Spatio-temporal change of land use pattern in the northwest of Hubei Province

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Abstract. Exibei, located in the northwestern Hubei Province, is recognized as an important region for the geographical transition from north to south, which has significant ecological status. Consequently, the research on land use pattern in this region contains non-negligible value for environmental protection. This research provided a scientific basis and an effective support for the sustainable development of ecological environment in Exibei region and the rational use of land resources. In this paper, combing with geographic information technology and spatial statistical methods, we mainly focused on the temporal and spatial changes of land use in Exibei region based on remote sensing maps from 1990 to 2015. The results show: 1) during the study period, the distribution area of farmland, grassland and unused landscape decreased, whereas the forestland and water land were opposite; 2) the Single Land Use Dynamic Degree of building land was 1.46%, which was the largest among all land use types; 3) the Comprehensive Dynamic Degree in the study area was 0.06%, indicating that pattern change was not obvious.

1. Introduction

Land use and land cover change (LUCC) is an important component of global change and it is a significant manifestation that anthropogenic activities affect the natural environment [1-2]. It is widely acknowledged that the LUCC is a primary cause of changing ecological process including atmosphere, soil, hydrology, biology and other environmental elements, which can directly affect the service function of the ecosystem [3-4]. Human factors and natural factors are the main drivers of land use change [5-6]. Over past decades, rapid population growth and urbanization have resulted in land use change, and increased land use intensity has caused deforestation and forests transitioning into farmland all over the world [7]. Understanding the change of land use pattern is valuable for the sustainable development of regional ecological environment and renders technical support to policy makers.

Exibei Region, located in the northwest of Hubei Province, is the water source of the Central Line Project of South-to-North Water Diversion with an important ecological function and status. Exibei has abundant natural resources, but its economic development is relatively lagging behind. In addition, Exibei is a typical ecological vulnerability area. Therefore, it is necessary to provide the research on dynamic variations of Exibei Region’s land use in the past decade and facilitate further study on land use management in the future.
2. Study area and method

2.1. Study area

Exibei Region, between 109°29′-113°43′E and 31°14′-33°16′N, is located in the northwest of Hubei Province, covers area of 4.67×10^6 ha and accounts for 25.1% of Hubei Province’s total land area. It shares land borders with Henan Province, Shanxi Province, and Chongqing City. The region has a subtropical monsoon climate with average annual precipitation about 800 mm, of which mean annual temperature is around 15℃. And special terrain conditions with altitude ranging from 90m to 3100m interact with each other and generate distinctive natural environment and unique land use pattern. Exibei Region contains Shiyan City, Xiangyang City and Shennongjia Forestry District. In total, there are 15 counties in this region. The population in the region reached 9,124,930, accounting for 15.5% of the total population of Hubei Province [8].

2.2. Method

Quantifying land-use change is fundamental for the establishment of effective land use conservation and the study of ecosystem function. We used Landsat ETM remote sensing images at a spatial resolution of 30m by 30m from 1990 to 2015, which was obtained from Satellite Environment Centre for research. Land use/cover was classified into six primary types including farmland, forestland, grassland, water land, building land, and unused land (Fig. 2). On the base of RS and GIS, we analysed distribution of land use type in Exibei Region from 1990 to 2015 using Single Land Use Dynamic Degree and Comprehensive Land Use Dynamic Degree [9].

Single Land Use Dynamic Degree:

\[ K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \] (1)

Comprehensive Land Use Dynamic Degree:

\[ LC = \frac{\sum_{i=1}^{n} ALU_{i,j}}{2 \sum_{i=1}^{n} LU_i} \times \frac{1}{T} \times 100\% \] (2)

Where \( U_a \) and \( U_b \) are the area of a single land use type at beginning and end of the study period. \( T \) is the range of the study period. \( LU_i \) is the initial area of land use type \( i \). \( ALU_{i,j} \) is the area of land use type \( i \) converted to land use type \( j \) during the study period.
3. Results
From the Table 1, it can be seen that the farmland is dominant land use accounting for around 50% of the total land area and its area decreased from 51.24% in 1990 to 50.35% in 2015. Forestland was the second largest land use type in the study area. The forestland distributed mainly around the main districts and counties in the northwestern and northeastern Exibei. Forestland constituted approximately 22% of the total land area and showed slow growth. Grassland was another major land use type in Exibei and distributed in the same area with forestland, around Xunxi County, Xunxi County, Zhushan County, Zaoyang City and Nanzhang County. Grassland accounted for about 20% of the land area and its area decreased from 20.91% to 20.32%. There were small areas of water land, building land, and unused land in the study area. These three land use types respectively constituted about 2%, 4%, and 0.5% of the total land area.

The dynamic degree of land use can reflect the trend and intensity of regional land use change. The Single Land Use Dynamic Degree of building land for 1990–2015 was the largest among all land use types, which was 1.46%. In this period, the urbanization rate in Exibei increased so rapidly that the demand for land of infrastructure construction expanded continuously and gradually. The study area maintained good water quality, which led to the increasing of water land area by 7.29% during the period of 1990 -2015. Grassland was easy to be changed into other land use types due to anthropogenic activities, which decreased in most cities and counties. There was only slight increase in forestland area with an average annual rate of 0.58%, due to the implementation of ecological protection projects, including the Grain for Green Programme and the establishment of nature reserves. Farmland, as the main land use type in Exibei, decreased in most cities and counties except in Danjiangkou City, Nanzhang County and Xunxi County (Fig. 3). The comprehensive land use degree of the study area was 0.06%, which indicated the range of land use types change in the study area was small, and the degree of land exploitation and utilization was low. (Table 1)
4. Conclusions

In this article, on the basis of RS and GIS, we have explored the quantitative and spatial pattern characteristics of land use change in Exibei Region since 1990. The results might provide insights into the theory of land use changes. The results were as follows:

1. During this period, distribution of farmland, grassland and unused land decreased while the area of forestland and water land increased;
2. The Single Land Use Dynamic Degree of building land was largest among all land use types, which was 1.46%;
3. The comprehensive dynamic degree in the study area was 0.06%, indicating that the total land use pattern changed little.

Land use change is an important component of ecological environment change, and also has impact on ecosystem change. Further studies on the possible driving forces of land use change in this study may be required for effective management strategies. In the future, the study area should continue to implement the corresponding ecological protection policy, maintain and strengthen its ecological function. On the basis of the guarantee food security, the region should adjust the structure of agricultural production, improve the productivity of agricultural land, and advance the construction land regulation. At the same time, we should adjust measures to local conditions to develop ecological tourism economy and coordinate economic and social development with abundant ecological and cultural resources in the region.

Table 1. Area, proportion and dynamic degree of land use in Exibei Region, 1990–2015.

| Year | Farmland | Forestland | Grassland |
|------|----------|------------|-----------|
| 1990 | Proportion(%) | 51.24 | 21.78 | 20.91 |
| 1995 | Proportion(%) | 49.30 | 22.35 | 22.02 |
| 2000 | Proportion(%) | 51.44 | 21.77 | 20.27 |
| 2005 | Proportion(%) | 50.96 | 21.81 | 20.40 |
| 2010 | Proportion(%) | 50.81 | 21.93 | 20.36 |
| 2015 | Proportion(%) | 50.35 | 21.90 | 20.32 |
| Year     | Dynamic degree (%) | Water land | Building land | Unused land |
|----------|--------------------|------------|---------------|-------------|
| 1990     | Proportion(%)      | 2.08       | 3.65          | 0.35        |
| 1995     | Proportion(%)      | 2.24       | 3.85          | 0.22        |
| 2000     | Proportion(%)      | 2.06       | 4.22          | 0.24        |
| 2005     | Proportion(%)      | 2.21       | 4.40          | 0.22        |
| 2010     | Proportion(%)      | 2.15       | 4.53          | 0.21        |
| 2015     | Proportion(%)      | 2.23       | 4.98          | 0.22        |
| 1990-2015| Dynamic degree (%)| 0.29       | 1.46          | -1.52       |
| 1990-2015| Comprehensive dynamic degree(%) | 0.06 |