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Change trends of food provisions in China

Tian-Xiang Yue [a,b,*], Qing Wang [a], Yi-Ming Lu [a], Xiao-Ping Xin [c], Hong-Bing Zhang [c], Shi-Xin Wu [d]

[a] Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A, Datun Road, Anwai, 100101 Beijing, China
[b] Botany and Plant Sciences, Batchelor Hall/4133, University of California, Riverside, CA 92521, United States
[c] Institute of Agricultural Resources and Regional Planning, 12 South Zhongguancun Avenue 100081, Beijing, China
[d] Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, No.40, South Beijing Road, 830011 Urumqi, Xinjiang, China

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ABSTRACT

This paper analyzes change trend of farmland food production, grassland food provision, marine and inland aquatic products, and imports and exports in terms of calorie, protein and fat under consideration of Grain-for-Green program and urbanization. The analysis shows that annual mean production of farmland in the first period from the year of 1985 to 1995 was calorie of 1,179,629,173 million kcal, protein of 35,720 million kg and fat of 11,752 million kg on an average. In the second period from 1995 to 2005, farmland provision was 1,389,489,929 million kcal, 42,880 million kg of protein and 16,694 million kg of fat. Calorie production increased by 209,860,756 million kcal, protein by 7160 million kg, and fat by 4943 million kg annually. Annual grassland provision was 318,964.1 million kg of dry biomass during the period from 1982 to 1992 and decreased by 3159.3 million kg during the period from 1992 to 2002 on an average. Total aquatic production, including marine and inland aquatic products, has a considerable increasing trend since 1998 and reached to 49,017.17 million kg in 2004. Net imports, imports subtracting from exports, became bigger than zero greatly since 1995 and net imports of calorie increased to 121,460,766 million kcal, protein 7546 million kg and fat 5880 million kg in 2004. China supplied calorie for 1917 million persons, protein for 2193 million persons and fat for 1111 million persons under primary well-to-do life in 2004. China had a great problem of fat shortage. If foods on the first trophic level such as grain, beans and oil-crops were appropriately converted into foods on the second trophic level such as meats, China would find a solution for fat shortage problem and could supply food for 1534 million persons, 1500 million persons and 1411 million persons under primary well-to-do life, full well-to-do life and well-off life respectively in 2004 in terms of a model for balancing nutrients.

1. Introduction

According to the results from surface modeling of carrying capacity of terrestrial ecosystems in China (Yue et al., 2008), maximum amounts of calorie, protein, and fat, which could be provisioned by farmland ecosystems, are 4,155,620,000 million kcal, 116,643 million kg of protein, and 36,246 million kg of fat, respectively. Grassland ecosystems in China could produce 17,970 million kg of mutton, which amounts to 43,320,000 million kcal, 2139 million kg of protein and 3793 million kg of fat. Woodland ecosystems could provide 229,780,000 million kcal of calorie, 4299 million kg of protein and 8200 million kg of fat. Aquatic ecosystems in China could supply 50,930,000 million kcal, 7255 million kg of protein, and 2200 million kg of fat. In view of the threshold of carrying capacity (Yue, 2000), 78.9% of food produced by ecosystems can be used for human demand. An 11% production drop has been caused by natural disasters according to statistical analysis. Thus 3,101,800,000 million kcal, 90,247 million kg of protein, and 34,925 million kg of fat would be available for human consumption.

In terms of the food development strategy and food security goal of China (Lu, 2003), living standards during different development stages of China would go through primary well-to-do life, full well-to-do life, and well-off life (Table 1). Under the living standard of the primary well-to-do life, 2289 kcal, 77 g of protein, and 67 g of fat would be consumed daily by one person. Under the full well-to-do life, 2295 kcal, 81 g of protein, and 67.5 g of fat would be consumed daily by one person. Under the well-off life, 2347 kcal, 86 g of protein, and 72 g of fat would be demanded daily by one person. Under the primary well-to-do life, full well-to-do life, and well-off life, the human carrying capacity of calories could be 3765, 3755, and 3672 million individuals, protein could be 3265, 3096, and 2916 million individuals, and fat could be 1448, 1438 and 1348 million individuals, respectively. After the nutrients were balanced by improving the agricultural production structure, the human carrying capacity could

* Corresponding author. Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A, Datun Road, Anwai, 100101 Beijing, China. Tel.: +86 10 64889041, +1 951 827 6555; fax: +86 10 64889630, +1 951 827 4190.
E-mail address: yue@lreis.ac.cn (T.-X. Yue).

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Table 1
Nutrients consumed daily by one person under different living standards.

Living standard	Calorie (kcal)	Protein (g)	Fat (g)
Primary well-to-do	2289	77	67
Full well-to-do	2295	81	67.5
Well-off	2347	86	72

be 2029, 1914, and 1794 million individuals under the living standards of primary well-to-do life, full well-to-do life, and well-off life respectively.

The surface modeling of human carrying capacity provides an upper limit of population that could be supported by the food provision services of terrestrial ecosystems in China, which are independent of economic and social factors. Change trend of food production in China deals with effects of climate change, land-use change, Grain-for-Green program, fisheries catches along Chinese coast and the importing of food.

2. Farmland change

Statistics, published by the State Statistical Bureau, have underreported area of farmland. The State Statistical Bureau reported 96.846 million ha of farmland in 1985, 94.974 million ha in 1995 and 130.039 million ha in 2005. Farmland estimates derived from remote sensing of satellite were respectively 183.676, 181.301 and 179.688 million ha in 1985, 1995 and 2005. Annual surveys of agricultural ministry since 1985 also exceeded the statistics 34% on an average (Table 2). The comprehensive land survey conducted in 1996 by the ministry of land and resources reported 130.039 million ha of farmland and 10.0 million ha of horticultural land (Lichtenberga and Ding, 2008). Farmland area from annual survey of agricultural ministry in 1996 was 149.265, which was 9.226 million ha more than the one from the comprehensive land survey conducted by the ministry of land and resources in 1996, of which the difference was 6.2%. The interpretation of the farmland from satellite image had a difference of 21.9% comparing with the surveys conducted by agricultural ministry on the average. It might be concluded that the remotely sensed data of the farmland had an error of 21.9%. We take the annual survey of agricultural ministry as the 'true' data approximately, i.e. 154.651 million ha in 1985, 143.196 million ha in 1995, and 156.988 million ha in 2005.

2.1. Grain-for-Green program

Grain-for-Green program is one of the world's largest environmental set-aside programs, of which the main objective is to restore the country's forests and grasslands to prevent soil erosion. Program designers have made the steepness of the slope, one of the main criteria on which plots are selected, for inclusion into the Grain-for-Green program (Xu et al., 2006). The steepness criterion means that the program targets land with a slope more than 25°.

The Grain-for-Green program has been divided into three phases. The period from 1999 to 2001 is the experimental phase, from 2002 to 2010 the construction phase and from 2011 to 2020 the consolidation phase. By the end of 2001, 1.206 million ha of farmland had been converted into forestland or grassland and 1.097 million ha of barren land had been afforested. Before 2011, 14.667 million ha of farmland would have been converted to forestland or grassland, for which almost all farmland with a slope more than 25° would have been converted and 2.667 million ha of cultivated desertification land have been converted to grassland; 17.333 million ha of barren land would have been afforested. During the consolidation phase, scientific management of the converted land and afforestation land would be strengthened to keep the achievement of Grain-for-Green program, for which 72.933 billion kg of grains and 11.515 billion of RMB have been planned (Li, 2006).

In 1999, the pilot program was first experimented in three provinces, Gansu, Shaanxi and Sichuan; 0.381 million ha of farmland was converted into forestland and 0.066 million ha of barren land was afforested. In 2000, the experimented area was expanded to 17 provinces; the converted farmland and the afforested barren land were respectively 0.41 million ha and 0.449 million ha. In 2001, 20 provinces were involved in the experiment; 0.42 million ha of farmland was converted into forestland and 0.563 million barren land was afforested (Table 3). In 2002, the Grain-for-Green program was overall launched in China. By 2005, 9.001 million ha had been withdrawn from farmland and planted with trees or converted to permanent grassland.

Farmers receive compensation payments of RMB1575 per hectare in south China and RMB1050 per hectare in north China for the land they dedicate to those soil conservation measures. Participating households enjoyed a faster increase in assets such as livestock. In some local areas, agricultural income increased due to more intensive agricultural production on non-program plots, such as using better seed stock, switching from single to multi-cropping or increasing livestock production.

2.2. Urbanization

Statistics from the Ministry of Construction of China showed that urbanization level in China increased from 17.9% in 1978 to 40.5% in 2003, which demonstrated a growth twice as fast as the world average in the same period (Chen, 2007). Recognizing urbanization's central role in further economic growth and social development, China will continue to give high priority to urbanization in the coming decades. According to National Report of China Urban Development (2001–2002) (Editorial Committee of National Report of China Urban Development of China Mayor Association, 2003), the urban population proportion would be 56.22% in 2020. The urbanization is characterized by extensive establishment of development zones in and near cities and drastic expansion of rural construction driven by the development of township–village enterprises.

The built-up areas interpreted from satellite images have a much higher accuracy comparing with other land-use types such as farmland, grassland and forestland. The interpretation of remotely sensed data from Advanced Very High Resolution Radiometer (AVHRR) indicates that built-up area was 5.291 million ha in 1985, 6.579 million ha in 1995 and 19.136 million ha in 2005. Built-up area increased by 13.845 million

Table 2
Farmland area from different sources (unit: million ha).

Year	Interpretation from satellite image	Investigation data of agricultural ministry	Statistics
1985	183.676	154.651	96.846
1995	181.301	143.196	94.974
2005	179.688	156.988	130.039

Table 3
Converted farmland and afforested barren land in the Grain-for-Green program in China (million ha).

Year	Converted farmland	Afforestation on bare land	Total
1999	0.381	0.066	0.448
2000	0.405	0.468	0.872
2001	0.420	0.563	0.983
2002	2.647	3.082	5.729
2003	3.367	3.767	7.133
2004	0.667	3.333	4.000
2005	1.114	1.321	2.435
1999–2010	14.667	17.333	32