

Optimization of Land Use Structure in Resource-Based Cities Transformation: A case study in Daqing, China

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Abstract. The process of resource-based city transformation requires some proper adjustment of land use structure, so land use optimization and resource-based city transformation are complement each other to a certain extent. Taking Daqing city in China as the study objects, Pearson correlation analysis and land location theory was used in this paper to analyze the quantity and spatial layout of land use for optimizing the land use structure. Results: (1) In terms of quantity, the proportion of output value of primary industry and total power of agricultural machinery are positively correlated with the quantity of agricultural land; Urban population and social fixed investment play a leading role in construction land; Urban population and output value of tertiary industry have negative impact on ecological land, while Animal husbandry output value and forestry output value have positive impact. (2) In terms of spatial distribution, the distance to river and railway had positive influence on cultivated land distribution. (3) Population density, per capita GDP and other factors are negatively correlated to the distribution of cultivated land; Population density has a positive correlation with the distribution of construction land, but a negative correlation with the distance to the county center; The distribution of ecological land is positively correlated with the distance of oil field line, distance from highway, altitude and slope.

Keywords: resource-based city, Daqing city, land use

1. Introduction

The report of the 18th National Congress of the Communist Party of China, proposed that "ecological civilization should be vigorously promoted, the concept of green, circular and low-carbon development should be strive to promoted, and the spatial pattern, industrial structure, mode of production and way of life should be formed to save resources and protect the environment". And in the report of the 19th National Congress, it was put forward the idea of harmonious coexistence between man and nature, emphasizing that we must establish and practice the concept that clear water and lush mountains were invaluable assets, we must protect the natural environment and provide people with higher quality ecological products while the economy and society develop actively and stably. In order to coordinate the contradiction between economic development and land resources, improve the utilization rate of urban land and promote the sustainable development of ecological environment in the future, it was necessary to conduct research on the optimization of land use structure.

Both scholars at home and abroad had paid much attention to the optimization of land structure in resource-based cities. As early as 1921, foreign scholars had put forward the concept of resource city and then Canadian economists had analyzed the development track of resource exploitation by single industry mode in cities in 1930 , which were paving the way for resource economies and resource cities[1]. Some scholars have explained the relationship between economic development and land through the brief model framework from the perspective of combining theoretical research with practical facts, and believed that preventing the indiscriminate occupation of land and curbing serious environmental pollution were of great importance to economic development [2].

The research in China began in the 1980s, many scholars believed that the main limiting factor for resource-based cities was the monotony of economic structure, and the upgrading of industrial structure was the most important issue in the transformation of resource-based cities. The choice of industrial transformation model project and alternative industries became the focus of research. And three models for

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the industrial transformation model of resource-based cities, namely, the industrial extension model, the renewal model and the composite model were proposed [3]. In August 2005, General Secretary Xi Jinping put forward the important idea of "gold and silver mountains, as well as clear water and green mountains" during his investigation in Yucun. Based on this background, domestic researchers had begun to chose different objectives for land use structure optimization research from past, tend to comprehensively consider ecological-economic benefits. For example, Wang Guanyong, Zhang [4], Li Tianchai and Li Wei all constructed ecologically economic benefit objective function to study the optimization of land use structure in different regions [5]. The structure of land use is the basis of various production development and urban construction in a city. This paper takes Daqing city, a typical resource-based city, as the research object, studying its land use structure, not only conducive to the efficient utilization and rational management of Daqing's land resources, but also providing a reference direction for the structure of Daqing's industrial transformation and sustainable development in the future.

2. Overview of the Study Area, Data Sources and Resources Methods

2.1. Overview of study area

Daqing City is located in the western part of Heilongjiang Province, close to Suihua City in Heilongjiang Province to the east, and separated from the Songhua River in Jilin Province to the south, and Qiqihar City is connected to the northwest. As a typical resource-based city, Daqing oilfield exploration includes the whole Heilongjiang Province and Inner Mongolia, with a total area of 72000 square kilometers. According to scientific predictions, the oil reserves in this area are between 8-10 billion tons. Since its development and construction in 1960, Daqing Oilfield has accounted for half of the country's total land oil output during the same period. It has achieved a stable oil output of more than 50 million tons for 27 consecutive years, and a stable oil output of more than 40 million tons for 12 consecutive years. The cumulative production of crude oil has exceeded 2.1 billion tons and been called "The Miracle of World Oil Development"[6].

2.2. Data sources

Pearson correlation analysis data in this paper comes from the statistical yearbooks of 2005, 2012, 2015 and 2018. And the theoretical data of land location comes from the social economic data obtained by the Bureau of Land and Resources of Daqing City and the Bureau of Statistics of Daqing City, at the same time combined with the selection of location factors in the relevant literature.

2.3. Research methods

In this paper, the following two methods were used to analyze the factors that affect the amount of land and the spatial layout in the process of land use structure transformation: 1) Pearson correlation analysis method was used to identify the factors affecting the amount of land use, and then the stepwise regression analysis was carried out to study the possibility of multiple factors working together. 2) The impact of land use structure transformation on spatial layout was analyzed by the location theory.

1) The research types in this paper are agricultural land, construction land and ecological land, and the method of studying these land use quantity is Pearson correlation analysis. Firstly, selected the influencing factors and marked these as shown in Table 1. Social and economic factors are the main influencing factors, because natural factors will not change significantly in a certain period of time, and the changes of social and economic factors play a major role.

Table 1: List of impact factors

Impact Factors			
X ₁ Total population	X ₂ Urban population	X ₃ Social fixed investment	X ₄ Total power of agricultural machinery

Impact Factors			
X ₅ Proportion of output value of primary industry	X ₆ Grain yield per unit	X ₇ GDP total	X ₈ Output value of agriculture
X ₉ Proportion of output value of secondary industry	X ₁₀ Output value of animal husbandry	X ₁₁ Total grain output	X ₁₂ Proportion of tertiary industry output value
X ₁₃ Output value of Forestry	X ₁₄ Rural population	X ₁₅ Fertilizer application rate	

Pearson correlation coefficient analysis is usually used to analyze the relationship between the two variables X and Y. And the product difference correlation formula should also meet some conditions: (1) Variables X and Y are continuous; (2) The variables are basically close to the normal distribution; (3) The value of each pair of data does not affect the values of other pairs of data, and they are independent of each other. Only when the above requirements are met, can the results presented be reliable, and the value of correlation coefficient r should be within the range of $-1 \leq r \leq 1$. The closer the absolute value is to 1, the greater the degree of correlation between the two. When r is positive, the relationship between the two is positive. On the contrary, if r is negative, then it is negative. Perform Pearson correlation analysis on the selected land use types and the 15 social economic factors in Table 1 extracted from the analysis factors of other scholars. Take the impact factor as the variable X and the three main types of land use as the variable Y, then conduct a stepwise regression analysis to quantitatively analyze the impact of each influencing factor on the change in the quantity of land use. After the Pearson correlation analysis, select the factors with a significance level below 0.05, as the independent variables of the subsequent stepwise regression model. Because the quantitative changes of the three types of land use do not only involve a single factor, the analysis of the driving mechanism is also. So, it is necessary to combine the possibility of other driving factors to work together, and then perform stepwise regression analysis on the factors that have passed the significance test.

2) The center of land location theory includes two points, the first is the choice of land use spatial layout to discuss through the land location theory, the second is the land location layout and whether it can maximize the benefits of land use. It means that the land location theory should rationally allocate the resources of land to achieve the optimal effect. The research focus of land location theory is mainly on the natural characteristics of the land and the external economic benefits that the land can produce. Urban land has the advantages of fixed location, scarcity and high value in the spatial and geographic layout. Land location theory is used to guide the rational layout of urban land. At the same time, it can also make scientific and accurate assessments of the value and expected benefits of each land, so as to set the optimal and most efficient urban land layout, so that the comprehensive benefits of urban land have been brought into full play.

Table 2: Location factors enumeration

Location Factors			
X ₁ The population density	X ₂ GDP per capita	X ₃ Distance from the oil field	X ₄ Distance from county road
X ₅ Distance to railway	X ₆ Distance from county-level city center	X ₇ Distance from provincial highway	X ₈ Distance to the river
X ₉ Distance to highway	X ₁₀ Distance to tourist attractions	X ₁₁ Slope	X ₁₂ Altitude
X ₁₃ Distance from municipal city center			

As shown in Table 2, combined with the location factors of other scholars, 13 location factors were finally selected and marked. The following formulas can be used to calculate the probability of different types of land under the influence of different location factors. The greater the p value obtained, the greater the probability of change. Calculation formula:

$$P = \frac{\exp(\alpha + \beta_{1x1} + \beta_{2x2} + \dots + \beta_{n \times n})}{1 + \exp(\alpha + \beta_{1x1} + \beta_{2x2} + \dots + \beta_{n \times n})}$$

After transformation:

$$\ln \left[\frac{P_i}{1 - P_i} \right] = \alpha + \sum_{k=1}^k \beta_k X_{ki} \quad (1)$$

P_i is the probability of occurrence of a certain type of i in each cell after after given value of independent variable, α is a constant term, and β is the slope which is the regression coefficient.

3. Results and analysis

3.1. Analysis on influencing factors of land use quantity

3.1.1 Analysis on influencing factors of cultivated land quantity

As shown in Table 3, combined with the analysis of the significance of the cultivated land that the influencing factors with significance less than 0.05 have a significant correlation with the number of cultivated land, and combined with the correlation close to 1, the effect is the most obvious. Then it can be concluded that: the main influencing factors that show the positive correlation with the amount of agricultural land mainly include the proportion of the output value of the primary industry, the total power of agricultural machinery, and the rural population. From 2005 to 2018, the amount of agricultural land had been steadily increasing. The overall proportion of the output value of the primary industry had also showed a rising trend, and agricultural land had a decreasing trend, but it had basically remained stable, indicating that with the development of agriculture and animal husbandry, the economic scale of the primary industry had been relatively expanded. The influencing factors showing a negative correlation with the amount of arable land mainly included the urban population and the output value of the tertiary industry. With the progress of urbanization, the urban population had increased year by year, which had led to a decline in the proportion of rural population in the total population. In addition, the increase in the output value of the tertiary industry had led to adjustments in the economic structure, both of which have a negative impact on the supply of agricultural land. The actual changes in cultivated land indicated that the amount of cultivated land in the city had been showing a fluctuating and increasing trend, and basically returning farmland to forests and grasses to improve the ecological environment. The influence of the above-mentioned factors and the interaction between the farmland protection policies basically determined the change in the amount of farmland in the city during this period.

3.1.2 Analysis on influencing factors of construction land quantity

As can be seen from Table 3, combined with significance lower than 0.05 and correlation close to 1, it can be found that the influential factors that play a leading role in the change of the amount of construction land in Daqing during this period include urban population and social fixed investment. The urban population of Daqing City increased during this period, while the urbanization process accelerated and the level improved and the increase in urban construction land, the average income of the urban population also increased year by year. During this time, the main new construction land in the city was basically urban construction land. The main part of the increase in social fixed investment was used for infrastructure construction and the construction of new production capacity in secondary and tertiary industries, which lead to the increase of land for infrastructure construction, such as transportation, urban and industrial land. In the past few years, Daqing City had accelerated its urban process and completed urban construction. Daqing City strictly followed the principles of controlling total volume, limiting increments, and revitalizing stocks, and rationally arranges for the addition of various types of construction land. The proportion of primary industry output value was negatively correlated with forestry and animal husbandry to construction land, indicating that this was a deterrent factor. The above is the mutual influence among urbanization, social

fixed investment and the economic benefits of large agriculture, which determined the change in the amount of construction land in the city during this period.

3.1.3 Analysis on influencing factors of ecological land quantity

As shown in Table 3, combined with the condition that the significance is lower than 0.05 and the correlation is close to 1, it can be seen that the two influencing factors of the output value of the tertiary industry and the output value of animal husbandry had a positive correlation with the amount of ecological land. The two influencing factors of grain yield and urban population were the main negative driving forces for the amount of ecological land during this period, which showed that they were the main negative driving forces for the change of ecological land. The impact of the two influencing factors of grain yield and urban population on the amount of ecological land was a quantitative manifestation of the implementation results, indicating that the transfer of high-quality arable land to forest land had been stopped, and the project of returning farmland to forest and grassland had basically ended. The increase in urban population led to an increase in urban construction land, and the expansion of urban construction land easily led to a situation where it was supplemented by the occupation of ecological land. In summary, the above-mentioned driving forces determined the changes in the amount of ecological land in Daqing during this period.

Table 3: Pearson related analysis data result

Impact factor	parameter	cultivated land	Construction land	Ecological land
Total population	Pearson correlation	0.654	0.516	0.376
	Significance	0.000	0.000	0.000
Urban population	Pearson correlation	-0.321	0.597	-0.340
	Significance	0.003	0.000	0.001
Social fixed investment	Pearson correlation	-0.199	0.528	0.118
	Significance	0.056	0.000	0.265
Total power of agricultural machinery	Pearson correlation	0.889	0.406	-0.016
	Significance	0.000	0.000	0.883
Proportion of output value of primary industry	Pearson correlation	0.926	0.225	0.362
	Significance	0.000	0.044	0.000
Grain yield per unit	Pearson correlation	0.368	0.061	-0.478
	Significance	0.079	0.563	0.024
GDP total	Pearson correlation	0.588	0.424	0.180
	Significance	0.000	0.000	0.078
Output value of agriculture	Pearson correlation	0.751	0.426	0.098
	Significance	0.000	0.000	0.059
The proportion of secondary industry output value	Pearson correlation	0.452	0.664	0.248
	Significance	0.000	0.376	0.000
Output value of animal husbandry	Pearson correlation	0.659	-0.279	0.858
	Significance	0.000	0.004	0.003
Total grain output	Pearson correlation	0.168	0.061	0.024

	Significance	0.077	0.568	0.824
Proportion of tertiary industry output value	Pearson correlation	-0.880	0.175	0.573
	Significance	0.000	0.052	0.000
Output value of Forestry	Pearson correlation	0.316	-0.195	0.628
	Significance	0.003	0.064	0.000
Rural population	Pearson correlation	0.879	0.295	0.556
	Significance	0.000	0.108	0.000
Fertilizer application rate	Pearson correlation	0.544	0.226	0.000
	Significance	0.000	0.027	1.000

3.2 Analysis on influencing factors of use spatial layout

3.2.1 Analysis on influencing factors of spatial layout of cultivated land

According to the formula combined with the analysis of location factors selected in Table 2, the probability of changes in land types can be obtained. It can be concluded that there are 7 factors that positively affect the location distribution of cultivated areas include the distance from the river, the distance from the railway, the distance from the county road, the distance from the city center, and the distance from the oil field and so on. When the above factors increase, the probability of cultivated land distribution also increases, which means that as you move away from the above location factors, the probability of cultivated land distribution increases. On a city scale, it is true that the distance from the oil field is inversely proportional to the probability of cultivated land distribution. The closer the oil field is, the less arable land is distributed, while the more arable land is in the area far away from the oil field. The population density, GDP per capita, distance from expressways, altitude, slope and other factors have a negative correlation with the distribution of cultivated land. This means that altitude and slope have a limiting effect on the distribution of cultivated land, as the altitude and slope increase, the possibility of cultivated land decreases. Therefore, cultivated land is more suitable for distribution in areas with suitable altitude and slope. At the same time, the probability of the distribution of cultivated land will decrease with the increase of population density and per capita GDP. This is how the four counties in the Xiawu districts and four counties of Daqing City are distributed. Among them, each location factor has a different degree of contribution to the distribution of cultivated land in Daqing City. The main factors that have a greater influence on the probability of cultivated land distribution are the distance from the county-level city center, the distance from the municipal city center, the altitude, and the slope.

3.2.2 Analysis on the influencing factors of the spatial layout of construction land

The factor of population density is positively correlated with the location distribution of construction land, which indicates that the greater the population density, the higher the probability that construction land will be distributed nearby. This is in line with the actual distribution of construction land at the district/county scale during this period. The distribution of built-up land has a negative correlation with the distance from the county-level city center, the distance from the oil field, the altitude, and the distance from the city-level city center. The closer to the city and county center, the higher the probability of construction land distribution. It can be concluded that the expansion of internal construction land and existing towns still occupied a major position during this period. But as a resource-based city, Daqing is a city built along with oilfield exploitation, and the distribution of construction land has a positive correlation with the distance of oilfields. However, in recent years, Daqing City has begun to concentrate on planning residential areas and carry out relocation work in remote areas. At the same time, the factor of altitude should also be considered within the influence of the distribution, the higher the altitude, the lower the probability of construction land distribution.

3.2.3 Analysis on the influencing factors of the spatial layout of ecological land

Among the selected location factors, there are seven factors that have a negative impact on the distribution of ecological land, including population density, distance from county roads, distance from rivers, and tourist population by counties and so on. The distribution of ecological land is positively correlated with the distance from the oil field line, the distance from the county-level urban center, the distance from the expressway, altitude and slope. Daqing City has a semi-arid grassland ecological zone and four ecological functional zones, namely the western wind-proof and sand-fixing zone, the central grassland and its biodiversity conservation zone, the northern wetland and farmland protection zone, and the southern farmland zone. The forest land in Daqing City tends to be distributed in areas with higher altitudes and steep slopes, and is far from the center of county-level towns, and the ecological land is more likely to occur in areas far away from expressways.

4. Conclusion and recommendation

4.1. Conclusion

Based on the above research, the conclusions are as follows:

1) According to the results obtained by Pearson analysis, it can be known that the proportion of the output value of the primary industry, the total power of agricultural machinery and the rural population have a positive correlation with the amount of agricultural land. And it can be known from the results of the location factor analysis method that the distance to the river, the distance to the railway, the distance to the county road, the distance to the provincial road and other factors that have a positive impact on the distribution of cultivated land; and the population density, per capita GDP, distance to the highway, etc. Factors such as those have a negative correlation with the distribution of cultivated land.

2) From the analysis of quantitative influencing factors, it can be known that the positive driving force for leadership is mainly urban population, social fixed investment and secondary output value. And the analysis of location influencing factors shows that population density factors have a positive correlation with the distribution of construction land, while it has a negative correlation with factors such as the distance from the county-level city center and the distance from the city-level city center.

3) From the previous analysis, we can know that the influencing factors that have a negative impact on ecological land are urban population, grain output and the output value of the tertiary industry, while the influencing factors showing positive effects are the output value of animal husbandry, forestry and rural population. The distribution probability of ecological land is affected by location factors. And location factors such as distance from oil field line, distance from county-level city center, distance from expressway, altitude and slope have a positive impact on ecological land.

4.2. Recommendation

Based on the analysis of the optimization of land use structure in Daqing under the transformation of resource-based cities, this paper puts forward four suggestions: adhering to the cultivated land protection system, control the scale of land use, coordinating land use and ecological construction, and increasing the utilization rate of land reclamation.

1) Strictly adhere to the cultivated land protection system. From the above conclusion analysis, it can be seen that Daqing must ensure the position of the output value of the primary industry in the economic proportion, strengthen the improvement of agricultural mechanization, strictly implement the protection policy for the basic farmland, maintain the balance of the total amount of cultivated land, reasonably arrange the adjustment of the internal agricultural land use structure, according to the principle of balance between occupation and compensation of cultivated land, establish a perfect cultivated land compensation system, reasonably develop and protect every inch of land [7].

Daqing City should not only use the strictest cultivated land protection system to effectively protect the land, but also all departments must implement the basic national policy of conscientiously protecting cultivated land as the main direction of development. Regarding construction land, it is necessary to strictly control the occupation of non-agricultural land, conduct adequate inspections during construction land approval, so as to prevent excessive occupation of cultivated land. With regard to returning farmland to

forests and afforestation, it is necessary to strengthen the guidance and management of agricultural land restructuring and occupation of cultivated land, except for including it in the national afforestation and reforestation plan, no more tasks should be arranged. For the construction of basic farmland, it is necessary to vigorously carry out land improvement work, mainly in the comprehensive management of fields ways, water ways, and forest villages, increase effective farmland occupation, and improve agricultural production and ecology.

2) Strictly control the scale of land use. If Daqing City wants to solve the extensive land use structure, it is necessary to further optimize the layout of urban and rural land in accordance with the requirements of overall urban and rural development, and combined the influencing factors of the amount and location of its own construction land. For the contradiction between newly added construction land and cultivated land, the following steps can be specifically taken: the first is to fully improve the land market mechanism, strengthen planning control and planning management, and plan the total, incremental, and stock of construction land by means; Secondly, strengthen the management of land use standards, make the land use quota more complete, and strictly manage the selection of sites for construction projects; Third, compared with the countryside, strengthen and standardize the conservation of rural collective construction land, do a good job in the consolidation of rural residential areas and the merger of villages, and actively support the construction of new rural areas [8]; Among the factors affecting the spatial layout, population density is positively related to the distribution of construction land. Therefore, the construction of new countryside and planning of rural residential areas with the use of agricultural land can make agricultural land contiguous and increase population density, thereby transforming rural residential areas into townships and controlling the scale of urban and rural land use.

3) Coordinating land use and ecological construction. According to the above analysis, most of the forest land in Daqing is located in the areas with high elevation and steep slope, it is far away from the center of county-level cities and towns, and the ecological land is more likely to located in areas far away from expressways. The growth of forestry and animal husbandry and the increase in the output value of the tertiary industry can promote the increase in the number of ecological land, thereby promoting the development of tourism and ecological undertakings. In accordance with the basic requirements of constructing ecological civilization, economical and intensive and environment-friendly society, Daqing city should strengthen and promote the protection and regulation of land ecology while protecting the basic ecological land, and improve and innovate the pattern of land use. First is to establish different land use pattern according to different types, ecological agriculture should develop agriculture, establishing production base of green food, pastoral areas should increase the artificial, improve grassland areas, and develop the animal husbandry, and wind erosion region should establish a shelter forest which is given priority to prevention and control system, prevent sand, coordinate both land use and the development of the ecological environment. Secondly, Daqing City should vigorously promote the construction of farmland shelterbelts, and delineate ecological safety zones and nature reserves, expand forest coverage, so comprehensively improve the ecological environment. Finally, attention should also be paid to controlling the discharge of industrial "three wastes", preventing the pollution of land, water and air by "three wastes" such as petrochemical enterprise [9].

4) Fourth, increase the utilization rate of land reclamation. In 2005, there were 8,850 hectares of abandoned industrial and mining land in Daqing Oilfield. The distribution of abandoned land is very scattered, remote and large in size and these characteristics have made land reclamation work difficult. Land reclamation is a very necessary task in resource-based cities, it can improve the efficiency of land use in particular, reclamation of abandoned land after oilfield development [10]. Therefore, the reclamation of the abandoned land after the oilfield development in Daqing is the only way for Daqing as a resource-based city to become a new sustainable development city. In order to solve the problem of oilfield land, the land reclamation project in Daqing City should focus on the treatment of waste oil extraction land, and restore to agricultural land and construction land through land reclamation. At the same time, it can also be handled by the local government and Daqing Oilfield Company in collaboration, and the enterprises cooperate to optimize the reclamation of abandoned oilfield land, which is of great significance to the optimization of the land use structure of Daqing City.

5. Summary

The relationship between industrial structure optimization and land use structure optimization is the foundation and prerequisite. Therefore, it is concluded that the transformation of resource-based cities is closely related and interactive with land use structure. Through the analysis of the influencing factors of land use in terms of quantity and location, and finally put forward suggestions to solve the existing problems based on the analysis results. Through research, it is found that optimizing the land use structure of Daqing City can alleviate the problem of supply and demand misalignment caused by the adjustment of industrial structure and land use structure during the transformation process. At the same time, it is also necessary to further optimize the structure of land use based on the transformation goals of economic, ecological and social comprehensive development, to give full play to the comprehensive benefits of the land. This paper aims to find and solve the problems through the study of Daqing city, and to provide reference for solving the optimization of land use structure under the transformation of resource-based cities.

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