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Review Article

Improving Land Use Planning through the Evaluation of Ecosystem Services: One Case Study of Quyang County

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Competition for land is increasing as demand for multiple land uses and ecosystem services rises. Land regulation of the principles of landscape ecology is necessary to develop more sustainable approaches to land use planning. The research evaluated the present land patterns and determined best practices for its regulation of Dongwang Township in Quyang County, located in the Taihang Mountain area of Hebei Province, China. The research used the landscape ecology theory to construct an index system for landscape pattern analysis based on the GIS and Fragstats 3.3 software. In this study, we examined the specific reasons that landscape ecology is superior to traditional methods in land consolidation planning and design, which is conducive to the comprehensive development of land ecological benefits. Landscape ecological planning can effectively reduce landscape fragmentation and improve intensive management. The result found that the descending order of the Shannon index was current landscape, landscape ecological planning, and traditional planning. Landscape ecological planning could protect the natural diversity than traditional planning. Landscape ecological planning enables the creation of long corridors, with higher densities and connectivity and lower average corridor widths than traditional planning. Besides, it can improve ecological service function values in the study area to varying degrees, thus discouraging residents from limiting themselves to grain production. This research has great potential to improve the visibility of ecosystem services in local land use planning and, thus, to improve the ecological functioning of future landscapes.

1. Introduction

Competition for land is increasing as demand for multiple land uses and ecosystem services rises. The quantity and quality of cultivated land are declining, which seriously threaten food security and ecological security [1–3]. Land consolidation planning helps alleviate the strained relations between man and land, especially in safeguarding the construction land required in the context of economic development. Land regulation primarily originated in European countries in the Middle Ages. However, there is some evidence that land regulation began earlier in countries such as Germany, France, and Russia [4, 5]. In general, the history of land regulation involved three stages. The first stage extended from the middle of the 16th century to the end of the 19th century and was defined by organized and planned land consolidation, adjustments of ownership, and improvement of agricultural production conditions to carry out simple land renovations. The second stage stretched from the beginning of the 20th century to the 1950s; with the emergence of industrialization, land renovation began to revolve around urban construction and industrial development, which is a specific stage of land renovation. The third stage occurred in the 1960s, when land renovation began to be geared toward promoting regional economic development, narrowing the gap between urban and rural areas, increasing incomes, and protecting and improving the ecological environment. It was a more comprehensive stage of land renovation, and the integration of landscape ecology would play an important role in the improvement of Europe's ecology [6, 7].

Meanwhile, the history of land regulation in China can be traced back to the Jingtian system in the pre-Qin period [8]. Since the Qin and Han dynasties [9–11], China has notably been home to a state-owned land manor and farmland system, to name but a few of its approaches to land use. Although land renovation has been carried out in various forms since the founding of the People's Republic of China, the nation lagged in generally accepted theoretical and technical aspects of land renovation until the formulation of the Land Management Law in the 1990s, which promotes China's land renovation activities to a new level [12]. At present, the research on land consolidation in China mainly focuses on land suitability evaluation; however, methods for land regulation project planning and design, comprehensive benefit analyses of land, and making land consolidation planning are greater research potential [13–18].

Landscape ecological planning and design uses landscape ecology theory and its related methods. At present, several main approaches to ecological planning and landscape design are employed globally. One of these approaches is the thousand-layer cake planning model [19], which was presented by American ecological landscape architect McHarg. This approach involves calculating the ecological suitability of natural resources in a regional landscape ecosystem to optimize its landscape utilization and regional development direction. Another approach is the one-compartment model of ecological land use [20]; proposed by American ecologist Odum, this model, based on system science theory, takes the regional landscape ecosystem health as optimal goals, discusses the regulation mechanism of natural and social-economic factors, and yields an allocation decision. Finally, the differentiated land-use model, which was proposed by German biologist Haber [21], is mainly suitable for the overall planning of landscapes in high-density areas and involves an evaluation of the overall effect of a proposed landscape plan by environmental diagnostic and pattern analysis indices.

In the late 20th century, theories and principles of landscape ecology were integrated with traditional approaches to landscape planning. The integrated development is largely attributed to Forman's 1995 book *Landscape Ecology*, which summarizes the methods of landscape ecological pattern optimization [22]. More specifically, as populations, food demand, and environmental pollution increased during the mid to late 20th century, many nations such as Germany and the Netherlands turned to land as their main research object, thereby encouraging interest in landscape ecology. At the same time, the International Landscape Ecology Society (IALE) was formally established at the Sixth International Symposium on Landscape Ecology in Czechoslovakia in 1982; this marked a new stage in the development of landscape ecology [23]. The study of landscape ecology has gradually prevailed from European countries throughout the world [24]. Huang and Liu introduced landscape ecology to China in 1981 [25, 26]. Although the implementation of landscape ecology principles in China lagged to Europe and America, the application was prompted rapidly. Meanwhile, outside of China, in 1984, Naveh and Lieberman published a notable landscape ecology monograph, *Landscape Ecology: Theory and Application*, which was the first monograph in the field. The first National Colloquium on Landscape Ecology in China was held in October 1989 in Shenyang; this opened a new chapter for the study of landscape ecology in China. In 1992, the Committee of Landscape Ecology of the Chinese Society of Ecology was established; since then, the study of landscape ecology has progressed greatly in China [27]. During the 10 years since the establishment of the Professional Committee on Landscape Ecology, Chinese scholars have published a series of monographs on landscape ecology.

Today, it is clear that land renovation must include a series of biological and engineering measures, which will inevitably break the original state of land resources in a certain area and directly and indirectly benefit and harm regional environmental factors such as water resources, soil, vegetation, and biology and their ecological processes [28–31]. The sustainability of land resources can also be seriously affected if inappropriate remediation damages ecosystems and reduces land productivity. To improve the environment of agricultural areas and the land production capacity, and preserve the sustainable use of regional land, landscape ecological planning and design should be normalized in the planning layout of land renovation projects for diverse design to protect and strengthen the region's fragile and simple ecosystems [32–34].

There may be several concrete objectives of landscape ecological planning for land renovation. These include increasing the area of cultivated land, expanding the scale of farmers' land management, enhancing the potential of land production and farmer competitiveness through the renovation of broken farmland and land ownership, improving rural life, ecology, environmental, and landscape functions, while also constructing green infrastructure for urban-rural integration that protects biodiversity, prevents rural pollution, protects natural resources, maintains and improves rural ecological landscape service functions, and realizes land management at different levels, and realizing the integrity of ecological function, that is, coupling the land-use system with its external environment to realize the entire function. More specifically, the land use mode and ditch road design can be determined by considering the topography, climate, hydrological condition, water resource condition, social condition, and economic condition; improving natural function compatibility states that the planning and design of the land renovation of agricultural ecosystems should apply the principles of landscape heterogeneity and ecological diversity to enhance the ecological functions of landscape patch in line with the requirements of agricultural production.

2. Landscape Ecological Planning and Design

2.1. Landscape Ecological Pattern Adjustment. Land renovation is the process of optimizing an area's current land use pattern. Guided by the theory of landscape ecology, land renovation follows the sustainable development principles of protecting and improving the ecological environment. Notably, it involves the comprehensive adjustment and reconstruction of the landscape's spatial structure and patterns; for example, modifications include laying out roads, drainage and irrigation networks, crops, farmland structures, shelterbelt systems, and land units in ways that construct harmonious spatial structures, stabilize ecosystems, and ultimately realize the goal of the sustainable use of land resources.

2.2. Landscape Ecological Patch Planning and Design. The types of landscape ecological patches in the study area included irrigated land, dry land, garden land, woodland, residential land, funeral land, sandy land, bare land, and wasteland. Based on the characteristics of the land renovation project, some forestland with high ecological service value in the study area was reserved, and some bare land near the forest land in the east of the study area was transformed into forest land to increase the area's ecological service value.

Our analysis of the landscape pattern index revealed that our area had a high number of cultivated landscape patches, a small average patch area, and high landscape fragmentation. Notably, the latter weakens biodiversity and land production capacity. The farmland landscape patches (where wheat and corn are mainly planted) should therefore be rectangular, in line with the topography and distribution of water resources in the Taihang Mountain front plain area. The width and length of the field were 200–300 m and 400–600 m, respectively, and the average patch area was 7–10 hm^2. Meanwhile, land leveling in the study area exhibited the mechanical local leveling scheme; adapted land leveling should not reduce soil fertility and should maintain the fertility of the thin soil layer.

2.3. Landscape Ecological Corridor Planning and Design

2.3.1. Ditch Corridor. The analysis on the landscape pattern revealed that the number of ditch corridors in the study area was small, their total length low, and their width uneven; moreover, the ditch corridors were in a state of abandonment or semiwaste, which precludes irrigation and drainage. During the planning and design of the irrigation and drainage corridor, the water conveyance channel was created according to the traditional planning and design to save cultivated land; more specifically, an underground low-pressure water conveyance PVC pipeline was adopted. Meanwhile, as per the design plan of our area's cultivated landscape patch unit, the drainage ditch was arranged reasonably; it effectively formed the channel corridor network, kept the water circulation unblocked, reduced the probability of flood disaster, and ensured the reasonable circulation of water resources in the region.

Moreover, the landscape ecological design of the drainage ditch was based on the drainage area. Once every 10 years, the daily rainstorm amount (210 mm) in the dry farming area and the daily rainstorm amount (210 mm) in the paddy fields are discharged to the related depths of crop flooding. According to the Design Code for Irrigation and Drainage Engineering (GB50288-99), the widths of an agricultural and bucket ditch are designed to be 2.5 and 4.2 m, respectively. We were concerned primarily with our drainage ditch's soil quality and trapezoidal structure. The slope of the drainage ditch was designed to be gentle; the Dougou slope ratio was 1 : 1.5 and the Nonggou slope ratio was 1 : 1, which were selected to enhance the area's ability to serve as a habitat for its resident species. Besides, to protect the drainage ditch slope and provide this green habitat, the turf was planted in the drainage ditch slope.

2.3.2. Road Corridor of Farmland. Our analysis of the landscape pattern index showed that the field and production were messy and narrow; moreover, their pavement quality and connectivity were poor, which complicates vehicle transportation and the underground operations of farmland machinery. Notably, the mechanization of cultivated land patches was also seriously affected. After renovation, the road corridors formed a network connection system, with their layout in alignment with the designs of each patch. Meanwhile, the design of the farmland roads was mainly based on traditional approaches to ecological modification and construction fused with ecological engineering. Compared with traditional planning approaches, the landscape ecological design of the farmland road corridor reduced its width; the width of the field road was reduced to 4 m, and the width of the production road was set at 2.5 m; the cultivated land was meant to enable the movements of vehicles and farmland machinery. Moreover, the road corridors were designed to include an ecological hole with a diameter of 20 cm every 100 m below the roadbed to account for the movements of small animals in the field, fostering their survival and habitat.

2.3.3. Shelterbelt Corridor of Farmland. Our analysis of the landscape pattern index also made clear that there were only a few farmland shelterbelt corridors in our area. Ultimately, such a small number cannot form the perfect farmland shelterbelt system necessary for protecting the ecological environment. In response, the farmland shelterbelt project plans propose modifying the forest belt according to local conditions by adopting the permeable shelterbelt. The farmland shelterbelt was mainly arranged in line with existing standards along the drainage ditch and farmland road; a single arbor road layout model was adopted. The tree species selected was a fast-growing poplar suitable for the local climate and soil conditions; meanwhile, plant spacing was set at 2 m. It is helpful to note that the farmland shelterbelt is not only an important means of improving the local microclimate, water, wind, and sand conservation but also an effective way of increasing land use space and biodiversity.

3. Material and Methods

3.1. Overview of the Study Area. The study area was located in the west of the North China Plain, along the eastern foot of Taihang Mountain (Figure 1). The geographical coordinates of the area are 38°35″–38°38′15″N and 114°48′08″E–114°52′31″E. In the warm, temperate, and continental monsoon climate, the average annual precipitation is 571 mm, which is concentrated mainly between July and September and accounts for 64.4% of the annual precipitation. Meanwhile, the annual evaporation is 1,230 mm, which is more than 2.15 times higher than the precipitation. The annual mean temperature is 11°C. The average annual wind speed is 2.3 m/s, with the maximum wind speed occurring in spring, at 2.9 m/s. Besides, the permafrost depth is usually between 30 and 55 cm [35]. The region also experiences approximately 2,600 h of sunshine a year, and its frost-free period extends for 190 days. Notably, the research area belongs to the flood alluvial plain in front of Taihang Mountain. High in the northwest and low in the southeast, the area's surface slope falls between 1/1500 and 1/2000. Overall, however, the terrain is flat, with only gentle slopes and depressions. Meanwhile, the groundwater resources in the study area were divided into deep and shallow freshwater. Deep groundwater is not easy to access, and supply difficulties can occur. Shallow freshwater is the main resource of current industrial and agricultural production and domestic water use. Meanwhile, the main recharge modes include rainfall infiltration, backward supply, channel infiltration, and irrigation field infiltration.

The study area was located along the ancient road of the Tang River, where the soil is mainly flooded alluvial cinnamon, the soil surface is sandy loam, and the tillage layer nutrient content is low. Notably, the soil is characterized by fertilizer leakage, good permeability, 0.87% organic matter, 0.055% nitrogen, 29 mg/kg of alkali-hydrolyzed nitrogen, 3 mg/kg of kinetic phosphorus, and 88 mg/kg of available potassium. These conditions are suitable for planting winter wheat, summer corn, and peanuts, to name but a few consequential crops. Generally, the main cash crops include wheat, barley, corn, strawberry, soybean, black bean, mung bean, cotton, sesame, and peanut. Meanwhile, herbaceous plants include *Eragrostis pilosa*, *Digitaria sanguinalis* (L.) Scop., *Chloris virgata* Sw., *Xanthium sibiricum*, *Taraxacum mongolicum* Hand.-Mazz., *Dendranthema indicum*, *Atractylodes macrocephala* Koidz, and *Rehmannia glutinosa*. Trees belong to the *Salix*, *Populus*, *Ulmus*, *Sophora*, *Toona*, *Amygdalus*, *Pyrus*, *Ziziphus*, and *Malus* genera.

The total area of cultivated land is 920.8073 hm^2 across North Xinshu, West Xinshu, South Xinshu, and Zhicao villages. The total population is 10,482, the cultivated land per-capita is 0.0913 hm^2, the annual per-capita net income is 962 yuan, the wheat yield is 5,250 kg/hm^2, and the corn yield is 6,000 kg/hm^2. Local farmers are engaged mainly in agricultural production, owing to the poor natural conditions, a low degree of intensification of agricultural production, low output efficiency and per-capita output value, low per-capita net income, and the abundance of labor and land resources, which offer great potential for remediation.

3.2. Research Methods. The analysis performed using software included image vectorization, landscape pattern index calculation, and ecosystem service value calculation. The MapGIS software was used to plan and design the land regulation in the study area, and ArcGIS software was used to convert the image into a grid map. The landscape index included three indices: patch characteristics, landscape diversity, and corridor characteristics. The landscape index included the patch index, landscape diversity index, and corridor characteristic index. The landscape diversity index included the Shannon diversity index, evenness index, and dominance index. The corridor characteristic index included the average corridor width index, corridor density index, corridor fractal dimension, and corridor connectivity index.

Costanza's [36] adapted formula of the ecosystem service value was used to calculate the service value of the terrestrial ecosystem in the study area. The formula is as follows:

$$\mathrm{ESV} = \sum_{i=1}^{6} \left(A_i \times \mathrm{VC}_i\right), \tag{1}$$

where ESV represents the total value of ecosystem services in one year, A_i represents the distribution area of i land-use type in the study area (hm^2), and VC_i represents the ecosystem service value (Yuan/hm^2·a) of i land-use type.

This study sought to uncover the benefits of different approaches to land regulation in this area to optimize land regulation theory, planning, and design by analyzing the landscape pattern analysis index and ecological service value across traditional land regulation and landscape ecological planning.

4. Comparison and Analysis of Results

4.1. Current Situation of the Landscape Pattern

4.1.1. Landscape Structure. The landscape structure of the study area (Figure 2 and Table 1) was obtained using the 1 : 1000 land-use status map as the base map. The total landscape area of the village of North Xingshu in Dongwang Township in this study was 1,522.7820 hm^2 and included 13 different landscape types (Table 2). As indicated above, this study used MapGIS software to process the land-use status map of the study area and ArcGIS software to convert the image into a grid map before introducing it into Fragstats 3.3 to calculate the various landscape indexes. Because farmland roads, farmland shelterbelts, ridges, and some ditches emerged as linear features, these parts of the area were merged into local categories.

4.1.2. Patch Characteristics Index. Notably, Table 2 demonstrates that the spatial structures of the study area's landscape elements differ significantly; in particular, a large number of patches and relatively higher patch density were

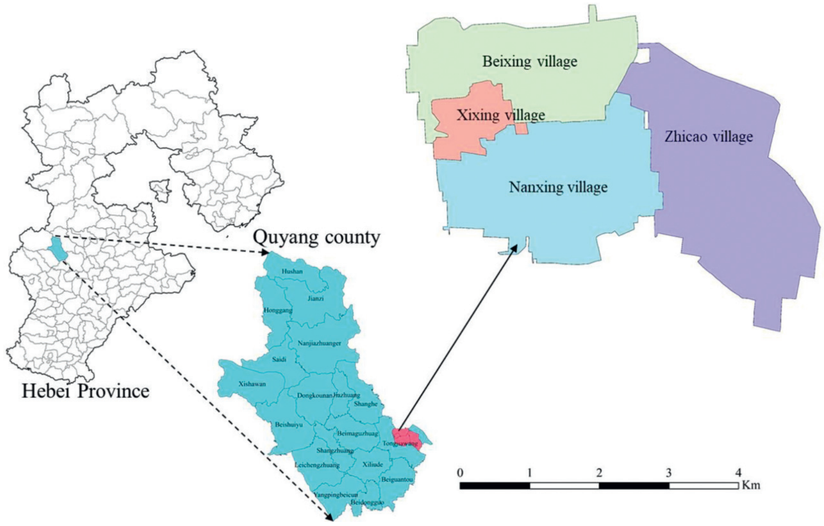

Figure 1: Location of the study area.

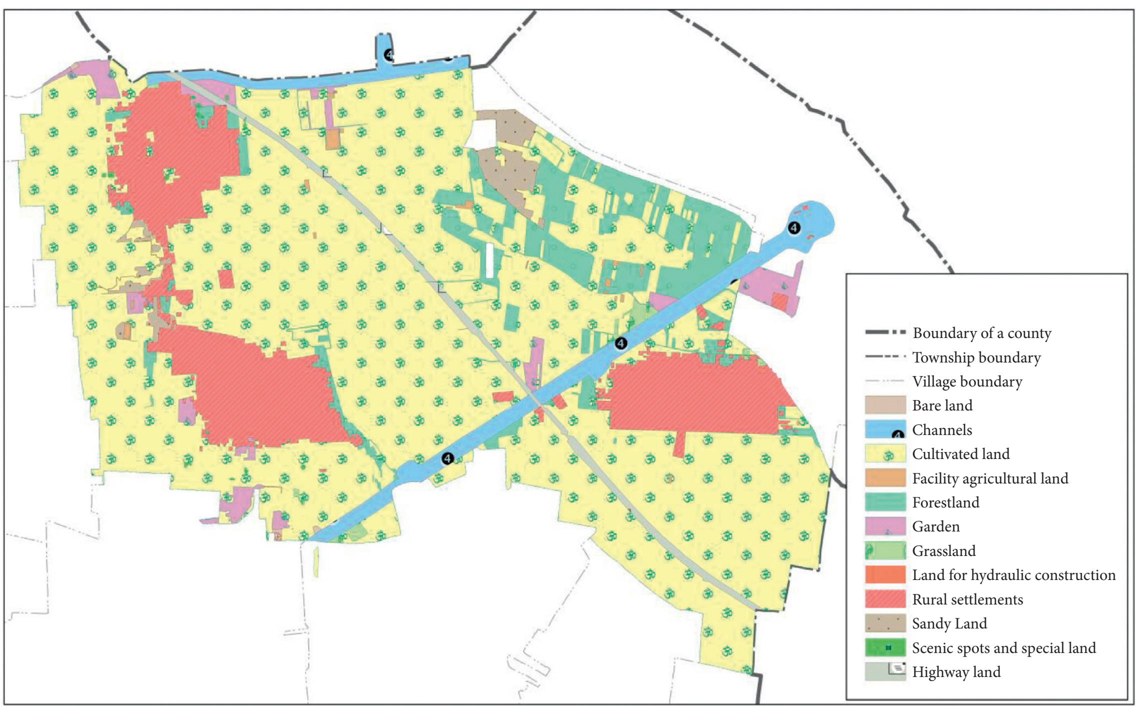

Figure 2: The map of land uses on Beixingshu village, Dongwang Township, Quyang County, and Baoding City, Hebei Province in 2017.

present in the cultivated land, which indicates high cultivated land fragmentation. Crucially, high cultivated land fragmentation is not conducive to large-scale cultivated land management and thus affects the area's crop production capacity. Along these lines, the average patch area was small, which hinders biological survival and reproduction; accordingly, species richness in this area was relatively low. Meanwhile, as noted above, patch dimensionality was high, indicating that cultivated land patches were not properly remedied and affected by topographic factors, and the patch edges of cultivated land patches were complex. The patch number, average patch area, and patch density of rural residential and woodland landscapes were not different, but the patch fractal dimension of the rural residential landscape was much smaller than that of the woodland landscape, which indicates that the rural residential landscape was seriously affected by human activity; accordingly, its edge was more regular. Besides, the density index of the wasteland grassland in the unused landscape was high, which indicates that the fragmentation degree of the landscape was also higher and its influence on the surrounding landscape was significant, thereby suggesting that treatment is needed. Meanwhile, the fractal dimensions of the patches in sandy land, bare land, and wasteland were large, which suggests that the patch edge was more complex. Moreover, human activities did not significantly affect the landscape.

Table 1: Current landscape structure of the study area.

Landscape type			Area (hm^2)	Ratio (%)
Agricultural land landscape	Cultivated land landscape	Water irrigated landscape	691.9296	45.44
		Dryland landscape	228.8777	15.03
	Forestland landscape		209.8259	13.78
	Landscape		44.3930	2.92
	Other agricultural land landscape	Farmland road landscape	38.0402	2.50
		Trench landscape	30.0666	1.97
		Landscape of farmland shelter	0.1882	0.01
Construction land landscape	Rural settlements landscape		223.7001	14.69
	Special land landscape	Funeral land landscape	1.0948	0.07
Other land landscape	Nature reserve landscape	Sandy land landscape	35.7669	2.35
		Naked landscape	11.8958	0.78
		Tian Kan landscape	0.0875	0.01
		Grassland landscape	6.9157	0.45
Total			1,522.7820	100.00

Table 2: Landscape patch characteristics in the study area.

Landscape type	Number of patches	Average plaque area	Plaque density index	Dimensions
Cultivated land	185	5.1811	0.19	1.065
Garden	13	3.6432	0.27	1.037
Forestland	37	5.7970	0.17	1.236
Channels	1	20.5768	0.05	1.030
Rural settlements	42	5.3677	0.19	1.048
Funeral and burial sites	12	0.0823	12.15	1.046
Sandy land	5	7.3155	0.14	1.176
Bare land	2	5.9126	0.17	1.126
Grassland	5	1.4053	0.71	1.112
Total	302	5.0423	0.20	1.109

Table 3: Current landscape diversity indices of the study areas.

Maximum diversity index	Shannon index	Evenness index	Advantage index
2.302585	1.17324	0.509531	1.1293

4.1.3. Landscape Diversity Index. According to the maximum landscape diversity index, outlined in Table 3, there were many landscape types in our study area. However, the landscape diversity index was only 1.17324, which differs from the maximum diversity index. The decrease in the landscape diversity index is due to the large variety of landscape types in our study area. Notably, the landscape evenness index and dominance index were 0.509531 and 1.1293, respectively, which indicate that the distribution of landscape types is not very uniform, primarily because cultivated land accounts for a large proportion of the landscape.

4.1.4. Corridor Characteristic Index. Table 4 shows that the width of the landscape corridor was uneven, ranging from 0.5 to 13 m. Meanwhile, the density of the corridor was small, the average corridor dimension was high, and the connection degree of the corridor was low. These conditions are not conducive to the use of farmland machinery and the transportation of farmland products. Besides, according to the results of our field investigation, there are only a few farmland shelterbelt corridors in the present study area; ultimately, these cannot form a perfect farmland shelterbelt system.

4.2. Ecological Service Value of the Study Area. Ecosystem service value equivalence of land use types draws on Xie's research results [37]. However, Xie provided the unit price of ecosystem ecological service value under the national average state. The size of ecological service function in different regions is closely related to the biomass of ecosystem. According to the linear relationship between ecosystem service value and biomass in different regions, it is necessary to modify the ecosystem service value before it can be used. According to Mr. Xie's unit price correction formula for ecosystem service value [3], the study area belongs to Hebei Province. After calculation, the correction coefficient (1.02) is obtained, and finally a table of equivalent factors of ecosystem service value suitable for the study area is formed (Table 5), in which cultivated land corresponds to farmland, forest land corresponds to the forest, water area corresponds

Table 4: Current landscape corridor characteristics.

Project landscape type	Corridor length	Average corridor width	Corridor density	Average corridor dimension	Corridor connectivity
Farmland road landscape	59,817.63	2–13	39.28	1.002	0.292
Irrigation and drainage ditch landscape	16,292.3	0.5–5	10.70	1.003	0.186
Landscape of farmland shelter	3.764	0.5	2.47	1.000	1.000
Total	79,873.93	3.97	52.45	1.002	0.274

Table 5: Ecosystem service value per unit area of the ecosystem in the study area (yuan/hm^2·a).

Function	Farmland	Garden plot	Forestland	Rural construction land	Water surface	Unused land
Gas regulation	451.25	1940.50	3158.94	0.00	0.00	0.00
Climate change	803.25	1624.61	2436.88	0.00	415.14	0.00
Water conservation	541.52	1805.09	2888.13	27.03	18393.86	27.03
Soil formation and conservation	1317.74	2639.96	3519.92	18.05	8.98	18.05
Waste disposal	1480.22	1182.38	1182.38	8.98	16408.33	8.98
Biodiversity conservation	640.76	1963.04	2942.29	306.82	2247.37	306.82
Food production	902.60	180.54	90.27	8.98	90.27	8.98
Raw materials	90.27	1195.85	2346.61	0.00	8.98	0.00
Entertainment culture	8.98	595.68	1155.25	8.98	3917.00	8.98
Total	6236.59	13127.66	19720.68	378.83	41489.93	378.83

to rivers and lakes, the unit area ecological service value of garden ecosystem takes the average value of grassland and forest land, unused land corresponds to the desert, and rural construction land corresponds to the practice of scholars such as Cai Bangcheng [38]. According to the value of ecological service of desert ecosystem type, hydrological regulation function corresponds to water conservation, and aesthetic landscape corresponds to the ecotourism service function.

Inclusion of pothole is a small land type, which is merged with wetland type in constructed wetlands [38, 39]. However, the total rural roads and ditches in the project area only account for 4% of the total area of the project area, and the existing ecological service value evaluation methods cannot evaluate the ecological service value of the above land types, so it is omitted.

4.3. Changes of Landscape Structure in Ecological Landscape Planning

4.3.1. Adjustment Target of Landscape Ecological Pattern. Land remediation is a process of optimizing the current land use pattern, that is, under the guidance of the theory of landscape ecology, following the principles of protecting and improving the ecological environment and adhering to sustainable development, and taking the adjustment and reconstruction of the spatial structure of landscape units as the basic means, comprehensively adjust the current land landscape pattern in the study area, layout roads, drainage and irrigation networks, crops, farmland structure Shelterbelt system, and land unit, build a harmonious spatial structure and stable ecosystem, so as to form a coordinated landscape of "farmland rules, trees, ditches, and production roads," and realize the goal of sustainable utilization of land resources.

4.3.2. Contents of Landscape Ecological Pattern Adjustment in the Study Area. To maintain the ecological diversity of the study area, a certain type of patches in the study area were retained when the ecological pattern of the land landscape was adjusted [40] (Table 6). First of all, we consider preserving 181.7828 hm^2 with high ecological value landscape of natural, artificial, or ecological woodlands, 20,5757 hm^2 ecological ditch landscape, unsuitable 3.3029 hm^2 sandy landscape, 0.7820 hm^2 bare landscape, and 0.2322 hm^2 barren landscape near the ditch. Secondly, the scattered distribution of landscape fragmentation in the study area was 0.5256 hm2 inside the cultivated land Funeral Land Landscape 1.6206 hm2 Rural settlements landscape, 1.8737 hm2 Ditch landscape and 4.3319 hm2 Garden landscape is transformed into the cultivated land landscape, and the ecological benefit is not high 28.0431 hm2 Forest land landscape adjusted to cultivated land landscape, will 10.9058 hm2 Sandy landscape, 3.2951 hm2 Bare landscape and 1.8551 hm2 The landscape of wasteland is developed as cultivated land landscape. Thirdly, to strengthen the ecological environment protection and improve the ecological value of land landscape in the study area will be made on Sandy Land Landscape, 4.8284 hm2 Grassland landscape and 7.6165 hm2 The bare land landscape is adjusted to the woodland landscape. Based on making full use of the existing landscape corridors, 34.1695 hm2 are planned around the cultivated land landscape patches to improve the productivity of farmland landscape ecosystem Farmland Road Landscape, 28.1929 hm2 Drainage ditch landscape, 4.0415 hm2 Farmland shelterbelt landscape.

Table 6: Landscape structure comparison before and after planning.

Land classes			Prior period (hm^2)	Percentage (%)	Regulation (hm^2)	Percentage (%)	Increase or decrease (hm^2)	Percentage (%)
Agricultural land	Cultivated land	Water irrigated land	691.9296	45.44	973.2583	63.91	281.3287	18.47
		Drylands	228.8777	15.03	0.0000	0.00	−228.8777	−15.03
	Subtotal	920.8073	60.47	973.2583	63.91	52.4510	3.44	
	Garden		44.3930	2.92	40.6031	2.67	−3.7899	−0.25
	Forestland		209.8259	13.78	213.4238	14.02	3.5979	0.24
	Other agricultural land	Farmland roads	38.0402	2.50	41.3922	2.72	3.3520	0.22
		Channels	30.0666	1.97	28.1929	1.85	−1.8737	−0.12
		Farmland shelter	0.1882	0.01	4.0415	0.27	3.8533	0.25
	Subtotal		68.2950	4.48	73.6266	4.84	5.3316	0.35
Total			1243.3212	81.65	1300.9117	85.43	57.5905	3.78
Construction land	Rural settlements		223.7001	14.69	217.1249	14.26	−6.5752	−0.43
	Subtotal		223.7001	14.69	217.1249	14.26	−6.5752	−0.43
	Special land use	Funeral and burial sites	1.0948	0.07	0.3408	0.02	−0.7540	−0.05
	Subtotal		1.0948	0.07	0.3408	0.02	−0.7540	−0.05
Total			224.7949	14.76	217.4657	14.28	−7.3292	−0.48
Other land	Natural reserves	Sandy land	35.7669	2.35	3.3029	0.22	−32.4640	−2.13
		Bare land	11.8958	0.78	0.7820	0.05	−11.1138	−0.73
		Tian Kan	0.0875	0.01	0.0875	0.01	0.0000	0.00
		Grassland	6.9157	0.45	0.2322	0.02	−6.6835	−0.44
	Subtotal		54.6659	3.59	4.4046	0.29	−50.2613	−3.30
Total			54.6659	3.59	4.4046	0.29	−50.2613	−3.30
Total land area			1522.7820	100.00	1522.7820	100.00	0.0000	0.00

Table 7: Index of plaque characteristics after treatment.

Landscape type	Number of patches		Average patch area (hm^2)		Plaque density index		Dimensions	
	Traditional traditions planning	Landscape state planning	Traditional traditions planning	Landscape state planning	Traditional traditions planning	Landscape state planning	Traditional traditions planning	Landscape state planning
Cultivated land	152	139	7.3682	7.2724	0.14	0.14	1.033	1.030
Garden	10	10	2.4833	4.2163	0.40	0.24	1.054	1.049
Forestland	23	30	5.5631	7.3688	0.18	0.14	1.127	1.142
Channels	1	1	20.5768	20.5768	0.05	0.05	1.025	1.025
Rural settlements	42	37	5.3677	6.0462	0.19	0.17	1.048	1.046
Funeral and burial sites	12	3	0.0823	0.1213	12.15	8.24	1.046	1.032
Sandy land	5	5	0.6047	0.6047	1.65	1.65	1.087	1.087
Bare land	0	1	—	0.7904	—	1.27	—	1.018
Grassland	0	1	—	0.2326	—	4.30	—	1.013
Total	245	227	6.2154	6.7083	0.16	0.15	1.048	1.048

4.4. Comparative Analysis of Traditional Planning and Landscape Ecological Planning Landscape Pattern Index

4.4.1. Plaque Characteristic Index. Comparing Table 7 with the present patch characteristic index table reveals that the land in the study area changed greatly after the traditional planning and design and landscape ecological planning and design. Compared with the present situation, the number of patches reduced, the average patch area improved, and the patch density decreased significantly, indicating that both schemes made some progress toward reducing landscape fragmentation and increasing land scale management and farmland crop yield. Across these two kinds of planning, the number of patches was lower, the average patch area slightly higher, and the patch density lower in landscape ecological planning than in traditional planning, which indicates that

Table 8: Index of landscape diversity after the study area regulation.

Maximum diversity index		Shannon index		Evenness index		Advantage index	
Traditional planning	Landscape ecological planning	Traditional planning	Landscape ecological planning	Traditional planning	Landscape ecological planning	Traditional planning	Landscape ecological planning
1.945910	2.197225	0.85970	1.01217	0.441796	0.460657	1.0862	1.1851

landscape ecological planning more effectively reduces landscape fragmentation. Meanwhile, after the implementation of the two planning approaches, the fractal dimension of cultivated land patches also decreased to 1.033 and 1.030, respectively, indicating that landscape ecological planning carried out more appropriate remediation activities on cultivated land and reduced more effectively the edge complexity of cultivated land patches than traditional planning. Besides, after the implementation of the two planning and design approaches, the number of patches also declined; in traditional planning and design, bare land and wasteland were developed into cultivated land; meanwhile, in landscape ecological planning and design, certain amounts of unsuitable bare land and wasteland were retained to maintain landscape diversity and ensure the survival and reproduction of local organisms.

The above analysis suggests that these two approaches to land regulation planning and design greatly influenced the landscape pattern of the study area; in particular, they tended to simplify its land types, regularize the patch shape, and increase the average patch area. Ultimately, landscape planning and design proved more effective than traditional design.

4.4.2. Landscape Diversity Index. Compared with the present landscape diversity index of the study area [41] (Table 8), the land landscape Shannon index of the study area before and after the renovation demonstrated the following rank: current landscape > landscape ecological planning > traditional planning. However, landscape ecological planning still proved beneficial for protecting the landscape's diversity and, compared with traditional planning, more effective for restraining the uneven trend of land type distribution bias, which encourages sustainable development.

4.4.3. Corridor Characteristic Index. After the planning and designing of the land pattern in the study area [42], the landscape corridor added roads, irrigation, drainage ditches, and farmland shelterbelts, thereby forming a perfect system. After planning and designing, the road corridors in the study area were divided into two types: field and production roads. The length and density of the corridor increased (Table 9). After planning, the roads in the study area were staggered, forming a network; the average corridor dimension was reduced, and the corridor connection improved. Compared with the lack of a complete shelterbelt system in the study area before planning, the planned farmland shelterbelt combined with the field road layout increased the density and formed a perfect farmland shelterbelt system.

Compared with traditional planning, the corridor length, density, and connection degree were higher, but the average corridor width was slightly lower, which indicates that landscape ecological planning pays more attention to the protection of the landscape ecology in the study area based on improving the corridor connection degree and is more reasonable for the corridor design.

4.5. Comparative Analysis of the Value and Benefit of Ecological Services before and after Traditional Planning and Landscape Ecological Planning. By quantitatively estimating the value of ecological services before and after land regulation, the amount of increase or decrease in ecological service value brought by land regulation can be determined, and the ecological benefit of land regulation can be quantitatively evaluated and calculated. The ecological value of the traditional planning scheme and the landscape ecological planning scheme in the study area are shown in Table 10.

Our ecological value calculation shows that, according to the landscape ecology planning method, the land renovation project offers more significant benefits to our ecological environment than the traditional planning method, especially with improving and intensifying land use. It is important to note that the total ecological service value of Dongwang Township before the land renovation was 10.5693 million yuan and the renovation reduced this value to 9.7214 million yuan. The reduction rate (percentage of the ratio of ecological service value reduction to the total ecological service value before regulation) was 8.02%. In terms of ecosystem service value of various types of land after renovation, cultivated land increased by 945000 yuan, garden land decreased by 295700 yuan, forest land decreased by 1477600 yuan, and unused land decreased by 19500 yuan. Land for rural construction and water use remained unchanged.

After the renovation following landscape ecology principles, the value of the total ecological services increased to 10.9853 million yuan, which represented an increased rate of 3.94. After remediation, the values of the ecosystem services of cultivated land, forest land, and unused land increased by 327,100 yuan (this was 617,900 yuan less than the traditional planning scheme), 71,000 yuan (this was 1.5485 million yuan more than the traditional planning scheme), and 71,000 yuan (this was 90,000 yuan more than the traditional planning scheme), respectively, while those of garden land and rural construction land decreased by 49,800 yuan (this was 246,000 yuan more than the traditional planning scheme) and 2,800 yuan (this was 100 yuan more than the traditional planning scheme), respectively; the value of water

Table 9: Landscape corridor characteristics after the study area regulation.

Landscape type	Corridor length (m)		Average corridor width (m)		Corridor density (m/hm^2)		Average corridor dimension		Corridor connectivity	
	Traditional planning	Landscape state planning	Traditional planning	Landscape state planning	Traditional planning	Landscape state planning	Traditional planning	Landscape state planning	Traditional planning	Landscape state planning
Farmland road landscape	98,831	100,816	3–6	2–4	64.90	66.21	1.000	1.000	0.424	0.433
Irrigation ditch canal landscape	40,007	43,711	1	2–5	26.27	28.70	1.000	1.000	0.376	0.379
Farmland protection forest landscape	38,972	42,297	0.5	0.5	25.59	27.78	1.001	1.001	0.217	0.229
Total	177,810	186,824	2.85	2.79	116.77	122.69	1.001	1.001	0.399	0.403

Table 10: Comparison of the ecological values of the traditional planning scheme and the landscape ecological planning scheme (yuan, %).

Land classes	Prior period		Traditional planning methodology		Landscape ecological planning	
	Output	Percentage	Output	Percentage	Output	Percentage
Cultivated land	5,742,698	54.33	6,687,683	68.79	6,069,813	55.25
Garden	582,776	5.51	287,035	2.95	533,023	4.85
Forestland	4,137,907	39.15	2,660,334	27.37	4,208,860	38.31
Rural construction land	85,161	0.81	85,159	0.88	82,385	0.75
Water surface	0	0.00	0	0.00	0	0.00
Unused land	20,710	0.20	1,182	0.01	91,218	0.83
Total	10,569,252	100.00	9,721,393	100.00	10,985,299	100.00

Table 11: Comparison of the value changes of the individual ecological services of land in the study area (yuan, %).

Function	Prior period output	Percentage	Traditional regulations program output	Percentage	Landscape state planning output	Percentage	Traditional mention high value change	Rate of change	Landscape increase change	Rate of change
Gas regulation	1,164,486	11.02	952,462	9.80	1,192,166	10.85	−212,025	−18.21	27,680	2.38
Climate change	1,323,080	12.52	1,225,608	12.61	1,367,822	12.45	−97,472	−7.37	44,742	3.38
Water conservation	1,192,327	11.28	1,015,928	10.45	1,229,113	11.19	−176,399	−14.79	36,786	3.09
Soil formation	2,074,195	19.62	1,949,728	20.06	2,149,198	19.56	−124,467	−6.00	75,003	3.62
Protection										
Waste disposal	1,666,090	15.76	1,774,688	18.26	1,745,108	15.89	108,597	6.52	79,018	4.74
Biological diversity	1,380,275	13.06	1,196,874	12.31	1,471,885	13.40	−183,400	−13.29	91,610	6.64
Sexual protection										
Food production	860,586	8.14	986,057	10.14	909,174	8.28	125,471	14.58	48,588	5.65
Raw materials	628,588	5.95	439,506	4.52	637,234	5.80	−189,082	−30.08	8,645	1.38
Entertainment culture	279,624	2.65	180,545	1.86	283,599	2.58	−99,079	−35.43	3,975	1.42
Total	10,569,252	100.00	9,721,393	100.00	10,985,299	100.00	−847,858	−8.02	416,047	3.94

remained the same. Meanwhile, the single land service value function (Table 11) demonstrates that the soil formation and protection value function were the highest before remediation, accounting for approximately 20% of the total service value of the study area. The entertainment cultural function was the smallest, accounting for approximately 2% of the value of regional services.

The traditional plan reduced the value of single services, with the exceptions of the waste treatment and food production; most notable is the function of entertainment culture, which was under the aim of the traditional land renovation of increasing grain production, but neglected the comprehensive service value of the land. Conversely, the landscape ecological planning scheme improved the value function of every single ecological service. The highest increase rate was in the biodiversity protection function, which reached 6.64; the smallest increase was in the entertainment cultural service function [43]. These results could be attributed to the increases in woodland, which offset the value of individual services lost by reducing cultivated land. A comparison of the traditional and landscape ecology planning schemes reveals that the latter can improve the area's comprehensive service function value, prevent the simple pursuit of grain production, and realize the modern land regulation goals of protecting biodiversity and improving rural ecological service functions and landscape value through natural resource protection [44], the biological restoration of the ecological environment, nonpoint source pollution control, and the construction of ecological networks and green infrastructure [45].

5. Conclusions

In this study, we conducted a comparative analysis of the landscape pattern status, traditional landscape pattern planning results, and ecological landscape planning results of Quyang County using the landscape pattern index and the calculation results of ecological service value to assess best practices for land regulation planning in the study area. The results are as follows:

(1) The average patch area in the landscape ecology planning and design scheme was higher than that of the traditional planning scheme; meanwhile, the number and density of patches in the landscape ecology scheme were lower than in the traditional

planning scheme, which indicates that the landscape ecology planning scheme can effectively reduce landscape fragmentation and intensify its management. Notably, the hierarchy of the landscape approaches according to the Shannon index is as follows: current landscape > landscape ecological planning > traditional planning; landscape ecological planning was most conducive to the protection of the now-declining diversity of the landscape.

(2) Landscape ecological planning offered better outcomes than traditional planning in terms of corridor length, density, and connectivity, although it slightly lowered the average corridor width, which indicates that more attention is paid to the protection of landscape ecology in the study area based on increasing corridor connectivity and that the corridor design is more reasonable.

(3) Landscape ecological planning can improve ecological service values in the study area to varying degrees and thus discourages the simple pursuit of grain production; ultimately, this brings the area closer in line with modern approaches to comprehensive land regulation.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Yin Haikui and Yapeng Zhou contributed equally to this work.

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