The Dynamic Change in the Total Arable Land and its Driving Forces in Tongling City of Anhui Province

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Abstract According to *Anhui Statistical Yearbook* (2003 –2012) and the second national land survey data, this article analyzes the current situation of land use and the dynamic change in the total arable land in Tongling City. On the basis of this, using grey relational analysis, this article analyzes the driving forces for arable land changes in Tongling City. Studies show that population growth, the improvement of level of urbanization and the rapid development of the economy are the main driving forces for arable land changes. Based on the findings, the strategies are put forth in order to ensure the dynamic balance of total arable land.

Key words Tongling City, Total arable land, Dynamic change, Driving forces

The Chinese government has always attached importance to arable land protection, and proposed the most stringent measures in the world to protect arable land. However, due to a long period of arable land occupation and runaway population growth, it has seriously reduced the per capita arable land area. In the period 1975 –1983, the world's arable land increased by 2.3%, while China's arable land decreased by 2.6% [1]; in the period 1996 –2006, the amount of China's arable land decreased from 1.3×10^8 hm^2 to 1.2×10^8 hm^2, a total reduction of 0.1×10^8 hm^2 over a decade, and the per capita arable land area declined from 0.11 hm^2 to 0.09 hm^2 [2]. At present, the momentum of China's population growth and arable land reduction has still not been fundamentally curbed, and the contradiction between people and land is becoming increasingly tense. Therefore, the analysis of the dynamic change in total arable land and the driving forces[3 –7], is of great significance to establishing the arable land protection mechanism, achieving the synchronized improvement of arable land quantity and quality, and ensuring China's food security. Based on this, on the basis of analyzing the dynamic change in total arable land and the driving forces in Tongling City, this article proposes the ways to ensure the dynamic balance of total arable land, in order to provide a reference.

1 Natural and socio-economic status and current situation of land use in Tongling City

1.1 Natural and socio-economic status Tongling (117°42′00″ –118°10′6″E, 30°45′12″ –31°07′56″N) is a prefecture-level city in southern Anhui province. A river port along the Yangtze River, Tongling borders Wuhu to the east, Chizhou to the southwest and Anqing to the west. It has warm climate and abundant rainfall, and the excellent natural conditions makes it become a national garden city.

Although Tongling City is mostly mountainous, the surrounding flatlands are rich agricultural regions producing rice, wheat, cotton, beans, garlic, herbal medicines and ginger. Large amounts of fish are also harvested in the region. The local mineral resources also include iron, coal, gold, silver, tin, iron sulfide, plus more than twenty other rare minerals associated with them such as nickel, cadmium, gallium, molybdenum, germanium and selenium.

The prefecture-level city of Tongling, built in 1956, now administers 4 county-level divisions and 1 economic and technological development zone including 3 districts (Tongguanshan District, Shizishan District and Jiao District) and 1 county (Tongling County), and 1 national economic and technological development zone (Tongling National Economic and Technological Development Zone), with an area of 1200 square kilometers and a population of 740000.

The social cause development is balanced in Tongling City. The urban compulsory education has basically achieved balanced development, and it takes the lead to popularize the secondary education in the province; the culture cause is distinctive and the public culture has a solid foundation.

Tongling has a solid industrial foundation, and today the city's industrial base still revolves around the several nearby copper mines and copper processing operations. Other important industries include chemical works, textiles, building materials, electronics, machinery and food processing. Long a hub of water transportation, in 1995 Tongling became the site of Anhui Province's first highway bridge spanning the Yangtze River.

After years of development, Tongling has become China's largest electrolytic copper production base, major sulfur and phosphorus chemical industry base, and State Torch Program electronic materials industry base, and it has six listed companies. Tongling, as the emerging modern port city, is an important gateway for

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Anhui's opening up. In 2012, Tongling's GDP reached 62.13 billion yuan, an increase of 11% over the previous year.

1.2 Current situation of land use The geographical area of Tongling is small, and it is mostly mountainous. There is a severe shortage of arable land reserve resources and land supply.

(i) The amount of per capita land resources is significantly lower than the national average. According to the statistics in 2010, the national average per capita land area was about 0.7 hm^2, and the per capita arable land area was 0.093 hm^2, while in Tongling City, the per capita land area was about 0.15 hm^2, and the per capita arable land area was 0.0319 hm^2.

(ii) The development of industrialization and new urbanization has a large demand for construction land. Especially in recent years, the proportion of new construction land for the new projects has been substantially increased.

(iii) The per capita level of construction land is high. The suburban and rural construction land is scattered, and there are many "hollow villages".

(iv) The intensification level of industrial land is improved but still lower than in the developed regions. In 2010, the average investment intensity of the development zone of Tongling City was about 16.5 million yuan/hm^2, and the yielding benefits were 22.5 million yuan/hm^2. In the same period, the investment intensity of Hefei Economic Development Zone and High-tech Industrial Development Zone was 30 – 37.5 million yuan/hm^2, and the investment intensity of Wuhu Economic and Technological Development Zone was 22.5 – 27 million yuan/hm^2.

(v) The phenomenon of idle land and inefficient use of land is still common. From the point of view of regions, they are mainly in the east of Tongxu, and the west of Taishan Road; others are distributed in "Datong Industrial Park" of Daqiao Economic Development Zone and Jinqiao Industrial Park of Tongling County.

2 Arable land changes in Tongling City

2.1 The stage of arable land changes According to *Anhui Statistical Yearbook* (2003 – 2012) and the second national land survey data, the amount of arable land in Tongling City declined from 23952 hm^2 in 2002 to 23476 hm^2 in 2011, with the average annual net decrease of 47.6 hm^2; the amount of per capita arable land declined from 0.0341 hm^2 in 2002 to 0.0317 hm^2 in 2011.

As shown in Table 1 and Fig. 1, the arable land changes in Tongling City are divided into the following four stages:

(i) At the first stage, the amount of arable land and per capita arable land tended to decline slowly, mainly due to increase in the needs for arable land for economic and social development of Tongling City.

(ii) At the second stage, the amount of arable land and per capita arable land declined rapidly, and the decline was the greatest in 2006, mainly due to the occupation of a lot of arable land for construction in the context of rapid economic and social development.

(iii) At the third stage, the amount of arable land and per capita arable land gradually increased, mainly due to the government's intensified control over the arable land. In addition to the land reclamation and rural settlement consolidation, the amount of arable land began to increase in 2007, and peaked in 2008.

(iv) At the fourth stage, the amount of arable land and per capita arable land declined slowly. Although there were land consolidation and other measures to supplement arable land, it eventually could not keep up with the economic and social development.

Table 1 The area of arable land and per capita arable land in Tongling City during the period 2002 – 2011

Year	The area of arable land // hm^2	The area of per capita arable land // hm^2
2002	23 952	0.034 1
2003	23 548	0.033 2
2004	23 754	0.033 2
2005	23 738	0.032 9
2006	22 373	0.030 6
2007	23 145	0.031 4
2008	24 094	0.032 6
2009	23 638	0.031 9
2010	23 574	0.031 9
2011	23 476	0.031 7

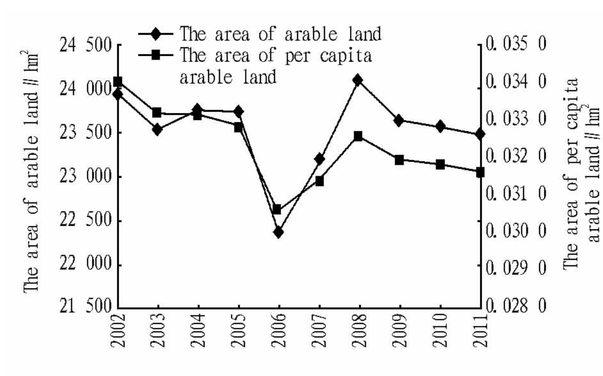

Fig. 1 Changes in the area of arable land and per capita arable land in Tongling City during the period 2002 – 2011

2.2 The driving forces for arable land changes

2.2.1 The selection of driving factors. From the above analysis, the dynamic change in total arable land in Tongling City are mainly closely related to social and economic development factors, therefore, the following factors are selected for the analysis of driving forces according to the study needs and actual situation (Table 3).

Table 2 The driving force factors for the dynamic change in total arable land in Tongling City

Indicator layer	Factor layer	
	First level	Second level
Social driving forces	Population growth	Total population(X_1)
		Non-agricultural population(X_2)
Economic driving forces	The level of urbanization	Urbanization rate(X_3)
		Urban construction land area (X_4)
	Economic development	Fixed asset investment(X_5)
		GDP(X_6)

2.2.2 Correlation analysis. Correlation refers to any of a broad class of statistical relationships involving dependence. It is a term of grey relational analysis. Grey relational analysis uses a specific concept of information. It defines situations with no information as black, and those with perfect information as white. However, neither of these idealized situations ever occurs in real world problems. In fact, situations between these extremes are described as being grey, hazy or fuzzy.

Therefore, a grey system means that a system in which part of information is known and part of information is unknown. With this definition, information quantity and quality form a continuum from a total lack of information to complete information – from black through grey to white. Since uncertainty always exists, one is always somewhere in the middle, somewhere between the extremes, somewhere in the grey area.

Grey analysis then comes to a clear set of statements about system solutions. At one extreme, no solution can be defined for a system with no information. At the other extreme, a system with perfect information has a unique solution. In the middle, grey systems will give a variety of available solutions. Grey analysis does not attempt to find the best solution, but does provide techniques for determining a good solution, an appropriate solution for real world problems.

(i) Standardization. In order to avoid the influence of different data units and make the data comparable, the raw data must be dimensionless. This article sets the raw data of arable land area (X_0) and various driver indicators in 2002 as the standard amount of 1, and takes the ratio of factor values in various years to factor values in 2002 as the processing results, to get the standardized data of arable land area and various factor indicators (Table 4).

Table 4 Standardized values of arable land area and various indicators in Tongling City during the period 2002 – 2011

Year	Arable land area(X_0)	Total population (X_1)	Non-agricultural population(X_2)	Urbanization rate(X_3)	Urban construction land area(X_4)	Fixed asset investment(X_5)	GDP(X_6)
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.983	1.009	1.022	1.013	1.000	1.322	1.187
2004	0.992	1.019	1.049	1.029	1.000	1.743	1.569
2005	0.991	1.027	1.067	1.038	1.091	2.163	1.964
2006	0.934	1.040	1.139	1.096	1.091	2.605	2.558
2007	0.966	1.048	1.164	1.111	1.364	3.348	2.996
2008	1.006	1.051	1.169	1.112	1.424	4.937	3.390
2009	0.987	1.053	1.169	1.110	1.424	7.981	3.693
2010	0.984	1.053	1.162	1.103	1.455	10.219	5.016
2011	0.980	1.055	1.160	1.100	1.879	11.642	6.227

(ii) Calculating the corresponding difference values between arable land area (X_0) and various driving factors (X_i). The difference values (absolute values) = $|X_0(k) - X_i(k)|$, where T is discrimination coefficient, $0 < T < 1$. T is set as 0.5, and the correlation is not affected by the size of discrimination coefficient (Table 5).

Table 5 The corresponding difference values between arable land area (X_0) and various driving factors (X_i)

$\|X_0(k) - X_i(k)\|$	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Min(k)	Max(k)
$\|X_0(k) - X_1(k)\|$	0	0.026	0.027	0.036	0.106	0.081	0.045	0.066	0.069	0.075	0	0.106
$\|X_0(k) - X_2(k)\|$	0	0.039	0.057	0.075	0.205	0.198	0.163	0.182	0.177	0.180	0	0.205
$\|X_0(k) - X_3(k)\|$	0	0.030	0.037	0.047	0.161	0.145	0.106	0.123	0.119	0.120	0	0.161
$\|X_0(k) - X_4(k)\|$	0	0.017	0.008	0.100	0.157	0.397	0.418	0.437	0.470	0.899	0	0.899
$\|X_0(k) - X_5(k)\|$	0	0.339	0.751	1.172	1.670	2.382	3.931	6.994	9.235	10.662	0	10.662
$\|X_0(k) - X_6(k)\|$	0	0.204	0.577	0.973	1.624	2.030	2.384	2.706	4.031	5.247	0	5.247

Minimum difference value:

$\Delta\min = \min_i \min_k |X_0(k) - X_1(k)|$;

Maximum difference value:

$\Delta\max = \max_i \max_k |X_0(k) - X_1(k)|$;

Therefore, of the corresponding difference values between arable land area (X_0) and various driving factors (X_i), the minimum is $\Delta\min = 0$, and the maximum is $\Delta\max = 10.662$.

(iii) Calculating the correlation coefficient $T_i(K)$. Using the formula $T_i(k) = \dfrac{\Delta\min + T\Delta\max}{\Delta_{0i} + T\Delta\max}$, the correlation coefficient of the point K in the driving factors (X_i) and the reference point in the arable land area (X_0) is calculated (Table 6).

(iv) Calculating the degree of correlation Y_i between X_i and X_0. The formula is: $Y_i = \dfrac{1}{N}\sum_{k=1}^{N} T_i(k)$. The degree of grey correlation between the driving factors influencing dynamic change in arable land in Tongling City is calculated (Table 7).

3 Results and discussions

(i) Among the driving factors for dynamic change in arable land in Tongling City, total population growth has the highest degree of correlation (0.99), which is the most direct factor influencing the dynamic change in total arable land in Tongling City. With the population growth, there will be an inevitable demand for housing, transportation and living environment, as well as the construction land, thereby generating enormous pressure on arable land.

So, in the future economic development, Tongling City must strengthen land use control, strictly and effectively protect the arable land, and constantly improve the quality of arable land. In the process of protecting arable land, Tongling City should develop the characteristic agricultural industries based on agricultural resource endowment, such as white ginger and root-bark of tree peony, to improve the agricultural output value and farmers' per capita net income, and effectively protect arable land.

Table 6 Correlation coefficient $T_i(k)$ of driving factor X_i and arable land area X_0

$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{0i}+T\Delta\max}$	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{01}+T\Delta\max}$	1	0.995	0.995	0.993	0.981	0.985	0.992	0.988	0.987	0.986
$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{02}+T\Delta\max}$	1	0.993	0.989	0.986	0.963	0.964	0.97	0.967	0.968	0.967
$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{03}+T\Delta\max}$	1	0.994	0.993	0.991	0.971	0.974	0.981	0.977	0.978	0.978
$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{04}+T\Delta\max}$	1	0.997	0.998	0.982	0.971	0.931	0.927	0.924	0.919	0.856
$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{05}+T\Delta\max}$	1	0.94	0.877	0.82	0.761	0.691	0.576	0.433	0.366	0.333
$T_i(k)=\frac{\Delta\min+T\Delta\max}{\Delta_{06}+T\Delta\max}$	1	0.963	0.902	0.846	0.766	0.724	0.691	0.663	0.569	0.504

Table 7 The Ranking of degree of grey correlation between the driving factors influencing dynamic change in arable land in Tongling City

Indicator layer	Factor layer		Measuring results	
	First level	Second level	The degree of grey correlation	Ranking
Social driving forces	Population growth	Total population(X_1)	0.990	1
		Non-agricultural population(X_2)	0.977	3
Economic driving forces	The level of urbanization	Urbanization rate(X_3)	0.984	2
		Urban construction land area (X_4)	0.951	4
	Economic development	Fixed asset investment(X_5)	0.680	6
		GDP(X_6)	0.763	5

(ii) The degree of correlation between urbanization rate and dynamic change in arable land in Tongling City is 0.984, and the degree of correlation between non-agricultural population growth and dynamic change in arable land in Tongling City is 0.977. They are the dominant factors affecting dynamic change in arable land in Tongling City.

With the continuous transfer of rural population to urban areas, the non-agricultural population and urbanization rate are increased. The level of urbanization in Tongling City is affected by the "amphibian population", who live in the city but have household registration in rural areas. To improve the quality of urbanization and get rid of the land bottlenecks, Tongling City should steadily implement the urbanization of agricultural population and essay the "policy of linking human and land".

(iii) The degree of correlation between urban construction land area and dynamic change in arable land in Tongling City is 0.951, and urban construction land area is the major factor contributing to the dynamic change in arable land in Tongling City. To protect arable land, Tongling City should strengthen the construction land control, and improve the level of economical and intensive use of construction land.

The township should make full use of idle land and the land that is approved but not used, tap the potential of urban land, and orderly link urban and rural construction land change; raise the volume rate of urban land, and develop the urban underground space; control the sprawl of natural villages based on the rural construction planning and rural land remediation demonstration projects; make greater efforts to promote the construction of central village to promote moderate concentration of rural settlements.

(iv) GDP (0.763) and fixed asset investment (0.68) are important factors affecting the dynamic change in arable land in Tongling City. Currently, with the rapid economic development in Tongling City, the construction land area is constantly increased but the arable land area is gradually reduced.

In this context, in order to ensure economic development and the protection of arable land, improve the economic efficiency of construction land use and GDP per unit area of construction land, it is necessary to rationally and efficiently use construction land, optimize the industrial structure and transform the economic growth mode.

4 Conclusions

Chinese Government points out that it is necessary to always attach importance to food production, adhere to the red line of protecting 1.8 billion mu of arable land, designate the permanent basic arable land, and strictly control the occupation of arable land for construction. However, the Chinese population still grows at an annual

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social reform with brand new spirit, speed up the process of building a moderately prosperous society in all aspects, and accelerate pushing forward socialist modernization.

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Finally, the government should promulgate some energy-saving systems, and develop incentives, to drive the villagers to carry out the transformation of energy saving and emission reduction of buildings, and improve the indoor and outdoor living environment.

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rate of more than 10 million, and the industrialization and urbanization are in the period of rapid advance, so occupying the arable land for economic development is inevitable. The research results on Tongling City show that the strongest driving factor for dynamic change in arable land is the total population growth, followed by the urban development and GDP.

Therefore, in order to ensure food security and achieve sustainable economic and social development, firstly, it is necessary to adhere to implementing the long-term family planning policy; secondly, it is necessary to implement the urban scale and boundary control strategy; thirdly, it is necessary to abolish GDP performance appraisal system, and implement one-vote-down system for arable land protection, to ensure the quantity and quality of arable land not to drop.

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