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To cite this article: Xiaowei Wang 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **569** 032083

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Spatial Differentiation of Land Reclamation in Shandong Province since the 21st Century

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Abstract. Cultivated land refers to the land on which crops are grown, which are the basic resources and conditions for human survival. This paper uses the data of Shandong Statistical Yearbook (2001-2018) to study the spatial and temporal distribution pattern of cultivated land resources in Shandong Province by using GIS technology. The results show that the area of cultivated land between 2000 and 2016 is generally increasing, which is divided into attenuation and recovery. After adjusting the three stages, the cultivated land area has a downward trend after 2012, which is worthy of attention. From the perspective of the characteristics of the cultivated land resources, the cultivated land resources of the province are characterized by the lack of more than the east and the east, and the growth of the land reclamation rate is expanding to the east. From the perspective of the overall distribution of cultivated land resources, the average annual growth rate of cultivated land area in Shandong Province during the period from 2000 to 2016 was 0.89%, the average annual growth rate in Luzhongnan area was slightly faster at 1.07%, and the highest rate of land reclamation in northwestern Shandong was 60.96%, the most extensive cultivated area is Linyi City, the largest land reclamation rate is Liaocheng, the land reclamation rate is 67.50%, and about 2/3 of the land is cultivated land.

1. Introduction

Cultivated land resources are the necessary resources and basic conditions for human survival. According to the Classification of Land Use Status (GB/T21010-2007): Cultivated land refers to the land on which crops are grown, including mature land, newly developed, reclaimed, reorganized land, recreational land (including rotation, rotation); (including vegetables), with scattered spruce trees, mulberry trees or other trees; on average, it can guarantee the harvest of the beaches and tidal flats in one season. With the increasing population in the 21st century, the continuous reduction of cultivated land, and the gradual improvement of people's living standards, ensuring the quantity and quality of cultivated land is the primary task of sustainable agricultural development. Land use and land cover change are important topics in global environmental change research[1,2].

The number of cultivated land resources in China is insufficient, the reserve resources are lacking, and the improvement and development are difficult. The situation of farmland resources protection is very severe, and the trend of reducing cultivated land resources has not yet been resolved. With the increase of population and economic development, the trend of occupation of cultivated land resources is increasing[3,4]. Shandong Province is located in the eastern part of China and the lower reaches of the Yellow River. The area of cultivated land is reduced, and the contradiction between people and land is prominent[5,6]. In fact, the relationship between man and land in the Shandong region has begun to deteriorate as early as the historical period; In the early Qing Dynasty, in order to restore and



develop the social economy and consolidate the rule, the Qing government adopted various measures to encourage the people to open up wasteland. The Yilan area in the Qing Dynasty in Shandong Province has basically been completed; Under the pressure of rapid population growth, mountainous areas, hills and river beaches have also been extensively developed, the ecological environment has been severely damaged, and human-land relations have deteriorated[7]. The contradiction between cultivated land resources and economic development is growing[8]. This paper uses the data of Shandong Statistical Yearbook for 18 consecutive years from 2001 to 2018, and uses GIS technology to study the spatial and temporal distribution pattern of cultivated land resources in Shandong Province, in order to improve the construction of discipline system and land use on the basis of summarizing the law. Provide a reference for sustainable development.

2. Data source and overall overview

2.1. Data sources

Through the official platform of Shandong Statistical Information Network, query the information on cultivated land resources in the "Shandong Statistical Yearbook" from 2001 to 2018, and sort out the information on cultivated land resources from 2000 to 2016 for 17 years. The data in 2009, 2010 and 2011 are missing. The 2008 data is replaced). Based on the year and the region, the statistics of cultivated land resources and Jinan, Qingdao, Zibo, Zaozhuang, Dongying, Yantai, Weifang, Jining, Tai'an, Weihai, Rizhao, Laiwu, Linyi, Dezhou, Liaocheng, Binzhou, Heze, etc. 17 cities and information on cultivated land resources in the province, Ludong Peninsula, Luzhongnan, and Northwest Shandong. According to the topographical conditions and economic development level of the province, the province is divided into Ludong Peninsula area (Dongying, Weifang, Rizhao, Qingdao, Yantai, Weihai 6 cities), Luzhongnan area (Laiwu, Jinan, Zibo, Tai'an, Jining, Zaozhuang, Linyi 7 city), northwestern Shandong (Dezhou, Binzhou, Liaocheng, Heze 4 cities).

2.2. Overall analysis

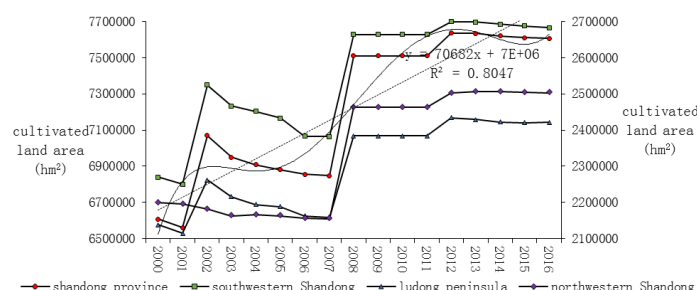


Figure1. Distribution of cultivated land area in Shandong Province from 2000 to 2016

According to the first-level classification, the land use types in Shandong are divided into eight categories: cultivated land, garden land, forest land, grassland, urban and rural residential areas, industrial and mining land, transportation land, water area and unused land. The characteristics are high reclamation rate and low reserve resources. Due to the influence of biology, climate and geography, the soil in Shandong Province is diversified. There are 15 soils, 36 sub-categories, 85 soil genus and 257 soil types. The soil suitable for farmland and garden is mainly fluvo-aquic soil. There are 15 sub-categories of 6 soil types, brown soil, cinnamon soil, sandy black soil, paddy soil and coarse soil. Among them, the area of fluvo-aquic soil, brown soil and cinnamon soil is larger. The physical and chemical properties of the soil are general. In the long-term cultivation process, the light nutrient is reused, and the organic fertilizer input is seriously insufficient. A considerable part of the cultivated land is not high in fertility. The Luzhongnan area and the Shandong Peninsula area are mainly composed of cinnamon soil and brown soil. The texture is rough, the soil layer is shallow, and the water storage capacity is poor. In low hilly areas, soil erosion is serious. More and more cultivated land is polluted by industrial "three wastes". Since the founding of the People's Republic of China, the

area of cultivated land in Shandong Province has experienced a process of increasing first and then decreasing. In 1999, the net decrease was 2.89 million hm^2 compared with 1949, and the average annual reduction rate was 0.48%; From 1949 to 1952, the area of cultivated land increased year by year, from 8.727 million hm^2 to 918.27 million hm^2 , with an average annual growth rate of 5.21%. 1952 was the year with the largest number of cultivated land in Shandong Province; From 1953 to 1999, the area of cultivated land showed a downward trend. The rate of cultivated land decreased rapidly from 1953 to 1978. The annual change rate was -0.82%. The rate of reduction of cultivated land slowed down from 1979 to 1999, and the annual rate of change was -0.43%[9].

Figure 1 is a time distribution of cultivated land resources in Shandong Province and various regions between 2000 and 2016. It can be seen from the figure that the area of cultivated land between 2000 and 2016 is generally on the rise, and the linear slope of cultivated land area in the province is 70682; In view of the trend of lowering, rising, and lowering in the northwestern part of Shandong Province, the rest of the province, Ludong Peninsula, and Luzhongnan area have the trend of decreasing, rising, descending, rising, and descending. From the 6th-order polynomial trend line, $R^2=0.8892>0.8$, the regression fitting effect is more significant, and the regression equation is $y = -0.709x^6 + 86.442x^5 - 3056.8x^4 + 45918x^3 - 312359x^2 + 950088x + 6E+06$. It can be seen that there are two obvious peaks and two obvious troughs in the cultivated land area of the province. The peaks appeared in 2002 and 2012 respectively. The valleys appeared in 2005 and 2015 respectively, and the cycle is about 10 years. Through the evolution of the timeline, the time evolution of the cultivated land area in the province from 2000 to 2016 can be roughly divided into three stages: the gradual decay phase (2000-2007), in which the overall cultivated land area increases slightly, with an average annual growth rate of 0.52%, in 2002-2007, the rate decreased by 0.63%. The province, Ludong Peninsula, Luzhongnan area reached the lowest value of cultivated land in 2001, and the northwestern part of Shandong reached the lowest value of cultivated land in 2007; In the incremental phase (2008-2012), the area of cultivated land increased as a whole, increasing at a rate of 0.33% year by year. Except for the maximum area of cultivated land in northwestern Shandong in 2013, the rest of the region reached the maximum area of cultivated land in 2012; Stabilization adjustment stage (2013-2016), the overall area of cultivated land is reduced at this stage, the average annual growth rate is -0.087, the continuous growth of population and the rapid development of the economy, making a large amount of cultivated land into construction land, resulting in the area of cultivated land The period continues to decrease. In particular, except for the Ludong Peninsula, the cultivated land area has a trend of increase in 2016, and the rest are all decreasing. The overall downward trend of cultivated land area afterwards and the partial recovery trend of cultivated land area after 2016 are worthy of attention and attention.

3. Results and analysis

3.1. Changes in the distribution of characteristics of cultivated land resources

3.1.1. Pre-distribution characteristics. During this period, the top three arable land areas in the province were Heze City, Weifang City and Linyi City, and the last three were Rizhao City, Weihai City, and Laiwu City. Fig.2a is a distribution map of land reclamation rate in Shandong Province in 2000. The land reclamation rate refers to the percentage of cultivated land area and total land area in a certain area in a certain period. The land reclamation rate in Liaocheng, Heze and Dezhou is the highest, and the land reclamation rate is $> 55.20\%$, Weihai City, Laiwu City, Dongying City had the lowest land reclamation rate and the land reclamation rate was $< 32.90\%$. It can be seen from the figure that in addition to the two prefecture-level cities of Qingdao and Weifang, which are located outside the high-value area, the province's cultivated land resources tend to decrease from west to east.

3.1.2. Medium-term distribution. During this period, the top three arable land areas in the province were Linyi City, Heze City and Weifang City, and the last three were Zibo City, Weihai City and Laiwu City. Fig.2b is the distribution map of land reclamation rate in Shandong Province in 2008.

Heze City, Liaocheng City and Dezhou City have the highest land reclamation rate, and the land reclamation rate is $>61.09\%$. The land reclamation rate in Zibo City, Yantai City and Laiwu City is the lowest, and the land reclamation rate is the lowest. Both $<35.05\%$. It can be seen from the figure that the high-value area shows the characteristics of the Gongwei Luzhong area. Compared with the distribution of cultivated land in the previous period, the land reclamation rate has a tendency to expand eastward.

3.1.3. Late distribution characteristics. During this period, the top three arable land areas in the province were Linyi City, Heze City and Weifang City, and the last three were Zibo City, Weihai City and Laiwu City. Fig.2c is a distribution map of land reclamation rate in Shandong Province in 2016. Heze City, Liaocheng City and Dezhou City have the highest land reclamation rate, and the land reclamation rate is $>63.49\%$. Laiwu City, Zibo City and Yantai City have the lowest land reclamation rate and land reclamation rate. Both were $<36.23\%$. It can be seen from the figure that the high-value area still shows the characteristics of the Gongwei Luzhong area. On the whole, the province's cultivated land resources are characterized by more western and less eastern, and the density of growth in the middle of the cultivated land is consistent with the eastward expansion trend.

3.1.4. Overall distribution characteristics. Based on the average of the land reclamation rate from 2000 to 2016, the overall distribution of cultivated land resources in the province was counted. Linyi City, Weifang City and Heze City ranked the top three in the province's cultivated land area, and Zibo City, Weihai City and Laiwu City ranked the whole. The latter three areas of cultivated land in the province, the area of cultivated land in the west is less in the middle and east. Fig.2d is the distribution map of the overall land reclamation rate in the province. Liaocheng City, Heze City and Dezhou City have the highest land reclamation rate and the land reclamation rate is $>58.34\%$. Yantai City, Laiwu City and Zibo City have the lowest land reclamation rate and land reclamation rate. $<34.03\%$. It can be seen from the figure that except for Weifang City, which is located in the high value area, the province's cultivated land resources are characterized by the lack of more than the east.

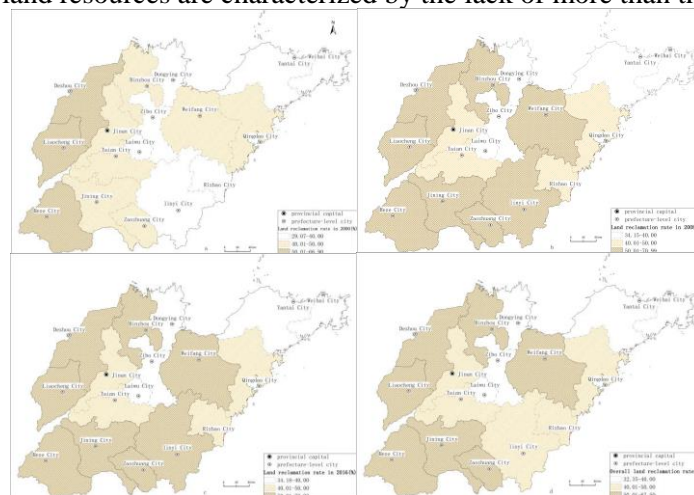


Figure2. Spatial pattern of land reclamation in Shandong Province from 2000 to 2016

3.2. Changes in the overall distribution of cultivated land resources

3.2.1. Regional difference. From 2000 to 2016, the average area of cultivated land in Shandong Province was 7,225,427 hectares, an increase of 999,487 hectares, with an average annual growth rate of 0.89%, including 2,299,927 hectares in Ludong Peninsula, 2,545,687 hectares in Luzhongnan and 2,338,264 hectares in northwestern Shandong. The Ludong Peninsula region has an increase of 282,369 hectares, with an average annual growth rate of 0.78%. Luzhongnan has an increase of

4,130,48 hectares, with an average annual growth rate of 1.07%. The northwestern region has an increase of 304,070 hectares with an average annual growth rate of 0.81%. This shows that the Luzhongnan area has been in the past 17 years. The rate of adjustment of cultivated land resources is slightly faster. The land reclamation rate in Shandong Province is 48.84%, that is, about 50% of the land in the province is cultivated land, the land reclamation rate in Ludong Peninsula is 41.85%, and the land reclamation rate in Luzhongnan area is 46.61%. The land reclamation rate in northwestern Shandong Province For 60.96%, the land reclamation rate in Ludong Peninsula is the lowest, and the land reclamation rate in northwestern Shandong is 1.46 times that of Ludong Peninsula. It also shows that the cultivated land resources in Shandong Province are characterized by decreasing east, west and west.

3.2.2. Inter-city difference. Linyi City has the largest cultivated land area, and Heze City has the highest land reclamation rate. From 2000 to 2016, the land use change in 17 cities in Shandong Province was quite different, and the situation faced by cultivated land resources was severe. From 2000 to 2016, the most extensive cultivated land in Shandong Province was Linyi City in the Luzhongnan area. The average cultivated area was 788,595 hectares. The least cultivated area was in Laiwu City in the Luzhongnan area, with an average cultivated area of 68,316 hectares. The largest land reclamation rate is located in Liaocheng City in the northwestern part of Shandong Province. The land reclamation rate is 67.50%, and about 2/3 of the land is cultivated land; the land reclamation rate of Zibo City in Luzhongnan area is 32.36%, and the cultivated land resources are less than the land area. 1/3, the former is 2.09 times the latter. There is a wide disparity in the rate of land reclamation between cities. As a spatial complex, land has not only a planar direction but also a vertical depth. The scarcity of land resources and the acceleration of urbanization require urban development from extensive extension and expansion to intensive three-dimensional comprehensive development. This will not only expands land use efficiency, create greater economic benefits, but also alleviates human-land conflicts and save a lot of valuable land resources.

4. Conclusion

This paper uses GIS spatial analysis and mapping technology to study the spatial and temporal distribution pattern of cultivated land resources in Shandong Province, and draws the following conclusions: Firstly, the area of cultivated land between 2000 and 2016 is on the rise. It is divided into three stages: attenuation, recovery and adjustment. The overall decline trend of cultivated land area after 2012 and the partial recovery trend of cultivated land area after 2016 are worthy of attention. Commonly used cultivated land is China's basic and valuable land resources. It is strictly protected by China's Land Law. Although the cultivated land resources in Shandong Province have certain restoration and adjustment, they still need to follow the National Land Use Planning Outline (2006-2020). The requirements of the "Shandong Provincial Quality Improvement Plan (2014-2020)" and other documents have promoted the sustainable development of land use.

Secondly, from the stage distribution of cultivated land resources in Shandong Province, the land reclamation rate of the three cities of Liaocheng, Heze and Dezhou was the highest, and the land reclamation rate was >55.20%. The land reclamation rate was the highest in the middle stage of Heze City, Liaocheng City and Dezhou City. The reclamation rate was >61.09%. The land reclamation rate was the highest in Heze, Liaocheng and Dezhou in the later period, and the land reclamation rate was >63.49%. Overall, the pattern of land reclamation rate in Liaocheng, Heze and Dezhou was unchanged, and the land reclamation rate was unchanged. The average >58.34%, the province's cultivated land resources are characterized by the West and the East is less, the growth rate of land reclamation shows a trend of expanding eastward.

Thirdly, from the overall distribution of cultivated land resources in Shandong Province, the area of cultivated land in Shandong Province increased by 999,487 hectares from 2000 to 2016, with an average annual growth rate of 0.89%. The average annual growth rate of Luzhongnan area was slightly faster at 1.07%. The highest rate of reproduction is 60.96%. In 17 years, the most cultivated

land area in Shandong Province is Linyi City in the Ludong Peninsula area. The largest land reclamation rate is located in Liaocheng City in the northwestern part of Shandong Province. The land reclamation rate is 67.50%, and about two-thirds of the land is cultivated land.

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The number of cultivated land in China is insufficient, the shortage of reserve cultivated land resources is difficult and the improvement and development are difficult. It is especially important for the development and control of the cultivated land resources of the country to properly control and adjust the distribution and total amount of cultivated land resources. Investigating and summarizing the land reclamation rate in Shandong Province since the 21st century is conducive to early control of the development of cultivated land resources in the province, and improving the quality of existing cultivated land is an important way to ensure food security in China. In the future, we can further understand the realistic level of cultivated land quality in the study area and the obstacle factors that restrict the use of cultivated land, further increase the production potential of the production field, increase the grain yield through the extension and connotation of cultivated land resources, and further explore the new path and new method of sustainable development and utilization of cultivated land. At the same time, further explore the relationship between cultivated land resources and population development, the relationship between cultivated land resources and economic development, the relationship between cultivated land resources and new urbanization, the relationship between cultivated land resources and food security, and the relationship between cultivated land resources and environmental pollution also has very realistic value and meaning.

Acknowledgments

This work was financially supported by Ministry of Education Humanities and Social Sciences Youth Fund (No.15YJCZH175), Shandong Provincial Social Science Planning Research Fund (No.18CLYJ34) and Shandong Provincial Higher Education Research Fund (No.J18RB200).

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