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Can the Establishment of National Parks Promote the Coordinated Development of Land, the Environment, and Residents' Livelihoods?

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Abstract: National parks play a crucial role in the worldwide system of natural conservation, significantly influencing land utilization, the sustainability of local livelihoods, and the environmental integrity of nearby regions. In this study, the coupled coordination model and ArcGIS tools are applied to examine the temporal and spatial progression of the coordination of the system of land, the environment, and residents' livelihoods (the LEL system). The construction of the LEL system and the use of natural geographic and socio-economic data are the main innovations of this research. The findings indicate that over the last 15 years, Wuyishan National Park has witnessed growth in its ecological and agricultural areas alongside a decline in its water-based ecological zones. The creation of the national park has obviously promoted the coordination of the LEL systems in nearby areas and has a significant spatial spillover effect. Consequently, for the upcoming development of Wuyishan National Park, it is crucial to modify the framework of the agricultural sector, enhance local public infrastructure, and bolster the safeguarding of water ecological areas.

Keywords: production–living–ecological space (PLES); land–environment–residents' livelihoods (LEL) system; coupled and coordinated development; Wuyishan National Park

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1. Introduction

National parks are an essential component of the global natural reserve system, exerting significant influences on the economic and social development, as well as the ecological environment, of the surrounding areas [1,2]. The coordinated development of regions is significantly influenced by three key factors: the utilization of land, peoples' livelihoods, and the environmental conditions [3]. The effective management of the interplay among these three elements can significantly foster the sustainable and superior development of a region, thus offering insights and direction for establishing and building natural reserve systems globally. As such, the development of the global natural reserve system can be aligned with economic and social advancement.

To date, the majority of both national and international studies examining the interplay among land, the economy, and ecology has originated from a solitary subsystem or has focused on the interconnection and synchronization of two subsystems, with a lesser emphasis on the interplay among all three subsystems [4,5]. Earlier research primarily concentrated on the qualitative analysis of implications, connections, and traits [6], whereas subsequent studies predominantly utilized quantitative research models [7–9]. In the majority of contemporary studies, a systematic evaluation index system is developed by employing methods like the entropy value, principal component analysis, and multi-index comprehensive evaluation, and the comprehensive score is computed by a coupling coordination model [10–12]. However, these methods do not fully reflect natural geographical information and are unable to reveal the interaction between natural geographical conditions and socio-economic development.

The main innovations of the present study are summarized as follows. First, a novel system comprising land, the environment, and residents' livelihoods (herein referred to as the LEL system) is constructed. Second, a coupled coordination model is constructed by making full use of natural geographical data and socio-economic data, thus improving the comprehensiveness and credibility of the study. In addition, a national park is chosen as the research area, which provides a reference for the construction of the global nature reserve system.

The focus of this study is the interconnection of the LEL system in Wuyishan National Park. Both the chronological and spatial development traits of this system from 2008 to 2022 are examined, and 2015 is considered a pivotal moment to assess whether the construction of Wuyishan National Park has improved the coupling coordination of the regional LEL system. This research serves two purposes. First, it provides a theoretical guide for government departments engaged in the construction of Wuyishan National Park and can aid in the creation of actionable and efficient policies for the coordination and sustainable development of the region. Second, it provides a resource and reference for studies on the synchronized evolution of the global LEL system of natural reserves, thus holding significant practical value.

2. Materials and Methods

2.1. Study Area

2.1.1. Natural Geographical Conditions

Wuyishan National Park (Figure 1) includes Fujian and Jiangxi provinces along with the cities of Nanping and Shangrao. Its geographic coordinates are 117°24′13″–117°59′19″ east longitude and 27°31′20″–27°55′49″ north latitude. The region experiences a standard subtropical humid monsoon climate with an average annual temperature of 19 °C. There exist 7407 wildlife species in the park, encompassing 558 types of wild vertebrates and 6849 insect species. Spanning 1280 km^2, the conservation zone includes a portion (1001.41 km^2) of Nanping City, which represents 78.2% of the overall area.

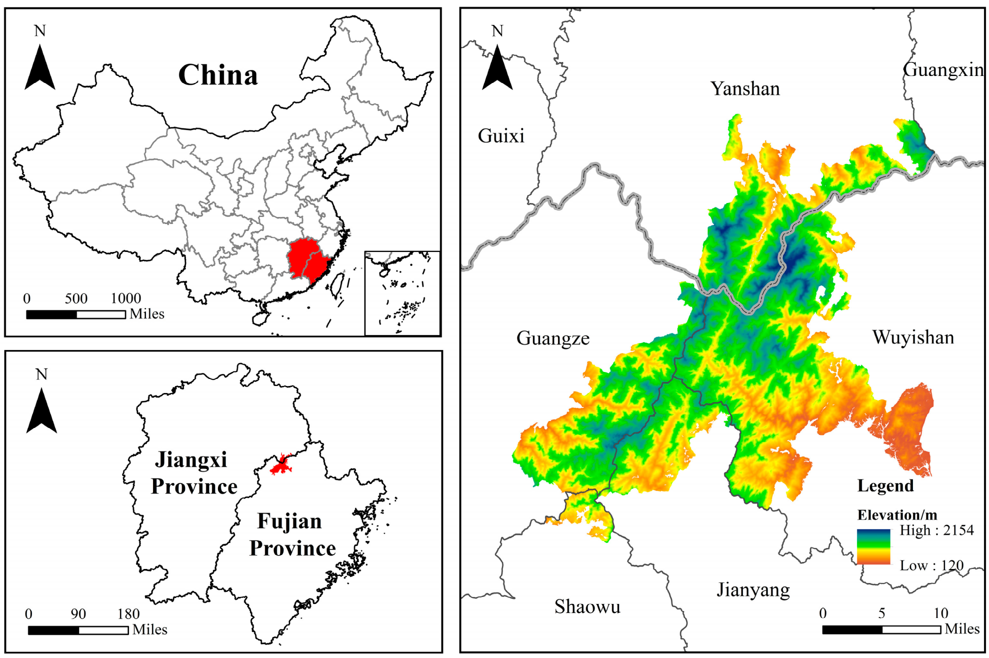

Figure 1. The geographical location of the study area.

Situated on the southeastern edge of the northern part of the Wuyi Mountains, Nanping City, a prefecture-level city within Fujian Province's jurisdiction, lies at the convergence of Fujian, Zhejiang, and Jiangxi provinces. With an area of 26,300 km^2, it is Fujian Province's largest prefecture-level city. Presently, it manages two districts (Yanping and Jiangyang) and five counties (Shunchang, Pucheng, Guangze, Songxi, and Zhenhe), and supervises three cities at the county level (Shaowu, Wuyishan, and Jianou).

2.1.2. Social and Economic Conditions

The groundwork for Wuyishan National Park was laid in 2015 and the Wuyishan National Park Management Bureau was formally inaugurated in 2017. Wuyishan National Park, sanctioned by the State Council, was inaugurated in September 2021, marking it as one of the nation's earliest national parks. The creation of Wuyishan National Park has significantly enhanced the area's tourism sector. The park welcomed 4.92 million visitors in 2021, which escalated to 15.5 million by 2023.

Following the establishment of the park in 2015, Nanping City's GDP has consistently increased. As of 2023, the aggregate GDP reached RMB 227 billion. Moreover, the value added to tertiary industries escalated to RMB 107.845 billion, marking a 4.3% increase and propelling a 2.0% increase in GDP. Since 2008, Nanping City's recorded population has exhibited a pattern of initially rising followed by a decline.

2.2. Data Collection

2.2.1. Land-Use Data Acquisition

The land-use data were sourced from the Resource and Environment Data Center of the Chinese Academy of Sciences (https://www.resdc.cn/ accessed on 2 February 2024), and had a spatial resolution of 30 m. The land-use data were processed via resampling, classification, and extraction using ArcGIS 10.8 software, resulting in the distribution data of the production–living–ecological space (PLES) in Nanping City for three periods (2008, 2015, and 2023). Due to the lack of land-use data for 2022, and because land-use changes can be essentially ignored within one year, the land-use data for 2023 were used as a substitute for 2022.

2.2.2. Collection of Socio-Economic Data

Socio-economic information was obtained from various sources, including the China City Statistical Yearbook, the China Environmental Statistical Yearbook, the Fujian Statistical Yearbook, the Nanping City Statistical Yearbook, and the yearbooks of cities (counties) within Nanping City, in addition to statistical bulletins and government websites. A very small amount of missing data were supplemented by linear interpolation.

2.3. Research Methods

2.3.1. Construction of the PLES Classification and the LEL System

The PLES focuses on the diverse roles of territorial areas, which are categorized into various forms according to the primary purposes of the land [13]. Drawing on current research findings, the study categorizes production spaces into two types, namely, those for agriculture and those for industry. The division of living spaces encompasses urban and rural areas, whereas ecological spaces include forest, grassland, water, and other ecological zones [14,15].

The efficient use of the production–living–ecological functions of the land, along with the sustainable living conditions of the inhabitants and safeguarding the environment, play vital roles in shaping the superior development of a region. Figure 2 depicts the process of how these factors interact. Regarding the interplay between the production–living–ecological functions of land and the sustainable living of inhabitants, the efficient utilization of the production function of land can enhance the grain yield per unit area and boost agricultural earnings. The improvement of the sustainable livelihood level enables residents to pursue high-quality development, thereby transforming land development from traditional extensive cultivation to appropriate use according to local conditions, and ultimately promoting the full play of the production–living–ecological functions of land. Concerning the interplay between production–living–ecological functions and ecological environment quality, the efficient operation of the ecological roles of land aids in elevating the ecological state of a region. This also propels the evolution and enhancement of land-use trends, leading the government to persistently rejuvenate less efficient construction areas and amplifying the overall advantages of land. From the perspective of the link between the sustainable living of residents and their ecological surroundings, the enhancement of their sustainable living standards leads to more eco-friendly and sustainable development. This shift toward sustainable development methods not only elevates the quality of the local ecological environment, but also fosters an environment conducive to the advancement of the sustainable livelihoods of residents.

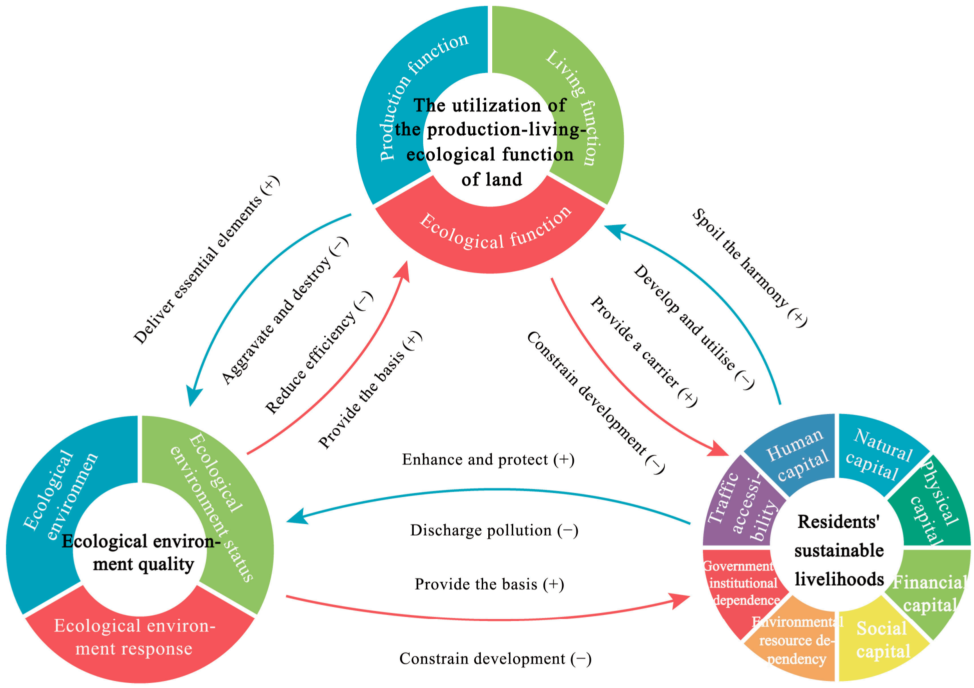

Figure 2. The interaction mechanisms of the LEL system.

2.3.2. Dynamic Attitude toward Land Use

According to the formulas for the dynamic degrees of integrated and single land use [16,17], the transfer rate and variation amplitude of the PLES of Wuyishan National Park can be calculated as follows:

$$K = \frac{\left[(L_b - L_a)/L_a \right]}{T} \times 100\% \quad (1)$$

where K represents the dynamic degree of a certain land-use type within the research period, L_a and L_b, respectively, represent the areas of a certain land-use type at the beginning and end of the study period, and T represents the research period, the unit for which is usually years.

$$LC = \left[\frac{\sum_{i=1}^{n} \Delta LU_{i-j}}{\sum_{i=1}^{n} LU_i} \right] \times \frac{1}{T} \times 100\% \quad (2)$$

In Equation (2), LC is the dynamic degree of regional comprehensive land use during the research period, LU_i is the area of land-use type I at the beginning of the research period, ΔLU_{i-j} is the area of land-use type i transferred to land-use type j during the research period, and T is the research period, which represents the annual comprehensive change rate of land use in the region.

2.3.3. Land Transfer Matrix

The land transfer matrix can quantitatively characterize the spatial changes and transfer directions of the space type. ArcGIS 10.8 software was used to calculate the land transfer matrix of 2008, 2015, and 2023, and the formula is as follows [18]:

$$S = \begin{bmatrix} S_{11} & \cdots & S_{1n} \\ \vdots & & \vdots \\ S_{n1} & \cdots & S_{nn} \end{bmatrix} \tag{3}$$

where Sij represents the area for which land-use type i at the beginning of the study transitions to land-use type j at the end of the study, with n being the number of land-use types.

2.3.4. Entropy Weight Method

In the process of selecting indicators, to reduce the interference of subjective factors [19,20], the entropy weight method was used to weight each indicator (Table 1). The main calculation steps are as follows:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{4}$$

$$E_j = -\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{5}$$

$$W_j = \frac{1 - E_j}{\sum (1 - E_j)} \tag{6}$$

Table 1. The classification criteria for coupling coordination types.

Coordination Degree	Coordination Level	Coordination Degree	Coordination Level
[0, 0.1)	Extreme imbalance	[0.5, 0.6)	Slight coordination
[0.1, 0.2)	Severe imbalance	[0.6, 0.7)	Primary coordination
[0.2, 0.3)	Moderate imbalance	[0.7, 0.8)	Intermediate coordination
[0.3, 0.4)	Mild imbalance	[0.8, 0.9)	Good coordination
[0.4, 0.5)	Near imbalance	[0.9, 1.0]	High-quality coordination

2.3.5. Coupling Coordination Degree Model

The collaborative operation level between subsystems can be reflected by the coupling coordination degree [21,22]. According to the comprehensive evaluation results, a coupling coordination degree model for economic development, the production–living–ecological functions of the land, and the ecological quality of the research area was constructed, as follows:

$$C = \sqrt{\left[1 - \frac{\sqrt{(U_3 - U_1)^2} + \sqrt{(U_2 - U_1)^2} + \sqrt{(U_3 - U_2)^2}}{3}\right] \times \sqrt{\frac{U_1}{U_3} \times \frac{U_2}{U_3}}} \tag{7}$$

$$T = \alpha U_1 + \beta U_2 + \gamma U_3 \tag{8}$$

$$D = \sqrt{C \times T} \tag{9}$$

In the equations, C represents the system coupling degree, the value range of which is [0, 1]; U_1, U_2, and U_3, respectively, represent the comprehensive scores for the production of the land, the residents' sustainable livelihoods, and the ecological environment quality, and T is the comprehensive evaluation index of the system, which represents the overall development level. Moreover, α, β, and γ are undetermined coefficients. Because the production function of land can support economic activities, and because the ecological function has a significant impact on the environment, $\alpha = 0.4$ and $\beta = \gamma = 0.3$ were set in this study. Finally, D denotes the coupling coordination of the system, which reflects the degree of coordination in the interactions of the subsystems.

Referring to existing research results [23,24], the coupling coordination level (Table 1) was segmented; $0 \leq D < 0.4$ indicates a mismatched state, $0.4 \leq D < 0.6$ indicates a transitional state, and $0.6 \leq D \leq 1$ indicates a coordinated state.

2.3.6. Panel Data Multiple Linear Regression Model

Explained variable. To explore whether the establishment of national parks can enhance the coupling coordination of the LEL system in the region, the coupling coordination degree of the 10 counties in Nanping City from 2008 to 2022 was selected as the explained variable.

Core explanatory variable. The establishment of national parks is the core explanatory variable of this study, which was set as a dummy variable Z_1, where $Z_1 = 1$ represents the year when the national park was prepared for establishment, and $Z_1 = 0$ represents the years when the national park had not been prepared for establishment.

Other control variables. In consideration of existing research findings, the regional GDP (Z_2), permanent resident population (Z_3), urbanization rate (Z_4), and Engel coefficient (Z_5) were selected as control variables, with exponential decay set for the regional GDP. The model was constructed as follows:

$$D_{it} = \alpha_0 + \alpha_1 Z_1 + \alpha_2 \ln Z_2 + \alpha_3 \ln Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \varepsilon_{it} \tag{10}$$

where D_{it} represents the coupling coordination degree of the LEL system in the t-th area of the i-th year, and Z_1 represents the virtual variable of whether a national park has been established. Moreover, Z_2, Z_3, Z_4, and Z_5, respectively, represent the regional GDP, regional permanent population, urbanization rate, and Engel coefficient, and ε_{it} is the random disturbance term.

To explore whether the establishment of national parks exhibits regional heterogeneity in the coupling coordination of the LEL system in surrounding areas, the 10 counties under the jurisdiction of Nanping City were divided into two groups based on their distance from the national park: those with town governments located less than 50 km from the national park (the "near national park" group) and those with town governments located more than 50 km from the national park (the "far from national park" group). By conducting grouped regression analysis on the two groups of samples, it was investigated whether the establishment of national parks has spatial spillover effects.

2.3.7. Indicator System Construction

An assessment index for the LEL system was constructed based on current research findings, as depicted in Table 2.

Table 2. The evaluation index system for the coordinated development of LEL system coupling.

System Layer	Criterion Layer	Indicator Layer	Unit	Indicator Attributes	Weight
The utilization of the land's production–living–ecological functions (A)	Production function (A1)	Average crop yield per plot (A11)	kg/hm^2	+	0.219
		Economic density (A12)	10,000 RMB/hm^2	+	0.135
	Living function (A2)	Per capita construction land area (A21)	hm^2	+	0.203
		Population density (A22)	persons/km^2	+	0.211
	Ecological function (A3)	Ecological space proportion (A31)	%	+	0.113
		Ecological environment quality (A32)		+	0.119

Table 2. *Cont.*

System Layer	Criterion Layer	Indicator Layer	Unit	Indicator Attributes	Weight
Ecological environment quality (B)	Ecological environment pressure (P)	Per capita urban sewage discharge (P1)	10,000 m^3	–	0.064
		Per capita urban domestic waste removal volume (P2)	10,000 t	–	0.068
	Ecological environment state (S)	Forest coverage rate (S1)	%	+	0.189
		Daily excellent air rate (S2)	%	+	0.243
		Per capita park green space area (S3)	m^2	+	0.063
	Ecological environment response (R)	Afforestation area (R1)	acre	+	0.083
		Sewage treatment rate (R2)	%	+	0.063
		Urban solid waste treatment rate (R3)	%	+	0.228
Residents' sustainable livelihoods (C)	Human capital (C1)	Proportion of the rural labor force (C11)	%	+	0.075
		Proportion of the labor force with a college degree or above (C12)	%	+	0.085
		Proportion of healthcare-related expenses (C13)	%	–	0.072
	Natural capital (C2)	Actual irrigated area of farmland per household in rural areas (C21)	10,000 acres/household	+	0.082
	Physical capital (C3)	Per capita housing construction area of households (C31)	m^2	+	0.104
		Proportion of households with toilets in their housing (C32)	%	+	0.069
	Financial capital (C4)	Per capita disposable income of rural residents (C41)	RMB	+	0.090
	Social capital (C5)	The proportion of rural collective economic income (C51)	%	+	0.072
		Participation rate of medical insurance for urban and rural residents (C52)	%		0.074
	Environmental resource dependency (C6)	Proportion of agricultural income (C61)	%	+	0.087
	Government institutional dependence (C7)	Rural household average subsistence allowance amount (C71)	10,000 RMB/household	+	0.115
	Transportation accessibility (C8)	Proportion of land used for road traffic facilities (C81)	%	+	0.075

The indicators of the index system are described as follows:

(1) Indicators for the production–living–ecological functions of land. These functions originate from the PLES and are a specific manifestation of its connotation [25–27].

Production functions (A1): The production function is mainly focused on providing agriculture, industry, and services. Agricultural products are the foundation of human material life, and rice and tea are the main food and cash crops in Nanping City. Thus, the choice of per capita crop yield (the per capita rice yield and tea yield) reflects the agricultural production function. Economic density reflects the production function of agriculture, industry, and services in the region.

Living functions (A2): The living function mainly provides residential support and life security. This is mainly reflected in public infrastructure investment, urban construction, public services, etc. The degree of population aggregation can also reflect the utilization of the living function of land. Therefore, the per capita construction land area and population density were selected for characterization.

Ecological function (A3): The ecological function primarily focuses on providing ecological conservation and environmental protection. The quality and quantity of ecological space reflect the performance of the regional land ecological function. Therefore, the proportion of ecological space was selected to reflect the quantity of ecological space, and habitat quality was selected to reflect the quality of ecological space. The proportion of ecological space includes woodland, wetland, grassland, water, and other ecological space. Habitat quality reflects the level of ecosystem integrity and quality.

(2) Ecological environment quality index. The Pressure–State–Response (PSR) model, a classical causal network model, has been widely used in various land and resource security assessments [28]. The PSR model emphasizes the interaction between human activities and the natural environment, and is currently widely used in land ecological security, wetland resource ecological security, and farmland safety evaluation [29].

Pressure indicators (P): The first pressure indicator is the per capita urban sewage discharge (P1). This is the annual amount of domestic sewage generated per capita annually, and mainly includes sewage from residential buildings, reflecting the harmful effects of human activities on the ecological environment. The second indicator is per capita urban solid waste removal (P2), which is the amount of domestic waste collected and transported to waste treatment plants within a certain period. It also reflects the impact of human activities on the ecological environment.

State indicators (S): Drawing on existing research [28], forest coverage (S1) was chosen as a state indicator. Forest coverage is the ratio of the forest area to the administrative area, which reflects the degree of forest resource coverage and actual occupancy. Since the study area has more than 90 percent forest cover, forest coverage was used as the main indicator. The air quality index (S2) is measured as the percentage of days in a year with an air quality index (AQI) less than 100, and the per capita park green area (S3) is the amount of green area per person on average in the region, which reflects the richness of green space resources in each region.

Response indicators (R): The afforestation area (R1) indicates the proportion of artificially created forest area among the region's land area and reflects the intensity of artificial afforestation and the status of green development. The sewage treatment rate (R2) is the proportion of treated domestic sewage and industrial wastewater among the total sewage discharge. Finally, the urban household waste treatment rate (R3) indicates the proportion of treated household waste among the total amount of household waste. These factors reflect the effectiveness of human intervention in reducing environmental pollution.

(3) Sustainable livelihoods index. Sustainable livelihoods refer to the ability of households or individuals in a vulnerable context to utilize various resources stably in the long term without compromising the renewable capacity of the resources [30]. The sustainable livelihoods (SL) framework divides livelihood assets into five categories: natural, human, material, financial, and social capital [31]. The indicator system was improved by selecting environmental resource dependency, government institution dependency, and transportation accessibility as additional indicators.

Human capital (CB1): Human capital refers to the knowledge, skills, and health level possessed by the labor force. The quantity and quality of the labor force directly impact the ability of farmers to manage livelihood strategies, and are mainly reflected in the labor capacity and educational level of the labor force. The proportion of the rural labor force and the proportion of health and hygiene expenditures were chosen to reflect the labor capacity of the family, and the proportion of the labor force with a college degree or above was chosen to reflect the educational level of farmers.

Natural capital (CB2): Natural capital mainly refers to the land, water, and biological resources that people rely on for survival. Due to factors such as the remote location of Wuyishan National Park, households have a high dependence on the land. Therefore, the actual irrigated area per rural household was chosen to reflect natural capital.

Material capital (CB3): Material capital refers to the houses, production equipment, and infrastructure (such as roads, water and electricity networks, schools, medical facilities, etc.) used by households for production and living. Based on existing research and the actual situation of residents in Nanping City, the per capita residential building area of households and the proportion of households with toilets were selected to reflect this indicator.

Financial capital (CB4): Financial capital refers to the cash stock that households can dispose of independently and the opportunity to obtain loans. Financial capital can provide security for diversified livelihood strategies and can also be directly converted into material capital to ensure livelihood security. The financial capital of residents in Nanping City was mainly reflected as the per capita disposable income of rural residents.

Social capital (CB5): Social capital refers to the social assistance that farmers can seek to improve their livelihood strategies and is the social resource that farmers possess. Based on existing research, indicators such as the proportion of rural collective economic income and the rate of participation of urban and rural residents in medical insurance were chosen to reflect this.

The remaining indicators in this index include environmental resource dependency (C6), which is measured by the proportion of agricultural income, government institutional dependency (C7), which is measured by the per capita minimum living allowance in rural areas, and transportation accessibility (C8), which is measured by the proportion of land used for road traffic facilities.

3. Results and Analysis

3.1. Evolution of the PLES in Wuyishan National Park

3.1.1. Characteristics of the Spatial Distribution of PLES

ArcGIS 10.8 was employed to illustrate the spatial distributions of the PLES in Wuyishan National Park for the three periods of 2008, 2015, and 2023 (Figure 3). The findings show that during the study period, the predominant ecological area in Wuyishan National Park was the forest, with percentages of 92.97%, 92.89%, and 92.88% in 2008, 2015, and 2023, respectively; the average value was 92.91%. The other types of ecologies, from the greatest to the least area, were grassland ecological space, agricultural production space, water ecological space, rural living space, and urban living space. The areas for production, residential spaces, and ecological zones, respectively, constituted 2.41%, 0.02%, and 97.58% of the total space.

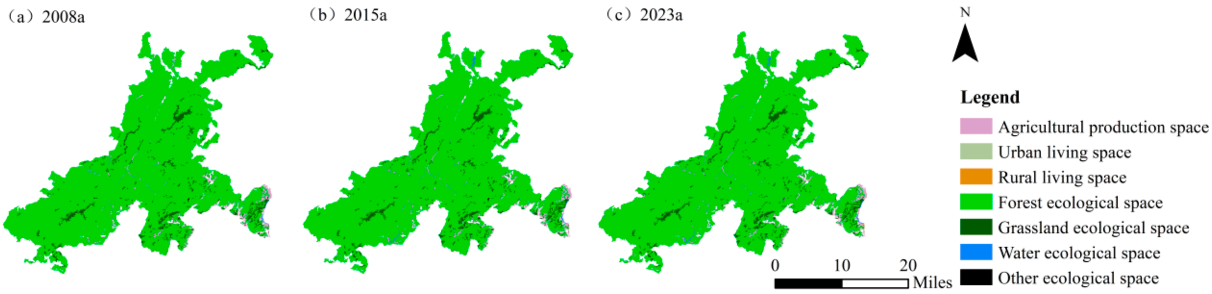

Figure 3. The distribution maps of PLES in Wuyishan National Park.

3.1.2. Characteristics of Land Transfer in the PLES

From 2008 to 2015, the spatial pattern of the PLES mainly changed between forest ecological space and grassland ecological space (Figure 4), with 7.16 km^2 of grassland converted into forest, and 7.400 km^2 of forest converted into grassland. Simultaneously, there was also a significant outflow of agricultural production space, which was mainly converted into forest ecological space and water ecological space. From 2015 to 2023, the spatial transformation of the PLES also mainly occurred between forest ecological space and grassland ecological space, with 4.791 km^2 of grassland converted into forest, and another 4.624 km^2 of forest converted into grassland. Moreover, 2.579 km^2 of forest ecological space was converted into agricultural production space.

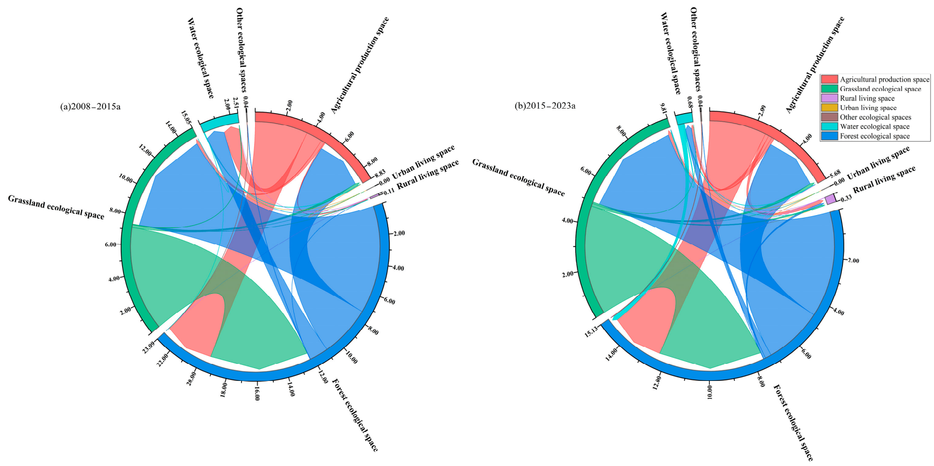

Figure 4. The change of the landscape types in Wuyishan National Park from 2008 to 2023 (unit: km^2).

3.1.3. Dynamic Evolution Characteristics of PLES

An analysis of the alterations in different spatial categories from 2008 to 2023 reveals a steady growth in agricultural areas over the last 15 years, amounting to an overall expansion of 1.481 km^2. In contrast, urban and rural areas experienced a steady decline, shrinking by 0.006 km^2 and 0.433 km^2, respectively. The forest ecological space expanded by 1.378 km^2, while the grassland ecological space decreased by 0.04 km^2. The water ecosystem also experienced a steady decline, amounting to a total reduction of 2.504 km^2. The geographical layout of the PLES in Wuyishan National Park underwent notable alterations between 2008 and 2015, with a tendency to level off from 2015 to 2023.

The single dynamic attitude of the PLES was calculated, and Figure 5 illustrates that changes in rural living areas and water ecosystems occurred the most rapidly. Between 2008 and 2015, the water ecological space swiftly expanded, achieving a dynamic rate of 31.07%. In contrast, the rural living area experienced the most rapid transformation from 2015 to 2023, increasing by 28.38%. Other types of spaces underwent relatively little change, with the ecological spaces of forests and grasslands remaining stable. The findings indicate that the comprehensive dynamic attitude of the land use of Wuyishan National Park is tending toward stability.

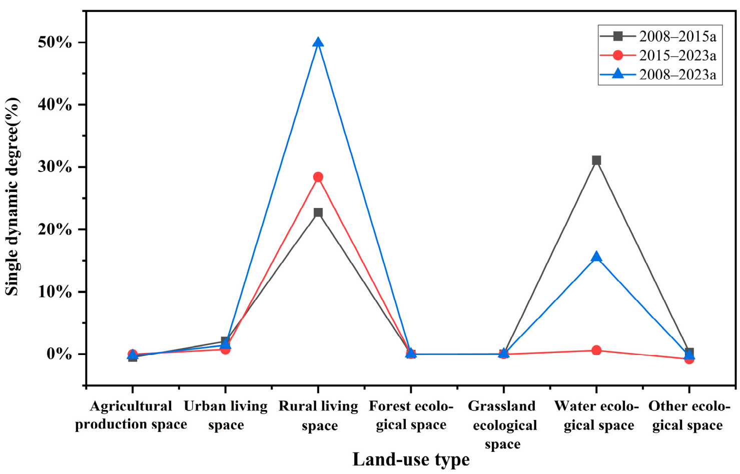

Figure 5. The single dynamic degree of land transfer in Wuyishan National Park from 2008 to 2023.

3.2. Calculation Results and Analysis of Coupling Coordination

Employing the coupling coordination degree model, Table 3 illustrates that from 2008 to 2022, the yearly coupling coordination degree for the 10 counties in Nanping City was predominantly between 0.4 and 0.6, oscillating from a state of imbalance to a state of weak coordination. From the perspective of the temporal evolution characteristics, the overall coupling coordination degree of various regions has been on the rise from 2008 to 2022, and the most significant increase was seen from 2015 to 2022. From the perspective of spatial characteristics, the coupling coordination degree in Wuyishan, Jianyang, Guanze, Shaowu, and Yanping was slightly higher than that in other cities and counties.

Table 3. The coupling coordination degree of the LEL system in each county of Nanping City.

Year	Wuyishan	Jianyang	Guangze	Shaowu	Yanping	Shunchang	Pucheng	Songxi	Zhenghe	Jian'ou
2008	0.491	0.448	0.474	0.392	0.478	0.415	0.440	0.470	0.470	0.463
2009	0.529	0.451	0.496	0.357	0.456	0.385	0.424	0.411	0.475	0.471
2010	0.509	0.441	0.460	0.359	0.424	0.412	0.395	0.398	0.455	0.434
2011	0.460	0.496	0.492	0.376	0.441	0.403	0.398	0.348	0.466	0.429
2012	0.418	0.478	0.463	0.369	0.403	0.393	0.407	0.359	0.425	0.381
2013	0.424	0.494	0.452	0.462	0.421	0.479	0.353	0.381	0.411	0.481
2014	0.422	0.520	0.431	0.535	0.418	0.499	0.366	0.519	0.472	0.437
2015	0.514	0.495	0.472	0.414	0.454	0.556	0.442	0.564	0.502	0.529
2016	0.416	0.483	0.473	0.41	0.404	0.537	0.387	0.507	0.404	0.521
2017	0.408	0.509	0.468	0.389	0.415	0.561	0.401	0.494	0.497	0.561
2018	0.498	0.517	0.402	0.393	0.384	0.512	0.464	0.435	0.503	0.484
2019	0.464	0.450	0.373	0.402	0.404	0.450	0.448	0.408	0.526	0.438
2020	0.467	0.499	0.393	0.431	0.406	0.529	0.426	0.448	0.480	0.495
2021	0.478	0.505	0.409	0.405	0.409	0.501	0.491	0.395	0.503	0.441
2022	0.709	0.626	0.478	0.556	0.546	0.530	0.490	0.488	0.465	0.470

3.2.1. Temporal Evolution Characteristics of the Coupling Coordination Degree of the LEL System in Wuyishan National Park

The coupling coordination degrees of the LEL system of the 10 counties in Nanping City demonstrated varying trends and fluctuation ranges from 2008 to 2022 (Figure 6). Within this group, Wuyishan, Jianyang, Shaowu, and Pucheng exhibited a distinct rise in coupling coordination levels between 2008 and 2022, with Wuyishan shifting from near imbalance to intermediate coordination. Jianyang had the second-highest increase, moving from near imbalance to primary coordination. In 2022, Guangze, Pucheng, Songxi, Zhenghe, and Jian'ou were on the brink of imbalance. Moreover, Shaowu, Yanping, and Shunchang were in a state of slight coordination, while Jianyang was in a primary coordination state. Finally, Wuyishan was in a state of intermediate coordination. From 2008 to 2022, excluding a slight decline in the coupling coordination degree of the LEL system in Zhenghe, the coupling coordination degrees in the other nine counties all exhibited varying degrees of increase.

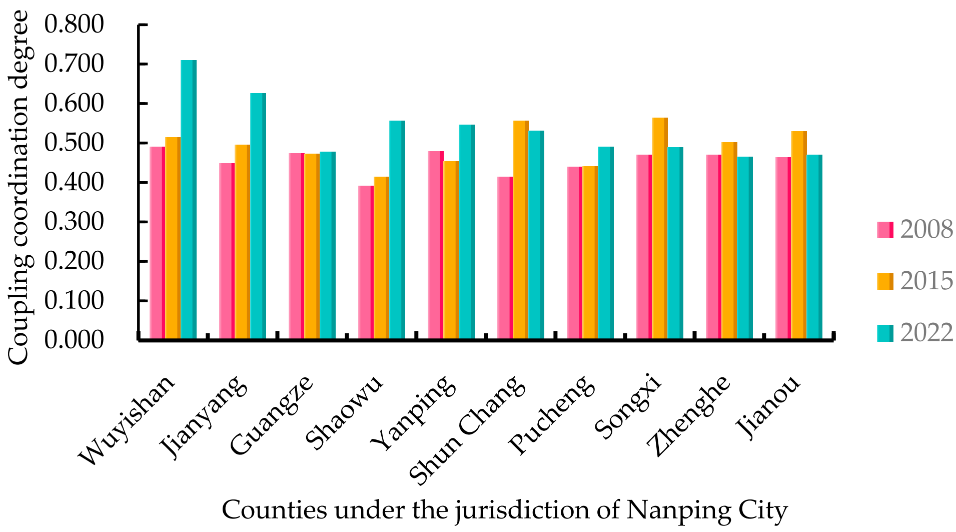

Figure 6. The temporal evolution of the coupling coordination degree in the counties of Nanping City.

3.2.2. Spatial Evolution Characteristics of the Coupling Coordination Degree of the LEL System in Wuyishan National Park

From 2008 to 2022, the overall coupling coordination degree of the LEL system of the 10 counties under the jurisdiction of Nanping City exhibited an upward trend (Figure 7). Throughout the preparatory construction period of Wuyishan National Park between 2015 and 2022, there was a notable rise in the coupling coordination degree. Within this group, Wuyishan experienced the most significant surge, with the coupling coordination degree escalating from 0.514 to 0.749. Beginning in 2015, as the coupling coordination degrees across different regions increased, the disparities in coupling coordination degrees at the regional level likewise expanded. The Wuyishan National Park, encompassing Wuyishan, Jianyang, and Shaowu, experienced a notable rise in the coupling coordination degree, averaging a growth rate of 0.113. Wuyishan shifted from near imbalance to intermediate coordination, Jianyang evolved from near imbalance to primary coordination, and Shaowu evolved from mild imbalance to slight coordination. The total coordination level among Nanping City's counties (Guangze, Yanping, Shunchang, Pucheng, Songxi, Zhenhe, Jian'ou) increased by 0.029, which was markedly less than that in Wuyishan National Park. Among them, Shunchang had the largest increase in the coupling coordination degree, reaching 0.115. Guangze and Jianou experienced the smallest increase with stable coupling coordination degrees, while that of Zhenghe slightly decreased.

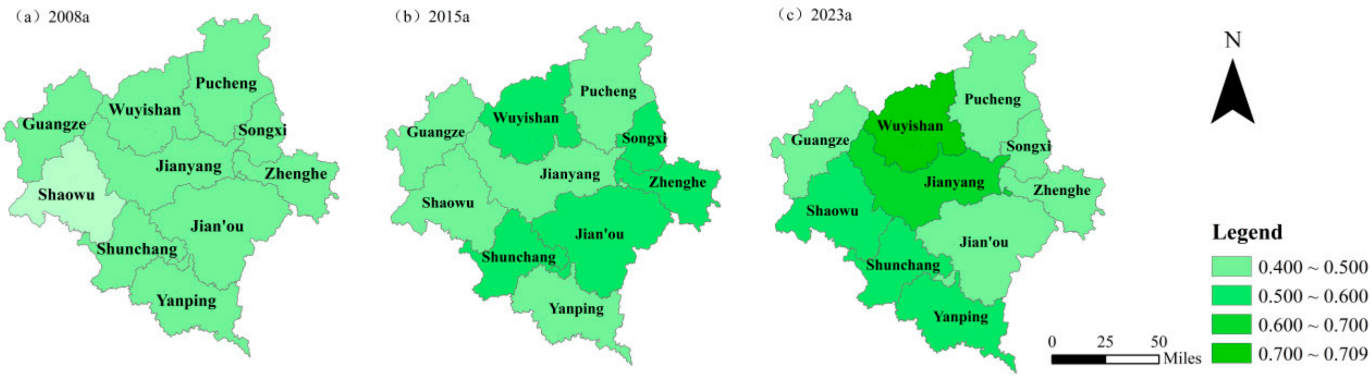

Figure 7. The spatial evolution of the coupling coordination degree in the counties in Nanping City.

3.3. How Establishing National Parks Affects the Coordination of Regional Connections

To explore whether the establishment of Wuyishan National Park has enhanced the coupling coordination of the regional LEL system, the 10 counties in Nanping City from 2008 to 2022 were taken as dependent variables. The establishment of Wuyishan National Park was taken as the key variable, and the regional GDP, permanent population, urbanization rate, and Engel coefficient were used as control variables. The regression results are reported in Table 4.

Table 4. The regression analysis results.

Variable	Coefficient	Standard Error	*t*-Test	*p*	Coefficient 95% Confidence Interval	
					Upper Limit	Lower Limit
Constant	0.506	0.027	19.040	0.000 ***	0.454	0.559
National park established or not	0.038	0.010	3.720	0.000 ***	0.018	0.059
GDP	0.001	0.001	2.050	0.042 **	0.000	0.003
Regional permanent population	−0.008	0.005	−1.680	0.094 *	−0.017	0.001
Urbanization rate	−0.118	0.060	−1.970	0.050 *	−0.236	0.000
Engel's coefficient	0.001	0.001	2.390	0.018 **	0.000	0.002

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Findings from the regression analysis reveal that the creation of the national park has had a significantly positive impact on the coupling coordination degree of the LEL system in the region. The regional GDP and Engel coefficient were found to positively influence this coupling coordination degree, whereas the permanent population and urbanization rate of the area were found to adversely affect it.

The establishment of the national park has significantly improved the coupling coordination of the LEL system of the 10 counties under the jurisdiction of Nanping City. One possible explanation for this is that the establishment of Wuyishan National Park has led to the stricter implementation of local environmental protection and land-use policies, while also continuously strengthening the green development awareness of local residents. This has resulted in more scientific and efficient land use in the region, more sustainable economic development, and continuous improvement in the quality of the ecological environment. Moreover, the increases in the regional GDP and Engel coefficient have enhanced the coupling coordination degree. A possible explanation for this is that the increase in regional GDP has enhanced the score of the sustainable livelihood subsystem of residents while also reflecting the coordinated utilization of land, thus improving the coupling coordination degree of the system. The Engel coefficient measures the living standards and happiness of residents [32]; the higher the Engel coefficient, the higher the indicators of capital in the sustainable livelihood subsystem, and the higher the coupling coordination degree of the LEL system. The increases in the region's permanent population and urbanization rate have lowered its coupling coordination degree. This can possibly be explained by the increase in the permanent population exerting excessive pressure on the land-carrying capacity, leading to a decrease in the land subsystem score. Furthermore, the increase in population has also increased the pressure on and destruction of the ecological environment, thereby reducing the coupling coordination degree of the overall system. The increase in the urbanization rate implies population migration to urban areas, which is not conducive to land production and ecological functions, sustainable livelihoods, or environmental protection.

The counties under the jurisdiction of Nanping City were divided into two groups based on their distance from the national park, and the model was then regressed. The regression results are reported in Table 5. The establishment of the national park was found to have a significant positive impact on the coupling coordination degrees of cities closer to the national parks, while the impact on cities further away from the national parks was not highly significant. This indicates that the establishment of national parks has a radiating effect on the coupling coordination degree of the LEL system in the surrounding areas. This verifies that the establishment of national parks has a spatial spillover effect on surrounding cities, and the closer a city is to the national park, the more significant the spatial spillover effect.

Table 5. The results of the grouped regression analysis.

Variable	"Near National Park" Group	"Far from National Park" Group
National park established or not	0.000 ***	0.062 *
GDP	0.331	0.071 *
Regional permanent population	0.085 *	0.238
Urbanization rate	0.013 **	0.003 **
Engel's coefficient	0.268	0.081 *
Constant	0.994	0.000 ***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4. Discussion

4.1. Changes in the PLES Pattern of Wuyishan National Park

The findings show that the space for agricultural production in Wuyishan National Park has steadily increased over the past 15 years, which may be attributed to the fact that the Wuyishan National Park Authority advocates for the preservation of space for agricultural production without encroaching on ecological space. This conclusion further supplements the research findings of Zhu et al. [33], whose study indicated that the proportion of cultivated land in Wuyishan National Park decreased from 13.4% to 9.7% between 2010 and 2020, a decrease of 10,190 hm^2. The agricultural production space in Wuyishan National Park mainly includes cultivated land and tea gardens, further demonstrating that the tea garden area has expanded since the establishment of the park, leading to an overall increase in the agricultural production space. This conclusion is consistent with existing findings [34]. Possible reasons for this could be that in the early 21st century, the local government required the large-scale destruction of tea seedlings, and later, with the continuous adjustment of the economic structure, the area of the tea gardens expanded. Overall, the PLES pattern in Wuyishan National Park underwent significant changes from 2008 to 2015 and stabilized from 2015 to 2023, aligning with previous research findings.

4.2. Changes in the Coupling Coordination Degree of the LEL System in Nanping City

The general trend of the changes in the coordination of the LEL system in Nanping City is consistent with the findings of previous studies [35], but differences in spatiotemporal heterogeneity were found as compared to Hou et al. [36]. Their study pointed out that since the outbreak of the COVID-19 pandemic, the sustainable livelihood level of residents in Wuyishan National Park has decreased. The discrepancy in the findings is possibly due to the different research areas and survey methods utilized. The impact of the COVID-19 pandemic on the natural capital, material capital, and financial capital of community residents in Wuyishan National Park was significant, leading to a decline in the sustainable livelihood level of residents in the park. The nearby areas of the national park had stronger resilience against the damage to natural and material capital, resulting in a relatively stable sustainable livelihood level for residents. This study's findings of the overall characteristics and trends in temporal and spatial changes are in line with existing research [35,37]. This research also provides theoretical references for the targeted formulation of policies in different counties in Nanping City and offers ideas and references for the development of other national parks.

4.3. How Establishing National Parks Affects the Level of Coordination in Regional LEL Systems

The grouped regression model revealed that the creation of the national park strengthened the coordination of the regional LEL system, with significant positive spatial spillover effects. Wang et al. revealed that the founding of the Three Rivers Source National Park markedly enhanced the environmental integrity of the park and its neighboring regions and alleviated the economic strain on farmers and herdsmen [38]. Dou et al. indicated that national parks foster a logical, balanced, and systematic pattern of national land conservation, promoting peaceful coexistence between people and the natural world [39]. The study by Cumming et al. revealed that the creation of Canadian national parks enhanced the ecological interconnectivity in the area [40]. The present work largely aligns with prior studies while showcasing innovative research approaches, assessing the extensive effects of national park establishment on the land, economy, and ecosystems of nearby regions, and integrating geography and socio-economics to enhance its comprehensiveness.

5. Conclusions

Studies indicate that over the last 15 years, forest ecological space has been the predominant spatial category in Wuyishan National Park, with an average of 92.91%. In addition, there exist areas designated for grasslands, agriculture, and water, as well as rural and urban living spaces. The amount of living areas in both urban and rural settings, along with water-based ecological spaces, is steadily diminishing. According to land transfer matrices, there has been a steady growth in the area dedicated to agricultural production, with more than half of the land changing from urban residences to agricultural zones.

From 2008 to 2022, temporal phases and spatial heterogeneity were present in the development of the coupling coordination of the LEL system in the 10 districts in Nanping

City. Temporally, since the preparation and construction of the national park in 2005, there has been a significant increase in the coupling coordination of the area, with the scores of the land, environment, and residents' livelihoods in the 10 districts exhibiting upward trends. Spatially, the increase in the coupling coordination degree was found to decrease with the increase of the distance from the region to the national park. One possible explanation for this is that the establishment of Wuyishan National Park has greatly promoted local tourism, which has boosted the level of economic development [41]. Additionally, the implementation of various protection policies has increased the rigor of environmental protection, leading to a noticeable improvement in ecological quality. Specifically, on the one hand, due to the different distances between various cities and counties and Wuyishan National Park, which have varied levels of economic development, ecological conditions, and land-use degrees, the establishment of the park has had regionally heterogeneous impacts on the coupling coordination degree of the LEL system in each area. On the other hand, since the preparation and construction of Wuyishan National Park in 2015, all protection policies have adhered to the new development concepts of innovation, coordination, green, openness, and sharing. This has continuously enhanced the coupling coordination degree of the regional LEL system, which has exhibited a clear temporal stage as compared to the period of 2008–2015.

The establishment of national parks significantly increases the coupling degree of the LEL system in the neighboring areas, and the closer the area is to the national park, the greater the increase in the coupling degree. This verifies that the establishment of national parks has a significant spatial spillover effect on the coupling and coordinated development of the neighboring areas.

6. Suggestions

6.1. How to Enhance the Efficiency of the Production–Living–Ecological Functions of Land

Initially, the structure of the agricultural industry should be actively adjusted to fully leverage the production function of the land. The development of emerging green industries should be promoted in a targeted manner. In regions closer to the national park, like Wuyishan and Jianyang, the utilization of the distinctive branding and natural landscapes of the park can enhance health and leisure tourism, establish unique homestays and health and leisure parks, and slightly increase the production capacity of the service industry. In regions distant from the national park, like Shaowu and Yanping, the abundant forest resources can be harnessed to enhance the underforest economy, grow unique products, and further solidify the conventional bamboo and red tea production industries, thereby increasing product value.

Second, regional public service facilities and infrastructure should be enhanced while emphasizing the role of the land in living functions. The design of urban development areas should be enhanced, and the building of public amenities like senior care facilities, elementary education facilities, and healthcare centers should be upgraded. Moreover, the development of public parks should be bolstered. Urban transit zones should be strategically developed, transit ease should be improved, and urban greenery and landscape design should be concurrently fortified with an emphasis on managing urban noise.

Third, the safeguarding of water-based ecological areas within Wuyishan National Park should be enhanced, and a strategy for sustained water management and safeguarding should be developed. The execution of projects aimed at safeguarding wetlands should be improved, and ecological passageways should be established. It is also imperative for the relevant department of the national park to routinely inspect water zones and their quality, swiftly grasp ecological shifts, and document the factors that affect them. Conversely, it is crucial to engage local inhabitants in executing water conservation efforts, investigating various collaborative methods, and appointing indigenous individuals to oversee the national park, thus enabling them to assume duties like overseeing water quality and directing tourist activities.

6.2. How to Improve the Quality of the Ecological Environment

Initially, focus should be placed on fortifying the infrastructure of Wuyishan National Park to improve its radiation efficiency and overall reach. The current natural scenery should be utilized to its fullest potential, and the construction of eco-friendly structures like greenways, wetlands, and rain gardens in the national park should be advocated. Forest areas should also be expanded, and the cultivation and safeguarding of indigenous plants should be bolstered. The safeguarding of wildlife habitats and wetlands should be increased, and protective barriers like fences and nets should be erected. Moreover, the construction of blue and green rooftops in the national park should be championed, compact water storage systems should be created on these roofs, and vegetation should be expanded to optimize the park's advantages.

Additionally, collaboration must be enhanced between Wuyishan National Park and the neighboring regions to foster synchronized growth in land, economic, and ecological aspects in those areas. Drawing from the traits of Wuyishan National Park and adjacent regions, specific plans for synchronized development should be formulated to bridge the disparity in coordinated development across different areas in Nanping City. In the case of Wuyishan and Jianyang, the implementation of ecological compensation can boost the drive for ecological conservation and sustainable practices. In other regions of Nanping City, increased investment in environmental safeguarding and the bolstering of environmental surveillance, management, and restoration efforts are crucial for the betterment of the ecological landscape.

6.3. How to Promote Sustainable Livelihood Development for Residents

Initially, the prioritization of the safeguarding and enhancement of human, material, and social capital within the region, along with the elevation of the educational standards of the workforce, is crucial. By implementing favorable policies, forming top-notch teams for management and technological innovation, and fostering the synchronized and enduring growth of Wuyishan National Park, local authorities can lure research experts and high-level management staff. Educational assets in and near the conservation zone can be combined [42], and assistance and favorable strategies for educating children from underprivileged backgrounds should be offered. This will elevate the region's educational quality and uplift the populace's standard of living.

Next, advocating for the creation of eco-friendly tea gardens would foster the collective growth of the ecological economy. Tea cultivation on the land serves both agricultural and environmental roles, and because the tea sector is a hallmark of Wuyishan National Park, it would attract the villagers' keen interest. Presently, the majority of tea cultivators cultivate tea primarily due to its substantial economic advantages [2,43], often overlooking its ecological safeguarding impact. Therefore, the national park management department must amplify awareness about ecological conservation, raise local consciousness about eco-friendly development, delve deeper into methods to encourage the refurbishment of tea mountains and the creation of ecological tea gardens, and prevent indiscriminate growth. Local tea gardens can be employed for scientific purposes, the growth of eco-friendly sectors like tea, tourism, and lodging can be steered, and mutually beneficial economic safeguarding and environmental advancement can be persistently fostered.

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