# Temporal-spatial Changes Analysis of Land Use Structure in JilinCity Based on Information Entropy

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**Abstract.** City land use is a very complex system, and its development is influenced by many factors. The city land utilization structure will directly affect the development of the city. Information theory can reflect the order and structure of land use, which provides decision support for the city land utilization structure optimization. Based on the land use data of Jilin from 2000 to 2012, this paper selects information entropy, Equilibrium degree and Advantage degree as evaluation indexes. The land use change is done spatial-temporal analysis of recent years, and exploring the main driving factors of influencing the change of structure. The results show that, the information entropy of Jilin city land use is reduced gradually in recent years, and the land use structure tend to be ordered steadily; spatial difference of information entropy is bigger, showing obvious regional characteristics, and the larger entropy mainly concentrated in the economically more developed regions. In land use change, economic and demographic factors, land use change has the maximum effect on the information entropy, and the economic and demographic factors have different degree restricts on the information entropy.

## Introduction

This paper uses the information entropy theory to study the change of land use in Jilin City, analyzes the variation of entropy, then analyzes land use information entropy variation of sub region, so as to further understand the evolution and spatial pattern of land use system in Jilin City. Finally this paper analyzes the impact factor and related degree of the land use structure information entropy in Jilin City, revealing the driving factors of affecting land use structure information entropy, which provides a theoretical basis and decision reference for promoting the sustainable use of land resources and the rapid and efficient development of regional economy.

## The General Situation of Research Area and Data Sources

Jilin city is located in the central part of Jilin province and slightly northeast, the northeast hinterland of Changbai Mountain, to the transition zone of Songliao Plain of Songhua River, across the upper and middle reaches of the Songhua River banks, three facing the water, surrounded by mountains. Forest coverage rate is high, and the forest land area accounts for 60.7% of land area. In Jilin City, there are four districts of Changyi, Chuanying, Longtan and Fengman as well as Yongji county, at the same time there are four county-level cities of Shulan, Panshi, Jiaohe and Huadian.

This paper uses the land use change data in Jilin City from 2000 to 2012, and the data is from Jilin Municipal Bureau of land and resources, and related socio-economic data is from Jilin province Statistical Yearbook from 2000 to 2012.

## Research Method

### Information Entropy

The information entropy of regional land use structure can reflect the comprehensive dynamic change and conversion degree of various land use type in this area during a certain period[1], which has a certain guiding significance to the regional land use structure adjustment [2]. Assuming that *A*

 

represents the total area of a certain region, and the region is divided into $n$ types of land use, $A_1, A_2, \cdots, A_n$ represent Each type of area respectively, and $A_1 + A_2 + ... + A_n = \sum A_i (i = 1,2,...,n)$ .Each type accounts for $P_i = A_i / A = A_i / \sum A_i$ , and $\sum P_i = 1$ . So the information entropy of land use structure can be expressed as:

$$H = -\sum_{i=1}^{N} P_i \log P_i . \quad (1)$$

Where $H$ is the information entropy of land use structure, When the area of region various land use type is the same, namely, $P_1 = P_2 = \cdots = P_n = 1/n$ , the information entropy value reaches the maximum. Entropy is high, the land use types are more, the area difference is smaller; entropy is smaller, land use types are less, the area difference is bigger. The above formula can be expressed as:

$$H = -\sum_{i=1}^{N} P_i \ln P_i . \quad (2)$$

**Equilibrium degree and Advantage degree**

Equilibrium degree can be expressed as [4]:

$$J = H / H_{\max} = -(\sum_{i=1}^{N} P_i \ln P_i) / \ln N . \quad (3)$$

Among them, $J$ is balance degree, $H_{\max}$ is the maximum information entropy, and due to $H \le H_{\max}$ , so $0 \le J \le 1$ . The bigger of $J$ value is, the more land use types are, so the equilibrium degree of land is stronger. Accordingly, Advantage degree can be expressed as:

$$I = 1 - J . \quad (4)$$

Where $I$ is advantage degree, and $0 \le I \le 1$ . It reflects one or several types of land use in the region dominating land types, which is contrast with equilibrium degree.

## Results and Analysis

### The Spatial-temporal Evolution of Land Use Structure

**The time dynamic evolution of land use structure in Jilin City.** Based on the information entropy, equilibrium degree, dominance and entropy variable rate of land use structure in Jilin city during 2000-2012, the land utilization structure has changed little, and the proportion of land use types shows a more stable situation. Among them, forest proportion increased from 60.93% in 2000 to 61.07% in 2012; the grass proportion is reduced from 2.69% to 2.58%; From 2000 to 2012, the urban and industrial land area increased by 2886.59 hectares, traffic land increased by 1367.80 hectares. And the view of information entropy has demonstrated more stable from 2000 to 2012, the average value is 0.1665, down from 1.1675 in 2000 to 1.1656 in 2012, and the overall decrease rate reached 0.16%. Compared to nationwide information entropy 1.409, it still belongs to the low state [5]. Although in recent years the industrialization and the urbanization level of Jilin city continues to increase, but woodland and farmland still occupy a dominant position in the land use, so land use of urban and transportation increased slightly and not too much influencing the city land utilization structure, so the information entropy has been in more stable level.

As shown in Table 1, the information entropy shows a trend of gradual decline, and this shows that the land use system in Jilin City is from disorderly to orderly gradually. This value is showing signs of increased slightly in 2001 and 2010, and the entropy change ratio is not big, basically fluctuating in the zero.

Table 1. The information entropy, equilibrium degree, dominance degree and entropy variability of land-use in Jilin from 2000 to 2012

| Year | Information entropy （H） | Equilibrium degree （J） | Advantage degree（I） | Information entropy change rate (Vt)（%） |
|---|---|---|---|---|
| 2000 | 1.1675 | 0.5614 | 0.4386 | - |
| 2001 | 1.1676 | 0.5615 | 0.4385 | 0.0122 |
| 2002 | 1.1676 | 0.5615 | 0.4385 | 0.0018 |
| 2003 | 1.1675 | 0.5614 | 0.4386 | -0.0124 |
| 2004 | 1.1672 | 0.5613 | 0.4387 | -0.0254 |
| 2005 | 1.1667 | 0.5611 | 0.4389 | -0.0401 |
| 2006 | 1.1662 | 0.5608 | 0.4392 | -0.0457 |
| 2007 | 1.1658 | 0.5607 | 0.4393 | -0.0297 |
| 2012 | 1.1658 | 0.5606 | 0.4394 | -0.001 |
| 2009 | 1.1657 | 0.5606 | 0.4394 | -0.0099 |
| 2010 | 1.1659 | 0.5607 | 0.4393 | 0.0137 |
| 2011 | 1.1656 | 0.5605 | 0.4395 | -0.0275 |
| 2012 | 1.1656 | 0.5605 | 0.4395 | 0.0032 |

**Spatial difference of land use structure in Jilin City.** Through the proportion statistics of and use type and the calculation of information entropy, equilibrium degree and advantage degree for cities and counties in Jilin city in 2012 (Table 2), Longtan District has the maximum information entropy (1.2679), Huadian city is the minimum (0.8537). The average information entropy of land use structure in Jilin City of 2012 is 1.1167. In the 9 districts (city, county), the information entropy of Huadian City, Jiaohe City, Shulan City and Panshi City is below the average, the remaining areas are higher than the average. So higher information entropy areas are mainly concentrated area in Jilin center city, because higher land use degree in these areas, and the economy is more developed, especially in recent years, accompanied by a decrease in area of cultivated land and garden plot, urban and transportation land increased significantly, the urbanization process further intensified, the population data has a corresponding increase, leading to the higher urban land utilization rate, so the information entropy is bigger. For the four districts of center city , with the lowest information entropy, the economy is less developed and the land use structure is more orderly, but it does not mean that the land use is reasonable. Spatial equilibrium degree is the same as information entropy distribution, and the regularity of advantage degree is contrary to the former two.

Table 2. The information entropy, equilibrium degree and advantage degree of land-use in Jilin, 2012

| Administrative regions | Information entropy （H） | Equilibrium degree（J） | Advantage degree（I） |
|---|---|---|---|
| Jilin city | 1.3011 | 0.6257 | 0.3743 |
| Changyi district | 1.2091 | 0.5815 | 0.4185 |
| Chuanying district | 1.2588 | 0.6054 | 0.3946 |
| Fengman district | 1.1772 | 0.5661 | 0.4339 |
| Longtan district | 1.2679 | 0.6097 | 0.3903 |
| Huadian city | 0.8537 | 0.4106 | 0.5894 |
| Jiaohe city | 0.9003 | 0.4330 | 0.5670 |
| Pabshi city | 1.0419 | 0.5011 | 0.4989 |
| Shulan city | 1.0376 | 0.4990 | 0.5010 |
| Yongji county | 1.1198 | 0.5385 | 0.4615 |

**Analysis on the driving factors of land use change**

**Land use types change:** When the significant level is 0.01, the correlation coefficient among cultivated land, woodland, grassland, urban ,village and industrial land, traffic land and other land and the information entropy is: 0.862, -0.939, 0.851, -0.726, -0.873 and 0.951. Among them, the coefficient of forest land, urban, industrial land and transportation land is negatively correlated to information entropy, and the coefficient of cultivated land, grassland and other land is positively correlated with information entropy. This result is different from other region and the reason lays in unique types of land use structure in Jilin city. Because cultivated land and woodland proportion in Jilin city is great, in recent years the area has declined, but it doesn't affect the dominant position in whole land use. So town and city land use increasing doesn't make information entropy increasing to a large extent, but showing a decrease trend.

**Economic factors:** This paper selects the first, the second and the third industry output and per capita GDP as a measure of economic indicators, and they were analyzed with information entropy. When the significant level is 0.01, the correlation coefficient between the first, second third industrial output, per capita GDP and information entropy are -0.809, -0.788, -0.816 and -0.802. This shows that information entropy is negative correlation to them, and the correlations between the first, third industry output value and information entropy is higher than that of the second industry.

**Demographic factors:** This paper selects the total population and the agricultural population to test the correlation with information entropy. When the significant level is 0.05, the correlation coefficient between total populations, the agricultural population and information entropy are -0.579 and 0.525.

## Summary

This paper uses information entropy theory to do time series and spatial variation analysis on land use system in Jilin City, and the conclusions and recommendations are as follows:

(1) From the view of time, land use and constitution in Jilin city have some changes from 2000 to 2012, but the proportion of each type of land use has less volatility, information entropy show went trends, changes in equilibrium degree and advantage degree are not obvious, which shows that land use structure changes little and the system tends to be order;

(2) From the view of space, land use types are in Jilin city not balanced, information entropy shows obvious spatial difference. four districts and Yongji county have higher information entropy, other regions have lower information entropy, which is mainly affected by the local economic development level and population factors, et al. So information entropy can not only reflect the orderly degree of land use structure, also reflect the level of region urbanization and industrialization;

(3) land use types change has strong correlation with information entropy among the three factors of land use types change, economic and demographic. The second degree of correlation is the economy. At the same time, the three industries output value restrict information entropy. Population factors has the smallest affecting on information entropy ,but still there exist a certain correlation.

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