Exploration and application of a coordinated development index system based on the Pro-Liv-Eco coupling equation

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Abstract. The main purpose of this paper is to explore in depth the policy documents and actual situation of rural development in Zhejiang Province, while using semi-structured interviews and data collection means, including manual research, drones, official statistical yearbooks, NSMC, etc., GIS-based data mining, fusing multiple sources of rural and resource synergistic data, reviewing relevant research papers, and constructing a production-life-ecology, or "Pro-Liv-Eco coupling" measurement model. The team introduced the "Pro-Liv-Eco coupling" measurement model to measure the counties and districts in Zhejiang Province to better assess and monitor the sustainable development of rural areas. In addition, the team also used cluster analysis to summarize the development patterns of different villages by combining their geographical locations and development experiences in order to optimize the existing village development patterns. Ultimately, the team not only conducted an in-depth analysis and assessment of rural development in Zhejiang Province, but also provided effective solutions and suggestions for better achieving sustainable rural development, as well as common models for individualized development, providing useful references and ideas for "rural" research and practice.

Keywords: Pro-Liv-Eco, coupled equation, NSMC, coordinated development index system, cluster analysis method

1 INTRODUCTION

As a link between the natural environment and the needs and well-being of economic and social systems, ecosystem services are an effective tool for optimizing the regulation of regional ecosystems.[1] But actually, at present, there is no comprehensive and systematic policy document for the development of "integration of the Pro-Liv-Eco" and specific localized programs.

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It is difficult to coordinate the balance of production, life and ecology in rural development, and promoting more balanced and adequate coordinated regional development is also an intrinsic requirement and an effective way to realize common prosperity in the region.[2] Therefore, this team will take Zhejiang Province as the starting point to conduct in-depth investigation and research analysis of 64 typical villages in 56 counties in the province. It is important to sort out the overall status of the development of "Pro-Liv-Eco integration" in Zhejiang Province from the current situation in different areas of the province and to identify the main problems that limit the integration development.

1.1 Current status of domestic and international research

Resource endowments and developmental foundations constrain agricultural development patterns in different countries.[3] And Table 1 shows that different countries have different national conditions and different rural development strategies. For different development concepts, most of them are limited to only one aspect, such as Japan, Thailand and the United States, which focus on industrial development, and Germany, which focuses on ecological protection. The original logic is to develop an industrial economy and to use economic development to drive the countryside. And such measures will inevitably have omissions, so the need to focus on the three dimensions of production, life and ecology, the development of its production driven, so as to achieve life, ecology to enhance life, production to help ecology and other water and milk of the union, to achieve the ultimate ideal of the three spiraling development eventually to achieve a joint symbiosis.[4]

Table 1. Review of the literature

Author	Viewpoint theory
Nguyen Thi Anh Thu	One Village One Product Project is proposed to promote rural development by using the endogenous power of villages to achieve both industry and income.
Nguyen Thi Anh Thu	Proposing one product for one district, helping industry development by subsidizing villagers and providing professional training
Leah Platt Boustand	Realizing the value of a defined workforce is key to urbanization in rural America
Dieter Kirschke	Mitigating conflicts between agricultural land and natural resources, developing policies to avoid land shortages and conflicting uses, and upholding the rationale of putting ecology first
Zuhui Huang	The future of the countryside is to add new technological elements to the basic rural elements[5]
Chenyin Ding	Village construction is an organic whole, and the sustainable development of the village is achieved at a balance point where the development needs of each of the Pro-Liv-Eco spaces are met.
Yeling Sun	Propose the "future community concept" to realize the development scenario of Pro-Liv-Eco in harmony
Xiangyong Zou	Through the city park to achieve the ecological base, production environment, life scene "a public Pro-Liv-Eco" goal

2 The establishment of "Pro-Liv-Eco" coupling and coordination evaluation index system

2.1 Establishing a database of typical villages in Zhejiang Province through research and questionnaires

This project intends to divide the sample zones according to the situation of each prefecture-level city in Zhejiang Province, and select typical villages according to the sample zones. It is planned to collect data from typical villages through field research, semi-structured interviews, data cloud, and questionnaire distribution, etc. The data will be processed and a database will be established; it is proposed to combine ArcGIS and use geographic grid analysis method and spatial analysis method to visualize the data.

Data Standardization.

There are generally differences in order of magnitude between different indicators, and in order to eliminate such differences and make them measurable and comparable, standardization of the data needs to be carried out. Also, in order to eliminate the effect of negative numbers and zeros, the data are leveled. The formula for performing data normalization based on the positive and negative attributes of the indicators is as follows:

$$Positive\ indicators: U_{ij} = \frac{X_{ij} - X_{ij\min}}{X_{ij\max} - X_{ij\min}} + 0.0001$$

$$Negative\ indicators: U_{ij} = \frac{X_{ij\max} - X_{ij}}{X_{ij\max} - X_{ij\min}} + 0.0001$$

Determine the entropy value.

$$S_{ij} = U_{ij} / \sum_{i=1}^{m} U_{ij}$$

$$h_j = \frac{1}{\ln m} \sum_{i=1}^{m} S_{ij} \ln S_{ij}$$

Determine the weighting.

$$w_j = \frac{1 - h_j}{\sum_{j=1}^{n} 1 - h_j}$$

Coordinated development index system of "integration of the Pro-Liv-Eco.

Table 2 below shows the specific elections of our ecological and environmental protection integration" coordinated development indicator system

Table 2. Coordinated development index system of "integration of the Pro-Liv-Eco

The "Pro-Liv-Eco" System	Evaluation Indicators	Explanation of indicators
High quality production	Share of output value of primary industry (+)	Primary industry output/GDP
	Share of output value of secondary industry (+)	Secondary industry output/GDP
	Share of tertiary industry output value (+)	Tertiary industry output/GDP
	Rationalization of industrial structure (-)	Industrial Structure Rationalization Index
	Advanced industrial structure (+)	Industrial structure advanced index
	Foreign trade openness (+)	Total imports and exports/GDP
	Foreign investment openness (+)	Foreign Direct Investment/GDP
High Quality of Life	Traffic accessibility (+)	Road and high-speed rail density
	Medical resource ownership rate (+)	Number of beds per capita in medical and health institutions
	Sanitation penetration rate (+)	Number of public toilets per 10,000 people
	Network coverage (+)	Number of Internet broadband access ports per capita
	Worker's compensation (+)	Per capita wage level
	Urban-rural income balance index (+)	The inverse of the urban-rural income gap
High level of ecology	Air Quality Index (+)	The proportion of good air quality days
	Surface water quality (+)	Actual monitoring data
	Soil erosion rate(-)	Soil erosion area / original soil and water area
	Percentage of quality arable land (+)	Quality arable land area/total area of the region
	Renewable freshwater resources per capita (+)	Renewable inland freshwater resources/total population
	Arable land per capita (+)	Arable land area/total number of people
	Forest cover (+)	Forest area/land area
	Biodiversity (+)	Abundance of biodiversity in the region

2.2 Comprehensive evaluation of the coordinated development of the "Pro-Liv-Eco"

With the help of the comprehensive evaluation model, the formula for calculating the comprehensive evaluation index of production function, living function and ecological function is determined as follows:

$$f(x) = \sum_{j=1}^{k} a_j x_j,\ g(y) = \sum_{j=1}^{l} b_j y_j, h(z) = \sum_{j=1}^{r} c_j z_j$$

The degree of coupling coordination reflects the degree of interaction between spatial functions, and also reflects whether the interaction between spatial functions is positive or negative, and whether they promote or restrict each other. Therefore, based on the existing research, this paper selects the coupling coordination degree model to describe the linkage and strength of the "Pro-Liv-Eco" spatial functions and classify the coupling coordination level. The specific function expression is：

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

Where: C is the spatial function coupling degree of "Pro-Liv-Eco", which can reflect the intensity of the linkage between spatial functions, but cannot judge the nature of the linkage. Therefore, the coupling coordination degree model is introduced to further grasp the coordination level and evolutionary characteristics of the "Pro-Liv-Eco" spatial functions, and the specific measurement formula is

$$D = \sqrt{C \times T}$$

Based on this, a two-coupling coordination model of the "Pro-Liv-Eco" spatial functions can be evolved, and the specific calculation steps are as follows:

$$C_1 = 2 \times \left\{ \frac{f(x) \times g(y)}{[f(x)+g(y)]^2} \right\}^{\frac{1}{2}},\ C_2 = 2 \times \left\{ \frac{f(x) \times h(z)}{[f(x)+h(z)]^2} \right\}^{\frac{1}{2}},\ C_3 = 2 \times \left\{ \frac{g(y) \times h(z)}{[g(y)+h(z)]^2} \right\}^{\frac{1}{2}}$$

$$D_1 = \sqrt{C_1 \times T_1},\ D_2 = \sqrt{C_2 \times T_2},\ D_3 = \sqrt{C_3 \times T_3}$$

$$T_1 = \alpha f(x) + \beta g(y),\ T_2 = \alpha f(x) + \chi h(z), T_3 = \beta g(y) + \chi h(z)$$

3 Evaluation results and analysis of the spatial function coupling and coordination of the "Pro-Liv-Eco"

Based on the results of the comprehensive evaluation of each spatial function, this project selected 64 villages in 54 counties of Zhejiang as samples, covering 11 prefectural-level cities in Zhejiang, and applied the coupled coordination degree model to measure the development status of different villages. The specific results are shown in Table 3 below:

Table 3. Coupling degree data of Zhejiang Province

Region	County-level cities	2018	2019	2020	2021	2022
North Zhejiang	Tongxiang	0.522	40.553	90.573	90.592	80.616
	Haining	0.503	40.519	00.548	40.578	40.609
	Yuyao	0.514	30.540	80.575	20.590	60.616
	Anji	0.550	50.578	20.602	70.620	20.640
	Deqing	0.510	30.519	80.560	90.593	50.609
	Tonglu	0.511	50.550	90.571	60.581	20.592
Central Zhejiang	Zhuji	0.669	60.698	10.725	20.748	60.776
	Lanxi	0.565	50.579	20.624	80.667	30.694
	Yiwu	0.539	20.540	20.589	20.611	30.665
	Dongyang	0.573	40.576	50.594	10.607	80.647
Southern Zhejiang	Longquan	0.592	30.605	70.632	30.642	40.678
	Suichang	0.609	00.623	80.643	70.670	60.707
	Linhai	0.623	90.619	90.642	70.662	00.697
	Yongjia	0.577	10.585	00.603	50.586	20.627
	Yueqing	0.600	50.608	00.616	90.636	60.683
	Cangnan	0.631	70.632	10.648	20.693	80.733

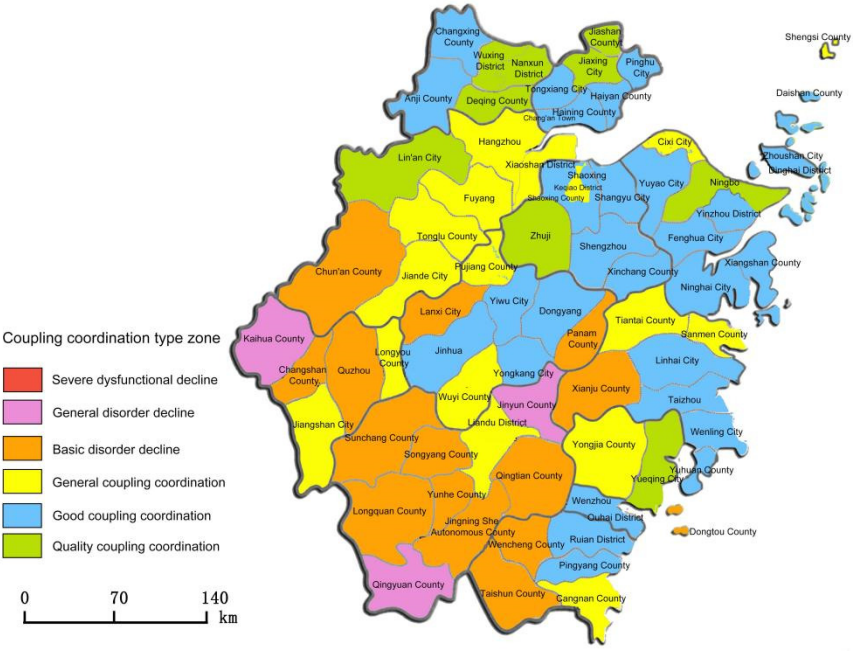

Fig. 1. The degree of trigeneration coupling diagram

In order to show the spatio-temporal variation of the spatial function coupling and coordination degree of "Pro-Liv-Eco" in Zhejiang Province, this paper selects the data of 2022 according to the classification standard of coupling and coordination level, and generates the spatial distribution map of "Pro-Liv-Eco" spatial function coupling and coordination in Zhejiang Province by using ArcGIS software. The specific results are shown in Fig.1

4 CONCLUSIONS

This dissertation thoroughly researches the current situation, problems and patterns of the development of "Pro-Liv-Eco integration" in Zhejiang Province, and collects and analyzes a large amount of relevant data through in-depth research in 56 counties and 64 typical villages. On this basis, the study constructed an evaluation index system for the development of the "integration of the Pro-Liv-Eco" and used a coupled coordination model to evaluate and monitor the indicators in order to assess and promote sustainable rural development. The study provides in-depth thinking and comprehensive solutions for promoting sustainable rural development, and has certain inspirations and implications for rural development in Zhejiang Province and other regions of China.

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