

# Dynamic Monitoring of Land Use in the Loess Plateau from 1995 to 2015

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## Abstract

Taking the Loess Plateau region as the research object, using 1995, 2000, 2005, 2010 and 2015 land use spatial data sets, based on ArcGIS platform, land use dynamic degree model and land use degree comprehensive index model to study 1995 From year to 2015, the dynamic change process of land use in the Loess Plateau region and the characteristics of temporal and spatial differences. The results showed that in the land use types of the Loess Plateau, the area of woodland, water area and construction land increased, while the area of arable land, grassland and unused land decreased, and the area of woodland and construction land increased significantly. Since the implementation of ecological control measures on the Loess Plateau, the decline in the area of cultivated land has increased significantly. The urban districts and surrounding areas of the Loess Plateau, as well as the counties and cities with large areas of conversion of farmland, have changed drastically. The changes in other areas have been relatively slow. Space difference.

## Keywords

Land Use; Dynamic Change; Loess Plateau; GIS; Remote Sensing.

## 1. Introduction

Land use refers to the periodic or long-term development and utilization of land and governance and protection by a series of technical means according to certain economic and social purposes. Land use change is affected by many aspects such as nature, society, economy and technology, which is a comprehensive and complex process and has always been a research hotspot in the field of resources and environment [1].

The Loess Plateau, as the largest loess accumulation area in the world and the plateau with the largest loess cover area, is the most serious soil erosion and the most fragile ecological environment in China and even in the world. It has become one of the areas with the most acute contradiction between human and land in China [2]. The region is a hot area for studying the ecological process. The land use change, soil and water conservation and ecological environment problems in the region have been the focus of attention of scholars at home and abroad. Over the past 20 years, land use in the Loess Plateau has undergone significant changes affected by natural and human environments. At present, the research on land use change in the Loess Plateau is mostly concentrated on the typical regional scale, and there is little research on the long-term sequence of the whole Loess Plateau. There is no research on the comprehensive degree of land use by province in the whole Loess Plateau. Based on ArcGIS platform, land use dynamic attitude model and comprehensive index model of land use degree, this study uses the land use status data of the whole Loess Plateau in 1995, 2000, 2005, 2010

and 2015, and takes a series of ecological restoration projects implemented in the past 20 years in the Loess Plateau as the background. Through the analysis of land use time series, dynamic attitude and land use degree characteristics, it explores.

## 2. Overview of the Study Area

The Loess plateau starts from Taihang Mountain in the east, reaches Wushaoling mountain in the west, Qinling Mountain in the south and the Great Wall in the north. From southeast to northwest, the climate is warm temperate sub-humid climate, semi-arid climate and arid climate. The plateau is covered with a deep loess layer. The thickness of the loess ranges from 50 to 80m, with the maximum thickness of 150 to 180m. The average annual temperature is 6 to 14°C, and the average annual precipitation is 200 to 700mm.

## 3. Data Sources and Research Methods

### 3.1. The Data Source

The land use/cover data of 5 periods used in this paper are from the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences ([www.resdc.cn](http://www.resdc.cn)), with a resolution of 1km, and the time period is 1995, 2000, 2005, 2010 and 2015. The land use types are mainly divided into: Cultivated land, forest land, grassland, water body, construction land and unused land.

### 3.2. The Research Methods

#### 3.2.1. Calculation of Land-use Dynamics

Based on five periods of land use/cover data and the theory of land use dynamic attitude model [3], this paper analyzed the dynamic change process and spatio-temporal difference characteristics of land use in the Loess Plateau during the past 20 years (1995-2015).

Dynamic attitude of single land use:

$$W = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\%$$

Where, W is the dynamic attitude of land use type;  $U_a$  and  $U_b$  are the area of a certain land use type at the beginning and end of the study respectively. T stands for study time.

Dynamic attitude of integrated land use:

$$LC = \left[ \frac{\sum_{i=1}^n \Delta LU_{i-j}}{2 \sum_i LU_i} \right] \times \frac{1}{T} \times 100\%$$

Where LC is the dynamic attitude of comprehensive land use;  $LU_i$  is the initial area of class I land use type study.  $LU_{i-j}$  is the absolute value of area of type I land use converted to Type J land use; T is the research time.

#### 3.2.2. Calculation of Comprehensive Index of Land Use Degree

Based on the five-period land use/cover data and the comprehensive index model of land use degree [4], this paper analyzes the dynamic change process and spatial-temporal difference characteristics of land use in the Loess Plateau during the past 20 years (1995-2015).

The comprehensive index of land use degree can effectively describe the differences of land use patterns in different regions, which is one of the indicators to describe the degree of land use. The comprehensive index of land use degree is used to quantitatively describe the restriction of natural ecological environment on land use intensity and depth in the Loess Plateau, and the

depth and breadth of human activities and social development on land resources development are analyzed. The comprehensive index of land use degree reflects the level of land use [5-6].

$$I_d = 100 \times \sum_{i=1}^n A_i \times C_i$$

Where,  $I_d$  is the comprehensive index of land use degree;  $a_i$  is the class  $i$  land use classification index;  $c_i$  is the percentage of land use classification area of class  $i$ .

$$\Delta I = I_b - I_a = \left| \sum_{i=1}^n (A_i \times C_{ib}) - \sum_{i=1}^n (A_i \times C_{ia}) \right|$$

Where,  $I$  for regional land use change;  $i_a$  and  $i_b$  are the comprehensive indexes of regional land use degree at the beginning and end of the study, respectively;  $c_{ia}$  and  $c_{ib}$  were the percentage of class  $I$  land use classification area at the beginning and end of the study, respectively.

$$R = \frac{\sum_{i=1}^n (A_i - C_{ib}) - \sum_{i=1}^n (A_i - C_{ia})}{\sum_{i=1}^n (A_i - C_{ia})}$$

Where,  $R$  is the change rate of land use degree.

## 4. Results and Analysis

### 4.1. Analysis of Interannual Change of Land Use in Loess Plateau

The land use types in the study area in 1995, 2000, 2005, 2010 and 2015 were classified into six types: cultivated land, forest land, grassland, water area, construction land and unused land. From 1995 to 2000, cultivated land, forest land, water area, construction land and unused land increased by 4440km<sup>2</sup>, 5134km<sup>2</sup>, 351km<sup>2</sup>, 760km<sup>2</sup> and 460km<sup>2</sup> respectively. Grassland decreased by 11145km<sup>2</sup>, and the change rate of forest land was 6.04%. The minimum change rate of unused land area is 1.08%. From 2000 to 2005, cultivated land and grassland decreased by 3,629km<sup>2</sup> and 2,900km<sup>2</sup> respectively, construction land increased by 1188km<sup>2</sup> with an increase rate of 8.07%, forest land, water area and unused land increased by 3987km<sup>2</sup>, 101km<sup>2</sup> and 1253km<sup>2</sup> respectively. From 2005 to 2010, woodland, grassland and construction land increased by 484km<sup>2</sup>, 321km<sup>2</sup> and 576km<sup>2</sup> respectively, while cultivated land, water area and unused land decreased by 747km<sup>2</sup>, 29km<sup>2</sup> and 605km<sup>2</sup> respectively. From 2010 to 2015, construction land increased by 3439km<sup>2</sup> with a growth rate of 20.85%, forest land and water increased by 33km<sup>2</sup> and 247km<sup>2</sup> respectively, and cultivated land, grassland and unused land decreased by 1280km<sup>2</sup>, 1103km<sup>2</sup> and 1336km<sup>2</sup> respectively. During the past 20 years from 1995 to 2015, construction land increased by a large amount of 5963km<sup>2</sup> at a rate of 42.69%, forest land and water body increased by 9638km<sup>2</sup> and 670km<sup>2</sup> respectively, and cultivated land, grassland and unused land decreased by 1216km<sup>2</sup>, 14827km<sup>2</sup> and 228km<sup>2</sup> respectively. The change rate of grassland reduction was 5.43%.

From 1995 to 2015, with the implementation of ecological management projects such as comprehensive management of small watershed on the Loess Plateau, returning farmland to forest and grassland, and ditching and land reclamation [5], the woodland area increased by 11.34%, while the cultivated area decreased by 0.6%. The land for construction increased by 5963km<sup>2</sup>, indicating that the urbanization in loess plateau region achieved remarkable achievements. The unused land increased first and then decreased. In the early period (1995-2005), there were more wasteland grassland reclaimed and grassland degraded to unused land, while in the later period (2005-2015), farmland was converted to forest and unused land to

grassland. The water area increased by 8.07%, and the construction of water conservancy facilities was the main reason for the increase.

#### 4.2. Dynamic Attitude Analysis of Land Use Change in Loess Plateau

Based on the dynamic attitude model of single land use type and comprehensive land use dynamic attitude model, the characteristics of dynamic attitude change of land use during 1995-2005, 2005-2015 and 1995-2015 were quantitatively analyzed.

As can be seen from Table 5, from 1995 to 2005, the dynamic attitude of arable land, forest land, water area, construction land and unused land was greater than zero, while the grassland area decreased, and the dynamic attitude was 0.51%. From 2005 to 2015, the dynamic attitudes of cultivated land, grassland and unused land were less than zero, which were 0.10%, 0.03% and 0.43%, respectively. The dynamic attitudes of forest land, water area and construction land were more than zero. From 1995 to 2015, the dynamic attitude of land use of forest land, water area and construction land were greater than zero, while the dynamic attitude of land use of cultivated land, grassland and unused land was less than zero. Construction land increased by far more than other categories.

The dynamic attitude of comprehensive land use was 1.86 from 1995 to 2005, 0.11 from 2005 to 2015, and 0.95 from 1995 to 2015. From the comprehensive dynamic attitude of land use in these three periods, it can be seen that the circulation of land use types from 1995 to 2005 was much higher than that from 2005 to 2015, indicating that human activities were more intense in the first 10 years. This phenomenon corresponds to a series of engineering and biological treatment on the Loess Plateau, indicating that the overall development level of the Loess Plateau was relatively fast from 1995 to 2005, which effectively promoted the economic and social development of the loess Plateau.

#### 4.3. Comprehensive Index Analysis of Land Use Degree in Loess Plateau

The comprehensive index of land use degree can effectively describe the differences of land use patterns in different regions, which is one of the indicators to describe the degree of land use. The comprehensive index of land use degree is used to quantitatively describe the restriction of natural ecological environment on land use intensity and depth in the Loess Plateau, and the depth and breadth of human activities and social development on land resources development are analyzed. Taking into account the ecological construction of the Loess Plateau, the overall weight of water, woodland and grassland is increased, and the weight of cultivated land is reduced. The comprehensive index of land use degree in the Loess Plateau is calculated according to the method (formula 2) and the land use degree classification assignment table.

In 1995, 2005 and 2015, the maximum comprehensive index of land use degree was Qinghai Province, and the minimum values in 1995 were Inner Mongolia Autonomous Region, Henan Province and Ningxia Hui Autonomous Region. The minimum values in 2005 and 2015 are Inner Mongolia Autonomous Region, Ningxia Hui Autonomous Region and Henan Province, respectively. In the seven provinces across the Loess Plateau, the area of cultivated land, forest land and grassland are relatively large, and the contribution to the comprehensive index of land use degree is also greater. In 1995, the top three comprehensive indexes of land use degree were Qinghai Province (271.65), Shanxi Province (265.39) and Gansu Province (262.32). In 2005, the top three comprehensive indexes of land use degree were Qinghai Province (272.42), Gansu Province (263.31) and Shanxi Province (263.02). In 2015, the top three comprehensive indexes of land use degree were Qinghai Province (272.85), Gansu Province (264.12) and Shanxi Province (263.85).

It can be seen from the change rate of land use degree that from 1995 to 2005, the change rate of land use degree in seven provinces across the Loess Plateau was positive in Qinghai Province, Gansu Province, Ningxia Hui Autonomous Region and Henan Province, and negative in Inner

Mongolia Autonomous Region, Shaanxi Province and Shanxi Province. Among them, Henan Province developed the fastest, with the change index of land use degree of 6.23 and the change rate of 2.5.

## 5. Conclusion

Based on the land use data of the Loess Plateau in 1995, 2000, 2005, 2010 and 2015, this paper analyzes the macro land use change in the Loess Plateau in the past 20 years, and draws the following main conclusions:

- (1) The increase of woodland area in the Loess Plateau was 11.34%, and the decrease of cultivated land area was 0.6%. The unused land increased first and then decreased, and the water area increased by 8.07%. The results of urbanization construction were obvious, and the construction land increased by 5963 km<sup>2</sup>.
- (2) The dynamic degree of land use of woodland, water area and construction land is greater than zero, and that of cultivated land, grassland and unused land is less than zero; the land use type transfer from 1995 to 2005 was much higher than that from 2005 to 2015, indicating that human activities were more intense in the first 10 years.
- (3) Henan Province has the fastest development, followed by Ningxia Hui Autonomous Region, Gansu Province, Inner Mongolia Autonomous Region, Qinghai Province and Shaanxi Province. Shanxi Province belongs to the adjustment period and develops relatively slowly. Overall, the Loess Plateau is in continuous development, there is no obvious recession.

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