



Landscape ecological risk assessment in Yellow River Delta

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Abstract

The landscape ecological risk assessment has been widely used to describe and evaluate the possible effects of natural disasters or human activities on the landscape structure, function and process. Because of the wide spread of the saline-alkali land, the pollution of the oil exploiting and the serious damage of ecosystem, the landscape ecological risk is relatively low in the Yellow River Delta. In order to study the landscape ecological risk there, this paper assessed the landscape ecological risk assessment by building the loss index of ecosystem with the macroscopic landscape ecosystem as the ecological risk acceptor based on the six categories landscape structure data derived from the remote sensing images in 2000 and 2005, as well as the field survey data. The results indicated that the minimum landscape ecological risk appears in the cultivated land and the maximum landscape ecological risk is in the area of forest land, therefore, the control and management of forest land system should be taken advantage. The areas with higher landscape ecological risk accounted for about one third of the total area, and the areas with no landscape ecological risk accounted for about half of the total area in 2000. The landscape ecological risk has magnified conspicuously in 2005, with the degraded landscapes located mainly in the northern and middle part of Yellow River Delta. Despite of uncertainties, the research results can provide scientific reference information for the local landscape protection and have an important significance for the comprehensive control and management of ecological restoration of the local government.

Key words: Landscape pattern, ecological risk, the Yellow River Delta, remote sensing and GIS.

Introduction

The landscape ecological risk assessment has been a hot topic in ecology research due to the landscape degradation at the global and regional scales^{1,2}. The great efforts have been made to describe and evaluate the adverse effects of natural disasters or human activities on the landscape structure, function and process³. Significant consideration has been taken into spatial heterogeneity, as well as the habitat dynamics⁴. The petroleum has been the most widely used energy, but the environmental pollutions caused by oil mining activities have led to great ecosystem risk. For example, soil pollution induced by petroleum pollutant may have influence on the soil fertility and the aboveground vegetation. The landscape ecological risk assessment and ecological restoration in the oil mining area has become an important issue. While there have been only few preliminary studies on the effects of oil mining and petrochemical activities on ecosystems in the oil mining area, even fewer have been carried out at the ecosystem or landscape level. The current ecological risk assessment researches focus mainly on how pollutants influence ecosystems and their components without much consideration on ecosystem or its landscape⁵.

The Yellow River Delta is located in Dongying, Shandong Province (36°55'2"-38°10'2" N, 118°07'2"-119°10'2" E). It is the largest river delta in China and one of China's important energy bases with Shengli oil field located in this area. Various human activities

such as the oil mining and petrochemical activities have led to the serious landscape fragmentation and degradation. In recent years, the infrastructure construction, oil mining and petrochemical activities have greatly destroyed the aboveground vegetation and altered the landscape pattern. The oil mining and petrochemical activities of Shengli oil field have been the most influencing factors of local ecosystems⁷. The Yellow River Delta plays a very important role in conserving biodiversity and promoting the regional economic development, this study aimed to assess the local landscape ecological risk with the landscape loss index so as to provide information for the regional ecological environment management and protection⁸.

Materials and Methods

Data and processing: In this study, the Landsat Thematic Mapper (TM) and/or Enhanced Thematic Mapper (ETM) images are chosen and used as the basic information given that the application of satellite remote sensing proves to be a good choice for detecting and monitoring forest area changes. Landsat TM/ETM images of bands 3, 4, and 5 with a spatial resolution of 30 m × 30 m in 2000 and 2005 were interpreted at a scale of 1:100,000 and the overall interpretation accuracy of the land-use categories reached 92.7% by field survey and random sampling check conducted by the Data Center of the Chinese Academy of Sciences (CAS). The

Land use/cover types are explained as macro-ecosystem types; there are 6 types of land uses/covers, i.e. arable land, forest, grassland, waters, built-up area and unused land.

Models and methods: After analyses on the structures and functions of various landscape types, ecological risk indexes were used to measure ecological risk. There are six landscape ecological indices to represent the loss of ecosystem: the landscape fragmentation index, the landscape separation index, the landscape dominance index, the landscape structure index, the landscape fragility index and the landscape loss index. Landscape fragmentation index is adopted to represent the degree of interference to different ecosystems, Landscape separation index is applied to represent disaggregating levels of individual plaques within the same landscape type, landscape dominance index is used to represent the dominant degree of single or multiple landscape types to the whole landscape. Landscape structure index is employed to represent the disturbance to landscape oriented ecosystems by interference from saline, natural disasters and oil-contaminated. Landscape fragility index is applied to reflect the vulnerability of different ecosystems and loss of landscape. The landscape loss index (R_i), the difference among ecological loss of each landscape types, is represented as $R_i = S_i \times F_i$, where S_i is the landscape structure index and F_i is the landscape fragility index of the i^{th} landscape type. The landscape fragility index is related to the natural succession stage of the landscape, etc. according to their characteristics. Their fragility is

calculated by triangular fuzzy numbers, the order of which were built-up area, forest, grassland, garden plot, arable land, waters, and unused land.

The landscape structure reflects the degree of disturbance (mainly the human activities) the landscapes suffered from. It is represented as $E_i = aC_i + bS_i + cD_i$, where a , b and c are the weights of indices, set to be 0.5, 0.3 and 0.2 according to their importance. All the three indices are normalized.

In order to relate the landscape structure with the regional comprehensive eco-environmental conditions, the ecological risk index was calculated based on the area percentage of landscape types to describe the comprehensive ecological loss in the plots using the following formula:

$$ER = \sum_{i=1}^n \frac{S_{ki}}{S_k} R_i$$

where ER is the ecological risk index, n is the number of landscape types, S_{ki} is the area of the i^{th} landscape type in the k^{th} area, S_k is the total area of the k^{th} area and R_i the landscape loss index.

Results and Discussion

With the normalized data we got the landscape ecological risk index of the five counties of the Yellow River Delta (Table 1). By importing loss index into ArcGIS, we got the landscape ecological risk map; then we classified the landscape ecological risk into 6 grades using natural break method in ArcGIS software to get the ecological risk classification map (Fig. 1).

Table 1. Landscape loss index of the Yellow River Delta.

District or county	Year	Arable land	Forest	Grassland	Waters	Built-up area	Unused land
Kekou district	2000	0.82	60.33	0.83	4.76	0.67	1.76
	2005	0.79	66.00	2.06	4.12	0.57	2.68
Guangrao district	2000	0.60	15.14	3.02	3.05	2.75	4.09
	2005	0.31	11.34	50.53	7.76	2.45	13.22
Dongying District	2000	0.40	17.16	1.70	6.31	1.04	2.98
	2005	0.55	17.16	3.39	7.33	1.02	2.44
Lijin County	2000	0.15	6.57	6.89	12.35	2.14	7.36
	2005	0.22	10.31	7.24	16.12	2.24	13.45
Kenli County	2000	0.61	11.94	0.45	1.74	0.85	2.26
	2005	0.97	4.04	1.84	5.52	1.70	3.27

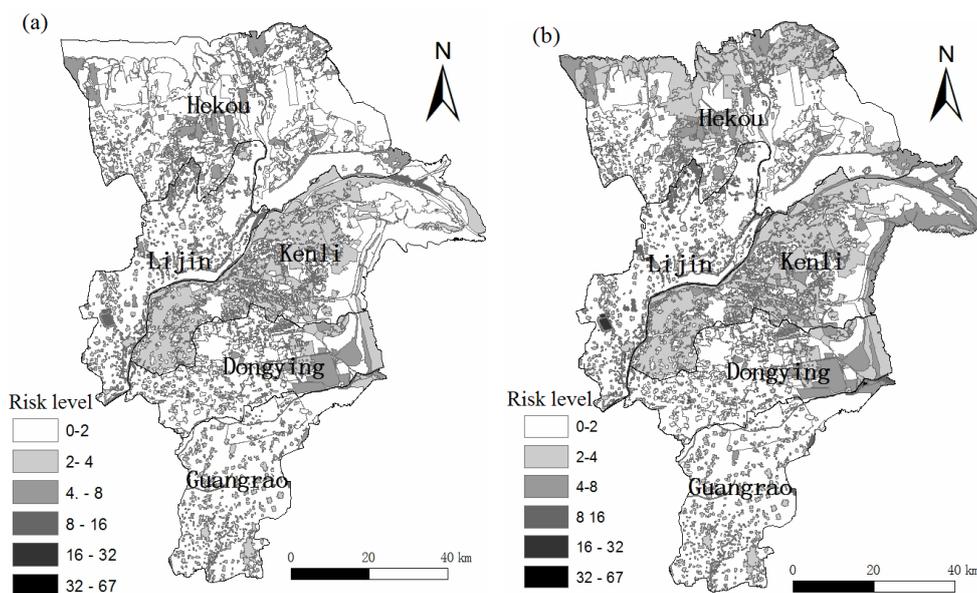


Figure 1. Landscape ecological risk level of the Yellow River Delta in 2000 (a) and 2005 (b).

The landscape ecological risk varied greatly among regions in the Yellow River Delta on the whole. In 2000, the areas with higher landscape ecological risk accounted for about one third of the total area, mainly concentrated in the middle part and southern part of Kenli County and the northern part of Dongying District; the areas with no landscape ecological risk accounted for about half of the total area, mainly located in the eastern part and western part of Hekou District. The areas with lower landscape ecological risk were sparsely distributed in Guangrao County and Lijin County. The landscape ecological risk has aggravated obviously in 2005, with the degraded landscapes mainly located in the northern part and middle part of the Yellow River Delta. The higher landscape ecological risk area expanded to the northern part and eastern part; meanwhile the risk level also rose in these areas, some part of Lijin County reached the sixth ecological risk level and a high risk area appeared along the shoreline of Kenli County. But on the whole, the landscape loss levels of each landscape type remained the same, only fluctuated in the value.

The landscape ecological risk also varied greatly among landscape types. On the whole, the landscape loss index of the forest was highest while that of the arable land was lowest; for example, the landscape loss index of the forest was higher than 60 in Hekou District and Guangrao County in both 2000 and 2005; the resilience of the forest is lowest in the six landscape types, and consequently it will take a long time for the forest to develop into the stable landscape. The human activities played a key role in the landscape ecological risk change; for example, the arable land is easy to be damaged but will not lead to great landscape loss, which is closely related to the human management and modification; besides, the landscape type with the highest landscape loss index in Guangrao County changed into the grassland, mainly due to the decrease of the grassland area of 1955 hectares in 2000 to 235 hectares in 2005, which made the landscape structure index 16 times higher in 2005 than in 2000.

The results of the landscape ecological risk assessment can provide very important reference information for the ecosystem management, which is of great significance to the risk control. There is widespread saline-alkali land and large-scale oil mining and petrochemical activities in the Yellow River Delta, which makes the forest very susceptible to disturbances; so it is necessary to regulate human activities. There was a great spatial heterogeneity of the landscape ecological risk in Hekou District, it is necessary to deeply analyze the source of the deterioration of the landscape ecological risk to carry out appropriate management measures.

Conclusions

Based on the regional landscape data prepared with the remote sensing images, the authors analyzed the spatiotemporal characteristics of landscape ecological risk in the Yellow River Delta from the perspective of the landscape pattern. The results indicated that there was significant spatial heterogeneity of the landscape ecological risk in the Yellow River Delta, which can provide very important scientific reference information for the local landscape ecological risk management. The landscape ecological risk assessment is very complex since there are many uncertainties that influence the accuracy of the assessment result. For example, the remote sensing data only meet the need of large-scale landscape ecological risk assessment since it is inevitable that there are some errors in the data interpretation and

categorization of landscape types. So there are only preliminary researches on the landscape ecological risk assessment by selecting the characteristic risk sources and using the remote sensing data, it is still necessary to improve the assessment method. Nevertheless, our research results can provide the governmental landscape managers with important reference information for the local landscape ecological risk management, which is of great significance the conservation and protection of the local landscape.

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