ISSN: 2710-0588

A Study On Land Use Change in Changsha City Based on Landsat Data

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Abstract

In recent years, with the rapid development of economy and society, people's land use activities have become more and more frequent and intense, which has caused many environmental and resource problems, and the changes in the global environment have increasingly become the focus of human society. With the deepening of relevant research, the main reason for environmental change is the change of people's land use. Therefore, in order to achieve coordinated economic development and the protection of resources and environment, land use change has become a hot issue in the study of global environmental change. In order to reveal the characteristics of land use change in Changsha in recent years, this paper applied remote sensing technology and geographic information system technology to carry out a series of studies on the three Landsat remote sensing images and basic geographic data in Changsha in 2012, 2015 and 2018. The results show that from 2012 to 2018, the area of cultivated land and forest land in Changsha decreased, and the area of construction land and grassland increased, and in terms of ecological protection, the water area and water volume of Changsha decreased slightly in the past six years.

Keywords

Land-use change; Changsha city; Remote sensing; geographic information system.

1. Introduction

Land is an indispensable and important raw material for sustainable social and economic development, and plays a fundamental and cohesive role in the process of urbanization. The scientific, rational and effective use of land is related to the overall macroeconomic development of the country and the people's livelihood. At the same time, the rapid growth of population has also made the contradiction between man and land more and more prominent, so it is very important to solve the problem of effective use of land and the development of human society. The significance of studying land use change in a region lies in the fact that it can make effective and rational use of land resources and improve the ecological environment in the region, and at the same time, it can also provide a theoretical basis for local land use planning decisions.

2. Overview of the Study Area

The main object of this study is Changsha City, the capital city of Hunan Province, located at 111°53'~114°15'E longitude, 27°51'~28°41'N latitude, the longest point from east to west is about 230 kilometers, the widest point from north to south is about 88 kilometers, and the total area of the city is 11819.5 square kilometers. It belongs to the subtropical monsoon humid climate, with rain and heat at the same time, four distinct seasons and a long frost-free period. The water resources are mainly surface water, the Xiangjiang River is the main water system,

ISSN: 2710-0588

and there are 15 tributaries in the city that flow into the Xiangjiang River, the water system is numerous, the river network is dense, and the water source is sufficient. It is located in the third step of China, the lower reaches of the Xiangjiang River and the south of the Dongting Lake Plain. The regional outline presents a long east-west shape, with hills in the southeast, hills in the northeast, and mountains in the others.

3. Data Sources and Information Processing

3.1. Data Sources and Processing

3.1.1. Data Sources

In 2012, 2015 and 2018, there were an average of 5 remote sensing images in Changsha per year, and the datasets were Landsat7 ETM SLC-on and Landsat8 OLI_TIRS, respectively, the cloud cover is controlled below 10%. Because some images cannot be downloaded during the same period, the imaging time of the remote sensing images in this paper is inconsistent, but the information of the ground objects is clear, and the reflectance spectrum of the ground objects is significantly different, which is easy to identify and interpret the images.

3.1.2. Data preprocessing

Firstly, the downloaded remote sensing images were radiometrically calibrated. Due to the influence of illumination, radiation and other factors, the sensor will cause a certain degree of distortion in the process of acquiring and transmitting remote sensing data, so it is necessary to perform radiometric calibration on remote sensing images. In this paper, the Radiometric Calibration tool in ENVI5.1 is used to preprocess the remote sensing images in the first step to improve the accuracy of the remote sensing images.

Secondly, the atmospheric correction of the remote sensing images is carried out. Due to the error of ground radiation caused by the scattering of the atmosphere, there is a certain error between the total radiation of ground objects obtained by satellites during imaging and the real reflectance of the surface. In this paper, the FLAASH correction in ENVI5.1 is used to correct the atmosphere of the remote sensing image, so as to eliminate the influence of external factors such as atmosphere on the image.

Finally, the remote sensing images that have been preprocessed in the first two steps are fused with images, and the fused images are cropped by using vector files of Changsha City, and the final cropping results are as follows:

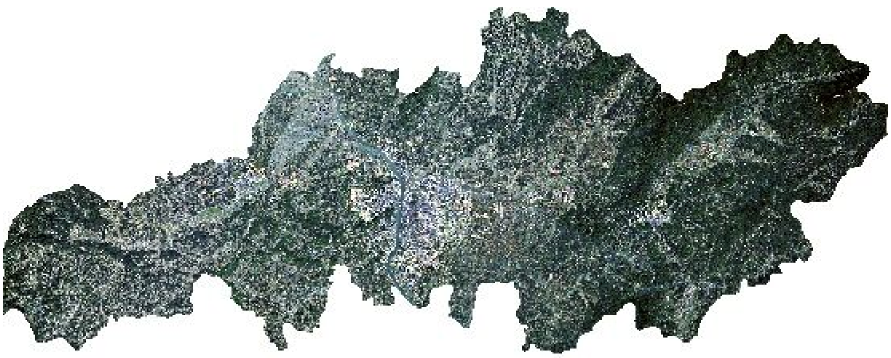

Figure 1. Cropping results of Changsha City

3.2. Thematic information extraction

3.2.1. Land use classification system

On the basis of Landsat data, taking into account the scales involved in this study and the types of land and land use in the study area, the classification system of six categories, including

ISSN: 2710-0588

cultivated land, forest land, grassland, water area, construction land and unused land, was determined.

Table 1. Content and meaning of land use classification

1	Arable land refers to the land on which crops are grown.
2	Forest land refers to forestry land for the growth of trees, shrubs, bamboos and other forestry land.
3	Grassland refers to animal husbandry land and various types of grassland, which are mainly used for the growth of herbaceous plants.
4	Water area refers to natural land water area and land for water conservancy facilities.
5	Urban-rural, industrial, mining and residential land refers to land used for urban and rural construction and other infrastructure such as factories, mines, transportation, energy stations, and water conservancy stations.
6	Unused land refers to land that has not been used, including land that is difficult to use.

3.2.2. Land use classification in the study area

The commonly used algorithms for classification of remote sensing images include maximum likelihood classification, minimum distance classification, Mahalanobis distance classification, and K-NN classification. There are many types of land use and complex topography in Changsha City, so the maximum likelihood classification method is used to supervise and classify the remote sensing images of Changsha City. Solid color samples are selected during the training process and are evenly distributed throughout the study area. After the sample is selected, the resolution of the sample is calculated, and the evaluation index of the resolution is whether the sample parameter is greater than 1.9. If it is greater than 1.9, it indicates that the sample separability of this classification is good, otherwise, it indicates that the sample selection of this classification needs to be corrected. In the process of supervised classification, there will be some errors in the classification results, and there will also be some fragments and small patches, so it is necessary to merge the fragments of the supervised classification images by using Clump Classes in ENVI to obtain the land use distribution map of Changsha City (Figs. 2, 3, 4).

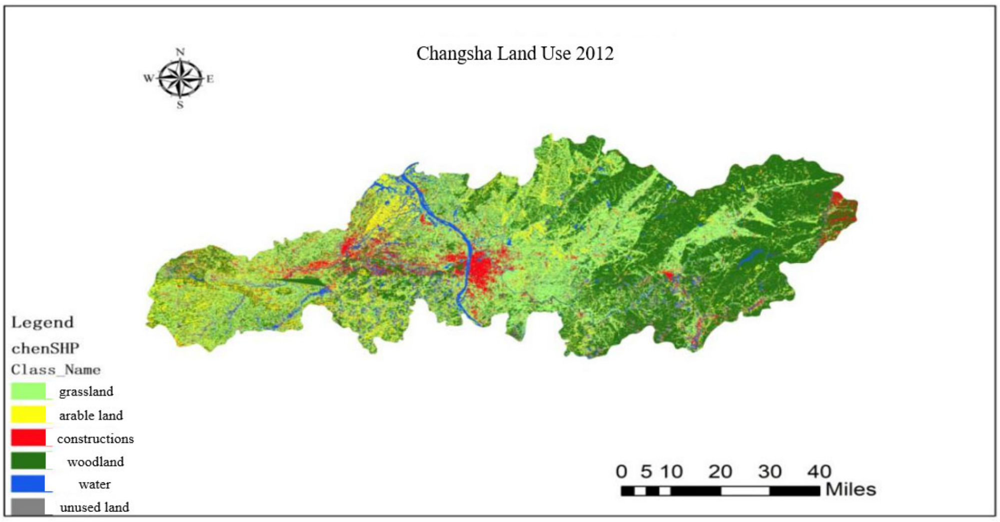

Figure 2. Land use distribution in Changsha in 2012

ISSN: 2710-0588

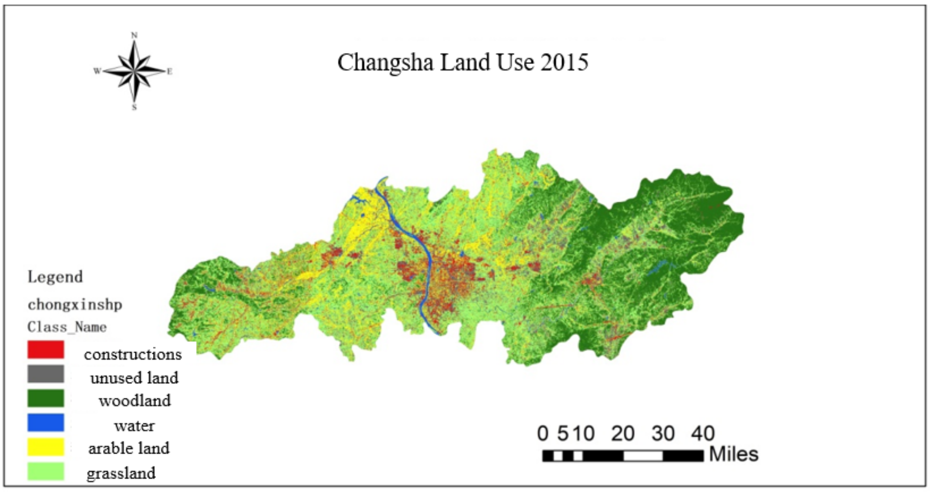

Figure 3. Land use distribution in Changsha in 2015

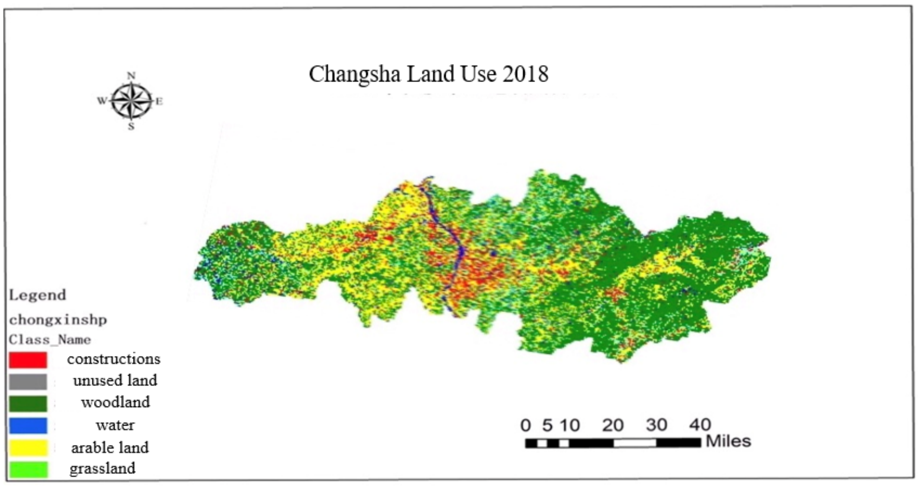

Figure 4. Land use distribution in Changsha in 2018

3.3. Classification results and evaluation

3.3.1. Vectorization and area statistics of remote sensing images

In ArcGIS, the data of the three periods of 2012, 2015 and 2018 were converted to raster to surface, and the areas of six types of land in the land use distribution map of Changsha City were counted with the help of the values in the attribute table, and the land use situation of these three time points in Changsha City was represented by land use type structure map and area map (Table 2).

Table 2. Area and percentage of land use types from 2012 to 2018

	In 2012		In 2015		In 2018	
	Area km2	Percentage %	Area km2	Percentage %	Area km2	Percentage %
cultivated land	2705.48	22.89	2427.72	20.54	2300.08	19.46
woodland	5184.03	43.86	5090.66	43.07	5148.57	43.56
grassland	1860.39	15．74	2086.14	17.65	2209.06	18.69
Landfor construction	743.45	6.29	1127.58	9.54	1457.34	12.33
waters	358.13	3.03	348.68	2.95	330.95	2.80
Unused land	968.02	8.19	738.72	6.25	373.50	3.16

ISSN: 2710-0588

3.3.2. Evaluation of results

From Table 2 and Figure 5, it can be concluded that the changes in the area of cultivated land, forest land, grassland, water area and construction land in Changsha City at these three time points in 2012, 2015 and 2018 are relatively reasonable, and the total land use area of the three time points is about 11819.5 km2, which is the same as the total land use area of Changsha City.

4. Analysis of Land Use Change in Changsha City

4.1. Land use dynamics

The dynamic change of land use can be analyzed from the two dimensions of change range and speed, and fully grasping the change range and speed is conducive to the management of land resources, and the purpose of rational use of land can be achieved while managing land resources. The formula for the magnitude of land use change is:

$$K_i = U_b - U_a \quad K_i = U_b - U_a \qquad \text{(Equation 3.1)}$$

where Ki — the total area of change of land use types from the beginning to the end of the year i; U_a — the number of areas of a certain land class in the initial year; U_b —The number of areas of a land class at the end of the year.

The formula for the rate of land use change is:

$$K_j = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \qquad \text{(Equation 3.2).}$$

where Kj — the dynamics of a certain type of land from the beginning to the end of the year; UA — the area of a certain land class in the initial year; UB — the area of a certain land type at the end of the year; T—length of study.

According to the area statistics in Table 2, Table 3 and Figure 6 are calculated using Equation 3.1 and Equation 3.2:

Table 3. Land use change and dynamics in Changsha from 2012 to 2018

		Cultivated land	woodland	grassland	Land for construction	waters	Unused land
2012-	Variation (km)	-277.76	-93.37	225.75	384.13	-9.45	-229.30
2015	Dynamics (%)	-3.42	-0.60	4.04	17.22	0.88	-7.90
2015-	Variation (km)	-127.64	57.91	122.92	329.76	-17.73	-365.22
2018	Dynamics (%)	-1.75	0.38	1.96	9.75	-1.69	-16.48
2012-	Variation (km)	-405.40	-35.46	348.67	713.89	-27.18	-594.52
2018	Dynamics	-2.50	-0.11	3.12	16.00	-1.26	-10.24

4.2. Analysis of land use dynamics

4.2.1. Analysis of land use dynamics from 2012 to 2015

According to Tables 2, 3, the main characteristics of land use dynamics in Changsha from 2012 to 2015 can be obtained

From 2012 to 2015, the area of construction land in Changsha changed the most, increasing by 17.22%. This was followed by arable land, which decreased by 3.42 percent. The range of land use types was as follows: construction land (17.22%), unused land (7.90%), grassland (4.04%), cultivated land (3.42%), water area (0.88%) and forest land (0.).60%).

ISSN: 2710-0588

The cultivated land area decreased from 2705.48 km2 in 2012 to 2427.72 km2 in 2015, a decrease of 277.76 km2 in three years, and the percentage of cultivated land in the total area of Changsha decreased by 2.35%. At the same time, the area of forest land has also decreased, by 93.37 km2 in three years. It shows that in the past three years, with the rapid development of urbanization, a large number of rural population has been lost, and the urban population has increased sharply, resulting in a large number of arable land and forest land being occupied.

The construction land increased from 743.45 km2 in 2012 to 1127.58 km2 in 2015, an increase of 384.13 km2, accounting for an increase of 3.25%. To explore the reasons for this, to a large extent, the rapid development of Changsha's economy and the growth of urban population have led to the expansion of construction land area, especially the increase in the demand for urban and rural residential and public facilities, which has had a great impact on the field of construction land.

The grassland area increased from 1860.39 km2 in 2012 to 2086.14 km2 in 2015, accounting for 1.91%. The area of forest land decreased from 5184.03 km2 in 2012 to 5090.66 km2 in 2015, accounting for 0.79%, and the area changed greatly, which may be due to people's illegal and excessive logging of forest resources.

The water area decreased by 9.45 km2, a decrease of 0.88%. Based on the average precipitation and average temperature in Changsha over the past few years, there are no extremes, and it can be found that it is not determined by temperature or rainfall, but due to man-made, but basically in a stable state.

4.2.2. Analysis of land use dynamics from 2015 to 2018

According to Tables 2, 3 and Fig. 6, the main characteristics of land use dynamics in Changsha from 2015 to 2018 can be obtained

The land use area of Changsha also changed from 2015 to 2018, and in terms of the magnitude of change, the unused land had the largest change, decreasing by 365.22 km2, followed by construction land, increasing by 329.76 km2. In order of percentage change (absolute value), unused land (16.48%), construction land (9.75%), grassland (1.96%), cultivated land (1.75%), water area (1.69%) and forest land (0.38%).

In terms of the decrease in land use area, the area of unused land has decreased significantly, from 738.72 km2 in 2015 to 373.50 km2 in 2018, and the percentage of unused land in the total area of Changsha has decreased by 3.09%, which is the land type with the largest change in the area of Changsha. At the same time, the area of water and cultivated land is also decreasing, by 17.73 km2 and 127.64 km2, respectively, and the overall decrease is not large. The decrease in the area of unused land indicates that the use of unused land in Changsha is relatively sufficient in the past three years, and the decrease in the area of forest land indicates that the forest land has been occupied and trees have been cut down during these three years, mainly in the western mountainous areas.

From 2015 to 2018, the area of forest land increased from 5090.66 km2 in 2015 to 5148.57 km2 in 2018, an increase of 57.91 km2 in three years, with a small increase. The growth rate of grassland was similar to that of forest land, and the increase was not large, from 2086.14 km2 in 2015 to 2209.06 km2 in 2018.

The area of construction land has been in a growth phase as in the previous three years, from 1127.58 km2 in 2015 to 1457.34 km2 in 2018, an increase of 329.76 km2 in three years. This is mainly due to the high level of economic development in Changsha from 2015 to 2018, which led to a sharp increase in demand for construction land.

ISSN: 2710-0588

5. Concluding Remarks

1) The area of cultivated land continues to decrease. Through the analysis of land use change in Changsha from 2012 to 2018, it is found that the cultivated land area has been decreasing continuously in the past six years. This can be improved in the following aspects: First, it is necessary to strictly control the conversion of existing cultivated land into other land. For the sake of local economic development, unused land and other land can be reclaimed rationally according to the actual situation, and the cultivated land should be occupied as little or no as possible. Second, it is necessary to vigorously improve the quality of cultivated land. It is difficult to break through the natural supply of land, and efforts must be made to increase the area of cultivated land indirectly by working on economic supply. The main measures are to improve the fertility of the soil itself, strengthen the construction of water conservancy facilities on farmland, improve the farming skills and conditions of farmers, and build shelter forests on farmland. Third, it is also necessary to rationally utilize and protect forests, grasslands, waters, and other reserve land resources, especially the land around cultivated land, and strictly control the flow of pollutants such as industrial waste gas, waste water, and residential water into cultivated land.

Acknowledgments

Funding: This work was supported from the projects of "The Natural Science Basic Research Plan in Shaanxi Province of China (Program No. 2024JC-YBQN-0329). Internal scientific research projects of Shaanxi Land Engineering Construction Group (DJNY2023-TD-1, DJNY-ZD-2023-3, DJNY2024-16, DJNY2024-36).

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