Spatio-temporal characteristics of land cover changes of Liangjiang new destrict in China during 2010-2018

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Abstract. Based on Worldview-2 remote sensing images and other survey materials, we analysis the spatio-temporal characteristics of land cover change in Liangjiang New District during 2010 to 2018. The results are summarized as follows: 1) Land cover pattern changed dramatically, with the built-up increase, while the crop land, forest and grass land decrease. 2) Change in land cover types showed marked fluctuations over the three stages (2010-2012, 2012-2015, 2015-2018). Districts with the most obvious change of CL and FGS concentrated in the East and north of the Liangjiang New District. 3) There were significant differences in the intensity of land use dynamic degree change among different regions. The relative change land use dynamic degree of Lijia Street is the biggest, followed by Yuelai Street, Fusheng Town and Longxing Town.

1. Introduction
As all we knows, the land use and land cover change (LUCC) research plan was proposed in 1995. After that, many scholars have carried out a lot of researches on LUCC [1-7]. Research on the trend, mechanism and the evaluation of its eco-environmental effects was focused in land use and cover change in recent years. Yu et al. use the land resource quantity change model and land use and cover change index to study the dynamic change and driving force of land use and cover change in Tianshui, Gansu Province [8]. Liu et al. proposed a dynamic zoning method to analyze the spatio-temporal characteristics, differences, and causes of land use changes in China[9]. It is generally accepted that GIS and RS techniques are wildly used in land use and cover change. Zhang et al. uses GIS and RS technologies to analysis the dynamic change of land use and its driving force in Fushun City, Liaoning Province [10]. Wu et al. extracted the land use data of Beiluo River Basin by using GIS and RS techniques, and analyzed the spatio-temporal characteristics of land use/cover change from the land use change rate, land use conversion direction and land use degree algorithms [11].

It should be note that the land use and cover change is the foundation of human survival and production activities. In view of the rapid economic development in national New District, it is necessary to analyze the regional land use and cover change. This paper use man-computer interactive image processing methods to acquire the land cover data of Liangjiang New District in 2010, 2012, 2015 and 2018, with Worldview-2 remote sensing images. We analyzed the spatio-temporal characteristics of land use and cover changes in Liangjiang New District during 2010-2018 from the
rate of land cover change, the direction of land cover transformation and the dynamic degree of land use.

The rest of this paper is outlined as follows. Section 2 reviews the study area and data sources. Section 3 shows the research methods, including the rate of land cover change, the direction of land cover transformation and the dynamic degree of land use. Section 4 analysis the land cover change of study area. Finally, conclusions are summarized in section 5.

2. Study area and data sources

2.1. Study area
Chongqing Liangjiang New District is the third national new district approved by the State Council of China in 2010, is the first national new district in western China. The area of Liangjiang New District is about 1200 square kilometers.

This rapidly developing economic region is speeding up its development with a large population density and a highly developed industry. With the acceleration of industrialization and urbanization, dramatic changes have taken place in the spatial pattern of land use/cover in Liangjiang New District.

2.1.1. Data sources. The main data sources as Figure 1 showes, are digital WorldView-2 images (2010, 2012, 2015, 2018), those images acquisition was from August to October. That were sourced from Chongqing Geomatics and Remote Sensing Center. We extract the land cover data by using human-machine combination method.

The land cover was divided into five categories: CL-crop land (including arable land and garden), FGL-Forest and grass land (including forest land and grass land), WT-water (including lakes, rivers, and artificial ponds), URS-urban and rural settlement (including road, building, structure and site), UL-unused land.

![Figure 1. Remote Sensing of Liangjiang New District in the year of 2010, 2012, 2015 and 2018.](image)
3. Methodology

3.1. The rate of land cover change
The rate of land cover change can quantitatively describe the speed of land cover change in a certain period, which including single rate of land cover change and comprehensive rate of land cover change. The single rate of land cover change can express the change of each land use types in a certain period, which is defined as:

$$K_i = \frac{s_{i_{t_2}} - s_{i_{t_1}}}{s_{i_{t_1}}} \times \frac{1}{t_2 - t_1} \times 100\%$$

(1)

where $K_i$ is the single rate of land cover change of class $i$ from time $t_1$ to $t_2$. $K_i > 0$, means the land use of class $i$ is mainly transferred in. On the otherwise, $K_i < 0$, means the land use of class $i$ is mainly transferred out. If $K_i = 0$, means land use transfer is balanced, but there may still transfers among classes. $s_{i_{t_1}}$ denotes the area of class $i$ at $t_1$, $s_{i_{t_2}}$ denotes the area of class $i$ at $t_2$.

The comprehensive rate of land cover change is defined as:

$$K = \left( \sum_{i=1}^{n} (\Delta S_{i-j}/S_i) \right) \times \frac{1}{T} \times 100\%$$

(2)

where $K$ is the comprehensive rate of land cover change of all classes during $T$ periods. The greater value of $K$, the more intense of the land cover changes. $S_i$ denotes the area of class $i$ at the beginning of the study. $\Delta S_{i-j}$ denotes the area of class $i$ transfer into others.

3.2. The land cover transformation
The land cover transfer matrix comprehensively and specifically describes the structural characteristics of land cover change, which may better reveal the land cover change of temporal and spatial evolution. The land cover transformation is defined as:

$$M_{ij} = \begin{bmatrix} m_{11} & \ldots & m_{1n} \\ \vdots & \ddots & \vdots \\ m_{n1} & \ldots & m_{nn} \end{bmatrix}$$

(3)

$M_{ij}$ denote the area of class $i$ transferred into class $j$.

3.3. The Dynamic Degree of Land Use
The dynamic degree of land use can quantitatively describe reflect the impact of human activities on the land cover change in a certain period, which can quantitatively express the comprehensive level and trend of land use. This method is defined as:

$$L_b = 100 \times \sum_{j=1}^{n} A_j \times C_{jb}$$

(4)

where $L_b$ is the land use dynamic degree at time $b$, $C_{jb}$ denotes the area percentage of class $i$ at time $b$. $A_j$ is the index of land use dynamic degree [12]. The value of land use dynamic degree are shown in Tabel 1.

| Categorie | CL | FGL | WT | URS | UL |
|-----------|----|-----|----|-----|----|
| Index     | 3  | 2   | 2  | 4   | 1  |

$\Delta L_{a-b}$ denotes the comprehensive change of land use dynamic degree from time $b$ to time $a$. $\Delta L_{a-b}$ is defined as:

$$\Delta L_{a-b} = L_a - L_b = \left( \sum_{i=1}^{n} A_i \times C_{ia} - \sum_{j=1}^{n} A_j \times C_{jb} \right) \times 100$$

(5)

where, $\Delta L_{a-b} > 0$, denotes the land use in the development stage. otherwise, denotes the land use in the adjustment or recession stage.

4. Analysis

4.1. Comprehensive feature of land cover
We use human-machine combination method to extract the land cover of Liangjiang New District during 2010-2018. Land cover change in Liangjiang New District has a definite and significant
spatiotemporal characteristic from 2010 to 2018. As Figure 2 shows, the significant differences can be summarized as follows: 1) the built-up areas expanded rapidly; 2) arable land, forest and grass decreased correspondingly.

![Figure 2. Land cover of Liangjiang New District from 2000 to 2018.](image)

| Rate of Land cover change | Period/Year          |
|---------------------------|----------------------|
|                           | 2010-2012 | 2012-2015 | 2015-2018 |
| CL                        | -11.71    | -5.56     | -1.96     |
| FGL                       | 2.88      | -2.55     | -2.11     |
| WT                        | 0.41      | -1.88     | -0.36     |
| URS                       | 12.75     | 13.15     | 5.58      |
| UL                        | -0.59     | -5.08     | -0.76     |
| Comprehensive             | 28.35     | 18.81     | 7.18      |

As shown in Table 2, the growth rate of the built-up area is decreasing year by year. The annual rate of decline in forest and grass cover is also increasing year by year. The most dramatic change of land cover occurred during 2010-2012 and then the intensity of change gradually weakened. The comprehensive index of land cover changes also decreased from 28.35 to 7.18, which indicates that the speed of urban development is slowing down slightly.

4.2. Conversion characteristics of land cover

The conversion matrix of land cover types in Liangjiang New District during the three periods (2010-2012, 2012-2015 and 2015-2018) were further analysis in Figure 3, Figure 4, Figure 5. Land cover change at these three stages showed difference.
During the period of 2010-2012, the change of land cover was mainly reduction of CL. During 2012-2015, land cover change showed a simultaneous decrease of CL and FGL. During 2015-2018, land cover change is mainly based on FGL reduction. Which indicate that, in the process of early urban construction, urban construction and development are concentrated in the vicinity of residential areas and crop land around them. With the rapid expansion of cities, built-up areas develop to more marginal areas. Districts with the most obvious change of CL and FGS were concentrated in the east and north area of Liangjiang New District from 2010 to 2018.

**Figure 3.** Land cover Transfer from 2010 to 2012.

**Figure 4.** Land cover Transfer from 2012 to 2015.
Figure 5. Land cover Transfer from 2015 to 2018.

4.3. Change of land use dynamic degree

We compared the spatial distribution of land use dynamic degree in Liangjiang New Area from 2010 to 2018, and subdivided it into block-level. The deeper the color, denote the human activities more intensity. There were significant differences in the intensity of land use dynamic degree change among different streets.

As Figure 6 show us, human activities in some areas of Liangjiang New District are intense. The relative change land use dynamic degree of Lijia Street is the biggest, followed by Yuelai Street, Fusheng Town and Longxing Town.

Figure 6. Change of Land Use Dynamic Degree from 2010 to 2018.
5. Conclusion
Land cover pattern changed dramatically in Liangjiang New Area during 2010-2018: the URS areas increased continuously, but the rate of land cover change decreased slowed down. The CL always decreased from 2010 to 2018, but the rate of CL decrease slowed down. Change in FGS showed marked fluctuations, first increase and decreased in recent years.

Change in land cover types showed marked fluctuations over the three stages: The most obvious decrease of CL were concentrated in 2010 to 2012. During 2012-2015, land cover change showed a simultaneous decrease of CL and FGL. From 2015 to 2018, the relative decrease of FGS is the biggest, followed by CL. Districts with the most obvious change of CL and FGS concentrated in the East and north of the Liangjiang New District.

There were significant differences in the intensity of land use dynamic degree change among different streets. The relative change land use dynamic degree of Lijia Street is the biggest, followed by Yuelai Street, Fusheng Town and Longxing Town.

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References
[1] Scientific Steering Committee and International Project Office of LUCC, Nunes C, Augé, J. I. Land-Use and Land-Cover Change (LUCC): Implementation Strategy [J]. Environmental Policy Collection 1999
[2] Gao Z, Liu J, Deng X 2003 Spatial features of land use/land cover change in the United States [J]. Journal of Geographical Sciences 13(1) 63-70
[3] Ding H, Wang R, Jia Ping W, et al. 2007 Quantifying Land Use Change in Zhejiang Coastal Region, China Using Multi-Temporal Landsat TM/ETM+ Images [J]. Pedosphere 17(6) 0-720
[4] Gao J, Liu Y, Chen Y 2006 Land cover changes during agrarian restructuring in Northeast China [J]. Applied Geography 26(3-4) 0-322
[5] Maimaitijiang M, Alimujiang K 2018 Spatial-temporal change of Urumqi urban land use and land cover based on grid cell approach [J]. Transactions of the Chinese Society of Agricultural Engineering 34(1) 210-216
[6] Ndidi N F 2016 Spatio-temporal analysis of land use transition and urban growth characterization in Benin metropolitan region, Nigeria [J]. Remote Sensing Applications Society & Environment 4 119-137
[7] Sapena M, Angel Ruiz L 2019 Analysis of land use/land cover spatio-temporal metrics and population dynamics for urban growth characterization[J]. Computers, environment and urban systems 73(JAN.) 27-39
[8] Yu X 2009 Dynamic evolution and driving force analysis of land use/cover change on loess plateau watershed [J]. Transactions of the Chinese Society of Agricultural Engineering 25(7) 219-225
[9] Jiyuan L, Wenhui K, Zengxiang Z, et al. 2014 Spatiotemporal characteristics, patterns, and causes of land-use changes in China since the late 1980s [J]. JOURNAL OF GEOGRAPHICAL SCIENCES 24(2) 195-210
[10] Zhang L, Yang G, Liu J 2014 The Dynamic Changes and Hot Spots of Land Use in Fushun City from 1986 to 2012 [J]. Scientia Geographica Sinica 34(2) 185-191
[11] Linna W, Shengtian Y, Xiaoyan L, et al. 2014 Response analysis of land use change to the degree of human activities in Beiluo River basin since 1976 [J]. Acta Geographica Sinica 69(1) 54-63
[12] Liu J Y 1996 The Macro Investigation and Dynamic Research of The Resource and Environment[M]. Science and technology Press 158-188