Sustainability **2014**, *6*, 4028-4041; doi:10.3390/su6074028

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

The Transition of Farmland Production Functions in Metropolitan Areas in China

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Received: 16 March 2014; in revised form: 12 June 2014 / Accepted: 13 June 2014 / Published: 26 June 2014

Abstract: In metropolitan areas of China, farmland functions have undergone tremendous changes due to rapid urbanization and rising income per capita in the past three decades. This study examines tempo-spatial changes in the farmland functions, using a case study of the Beijing metropolitan area. The results indicate that: (1) during the past three decades, agricultural production experienced two transitions, in the years 1992 and 2003; (2) In terms of spatial differences, farmland functions of food production in Near Suburb significantly weakened. Middle Suburb produced the largest share of vegetables, while Far Suburb had the highest number of recreational farms. This case study may provide insights for large cities in China or other developing countries.

Key words: farmland production function; transition; metropolitan area; Beijing

1. Introduction

Farmland is one of the most important land-use types, which not only provides basic living goods, but also presents non-productive functions and services, such as recreation, cultural, and aesthetic functions [1–6]. Because of these various demands for functions and services provided by farmland, there are often some conflicts [7].

In peri-urban areas, the conflicts are more acute, since farmland is exposed to the pressures and tensions of diverse demands for multiple goods and services of local residents, with increases in urban population and per capita income [8–10]. The pressures, or tensions, vary across countries. In the developed world, the peri-urban areas are undergoing major transformation with the rise of the post-Fordist society [9] and consumption-oriented functions are added to the traditional

production-oriented agriculture [10,11]. For instance, in the peri-urban areas of Western European countries, large areas of grassland converted from farmland are used for horse-boarding and horse-riding facilities [6]. Similarly, in the United States, some urban residents seek relief from congested urban places and scenic beauty, open space, and a different lifestyle in rural places [12–14]. The needs and preferences of urban residents increase the pressures on farmland use on the fringes of urban areas. Therefore, in developed countries, one of the most important challenges (or opportunities) may be to design peri-urban agriculture to be multifunctional, including supplying food and fiber, providing recreational resources, and protecting the environment [15].

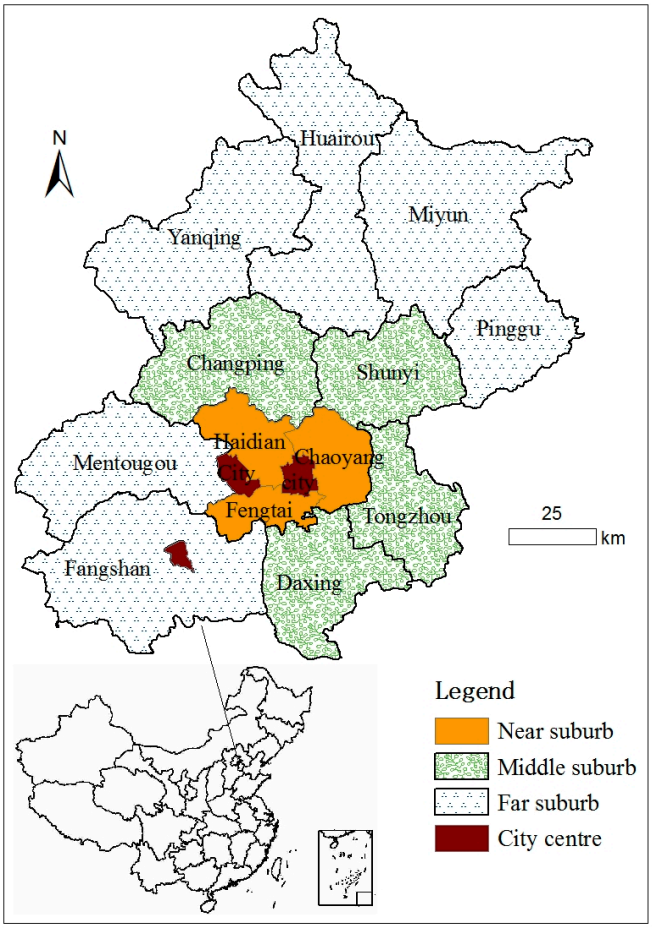
In the developing world, the importance, characteristics and potential of peri-urban agriculture have received attention only recently [16]. The production function remains an important role in the peri-urban areas of many cities, such as those in regions of sub-Saharan Africa, Latin America, and Southeast Asia. The existing research mainly focuses on improving the livelihoods of the poor in urban areas by providing food for consumption [15]. At present, with rapid growth of income per capita, consumption mode and demands from land function are witnessing a rapid transformation in many cities, especially in the areas around large cities. As a result, modern cash crops, vegetable production, and recreational farming are receiving increasing attention by rural and urban residents and governments [16–18]. In this context, it is necessary to examine the changes in land function, which may provide some insights for farmland use in metropolitan areas in the future. At present, few, if any, studies have focused on the function transition of farmland over several decades in metropolitan areas in the developing countries. To fill this gap, this study will examine the geography of farmland function evolution during the last three decades, focusing on Beijing, China. The evolution process is presented as a case study, which can be compared with farmland functions in the peri-urban areas of large cities in China or other developing countries.

2. Study Area

Beijing is the capital of China and the economic center of North China (Figure 1). In this study, Beijing refers to the Beijing Municipality (simply called Beijing subsequently), which is a provincial administrative unit with 16 districts/counties and covers an area of 16.8 thousand km^2. According to Beijing's Urban Master Plan for 2004–2020, Beijing is divided into three suburb categories: Near Suburb, Middle Suburb, and Far Suburb (Figure 1). In the division, geographical and historical factors, and levels of economic development are considered.

From 1978 to 2010, GDP (Gross domestic product) increased approximately 25-fold and the permanent population rose from 8.7 to 19.6 million in Beijing. The increase in income per capita for urban residents caused the Engel's coefficient to decrease to 32% in 2010 [19]. These factors exerted significant impacts on Beijing's peri-urban agriculture. The impacts are two-fold: (1) built-up areas expanded at the expense of conservation land and farmland, especially owing to the rapid growth of industrial land in rural areas and the construction of many economic development zones [8], and (2) changes in peri-urban agriculture functions; thus, both the quantity and function of farmland witnessed dramatic changes during the same time-frame.

Figure 1. The regional divisions of Beijing mainly based on Beijing's Urban Master Plan.



Note: The Plan was approved by the State Council in 2005.

3. Data and Methodology

The socio-economic data in this study was drawn mainly from *Beijing Statistical Yearbook* spanning the period from 1986 to 2012 [19]. Other data was collected from the *Investigation on the Current Situation of Recreational Agriculture of Beijing* (2005) [20], and *The Office of the Sixth National Census Beijing* (2010) [21].

It is very difficult to qualify different functions of farmland mainly because of two reasons: First, farmland functions are very diverse and numerous, including cultural, ecological and social functions. Second, farmland functions are intimately inter-related [2,3]. For instance, there is a close relationship between the function of food production and economic function. Therefore, this study mainly focuses on changes in farmland production functions, since the functions have experienced a dramatic change during recent decades, and production still plays an important role in the peri-urban areas in the developing countries. Indicators, including sown area and production quantities, are used to measure the production functions in this study.

Agritourism, which includes various activities that include picking fruits and vegetables, fishing, tasting farm's special food, *etc.*, has recently received increasing attention from local governments and some agricultural enterprises in Beijing. Agritourism is included in this study because it also has a function of food production. The numbers of recreation farms, and the visitors received by them, are

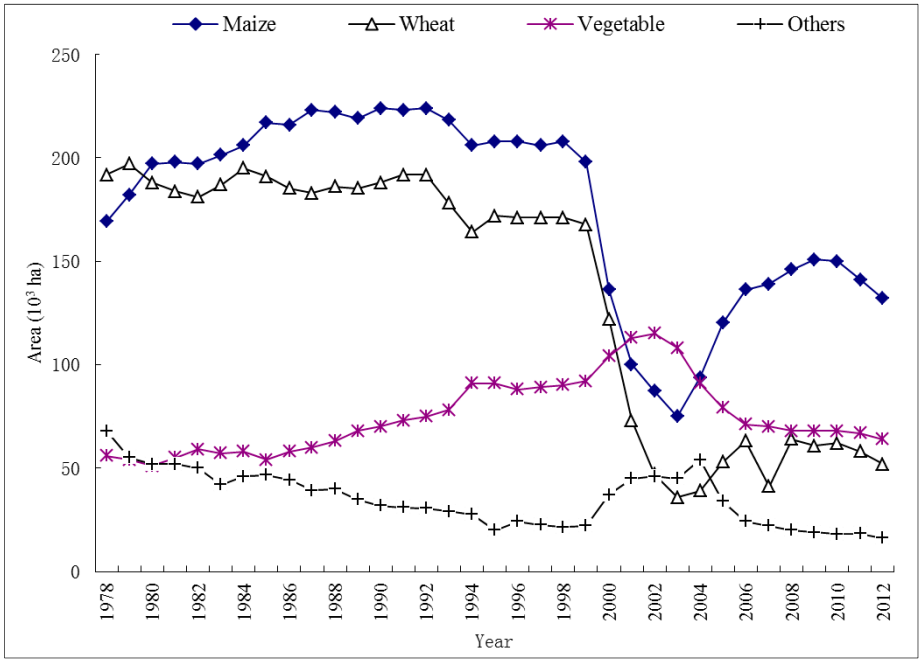
used to measure changes in the recreation function. In this study, ecological and socio-cultural functions will not be discussed, given that most of the benefits in their categories are not easy to capture in conventional, market-based economic analysis [2].

4. Results

4.1. Grain Production

In Beijing, the main grain crops are wheat and maize. Since 1986, the sown area for these two crops has usually occupied more than 80% of the whole grain area in Beijing (Figure 2). During the last three decades, the sown area of grain has changed dramatically. During the period 1978–1998, the sown area of grain, mainly characterized by the crops of wheat and maize, decreased slowly. From 1998 to 2003, the sown area of grain declined drastically from 5.61 million ha to 1.41 million ha. Since 2004, the sown area of maize has increased quickly, while the sowing area of wheat has increased slowly.

Figure 2. Changes in sown areas of different crops in Beijing, 1978–2010 [19].



Largely resulting from changes in sowing area, grain production also varied significantly. Grain production function decreased during the period 1993–2003. Although it increased slightly since 2003, the grain production in 2012 was still very low and about 44% of that in 1995 (Table 1).

In addition, there were obvious spatial differences in the changes of sowing area. In Near Suburb, the sowing area for grain production sharply decreased by 99%, from 29.82 thousand ha in 1985 to 0.31 thousand ha in 2010. Actually, in Near Suburb, there was very little farmland for grain production.

Similarly, grain production had significant spatial differences. In Near Suburb, grain production decreased by 91% (Table 1). In both Middle Suburb and Far Suburb, grain production decreased significantly. In 2012, the grain production in Middle Suburb and Far Suburb were, respectively, 41.9% and 52.2% of that in 1995. Even in Middle Suburb or Far Suburb, changes in grain production greatly varied across counties/districts (Table 1).

Table 1. Grain production (10^6 kg) in different counties/districts in Beijing, 1985–2012.

	District/county	1985	1995	2000	2003	2012
Near suburb	Chaoyang	82.4	84.6	39.2	2.2	1.6
	Fengtai	16.0	16.7	8.4	1.2	1.0
	Haidian	43.1	41.2	29.7	4.4	3.1
	In sum	141.5	142.5	77.3	7.8	6.3
Middle suburb	Tongzhou	379.9	516.3	223.9	122.8	169.5
	Shunyi	426.5	451.0	238.9	88.4	208.8
	Changping	156.3	185.6	117.6	28.6	21.1
	Daxing	267.7	347.0	231.1	115.4	229.5
	In sum	1230.4	1499.9	811.6	355.2	679.2
Far suburb	Fangshan	237.7	317.7	207.3	81.8	128.8
	Mentougou	15.0	10.4	5.5	1.1	2.5
	Huairou	111.9	139.6	78.4	30.3	57.4
	Pinggu	154.7	169.3	71.6	30.2	68.9
	Miyun	135.4	136.8	54.2	12.3	97.7
	Yanqing	160.6	148.0	146.2	61.6	125.9
	In sum	815.2	921.7	563.1	217.2	476.2
Total		2187.2	2564.2	1452.0	580.3	1116.1

Source: Beijing Statistical Yearbook (1986–2012) [19].

4.2. Vegetable Production Function

During the period 1980–2003, the sown area of vegetables experienced an increase in growth in Beijing (Figure 2). As a result, during this the period, the total production of vegetables also increased rapidly, especially since 1985. In 2003, the vegetable production was about 99 times greater than that in 1985 (Table 2). Since 2003, both the sowing area and the output of vegetables decreased dramatically.

Vegetable production also varied across counties/districts (Table 2). In 1985, the proportion of vegetable production in Near Suburb was the highest among three suburb categories, about 46.8% of the total production in Beijing. However, in the suburb, production has decreased sharply since 1995. After 1995, Middle Suburb had the highest share in the three suburb categories. In 2012, the share touched 69%. Similarly, the share of vegetable production in the Far Suburb increased from 21.5% in 1985 to 30% in 2012.

Table 2. Vegetable production in different counties/districts (10^6 kg) in Beijing, 1985–2010.

	District/county	1985	1995	2000	2003	2012
Near suburb	Chaoyang	8.4	224.8	174.2	110.3	7.6
	Fengtai	10.2	225.7	143.5	56.6	4.0
	Haidian	6.1	192.9	107.3	50.8	23.8
	In sum	24.8	643.4	425.0	217.7	35.4
Middle suburb	Tongzhou	5.1	715.6	866.3	914.4	632.4
	Shunyi	2.8	774.5	1009.8	1169.9	446.2
	Changping	2.1	92.4	127.5	108.0	41.6
	Daxing	6.8	992.4	1112.6	1321.1	816.6
	In sum	16.7	2574.9	3116.2	3513.4	1936.8

Table 2. *Cont.*

	District/county	1985	1995	2000	2003	2012
Far suburb	Fangshan	2.8	163.2	239.7	252.2	169.8
	Mentougou	1.4	29.5	21.9	20.1	3.1
	Huairou	1.4	49.2	54.2	453.5	37.5
	Pinggu	2.6	348.7	360.7	39.1	252.7
	Miyun	1.5	149.5	183.1	345.4	257.6
	Yanqing	1.8	199.9	481.0	431.8	106.2
	In sum	11.4	940.0	1340.6	1542.1	826.9
Total		52.95	4158.3	4881.8	5273.2	2799.1

4.3. Agritourism

In Beijing, agritourism began in the late 1980s. In 1996, the number of recreation farms was 119 and the visitors to these sites numbered about three million [22]. In 2005 and 2010, the numbers of farms increased to 1010 and 1300 respectively.

Like the growth of recreation farms, the number of visitors also increased quickly. During the period 2005–2010, there was a doubling in both the number of visitors and revenue from such farms (Table 3).

Table 3. The changes in recreational farms in Beijing, 2005–2012.

	District	Number of recreation farms		Visitors received (10^6)		Total income (million Yuan)	
		2005	2012	2005	2012	2005	2012
Near suburb	Chaoyang	13	14	1.4	1.3	192.47	408.0
	Fengtai	15	10	0.2	1.2	20.06	22.0
	Haidian	136	58	0.4	0.3	49.2	66.4
	In sum	164	82	2.0	2.8	261.73	496.4
Middle suburb	Tongzhou	30	47	0.2	0.7	15.55	102.1
	Shunyi	61	69	0.7	0.8	77.15	133.8
	Changping	145	201	0.8	2.0	70.79	320.6
	Daxing	72	108	1.0	2.2	95.46	182.4
	In sum	308	425	2.7	5.7	258.95	738.9
Far suburb	Huairou	112	232	1.3	1.8	52.84	139.9
	Pinggu	136	207	1.1	3.4	69.07	203.8
	Miyun	142	142	1.2	3.2	50.78	298.2
	Yanqing	32	35	0.1	0.5	14.44	46.2
	Mentougou	48	48	0.1	0.5	19.91	77.8
	Fangshan	68	108	0.4	1.6	59.96	170.3
	In sum	538	780	4.2	11.0	267	936.1
	Total	1010	1300	8.9	19.3	787.68	2171.5

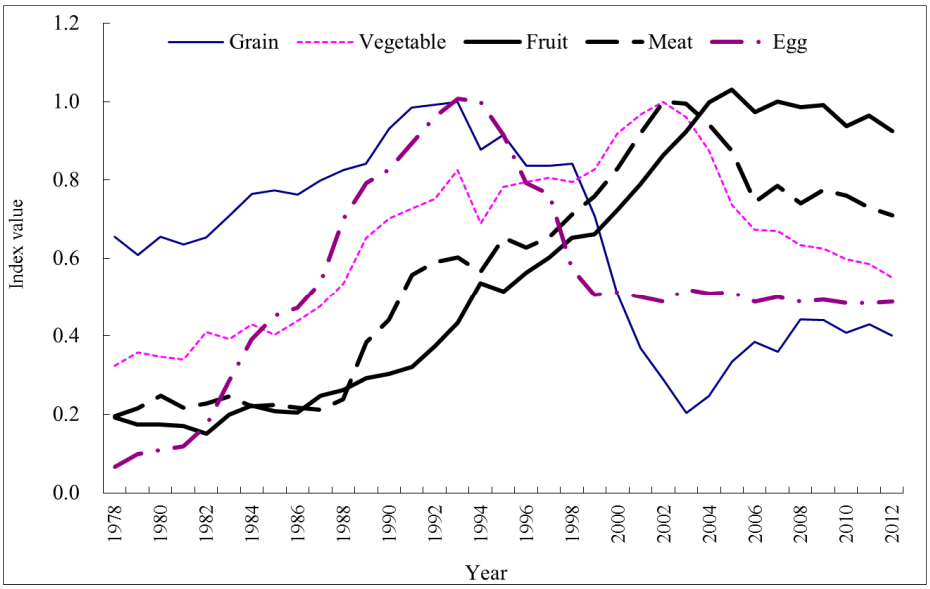
Note: Yuan is the Chinese currency; Source: Beijing Statistical Yearbook (1986–2012) [19].

These changes varied across districts/county. In Near Suburb, the number of recreation farms decreased significantly, from 164 in 2005 to 82 in 2012. In contrast, the Far Suburb experienced the highest growth rate in recreation farms between 2005 and 2010, increasing by 45%, from 538 in 2005 to 780 in 2010 (Table 3).

4.4. The Evolution of Farmland Function

In the past three decades, farmland functions have undergone tremendous changes in Beijing. Before 1992, food production farmland had been increasingly strengthened. Major agricultural crops were experiencing a growing trend, including grain yield, vegetables, meat, eggs, and fruit. During the period 1992–2003, grain production decreased dramatically. Similarly, egg production also showed a sharp decline and the production of vegetables, meat and fruit all decreased significantly (Figure 3). However, since 2003, grain production and sown areas have again shown an increasing trend (Figure 3). At the same time, the development of recreational farms has received increasing attention and the number of recreation farms and their revenue rose rapidly.

Figure 3. The changes in food production.



Note: For one type of food, the index value is calculated with the value divided by maximum value, to ensure the index value between 0 and 1.

In terms of spatial distribution, in Near Suburb, the functions of grain production and vegetable production have weakened, mainly due to the expansion of built-up areas. The number of recreational farms has also decreased, in spite of an increase in income from recreation farms in the suburb. Middle Suburb provided the largest share of vegetable production and grain production since 1995. Most of the recreational farms, and visitors, are concentrated in Far Suburbs.

5. Discussion

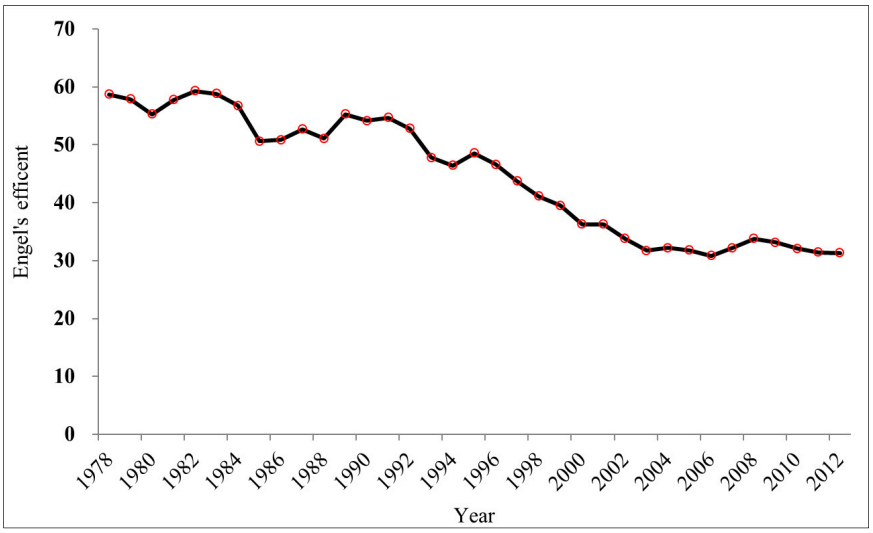
Farmland functions are services and products provided by land, which can be explained by the theory of supply and demand. Thus, changes in farmland function can be explained by supply and demand principles. The demand of local residents includes diet structure (especially for urban residents) and food preferences, and the supply capacity of agriculture production may be affected by agricultural labour input, changes in farmland, *etc.* [23].

5.1. The Demand of Urban Residents

5.1.1. Changes in the Engle's Coefficient

Engel's coefficient can reflect the structure and level of consumption [24]. When the coefficient is declining, the percentage of expenditure on food will decrease. Before 1992, the Engle's coefficient for urban residents was more than 50% in Beijing (Figure 4). This meant that survival consumption was the dominant consumption mode. In this stage, it was very important to provide enough food for local residents, which led to the rapid growth of main agricultural production, in particular, grain, eggs, and chicken.

Figure 4. Changes in Engel's coefficient, 1978–2012.



Source: Beijing Statistical Yearbook (1986–2012) [19].

Between 1992 and 2010, the Engle's coefficient steadily declined. As such, the diet structure of local residents experienced significant changes. Vegetables and meat consumptions per capita increased. In contrast, egg and chicken consumption per capita decreased during this period. In 2003, the Engle's coefficient decreased to about 30% in Beijing. The expenditure of urban residents shifted from food to recreational, or industrial products. This is one of the important factors causing the rapid development of agritourism.

Even so, in Beijing, as the second largest city in China, the Engle's coefficient for urban residents is still much higher than the average levels of many developed countries. For instance, in Japan, the expenditure share of food declined from 62% in 1920 to 23% in 2001 [21], and the share in the United States of America declined from 45% in 1900 to under 15% in 2000 [25]. Consequently, the development of recreation farms is still at low level in Beijing, and the income of agritourism is only 7.7% of the income from the agricultural sector in 2010 [19].

5.1.2. The Demand for Agritourism

As discussed above, due to per capita income rising and transportation improvement, urban residents would like to access beautiful natural scenery and enjoy the fresh air of the suburbs. Thus, tourism-based farm diversification in the countryside has been considered as an engine of rural development and

regeneration [26]. In the Beijing metropolitan area, agritourism is witnessing rapid development, because of diverse factors. For instance, in Beijing, private cars have become the main transportation mode for urban residents to access natural scenery. According to an investigation by Wang (2011), 61% of tourists travelled by private car [22]. In addition, in the case of Beijing, there are two particular factors causing the development of agritourism.

Firstly, in the large built-up areas in China, building and population densities are very high [27]. In 2010, urban population density was approximately 23.4 thousand/km^2 in downtown Beijing [18]. Public green spaces are not sufficient to meet the recreational demand of urban residents [14,18]. During vacation time, most public gardens are crowded in the downtown area. Thus, it becomes an important recreation mode for many urban residents to take a vacation in the countryside. In 2010, the number of people who visited recreational farms reached 17.7 million in Beijing (Table 3), more than the total urban population of 16.9 million [20], because some residents visit more than once and people from other provinces travel here to visit.

Secondly, in China, the number of vacation days largely increased, which may also promote the development of agritourism. On 1 May 1995, China implemented the policy of a two-day weekend. In 1999, the State Council promulgated a seven-day vacation for each of the three national festivals; National Day, Spring Festival, and Labor Day. In 2007, the three traditional festivals, Qingming Festival, Dragon Boat Festival, and Mid-Autumn Festival, became public holidays in China. With an increase in vacation days, urban residents have more time to travel in the countryside. For instance, according to the study from Wang [22], in 2009, 73% of tourists aspired to travel to the countryside on a two-day weekend. However, in Beijing, agritourism originated very recently, and the development of agritourism is nascent and cannot meet the demand of tourists [20,28].

5.2. Changes in the Supply Capacity of Agricultural Products

Agricultural production has close relationships with the changes in farmland areas and rural labor input. In addition, the competition from more extensive regions, because of a decline in transportation costs, also affects the mode of agricultural development.

5.2.1. Decrease in the Supply Capacity Due to Farmland Loss

During the past three decades, farmland has decreased by 45.6%, from 4290 km^2 in 1978 to 2317 km^2 in 2010. The main reasons behind this decrease are the expansion of built-up areas, conversion to grassland and forest due to the implementation of "Grain for Green policy", and adjustments in agricultural structure. For example, during the period 1999–2003, the sown area used for grain production fell dramatically, because of the conversions of farmland to urban built-up areas (273 km^2), to grassland and forest (224 km^2) and to orchard (238 km^2) [29–31]. Currently, urban land expansion has become the most important factor causing farmland loss [12,13].

Moreover, the farmland loss showed some significant spatial differences. In Near Suburb, farmland declined at the highest rate. From 1984–2008, farmland decreased by 71.5%, from 477 km^2 to 106 km^2, and in Far Suburb, farmland decreased by 34.0%, from 1593 km^2 to 1052 km^2 [19].

Rapid fall in farmland largely weakened land services and the capacity of supplying agricultural commodity goods. Since 2000, the sowing areas for all types of agricultural production have decreased

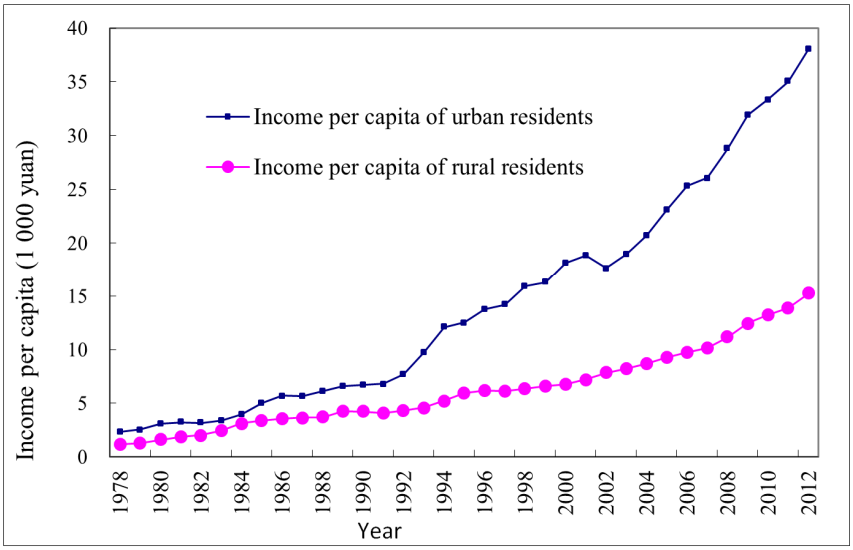
significantly, including grain, vegetable, melon, oil-bearing crops and flowers. After 2003, the sowing area of grain started to increase again. However, compared with 1985, the sowing area of grain in 2010 decreased by 47%, from 2187 million kg to 1163 million kg.

5.2.2. Agricultural Production Supply Affected by Rural Labor Loss

As discussed above, since 2003, the sowing area for grain (wheat and maize) has had an increasing trend. This is closely related to the shift of rural labor to non-agricultural sectors. In recent years, the opportunity cost for the rural workforce has increased rapidly (the opportunity cost is the money rural labors may earn if they worked instead), which causes the substantial shift of workforces from agriculture to non-agricultural sectors [32]. The shift of rural workforces largely affects labor-intensive farming [33], such as vegetable production. Because the production of maize and wheat can save labor, the sowing area for grain started to increase after 2003. The labor shift has already occurred in the developed countries. In Japan, the share of agriculture in employment was 5% in 2000 [24]. Meanwhile, in the United States of America, it was less than 3% in the same year [25].

Since it is difficult to express the changes of rural labor opportunity cost, we use the income level of urban residents to explain it. Figure 5 shows that income per capita of urban residents increased very quickly, indicating there are two important turning points, the years 1992 and 2003, which divided the process into three periods. After 2003, the increase rate was the highest, followed by the period between 1992 and 2003. This was very similar to the transitions of farmland functions as discussed above. In contrast, the income per capita of rural residents was much lower than that of urban residents, which could explain a shift of labor from rural to urban areas.

Figure 5. Changes in income of rural and urban residents (Yuan/person) in Beijing, 1978–2012.



Note: The income is calculated according at constant price in 2010; Source: Beijing Statistical Yearbook (1986–2012) [19].

In addition, the increase in area sown with maize was much higher than that of wheat. One of the main reasons may be the increase in the demand of maize due to the development of animal husbandry. This is very similar to the trend of the whole country. At the country level, the sowing area of wheat

decreased by 16.9%, while the area of maize increased by 62.8% from 1978 to 2010, especially in North China and Northeast China. For instance, from 1995 to 2010, the sowing areas of wheat decreased by 95.6%, 95.6% and 74.9% in, respectively, Liaoning, Jilin and Heilongjiang [34].

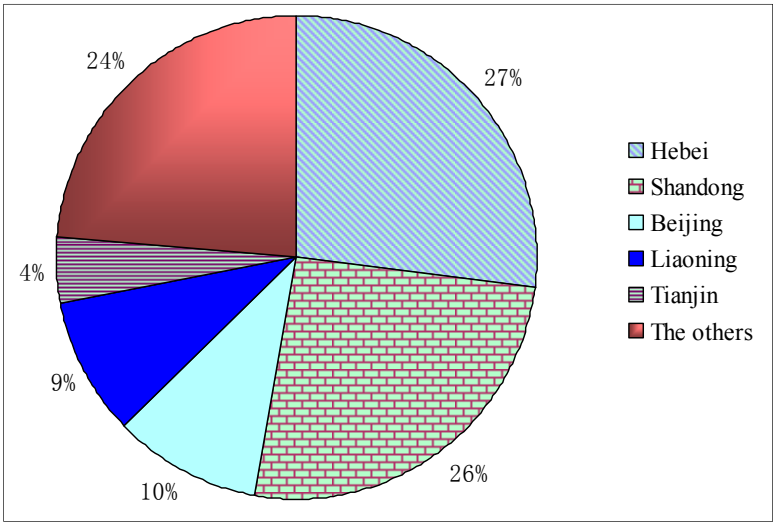
5.2.3. Agricultural Production Supply from Other Regions

Land functionality is often determined by both local and contextual factors synchronously [6]. A substantial decline in transportation cost enlarges the extent of the market for agricultural products to meet the demand of local residents. This gives rise to the competition between local and more distant regions, and affects functions of local agriculture. Currently, the total yield of grain is very low in Beijing. In 2010, the total yield of grain was 1.13 billion kg, while local rural residents numbered 2.75 million. Thus, the grain per rural resident is 409 kg in Beijing. The grain can only meet the demand of local rural residents, since per capita grain-equivalent consumption is near 500 kg at present [35].

The grain for urban residents has to be imported from other provinces.

The vegetable production in Beijing is affected by the other provinces, such as Hebei, Shandong and Liaoning (Figure 6). According to the investigation data during the period from December 2009 to November 2010, the amount of vegetables provided by Beijing only accounted for 10% of the total consumption, while that of Hebei and Shandong respectively accounted for 27% and 26% [36]. Owing to scarce land and labor resources, peri-urban vegetable and food production is difficult to compete with other regions, due to decreasing transportation and packaging costs [16]; a trend evident in Beijing where vegetable production has decreased dramatically since 2003.

Figure 6. The major provinces providing vegetables in Beijing, 2009–2010 [36].



6. Conclusions

In the past three decades, farmland functions have undergone two transitions in Beijing, marked by the years 1992 and 2003. Before 1992, survival consumption was the dominant consumption mode in Beijing, when the Engle's coefficient for urban residents was over 50%. In order to meet the survival consumption demand of local residents, major agricultural production experienced a growing trend, including grain yield, vegetables, meat, eggs, and fruit.

During the period 1992–2003, the Engel's coefficient had decreased to about 30%. Thus, the diet structure of local residents changed quickly, characterized by increases in vegetable and meat consumption per capita, while grain production fell dramatically. Like grain production, egg production also witnessed a sharp decline.

After 2003, the spending of residents shifted from agricultural goods to non-agricultural goods, or recreational services. Furthermore, an increase in vacation days and the numbers of private cars further spurred the development of agritourism in the study area, especially in the Far Suburb.

In addition, it is noticeable that grain areas have increased sharply since 2003. The main reason for this is that grain production (including wheat and maize) is more labor efficient, compared with labor-intensive farming, such as vegetable production. Thus, vegetable production declined dramatically.

Lastly, changes in farmland functions varied significantly across suburbs. In Near Suburb, the functions of grain production, vegetable production, and agritourism have significantly weakened during the past three decades, mainly due to the conversion of farmland to built-up areas and garden plots. Middle Suburb became the largest proportion of vegetable production and grain production in Beijing. From 1985 to 2010, the proportion of vegetable production in Middle Suburb rose from 32% to 69%. Far Suburb had the largest proportion of recreation farms.

In peri-urban areas of Beijing, farmland functions are experiencing dramatic changes. Similar to what has occurred in developed countries, consumption-oriented functions are added to traditional production-oriented agriculture, a shift which deserves more attention in land use planning or urban planning scholarship.

Acknowledgements

This study is financially supported by the Natural Science Foundation of China (Grant No. 41271119 and No. 91325302). I am grateful for the anonymous reviewers for their insightful comments and recommendations.

Conflicts of Interest

The author declares no conflict of interest in this study.

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