Cropland Contribution Index Based on the Regional Cropland-Grain-Population Relationship

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Abstract In order to reveal the attribute clearly and to understand the situation of the regional cropland-grain-population relationship, this paper presents the "cropland contribution index" model, and divides the cropland contribution land index into four levels, that is below subsistence, subsistence, well-off, and richness. Then, it analyzes the whole China, 13 main producing regions, 11 grain balancing regions, and 7 main sales regions. Results show that the overall cropland contribution index presented a rising trend in 1949 to 2010, it once reached well-off level in 1996 to 1999, and it reached the well-off level again in 2010, but there is still a long way to reach the level of richness. The cropland contribution index is relatively high in main producing regions. In 2010, all main producing regions reached the well-off level, and some provinces even reached the richness level. However, the cropland contribution index of main sales regions is lower and takes on a downtrend, especially in Guangdong, Zhejiang, and Fujian provinces. The cropland contribution index in grain balancing regions is not high, and most provinces are still at subsistence level. Researches have indicated that the cropland contribution index can simply and rapidly reflect the relation between regional cropland, grain and population.

Key words Cropland contribution index, Main producing regions of grain, Grain balancing regions, Main sales regions of grain

At present, researches on cropland are no longer confined to the cropland itself, but are put into the dynamic cropland-grain-population system. On the basis of the man-grain relationship, Feng Zhiming built the model of Land Carrying Capacity Index (LCCI) with reference to the land carrying capacity model. He analyzed space-time pattern of the evolution of land carrying capacity in China from 1949 to 2005 from three space dimensions, namely, whole China, provinces and counties. Then, with 2005 as a typical year, he discussed the land carrying capacity of 264 pastoral (semi-pastoral) areas and counties, 663 urban areas and 592 poor counties (districts)[1]. Cai Yunlong *et al.* analyze causes of loss of China's cropland and put forward concepts of minimum cropland area per capita and cropland pressure index from the point of view of cropland protection[2], to judge the level of scarcity and conflict of cropland in a certain place and present the threshold value of cropland protection[3].

After the Scientific Outlook on Development is put forward, comprehensive, coordinated and sustainable development becomes basic requirement of development. In this situation, there should be a simple quantitative index to assess the contribution of cropland as a type of resource to the dialectical relationship between population, resource, environment, and development, and the coordination degree of cropland and population. On the basis of these, I put forward the Cropland Contribution Index (CCI) model. From the statistical data from 1949 to 2010, I conduct a quantitative analysis of the situation of cropland-grain-population relationship in whole China, provinces and cities.

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1 Data source and research method

1.1 Data source Data of cropland, grain and population from 1949 to 2008 is selected from *China Compendium of Statistics* 1949 - 2008 issued by Department of Comprehensive Statistics of National Bureau of Statistics; the data of 2009 is selected from *China Statistical Yearbook* 2010; and the data of 2010 is selected from *China Statistical Yearbook* 2011.

1.2 Research method

1.2.1 The cropland contribution (*Ps*) model. The contribution of cropland to mankind is directly shown in utilization of cropland year after year. Certain amount of grain is reaped in cropland to feed certain number of population. The cropland contribution can be expressed in the number of population (*Ps*) that can be fed by total regional grain yield in certain per capita grain demand. Thus, the cropland contribution index turns the regional cropland-grain-population relationship into the relationship between grain and population. The equation is as follows:

$$Ps = Gt/Gd$$

where *Gt* refers to total output of grain, and *Gd* stands for per capita grain demand.

The per capita grain demand changes along with living standard of the people. The international recognized grain red line (namely, the grain security standard) is 500 kg per capita. According to actual conditions of China, the Institute of Agricultural Economics and Development of Chinese Academy of Agricultural Sciences says that a country with per capita grain consumption in 250 to 400 kg is in the period of dressing warmly and eating one's fill and a country with per capita grain consumption in 400 to 600 kg is at well-off level[4]. So, 250 kg is the lower limit of dressing warmly and eating one's fill, while the 400 kg is the limit of well-off level. The *National Medium and Long Term Grain Security Plan* (2008 -2020) fixes the per capita grain consumption of 2020 at "not lower than 395 kg". The

Food Development Research Program of Chinese Academy of Sciences points out that " when the per capita grain is below 300 kg, it is impossible to provide grain for feed; when it reaches 500 kg, the food consumption structure will be greatly improved; when it reaches 700 kg, the food consumption structure will be fundamentally improved" [5-6].

1.2.2 The Cropland Contribution Index (CCI) model. The CCI model is defined as the ratio of number of population fed by regional cropland to the actual number of population in the region. It can be expressed by following equation:

$$CCI = Ps/Pa$$

where *CCI* is the Cropland Contribution Index, *Ps* signifies the number of population fed by cropland, and *Pa* is the actual number of population.

According to this equation, the Cropland Contribution Index is determined by the number of population fed by cropland and the actual number of population in the region. When the number of population fed by cropland is equal to the actual number of population in the region, the regional grain production in certain per capita grain demand is self-sufficient, and at this time the CCI is 1; when the number of population fed by cropland is greater than the actual number of population in the region, the grain in this region has surplus, and the CCI is greater than 1; when the CCI is lower than 1, the grain in the region will fail to fed existing population in accordance with appropriate demand standard.

In view of these, to assess the coordination between regional cropland, grain and population, take 250 kg per capita grain demand as initial calculation standard. Combining actual conditions of living standards in China, I divide the CCI into four levels, namely, below subsistence, subsistence, well-off and richness. The specific classification criterion is shown in Table 1.

Table 1 Criterion for classification of CCI

Level	CCI value	Grain contributed kg/person
Below subsistence	< 1.00	<250
Subsistence	1.00 to 1.59	≥250 to < 400
Well-off	1.60 to 1.99	≥400 to < 500
Richness	≥2.00	≥500

2 Results and analyses

2.1 Analysis of CCI in the whole country Through analysis of CCI in the whole country, it is able to specifically quantize and show the level of China, especially the level of grain and population. From 1949 to 2010, China went through several development stages. In the period from 1949 to 1950 and from 1960 to 1963, in the early days of foundation of new China, everything was waiting to be taken up. In addition to natural calamities from 1959 to 1961, the CCI in these two periods existed at the level below subsistence, and there was a great scarcity of grain. In the period from 1951 to 1959, 1964 to 1995 and 2000 to 2009, it was at the level of subsistence. From 1996 to 1999, the total grain output gradually increased, and once it reached the well-off level. In 2010, it got to the well-off level again. By now, the CCI in China is far from the richness level. Fig. 1 and Table 2 give the detailed information.

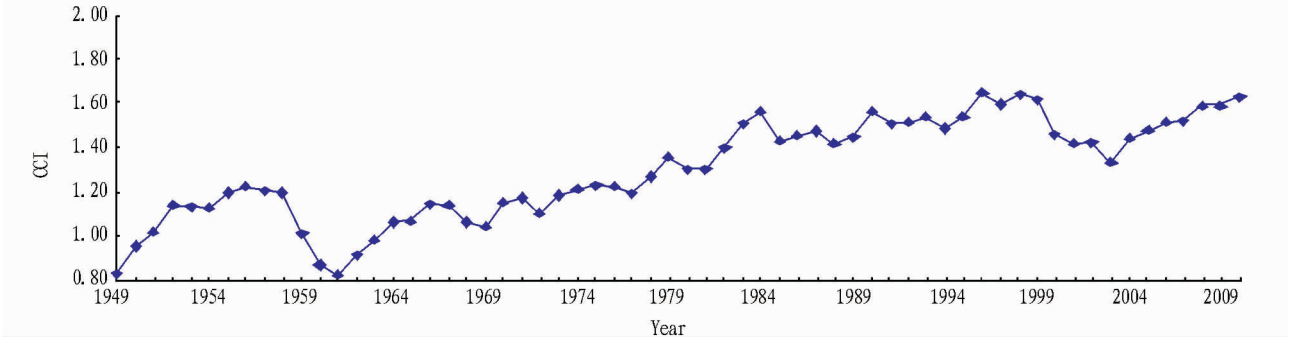

Fig. 1 Change of the CCI in China from 1949 to 2010

Table 2 Levels of CCI in China from 1949 to 2010

Period	Level of CCI	Period	Level of CCI
1949 to 1950	Below subsistence	1996 to 1999	Well-off
1951 to 1959	Subsistence	2000 to 2009	Subsistence
1960 to 1963	Below subsistence	2010	Well-off
1964 to 1995	Subsistence		

2.2 Analysis of CCI in provinces (cities)

2.2.1 Analysis of CCI in main producing regions of grain. The main producing regions of grain refer to those regions where the geographical, soil, climatic and technical conditions are suitable for planting grain crops. Such regions have certain economic advantages and mainly include Hebei Province, Inner Mongolia Autonomous Region, Jilin, Liaoning, Heilongjiang, Jiangsu, Henan, Shandong, Hubei, Hunan, Jiangxi, Anhui and Sichuan provinces[7]. A general survey of grain production since 2000 indicates that the annual grain yield in those main producing regions is over 10 million tons. For the peak one, Henan Province, the total grain yield reaches 54.371 million tons. Even the lowest one, Liaoning Province, the total grain yield is still up to 1.14 million tons.

The main producing regions have high capacity of grain production, thus the CCI is higher. Fig. 2 presents the CCI in main producing regions of grain in 2010. It is shown that the CCI in all 13 provinces reaches the well-off level in 2010. Heilongjiang, Jilin, Inner Mongolia, Henan, and Anhui Provinces reach the richness level. For the highest one, Heilongjiang Province, the CCI is up to 5.23. In other words, for Hei-

longjiang Province alone, the grain yield is enough to provide over 1 200 kg grain for each person.

2.2.2 Analysis of CCI in grain balancing regions. The grain balancing regions include Shanxi, Guangxi, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang provinces (cities)[8]. Since the cropland conditions are worse than main producing regions, as well as large population but little land, the CCI is not high. In 2010, the CCI in Qinghai is at the level below subsistence; in Guangxi, Yunnan, Shanxi, Tibet, Shaanxi, Gansu, and Guizhou, the CCI is at the subsistence level; Chongqing reaches the well-off level; Ningxia and Xinjiang even reach the richness level (Table 3).

2.2.3 Analysis of CCI in main sales regions of grain. Main sales regions of grain refer to Beijing, Shanghai, and Tianjin Cities, and Zhejiang, Hainan, Guangdong and Fujian Provinces[8]. In these provinces and cities, Beijing, Tianjin and Shanghai have lower capacity of grain production all the time. In addition to large population, the CCI in these cities is generally lower than others. Figure 3 shows that in 1949 to 2010, except in 1991, 1992 and 1993, the CCI in Beijing in other years is lower than 1. Since 1998, it drops by a big margin and grain demand of residents largely depends on purchasing from other regions.

Table 3 Total grain yield, total population and CCI in grain balancing regions in 2010

Grain balancing regions	Total grain yield//10^4 tons	Total population//10^4	CCI
Guangxi	1 412	4 610	1.23
Yunnan	1 531	4 602	1.33
Shanxi	1 085	3 574	1.21
Chongqing	1 156	2 885	1.60
Tibet	91.2	301	1.21
Shaanxi	1 165	3 735	1.25
Gansu	958	2 560	1.50
Qinghai	102	563	0.72
Ningxia	357	633	2.25
Xinjiang	1 171	2 185	2.14
Guizhou	1 112	3 479	1.28

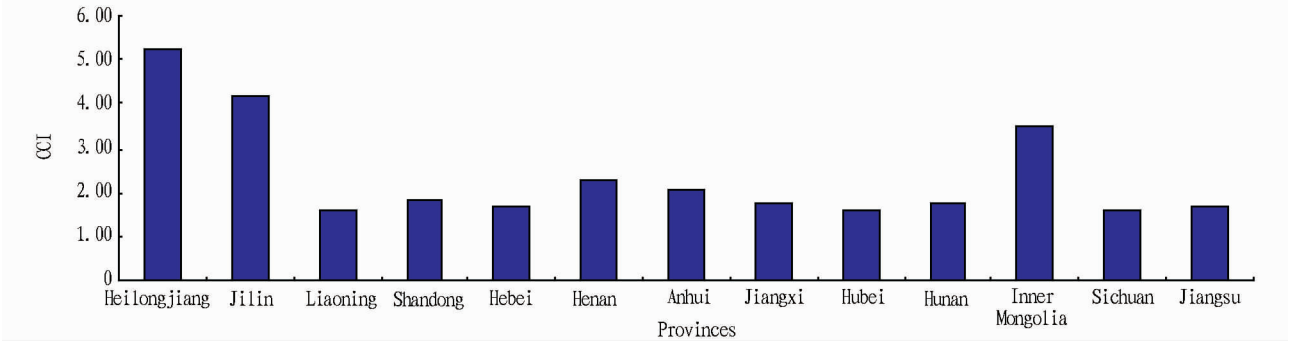

Fig.2 The CCI in main producing regions of grain in 2010

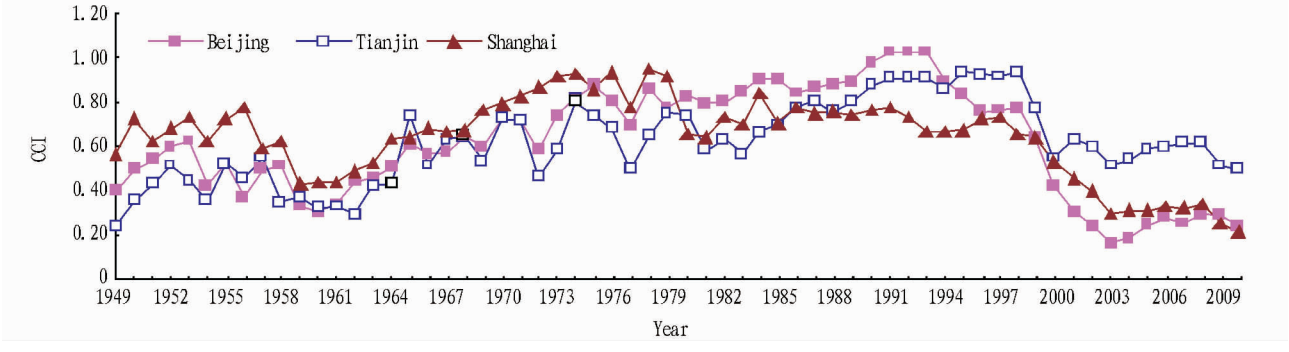

Fig.3 Changes of CCI in Beijing, Tianjin and Shanghai in 1949 to 2010

Compared with Beijing, Tianjin and Shanghai Cities, it is quite different in Zhejiang, Hainan, Guangdong and Fujian provinces. In particular, for Guangdong, Zhejiang and Fujian provinces, along with deepening of reform and opening-up, large population flows into these regions. What's worse, the cropland area is reducing year by year for various reasons, in addition to increasing deterioration of "double cropping to single cropping" in many regions, the sown area of grain crops is decreasing greatly. Therefore, since 1984, the CCI in these three provinces have been decreasing greatly. In 2010, the CCI is lower than 0.75 in these three provinces, and it is close to 0.5 in Guangdong and Zhejiang provinces. In Hainan Province, the aquatic products are abundant, the population is relatively small, so the dependence on crops is low. Thus, the change of CCI is not big (shown in Fig.4).

3 Conclusions and discussions

3.1 Conclusions Outwardly, the CCI reflects the relationship between grain and population. In fact, it indicates dynamic changes of such factors as regional cropland, multiple crop index, average per unit area yield, and population. Through building the CCI model, this research analyzes the whole country, main producing regions of grain, grain balancing regions and main sales regions, and concludes that:

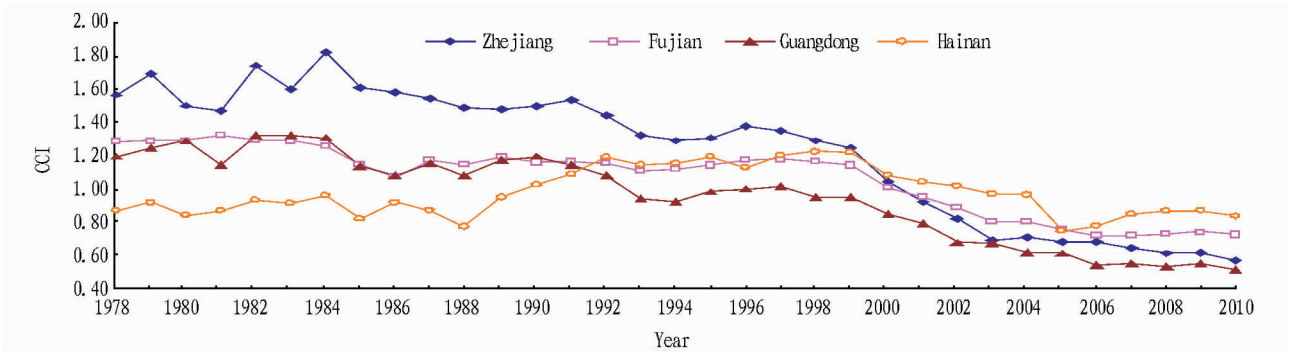

Fig. 4 Changes of the CCI in Zhejiang, Fujian, Guangdong and Hainan Provinces in 1978 to 2010

In the first place, for the whole country, from 1949 to 2010, the CCI takes on a rising trend. It once reached the well-off level in 1996 to 1999. It reached the well-off level again in 2010, but there is a still long way to get to the richness level;

Next, the CCI in those main producing regions is relatively high and reached the well-off level in 2010, and some provinces even get to the richness level. In main sales regions of grain, the entire CCI is low and has an obvious trend of decline, especially in Guangdong, Zhejiang and Fujian provinces. In grain balancing regions, the CCI is generally low, and most provinces are still at subsistence level.

3.2 Discussions Researches have indicated that the Cropland Contribution Index model can simply and rapidly reflect the relation between regional cropland, grain and population. Since the total grain yield in a region is used, the importance of cropland to grain production is stressed. In addition, it stresses the importance in raising the per unit area yield and multiple crop index through increasing inputs. Furthermore, the use of simple evaluation methods makes calculation become simple and feasible. Thus, the CCI model can be applied as a method to rapidly find out regional cropland-grain-population relationship.

The scope of application of the CCI model is wide. It not only can be used in the scope of whole country, but also can be applied in a small administrative village. Nevertheless, since the CCI directly uses total grain yield in a region as a calculation factor, it is difficult to reflect the regional cropland-grain-population relationship for pastoral areas or fishing areas which have lower dependence on cropland.

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and development of risk management tools for prices of agricultural products can decentralize price risks of agricultural products. On the basis of drawing on advanced experience of foreign countries in risk management tools of prices of agricultural products, and in combination with China' actual situations, we should gradually perfect such tools for management of price risk as forwards, futures and options of agricultural products. Relevant departments should provide certain education and training, guide farmers to better utilize the price risk management tools, and prevent risk of fluctuation in prices of agricultural products through such management tools as forwards, futures and options of agricultural products.

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