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The Comprehensive Management Zoning of Mountains, Rivers, Forests, and Farmlands Based on Element Recognition

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Abstract: Land subsidence, soil erosion, and landscape fragmentation frequently occur in regions of backward production capacity. Therefore, it is imperative to carry out efforts for ecological restoration in these mine-closed regions. The proposal of holistic conservation of mountains, rivers, forests, farmlands, lakes, grasslands, and deserts provides important guidance for ecological restoration. To support the governance of regional ecology, this paper aims to discuss the layout of element governance zoning in four southern towns of Qijiang District, Chongqing. SBAS-InSAR technology, vulnerability assessment, linear trend analysis, and suitability evaluation were used to divide the mountain, water, forest, and farmland management areas. Regional comprehensive management work was implemented according to the severity of each element's existing ecological questions. Eventually, a comprehensive management pattern of mountains, rivers, forests, and farmlands can be obtained. The results show that the mountain management area is 8.03 km^2 (3.24% of the total management area), the hydrological management area is 212.07 km^2 (85.80% of the total management area), the forest management area is 7.04 km^2 (2.84% of the total management area), and the farmland management area is 20.07 km^2 (8.12% of the total management area). In light of the current circumstances, this study advocates for the implementation of three integrated governance approaches, with a focus on managing hydrological factors. These approaches include ridge-based mountain, water, and forest governance, valley-based mountain, water, and farmland governance, and undergrowth economy-based water, forest, and farmland governance. This study explores the spatial layout and priority of the governance areas from the perspective of elements, which provides a new development direction for the current research on the life community based on policy analysis.

Keywords: life community; element recognition; comprehensive treatment; ecological restoration; region of the backward production capacity

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1. Introduction

Backward production capacity mainly refers to the production capacity whose equipment, technology, and output lag behind the average level of the industry and whose negative impacts outweigh the positive impacts. Mining areas are the most typical regions of backward production capacity. In recent years, ecological restorations have gradually become a hotspot of concern in the world, especially in eliminating districts of backward production capacity [1]. President Xi Jinping put forward "Mountains, Rivers, Forests, Farmlands, Lakes, Grasslands, and Deserts Life Community" at the 20th National Congress of the Communist Party of China (CPC). This is not only a profound summary of the law with ecological civilization construction but also a guideline for ecological governance in the new era [2]. The life community means that the elements of mountains, waters, forests, farmlands, lakes, grasses, and sands are integral organisms [3]. Their presence is a mutually symbiotic, dependent, and complementary relation. Farmland crops primarily depend on water irrigation and often originate from mountainous areas. Rocks and soil build up to form mountains, and vegetation such as forests helps preserve soil and water resources.

These elements collectively also constitute the natural system that human beings rely on for survival and that provides natural products and ecological services [4]. The essence of this theory is not limited to these few elements but can be essentially understood as encompassing all natural resources essential for human survival. It can be "Mountains, Rivers, Forests, Farmlands, Lakes, Grasslands and Sands" or "Mountains, Rivers, Forests, Farmlands, Lakes, Grasslands and Ices". In summary, it can be characterized as "Mountains, Rivers, Forests, Farmlands, Lakes, Grasslands and +". This concept was first proposed in China in 2013, and other countries have limited research on this concept. However, studies with similar connotations do exist, such as "nature-based solutions" and "integrated ecosystem management".

In the Horizon 2020 program of the European Union in 2013, the concept of "nature-based solutions" was defined as "living solutions inspired by, continuously supported by, and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits". [5] Subsequently, at the 2016 World Conservation Congress, nature-based solutions were further defined as "actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits [6]". In essence, nature-based solutions emphasize the use of natural, ecosystem-based approaches [7,8] to restore and transform nature to achieve sustainable utilization of ecological resources [9]. Since its inception, this concept has been widely applied in various aspects, such as the development of the ecological industry [10–12], ecological conservation and restoration [13–15], and urban environmental planning [7,16,17]. It is similar to the mountains, rivers, forests, farmlands, lakes, grasslands, and sands in terms of goals, emphasizing the need to balance nature, society, and economy to achieve sustainable development of humanity. However, in terms of connotations, the concept of life community not only emphasizes the relationship between humans and nature but also illustrates the connections and interactions among various ecological elements, depicting a systemic view of "ecosystem-subsystem-ecological elements". On the other hand, nature-based solutions focus more on the harmonious coexistence between humans and nature, emphasizing the imitation of ecosystems while neglecting the study of ecological elements.

An alternative theory similar to the life community of mountains, rivers, forests, farmlands, lakes, grasslands, and sands is Integrated Ecosystem Management (IEM) [18]. Margerum [19] argues that integrated ecosystem management serves as a tool for the holistic management of environmental regions, aiming to facilitate the construction of a coupled, coevolving social-ecological system [20]. Therefore, the theory is often regarded as a management tool that focuses on ecosystem management mechanisms. Its scope can be broadly divided into research on management subjects [21–23], research on management techniques [24–26], and the design of management strategies [27–29]. The IEM is more mechanism-oriented, highlighting the overall management process. In contrast, the "mountains, rivers, forests, farmlands, lakes, grasslands, and sands" approach prioritizes the means and techniques of management.

The theory of life community is proposed as a great practice of socialism with Chinese characteristics. On the one hand, it focuses more on the intricate and complex network of components within the ecosystem than other theories. On the other hand, it emphasizes comprehensive management and system restoration, which requires undertaking comprehensive restoration efforts to enhance the ecosystem's service functions based on diagnosing prominent ecological issues in the region. Currently, research on the life community in China primarily focuses on theoretical analysis, emphasizing its conceptual features, technical methods, and practical approaches. In terms of conceptual characteristics, there is a consensus on the fundamental understanding of this concept, which serves as the foundation for this study. In terms of technical methods, many studies with the life community at the core of theory virtually explore the enhancement of ecosystem service functions. Although this aligns with the objectives of the life community, aiming to improve

the quality of the ecological environment, these studies have yet to highlight the role of elements within the system. In practice, China has implemented 44 Shan-Shui Initiatives (the integrated restoration projects of mountains, waters, forests, farmlands, and lakes) since 2016. These pilot areas serve as the main subjects of research about experiences. Summarizing the involved pilot projects, they primarily focus on the protection of important ecosystems, water environment management, land restoration and regulation, ecological restoration of mining areas, and biodiversity conservation. Although these efforts have achieved some success in environmental restoration, there remains a lack of systematic understanding of the life community and scientific assessment of ecological issues.

In conclusion, research on the life community is still in its early stages and has yet to establish a universally recognized mechanism or procedure. This lack of consensus on this theory hampers the widespread dissemination of its ideas and associated methods. Consequently, this paper aims to conduct an objective and scientific quantitative study from the perspective of element identification to provide a new reference for the technical approach to achieving a comprehensive mountain, water, forest, and farmland life community. Element identification, as referred to in this paper, denotes the systematic process of scientifically diagnosing specific natural resources. Unlike previous ecological restoration efforts, it places more emphasis on the components of ecosystems. This approach allows for a more precise delineation of problem areas and improved efficiency of governance work while also facilitating the harmonious development of ecosystems through its comprehensive perspective.

One of the key focus areas for ecological management and economic transition is the eliminating region of backward production capacity. The traditional extraction and mining processes of outdated production capacity frequently lead to extensive ecosystem damage, posing a significant threat to the region's sustainable development. Therefore, there is an urgent need to carry out ecological restoration work. This paper selects the areas with backward capacity as the primary research object. To efficiently complete the ecological restoration project, we conducted an identification study with the main ecological elements of mountains, waters, forests, and farmlands in the study area. By diagnosing the ecological issues associated with these elements, areas with ecological risks were identified and designated as single-element governance zones. Subsequently, the areas of comprehensive governance are formed based on the severity of damaged areas caused by ecological elements. In a word, this paper aims to promote ecological restoration efforts in regions with outdated production capacities by establishing comprehensive management zones for mountains, waters, forests, and farmlands. This approach to element identification is not only beneficial for targeted solutions to regional environmental issues and the improvement of governance efficiency but also provides insights into new paths for transitioning towards green development during the restoration process. Furthermore, unlike previous concepts of ecological restoration, the research perspective of life community also represents a unique approach within the context of socialism with Chinese characteristics. It not only enriches the understanding of ecological restoration but also provides valuable Chinese experiences for global ecosystem construction.

2. Materials and Methods

2.1. Study Area

The four towns of Ganshui, Anwen, Datong, and Shihao are located in the southern part of Qijiang District, Chongqing Municipality (106°32′ E–106°52′ E, 28°26′ N–28°47′ N), as shown in Figure 1. With a total area of 528.04 km^2, this region comprises 20 communities and 57 villages. As the intersection area of the "Chengdu–Chongqing economic circle" and the "Chongqing–Guizhou Economic Belt", these towns have a rich history of coal mining spanning over 70 years. With a cumulative coal production of nearly 900 million tons and a total output value exceeding CNY 112 billion, they have emerged as significant contributors to the coal industry in China, ranking among the top 100 coal-producing counties in the country.

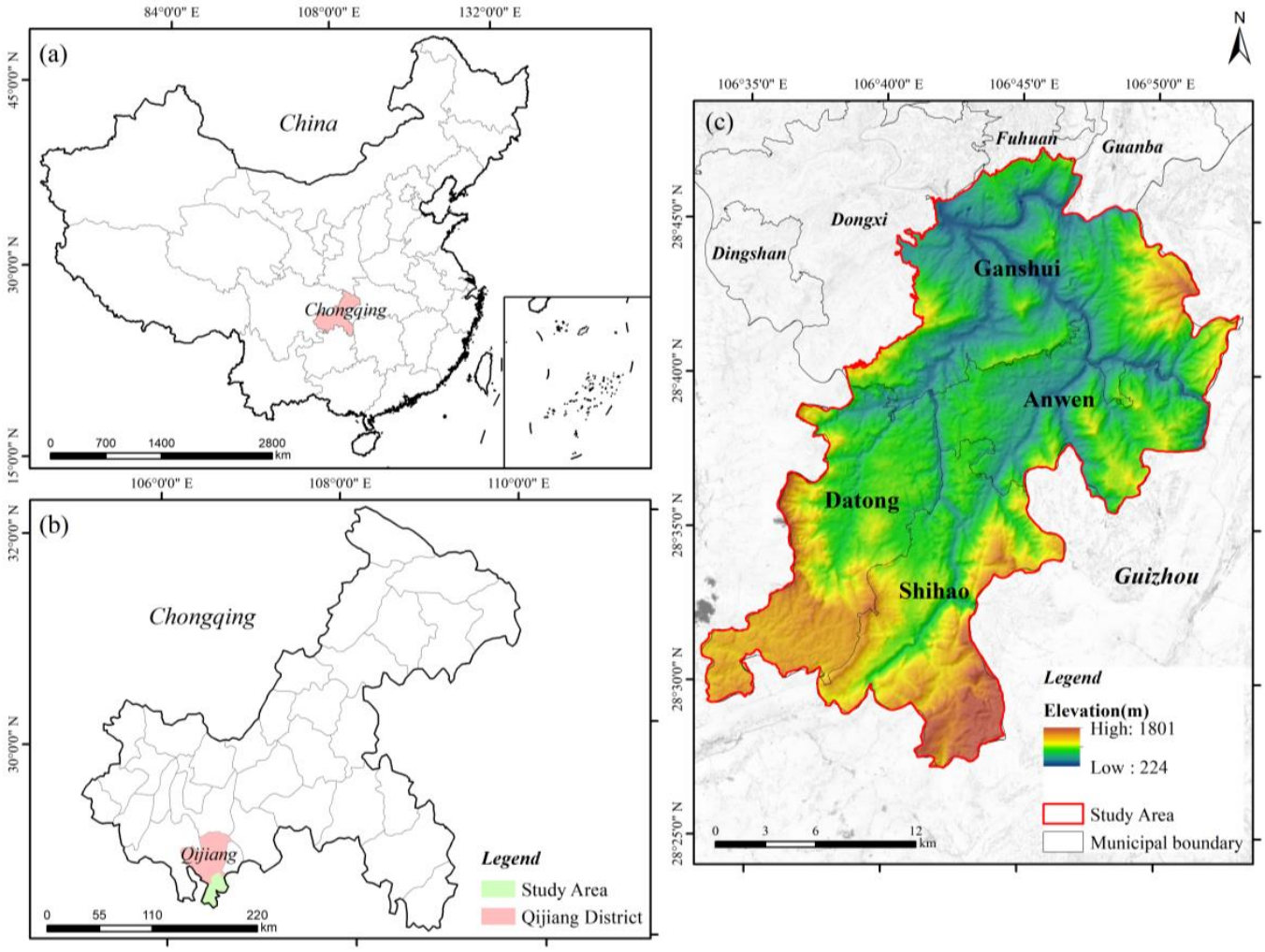

Figure 1. The location of the study area: (**a**) location of Chongqing Municipality in China; (**b**) location of Qijiang District in Chongqing; (**c**) location of the study area in Qijiang with altitude.

Following the complete closure of mines in 2021, there is an area of nearly 218 km^2 affected by coal mining subsidence and its impact. The pollution caused by coal waste, such as coal gangue, covers an area of approximately 150 km^2, while the suffering from severe soil erosion covers an area of 70 km^2. Furthermore, more than 95% of the rivers in the subsidence area are affected by mining wastewater pollution. A series of issues, including surface cracking, soil contamination, and depletion of water sources, pose a severe threat to sustainable development [30]. In this context, it becomes crucial to establish a comprehensive governance plan for the mountains, waters, forests, and farmlands life community in the research area.

2.2. Data

2.2.1. Data Sources

The identification of mountain elements utilizes Sentinel-1A radar satellite imagery provided by the European Space Agency (ESA) from February 2017 to December 2021, totaling 30 images. The detailed parameters of the satellite images utilized can be found in Table 1. Additionally, NASA's Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data with a resolution of 30 m are employed to eliminate interference from terrain phase information.

Table 1. Basic parameters of Sentinel-1A data in the study area.

Orbit Direction	Band/Wavelength (cm)	Spatial Resolution (m)	Viewing Angle (°)	Polarization Mode	Revisit Period (days)
Ascending	C/5.65	20	39.20	VV	12

For the identification of hydrological elements, the data primarily originate from various sources, including the "14th Five-Year Plan" for water security in Qijiang District, the statistical yearbook of Qijiang District in 2022, the High-Resolution Mountain Environment Mapping Program (China's 30 m resolution annual precipitation dataset), and the Underground Water Resources Information Service Network (underground water environmental map of Chongqing).

In the delineating areas of forest governance, the data are derived from the 30 m annual maximum NDVI dataset in China from 2000 to 2020, provided by the Remote Sensing Team of Land Use and Global Change Research Institute, Chinese Academy of Sciences [31].

For delineating areas of farmland governance, the data mainly include geographic information data and socio-economic data. Geographic information data are primarily obtained from online sources, while socio-economic data are sourced from the statistical yearbook of Qijiang District. Detailed data sources can be found in the table of the constructed evaluation indicator system.

2.2.2. Data Processing

In the delineation of mountainous areas, it is necessary to download SAR images from February 2012 to December 2021. Based on the study area, SAR information within the four southern towns was extracted using cropping. These data were imported into ENVI 5.6 in advance to obtain format data suitable for conducting SBAS-InSAR analysis directly.

In the delineation of water and farmland management zones, the primary task involved conducting evaluations of specific elements. It required data to be dimensionless. The method mainly adopted in this study was range normalization. Subsequently, a comprehensive evaluation was conducted based on specific weighting methods.

In forest management zoning, NDVI information within the study area was extracted using cropping. This allowed for the subsequent performance of a linear trend analysis based on the extracted data.

2.3. Research Methods

2.3.1. Identification of Mountain Element: SBAS-InSAR

Governance zoning of mountain elements can be achieved through the use of Synthetic Aperture Radar (SAR) technology [32]. As one of the earliest remote sensing techniques employed for surface-deformation monitoring, the interferometric processing technique of single temporal has been widely utilized [33–35] due to its wide monitoring range and high efficiency [36]. However, it still faces the problems of temporal and spatial decorrelation and atmospheric delay [37].

In this context, time series analysis techniques have been further developed, the most typical of which are Persistent Scatterer (PS-InSAR) and Small Baseline Subset (SBAS-InSAR). Among them, the PS-InSAR technique is a typical point target algorithm. It usually selects ground objects with strong reflection characteristics and stable scattering features (such as roads, houses, dams, bridges, and exposed rocks) as PS points. Based on these PS point targets, phase analysis is performed on time series to obtain deformation information on each point on the ground. Therefore, its application is mostly focused on urban areas, towns, and other places with low vegetation cover [38–40].

While the SBAS-InSAR technique is a typical distributed target algorithm, it utilizes existing SAR image datasets and sets thresholds for temporal and spatial baselines. It generates multiple subsets using free combinations and applies the least squares method to extract deformation information within each subset. The subsets are jointly solved using

singular value decomposition (SVD), ultimately obtaining surface deformation information. In SBAS-InSAR, the distributed targets are generally objects with weaker scattering characteristics compared to permanent scatterers, and natural surfaces can be selected as the study area.

Although the study area in this article belongs to a rural township, it is crucial to consider the high vegetation coverage in the southwestern mountainous region, which can affect the reflection and scattering characteristics of ground points. These can result in insufficient high-coherence points in PS-InSAR and introduce errors in the obtained information on surface deformation. In summary, the SBAS-InSAR technique was chosen as the preferred method for surface deformation monitoring in the four towns of the southern region of Qijiang District. The specific operational workflow in the SBAS-InSAR technology is illustrated in Figure 2 [41–43].

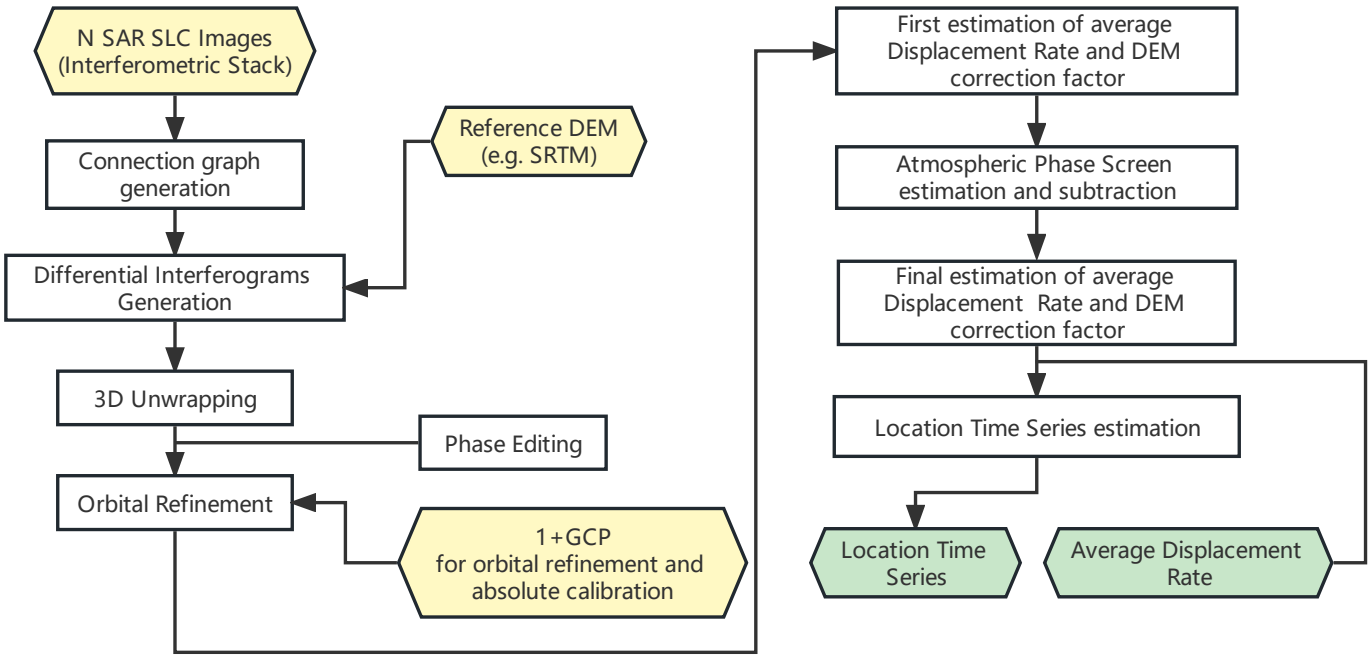

Figure 2. The processing flow of SBAS-InSAR technology is mainly divided into connection graph, interferometric process, inversion of first step, inversion of second step, and geocoding.

In practice, to reduce temporal and spatial decorrelation, thresholds of 2% and 180 days were set as the maximum spatial baseline and time baseline, respectively. Under these conditions, 69 sets of interferometric pairs were generated, and the image taken on 20 August 2019 was selected as the master image. Subsequently, interferometric stacking processing was applied to several pairs of images, and high-resolution Digital Elevation Model (DEM) data was employed to eliminate terrain phase interference. Multi-looking with a ratio of 1:4 and Goldstein filtering were applied to suppress spatial noise and improve the signal-to-noise ratio. Due to the dense vegetation on the mountainous surface in the Chinese southwestern region, the 3D unwrapping method was used to reconstruct lost information and minimize the influence of phase discontinuities. To further enhance the research results, atmospheric effects were removed. It involved setting atmospheric high-pass and low-pass filters of 365 days and 1200 meters, respectively. By following the aforementioned procedures, the final results of surface deformation in the vertical direction can be obtained.

2.3.2. Identification of Hydrological Element: Water Resources Vulnerability Assessment

Currently, research on hydrological elements can primarily be categorized into three aspects: carrying capacity [44–46], vulnerability [47–49], and pollution conditions [50–52].

Carrying capacity primarily focuses on quantifying the total amount of water resources within a given time and spatial scope. Pollution conditions primarily address the detrimental effects on water quality caused by specific chemical substances. Vulnerability assessment not only considers water pollution resulting from human activities but also emphasizes the influence of the natural environment on water systems. By assessing vulnerability, decision makers can gain valuable insights into the resilience and adaptability of water systems and identify priority areas for governance. Considering the objectives set by governance zoning, this study focuses on a problem-oriented vulnerability assessment of water resources. First, the entropy weight of the indicator was calculated using the formula. Based on the results of entropy weight, an importance comparison between indicators was carried out to create a judgment matrix in the Analytic Hierarchy Process (AHP). According to the obtained judgment matrix, the optimized weights were obtained through consistency tests in MATLAB 2016b. Finally, by multiplying and summing the standardization indicators with their corresponding weights using the ArcGIS raster calculator tool, the evaluation results could be obtained. The specific research steps are as follows:

1. Construction of evaluation indicator system

A vulnerability assessment of water resources is an important means to evaluate the security of regional water resources and predict potential issues that may arise in the future [49]. Referring to existing research results, we will start from three aspects: natural vulnerability, human vulnerability, and burdening vulnerability [53], and construct an evaluation indicator system as shown in Table 2.

Natural vulnerability generally refers to the inherent sensitivity of a water resource system, which is difficult to alter with human activities. It manifests as static characteristics of water resources. In this system layer, annual precipitation is chosen to represent the supplementary degree of rainfall for water resources; the rate of change in annual precipitation represents the inter-annual variation of water resources; groundwater quality and vulnerability indicate the sensitivity of groundwater resources; and the consumption rate of ecological water represents water usage for urban forests and vegetation greening.

Human vulnerability refers to the degree to which human activities affect and alter the structure of a water resource system, and it manifests as dynamic characteristics. In this system layer, domestic water consumption and the water consumption for primary, secondary, and tertiary industries are selected to represent the impact of industrial structure on water resource utilization; the capacity of the total reservoir and the water availability from water diversion projects represent the human capacity to overcome uneven spatial distribution of water resources.

Burdening vulnerability refers to the sensitivity of a water resource system to human activities or external disturbances while performing its functions. In this system layer, water consumption per capita and water consumption per GDP 10,000 represent the pressure exerted by human economic activities, and wastewater discharge represents irrational behavior during the utilization of water resources.

2. Optimization Method of Entropy Weight

The optimization method of entropy weight refers to the integration of the entropy weight method and the Analytic Hierarchy Process (AHP) for weighting evaluation criteria. The principle of this method is to pairwise compare the weight results obtained from the entropy weight method and use them as judgment matrices derived from expert ratings in the AHP. This is carried out to eliminate the influence of subjective factors. The specific steps are shown below [54].

(1) Data standardization: To eliminate the influence of different dimensions among evaluation criteria, this paper adopts the method of range normalization for dimensionless processing.

Table 2. Evaluation index system of water resource vulnerability for the four towns in the southern Qijiang District.

Objective Level	System Level	Indicator Level	Unit	Calculation Method	Nature	Entropy Weight	Optimized Weight
Vulnerability of water resources	Natural vulnerability	Annual precipitation	mm	Extracted from Chongqing's annual rainfall in 2021	+	0.0317	0.0364
		Rate of change in annual precipitation	%	Annual precipitation/30-year average precipitation	−	0.0794	0.0697
		Groundwater quality		4 for potable groundwater; 3 for groundwater suitable for drinking after proper treatment; 2 for groundwater suitable for agricultural and industrial use but not for direct consumption; 1 for groundwater not suitable for direct utilization	+	0.0139	0.0148
		Groundwater vulnerability		Vulnerable area is designated as 0; relatively vulnerable area is designated as 1	+	0.375	0.403
		Consumption rate of ecological water	%	(Urban green space ecological water consumption + urban environmental sanitation water consumption)/total water consumption	−	0.0575	0.0504
	Human vulnerability	Water consumption of domestic	10,000 m^3	(Urban population × per capita water consumption quota for urban residents + rural population × per capita water consumption quota for rural residents)/water utilization coefficient	−	0.0410	0.0399
		Water consumption of primary industry	10,000 m^3	Water consumption for agriculture + water consumption for orchards + water consumption for fishpond replenishment + water consumption for livestock breeding	−	0.0388	0.0399
		Water consumption of secondary industry	10,000 m^3	Water consumption for industry + water consumption for construction industry	−	0.0385	0.0399
		Water consumption of tertiary industry	10,000 m^3	Added value of the tertiary industry × water consumption quota per CNY 1 million of value added in the tertiary industry	−	0.0397	0.0399
		Capacity of total reservoir	m^3	Data obtained from town planning reports	+	0.0487	0.0454
		Water availability from water diversion projects	10,000 m^3	Data obtained from Chongqing's 14th Five-Year Water Security Plan and Qijiang District's 2022 Statistical Yearbook	+	0.0682	0.0655
	Burdening vulnerability	Water consumption per capita	m^3	(Total water consumption/total population)/365 days	+	0.0631	0.0626
		Water consumption per GDP 10,000	m^3	Total water consumption/regional GDP	−	0.0578	0.0504
		Wastewater discharge	10,000 m^3	Data obtained from reports of town planning	−	0.0466	0.0421

For positively oriented indexes, where larger values indicate greater stability of the water resources system, the normalization method used is:

$$X'_{ij} = \left(X_{ij} - X_{j,min}\right) / \left(X_{j,max} - X_{j,min}\right) \tag{1}$$

For negatively oriented indexes, where larger values indicate greater vulnerability of the water resources system, the normalization method used is:

$$X'_{ij} = \left(X_{j,max} - X_{ij}\right) / \left(X_{j,max} - X_{j,min}\right) \tag{2}$$

where X'_{ij} is the standardized value of the i evaluation object ($i = 1, 2 \cdots n$, n is the number of samples) for the j evaluation criteria ($j = 1, 2 \cdots m$, m is the number of criteria), X_{ij} is the original value, $X_{j,max}$ is the maximum value of the j evaluation criteria, and $X_{j,min}$ is the minimum value of the j evaluation criteria.

(2) Calculation of entropy weight:

Calculate the weight of the evaluation criteria:

$$P_{ij} = X'_{ij} / \sum_{i=1}^{n} X'_{ij}, \sum P_{ij} = 1 \quad (3)$$

Calculate the entropy value of the evaluation criteria:

$$e_j = -k \sum_{i=1}^{n} P_{ij} \times lnP_{ij}, k = 1/lnn \quad (4)$$

Calculate the weight using the entropy weight method:

$$W_j = (1 - e_j) / \sum_{j=1}^{m} (1 - e_j) \quad (5)$$

(3) Construction of judgment matrix: With the weights obtained from the entropy weight method, perform pairwise comparisons between criteria using a 9-point scale to construct the order judgment matrix A

(4) Consistency test:

Calculate the consistency index (CI):

$$CI = \lambda_{max} / (m - 1) \quad (6)$$

where λ_{max} is the maximum eigenvalue of matrix A, and m is the order of the matrix (number of evaluation criteria).

In calculating the consistency ratio ($CR = CI/RI$), a randomized index of consistency (RI) can be obtained based on the order [55]. If $CR < 0.1$, the judgment matrix passes the consistency test; otherwise, the matrix needs to be adjusted.

Eigenvalue method for weight calculation: When the consistency matrix has one eigenvalue equal to z, with all other eigenvalues equal to 0, the corresponding eigenvector, after normalization, provides the weights of the criteria.

2.3.3. Identification of Forest Element: Linear Trend Analysis Method

To estimate ecological disturbances in forests, the normalized difference vegetation index ($NDVI$), derived from the vulnerability assessment index, is selected to determine the vegetation growth status [56]. This indicator is relatively easy to obtain compared to others, and it is highly representative. It effectively reflects the vegetation growth at a specific time point based on the indicator itself. Subsequently, conducting a linear trend analysis of univariate data allows for a more precise assessment of vegetation changes over the course of 10 years. Linear trend analysis is commonly used to examine the linear relationship between a variable of interest and time. It is widely employed in various fields such as economics, environmental sciences, and social sciences to understand and predict long-term trends in data. It can also be employed in studies of surface vegetation [57]. The specific calculation formula is as follows:

$$S = \left(n \times \sum_{i=1}^{n} (i \times NDVI_i) - \sum_{i=1}^{n} NDVI_i \times \sum_{i=1}^{n} i\right) / \left[n \times \sum_{i=1}^{n} i^2 - \left(\sum_{i=1}^{n} i\right)^2\right] \quad (7)$$

In the equation, S represents the change trend of the NDVI. When $S > 0$, it indicates that vegetation growth exhibits a favorable trend. When $S < 0$, it indicates a deterioration in vegetation growth. i represents the year ($i = 1, 2, \cdots, n$, n is 10; in the year 2012, $i = 1$; in the year 2013, $i = 2$;...; in the year 2021, $i = 10$), $NDVI_i$ represents the NDVI value for that i specific year. In this paper, due to $n = 10$, it follows that $\sum_{i=1}^{n} i = 55$, $\left[n \times \sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2\right]$ =825. The specific results could be obtained by substituting the formula into the raster calculator in ArcGIS.

2.3.4. Identification of Farmland Element: Suitability Assessment of Agricultural Land

The suitability assessment of agricultural land can effectively reflect the suitability level of land for agricultural use. In unsuitable areas for agricultural development, it can be understood that certain limiting factors hinder agricultural development. These limiting factors then become the main targets of governance. By implementing relevant measures, it is possible to curb the adverse impacts of limiting factors and enhance the health of the farmland ecosystems. In this article, the delineation zones of farmland governance will be completed based on the spatial layout of basic farmland and the evaluation results of suitability. The specific method of suitability evaluation is the same as the previous assessment of water resource vulnerability. The constructed evaluation index system is shown in Table 3.

Table 3. Evaluation index system of agricultural land suitability for the four towns in the southern Qijiang District.

Objective Level	System Level	Indicator Level	Unit	Calculation Method and Source	Nature	Entropy Weight	Optimized Weight
Suitability of agricultural land	Pressure	Population density	Persons/km^2	Population/area	−	0.0434	0.0474
		Growth rate of natural population	‰	(Annual births − annual deaths)/average population × 1000‰	−	0.0547	0.0564
		Per capita GDP	CNY/Persons	Actual GDP/total population	−	0.122	0.107
		Sensitivity index of rocky desertification		(Percentage of exposed bedrock × Slope × NDVI)^(1/3) [58]	−	0.00270	0.00820
		Impact of mining area	m	Distance to each mining area: <1000 m = 1; 1000~3000 m = 3; 3000~6000 m = 5; 6000~7000 m = 7; >7000 m = 9.	−	0.0337	0.0377
	State	Annual precipitation	mm	China's annual rainfall in 2021 [59].	+	0.0132	0.0200
		Slope	%	Using Digital Elevation Model (DEM) [60] via ArcGIS.	−	0.00243	0.00810
		Aspect		South direction = 9; southeast and southwest directions = 7; east and west directions = 5; northeast and northwest directions = 3; north direction = 1.	+	0.0438	0.0474
		Soil texture		National soil database [61] , soil classification based on the USDA: Clay loam = 9; sandy loam = 7; silt loam = 5; sandy loam with silt content = 3; sandy soil = 1.	+	0.0105	0.0166
		Soil pH		National soil database [61] .	±	0.189	0.148
		Vegetation coverage		Normalized difference vegetation index (NDVI) [31].	+	0.00141	0.00730
		Water source	m	Distance to water sources: <200 m = 9; 200~500 m = 7; 500~1500 m = 5; 1500~3000 m = 3; >3000 m = 1.	+	0.00748	0.0131
		Distance to disaster-prone areas	m	Distance to disaster-prone areas: >2000 m = 9; 1500~2000 m = 7; 1000~1500 m = 5; 500~1000 m = 3, <500 m = 1.	−	0.0227	0.0313
		Density of road network		≥5 = 9; 5~3 = 7; 3~2 = 5; 2~1.5 = 3; ≤1.5 = 1	+	0.0418	0.0474
		Parcel regularity		4 × (Spot area)^(1/2)/Spot perimeter	+	0.0221	0.0308
		Terrain fragmentation		1/cos(slope)	−	0.0000893	0.00500
	Response	Share of primary industry in GDP	%	Statistical Yearbook of the four towns in 2022 [62].	+	0.0566	0.0583
		Proportion of agricultural, forestry, and water affairs in fiscal expenditure	%	Explanation of the final accounts of the four towns in 2021 [63–66].	+	0.0955	0.0901
		Density of planned road network		14th Five-Year Transportation Plan [67]: ≥5 = 9; 5~3 = 7; 3~2 = 5; 2~1.5 = 3; ≤1.5 = 1.	+	0.0312	0.0377
		Construction of high-standard farmland		Yes = 1; no = 0.	+	0.0669	0.0697
		Layout of reservoir construction	m	14th Five-Year Water Security Plan [68]: <200 m = 9; 200~500 m = 7; 500~1500 m = 5; 1500~3000 m = 3, >3000 m = 1.	+	0.139	0.113

In this study, an evaluation index system will be constructed from three perspectives: pressure, state, and response (PSR). The pressures faced by agricultural land can be divided into three categories: human, land, and industry. Population growth and economic development exert pressure on the spatial layout of agricultural land, while phenomena such as land degradation inhibit agricultural development. Additionally, the local mining activities of coal and electricity also pose a significant threat to land, thus greatly affecting agricultural development. Under the influence of various pressures, the farmland system exhibits various states, such as soil texture, pH, and other factors. To improve the negative impacts or expand positive responses, response indicators are selected from government investment, future planning, and other aspects.

3. Results

3.1. Identification and Zoning of Single Elements

3.1.1. Identification and Zoning of Mountain Elements

The surface deformation rates in the vertical direction of the four southern towns in Qijiang District from 2017 to 2021 were obtained using SBAS-InSAR technology, as shown in Figure 3. The results revealed that the distribution of surface deformation in the study area was uneven, with an annual average rate of deformation ranging from −93.83 to 42.65 mm/year. The surface movement was active. The area with the most significant surface subsidence was observed in the eastern part of Meizi Village, Ganshui Town, within a 1000 m distance from the Haoqing Coal Mine, Dashan Coal Mine, and Dongfeng Coal Mine [69]. The region experiencing the greatest uplift was located in the southernmost part of Wanlong Village, Shihao Town, surrounded by Zhanghegou Coal Mine, Changhong Coal Mine, and Xinglong Coal Mine. Additionally, significant surface subsidence was also observed around Datong Town, posing a potential threat to human life, health, and property. Therefore, this area was identified as a priority for restoration.

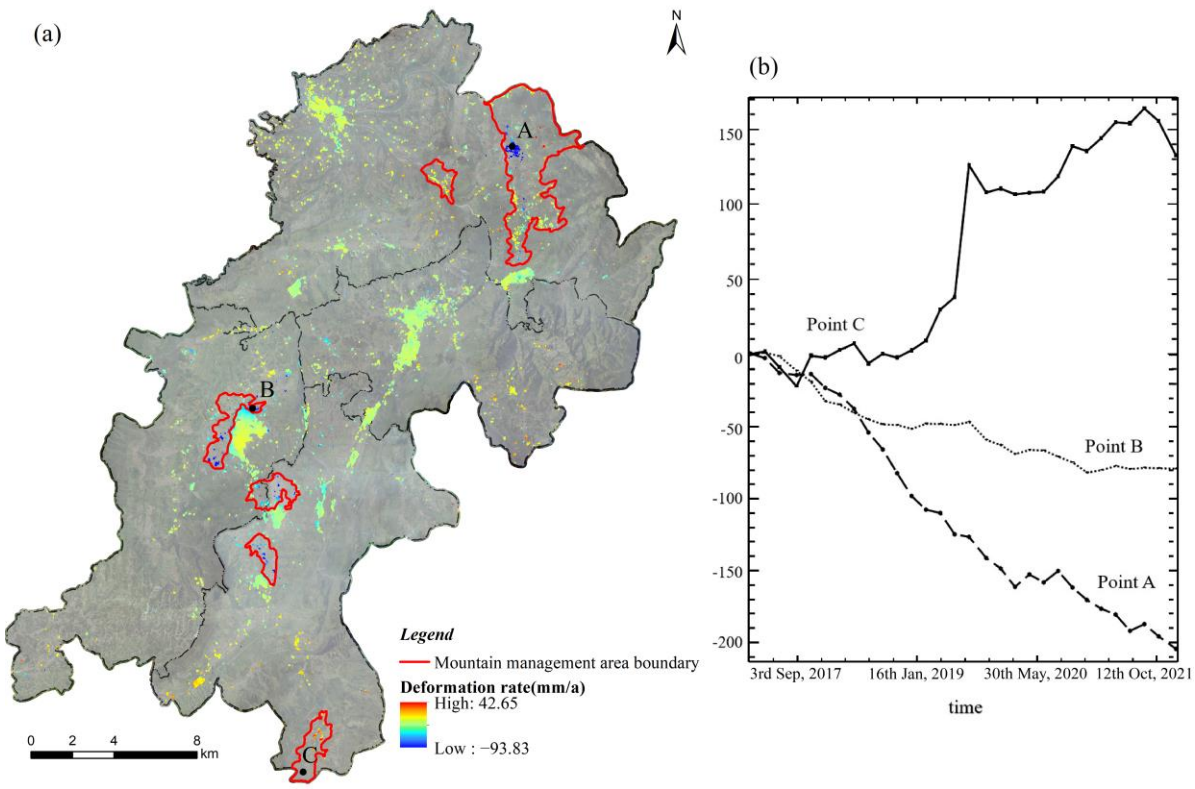

Figure 3. The average rate of surface deformation and the preliminary planning of the treatment area in the four southern towns of Qijiang District: (**a**) spatial distribution of the average surface-deformation rate in the study area; (**b**) time series analysis at points of significant deformation.

Points A and C were selected within the region of maximum surface deformation, along with point B in the subsidence area around the town. A time series analysis was conducted for these points. Point A is in the intersection district of three coal mines and has obvious surface subsidence. Accumulated subsidence of 205.36 mm was observed from February 2017 to December 2021, with a relatively fast rate of descent. However, starting in April 2020, the subsidence rate slightly slowed down, possibly due to measures implemented before the mine closure. Point C exhibited a similar relative position to point A, with three mining areas in its vicinity. However, the long-term uplift state was evident in its time series analysis. Initially, the surface uplift was attributed to the beam effect on elastic foundations caused by underground mining operations [70]. The subsequent significant uplift observed after June 2019 may be linked to the closure of mine drainage facilities, leading to groundwater rebound and consequent surface uplift. The refilling of water may result in the softening and destruction of rock pillars, triggering geological hazards [71]. Lastly, point B exhibited an accumulated surface deformation of −79.48 mm, showing a continuous downward trend since 2017. After 2021, the deformation rate slowed, with annual accumulated deformation not exceeding 1 mm, indicating a gradual stabilization of crustal movement in this area.

3.1.2. Identification and Zoning of Water Elements

The vulnerability assessment results of water resources in the four southern towns of Qijiang District are shown in Figure 4. The vulnerability index ranged from 0.22 to 0.80, with a mean value of 0.45. Overall, the water resources in the region exhibited relatively moderate stability. The areas with higher vulnerability were mainly distributed in the central and northeastern parts. These karst regions are characterized by complex topography and geology, with extensive development of karst depressions, conduits, and fractures, resulting in predominantly karst groundwater within the study area. The complex structure and strong permeability of the karst aquifers make them susceptible to being affected by mining pollutants. On the one hand, the infiltration of water leads to groundwater pollution in shallow areas. On the other hand, the closure of mines causes chemical elements in the formations to oxidize and form sulfates, resulting in water acidification and contamination. Through various fractures and conduits within the mining area, the contamination area expands. This is also one of the reasons for the vulnerability of the entire water ecosystem in the study area. Considering the significant impact of abandoned mines on water resources, a comparison of the spatial distribution of coal mining and water resource vulnerability reveals a significant correlation between the two. Mining activities not only affect the quality of groundwater but also impact the physical properties of water resources. The drainage operations in the mines result in a significant decline in the groundwater level, leading to water shortages in the surrounding areas. At the same time, changes in groundwater levels and flow patterns, interruption of surface water flow, and other issues [72] pose serious threats to the water circulation system in the mining areas. Therefore, the closer it is to the coal mining void area, the more vulnerable a water resource system tends to be. Based on the results of the vulnerability assessment, a water governance area of 212.07 km^2 was delineated within the region.

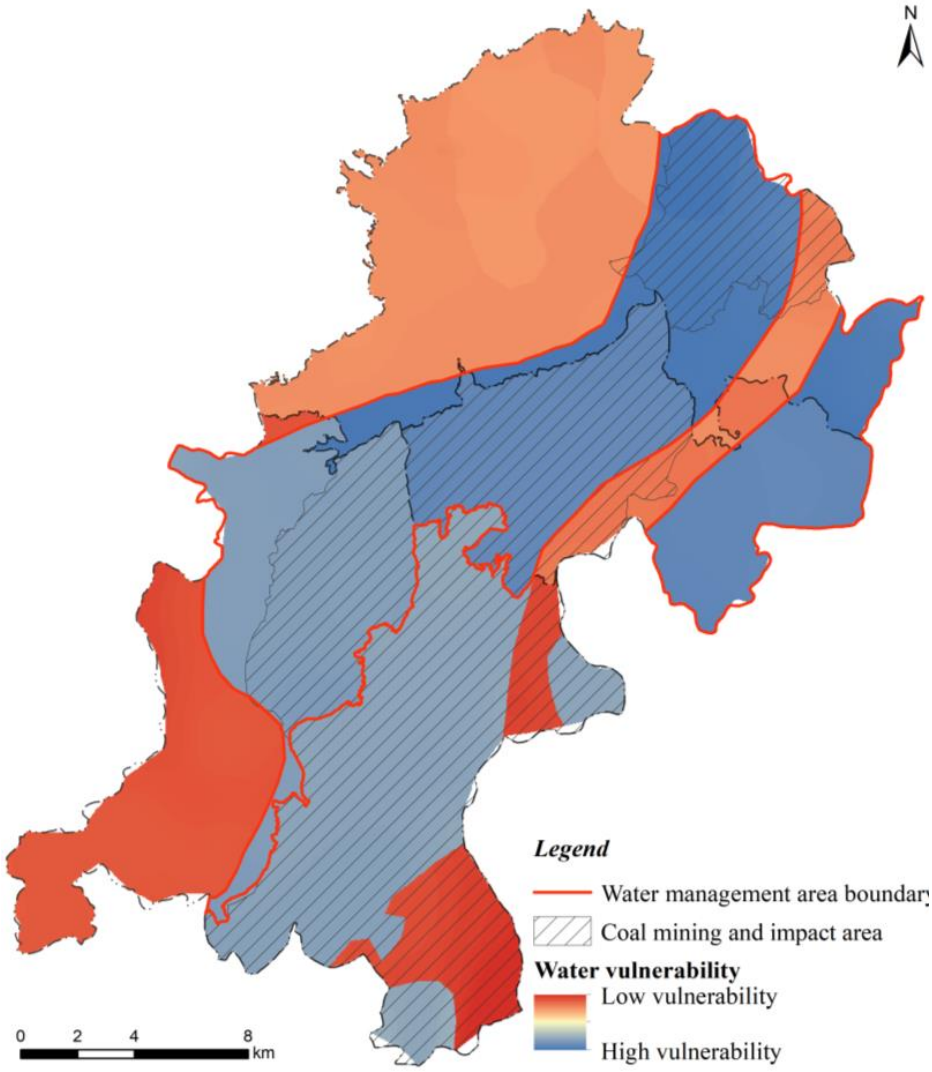

Figure 4. The results of water resources vulnerability assessment and the preliminary planning of the treatment area in the four southern towns of Qijiang District.

3.1.3. Identification and Zoning of Forest Elements

The NDVI trend in the study area from 2012 to 2021 is shown in Figure 5, indicating an overall slight increase. The maximum average value of NDVI increased from 0.73 in 2012 to 0.79 in 2021, with a growth rate of 0.006/year. This demonstrates that the vegetation coverage in the four southern towns has been improving year by year. The most significant increases are concentrated in the central part of the study area, the northern part of Ganshui Town, and the eastern part of Shihao Town. The central part of the study area refers to the adjacent areas between towns, which are part of the Qiyao Mountain–Jinfo Mountain basement fault zone. Therefore, these areas have potential geological hazards, which can be reinforced by planting vegetation to strengthen the soil. The valleys formed by faults can also be transformed into summer resorts by increasing vegetation cover. The northern part of Ganshui has a significant number of slopes greater than 25°. Therefore, the decision to reforest will increase forest density. The eastern part of Shihao Town serves as an ecological barrier in the southern part of Qijiang District, which has great significance for creating an ecological security pattern. In addition, some areas show a decrease in NDVI, which can be attributed to urban expansion phenomena observed in remote sensing images. Such expansion inevitably causes some disruption to vegetation growth.

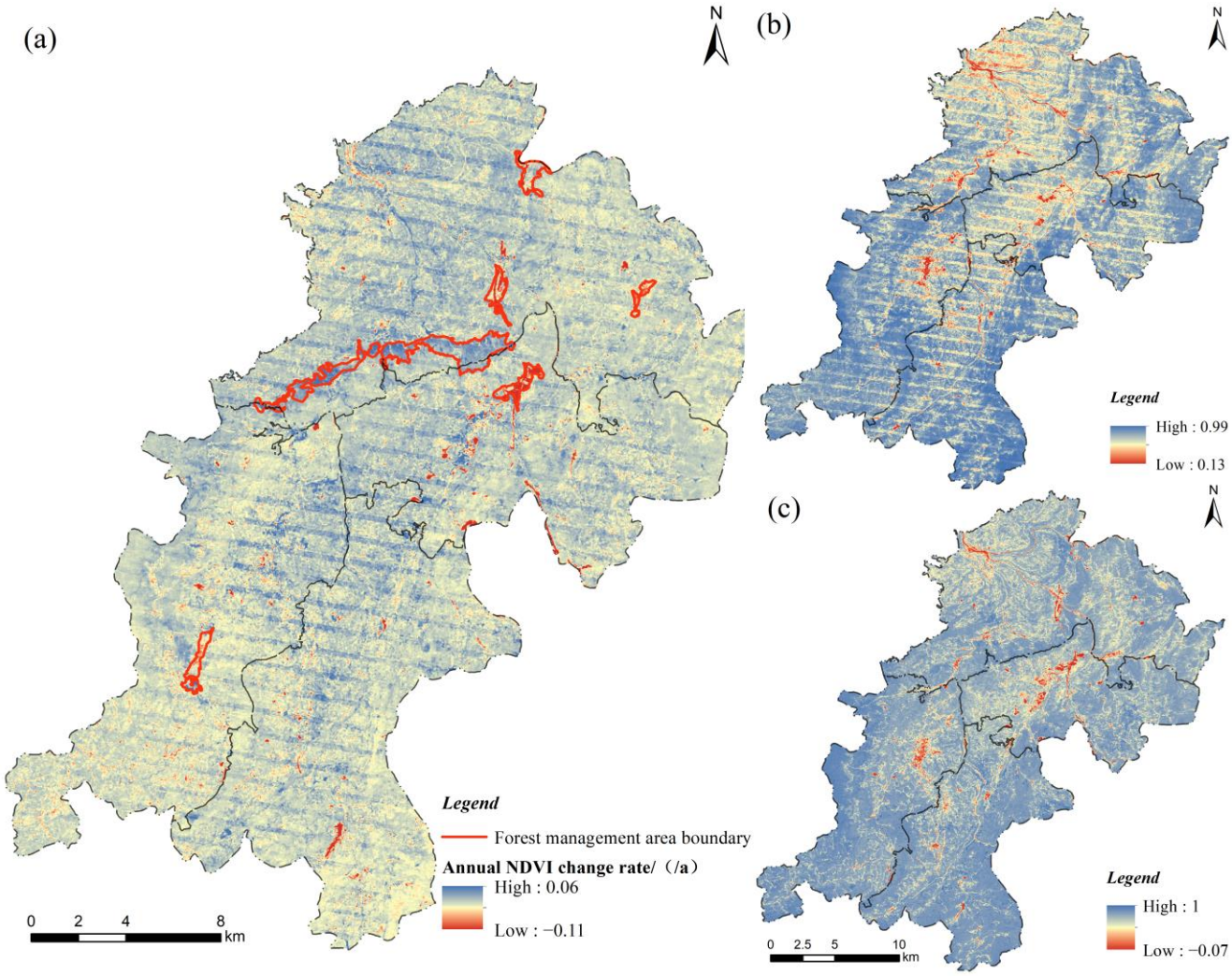

Figure 5. Annual average NDVI trends and the preliminary planning of the treatment area in the four southern towns of Qijiang District:(**a**) annual NDVI change rate from 2012 to 2021; (**b**) the maximum NDVI in 2012; (**c**) the maximum NDVI in 2021.

Based on the variation trend of NDVI over the ten years in the study area, regions with significant fluctuations were selected as forest governance areas, resulting in a total governance area of 10.75 km^2. The types of governance can mainly be classified into two categories. The first category includes areas with a decrease in NDVI, indicating a reduction in forest density and coverage compared to the past. Such reduction can be attributed to factors such as urban expansion, climate change, and construction projects. The second category comprises areas with a significant increase in NDVI due to new forest growth. Without proper measures of maintenance, the survival rate and reforestation rate of these newly established forests may be uncertain. Therefore, it is essential to implement relevant measures to maintain ecological stability in these newly planted forests.

3.1.4. Identification and Zoning of Farmland Elements

The suitability assessment results of agricultural land in the four southern towns of Qijiang District are shown in Figure 6, with evaluation indexes ranging from 0.23 to 0.71. The overall mean value is 0.45, indicating a generally medium suitability condition. The areas with high suitability are mainly concentrated in the northern and central parts of the study area, while the unsuitable areas are primarily located in the southwest and southeast. The towns are ranked in terms of their suitability indexes in agricultural land from highest

to lowest as follows: Ganshui Town (0.49), Anwen Town (0.47), Datong Town (0.44), and Shihao Town (0.39).

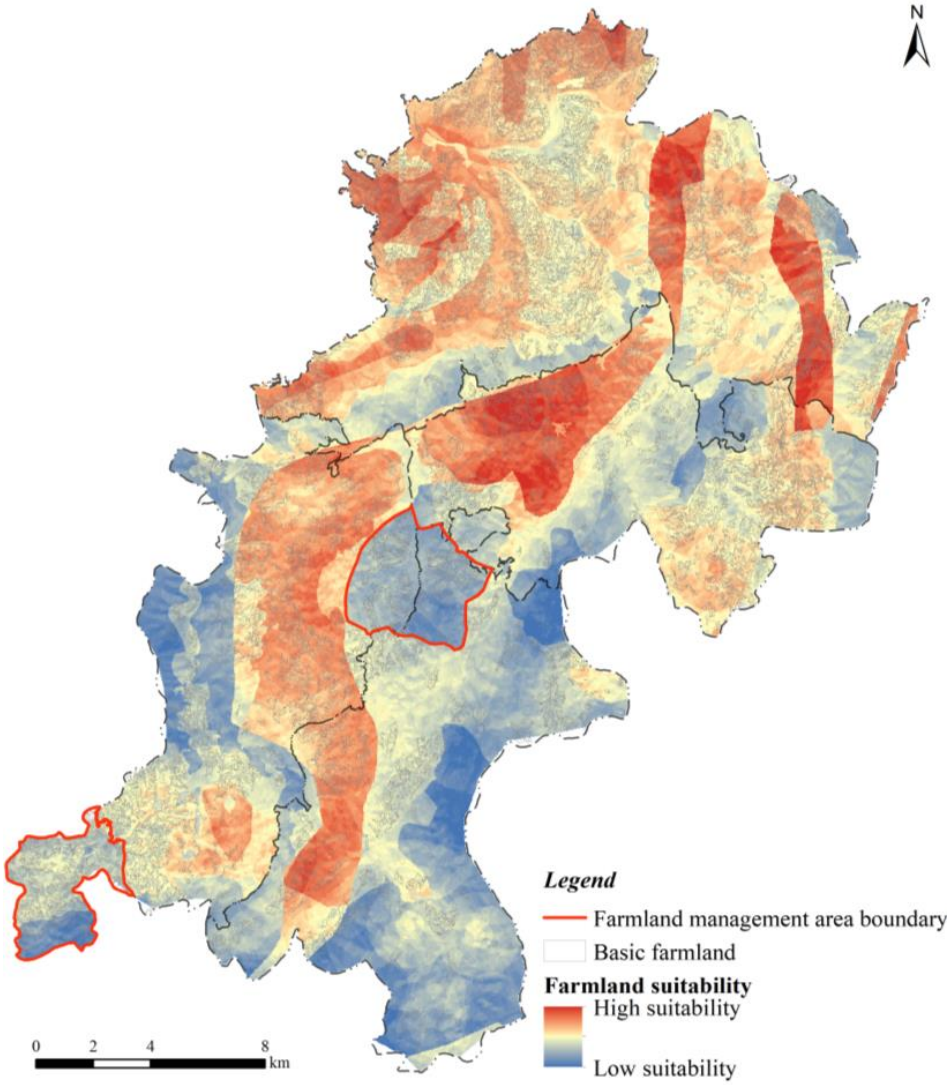

Figure 6. Results of farmland suitability evaluation and preliminary planning of the treatment area in the four southern towns of Qijiang District.

The reasons for these variations can be attributed to different pressures, states, and responses faced by each town. Ganshui Town experiences the least pressure, with a relatively small population and minimal land occupation for farming. It also has a stronger economic foundation, allowing for more resources to be invested in agricultural production. Moreover, the town has favorable natural conditions, with sufficient sunlight, temperature, water, and soil quality to support agricultural development. The planned layout of high-standard farmland and the construction of new reservoirs in Ganshui Town also contribute to its higher level of suitability in agricultural land compared to the other three towns. The low suitability of the southern region is not only related to its ecological barrier positioning but is also largely influenced by water resources. Compared to the northern regions, the southern regions, including Datong Town and Shihao Town, experience lower rainfall and less dense river networks. The difficulty in accessing water leads to a decrease in the suitability for agricultural development. These areas can be considered for accomplishing management of farmland elements through the new construction of water conservancy facilities. Considering the significant role of basic farmland in agricultural production, this

study selects the concentrated distribution of basic farmland with lower suitability as the key area for governance. Ultimately, the initial treatment area identified was 28.41 km^2.

3.2. Integrated Zoning and Governance Measures Based on Life Communities

By combining the zoning of mountain, water, forest, and farmland elements, the comprehensive governance zones for the entire study area can be determined. For overlapping areas, the type with more severe issues is selected for initial governance efforts. The zoning of comprehensive governance is shown in Figure 7.

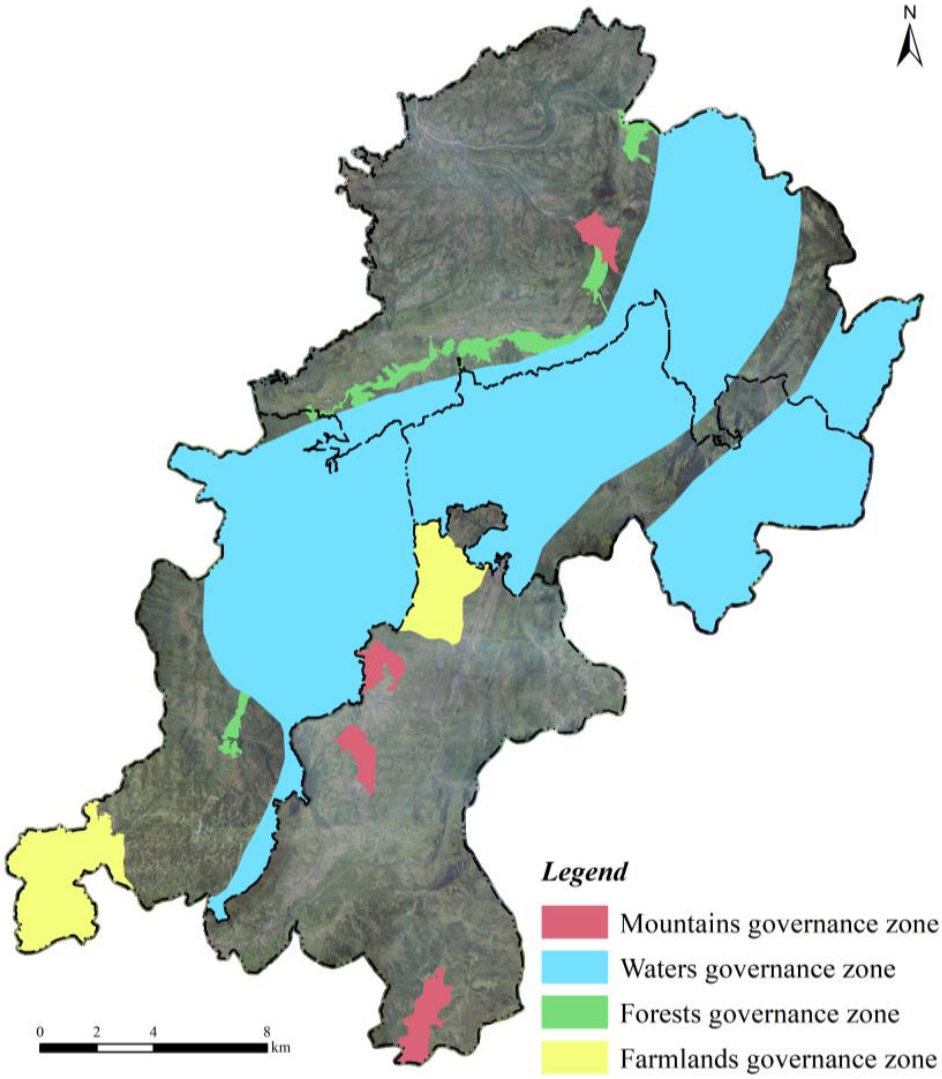

Figure 7. Integrated management zoning of mountains, waters, forests, and farmlands in four southern towns of Qijiang District based from an element identification perspective.

The governance zone of the mountain element covers an area of 8.03 km^2, with Ganshui Town accounting for 20.13% and Shihao Town accounting for 79.87%. For these areas with potential landslide risks caused by coal mining subsidence, measures such as reinforcement and support, sealing and isolation, and backfilling techniques can be employed to achieve regional restoration [73]. Regarding the treatment area with surface uplift in the southern part of Shihao Town, it is recommended to implement land consolidation projects and construct drainage ditches to address water accumulation in mining areas. Measures such as afforestation and slope reduction can also be implemented to reduce the losses caused by geological hazards.

The governance zone of the water element covers an area of 212.07 km^2, with Anwen Town accounting for 38.80%, Datong Town accounting for 31.78%, and Ganshui Town accounting for 29.42%. Due to the close relationship between the spatial distribution of water resource vulnerability and mining subsidence areas, efforts should focus on mining wastewater treatment. Considering that mining wastewater in southern China is often acidic, various technologies can be employed for the improvement of water quality, such as biological methods, neutralization and sedimentation, oxidation reduction, and membrane separation. In addition, constructing sewage treatment stations and using mine backfilling to adjust the terrain can create natural drainage ditches or reservoirs to mitigate surface erosion caused by runoff.

The governance zone of the forest element covers an area of 7.04 km^2 and is mainly concentrated in Ganshui Town (85.29%), Datong Town (14.27%), and Anwen Town (0.44%) in a strip-like distribution. The decrease in vegetation coverage can be attributed not only to natural urban expansion but also to the disturbance caused by road construction. The construction of the Yuzhu Expressway has led to vegetation destruction along its route, resulting in increased landscape fragmentation and exacerbated habitat risks [74]. This type of governance zone requires a suitability assessment of land consolidation along linear engineering projects to determine their reclamation direction [75]. Specific restoration work on the forest can be carried out after project completion based on the actual situation. For areas with increased vegetation coverage, proper nurturing and management activities should be conducted regularly to ensure the normal growth of newly planted seedlings, such as loosening the soil, fertilization, and watering.

Finally, the governance zone of the farmland covers an area of 20.07 km^2, mainly concentrated in Datong Town and Shihao Town, accounting for 62.85% and 37.15%, respectively. As the soils in these areas are predominantly acidic, the first step is to conduct amendment treatments of acidic soil. Approaches such as adjusting the fertilizer structure, applying soil amendments, and increasing the application of organic fertilizers or biofertilizers can be implemented to enhance the quality of arable land. Moreover, considering the poor conditions of water resources, land consolidation projects can be implemented to deploy irrigation and conservation water facilities such as ditches and ponds, thereby improving the agricultural infrastructure.

4. Discussion

This article concretizes the goals of the "Mountains, Rivers, Forests, and Farmlands Life Community" and implements them in real areas. By diagnosing ecological issues, it is possible to rationally delineate regions with potential ecological risks. Based on the level of risk, the spatial distribution of governance elements can be optimized. Specifically, within a given spatial domain, priority is given to addressing ecological issues (elements) with the highest risk level. This approach enables optimal utilization of limited resources, resulting in enhanced governance effectiveness and a minimized probability of ecological disasters. Moreover, concentrating resources on areas where ecological functionality has been significantly disrupted accelerates the process of ecosystem recovery, promoting the restoration of vegetation, soil improvement, water quality enhancement, and other ecological restoration effects, thereby achieving sustainable development of the ecological system. Consequently, based on the results of the single-element identification within this study, areas prone to high-risk ecological disasters were scientifically identified, and targeted governance measures were implemented. This approach not only enhances resource utilization efficiency and maximizes the comprehensive benefits of ecological restoration in the mining area, but also contributes to the enrichment of the concept of "Mountains, Rivers, Forests, and Farmlands Life Community" in China.

The proposed restoration objective, which is based on element recognition, coincides with the primary task of ecological restoration in mining areas. They both emphasize the identification and elimination of factors that restrict the restoration of the ecological environment [76]. By delineating the problematic areas of the systematical elements, the

correction of limiting factors can be achieved. The governance measures proposed in this study are essentially similar to the stages of reclamation in mining areas. For example, Feng et al. [77] proposed five stages of mine reclamation, including geomorphic reshaping, soil reconstruction, hydrological stability, vegetation restoration, and landscape rebuilding. Gao et al. [78] proposed that reclamation of open-pit mines can be achieved through engineering restoration such as stripping technology, water engineering, and new land construction, as well as biological restoration measures such as screening of crop varieties, vegetation techniques, and fertilization new land. Li et al. [79] regarded vegetation and soil restoration as the key to ecological reconstruction in mining areas. In conclusion, the current techniques of ecological restoration are closely related to element governance. Forest element governance is crucial for vegetation restoration, while soil restoration is related to mountain and farmland governance, and hydrological restoration undoubtedly contributes to water element governance. Although their connotations and objectives are similar, restoration from an elemental perspective can overcome the limitations of traditional techniques, i.e., shift attention to the ecosystem itself. It can aid in more precise restoration targeting different elements, which is beneficial for solving specific problems and improving restoration effectiveness. In addition, considering governance activities from an elemental perspective allows for greater flexibility. It can be flexibly adjusted according to different environmental conditions and restoration objectives, applicable to various ecosystems, demonstrating high adaptability and operational feasibility. This facilitates the achievement of more comprehensive and integrated benefits of ecological restoration, promoting overall enhancement of the ecosystem [80]. The concept of flexibility here emphasizes the ability to integrate many elements to create comprehensive models of governance. Overall, there are intrinsic and close connections between different governance elements. For example, landform restoration is not only related to mountains but also to surface runoff [81]. Therefore, in the discussion, the governance models of composite elements for the four towns in the southern part of Qijiang District will also be proposed [82–86].

(1) The governance model of mountains, waters, and forests

The mountain ridge, composed of the elements of mountains, water, and forests, serves as the source of the entire mountain, water, forest, and field governance and restoration work [87]. It can effectively enhance the quality of the entire regional ecosystem. Due to the direct impact of coal mining on mountains, water, and forests, the ecological restoration work of the three elements can be achieved from mine reclamation. Currently, the key technologies for ecological restoration of abandoned mine sites can be mainly divided into [88]: ① Site leveling. Combined with actual roads and drainage ditches, land leveling work is carried out. For slopes, slope cutting and leveling should be conducted, and the slope surface should meet the conditions for artificial planting. At the same time, according to the terrain, natural gullies should be modified using techniques such as excavation and filling and ecological bags to eliminate potential landslide hazards. ② Pollution control and diversion. Pollution control and diversion techniques are used to build drainage ditches, reducing the kinetic energy of surface runoff and soil erosion. ③ Three-dimensional vegetation configuration. In vegetation restoration of the mine site, it is necessary to first select plants that are resilient, capable of soil and nitrogen fixation, have well-developed root systems, and are easy to establish, such as hairyleaf litse fruit, bougainvillea goldraintree, ficus lacor, and other tree species, as well as mysorethom seed, common aucklandia root, and prickly ash for shrub vegetation. New afforestation is carried out to conserve water sources and stabilize the soil.

(2) The governance model of mountains, waters, and farmlands

The concept of mountain, water, and farmland governance can be seen as the ecological restoration of "valleys". Through techniques such as comprehensive land consolidation and soil pollution remediation, ecological security is maintained. On the one hand, ecological restoration is achieved with land leveling projects, field road projects, irrigation

and drainage projects, and farmland protection projects. These projects can also repair the damaged land in the mining area and consolidate fragmented agricultural land and inefficient construction land, thereby improving the conservation capacity of regional water and soil [89]. On the other hand, the investigations and assessments of soil pollution are actively conducted, and improvement projects in areas with acidified soil are properly defined. With a focus on food security, soil testing and formula techniques of fertilization are implemented, applying different types of soil amendments targeted at different soil conditions to enhance the quality of arable land [90].

(3) The governance model of waters, forests, and farmlands

Chongqing, an important region in the southwest forest area of China, aims to create the "Green Mountains on Both Sides · Thousand-mile Forest Belt" in the protection project of the Yangtze River forest. At the same time, it is necessary to increase the value of forestry and related industries and promote sustainable development in the region. The undergrowth economy relies on forest resources and ecological resources, focusing on the development of undergrowth planting and breeding industries, forest product processing industries, and forest tourism [91]. It can maximize the value of the forest and field elements in the same region.

To achieve this, the restoration and management of vegetation in rocky desertification areas are prioritized. Measures of soil and water conservation are implemented to promote clean construction in the Qijiang Basin, including exploring mixed afforestation and complementary water systems. Building upon increased coverage of regional vegetation, high-quality soil is excavated to escalate the potential values of forest resources. Under the forest canopy, economic crops such as soybeans, mung beans, sweet potatoes, medicinal plants like Rhizoma Gastrodiae, Radix Scutellariae, and Glycyrrhiza, as well as mushroom varieties like shiitake, grass fungus, and chicken mushroom [92], are cultivated to enhance the additional benefits of forest resources.

In conclusion, there are numerous elements in the natural system. In addition to the mountains, waters, forests, and farmlands factors, there are also lakes [93], grasslands [94], sands [95], glaciers [96], and more. These elements together influence the sustainable development of a region. While this study focuses on the mountains, waters, forests, and farmlands elements, it is important not to overlook the significance of other elements in achieving ecological restoration. Gradually improving and enriching the types of elements in natural systems will also be a key problem of research in the future.

In addition to enriching the types of factors within the life community, improving the identification methods for these elements will also be another focus. This study proposes universally applicable and scientific identification methods for the four types of elements: mountains, water, forests, and farmlands. The results have been validated with data verification and remote sensing imagery. Specifically, the zoning results of mountain management are validated with data on mining site distribution. The results of water resource vulnerability are validated with the distribution of subsidence areas. The forest management zones can be examined using remote sensing images from different years. The suitability results for agricultural land also largely match the distribution of basic farmland. This proves that the methodology used in this paper is capable of scientifically diagnosing ecological problems in the study area. However, these methods also have certain limitations. For example, the SBAS-InSAR technique is more suitable for monitoring areas with dense vegetation and fewer buildings. In contrast, PS-InSAR may be more suitable for identifying mountain elements in urban areas or towns on the northern plain in China. Furthermore, there is no standardized evaluation indicator system for assessing the vulnerability of water resources. It is possible to construct a new framework of evaluation tailored to local characteristics in subsequent studies. Though NDVI is a very common method for recognizing forests, a series of machine methods of recognition have also been developed now, such as random forest [97] and support vector machine [98], which can effectively, scientifically, and automatically identify forest elements. Lastly, besides

suitability evaluation, research can also be conducted from multiple perspectives, such as fragmentation, soil erosion, and land conflicts in recognition of farmland.

In summary, the methods used in this article are more suitable for research in mountainous regions in the southwest of China. Taking the research area as an example, it can be demonstrated that element identification is of significant importance in achieving regional ecological restoration. This method and model can be extended to more mountainous restoration cases. Furthermore, the discussion on topics such as improving accuracy and expanding the scope of application through advancements in the methodology will also be a key focus of future research.

5. Conclusions

This paper establishes a comprehensive governance zoning of mountains, waters, forests, and farmlands from the perspective of single-element identification in order to promote ecological restoration in regions with outdated production capacity. The SBAS-InSAR technique is used for monitoring surface deformation to delineate mountain management areas. Hydrological management areas are determined through vulnerability assessments of water resources. Areas with significant fluctuations in vegetation cover are selected as forest management areas based on the NDVI trend over a period of 10 years. Finally, basic agricultural lands with a low suitability index are chosen as farmland management areas. Through the perspective of element identification, the comprehensive governance zoning of the "Mountains, Rivers, Forests, and Farmlands Life Community" in the four southern towns of Qijiang District is established. The specific conclusions are as follows:

1. The deformation rate of the average annual surface in the four southern towns of Qijiang District ranges from −93.83 to 42.65 mm/year, indicating active surface movement, with risks of landslides and collapses in some areas. The vulnerability index of water resources ranges from 0.22 to 0.80, showing a close spatial relationship between zones of water fragility and coal mining areas. There is an increasing trend in the annual NDVI variation, but there are still some areas where vegetation cover has decreased due to road construction. The suitability index for agricultural land ranges from 0.23 to 0.71, with highly suitable areas mainly concentrated in the northern and central parts of the study area, while unsuitable areas are mainly located in the southwest.
2. The management area of the mountain element in the study area covers an area of 8.03 km^2 and can be addressed by measures such as reinforcing underground mining space and stabilizing the surface to reduce losses caused by geological hazards. The management area of the hydrological element covers an area of 212.07 km^2 and can be improved through mining wastewater treatment to enhance the stability of the regional system of water resources. The management area of the forest element covers an area of 7.04 km^2, and for areas where vegetation cover has decreased due to the construction of the YuZhu Expressway, a suitability evaluation of land consolidation along linear engineering areas should be conducted, while ensuring proper care and maintenance of areas with increased vegetation cover. The management area of the farmland element covers an area of 20.07 km^2 and can be addressed through soil acidification improvement and land consolidation projects to achieve farmland restoration.
3. Three composite governance models are proposed for the study area. The first is the governance model of mountains, waters and forests, which focuses on mountain ridges. The second is the mountain, water, and farmland governance model, which emphasizes valleys as the center. The third is the governance model of waters, forests, and farmlands, which prioritizes the development of an undergrowth economy. Ecological governance and restoration in the four southern towns of Qijiang District should begin with the management of hydrological elements as the starting point. This focus on water elements will drive works of comprehensive restoration within the entire region.

According to the above results, the research objective of this paper can be effectively achieved, which is to construct a comprehensive governance pattern for eliminating regions of backward production capacity. From the perspective of elements, it is possible to fundamentally address regional ecological issues and actively promote the process of regional transformation. This comprehensive governance pattern of elements contributes to enhancing governance efficiency through the rational allocation of resources and the implementation of precise measures. It is possible to facilitate ecological restoration and improve environmental quality in a region, while also providing sound ecological environment support for economic development.

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