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# Variation of Cultivated Land Quantity in Coastal Cities and Its Driving Forces

—A Case of Huludao City, China

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**Abstract** Variation of cultivated land quality in 10 major coastal cities and its driving forces are introduced in recent 10 years. And economic development and population growth are the common driving forces for the reduction of cultivated land in coastal cities. Among them, economic development is the main driving force. Taking Huludao City as an example, driving factors of cultivated land variation in Huludao City are studied by Principal Component Analysis according to the relevant statistical data in the years 1998–2007. Result shows that in recent 10 years, total cultivated land area has increased in Huludao City, especially in the years 1998–2002. Driving force of cultivated land variation in Huludao City can be summarized as economic development, population growth and agriculture science and technology development. Based on this, relevant measures to project cultivated land are put forward: controlling population, reducing land pressure; strengthening the protection of cultivated land and basic farmland, stabilizing cultivated land quality and quantity, strictly controlling the nonagricultural scale of cultivated land, improving the level of land economical and intensive use, enhancing land consolidation, reclamation and development, increasing agricultural science and technology input, and guiding the adjustment of agricultural structure.

**Key words** Coastal city, Cultivated land, Quantity variation, Driving force, Principal component analysis, China

The quantity and quality of cultivated land resources are the basic guarantee of grain production. Therefore, strengthening the research of cultivated land change and analyzing driving factors have important significance in reasonable utilization of cultivated land resources, controlling and preventing the reduction of cultivated land area and promoting the sustainable development of agriculture. Coastal cities are the forerunner and potential area of China's economic development, due to the acceleration of urban construction along with the economic development, the quantities of cultivated land in coastal cities reduce constantly and rapidly. The author takes Huludao city in Liaoning province for example, and is about to research on its quantity change of cultivated land and characteristics of driving force, so as to provide reference to sustainable utilization of cultivated land resources.

## 1 Quantity change of cultivated land and its driving force in coastal cities

In order to thoroughly analyze the quantity change of cultivated land and its driving force in Huludao city, based on relevance, comparability, data searchability, the Paper firstly analyzes and collects the relevant data of other ten coastal cities (Dalian, Tianjin, Yantai, Weifang, Shanghai, Wenzhou, Zhangzhou, Guangzhou, Shantou and Zhanjiang), sums up the same points and differences of quantity change of cultivated land and driving force in these cities. Statistics show that the total quantities of cultivated land in the above 10 coastal cities

have reduced fluctuantly since the Reform and Opening-up. In recent 10 years, government has attached great importance to the protection of cultivated land and carried out relevant policies, laws and regulations. So speed of the reduction of cultivated land has slowed down, but still with a declining tendency. Among them, the cultivated land area of Tianjin, Shanghai, Wenzhou and Shantou all declined constantly.

Through the analysis and summary of related data we can find that economic development and population growth are the common driving forces of the reduction of cultivated land in the above coastal cities. Among those cities, Dalian, Tianjin, Yantai, Shanghai, Wenzhou, Guangzhou and Zhanjiang are the first batch of opening-up coastal cities of the state; Shantou is one of the special economic zones in coastal areas. Under the influence of related preferential policies, since the reform and opening-up, the coastal cities have got rich first and the economy has developed rapidly. Economic development is inseparable to land resources. With increasing economic indexes such as GDP, fixed assets investment and industrial total value of output, coastal cities have a growing demand of land for construction purposes, in this process occupy a lot of cultivated land. According to correlational research, cultivated area reduction has an obvious space correspondence with economic growth. The more developed area, the higher level of the reduction of cultivated land, and *vice versa*. Therefore, the economic development is the main driving force of less cultivated land in coastal cities. Under the combined action of mechanical growth brought by urbanization and natural growth, the population in coastal cities will increase considerably, it is inevitable to build more residential buildings, parks, schools hospitals and other public infrastructure, and the reduction of cultivated land

is unavoidable.

Apart from the economic development and population growth, other driving forces that led to the reduction of cultivated land in coastal cities are urbanization process, urban construction and development, transportation, government policy, progress of agricultural science and technology, adjustment of agricultural industry structure, environmental change and natural disaster<sup>[1-10]</sup>.

## 2 General information of research area

Huludao City is located in southwest of Liaoning Province, 119°12' – 121°02' E, 39°59' – 41°12' N; It is neighbored with Jinzhou in the east, next to Shanhaiguan in the west and close to Liaodong bay in the south, and constitutes the Bohai economic circle along with Dalian, Yingkou, Qinhuangdao Qingdao and so on. It is the west gate of northeast China and the first city outside of the Shanhaiguan. Huludao City has 6 districts (cities) and counties, they are Lianshan district, Longgang district, Nanpiao district, Xingcheng city, Suizhong county and Jianchang county. In 2007, the total area of the city is 10 414.94 km<sup>2</sup>, the total population is 2 787 000, GDP is 41.753 billion yuan, per capita GDP is 14 963 yuan. Huludao is a coastal city, but the Bohai Sea is a continental sea, so the continental climate is significant with four distinct seasons. The mean annual temperature of the city is 8.2 – 9.2°C and the mean annual precipitation is 560 – 630 mm.

## 3 The change of cultivated land quantity in Huludao City

Based on the land utilization and alteration data, the city's cultivated land area is 224 700 hm<sup>2</sup> in 1998, and 225 900 hm<sup>2</sup> in 2007. The cultivated land area has increased 1175.09 hm<sup>2</sup> in ten years. Here we adopt dynamic degree of single type of land use to analyze the quantity change of cultivated land, the expression<sup>[11]</sup> is:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\%$$

In the expression,  $U_a$ ,  $U_b$  respectively is the beginning and the end of the research of cultivated land area;  $T$  is the research period;  $K$  is the change rate of utilization of cultivated land in the research period. According to expression 1, through calculation, we get the change rate of utilization of cultivated land in Huludao City in 1998 – 2007 is 0.052%.

From the change of cultivated land area in the past years, in 1998 – 2007, the quantity of cultivated land in Huludao has increased rather than decreased. The main reason is that it got the maximum – 226 300 hm<sup>2</sup> in 1998 – 2002 in ten years. Since 2003, the cultivated land area has fluctuated narrowly and had a trend of decrease in total. Relative to the increase of cultivated land area, the cultivated land area per capita has showed a decrease trend with the constant growth of population in Huludao City (Fig. 1). The cultivated land area per capita in Huludao was 0.084 7 hm<sup>2</sup> in 1998, 0.0811 hm<sup>2</sup> in 2007, decreased 4.25%.

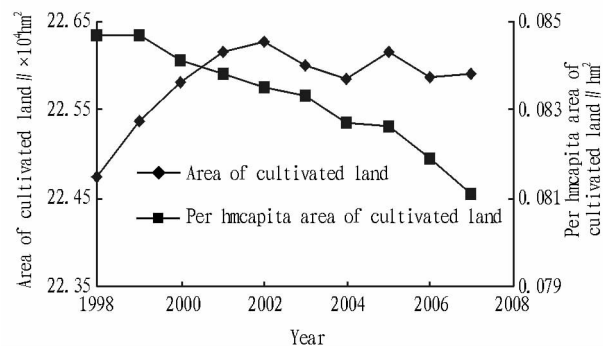


Fig. 1 Variation of the cultivated land in huludao in 1998 – 2007

## 4 Analysis on the driving force of cultivated land change

**4.1 Research method and index selection** With the support of statistical software-SPSS16.0, Using the principal component analysis to study the driving force of cultivated land area change in Huludao City. The data of cultivated land area comes from Huludao Bureau of Land and Resources, and the data of social economy comes from Huludao Statistical Yearbook in 1998 – 2007.

The driving force of cultivated land change is the factor of the change of utilization pattern and the purpose of cultivated land. Influence factors of cultivated land change are complex, to sum up, it mainly includes natural factors and social economic factors. Natural condition changes less in a relatively short period, so the effect of land utilization change is also comparatively little. Social economic factor is relatively larger than the natural factor, thus it plays a decisive role in temporal-spatial change of land utilization. In 1998 – 2007, the natural factor of Huludao is relatively stable, it hasn't made an obvious effect to the cultivated land change, so, here we mainly analyze the social economic factor of cultivated land change in Huludao City.

In the process of the selection of social economic index, we follow the principle of comprehensiveness, dominance, index availability and giving the priority to the basic statistical index. Based on experience, we select 9 indexes from the three aspects of economic development level, population and agricultural production capacity:  $X_1$  is the total population (10 thousand),  $X_2$  is the urbanization level (%),  $X_3$  is GDP (0.1 billion),  $X_4$  is output of tertiary industry (0.1 billion),  $X_5$  is the total investment in fixed assets (0.1 billion),  $X_6$  is the gross output of grain (t),  $X_7$  is the per unit yield of grain (kg/hm<sup>2</sup>),  $X_8$  is the per capita occupancy of grain (kg),  $X_9$  is the rural per capita net income (yuan);  $Y$  is the cultivated land area (hm<sup>2</sup>). Original data is shown in Table 1.

**4.2 The results of principal component analysis** On the basis of the selected index, using the statistical software-SPSS16.0 to analyze and calculate the samples, we get the related coefficient matrix, eigenvalue, contributor rate of principal component and cumulative contributor rate (Table 2, 3).

From Table 2, we can find that the factors that influence

the change of cultivated land area are relevant inordinately each other. There is a high relevance between  $X_6$  and  $X_8$ ,  $X_3$  and  $X_4$ ,  $X_3$  and  $X_9$ , the related coefficient is 0.999, 0.998, 0.981 re-

spectively. That shows they rely on and influence each other on the quantity, and further confirms the necessity of principal component analysis.

**Table 1 The original data of principal component analysis**

Year	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$	$X_6$	$X_7$	$X_8$	$X_9$	Y
1998	265.3	27.25	148.30	51.71	47.96	1 079 714	5 646	406.99	2 311	224 732.81
1999	266.2	27.50	150.68	56.62	70.29	399 237	2 018	149.96	1 837	225 361.39
2000	268.6	27.92	158.47	61.96	74.48	361 580	1 917	134.63	1 850	225 810.62
2001	269.8	28.54	178.55	68.34	51.64	925 804	5 376	343.18	2 277	226 147.81
2002	270.9	28.98	197.82	76.12	57.01	781 943	4 861	288.69	2 416	226 274.34
2003	271.4	29.26	225.54	85.14	63.41	738 278	4 833	271.99	2 572	226 003.17
2004	273.0	29.49	262.01	99.07	77.66	1 090 411	6 683	399.49	3 052	225 845.79
2005	273.7	30.07	299.52	113.76	102.42	976 079	5 473	356.60	3 428	226 147.75
2006	275.7	30.40	348.11	131.97	122.88	899 829	4 933	326.41	3 650	225 870.51
2007	278.7	30.50	417.53	153.58	156.74	1 057 936	6 003	379.59	4 313	225 907.90

**Table 2 Correlation matrix of driving force variables of changes in cultivated land**

Variable	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$	$X_6$	$X_7$	$X_8$	$X_9$
$X_1$	1								
$X_2$	0.972	1							
$X_3$	0.964	0.929	1						
$X_4$	0.974	0.945	0.998	1					
$X_5$	0.856	0.773	0.929	0.925	1				
$X_6$	0.467	0.490	0.518	0.494	0.262	1			
$X_7$	0.514	0.550	0.517	0.499	0.215	0.974	1		
$X_8$	0.421	0.448	0.475	0.449	0.217	0.999	0.970	1	
$X_9$	0.926	0.902	0.981	0.973	0.876	0.661	0.644	0.624	1

**Table 3 Eigenvalue and contribution of principal component**

Principal component	Eigenvalue	Contributor rate // %	Cumulative contributor rate // %
1	6.724	74.712	74.712
2	1.991	22.117	96.829
3	0.249	2.765	99.594
4	0.025	0.275	99.869
5	0.009	0.098	99.967
6	0.002	0.017	99.984
7	0.001	0.016	100.000
8	3.360E-35	0.000	100.000
9	5.893E-6	6.547E-5	100.000

From Table 3, we can find that cumulative contributor rate of the first and the second principal component reaches 96.829%, it means that the first two principal components have already provided enough information of initial data, it completely corresponds with the requirement of analysis (generally requires 85%). Therefore, extract the two principal components. From this, we further get the principal component transpose loading matrix (Table 4). The principal component loading reflects the related coefficient between principal component and analyzed variable.

From Table 4, we can find out that the first principal component has a very high relevance with  $X_1$ ,  $X_2$ ,  $X_3$ ,  $X_4$ ,  $X_5$ ,  $X_9$ . These six factors reflect the population growth and economic growth of Huludao City;  $X_6$ ,  $X_7$ ,  $X_8$  are positively correlated with the second principal component. According to the journey

of the development of agriculture in our country, the progress of agriculture science and technology is the important parameters to improve  $X_6$ ,  $X_7$ ,  $X_8$ . Based on this, the driving forces of cultivated land change in Huludao can be reduced to economic development, population growth and agriculture science and technology progress.

**Table 4 Transposed load matrix of principal component**

Variable	First component	Second component
$X_1$	0.968	0.139
$X_2$	0.931	0.183
$X_3$	0.982	0.175
$X_4$	0.989	0.148
$X_5$	0.949	-0.102
$X_6$	0.359	0.931
$X_7$	0.370	0.915
$X_8$	0.312	0.947
$X_9$	0.931	0.345

### 4.3 The driving factors of cultivated land change

**4.3.1** The driving factor of economic development GDP, the output of tertiary industry, the total investment in fixed assets and rural per capita net income are the four main factors constitute the first principal component. Since Huludao City set up in 1989, the economy has developed constantly, healthily and rapidly. The GDP of Huludao in 1998 was 14.83 billion yuan, and has increased 181.54% to 41.753 billion yuan in 2007; The output of tertiary industry, the total investment in fixed assets and rural per capita net income has increased 197%, 226.81% and 86.63% respectively.

Economic development needs some land as starting condition, GDP is a measure of value gained from land development and utilization. The rapidly increasing GDP in Huludao inevitably requires that the land utilization in the whole city transform to the direction of high efficiency and high yield. Therefore, the type, structure, pattern and level of land utilization come out changes. Correspondingly, the quantity of cultivated land arise large influent and effluent temporal-spatial changes<sup>[12]</sup>. Huludao is the famous historic and cultural city of Liaoxi Area. The Water Great Wall located in Jiumenkou, Suizhong County is the world cultural heritage. In recent years, the city has increased

the support and development of tertiary industry such as travel industry, *etc.* The tertiary industry has grown vigorously, and the construction of kinds of supporting facilities takes a lot of land, especially cultivated land. The investment in fixed assets of the city emphasizes on the infrastructure construction, real estate development and *etc.* which is tightly related to land occupancy. The 'Investment Fever' and 'Development Zone Craze' in 90s of 20<sup>th</sup> century occupied a large quantity of cultivated land. Along with the improvement of rural per capita net income, the quality of rural life generally be improved, construction of rural infrastructure and cultural facilities also takes part of the cultivated land. In 1998–2007, the newly increased land for construction is 4 801.95 hm<sup>2</sup>, the occupancy of cultivated land is 3 083.39 hm<sup>2</sup>, the rate of cultivated land occupancy is 64.21%. It is obvious that at the same time of economic development, large quantity of land is occupied, especially cultivated land.

**4.3.2** The driving factor of population growth The growth of population, on the one hand, requires to occupy more cultivated land for construction of production and living facilities, on the other hand, need more cultivated land to produce grain in order to meet the people's demand of living and production, which causes a dual pressure of cultivated land protection<sup>[12]</sup>. In 1998–2007, the total population of the city increased constantly, with average annual addition of 13 400. From the prediction of Eleventh Five-Year Plan of Huludao, the total population of the city will achieve 2 935 000 by 2010, 148 000 more than that in 2007. With the continuous growth of population and the improvement of living standard, people's demand for residential land and domestic installation land is increasing. which to a certain extent stimulate the occupancy of cultivated land. At the same time, the urbanization level of Huludao city is also rising. With the improvement of urbanization, the population is growing constantly, the scale of it is continuously expanding, and the quantity of cultivated land occupied will also increase.

**4.3.3** The driving force of agriculture science and technology progress. The gross output of grain, per unit yield of grain and per capita occupancy of grain are the main factors constitute the second principal component. In recent years, in order to improve the land productivity, ensure the stable development of agriculture, the city has used a series of measures to transform from traditional agriculture to modern agriculture. The progress of agriculture science and technology makes the gross output of grain, per unit yield of grain and per capita occupancy of grain increase. It is a good harvest year of Huludao City in 1998, the gross output of grain, per unit yield of grain and per capita occupancy of grain increased fluctuantly in the later 9 years except the decline by large margin caused by serious drought in 1999 and 2000. With the settlement of subsistence problem and pursuit of economic benefit, the people begin to look for a new business practice for increasing their income, such as planting fruit trees, excavating fishpond, *etc.* That makes cultivated land further decrease.

The same as the 10 coastal cities talked above, the most significant factors of cultivated land change in Huludao are economic development and population growth. But, meanwhile, at present, the rapid economic development area in Huludao fo-

cus on the coastal area. But, the inland area, particularly, the Jianchang county in the northwest mainly focus on soil and water ecological conservation and the development of agriculture. Therefore, compare to the other coastal cities, progress of agriculture science and technology is an indispensable driving force of cultivated land change in Huludao.

## 5 Countermeasures and suggestions

Compare to the other coastal cities, Huludao set up late, the infrastructure construction is relatively backward, economic aggregate and development speed are both not as good as the former, there is an obvious gap compare to the coastal opening-up cities and special economic zones. So, the total quantity of cultivated land has increased somewhat in recent 10 years. But, with the implementation of the development strategy of the Northeast Industrial Base and the adoption of Liaoning coastal economic zone development planning at the State Council routine conference, Huludao City has faced with a golden development opportunity. Under this background, the work of cultivated land protection is hard and heavy.

**5.1 Controlling the population size, relieving cultivated land pressure** Continuous population growth results the cultivated land area per capita in Huludao reduces year by year, the contradiction between people and land is increasingly sharp. Therefore, it is necessary to strictly control the population size, improve the quality of the people, relieve cultivated land pressure from population.

**5.2 Strengthening protection of cultivated land and basic farmland, stabilizing the quantity and quality of cultivated land** Cultivated land resource is non-renewable resource. In order to achieve the sustainable development of social economy, guarantee the stability of grain, ecology, economy, political security and society, Huludao City must strictly put the related policy and strategy of protecting cultivated land and basic farmland into effect. We must ensure that the requisition and compensation of the cultivated land is balanced, the quantity of basic farmland does not decrease, the purpose does not change and the quality improves.

**5.3 Strictly controlling the non-agriculturalization scale of cultivated land, improving the level of economical and intensive utilization of land** Repair in the new Huludao Overall Plan of Land Utilization (2006–2020), it is necessary to strictly control the non-agriculturalization scale of cultivated land, avoid occupying the land by construction and protect the scientificity and seriousness of the plan. At the same time, realize the pattern of economic development and the mode of land utilization to transform from extensive to intensive. Pay attention to deepen the connotation of land for construction on hand, improve the output benefit per unit, and promote the economic development technology of land-economizing, improve the level of economical and intensive utilization of land<sup>[13]</sup>.

**5.4 Increasing land consolidation, reclamation and development** The source of land increase is land consolidation, reclamation and development. Huludao City should do its best to increase its cultivated land area through land consolidation and reclamation of the land discarded by factories and mines. Land development is mainly on the land which is not used yet.

In the process of developing, we should follow the moderate principle, give consideration to the protection of ecology and maintain the quality of newly developed cultivated land.

**5.5 Increasing agricultural science and technology input and guiding the adjustment of agricultural structure efficiency** Increasing agricultural science and technology input can improve the out put in unit area and efficiency and ensure the grain security of Huludao City; At the same time, it is conducive to decreasing the cost, enhancing the agricultural contrast benefits, reducing the burden of the peasants and promoting farmers' income<sup>[14]</sup>. Guarantee the land demand in rural economic development as well as ensure the cultivated land not reducing too much and too quickly due to the adjustment of agriculture structure. In the process of adjusting the agriculture structure, we should adjust measures to local conditions and moderately control the adjustment of agriculture structure inside the planting industry. Meanwhile, we should avoid destroying the soil of plough horizon as possible as we can and make sure that do not decrease the quality of cultivated land because of agricultural structure adjustment.

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## 沿海城市耕地数量变化及其驱动力研究——以辽宁省葫芦岛市为例

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**摘要** 介绍了 1998~2007 年中国 10 个主要沿海城市的耕地数量变化情况及其驱动力, 认为经济发展和人口增长是导致沿海城市耕地减少的共同驱动力, 其中经济发展是最主要的驱动因素。以辽宁省葫芦岛市为例, 根据 1998~2007 年相关统计数据, 运用主成分分析法研究了葫芦岛市耕地面积变化的驱动因子。结果表明, 近 10 年来, 葫芦岛市的耕地总量不减反增, 耕地面积增加主要集中于 1998~2002 年; 葫芦岛市耕地数量变化的驱动力可以归纳为经济发展、人口增长及农业科技进步三大类。基于此, 提出了耕地保护的相关对策: 控制人口数量, 减轻耕地压力; 加强耕地和基本农田保护, 稳定耕地数量和质量; 严格控制耕地非农化规模, 提高土地节约和集约利用水平; 加大土地整理、复垦和开发力度; 加大农业科技投入, 引导农业结构调整。

**关键词** 沿海城市; 耕地; 数量变化; 驱动力; 主成分分析