supply risks, environmental and social impacts. Qorri, Mujkić and Kraslawski (2018) used an AHP model to evaluate the sustainability performance of supply chains. Rehman and Ryan (2018) established an AHP model for sustainable future proofing. Mohammed *et al.* (2018) used an integrated AHP model to screen supplier selection. Piadeh, Alavi-moghaddam and Mardan (2018) used an AHP model to evaluate the sustainability of industrial wastewater recycling in industrial parks. Chih *et al.* (2018) established a fuzzy-AHP model to evaluate sustainable campuses in Taiwan. Ren and Dong (2018) evaluated the electricity supply sustainability and security using the AHP model. Marimin *et al.* (2018) used an AHP model to evaluate and enhance the green production and sustainability of the motorcycle tire production process. Akhoundi and Nazif (2018) evaluated the sustainability of wastewater reuse alternatives using an AHP model. How and Lam (2018) evaluated the sustainability of biomass supply chain synthesis using a PCA (principal component analysis)-AHP composite model. These studies confirm that the AHP method is highly suitable for solving evaluation and decision-making problems related to sustainable development. In addition, there are two particularly obvious development trends in AHP-related research in recent years: one is that, from a methodological perspective, combining with other methods such as fuzzy logic to construct composite models is becoming increasingly popular (Sikalo, Arnaut-Berilo and Delalic, 2023). Secondly, its application fields are accelerating towards the expansion of natural sciences and engineering technology (Bharathi, 2019).

The grey model analysis method measures the degree of correlation between factors by analyzing the similarity or dissimilarity of their development trends, known as the 'grey correlation degree'. This method is particularly effective for addressing systems with incomplete or uncertain data, making it ideal for analyzing dynamic processes where traditional probability or fuzzy mathematical models may fall short. Typically represented by grey relational analysis (GRA), the grey model tackles problems with limited data, vague models, numerous variables, or complex processes that cannot be accurately analyzed by probability theory or fuzzy mathematics (Gerus-Gościewska and Gościewski, 2022; Çelebi and Selvi, 2014). The GRA method is widely used in various fields such as mathematics, economics, and engineering. For example, in economics, it can be used to analyze the degree of correlation between different economic indicators; in engineering, it can be used to evaluate the effectiveness of different design schemes, and so on. It is particularly noteworthy that the grey model analysis method has been widely applied in research related to green and sustainable development in recent years. According to Javanmardi's statistics, there were at least 145 articles in the Web of Science, Scopus, and ScienceDirect databases from 2010 to 2020 that studied the application of grey model analysis in the field of sustainable development (Javanmardi, Liu and Xie, 2020). The most widely used direction among them is to use grey models to evaluate sustainability or screen for optimal solutions. For example, Altintas *et al.* (2020) combined GRA with AHP to establish a fuzzy-AHP model for comparing the performance of energy sustainability. The elasticity characteristics of this model greatly improve its applicability (Altintas *et al.*, 2020). Tang *et al.* (2019) established a modified TOPSIS (technique for order preference by similarity to an ideal solution) model based on GRA to evaluate the sustainable development performance of cities, achieving scoring and grading of sample cities. Wei *et al.* (2019) used a grey model to dynamically analyze and compare the emergency ecological footprints of the Qinghai Tibet Plateau in China. Shao *et al.* (2019) established a GRA model for evaluating the sustainability of urban environmental quality. Chang and Cheng (2019) established a GRA model to analyze the sustainable development of manufacturing small and medium-sized enterprises in Taiwan. Wu *et al.* (2018a) established a fusion model based on GRA and AHP for evaluating the sustainability assessment of coal fire power units. Duman *et al.* (2018) established a balanced scorecard-based grey-DANP (decision-making trial and evaluation laboratory analytic network process) approach for the food industry, which integrates evaluations of environmental and social sustainability. Ebrahimi and Rahmani (2019) established an improved GRA model to evaluate the sustainability performance of energy producers from five dimensions and selected the optimal energy producers. Some studies use grey models to identify key factors that affect sustainable development. For example, Sun *et al.* (2020) used the GRA model to study the interaction mechanism between urbanization and the environment. Mahdiraji *et al.* (2018) developed a hybrid fuzzy-BWM-COPRAS method that can be used to analyze key factors of sustainable architecture. Antarciuc *et al.* (2018) used the grey-MCDM model to study sustainable venture capital investments and identified the driving factors for sustainable venture capital. Some also use grey models to predict future development trends related to sustainability, such as Duman, Kongar and Gupta's establishment of a multivariate grey-Bernoulli model that can be used to predict the generation trend of e-waste (Duman, Kongar and Gupta, 2019). Liu *et al.* (2018) established a grey model by constructing a comprehensive and scientific index system to predict the regional tourism sustainability of the Yangtze River Economic Zone in China. Overall, the integration of grey models with other methodologies is becoming more prevalent, as evidenced by the extensive studies cited above. This wealth of research confirms that grey models are particularly suited for analyzing and forecasting complex projects, such as green village and town construction, which involve a multitude of factors and diverse evaluation indicators.

3. Methods

3.1. Constructing the process of the evaluation model

An investigation is conducted on the overall economic, environmental, and cultural information of the Northern Zhejiang region to analyze the characteristics of the objects. Based on the results of the analysis, the basic thoughts of the evaluation model are determined. Figure 1 illustrates the 7-step process for constructing the grey-AHP model, which comprises investigation, method determination, target layer determination (R value calculation), criterion layer determination (first-level indicators), and measure layer determination (second-level indicators). This model consists of three levels, namely the target layer(A), the criterion layer(B), and the measure layer(C), with the aim of computing the R value in the target layer of a test sample. The R value is calculated by assessing the scores of each second-level indicator and inserting them into the formula.

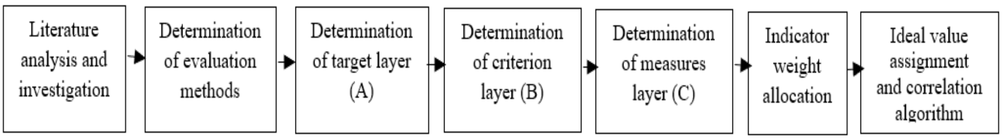

Figure 1: Construction process of the evaluation model

Source: The authors

3.2. Screening of evaluation indicators

The first-level indicators are determined by the expert-voting method. Briefly, five candidate schemes of first-level indicators are initially proposed based on several different academic interpretations of the concept of 'green village/township' as mentioned above. Then, 10 experts are invited to rank the 5 plans according to their levels of recommendation. Namely, the total score of each plan is calculated, and the plan with the highest ranking is selected as the optimal one.

As to the screening of second-level indicators, since the first-level indicators have been determined, a large number of candidate second-level indicators corresponding to them will then be proposed by us, referring to the previous literature, forming a large library of indicators. Then, 10 experts are invited to provide opinions on whether to recommend each indicator. To facilitate the experts' voting, the total number of candidate second-level indicators is limited to 100. Finally, we will determine which indicators will be selected based on expert voting results. In order to ensure the operationality of the evaluation model, the total number of second-level indicators is preferably reduced to a maximum of 30.

3.3. Weight distribution for indicators

To calculate the weights of first-level and second-level indicators within their corresponding hierarchy, importance judgment matrices are constructed, respectively. This involves 10 experts rating the relative importance of each pair of indicators using a 9-point scale (Table 1). The judgment matrix is then constructed using Formula 1 and normalized using the geometric mean method with the YAAHP software to calculate the weight of each indicator within its hierarchy. To test consistency, Formula 3 and Table 2 are used, with a requirement for the CR value to be less than 0.1. Finally, the weight of each second-level indicator (Wi) relative to the target layer can be obtained by multiplying the weight of the second-level indicator within the measures layer by the weight of the first-level indicator within the criterion layer.

$$A = \begin{bmatrix} 1 & a_{12}\cdots & a_{1i}\cdots & a_{1j}\cdots & a_{1n} \\ a_{21} & 1\cdots & a_{2i}\cdots & a_{2j}\cdots & a_{2n} \\ \vdots & \vdots\ \vdots & \vdots\ \vdots & \vdots\ \vdots & \vdots \\ a_{i1} & a_{i2}\cdots & 1\cdots & a_{ij}\cdots & a_{in} \\ \vdots & \vdots\ \vdots & \vdots\ \vdots & \vdots\ \vdots & \vdots \\ a_{j1} & a_{j2}\cdots & a_{ji}\cdots & 1\cdots & a_{jn} \\ \vdots & \vdots\ \vdots & \vdots\ \vdots & \vdots\ \vdots & \vdots \\ a_{n1} & a_{n2}\cdots & a_{ni}\cdots & a_{nj}\cdots & 1 \end{bmatrix} = (a_{ij})n \times n \quad (1)$$

$$Wi=[(\prod_{j=1}^{n} aij)^{1/n}][\sum_{i=1}^{n}(\prod_{j=1}^{n} aij)]^{1/n} \quad (2)$$

Note: Wi, weight of the i-th indicator in its hierarchy; aij, value of row i and column j in the relative importance score matrix

$$CR = [(\lambda max - n)/(n-1)]/RI \quad (3)$$

Table 1: Scales of relative importance judgment matrix

Grades	Relative importance	Connotation (taking m and n as examples)
1	equally important	Indicator m is equally important as indicator n
3	slightly more important	Indicator m is slightly more important than indicator n
5	significantly more important	Indicator m is significantly more important than indicator n
7	much more important	Indicator m is much more important than indicator n
9	absolutely more important	Indicator m is absolutely more important than indicator n
2, 4, 6, 8	adjacent median	The importance of m over n is between two adjacent importance levels

Source: The authors

Table 2: Consistency index of average random number

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0.52	0.89	1.12	1.26	1.26	1.41	1.46	1.49	1.52	1.54

Source: The authors

3.4. Ideal value assignment and correlation calculation determination

The process of assigning optimal values to the indicators is adaptable and is based on the unique characteristics of each indicator. There are three approaches to this process, namely, using the theoretical ideal value, conducting sample surveys, and utilizing the highest value as the ideal value, and having experts directly assign the scoring scheme. Once the ideal value of a second-level indicator is determined, the correlation degree of this indicator of a sample (Ri) can be calculated via dividing the sample value by the ideal value. Finally, by summing up all the Ri values of a sample's second-level indicators, the total correlation value (R) between the sample and the ideal model can be obtained.

3.5. Test of the model

Ten townships located in Northern Zhejiang Province have been carefully chosen as representative samples for the purpose of testing. Detailed data on each second-level indicator of these townships were collected from public data or through surveys. The established model was then utilized to test its effectiveness in differentiating between the various samples and to assist each village in identifying its strengths and weaknesses through further analysis of scores. The ultimate objective of the model is to provide invaluable references for the future development of the villages/townships in this region.

4. Results

4.1. The characteristics of Northern Zhejiang Province

As shown in Figure 2 (highlighted parts with red dots), the scope of this study encompasses all townships in Northern Zhejiang that have not been converted to urban streets, within the areas of full Huzhou region, full Jiaxing region, partial Hangzhou region (excluding Tonglu county, Jiande county, and Chun'an county), and partial Shaoxing region (excluding Zhuji City, Shengzhou city, and Xinchang county).

The main characteristics that distinguish Northern Zhejiang from other regions include: (1) Developed economy: In 2023, the per capita disposable income of rural residents in China was 21,691 CNY, while that in Hangzhou, Jiaxing, Huzhou, and Shaoxing was 48,180, 49,643, 47,455, and 48,825 CNY, respectively. Competitive characteristic industries have also been formed throughout Northern Zhejiang. (2) High urbanization rate: Northern Zhejiang, as a traditional agricultural region, is undergoing rapid urbanization. In 2023, the urbanization rate of the permanent resident population in China was 66.2%. While in Hangzhou, Jiaxing, Shaoxing, and Huzhou, the rates were 84.2%, 73.2%, 73.1%, and 67.5%, respectively. (3) Small urban-rural difference: In 2023, the urban-rural income ratio in China was 2.39. While that in Hangzhou, Jiaxing, Huzhou, and Shaoxing was 1.67, 1.53, 1.57 and 1.65, respectively. (4) High level of grassroots government governance: relying on the advantages of a developed economy, transportation, and talents, the governance efficiency of grassroots governments in Northern Zhejiang Province is generally higher, and the local government website updates and information disclosure are

Figure 2: Geographical coverage of the villages/townships in Northern Zhejiang Province

relatively timely. (5) Limited agricultural land resources and refined agricultural model: the per capita cultivated land in Zhejiang Province is about 0.34 mu, only 24% of the national average. Unlike the Northern plain areas, Zhejiang's agriculture is scattered into multiple types such as rice, tea, sericulture, aquaculture, and specialty fruits. (6) Strong awareness of green development: for example, Zhejiang Province has vigorously promoted the Five Waters Co-governance Action (You *et al.*, 2023; Tian *et al.*, 2022), Beautiful Countryside Construction (Huang, Wu and Xu, 2014), and Characteristic Town Construction (Wu *et al.*, 2018b). These projects should be introduced in some form into the evaluation system of green villages/townships to keep the continuity of government policies. Therefore, the construction and evaluation of green villages/townships in Northern Zhejiang have their own characteristics, requiring highly customized evaluation criteria.

The evaluation of green villages/townships in Northern Zhejiang should follow the following principles: (1) Economic indicators are the key areas of competition and evaluation for villages/townships in Northern Zhejiang in recent years. Therefore, the pressure on ecology, energy, and other areas caused by economic development should be given emphasis, and indicators such as green environment, green energy, and green economy should be reflected in the weight allocation. (2) Because the Northern region of Zhejiang Province has limited arable land and little dependence on planting industries, the number or weight of indicators related to the plantation industry should be reduced. (3) Unlike the large number of arid areas in Northern China, the Northern Zhejiang region has a rich water network, which makes its environment, climate, fisheries, and other aspects unique. Therefore, evaluation indicators related to water should be fully reflected in the model. (4) The achievements of some important projects that the government has previously made efforts to implement in the Northern Zhejiang region, such as the 'Five Waters Co-governance Action' and 'Low Carbon Small Towns Construction', should be reflected in some form in the model.

4.2. Screening of first-level indicators

Five alternative first-level indicator schemes have been designed as follow: Plan A: green environment, green buildings, green production, and green living; Plan B: green environment, green energy, green settlements, green agriculture, green economy, and harmonious society; Plan C: energy aspect, land aspect, transportation aspect, architecture aspect, ecology aspect, and society aspect; Plan D: planning and management level, land intensification, public infrastructure service level, energy conservation and emission reduction, environmental conditions, landscape greening level, and social and economic development level; Plan E: village/township planning, village/township housing, road and traffic, energy utilization, environmental protection, landscape greening, water resource utilization, and economic development.

As shown in Table 3, based on the ranking of the five candidate plans by experts, the Plan 2 has won the best total score. It consists of six first-level indicators: green environment, green energy, green settlements, green agriculture, green economy, and harmonious society. The indicator system not only emphasizes the differences between villages/townships and cities, but also better matches the fact that villages/townships in Northern Zhejiang generally have a good ecological environment, a developed economy, rich cultural heritage, and diversified land cultivation methods, all of which are different from other regions of China. By controlling the quantity, this plan also offers the advantages of simplicity and convenience.

Table 3: The expert ranking of the five candidate plans for the first-level indicators

	Specialist										Total scores
	1	2	3	4	5	6	7	8	9	10	
Plan A	5	3	5	3	5	4	5	4	3	4	41
Plan B	1	1	2	1	2	1	1	1	2	1	13
Plan C	2	2	1	2	3	2	3	2	1	2	20
Plan D	3	5	4	5	4	5	4	5	5	5	45
Plan E	4	4	3	4	1	3	2	3	4	3	31

Source: The authors

4.3. Screening of second-level indicators

As shown in Table 4, based on experts' voting on second-level indicators, a total of 30 second-level indicators were selected from 100 candidate second-level indicators for subsequent model construction. It should be noted that in order to control the total number of indicators, some indicators, although they received high votes, were not selected in the end.

4.4. Construction of AHP hierarchy

As shown in Figure 3, the hierarchical structure of the evaluation model constructed consists of three major levels: the goal level A (with one goal), the criterion level B (with six indicators), and the measure level C (with 30 indicators). By collecting the scores of the 30 measure-level indicators of the sample to be tested, a total score for the goal level is calculated by combining the weights of the C-level and B-level, in order to achieve the overall goal of evaluating the green level of the sample.

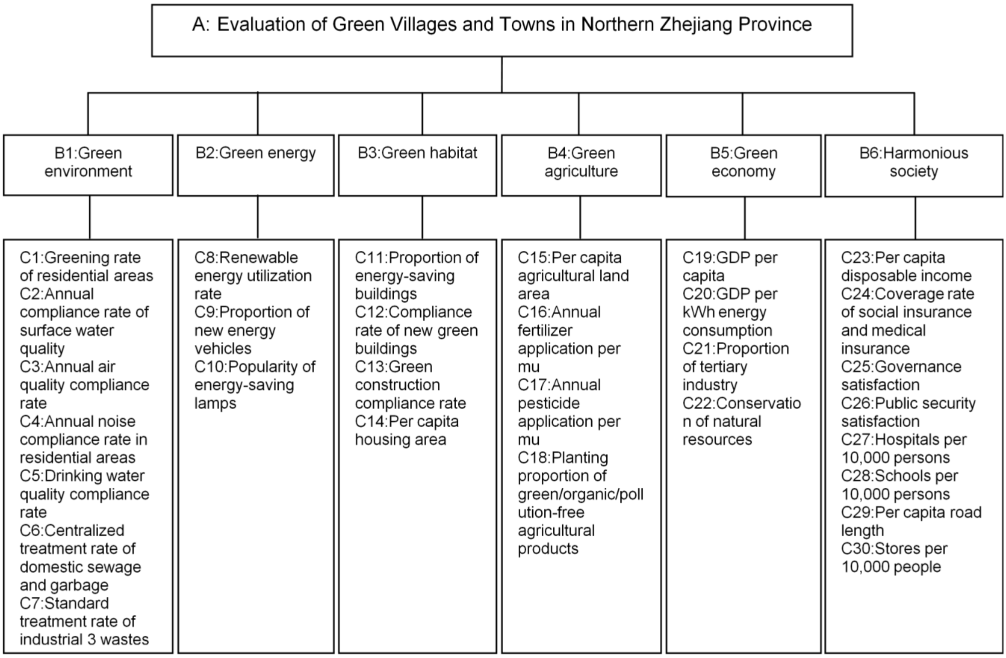

Figure 3: AHP hierarchy construction of the evaluation model

Source: The authors

4.5. Weight distribution and ideal value assignment of each indicator

The consistency ratio (CR) of the score matrix was calculated to test the consistency of the matrix, and all CR values in this study met the requirements. As shown in Table 5, the weight ranking of the first-level indicators is as follows: Green environment (0.3011) > Harmonious society (0.2695) > Green economy (0.1304) > Green energy

Table 4: The expert voting of the100 candidate second-level indicators

	Selected second-level indicators(votes)	Unselected second-level indicators(votes)
Green environment	Greening rate in residential areas (10 votes); Annual compliance rate of surface water quality (10 votes); Annual air quality compliance rate (10 votes); Noise compliance rate in residential areas (10 votes); Drinking water quality compliance rate (10 votes); Centralized treatment rate of domestic sewage and garbage (10 votes); Standardized treatment rate of industrial waste (10 votes).	Water compliance rate of drinking water source areas (10 votes); Domestic sewage treatment rate in built-up areas (6 votes); Proportion of villages with sewage treatment (6 votes); Harmless treatment rate of domestic waste in the built-up area (7 votes); Proportion of villages with resource utilization of household waste (7 votes); Emission compliance rate of key industrial pollution sources (7 votes); Emission compliance rate of cooking fumes in the catering industry (5 votes); Comprehensive utilization rate of feces from large-scale livestock and poultry farms (3 votes); Comprehensive utilization rate of crop straw (2 votes); Popularity rate of rural sanitary toilets (2 votes); Per capita public green space area (6 votes); Popularization rate of main road greening (5 votes); Forest or grassland coverage rate (3 votes); Harmless treatment rate of household waste (6 votes); Regulation rate of river and ditches (4 votes); Villagers' satisfaction with the environment (3 votes); Proportion of farmers conducting waste classification (3 votes); Proportion of farmers conducting village rules and regulations for resource conservation and environmental protection (3 votes).
Green energy	Renewable energy utilization rate (10 votes); Proportion of new energy vehicles (10 votes); Popularity rate of energy-saving lamps (10 votes).	Proportion of households using clean energy (9 votes); Centralized or energy-saving hot water systems utilization rate (3 tickets); Centralized/energy-saving heating systems utilization rate (3 tickets); Biogas utilization rate (3 tickets); Solar energy utilization rate (8 votes); Wind energy utilization rate (2 votes).
Green settlements	Proportion of energy-saving buildings (10 votes); New green building compliance rate (10 votes); Green construction compliance rate (10 votes); Per capita housing area (10).	Existing building energy-saving renovation area (7 votes); Ultra-low/zero energy consumption building area (5 tickets); Proportion of prefabricated building (4 votes); Solar photovoltaic installed capacity in new building (4 tickets); Geothermal energy installed area in new building (4 tickets); Renewable energy substitution rate in urban buildings (4 votes); Proportion of electricity consumption in building's energy consumption (4 votes); Hardening rate of courtyard floor (5 votes); Residential layout (4 votes); Proportion of environment-friendly building materials (7 votes); Lighting rationality in buildings (4 votes); Completeness of pipeline network facilities (3 votes); Water-saving device usage rate (3 tickets); Completeness of sewage treatment facilities (6 votes); Completeness of rainwater pipeline network facilities (3 votes); Treatment of fecal pollution in rural toilets (3 votes); Utilization rate of non-traditional water sources (3 votes).
Green agriculture	Per capita agricultural land area (10 votes); Annual application of fertilizer per acre (10 votes); Annual pesticide application per acre (10 votes); Proportion of green/organic/pollution-free agricultural product planting area (10 votes).	Agricultural film recovery rate (4 votes); Comprehensive utilization rate of feces (4 votes); Green agricultural product planting area (6 votes); Organic agricultural products planting area (6 tickets); Pollution-free agricultural products planting area (6 votes); Agricultural noise level (1 vote).

Green economy	Per capita GDP (10 votes); GDP per unit energy consumption (10 votes); Proportion of three industries (10 votes); Degree of Natural Resource Protection (10 votes).	Three industries ratio (10 votes); Development of characteristic industries (6 votes); Per capita electricity consumption (5 votes); Per capita water consumption (5 votes); Per capita natural gas consumption (5 votes).
Harmonious society	Per capita disposable income (10 votes); Social security and medical insurance coverage rate (10 votes); Government governance satisfaction (10 votes); Social security satisfaction (10 votes); Number of hospitals per 10,000 people (10 votes); Number of schools per 10,000 people (10 votes); Per capita road length (10 tickets); Number of stores per 10,000 people (10 tickets).	Overall planning of a village or township (10 votes); Completeness of village regulations and agreements (5 votes); Proportion of villagers complying with village rules and regulations (3 votes); Beautiful appearance of a village or township (3 votes); Preservation of rural scenery (3 votes); Characteristics of urban construction (5 votes); Protection of historical and cultural heritage (5 votes); Completeness of villagers' entertainment facilities (4 votes); Number of water stations per 10,000 people (4 votes); Proportion of households with indoor tap water (1 votes); Garbage removal frequency (4 votes); Public toilets per 10,000 people (4 votes); Distribution stations per 10,000 people (4 votes); Street light density (3 votes); Village road length (3 votes); Administrative office facility savings (5 votes); Appropriate use of land for road (4 votes).

Source: The authors

Table 5: Indicators and weights of the evaluation model

Weights of first-level indicators	Weights of second-level indicators	Final weight of second-level indicators (Wi)	Ideal value of second-level indicators (Mi)	Sources of ideal value
B1: Green environment (0.3011) (Note: Full marks for those with provincial honors of 'Beautiful village' or 'Five-water comprehensive treatment')	C1: Greening rate of residential areas (0.2200)	W_1= 0.0662	M_1=90%	Survey(Max)
	C2: Annual compliance rate of surface water quality (0.0879)	W_2= 0.0265	M_2=100%	Theory(Max)
	C3: Annual air quality compliance rate (0.1114)	W_3= 0.0355	M_3=100%	Theory(Max)
	C4: Annual noise compliance rate in residential areas (0.0891)	W_4= 0.0268	M_4=100%	Theory(Max)
	C5: Drinking water quality compliance rate (0.2143)	W_5= 0.0645	M_5=100%	Theory(Max)
	C6: Centralized treatment rate of domestic sewage and garbage (0.0809)	W_6= 0.0244	M_6=100%	Theory(Max)
	C7: Standard treatment rate of industrial three wastes (0.1964)	W_7= 0.0591	M_7=100%	Theory(Max)
B2: Green energy (0.1105) (Note: Full marks for those with provincial honor of 'Low carbon small towns')	C8: Renewable energy utilization rate (0.5001)	W_8=0.0553	M_8=80%	Survey(Max)
	C9: Proportion of new energy vehicles (0.2311)	W_9=0.0255	M_9=60%	Survey(Max)
	C10: Popularity of energy-saving lamps (0.2688)	W_{10}=0.0297	M_{10}=100%	Theory(Max)

Weights of first-level indicators	Weights of second-level indicators	Final weight of second-level indicators (Wi)	Ideal value of second-level indicators (Mi)	Sources of ideal value
B3: Green habitat (0.0898)	C11: Proportion of energy-saving buildings (0.2533)	W_{11}=0.0227	M_{11}=100%	Theory(Max)
	C12: Compliance rate of new green buildings (0.2561)	W_{12}=0.0230	M_{12}=100%	Theory(Max)
	C13: Green construction compliance rate (0.2488)	W_{13}=0.0223	M_{13}=100%	Theory(Max)
	C14: Per capita housing area (0.2418)	W_{14}=0.0217	M_{14}=120m^2	Theory(Max)
B4: Green agriculture (0.0987) (Note: Full marks for those with provincial honor of 'Green farmland')	C15: Per capita agricultural land area (0.0892)	W_{15}=0.0088	M_{15}=10mu	Survey(Max)
	C16: Annual fertilizer application per mu (0.2755)	W_{16}=0.0272	M_{16}=10kg	Survey(Min)
	C17: Annual pesticide application per mu (0.3140)	W_{17}=0.0310	M_{17}=1 bottle	Survey(Min)
	C18: Planting proportion of green/organic/pollution-free agricultural products (0.3213)	W_{18}=0.0317	M_{18}=80%	Survey(Max)
B5: Green economy (0.1304)	C19: GDP per capita (0.2442)	W_{19}=0.0318	M_{19}=450,000 CNY	Survey(Max)
	C20: GDP per kWh energy consumption (0.2603)	W_{20}=0.0339	M_{20}=80 CNY	Survey(Max)
	C21: Proportion of tertiary industry (0.2541)	W_{21}=0.0331	M_{21}=85%	Survey(Max)
	C22: Conservation of natural resources (0.2414)	W_{22}=0.0315	M_{22}=100%	Theory(Max)
B6: Harmonious society (0.2695)	C23: Per capita disposable income (0.2100)	W_{23}=0.0566	M_{23}=90,000 CNY	Survey(Max)
	C24: Coverage rate of social insurance and medical insurance (0.2412)	W_{24}=0.0650	M_{24}=100%	Survey(Max)
	C25: Governance satisfaction (0.1113)	W_{25}=0.0300	M_{25}=100%	Theory(Max)
	C26: Public security satisfaction (0.1230)	W_{26}=0.0331	M_{26}=100%	Theory(Max)
	C27: Hospitals per 10,000 persons (0.0871)	W_{27}=0.0235	M_{27}=5	Survey(Max)
	C28: Schools per 10,000 persons (0.0893)	W_{28}=0.0241	M_{28}=4	Survey(Max)
	C29: Per capita road length (0.0799)	W_{29}=0.0215	$M_{29=}$ 10m	Survey(Max)
	C30: Stores per 10,000 people (0.0582)	W_{30}=0.0157	M_{30}=40	Survey(Max)

Note: Ideal maximum values were designed for all indicators except M16 and M17, for which ideal minimum values were applied.

Source: The authors

(0.1105) > Green agriculture (0.0987) > Green habitat (0.0898). As to the weight of the second-level indicators relative to target layer (Wi), the indicators with the highest weight are 'greening rate of residential areas' (0.0662), 'coverage rate of social insurance and medical insurance' (0.0650), and 'drinking water quality compliance rate' (0.0645). And those with the lowest weight are 'per capita agricultural land area' (0.0088), 'stores per 10,000 people' (0.0157), and 'per capita road length' (0.0215).

An ideal value was then successfully assigned to each second-level indicator, and a scoring method for the indicator's relevance (Ri) was determined too. To improve the comprehensiveness and flexibility of the model, some indicators were designed as hybrids, such as combining medical insurance and social insurance into one overall indicator, and combining green agricultural products, organic agricultural products, and pollution-free agricultural products into another overall indicator. The algorithm used the average value of the two, but when a sub-indicator could not be obtained for a sample, only a specific sub-indicator was calculated. Additionally, for certain criteria levels, some provincial-level honors were used as alternative scoring plans due to the existence of highly matching government construction projects, as explained later.

4.6. Establishment of the grey-AHP evaluation model

The model scores each sample by calculating its correlation degree R value with the assumed ideal model. And the scores in each part can also be calculated separately to understand how the sample performs in each aspect. The total calculation formula for R value is as follows:

$$R = \sum_{i=1}^{30} RiWi = \sum_{i=1}^{30} (Si/Mi)Wi \quad (4)$$

Note: Si refers to the value of the i-th indicator, obtained through the survey. For S_{22}, S_{22}=100% (no mining or logging industries), 70% (with small-scale mining and logging industries), or 50% (with large-scale mining and logging industries); Wi refers to the total weight of the i-th indicator relative to the target layer; Ri refers to the correlation value of the i-th indicator, with a maximum value of 1. For R_{16} and R_{17}, Ri=Mi/Si.

4.7. Testing of the grey-AHP evaluation model

Ten townships were selected as samples for testing of the model, including Dama Township (located in Tongxiang City, Jiaxing), Heshang Township (located in Xiaoshan District, Hangzhou), Huangwan Township (located in Haining City, Jiaxing), Sandun Township (located in Xihu District, Hangzhou), Si'an Township (located in Changxing County, Huzhou), Tianhuangping Township (located in Anji County, Huzhou), Meixi Township (located in Anji County, Huzhou), Yucheng Township (located in Haiyan County, Huzhou), Zhapu Township (located in Pinghu City, Jiaxing), and Zhouwangmiao Township (located in Haining City, Jiaxing). The data for each indicator were obtained through investigation and calculated using the evaluation model established above.

As shown in Figure 4 and Table 6, the R values of the 10 samples range from 0.5827 to 0.8891, indicating significant differences between the samples. If converted to the percentile system that people are more accustomed to using, the score distribution range roughly corresponds to around 60 points to around 90 points, that is, from 'pass' to 'excellent'. This score range is very consistent with the traditional scoring range that people are accustomed to, so it is more in line with our expected results. Based on the score composition of each sample, the strengths and weaknesses of each sample can also be presented. Taking the scores of 10 samples in green environment as an example, the scores of the 10 samples in order are as follows: Dama (0.3011) = Huangwan (0.3011) > Si'an (0.2914) > Meixi (0.2853) > Sandun (0.2676) > Tianhuangping (0.2678) > Heshang (0.2612) > Zhouwangmiao (0.2611) >Yucheng (0.2463) > Zhapu (0.2273). It can be inferred that Dama and Huangwan have the highest scores, and their construction achievements in this area are the most impressive. On the other hand, Zhapu has done the worst in terms of the green environment and should make greater efforts in this aspect in subsequent construction.

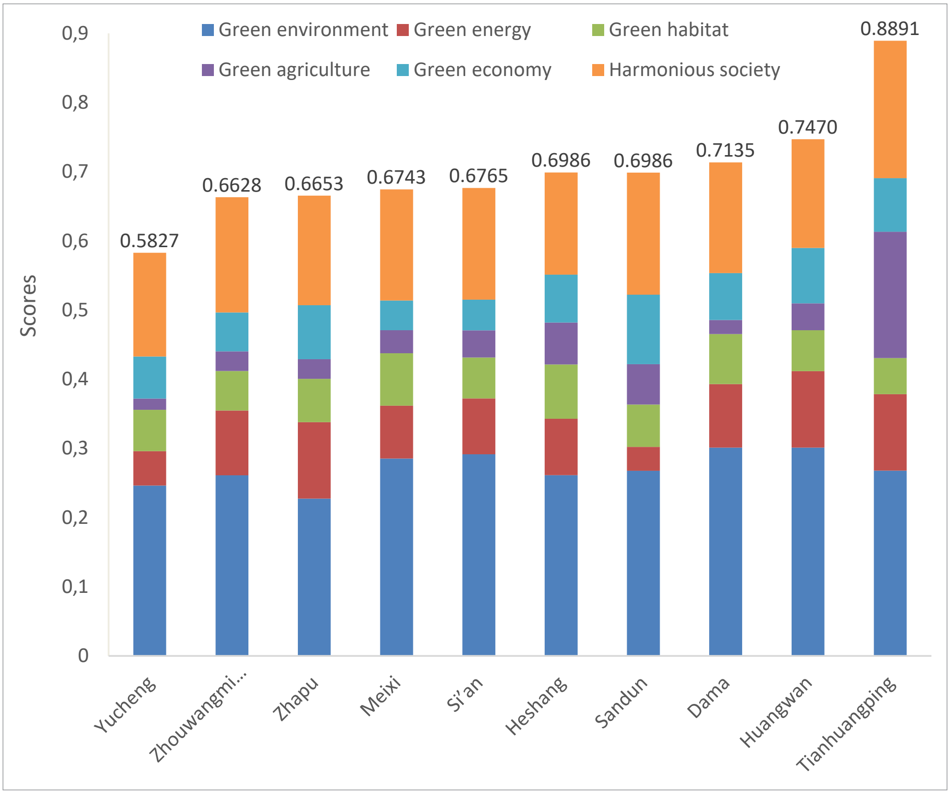

Figure 4: Total R values and respective composition of the 10 sample townships

Source: The authors

Table 6: Data survey and R value calculation of 10 sample townships in Northern Zhejiang

Indicators	Data of the sample townships									
	Dama	Heshang	Huangwan	Sandun	Si'an	Tianhuangping	Meixi	Yucheng	Zhapu	Zhouwangmiao
1. Greening	14%	50%	36%	50%	86%	60%	80%	31%	10%	40%
2. Water	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3. Air	93.2%	86.9%	100%	87.9%	90.9%	95.6%	93%	91.5%	91.9%	90.4%
4. Noise	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
5. Drink	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6. Waste-D	85%	75%	90%	100%	85%	60%	75%	65%	50%	100%
7. Waste-I	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8. Energy	80%	80%	50%	10%	78%	50%	67.9%	30%	50%	80%
9. Vehicle	30%	20%	30%	30%	18%	30%	42.6%	5%	50%	20%
10. Lights	80%	60%	80%	50%	65%	70%	37.8%	90%	50%	100%
11. Building-E	85%	80%	50%	60%	53%	20%	87.5%	70%	50%	50%
12. Building-G	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
13. Construction	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
14. Housing	80m^2	120m^2	51m^2	50 m^2	47m^2	50m^2	96m^2	30m^2	70m^2	40m^2
15. Farmland	0.7mu	0.48mu	4.4mu	0.11mu	2.3mu	4.3mu	0.71mu	1.5mu	0.92mu	0.75mu
16. Fertilizer	50kg	10kg	20kg	0kg	29kg	2kg	65kg	60kg	58kg	50kg
17. Pesticide	3B	0B	20B	0B	4.3B	0B	20B	3B	10B	3B
18. Agriculture	10%	5%	50%	0	52%	30%	67.9%	0	50%	30%
19. GDP-P	9.11w	15.37w	40.44w	2.79w	2.10w	115w	5.23w	9.21w	31.84w	6.75w
20. GDP-E	9.31	9.57	9.92	84.6	8.40	12.68	12.68	18.49	21.93	9.92
21. Industry-T	66.5%	58.6%	40.5%	92.28%	44.6%	46.7%	46.7%	38.2%	37.9%	40.5%
22. Resource	100%	100%	100%	100%	70%	70%	50%	100%	100%	100%
23. Income	43,709	32,883	55,000	80,000	37,707	44,571	33,050	45,597	40,146	45,415
24. Insurance	95%	90%	80%	100%	100%	90%	86.2%	90%	100%	100%

Indicators	Data of the sample townships									
	Dama	Heshang	Huangwan	Sandun	Si'an	Tianhuangping	Meixi	Yucheng	Zhapu	Zhouwangmiao
25. Government	95%	85%	90%	80%	92%	99%	86%	70%	80%	100%
26. Safety	95%	100%	90%	80%	94%	100%	91%	70%	90%	100%
27. Hospital	0.27	0.36	0.42	0.14	0.29	4.53	3.36	0.9	0.35	0.21
28. Education	0.54	0.71	1.27	1.32	1.16	2.72	0.76	1.36	1.23	0.83
29. Road	2.41	1.69	2.40	0.29	1.73	4.20	1.53	1.80	0.72	1.04
30. Store	16.18	9.63	11.01	5.06	14.17	29.46	19.11	15.83	13.51	9.73
Fiv-water Prize	√		√							
Bea-village Prize										
Low-carbon Prize			√			√			√	
Gre-farmland Prize										
B1 Scores	0.3011	0.2612	0.3011	0.2676	0.2914	0.2678	0.2853	0.2463	0.2273	0.2611
B2 Scores	0.0918	0.0816	0.1105	0.0345	0.0808	0.1105	0.0763	0.0496	0.1105	0.0935
B3 Scores	0.0723	0.0784	0.0591	0.0612	0.0591	0.0521	0.0758	0.0599	0.0626	0.0572
B4 Scores	0.0203	0.0606	0.0388	0.0583	0.0392	0.1826	0.0333	0.0162	0.0284	0.0283
B5 Scores	0.0678	0.0693	0.0801	0.1005	0.0445	0.0775	0.0430	0.0607	0.0781	0.0563
B6 Scores	0.1601	0.1476	0.1573	0.1764	0.1614	0.1986	0.1606	0.1500	0.1584	0.1665
R value	**0.7135**	**0.6986**	**0.7470**	**0.6986**	**0.6765**	**0.8891**	**0.6743**	**0.5827**	**0.6653**	**0.6628**

Source: The authors

5. Discussions

In recent decades, China has undergone a rapid process of urbanization. The proportion of the urban population has increased from 19.39% in 1980 to 66.16% in 2023, and it is expected to reach 73% by 2030 (Qiao and Huang, 2024). This transition has profoundly impacted rural areas, which are now encountering numerous development challenges. These challenges include the ongoing migration of high-quality labor from rural to urban areas, the relocation of factories with pollution risks from cities to rural regions, persistent disparities in urban-rural economic development, and the diminishing attractiveness of the agricultural sector to farmers due to the difficulty in achieving prosperity. With the Chinese government proposing the strategy of building a 'new countryside', the construction of green villages/townships has become a mainstream initiative and a vital goal in rural areas nationwide (Wang and Hua, 2021, pp. 33–35). There has been growing interest in developing objectives and scientific methods for evaluating the performance of these villages and townships, and the model proposed in this study represents a significant step forward in this regard. The main objective of this study is to address the challenges posed by regional differences. In fact, the Chinese government has previously encountered issues of regional differences in the construction of other projects. For example, in the evaluation system of the National Economic Township by the China Ministry of Environmental Protection, although the threshold values set for most indicators are unique, three indicators have adopted alternative solutions to address the significant impact of regional differences. Namely, the domestic sewage treatment rate and the proportion of villages carrying out domestic sewage treatment are set according to three different standards in the eastern, central, and western regions. Another indicator, vegetation coverage, is established with three different standards based on three ecological types of grasslands, hills, and plains. However, this method of addressing regional differences is deemed too simplistic and crude, suitable only for enhancing the flexibility of a small number of indicators, and not appropriate for the complex task of evaluating green villages/townships. If an evaluation system necessitates a comprehensive consideration of regional differences in the selection of indicators and the formulation of standards for each indicator, it is evidently a superior solution to directly develop a targeted evaluation system for each region based on its unique characteristics. The Chinese government has progressively embraced the adaptation of its evaluation methodologies for green villages/townships, acknowledging that a uniform approach is inadequate for rural development. China's extensive regional disparities result in distinct economic, environmental, and societal issues for every region. The government has transitioned from a rigorous, uniform evaluation system to one that can be tailored to better align with local requirements and situations. This change in strategy is essential for the Green Villages/Townships project, which seeks to sustainably and regionally enhance rural regions. For instance, locations such as Northern Zhejiang, characterized by urbanization and economic dynamism, require a distinct evaluative emphasis in contrast to more conventional, agricultural areas. The adaptability of the evaluation process is crucial in this context. The government has adopted a customized approach, permitting local variables to influence the evaluation of green village initiatives rather than enforcing uniform requirements across all regions. Therefore, this study customized a specialized evaluation model for green villages/townships in Northern Zhejiang. The advantage of this model is its capacity for interpretation at multiple levels. By encompassing 30 indicators across six different modules, the model offers a detailed and multifaceted overview of village/township performance. This is significant as it enables policymakers to discern both strengths and weaknesses in local development, facilitating more targeted resource allocation and interventions. By amalgamating these diverse indicators, the model presents a more comprehensive and nuanced depiction of local development than would be feasible with a narrower set of metrics. One area for further advancement is the utilization of the model for comparative analysis across different regions. While the authors primarily focus on the performance of individual villages/townships, it would be intriguing to examine how various regions compare in terms of overall performance and how this correlates with differences in socioeconomic or geographic factors. This could prove particularly beneficial for policymakers seeking to identify best practices or benchmark their region's performance against others. In conclusion, the model proposed in this study represents a significant advancement in the development of objective and scientific methods for evaluating the performance of villages/townships in China. Through the utilization of a comprehensive set of indicators and a weighted scoring system, the model delivers a more nuanced and accurate assessment of local development than traditional methods permit. On the other hand, the introduction of the grey concept and the design of alternative scoring plans for certain indicators could partially address the challenges in collecting data from villages/townships. In sum, the model's adaptability and comprehensiveness render it a valuable tool for local policymakers and researchers.

It is necessary to note that, although the model developed in this study is based on the 'six green' theory concerning green villages/townships, the selected indicators were deliberately designed to embody the fundamental objectives of the 'new countryside' system, namely, developed production, affluent living, civilized rural customs, clean village appearance, and democratic management. For instance, among the 30 selected indicators, those such as GDP per capita, GDP per kWh of energy consumption, proportion of tertiary industry, conservation of natural resources, annual fertilizer application per mu, annual pesticide application per mu, and the planting proportion of green/organic/pollution-free agricultural products are aligned with the goal of developed production. These indicators reflect a region's production efficiency, industrial structure, and levels of agricultural and industrial development. Indicators like per capita disposable income, per capita housing area, annual compliance rate of surface water quality, annual air quality compliance rate, residential noise compliance rate, drinking water quality compliance rate, per capita agricultural land area, energy-saving lamp usage rate, proportion of energy-saving buildings, hospitals per 10,000 persons, schools per 10,000 persons, per capita road length, stores per 10,000 people, and social and medical insurance coverage are directed towards the goal of affluent living. These indicators reflect the population's prosperity levels and quality of life. The indicator of public security satisfaction addresses the goal of civilized rural customs. Given that in rural China, most safety incidents, such as disputes and physical altercations, are rooted in traditional customs, outdated beliefs, and conflicting personal relationships, this indicator serves as a comprehensive measure of the region's level of civilization. Indicators like the greening rate of residential areas, centralized domestic sewage and waste treatment rate, industrial three-waste standard treatment rate, compliance rate of new green buildings, green construction compliance rate, renewable energy utilization rate, and proportion of new energy vehicles focus on the goal of a clean village appearance. All of these are linked to environmental quality, thus reflecting the cleanliness and aesthetics of rural areas. Finally, the governance satisfaction indicator pertains to the goal of democratic management. In sum, the model developed by this research institute acts as a guiding metric, significantly aiding local governments in advancing construction and development aligned with the objectives established by higher-level authorities.

To enhance the model's applicability across many locations, it is essential to demonstrate its adaptability to varying socioeconomic and environmental situations. This model, designed for Northern Zhejiang, could be readily modified to accommodate various regions with varying requirements. In economically underdeveloped regions, where agriculture is crucial, prioritization might be given to metrics concerning crop yields or agricultural infrastructure. Conversely, in urbanized or industrialized areas, such as coastal cities or technology centers, the model may prioritize energy efficiency, industrial sustainability, and intelligent urban design. In places with distinct environmental issues, such as drought-affected areas or those prone to flooding, the model might be modified to prioritize water management, climate adaptation, and the restoration of natural ecosystems. By customizing the indicators to local contexts. The economic, environmental, or social policymakers may ensure the model's relevance and practicality, therefore assisting communities in attaining sustainable growth that aligns with their unique conditions. In addition to the model itself, this study can also provide multiple values for policymakers in other regions from a methodological perspective, including choosing an evaluation model, screening evaluation indicators, and collecting grassroots data. Concerning the types of evaluation models, this study further substantiates the applicability of the hybrid model, which combines grey theory and AHP, for evaluating complex projects involving multiple factors and indicators. When senior managers of government departments in other regions need to evaluate, predict, or optimize multiple solutions for large-scale projects, such composite models are highly recommended. The method of decomposing the target and designing evaluation indicators hierarchically first aids in gradually clarifying vague and abstract concepts, which is the primary advantage of these models. The introduction of grey theory also enhances the model's adaptability. Given that numerous scholars have been exploring the integration of GRA with neural networks, fuzzy mathematics, and other methodologies in recent years, future users will have an expanded array of models to choose from. Regarding the selection of evaluation indicators, this study first provides a direct reference for regions facing similar challenges — characterized by developed economic circles, rapid urbanization, limited arable land, and a robust tertiary sector — by recommending an increase in the weight of economic indicators, a reduction in agricultural-related indicators, and a transformation of some agricultural indicators into quality metrics, such as the proportion of organic agricultural products and the degree of control over pesticide and fertilizer usage, which can more accurately reflect the level of agricultural development. Second, for regions significantly different from Northern Zhejiang, local governments can derive new models suitable for their contexts by adjusting the names, quantities, or weights of indicators across various modules. For instance, in economically underdeveloped traditional agricultural areas, indicators related to traditional agriculture, such as crop yield and agricultural infrastructure, can be prioritized. Conversely, in coastal areas primarily engaged in fishing, indicators related to crop cultivation can be significantly reduced, while those associated with marine aquaculture and fishing can be increased. As for the challenge of data collection, to be honest, the lack of public data at the township and village levels has indeed been a significant obstacle for many managers and scholars studying rural issues. The township is the smallest administrative unit in China and has not done well in disclosing data in the past. The village is one level even lower than the township in terms of hierarchy, and it does not even belong to an administrative unit, only a farmer autonomous unit, so the data collection and disclosure are done even worse. Encouragingly, our research indicates that, with the evolving governance concepts at all levels of the Chinese government and improvements in grassroots government website construction, accessing public data is becoming increasingly feasible. In the economically developed Northern Zhejiang region examined in this study, grassroots governance has become notably open and transparent. Most townships and some larger villages publish annual work summaries, releasing substantial amounts of public data to the community. Of course, in less developed and more isolated rural areas, challenges such as data collection and survey difficulties may prove more daunting. However, based on our experiences in this study, we offer several suggestions for researchers engaged in rural issues. Firstly, it is advisable to explore all official avenues to obtain data, including accessing various official online resources, reviewing posts from local residents in community forums, and consulting government departments and scholars studying rural issues via phone or email. Secondly, certain indicators, such as road length, road network density, and greenery, can be estimated using electronic maps through specific methodologies. Furthermore, for data that remains elusive, questionnaires can be designed for data collection and statistics, employing traditional methods such as phone and email, alongside new tools like WeChat apps. We particularly recommend seeking assistance from teachers in local schools (including universities, high schools, and junior high schools), who can access a large pool of local students and often excel at securing their cooperation. Additionally, they may be interested in participating in research efforts. Indicators such as government satisfaction, public safety satisfaction, household income levels, the proportion of new energy vehicles, and participation rates in social security and medical insurance are all suitable for data collection through a questionnaire survey. As evidenced by our study in the Northern Zhejiang region, the model established herein demonstrated that, by employing various data collection strategies — including online sources, maps, and questionnaires — data from the 10 sample townships were successfully gathered for most indicators. For government departments in other regions encountering difficulties in collecting data for certain indicators while establishing their models, we suggest addressing these challenges by incorporating alternative indicators into the model.

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