Spatio-temporal Evolution Analysis of Land Use in Henan Province

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Abstract. Aiming at the change of land use types and their formation mechanism, based on Digital Elevation Model and the land use grid data, this paper uses the spatial analysis method to quantitatively analyze their spatial-temporal evolution characteristics, formation mechanism in Henan Province. The results show that, from 1995 to 2015, the rate of linear decrease of farmland is higher than that of linear increase of construction land. The area of forest grassland remains stable, and the area of water land is gradually increasing. The area decrease rate of farmland in the elevation of 50-100m is obviously higher than that in other regions, the decrease proportion of farmland in the elevation of 150-200m is the highest, and the water land are mainly distributed in low elevation region. More than 72% of the construction land concentrates in the region of elevation 0-100m, the area increase rate of construction land in the elevation of 50-100m is obviously higher than that in other regions, the increase proportion of construction land in the elevation of 150-200m is the highest. The reduced farmland is mainly converted into construction land, forest grassland and water land, the area decrease rate of farmland in the elevation of 150-200m is the highest, and the water land are mainly distributed in low elevation region. More than 72% of the construction land concentrates in the region of elevation 0-100m, the area increase rate of construction land in the elevation of 50-100m is obviously higher than that in other regions, the increase proportion of construction land in the elevation of 150-200m is the highest. The reduced farmland is mainly converted into construction land, forest grassland and water land, the area of returning farmland to forest and grassland is basically occupied by construction land, the increased water land area mainly comes from farmland and forest and grassland, The increase area of construction land mainly occupies farmland, forest and grassland and water land.

Introduction

Land use spatial distribution refers to the spatial arrangement of different land use types, is the result of the interaction of natural and human factors [1]. The land use type is not only affected by terrain, Landform, geology, slope, elevation and other natural factors, but also by economic factors and social factors [2, 3, 4]. The economic and social development has been leading to the transition of land use type, at the same time, reasonable distribution of land use not only effectively promotes the rapid development of regional economy, but also has some influence on local climate change, hydrological process, biodiversity and other ecological processes [6,7]. Recently the study of land use transition mainly focuses on the spatial and temporal distribution differences and the expansion model and driving mechanism, the construction and application of land use change dynamic model, the rationality of land use spatial pattern, and the variation characteristics of land use in different terrain gradients, and so on[7-9]. They mainly focus on the specific time section, but the research on the spatial and temporal evolution of land use and its formation mechanism in a period of time is very little. In fact, by the effect of natural factors and policy factors, the transition of land use type plays a important role in optimizing the regional economic structure, and promoting the sustainable development of regional economies [10,11].

Based on the 30m×30m Digital Elevation Model(DEM) and 1km×1km land use spatial distribution grid data from 1995 to 2015, this paper quantitatively analyzes the temporal and spatial evolution of land use types and its formation mechanism in Henan province on 5 time sections and in 4 time periods, by using grid computing, zonal statistics and regression analysis, in order to explore the temporal characteristics of land use transition, spatial expansion process and their future development trend.
Data and Research Methods

Research Area Overview

Henan Province is located in the transition zone of China’s terrain from the second to the third ladder, with a total area of 167 thousand km$^2$ (250.5 million hectares). The landforms are complex and the terrain is high in the west and low in the east. The three sides as the north, west and south are semi-circular surrounded by Taihang, Funiu and Tabie mountains. The central and east regions are the Huang-Huaihai alluvial plain, the southwest region is Nanyang Basin. The terrain relief gradually decreases with the with latitude increase.

Henan Province is an agricultural province, agricultural population and agricultural land are the main forms of population and land use. In recent years, with the population urbanization, the construction of traffic infrastructure, and the implementation of a series of land policies, as returning farmland to forest and grassland, closing mountains for reforestation, the distribution of land use has undergone great changes.

Data and Research Methods

The data used in this study include 30m×30m DEM provided by Computer Network Information Center (http://www.gscloud.cn), and the land use status remote sensing data (1995-2012) provided by Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (http://www.resdc.cn) which is based on Landsat TM / ETM remote sensing image and generated by artificial visual interpretation. The land use types studied include farmland, forest land, grassland, water land, construction land and unused land. In order to guarantee the calculation accuracy, the land use grid data are recalculated by using the most natural neighbor method and the grid coordinate information of the 30m×30m DEM.

Results Analysis

Distribution Characteristics of Land Use in Henan Province

On the basis of the land use grid data of 30m×30m, the quantity of land use (unit: 10,000 hectares) on each section are calculated as Table 1. The farmland and forest land have been the main form of land use, but the transition patterns have their own characteristics.

From 1995 to 2015, the area of farmland is decreasing gradually, the decrease are in the first time period is the fastest, then followed by the second, fourth and third period. The linear regression analysis of the farmland area shows that the farmland area has some linear decrease feature as $S = \frac{24.12(y - 1995) + 16595.32}{(0.979, 0.004)}$ (see Figure 1(a)), the average annual decrease of 0.2412 million hectares.

The area of forest land decreases rapidly in the first period, and then are basically balanced in the rest three periods. The area of grassland increases rapidly in the first time period, and gradually reduces in the rest three periods. As the remote sensing images are similar to the forest and grassland, if merging of these two land types, the effect of returning farmland to forest and grassland is very obvious, but the effect gradually decreases over time, especially in 2000 to 2005 there is a certain phenomenon of re-farming.

The area of water land is gradually increasing. In the view of spatial distribution, due to the construction of Xiaolangdi Multipurpose Dam Project and some water conservancy infrastructure, and river regulation and development, the area of water land increases rapidly in the first and second periods. In the third and fourth periods, the increase of the water land area mainly benefits from the construction of the middle route project of the South-to-North Water Transfer Project.

The construction land shows some linearly increase features (see Figure 1(b)) as $S = 17.932(y - 1995) + 2466.60$ (0.986, Sig = 0.002), with 0.1793 million hectares of average annual increase. The first period increased is the most, then followed by fourth, second and third periods. On 2000, the unused...
land reaches 0.1374 million hectares, mainly distributes around the Yellow River in the northeastern part of the province. The reason is the project of returning farmland to forests and grassland fails, and causes some remedied area severe land desertification.

Table 1. The land use distribution in Henan province (1995-2015).

<table>
<thead>
<tr>
<th></th>
<th>Farmland</th>
<th>Forest land</th>
<th>Grassland</th>
<th>Water land</th>
<th>Construction land</th>
<th>Unused land</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>16638.88</td>
<td>4596.82</td>
<td>907.22</td>
<td>461.16</td>
<td>2443.49</td>
<td>2.42</td>
</tr>
<tr>
<td>2000</td>
<td>16448.78</td>
<td>4046.46</td>
<td>1418.92</td>
<td>542.74</td>
<td>2579.35</td>
<td>13.74</td>
</tr>
<tr>
<td>2005</td>
<td>16299.57</td>
<td>4038.57</td>
<td>1412.69</td>
<td>615.42</td>
<td>2674.26</td>
<td>9.50</td>
</tr>
<tr>
<td>2010</td>
<td>16246.83</td>
<td>4048.54</td>
<td>1410.71</td>
<td>621.86</td>
<td>2712.55</td>
<td>9.35</td>
</tr>
<tr>
<td>2015</td>
<td>16137.18</td>
<td>4045.70</td>
<td>1409.36</td>
<td>624.89</td>
<td>2823.37</td>
<td>9.50</td>
</tr>
</tbody>
</table>

Figure 1. The evolution characteristics of cultivated land and development land.

**Evolution Characteristics of Land Use Vertical Distribution**

Landform factors directly affect the distribution and growth of vegetation, to a certain extent could reflect the rationality of land use spatial pattern. There are some differences in the area distribution and transition pattern of land use at different elevation and slopes. In order to study the relationship of the spatial and temporal evolution of land use with the landform, the research divides the province terrain into 7 elevation zone as of <50, 50-100, 100-150, 150-200, 200-500, 500-1000, ≥1000m and so on. The interpolation analysis result (Figure 2), and the zonal statistics results of land use for the 5 time sections show that,

Figure 2. The terrain distribution of Henan.

(1) Farmland. As for the area, the area of farmland on each elevation zone is gradually decreased, the decrease rate of the second elevation zone is the fastest, the regression decrease index is 6.751, followed by 5th (5.689), 1st (3.533), 3rd (3.376), 4th (2.538), 6th (2.085) and 7th (0.146) elevation zones. As for the land use density, the distribution density gradually decreases with the elevation increase. The farmland is the main land form under the 500m elevation. The decreases rate of density on each elevation are significantly different, the range reaches up to 0.144. With the elevation increasing gradually, the decreases rate gradually increases, on the 4th elevation zone the regression decrease index is the largest as 0.156, and then the decreases rate gradually reduces from the 200m elevation, the regression decrease index respectively are 0.137 (5th), 0.116 (3rd), 0.081 (the first), 0.080 (6th), and 0.012 (7th).
(2) Forest land. As for the land use density, with the elevation raises the distribution density gradually increases, the forest land always is the main land form above 500m elevation. There are large reductions on all elevation zones under 1000m elevation in the first period, and then the area keeps basically stable in the following 15 years. On the 7th elevation zone, the area decrease is no obvious, but the area is also reduced by 0.1305 million hectares, the density decreases by 1.06%, and then gradually reduce, the annual decrease of less than 0.03%.

(3) Grassland. As for the land use density, with the elevation raises the density gradually increases, then decrease, which reaches peak in 5th elevation zone. The increase rates in the first period are faster than that in other periods for all elevation zones, especially on 5th elevation zone, the increase area amounts to 2.422 million hectares and get 5.82% density increase rate, and then 1.646 million hectares and 6.290% on 6th.

(4) Water land. The water land are mainly distributed in the low elevation area, especially on 2nd elevation zone, followed by the 3rd, 5th, 4th, 6th and 7th elevation zones. On 3rd elevation zone, the area reduces significantly in the first period, and soon recovers in the second period, and then increase year by year. On the other elevation zones, the area increase rapidly in the first period, and then increase slightly with time. The density increases very faster on 3rd elevation zone than that on the other elevation zones.

(5) Construction land. More than 72% of the construction land is mainly distributed in 1st and 2nd elevation zones, the area increase year by year on all elevation zones. For the elevation zone under 500m, the area linearly increase, under the significance level of 0.05 and residual of 0.9, especially on 2nd elevation zone, the regression increase index amounts to 8.70, followed by 3.90 on 3rd, 2.68 on 1st, 1.53 on 5th and 1.06 on 4th. Under the significance level of 0.05 and residual of 0.9, the distribution densities also have the characteristics of linearly increase, the increase rate is fastest on 3rd elevation zone, the regression increase index amounts to 0.134, then 0.107 on 2nd, 0.065 on 4th, 0.061 on 1st and 0.037 on 5th.

(6) Unused land. The unused land is mainly distributed on 2nd elevation zone. The distribution density on 2nd elevation zone increase rapidly in the first period, then gradually decreases on time. The distribution densities on the other elevation zones remain generally stable.

**Evolution Characteristics of Land Use Types**

The evolution mechanism of land use type refers to the transition law of land use type over time, which describes the basic characteristics of the land use types change and their transition patterns.

The land use space transfer matrices are constructed by superimposing the land use grid data of each year, the results show that:

(1) Farmland. From 1995 to 2015, the province has been re-cultivating land. In the first period, mainly re-cultivate construction land and forest land about 0.300 million hectares, but the area of farmland actually reduces 2.201 million hectares. In the second period, mainly re-cultivate construction land and grassland about 0.150 million hectares, but the area of farmland actually reduces 1.642 million hectares. In the third period, mainly re-cultivate water land about 84500 hectares, the area of farmland actually reduces 0.602 million hectares. In the fourth period, mainly re-cultivate construction land and water land about .0115 million hectares, the area of farmland actually reduces 1.214 million hectares.

(2) Forest and grassland. In the first period, although there are 107,000 hectares of farmland for returning to forest and grassland, 4100 hectares of water land and unused land in the first period grassing or afforesting, but the total area is still reduced by 386,600 hectares. In the next three periods, the change of forest and grassland area is relatively small. In the second period, the area of returning farmland to forest and grassland is 51,500 hectares, there are 12,300 hectares of water land and unused land in the first period grassing or afforesting, the total area also reduces by 141,300 hectares. In the third period, the effort of returning farmland to forest and grass increases, up to 99,600 hectares, re-cultivating construction land about 1,500 hectares, the total area increase by 80,000 hectares. In the fourth period, the intensity of returning farmland to forests and forests is the smallest, about 3,100.
hectares, about 7,500 hectares of construction land and 18,200 hectares of water land to be grassing or afforesting, the area increase by 41,900 hectares.

(3) Water land. In the first period, there are 26,700 hectares of farmland, 4,300 hectares of forest land, 1,200 hectares of grassland and 2,500 hectares of construction land to be translated into water land. In the second period, the area of translated farmland is the most up to 657,000 hectares, then grassland with 87,900 hectares, forest land with 69,600 hectares, construction land with 13,700 hectares and unused land with 0.76 hectares. In the third period, the area growth rate is obviously less than that in the first two periods. The farmland, forest land, grassland and construction land respectively contribute 124,900, 4,500, 6,100 and 10,500 hectares. In the fourth period, the area growth rate is the smallest. The farmland, forest land, grassland and construction land respectively contribute 77,100, 9,100, 10,600 and 7,500 hectares.

(4) Construction land. From 1995 to 2015, with the increase of population and the improvement of urbanization, the total area gradually increases. In the first period, construction land occupies farmland, forest land, grassland and water land respectively being 184,400, 5200, 800 and 20,100 hectares. In the second period, these numbers increase up to 931,400, 24,300, 15,100 and 28,600 hectares. In the third period, there are 387,500 of farmland, 12100 of grass land and 4500 of water land are occupied by construction land. In the fourth period, the area of forest land occupied by construction land reach the peak of 1,135,000 hectares, followed by 25,700 of forest land, 15,100 of grass land and 13,700 of water land.

(5) Unused land. In the first period, the area increases by 113,200 hectares, in which the contribution area of farmland, forest land, grassland, construction land and water land respectively are 58,100, 25,200, 2,500, 2000 and 7500 million hectares. The area reduces to 95000 hectares in second period, the area is 93500 hectares in the third period, but the area in the fourth time restores to the dimensions of the second period.

On the whole, the area of farmland continues to decrease, mainly due to the area increasing of construction land, returning farmland to forest and grassland and water conservancy facilities. The policy effect of returning farmland to forest and grassland is gradually weakened, the area of returning farmland to forest is slightly larger than that of forest and grassland occupied, in which the increase area almost all is occupied by construction land. Water area gradually increase, mainly occupies farmland and forest grassland. Construction land continues to increase, mainly occupies a large number of farmland, forest and grassland and water land. Unused land basically remains stable, although attempting to rehabilitate, but the effect is not obvious.

Conclusion

Based on the 30m×30m DEM and 1km×1km land use spatial distribution grid data, this paper quantitatively analyzes the temporal and spatial evolution of land use types and their formation mechanism on time in Henan province. The results show that.

(1) The rate of linear decrease of farmland is higher than that of linear increase of construction land. The effect of returning farmland to forest and grassland is not very obvious, the area of forest grassland remains stable. The area of water land is gradually increasing.

(2) The farmland is the main land form under the 500m elevation, the area is gradually decreasing, the decrease rate in the elevation of 50-100m is obviously higher than that in other regions, the decrease proportion in the elevation of 150-200m is the highest. The forest land is the main land form above the 500m elevation. The water land is mainly distributed in low elevation region. More than 72% of the construction land concentrates in the region of elevation 0-100m, the area increase rate in the elevation of 50-100m is obviously higher than that in other regions, especially in the elevation of 150-200m.

(3) The reduced farmland is mainly converted into construction land, forest grassland and water land. The area of returning farmland to forest and grassland is slightly larger than that of forest and grassland occupied, in which the increase area almost all is occupied by construction land. The
increased waters area mainly comes from farmland and forest grassland. The increase area of construction mainly occupies farmland, forest grassland and waters land.

The land use grid data, generated by Landsat TM / ETM remote sensing image, reflects the spatial distribution characteristics of regional land use. But the impact on the analysis result of the data accuracy and error transfer coming from the image resolution and remote sensing image feature is the problems needing to be further studied.

References


