Study on Land Use Structure of Hexi Corridor Based on Lorenz Curve and Gini Coefficient

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Abstract. The development of the Hexi Corridor area has been attached great importance due to the "Belt and Road" international cooperation initiative. Meanwhile, the optimization of land use structure has played a major role in the development of this area. In order to promote healthier and more efficient development of the Hexi Corridor area, this paper collects and reviews recent multidimensional data on the development of the area. In addition, by applying the Lorenz curve and Gini coefficient method, this paper also concentrates on several aspects in the development of the Hexi Corridor area: (a) quantifying the land use balance based on data from various prefecture-level Hexi cities; (b) revealing developmental experiences and efficiency; (c) exploring overall urban land use status; (d) and proposing targeting urban planning and development strategies.

1. Introduction

The Hexi Corridor is a region with cultural, economic and political elements in the western part of China, including five prefecture-level cities, namely Jiayuguan, Jinchang, Wuwei, Zhangye and Jiuquan. As a heavily industrialized city, Jiayuguan is the only prefecture-level city whose urbanization rate is above 90% within the Hexi Corridor area. However, this city is now actively seeking a structural transformation towards tertiary industrialization. Thus, both considering the situation and vision, Jiayuguan is positioned as a tourism-and-steel-industry complex. Jinchang, another Hexi city which is known as the “nickel city”, has been long paid attention to its rich mineral resources sorely. Yet, as near exhaustion of nickel reserves, Jinchang is also aiming to promote and develop tourism. Wuwei and Zhangye are other two prefectural cities that mainly rely on agriculture within the Hexi Corridor area. Since 2000, Wuwei has gradually moved its economy into the tertiary sector on the strength of abundant historical and cultural resources. At present, Wuwei is positioned as a famous national historical and cultural city, as well as an important node of the Silk Road Economic Belt. As for Zhangye, it has also successfully attracted a large number of tourists globally by virtue of the geologic wonders, especially by the “Danxia” landform. The last prefecture-level city investigated in this paper is Jiuquan. It is another important manufacturing-reigned locale in the Hexi Corridor area, being responsible for the production of energy and manufacturing of industrial equipment. Jiuquan is also noteworthy for one of its subordinate cities – Dunhuang – which is a most prominent international cultural resort. In recent years from 2010 to 2017, with the rapid development of the entire Hexi Corridor area, GDP (see Table...
1) and PCI (see Table 2) of all the above cities had remained actively growth. It can be seen that Wuwei’s GDP had increased the most by 88% from 2010 to 2017; while Jinchang increased the smallest by 5% in these five years. Similarly, Wuwei’s PCI had also increased the most by 108% and Jinchang’s CPI the smallest by 70% [1].

Table 1. GDP of Cities in the Hexi Corridor area in the year 2010 and 2017. (Unit: 10,000 yuan)

| Year | Jiayuguan | Jinchang | Wuwei | Zhangye | Jiuquan |
|------|-----------|----------|--------|---------|---------|
| 2010 | 1,843,192 | 2,105,134 | 2,287,676 | 2,127,010 | 4,050,348 |
| 2017 | 2,098,721 | 2,214,939 | 4,304,359 | 3,769,624 | 5,517,725 |

Table 2. PCI of Urban Residents in Hexi Corridor in the year 2010 and 2017. (Unit: yuan)

| Year | Jiayuguan | Jinchang | Wuwei | Zhangye | Jiuquan |
|------|-----------|----------|--------|---------|---------|
| 2010 | 18,791    | 20,396   | 12,267 | 11,817  | 16,348  |
| 2017 | 36,491    | 34,672   | 25,572 | 23,309  | 32,478  |

In the Hexi Corridor, primary, secondary and tertiary sectors are solely concerned with agriculture, industry, and services respectively. According to published data [2], portions of the three-sector at different main cities within the Hexi Corridor area are as followed (See Table 3):

Table 3. The Three Industrial Structures in Hexi Corridor Cities.

| City   | Primary Sector (%) | Secondary Sector (%) | Tertiary Sector (%) |
|--------|--------------------|----------------------|--------------------|
| Jiayuguan | 2.2                | 51.8                 | 46.0              |
| Jinchang  | 9.2                | 50.3                 | 40.5              |
| Wuwei   | 25.7               | 29.1                 | 45.2              |
| Zhangye  | 25.0               | 24.1                 | 50.9              |
| Jiuquan  | 15.6               | 32.8                 | 51.6              |

2. Lorenz Curve of Land Use Structure in the Hexi Corridor

In 1905, the American economist Lorentz proposed a curve based on frequency cumulant to reflect the distribution discretization of various indexes. This curve is called the "Lorentz curve" [3]. The Lorentz curve was first applied in the economic field, which can intuitively and accurately reflect the inequality of income and wealth. Subsequently, it is also utilized to evaluate the spatial distribution characteristics of land use structure. In this paper, all types of land use data of Hexi cities are collected [4], and the location entropy of urban land use in each city can be calculated by the following formula (1).

\[ Q_j = \frac{q_j / q_j}{q_i / q} \]  

(1)

Where \( Q_j \) refers to the location entropy of i type of land from j City; \( q_j \) is the area of i type of construction land from j City; \( q_i \) is the total area of j City's construction land; \( q_i \) refers to the sum of i type of land from all prefecture-level cities in Hexi Corridor area; \( q_i \) refers to the sum of all urban construction land in Hexi Corridor area. Subsequently, the location entropy of each urban land can be sorted sequentially from small to large. Next, the accumulated percentage of each construction land type in each prefecture-level city can be calculated. Additionally, the accumulated percentage of all construction land types in each prefecture-level city can be calculated as well. Eventually, according to those above-mentioned percentages, the Lorentz curve of various urban lands of the Hexi Corridor cities can be drawn as below. (See Fig 1-Fig. 5; the typical years 2007, 2011, 2013, 2015 and 2017).
3. Calculation of Gini Coefficient and Evaluation of Land Use Structure

The Gini coefficient is hereby to further quantify the land use structure on the basis of the Lorentz curve, which refers to the ratio of the area formed by each index accumulation curve and the absolute average line to the area above the absolute average line [5]. The smaller the value is, the more reasonable the distribution of the land use structure will be. The formula (2) is as follows:

Figure 1. Lorentz Curve of Urban Land Use, 2007.

Figure 2. Lorentz Curve of Urban Land Use, 2011.

Figure 3. Lorentz Curve of Urban Land Use, 2013.

Figure 4. Lorentz Curve of Urban Land Use, 2015.

Figure 5. Lorentz Curve of Urban Land Use, 2017.
\[ G_{nl} = 1 - \sum (X_l - X_{l-1}) \times (Y_l + Y_{l-1}) \]  

(2)

Where, \( G_{nl} \) represents the Gini coefficient of type \( l \) land in year \( n \); \( X_l, X_{l-1}, Y_l, Y_{l-1} \) respectively represent the coordinate values of the construction land cumulative percentage of type \( l \) land curve and the cumulative percentage of various types of land. The values of the Gini coefficient of typical years are respectively calculated (See Table 4 and Table 5). The land classification standards before and after 2012 are not consistent, so the statistics are respectively carried out. In general, the Gini coefficient under 0.2 represents the absolute average; the Gini coefficient from 0.2 to 0.3 represents very average; the Gini coefficient from 0.3 to 0.4 represents relatively reasonable; the Gini coefficient from 0.4 to 0.5 means a large difference in distribution; the Gini coefficient above 0.6 represents a gap in distribution [6].

Table 4. Gini Coefficient of Urban Land Use Types in the Hexi Corridor, the years 2007 and 2011.

| year | Residential Area | Area for Public Facilities | Area for Industrial Operation | Area for Storage | Area for Traffic System | Area for Roads and Plazas | Area for Municipal Utilities | Greenland Area |
|------|------------------|---------------------------|-------------------------------|-----------------|------------------------|---------------------------|----------------------------|----------------|
| 2007 | 0.200            | 0.113                     | 0.225                         | 0.286           | 0.342                  | 0.322                     | 0.364                     | 0.257          |
| 2011 | 0.141            | 0.127                     | 0.276                         | 0.112           | 0.321                  | 0.252                     | 0.299                     | 0.276          |

Table 5. Gini Coefficient of Urban Land Use Types in the Hexi Corridor, the years 2013, 2015 and 2017.

| year | Residential Administration and Public Services | Commercial and Business Facilities | Industrial, Manufacturing | Logistics and Warehouse | Road, Street and Transportation | Municipal Utilities | Green Space and Square |
|------|-----------------------------------------------|----------------------------------|--------------------------|-------------------------|-------------------------------|---------------------|------------------------|
| 2013 | 0.261                                         | 0.234                            | 0.215                    | 0.431                   | 0.211                         | 0.266               | 0.433                  | 0.314          |
| 2015 | 0.262                                         | 0.100                            | 0.187                    | 0.472                   | 0.213                         | 0.167               | 0.419                  | 0.300          |
| 2017 | 0.285                                         | 0.184                            | 0.195                    | 0.415                   | 0.229                         | 0.133               | 0.506                  | 0.302          |

In the period from 2007 to 2011, all types of land-based Gini coefficients were under 0.4, and the distribution of all land types were relatively reasonable. Among them, the Gini coefficients of the public facility land, industrial land, and green space were growing, and the balance of land use distribution was slightly decreased; all the Gini coefficients in the rest land types land were decreased, and the rationality of land use generally rised.

From 2013 to 2017, the Gini coefficients of residential land, logistics storage land, and public facility land had increased slightly while the Gini coefficient of other land use had decreased, among which the Gini coefficients of both industrial land and public utility land were above 2013. In 2017, the Gini coefficient of public facility land broke through 0.5, and the differentiation was more serious. The leading industries in the Hexi Corridor area were different, which led to the great differentiation of industrial land. With the industrial transformation, logistics warehousing land was undergoing a simultaneous but not synchronous transformation, which increased the differentiation of this type of land. The distribution of public utility land was quite different that Zhangye had the largest proportion of land use in this category, which accounted for 10.6% in the whole construction land in 2017; Jiayuguan had the lowest proportion of land use in this category, which accounted for only 0.6% in the whole construction land. In addition, the Gini coefficients of all other types of land had decreased from 2013 to 2017. In contrast to the period from 2007 to 2011, the overall distribution of land use increased from 2013 to 2017. However, the overall evolution trend had developed in a more rational direction.

4. Conclusion and Urban Planning Strategy

At first, the rationalization of the land use structure can be promoted. According to the calculation of the Gini Coefficients for various land use, it can be found that although the land use structure was developing towards a more reasonable direction, the Gini Coefficients of land use in various cities of Hexi Corridor area from 2013 to 2017 was generally higher than that from 2007 to 2011; and the
differentiation of land distribution increased. Therefore, for cities with more balanced distributions of land use structure, such as Wuwei and Jiuquan, correct guidance is needed to further enhance the intensification of the residential land, to improve the level of public service facilities, and to promote sustainable development.

Next, the differentiation of cities’ urban land use should be respected. Each city's dominant industries and nature varied and had its own characteristics. Moreover, each city's basic conditions were different. Accordingly, each city's land use distribution was different, too. For instance, Jinchang and Jiayuguan were both transformed from former industrial cities, whose industrial land definitely accounted for the most; Wuwei and Zhangye were mainly dominated by agriculture before so their agricultural land took up the most. In these cases, the land use promotion should be based on the cities’ original land structure and then gradually adjust to actual situation of each stage. There is no the “once for all” system for all cities. In addition, for cities with special conditions, the corresponding land use indicators and standard systems should be relaxed.

Finally, the scientific industrial transformation should be sped up. For instance, the industrial structure of Wuwei and Jiuquan presented the pattern of "the tertiary industry> the secondary industry> the primary industry". And from 2010 to 2017, GDP and PCI of Wuwei and Jiuquan had both obviously increased with the most reasonable land use structure. In this way, accelerating scientific industrial transformation can not only promote economic development but also improve the rationality of land use. Hence, it is necessary to make a positive transition according to the existing industrial structure, and to turn the secondary-industry-leading development into the tertiary-industry-leading one. Also, new sectoral balance should be brought to ensure the development of the primary and secondary industries.

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