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Analysis of Changes in Land Use Types and Driving Factors in Yan'an City

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Abstract

Using remote sensing monitoring data of China's land use/land cover in 1980, 2000, and 2020, this study explores the change patterns and driving forces of land use types in Yan'an City through the land use transfer matrix and land cover status index. The results show that the main land use types in Yan'an City are grassland, cultivated land, and unused land. From 1980 to 2020, the absolute changes in the area of land use types in the study area are ranked as follows: unused land > grassland > construction land > cultivated land > forest land > water area. The area of cultivated land first increased and then decreased, while unused land decreased and forest-grassland area increased, which is closely related to national ecological policies. The area of construction land increased slowly from 1980 to 2000 and significantly after 2000, consistent with the process of urbanization. The continuous reduction in water area is mainly influenced by natural factors. The changes in land use types in Yan'an City are jointly affected by natural and social factors, with ecological policies and urbanization playing a dominant role.

Keywords

Yan'an City; Land Use Types; Transfer Matrix; Cover Status Index.

1. Introduction

Land use is the most direct transformation of the Earth's surface by human activities, running through the entire process of human survival and development, and is a product of the joint influence of humans and nature [1]. In recent years, with the development of the economy and the change of human survival patterns, global land use/land cover has undergone significant changes, directly affecting the global changes in terrestrial ecosystems [2]. The dynamic changes of land use/land cover have gradually become a research hotspot for scholars at home and abroad and occupy an important position in the field of global sustainable development research [3].

At present, scholars at home and abroad have conducted research on the characteristics and driving mechanisms of land use type changes from multiple perspectives. Sahana M et al. [4] analyzed the driving forces of land use type changes and forest fragmentation in the Song River Basin of India, revealing a large number of disturbances in the forest fragmentation of this region. Zhang Junmao [5] analyzed the spatio-temporal characteristics and driving mechanisms of land use type changes in the Southeast River Basin from 1990 to 2015, and identified that population quantity and structure, urbanization level, and social industrial and agricultural structure were the main factors affecting the changes in cultivated land in the Southeast River Basin. Han Ruiying [2] et al. studied the changes in land use types and their driving factors in southern Xinjiang from 2000 to 2015 based on Landsat TM data, revealing that temperature,

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moisture index, and population density were the main driving factors for land use/cover changes and vegetation cover changes in this area. However, current research mainly focuses on urban expansion areas, and there are few reports on land use type changes in the arid and semi-arid regions of Northwest China. Therefore, it is necessary to further strengthen the research on the dynamic changes and driving forces of land use types in Northwest China to provide a scientific basis for the sustainable development of the ecological environment and economic system in this region [5].

Yan'an City is located in the northern part of Shaanxi Province, in the middle reaches of the Yellow River, in the central and southern part of the Loess Plateau (107°41'E - 110°31'E, 35°21'N - 37°31'N), with a total area of 37,037 km^2. The study area is located in the gully region of the Loess Plateau, with loess ridges and gullies in the north, accounting for 72% of the total area; loess plateaus and gullies in the south, accounting for 19% of the total area; and rocky mountains throughout the area, accounting for 9% of the total area [6-7]. The terrain shows a characteristic of being higher in the northwest and lower in the southeast, with an average altitude of 1,200 m. The study area has a continental monsoon climate, with the north being a semi-arid area and the south being a semi-humid area. Due to the influence of the monsoon, seasonal precipitation differences are significant, with most precipitation concentrated in summer and often in the form of heavy rain, with an average summer precipitation of about 310 mm, accounting for 57% of the annual total. Affected by climatic characteristics, soil types, and human activities, Yan'an City suffers from severe soil erosion and fragile ecological environment, making it a key area for the implementation of the Grain-for-Green Project in China. In recent years, with the protection and sand control of the Mu Us Sandy Land in China, Yan'an City has implemented ecological projects such as returning farmland to forest and grassland, resulting in significant changes in land use/land cover and effective restoration of the ecological environment. However, the stability of the ecological environment remains poor [8, 9]. Therefore, this study takes Yan'an City as the research area, based on land use remote sensing data from 1980 to 2020, and uses the land use transfer matrix to comprehensively grasp the spatio-temporal characteristics of land use types in Yan'an City and explore their driving factors, aiming to provide theoretical support for ecological environment protection and sustainable development of the regional ecological economy in the study area.

2. Data Sources and Processing

The data for this study was sourced from the China Land Use/Land Cover Remote Sensing Monitoring Database provided by the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http://www.resdc.cn). The database includes eight periods of land use remote sensing data from the late 1980s (1980), the mid-1990s (1995/1996), the late 1990s (1999/2000), 2005, 2010, 2015, and 2020, with a spatial resolution of 1 km [10]. The land use types include six primary types: cultivated land, forest land, grassland, water bodies, residential areas, and unused land, as well as 25 secondary types. This study selected data from 1980, 2000, and 2020 to investigate changes in land use types. The remote sensing monitoring data of land use types were mosaicked and masked to extract the spatial distribution data of land use types in Yan'an City for 1980, 2000, and 2020, and the projection transformation was completed, uniformly projected to WGS84, and stored in TIF format.

3. Research Methods

Land use type changes are not only about the increase or decrease in area but also involve mutual conversion among different types. This study is based on land use/land cover remote sensing monitoring data. Using functions such as density segmentation and confusion matrix in ENVI, the land use transition matrix was obtained to visually display the structural

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characteristics of regional land use type changes and the direction of changes in each land use type, and to quantitatively describe the land use type transitions. The calculation method of the transition matrix is shown in Formula 1:

$$S_{ij} = \begin{bmatrix} S_{11} S_{12} \cdots S_{1n} \\ S_{21} S_{22} \cdots S_{2n} \\ \vdots \quad \vdots \vdots \quad \vdots \\ S_{n1} S_{n2} \cdots S_{nn} \end{bmatrix} \tag{1}$$

In the formula, Sij represents the area of different land use types. n is the number of land use types, and i and j are the serial numbers of land use types at the beginning and end of the study period, respectively.

4. Results and Analysis

In 2020, the main land use types in Yan'an City were grassland, cultivated land, and forest land, with areas of 17,502 km^2, 9,211 km^2, and 9,718 km^2 respectively (Table 1). These types were widely distributed in the eastern and southern parts of Yan'an City, forming a mixed landscape of cultivated land and grassland, accounting for approximately 98.89% of the total area of the region. Construction land and water bodies were the next most significant types, with areas of 136 km^2 and 230 km^2 respectively. Unutilized land was mainly concentrated in the northwest of Yan'an City, while water bodies were scattered in a fragmented manner throughout the study area. Unutilized land was relatively small in area and mostly distributed in the central part of the study area.

Between 1980 and 2000, the overall spatial pattern of land use types in Yan'an City remained relatively stable, but individual land use types changed. Between 2000 and 2020, the changes in land use types were more significant. The absolute changes in land use type areas over the 40-year period were: cultivated land > grassland > forest land > water bodies > construction land > unutilized land. The area of cultivated land showed an initial increase followed by a decrease. The area of construction land increased slowly between 1980 and 2000 and significantly between 2000 and 2020. Other land use types showed a slow change trend. It is particularly noteworthy that the area of water bodies in Yan'an City has been continuously decreasing from 1980 to 2020. The main reason for this is the global climate drying trend. Under the background of global warming, the evaporation in this region has been increasing, while the rainfall has shown no significant change trend, leading to a reduction in water body area. For semi-arid regions, water bodies play a very important role in improving the ecosystem service functions. Therefore, it is necessary to mitigate the impact of global climate drying on the ecosystem in the study area and protect local water resources from pollution and destruction [9].

Table 1. Area Statistics of Land use types in Yulin City from 1980 to 2020

Land use	1980		2000		2020		1980~2020
	area/km^2	%	km^2	%	km^2	%	km^2
cultivated land	11389	30.90	11620	31.53	9211	25.00	-2178
forest land	8932	24.23	8945	24.27	9718	26.38	786
grassland	16248	44.09	15994	43.40	17502	47.51	1254
construction land	178	0.48	168	0.46	136	0.37	-42
water	105	0.28	125	0.34	230	0.62	125
unutilized land	4	0.01	4	0.01	42	0.11	38

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5. Driving Force Analysis

5.1. Natural Factors

The changes in natural factors will inevitably lead to alterations in the land use pattern of the study area. Temperature and precipitation directly affect the growth and distribution of vegetation. Against the backdrop of global warming, the average annual temperature in Yan'an City gradually increased from 1980 to 2000, while the annual rainfall decreased slowly. After 2000, the intensity of temperature changes weakened, and the rainfall fluctuated greatly but showed no obvious increasing or decreasing trend. The rise in temperature increased the evapotranspiration in Yan'an City, and with no significant change in rainfall, the area of water bodies in the region continued to shrink.

5.2. Social Factors

The changes in land use types are the result of the combined effects of multiple driving forces. Besides the influence of climatic conditions on land use types, human activities and national policies are also driving forces for the changes in land use types in Yan'an City . From 1980 to 2000, the land use type transfer rate in Yan'an City was only 4.14%. Since 1998, the implementation of the national sand control and afforestation projects, the policy of returning farmland to forest and grassland, and the policy of protecting cultivated land have accelerated the changes in land use types in Yan'an City. From 2000 to 2020, the area of cultivated land decreased, while the areas of grassland and forestland increased significantly, which is related to the policy of returning farmland to forest and grassland. The area of unused land decreased significantly, with the main transfer directions being to cultivated land and grassland, which is related to the sand control and afforestation projects. During this period, the area of construction land in Yan'an City increased several times, which is consistent with the process of urbanization. It can be seen that from 2000 to 2020, the implementation of ecological policies and human activities and other social factors played an undeniable role in the changes of land use types in Yan'an City.

6. Conclusion

(1) The main land use types in Yan'an City are grassland, cultivated land, and unused land. From 1980 to 2020, the absolute changes in land use type areas in the study area were: unused land > grassland > construction land > cultivated land > forestland > water bodies. The areas of grassland, construction land, and forestland increased by 1,249 km^2, 991 km^2, and 571 km^2 respectively, while the areas of unused land, cultivated land, and water bodies decreased by 1,736 km^2, 974 km^2, and 83 km^2 respectively.

(2) From 1980 to 2000, the land use type conversion in Yan'an City was not obvious, with a transfer rate of only 4.14%, and the largest transfer area was unused land. From 2000 to 2020, the land use type transfer in Yan'an City was significant, with the main transfer directions being between cultivated land and grassland, and between grassland and unused land. The area of construction land increased from 130 km^2 to 1,100 km^2, with the main increase coming from the transfer of cultivated land, grassland, and unused land. The area of water bodies continued to decrease, with the main transfer directions being to grassland and construction land.

(3) The changes in land use types in Yan'an City are influenced by both natural and social factors. Among them, the area of cultivated land first increased and then decreased, the area of unused land decreased, and the area of forest and grassland increased, which are closely related to national ecological policies; the area of construction land increased slowly from 1980 to 2000 and significantly after 2000, which is consistent with the process of urbanization; the continuous decrease in the area of water bodies is mainly due to natural factors.

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