ISSN:2790-167X Volume-6-(2023)

Assessing Habitat Quality and Identifying Influencing Factors in the Township Areas of Dawen River Basin

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Abstract. Dawen River is the development center of the ancient cultural region in Shandong. It is of great significance for the protection, inheritance and development of the basin civilization to study the quality of the habitat in the river basin. This paper builds ecosystem ternary model of habitat quality, using the InVEST model to evaluate the habitat quality of the river basin in 2020, combined with the spatial correlation model to explore the spatial characteristics, and the influence of habitat quality, habitat degradation of nine factors for exploratory regression, is divided into social factors, economic factors and natural factors for analysis. The results show that:(1) The habitat quality in Dawen River Basin varies greatly, showing habitat fragmentation and obvious spatial differentiation; (2) the habitat quality in Dawen River Basin shows an obvious trend of degradation, and the areas with high habitat degradation occupy most of the basin, showing an expansion trend of point-line-surface; (3) social factors, economic factors and natural factors have different effects on habitat quality and habitat degradation, and the influence of land development intensity is most significant. The results provide guidance for the politics of ecological protection in the Dawen River Basin.

Keywords: Dawen River; habitat quality.

1. Introduction

The idea of "Clear waters and green mountains are as good as mountains of gold and silver. " has reshaped people's value recognition of habitat quality. Habitat quality refers to the ability of the ecosystem to provide appropriate conditions for individual and population persistence in a certain range of time and space[1]. With the emergence of serious ecological problems such as heat island effect[2], water pollution[3], sharp decline of biodiversity[4] and so on brought about by the rapid urbanization, the conflict between social development and ecological protection is marked[5]. The protection of the ecological environment within the basin scale has become the focus of such current research[6], especially in the basin with important historical and cultural value, the study of habitat quality plays an irreplaceable role in the protection, inheritance and development of the basin civilization.

At present, most of the existing studies on ecological environment protection within the river basin are carried out from the perspective of large spatial units: Guo, W. investigates the synergistic evolution of river-lake runoff systems in the middle and lower reaches of the Yangtze River, which can serve as a scientific foundation for long-term water security and sustainable growth in the basin[7]. Zheng, L. Compared the landscape fragmentation of the Yangtze River Economic Belt and the Yellow River Basin from the whole region, city agglomeration and watershed, and propose corresponding policies for land use and biodiversity conservation[8].

There are few studies on basin habitat quality assessment in small-scale space units. Based on this, with the help of the habitat quality module in InVEST model, we evaluate the spatial change of habitat quality in Dawen River basin, reveal its spatial difference characteristics, and make exploratory regression on the nine factors affecting the habitat quality. The relevant results have great value for understanding how habitat quality participates in human-land interactions.

2. Study Area and Data Sources

2.1 Study Area

The Dawen River Basin has a long history and is the development center of the ancient cultural region in Shandong. The Dawen River Basin is located in the middle of Shandong Province, between 116° 11 ' 15 " -118° 0 ' 0 " E and 35° 37 ' 30 " -36° 32 ' 30 " N, flows through 104 towns and villages. As an important tributary of the lower Yellow River in Shandong Province, the improvement of ecological protection quality in the Dawen River Basin plays an important role in the ecological protection of the Yellow River Basin. As human activities have been strengthened in recent years, the long-term ecological balance in the water basin was broken and brounght negatively affected on the sustainable development of the basin.

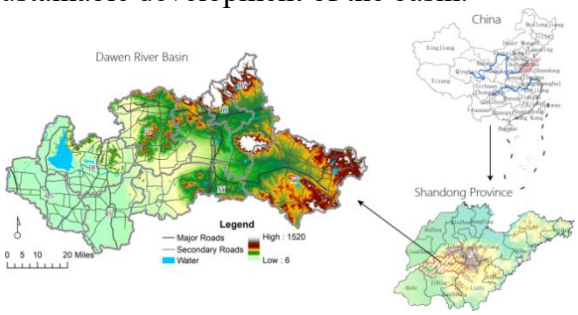

Fig. 1 Regional overview of the Dawen River Basin

2.2 Data Source

Data for the habitat quality assessment were obtained from the GlobeLand30 (http://www.globe.land30.org), used UTM-50N coordinate system. NDVI is a representation of the vegetation cover index, and this dataset was derived from the Resource and Environment Science and Data Center (https://www.resdc.cn). Surface fluctuations are obtained based on DEM (Digital elevation model), and NPP (Net primary productivity of vegetation) comes from urban data of Chinese Academy of Sciences. Population density and GDP per capita come from the national GDP and population 1km grid interpolation data of the Resource and Environment Data Sharing Center of the Chinese Academy of Sciences, and the land development intensity is divided by industrial types. The urbanization level, local financial level and industrial structure come from China Statistical Yearbook and Shandong Statistical Yearbook.

3. Analytical Framework and Methods

3.1 Analytical Framework

With the help of the spatial and temporal variations and influencing factors of habitat quality in the Dawen River basin, this paper constructs a ternary correlation model of society, economy and natural geography based on habitat quality (Figure 2): The need to meet human is realized through social and economic factors. Economic development relies on natural resources and affects its stability. The balance between social factors and natural geographical factors is manifested in the adjustment of human-earth relations. The proposal of the ternary correlation model of the ecosystem effectively clarifies the relationship between society, economy and nature, and provides a direction for guiding the industrial development, spatial layout and ecological policies of each township in the river basin.

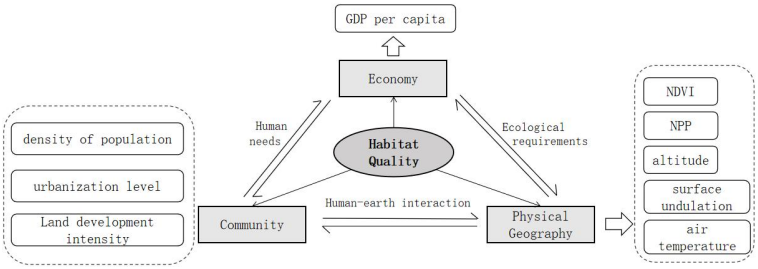

Fig. 2 A ternary correlation model of the ecosystem based on habitat quality

3.2 Methods

3.2.1 InVEST model

In this paper, the Habitat Quality Model in the InVEST model was applied to assess the habitat quality in the Dawen River Basin. The habitat quality calculation includes four functions: the relative impact of each threat factor, the relative sensitivity of each land use / cover to each threat factor, the distance between the land use / cover and the threat source, and the extent to which the land is legally protected[9]. The formula of habitat degradation is as follows:

$$D_{xj} = \sum_{r=1}^{R} \sum_{y=1}^{yr} \left(\frac{W_r}{\sum_{r=1}^{R} W_r} \right) r_y i_{rxy} \beta_x S_{jr} \tag{1}$$

where, D_{xj}、R、W_r、y_r、r_y, and ry respectively represent the habitat degradation index, threat factor number, weight of the threat factor r, number of grids of threat factor, and the value of threat factor on the grid; i_{rxy} represents the distance between habitat and threat source and the influence of threat on space; β_x is the factor that reduces threat influence on habitat through various protection policies; S_{jr} is the sensitivity of habitat type j to threat factor r, d_{xy} is the linear distance between grid x and grid y, and d_{rmax} is the maximum threat distance of threat source r.

Habitat quality assessment is done on the basis of habitat degradation, reflecting the stability of the ecological environment:

$$Q_{xj} = H_j \left(1 - \left(\frac{D_{xj}^z}{D_{xj}^z + K^z} \right) \right) \tag{2}$$

Where, Q_{xj} is the habitat quality index of grid x in land use j; H_j is the habitat suitability of habitat type j, and the value range is 0-1; k is the half-saturation constant, which is generally 1/2 of the maximum habitat degradation; z is the normalized constant, which is set to 2.5 by experience.

3.2.2 Spatial statistics method

Exploratory Spatial Data Analysis(ESDA) is a collection of spatial data analysis methods and technologies, emphasizing the spatial correlation measure as the core. In this paper, the global spatial autocorrelation index Moran's I is selected to reflect the correlation relationship between the spatial location of the township habitat quality in the Dawen River Basin, and explore its spatial correlation characteristics in each research unit to quantitatively measure the spatial dependence and agglomeration trend of the habitat quality in each township in the adjacent area. The formula is as follows:

$$\mathrm{I} = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} \sum_{i=1}^{n} (x_j - \bar{x})^2} \tag{3}$$

Where, n is the number of townships; xi and xj represent the spatial observations at positions i and j; it is the average of all data in n regions; Wij is the generated spatial weight matrix. The global Moran's I range from [-1,1]. The larger the index, the stronger the spatial autocorrelation.

4. Results analysis

4.1 Characteristics of habitat quality and space evolution

To describe the spatial heterogeneity of habitat quality in the Shandong section of the Dawen River Basin (Figure 3), the distribution pattern of habitat quality has significant spatial differences. In 2020, the habitat quality in the Dawen River Basin varies greatly, showing the phenomenon of habitat fragmentation. The areas with high habitat quality are sporadically distributed in the areas where Dongping Lake and Taishan are located in the northwest and northeast of the study area. Areas with low habitat quality are mainly located in the southwest and widely distributed in other areas, which are mainly plains or valleys with more dense towns. Villages with medium habitat quality are distributed in the central and southeastern part of the basin, with a large number, accounting for a large proportion in the basin. The above situation shows that the ecological situation in the Dawen River basin is poor, and the polarization in the region is serious.

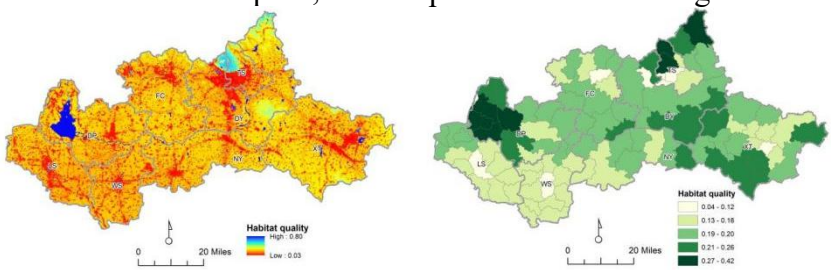

Fig. 3 Quality characteristics of typical township habitat in the Dawen River Basin

The habitat quality degradation in the Dawen River Basin in 2020 was assessed based on the InVEST model, as shown in Figure 4. High habitat degradation index indicates that the threat factor causes high potential degree of damage and high probability of habitat quality decline to the regional habitat quality, and vice versa. The habitat quality of the whole section of Dawen River basin showed an obvious trend of degradation, and the areas with high habitat degradation occupied most of the basin. Few township areas with low habitat degradation are scattered and distributed in the river basin. It can be seen from the comprehensive data that the habitat degradation in the Dawen River basin is obvious, showing a trend of point-line-surface expansion.

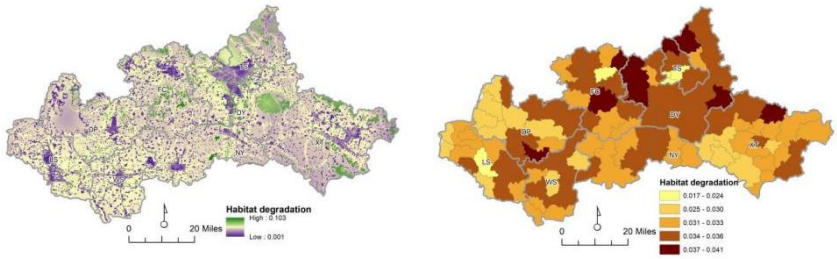

Fig. 4 Characteristics of habitat degradation of typical township in the Dawen River Basin

4.2 Analysis of spatial characteristics

In order to explore whether there is spatial autocorrelation between habitat quality and habitat degradation among typical townships in the Dawen River Basin, this paper calculates the global Moran's I of 104 townships in the basin in 2020. The results show that the habitat quality and habitat degradation in the township region of the Dawen River basin did not show a random distribution state, but had certain spatial autocorrelation characteristics, and its changes would be significantly affected by the neighboring areas.The habitat quality and habitat degradation in the Dawen River Basin show high-high (HH) concentration and low-low (LL) concentration in space.

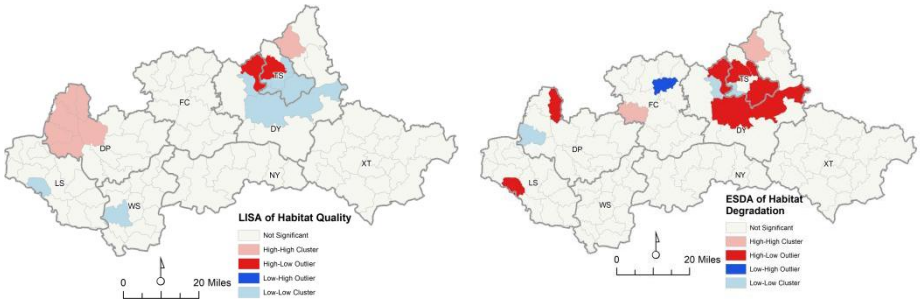

Fig. 5 LISA of habitat quality and ESDA of habitat degradation

4.3 Analysis of drivers

In order to more accurately grasp the significance of each influencing factors, this paper arranges the optimal regression index of habitat quality (CHA) and habitat degradation (CHD) in 2020, and obtains nine exploratory regression of habitat quality. The results are shown in Table 1.

Table 1. Results of the exploratory regression of the nine factors affecting habitat quality

type	Alternating quantity	CHA	CHD
Community	land development intensity	-0.5000	0.6830
	urbanization level	-0.3917	0.4420
	density of population	-0.4123	0.4082
Economy	GDP per capita	-0.2010	0.2347
Physical Geography	NDVI	0.5571	-0.5130
	NPP	-0.3528	0.5347
	surface undulation	0.1630	-0.0937
	altitude	0.3341	-0.3518
	air temperature	0.3183	-0.2259

Habitat quality is affected by many factors, which can be divided into three categories: social, economic and natural factors. To determine the contribution of each factors to habitat quality in the year 2020 is important for exploring habitat conservation policies compared with its role on habitat degradation. The regression index gives the following results:

(1) Social factors include land development intensity, urbanization level and population density. The regression results showed that social factors had significant effects on both habitat quality and habitat degradation and greatly on the ecological environment. The regression index of land development intensity was the highest among all the factors, with CHA and CHD being-0.5000 and 0.6830, respectively. This is due to the unreasonable phenomenon of the township land development mode in the Dawen River Basin, and the disorderly industrial layout, which has caused a huge damage to the ecosystem. The impact of urbanization level and population density is second only to the intensity of land development and NDVI, which has a significant impact on the ecological environment. Reasonable planning of urban development space and guiding the orderly flow of personnel play an important role in the ecological protection of the river basin.

(2) The economic factor is real GDP per capita, and the regression index of habitat quality and habitat degradation is about 0.2, which has little impact on the ecological environment. This shows that in the process of development, the level of its economic income is not the fundamental factor that determines the quality of the local habitat. In the process of economic development, each township should pay attention to the efficiency of economic improvement and achieve green and high-quality development.

(3) Natural factors include NDVI, NPP, surface fluctuation, elevation and temperature. Among them, NDVI was the second highest among all impact factors, especially for habitat quality, with a regression index of 0.5571. Implementing ecological protection policies and actively carrying out ecological restoration projects in areas with strong human activities to increase the vegetation coverage area can significantly improve the quality of the ecological environment. Unreasonable

exploitation and utilization in areas with high vegetation coverage will cause significant habitat degradation.

5. Conclusion and Discussion

The Dawen River is an important tributary of the lower reaches of the Yellow River in Shandong Province, which plays an important role in promoting the harmonious coexistence between man and nature. In 2020, the average habitat quality index of the Dawen River Basin was 0.238, showing the phenomenon of habitat fragmentation and obvious spatial differentiation. The change of habitat quality in each township area will be significantly affected by the adjacent area, showing spatial correlation. The habitat quality in the basin has spillover properties, Land development intensity, urbanization level, population density and NDVI are the influencing factors of high habitat quality, which show different effects on habitat quality.

Based on the study of the spatial and temporal evolution and influencing factors of habitat quality in Dawen River Basin, this paper puts forward the following suggestions for ecological protection and economic construction in the basin:

(1) Differentiated habitat quality strategy. Habitat quality in the Dawen River Basin showed a differentiated distribution in different regions. Since the habitat quality of Mount Tai and Dongping Lake are high, the environmental protection and restoration measures in the area should be improved; damaging the ecological environment in the plain area, radiating the surrounding area, the large-scale ecological restoration measures in the central area harm the stable development of social economy, improving the vegetation coverage by building parks and afforestation to prevent the spread of habitat degradation.

(2) Guiding social development policies based on differences in influencing factors. The impact of habitat degradation at the urbanization level is more obvious than that of habitat quality, indicating that it is more damaging to the ecological environment. The ecological environment in the river basin is sensitive, and the rapid urban expansion accelerates the degradation of habitat quality. In the process of urbanization construction, various measures should be taken, such as introducing new technologies to reduce the damage of urbanization on the ecological environment. Population density has a great impact on habitat quality. When carrying out the population introduction policy, all towns and townships should actively guide the flow of personnel and reduce the pressure on densely populated townships.

(3) Coordinate the industrial structure of each township in the province and improve the industrial diversity. The development and utilization of land is one of the important ways of social and economic development. The development and utilization of land has a significant impact on the habitat quality and habitat degradation of the counties around the Dawen River Basin. When developing and utilizing land, counties and districts need to weigh the economic benefits as enough to make up for the ecological damage brought by it. In land use planning, they need to coordinate the industrial structure layout of the whole region, improve the diversity of industries, and realize the balance between economic development and ecological protection.

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