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Design of Ecological Land Remediation Planning and Remediation Mode Based on Spatial Clustering Algorithm

Yuzhuo Yao
Hebei Bureau of Geology and Mineral Resources second geological brigade, Tangshan, Hebei, 063000, China
E-mail: yuzhuoyao9@163.com

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In this article a method is proposed based on a spatial clustering algorithm, in order to better realize the design of ecological land consolidation planning and regulation mode. Considering the GIS methods such as spatial clustering algorithm and least resistance model, the proposed model selects typical projects and put forward ecological land consolidation planning scheme. The unified engineering construction forms and rigid engineering construction standards aims at regularization and rigidization of traditional land consolidation by means of high-intensity engineering construction. Although in the process of stabilizing the amount of cultivated land and improving agricultural production conditions, played a positive role. However, under the current requirements of ecological civilization construction, there is an urgent need for transformation. Through the improvement of ecological land, the ecological improvement is realized, and the need for landscape improvement is foremost requirement. The study is guided by the theory of landscape ecology, according to the general idea of "landscape pattern evaluation-land remediation function zoning-corridor pattern optimization-patch matrix optimization". The experimental results are generated using Fragstates software for calculating various indicators. The results show that, before and after renovation, the landscape types with the largest landscape ecological security index LESi were all cultivated land, and the smallest one was forest land. Except for the river landscape ecological security index, which dropped by 9.84%, the ecological security of other types of landscapes improved. Among them, the largest increase was road (121.29%), followed by forest land (43.10%). According to formulas (1) and (2), the landscape safety index LES of the project area is 0.45 before the renovation, and 0.61 after the renovation. An increase of 35.56% is observed which shows that through the ecological land consolidation project area, the overall landscape ecological security status has been improved. It is proved that the spatial clustering algorithm can better realize the design of ecological land remediation planning and remediation mode.

Povzetek: Razvita je metoda, ki temelji na algoritmu prostorskega gručenja, za izboljšanje načrtovanja in regulacije ekološke konsolidacije zemljišč z uporabo GIS metod.

1 Introduction

With the rapid development of urbanization, many high-quality arable lands have been occupied in large quantities; In the countryside, there are a large number of hollow villages, houses that are idle or abandoned, rural infrastructure is poor, water pollution is serious, rural landscapes are damaged, and the quality of living environment is poor. Therefore, various regions have successively carried out new rural construction, village appearance improvement, rural land improvement, capital investment has been increased in projects such as agricultural infrastructure construction, comprehensive agricultural development, and returning farmland to forests. These policies and action plans are of great significance to China's rural development and urban-rural integration, and have achieved remarkable results [1]. However, in the process of new rural construction and land consolidation, due to the lack of ecological landscape theory and technical guidance, coupled with the limited business level of management and construction personnel, as a result, the construction of new rural areas is monotonous and has no characteristics. Some peasant resettlement sites are like urban communities, with high-rise and multi-storey barracks-like distribution, and the culture, size and color are seriously inconsistent; Because the ecosystem structure and function composed of local topography, water system and organisms are not brought into play, coupled with a blunt understanding and pursuit of the standardized construction of "Tian Chengfang, Road Chengwang, Canal Interconnection, Trees Forming", excessive transformation of the land in a bulldozer style, despising circulation and symbiosis, as a result, a large number of ditches and roads that need to be ecologicalized have been excessively hardened, and diversified groves have been cut down, the ponds were filled and the rivers were straightened, resulting in serious damage to the biological, ecological and local features of life that nurtured our regional culture [2]. These issues will be important issues and challenges faced by rural land consolidation.

Land consolidation is the arrangement and coordination of land resources and their utilization methods, it is an important platform for promoting new urbanization and implementing the rural revitalization strategy, as well as promoting the coordinated development of urban and rural areas, it is an important means to build beautiful and livable villages and promote targeted poverty alleviation and poverty alleviation. Objectively analyze the differences in regional natural and social and economic conditions, accurately grasp the direction and goals of land consolidation in the study area, scientific division of land consolidation types, it can effectively guide the smooth development of land consolidation work [3].

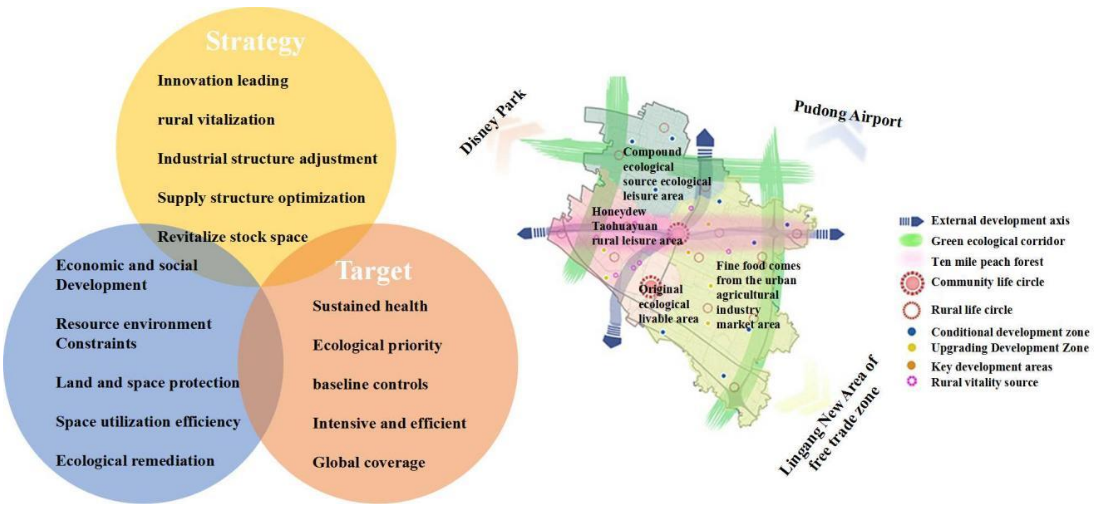

Figure 1: Area mapping based on target and strategy.

The area mapping based on target and strategy is presented in Figure 1. Landscape ecology is a multidisciplinary subject, it covers ecology, geography, environmental science, resource science, management science and other related theories, it is mainly based on the principle of ecosystem, combined with systematic research methods, analyze and study the internal structure, function and dynamic change process of landscape at a certain scale, in order to beautify the landscape pattern and optimize the landscape structure, promote the scientific utilization, rational protection and effective development of landscape. Landscape ecological land remediation, mainly based on the theoretical basis of landscape ecology and ecological security pattern, relying on ecological land remediation technology, by adjusting the functions and structures of patches, corridors and substrates in the landscape, optimize the spatial layout of land remediation, improve the ecological stability and ecological service value of land remediation landscape [4]. The rest of this article is systematized as literature is presented in section 2 followed by research methods in section 3. Section 4 depicts the results and the conclusion is presented in section 5.

2 Related work

In this section various state-of-the-art work in the field of land remediation and planning using several approaches are studied and discussed.

Moravcova *et al.* discusses that artificial land consolidation, not only can the road system be optimized, for improving water resources management system and natural landscape conditions, also played an important role. Some scholars also pointed out that, a series of engineering and biological measures during the implementation of land consolidation, it may affect the quantity and quality of vegetation on the surface [5]. Cong *et al.* pointed out the goal of land consolidation, if only limited to increasing agricultural productivity and improving production conditions, the implementation of the land consolidation, it is likely to have a negative impact on the ecological environment [6]. For example, Long *et al.* research shows that after land consolidation, farmers' labor rate of return has been effectively improved, thus prompting them to support the land consolidation policy [7]. Gong and Tan proposed that the social benefits of land consolidation should include four aspects, for example, the degree of support of local farmers and the implementation of the project, the impact on people's customs, entertainment and social welfare [8]. Guo *et al.* selected the properties of the plot itself, natural resource conditions, economic conditions and other aspects as evaluation indicators, for 3 different land consolidation projects in the Czech Republic, the pre-implementation benefit evaluation and the post-implementation benefit evaluation are carried out respectively. The results show that, the determination of the initial evaluation criteria and evaluation model has a significant impact on the benefits of land consolidation projects [9]. Ng presented a study which presents that according to the regional differences in topography, landforms, land use, and the unbalanced social and economic development of the province, combined with relevant national development strategies and relevant regional policy requirements, the province is divided into 6 districts for comprehensive development and improvement of land, resources and environment [10]. Tudor taking Qingzhou City, Shandong Province as an example, and taking the comprehensive agricultural productivity as the standard, with the help of related models and methods. Divide Qingzhou into different remediation zones in the remediation planning period, such as the recent land remediation area, and put forward the corresponding remediation suggestions for different finishing areas. Landscape-scale land consolidation zoning research, the main focus is on land consolidation projects implemented in specific spatial areas [11]. Zhai *et al.* suggested that on the basis of the division of the northern low mountains and hills and the North China Plain, the first-class project type area framework, the Tianjin land consolidation project type area is divided into 3 secondary project type areas, it is pointed out that the division of this type of area can provide a basis for the arrangement of engineering construction projects, the preparation of feasibility study reports, and engineering design [12]. Ji and Wang presented a study using the natural quality score of the intermediate results of agricultural land classification, and the type of factor combination, as an entry point, the research on the types of agricultural land remediation in Tianjin is carried out, the difficulty level of farmland remediation in different types of districts, the focus of remediation and the direction of future remediation were clarified [13]. Sankararaman *et al.* analyzed the regional differences in the proportion of land use, consolidation potential, and average size of rural settlements, the research on the remediation zones of rural settlements is carried out, the whole country is divided into 5 remediation areas, and the direction of regional renovation according to local conditions is proposed [14].

The model can further be extended by implementing some Machine learning and Artificial intelligence approaches to enhance the capability of cost estimation of reconstruction. Based on the current research, the author proposes a method based on spatial clustering algorithm. Based on GIS methods such as spatial clustering algorithm and least resistance model, typical projects are selected to propose ecological land consolidation planning [15]. Guided by unified engineering construction forms and rigid engineering construction standards, and aiming at regularization and rigidization, traditional land consolidation by means of high-intensity engineering construction, although it has played a positive role in stabilizing the amount of arable land and improving agricultural production conditions [16-17]. However, it is waiting for transformation under the requirements of the current ecological civilization construction. Through the improvement of ecological land, the ecological improvement is realized, and the need for landscape improvement is more urgent. The study is guided by the theory of landscape ecology, according to the "Landscape Pattern Evaluation-functional Zoning of Land Remediation - Optimization of Corridor Pattern-Plaque matrix optimization" general idea.

3 Research methods

This section includes the design process including pattern analysis, functional division and layout designing of the proposed study.

3.1 Landscape pattern analysis

According to the land use status of the project area and the characteristics of the land remediation project, appropriately merge the original land use types, converted into 2 types of matrix landscapes of cultivated land and pits and ponds, there are two types of patch landscapes, construction land and forest land, and three types of corridor landscapes, namely roads, rivers, and ditches (see Table 1). Among them, among the original land types, hardened rural roads with a pavement width of more than 1 m are defined as road corridors, other roads merge into adjacent other landscapes [18]. The landscape scale selects the number of landscape patches, patch density, average patch area, boundary density, coefficient of variation of plaque area, separation index, landscape richness index and Shannon diversity index reflect landscape characteristics; Type scale Select type area, proportion of project area, number of patches, patch density, the area variation coefficient, shape variation coefficient, separation degree and aggregation degree are used to evaluate the characteristics of each type of landscape; For the corridors in the project area, select the corridor length, corridor density, corridor line point rate, corridor connectivity, and corridor circulation to evaluate its current situation; The scale of the patch was evaluated by selecting the patch area, shape index, and perimeter-area ratio. The above indicator calculations are performed using Fragstates software.

Table 1: Land use type and landscape type conversion

Original land use type	Landscape classification	Landscape definition
Paddy field	Arable land	Matrix
Dry land	Arable land	Matrix
Tian Kan	Arable land	Matrix
Pond water surface	Hang pond	Matrix
River surface	River	Corridor
Ditch	Ditch	Corridor
Rural road	The way	Corridor
Village	Construction land	Plaque
Facility farm land	Construction land	Plaque
Garden	Woodland	Plaque
Scenic spots and special land	Woodland	Plaque

i. On the landscape scale, the project area can be divided into 7 types of landscapes. Compared with adjacent areas, the degree of landscape aggregation and spread is higher, lower separation, lower Shannon diversity index, it shows that the fragmentation degree of various types of landscapes in the study area is relatively low, landscape diversity and heterogeneity are low, and the same type of landscape has obvious aggregation;

ii. On the type scale, the largest proportion of the area, and the type with the largest number of patches is the pond landscape, and the pond and river landscape together accounted for 54.64% of the total area. The area of arable land and pits has the highest variation coefficient, and the area is uneven. The separation degree of cultivated land and pits and ponds is low, and most of them are concentrated and contiguous, however, the separation degree of ditches, roads and woodlands is much higher than other types, and they are scattered;

iii. In terms of corridor layout, the three types of corridors have low density and poor connectivity. The circulation of the river corridor is relatively good, and the channel channel has not yet formed a network structure. Referring to relevant research, make 100m buffer zones on both sides of roads and ditches, calculate its functional coverage, accounting for 28.78% and 13.23% of the total area of the project area, the current roads and ditches are difficult to fully meet the needs of production and life.

iv. On the spot scale, the cultivated map spot is generally small, the shape index and perimeter-area ratio are higher than those of pits, and the aggregation degree is lower, overall finer. The area of the pits varies greatly, but the shape is more uniform. The distribution of other types of spots is more scattered, on the whole, there is a fragmentation trend from southwest to northeast [19].

3.2 Functional division

According to the results of landscape pattern analysis, the study area has obvious spatial differences in landscape characteristics. In order to propose targeted remediation directions in different regions, arrange project types according to local conditions, select landscape type, patch area, perimeter-area ratio and aggregation degree as clustering conditions, using the KNN (k-nearest neighbor) spatial clustering algorithm, the study area was divided into 3 types of areas with similar landscape types, similar shape of the patches, and high degree of aggregation. Considering the integrity of the zoning, combined with the functional positioning of the study area, the results of spatial clustering and partitioning are corrected to obtain the functional partition of land consolidation, that is, the farmland remediation area, the water surface remediation area and the water town style enhancement area, determine the remediation goals, principles and leading project types for each sub-area:

i. In the farmland remediation area, the landscape type is mainly cultivated land. Taking high-standard farmland construction as the remediation goal, based on the principle of ecological maintenance, under the premise of reducing ecological disturbance and ecological damage as much as possible, through land type adjustment, implement land leveling, field roads, irrigation and drainage projects, etc, it is advisable to combine engineering measures such as biological ridge design, ecological pavement and biological passage design of field roads, ecological slope protection design of ditches and artificial wetlands, etc, on the premise of ensuring ecological connectivity and biodiversity, the productivity of cultivated land can be improved, improve agricultural production efficiency and promote large-scale operation [20].

ii. In the water surface improvement area, the landscape types are mainly ponds and rivers. Taking the construction of ecological sources and the construction of aquaculture bases as the rectification goals, based on the principles of ecological restoration and ecological improvement, through the construction of artificial wetlands, the construction of river bank ecological slope protection, and the deployment of ecological combined purification systems, etc, optimize water system structure, improve water quality, and improve production and ecological functions.

iii. The water town style enhancement area has a variety of landscape types. Taking rural landscape construction as the renovation goal, based on the principle of ecological maintenance, on the basis of maintaining the original natural features, layout road works with recreational functions, maximize the landscape richness within the view of the play trail. It is advisable to set up water-town-style hydrophilic platforms, covered bridges, pavilions, etc. in combination with the road layout. Implement rural landscape improvement projects, form a characteristic landscape experience in the south of the Yangtze River of "rice field-flowing water-people's house", and cultivate new formats such as sightseeing and experience agriculture and leisure agriculture.

3.3 Planning layout

3.3.1 Optimization of corridor pattern

The connectivity and circulation of rivers, roads, and ditch corridors in the study area are low, and their functional coverage is small, so structural optimization is required. By building new roads, ditches and farmland shelterbelts, it can meet traffic and irrigation needs, improve farmland ecological environment, and optimize water system structure. This study uses the least resistance model to generate new corridors, according to the rectification principles of each rectification zone, the corridors are revised and screened, get the corridor optimization results. Because ditches and shelter forests are laid along with the field roads.

3.3.2 Water surface improvement area

The substrate landscape in this area is a pit and pond, and most of them are aquaculture water surfaces with clear ownership. The southwest corner of the region is the industrial enterprise plaque, which is the key target of environmental pollution prevention and control. According to the actual situation of the aquaculture water surface in the area, some suitable pits and ponds can be adjusted to a depth of 3m at the bottom of the pond, the water depth is controlled within 2.5m, biological channels are set at the bottom of the pool, and a buffer zone of native shrubs and grasses is left beside the pool, while ensuring the breeding efficiency, it can ensure the habitat of aquatic animals and plants, and improve the water quality of the fish pond and the ecosystem environment. In order to prevent point source pollution, at the same time, the non-point source pollution caused by agricultural production is eliminated to a certain extent, based on the survey data of the water system flow in the project area, according to the migration principle of nitrogen and phosphorus pollutants in agricultural shallow drainage system, adopting the five-level load reduction governance model of “Riverside Vegetation Buffer Zone - Biological Pool Contact Oxidation Unit - Wetland Interception System - Estuary Ecological Interception - Plant Purification Integrated Technology”, form a series of ecological combination purification system [21].

3.3.3 Water Township Enhancement Area

The area is rich in landscape types, surrounded by water, and the landscapes of villages, fields and forests are intertwined. However, due to the scattered distribution of patches in villages and serious domestic waste pollution, the overall appearance is poor, waiting for remediation. According to the area's rectification goals to enhance the style of Jiangnan water towns, maintain the ecological environment, and guide rural leisure tourism, focus on improving facilities, village greening and village beauty, and implement rural landscape improvement projects. In terms of rural greening, different methods such as tree ponds, bamboo fences or cement masonry are used, carry out road greening, increase the greening of houses, courtyards, and corners, greening the nodes such as residential pools and existing open spaces to improve the ecological environment of the village. In terms of improving facilities, increase garbage collection points, considering the current population of the village and the number of recreational populations in the future, set up garbage bins and public health facilities in the village. In terms of village beautification, guide residents to renovate houses and vegetable gardens with characteristics of Jiangnan water towns, restore the visual style of Jiangnan water town from the aspects of color, morphological structure and greening; In addition, appropriately increase leisure and sightseeing facilities, combined with planning and play trails, water bridges, stone arch bridges, wooden octagonal pavilions and hydrophilic platforms will be built, it not only provides residents with a cool and resting place, but also builds a living space with a beautiful environment, highlight the unique charm of Jiangnan water towns and promote the development of rural tourism. For the cultivated land and woodland patches in the region, the original landscape pattern should be preserved, coordinate with the village landscape to form a multi-level rural landscape experience. Guide the development of experience agriculture, picking agriculture and other new formats with land consolidation infrastructure construction, create conditions for expanding rural tourism and farming experience. Through the optimization of the corridor pattern and the optimization of the patch matrix, the ecological land consolidation planning scheme in the project area is formed [22].

4 Experimental results and analysis

In order to verify the feasibility and implementation effect of the scheme, from the two aspects of engineering construction and landscape ecological security, the ecological land remediation planning scheme is evaluated. Through the project planning, 4 new field roads with a total length of 3102m were built; 13 new production roads with a total length of 3403m; 8 new play trails with a total length of 2693m; 2 new Dougou with a total length of 717m; 3 new bucket canals with a total length of 1479m; 5 new agricultural ditches with a total length of 1116m; 8 new agricultural canals with a total length of 1398m; 3743m of new shelter forest; Implement land leveling in 4 areas with a total area of 25.26hm2, accounting for 64.57% of the total cultivated land area; The newly constructed wetland is 1.24hm2, accounting for 2.91% of the total area of the pit. After the renovation, the functional coverage area of the ditches in the project area accounted for 54.02% of the total area of the project area, an increase of 40.79% compared with that before the renovation; The coverage area of road functions accounted for 88.84%, an increase of 60.06%, and the infrastructure in the project area was improved. Through the project planning, the corridor network pattern in the project area has undergone great changes. The calculation results show that, since the planning scheme does not involve changes in the river channel, the river corridor structure remains unchanged. However, through the construction of ecological ditches, the density of ditches and corridors increased by 447.31% compared with that before the renovation, the circulation degree of ditch corridors increased by 114.91%, and the network structure of ditch corridors was significantly improved. Through the construction of ditches, the water system in the project area has been connected, the water system corridor connectivity has increased by 55.43%, and the water system circulation has increased by 454.95%, the water system structure in the project area has been optimized. In addition, the road corridor pattern in the project area has also been significantly improved [23]. Landscape ecological security Build an ecological security pattern, maintaining the stability of the ecological environment is an important goal of ecological land consolidation planning, combined with the principles of landscape ecology, various types of landscapes in the project area are used as evaluation units, select the landscape ecological security index, ecological security evaluation is carried out before and after the renovation of the project area. The calculation method is as follows:

$$LES = \sum_{i=1}^{n} LES_i \times P_i \tag{1}$$

$$LES_i = 1 - 10 \times U_{i\text{standardized}} \times Q_i \tag{2}$$

$$\begin{cases} U_i = a \times C_i + b \times F_i + c \times D_i \\ C_i = N_i / A_i \\ F_i = \sqrt{S_i} / 2P_i \\ D_i = d \times L_i + e \times P_i \\ S_i = N_i / A \\ P_i = A_i / A \\ L_i = N_i / N \end{cases} \tag{3}$$

Where LES is the landscape ecological security index; LES_i is the ecological security index of landscape type i; Ui is the landscape disturbance index; Qi is the landscape vulnerability index; Ci is the landscape type fragmentation, Fi is the separation degree of landscape type, Di is the dominance degree of landscape type, Si is the distance index of landscape type, Pi is the relative cover of the landscape type, Li is the relative density of the landscape type; $a, b, c, d, and\ e$ are the weights, and the research determines that each weight value is 0.5, 0.3, 0.2, 0.4, 0.6; Ni is the number of landscape type patches, N is the total number of landscape patches, Ai is the area of landscape type patches, the unit is hm2, A is the total landscape area, the unit is hm2 [24].

Use Fragstates software to calculate various indicators (Figure 2 to Figure 8), the results show that, the landscape types with the largest landscape ecological security index LESi before and after the renovation were all cultivated land, the smallest is woodland [25]. Except for the river landscape ecological security index, which dropped by 9.84%, the ecological security of other types of landscapes improved, among them, the largest increase was road (121.29%), followed by forest land (43.10%). According to formulas (1) and (2), the landscape safety index LES of the project area is 0.45 before the renovation, and 0.61 after the renovation, an increase of 35.56%, indicating that through ecological land remediation, the overall landscape ecological security of the project area has been improved, but the optimization of river landscape should be strengthened [26].

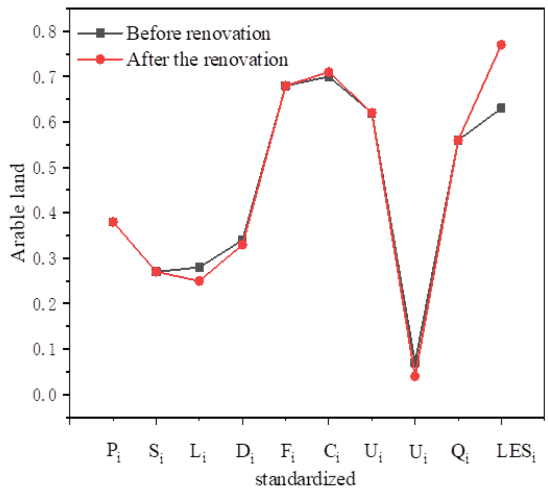

Figure 2: Calculation results of cultivated land safety index.

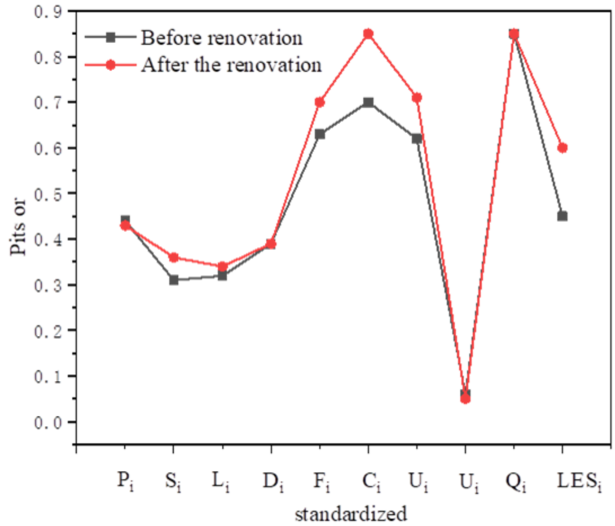

Figure 3: Calculation results of pit pond safety indicators.

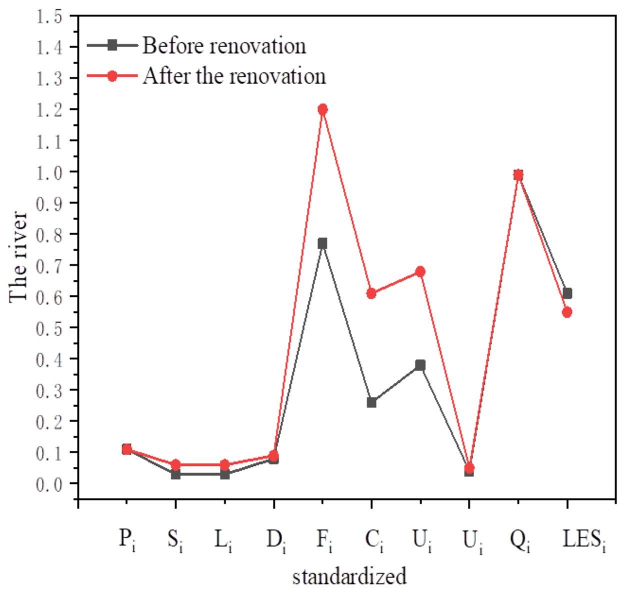

Figure 4: Calculation results of river safety indicators.

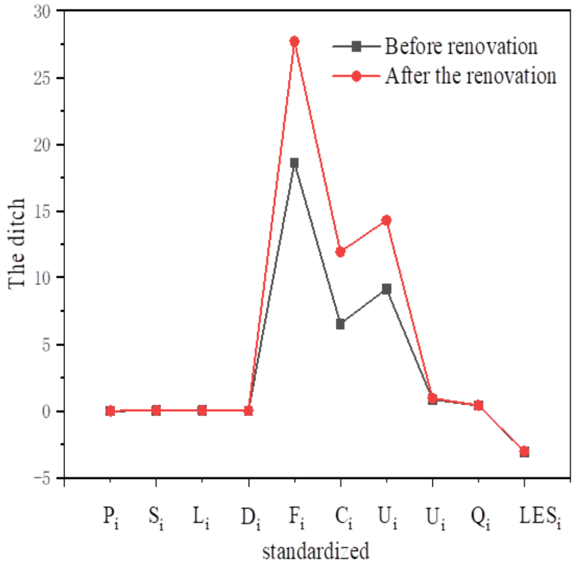

Figure 5: Calculation results of ditch safety indicators.

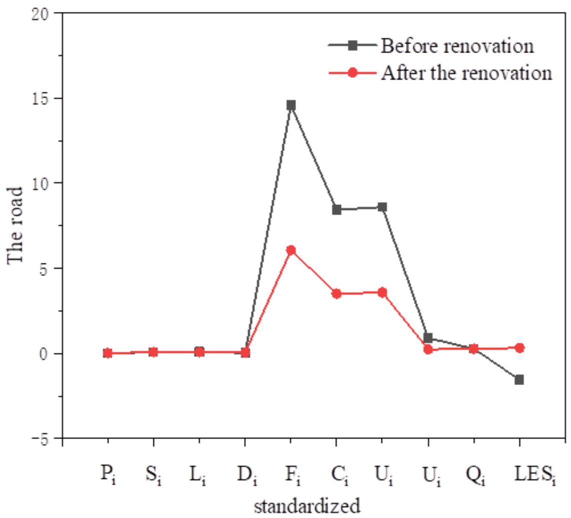

Figure 6: Calculation results of road safety indicators.

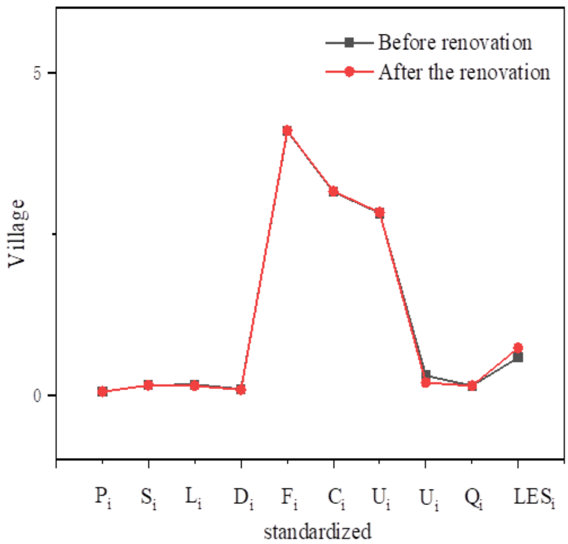

Figure 7: Calculation results of village safety indicators.

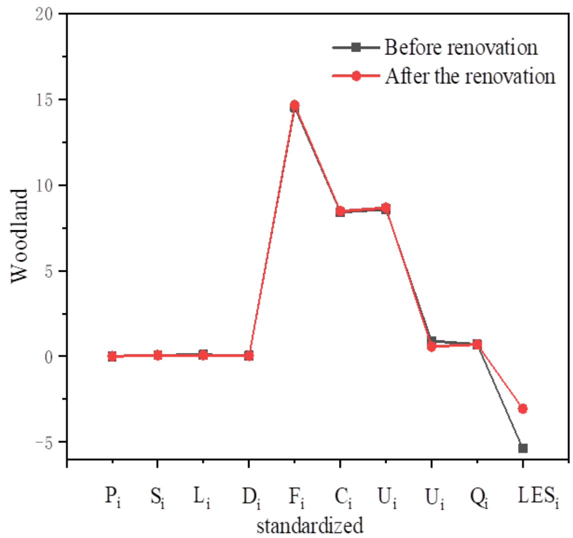

Figure 8: Calculation results of woodland safety indicators.

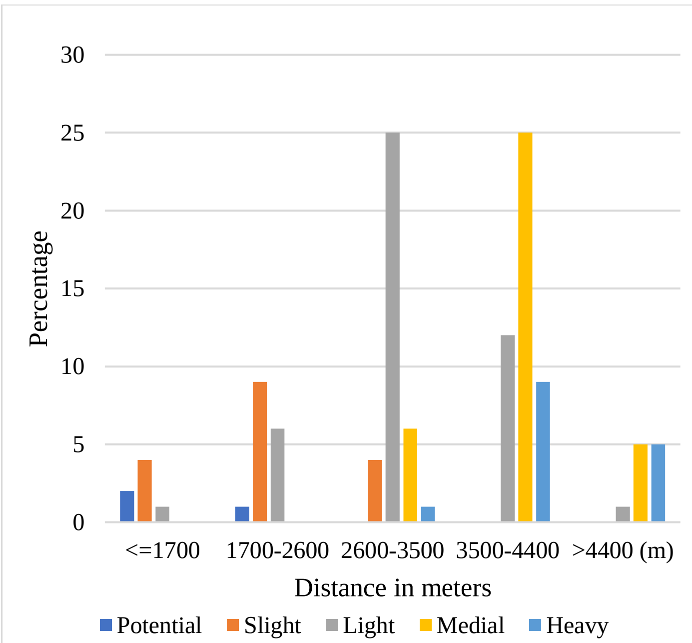

Figure 9: Eco-environmental vulnerability distribution level in different elevation.

Eco-natural weakness in concentrate on region presents distinct distribution of vertical-belt. As depicted in Figure 9, the weakness is connected with height clearly, in which levels III and IV are most broadly disseminated and essentially in rise belt going from 2600 to 4400 m, levels I and II dispersed underneath the rise 2600 m, and level V conveyed over the height 3500 m. Essentially, eco-natural weakness in this district likewise has plainly geological level belt dissemination. As a general rule, the weakness is heavy in the north while it is moderately light in the south.

5 Conclusion

Ecological land consolidation planning should be based on traditional land consolidation. It can be extended in terms of considering goals, modes and methods for landscape pattern analysis. The least resistance model like non-point source pollution control technology and other multi-field methods is considered such as land consolidation zoning. The integration of traditional land remediation planning methods such as road and ditch layout, promotes the realization of multi-functional goals of land remediation. At the same time, considering its agricultural production goals, the status quo of urbanization and industrialization oppression, and the improvement potential of rural landscapes rich in cultural characteristics, determines a reasonable direction of rectification according to local conditions, and combine traditional engineering rectification methods with regional industrial characteristics. The outcomes of this study show that the technique that coordinates the advancements, like RS and GIS, and the SPCA in a numerical way to deal with assess eco-climate weakness in mountainous area, cannot particularly address the input subject spatial circulation of mountain vertical-belt highlight, yet in addition regard the river valley in general framework. Through ecological land consolidation planning, while achieving the goal of improving agricultural facilities. The overall landscape ecological security status of the project area can be improved, and the ecological security indices of other types of landscapes except for rivers are improved.

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