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Changes in China's Grain Production Pattern and the Effects of Urbanization and Dietary Structure

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Abstract: Grain production patterns are the basis of a nation's food security. Since China's reform and opening-up began in 1978, China's urbanization process, driven by rapid social and economic development, has accelerated steadily. During this time, the dietary structure of urban and rural Chinese has also changed significantly. Accordingly, grain production patterns have undergone major changes. First, traditional grain production patterns in the north and the south have changed, and the food production center has shifted toward the north. In 1980, the grain yield of southern provinces accounted for 60% of China's total, while that of northern provinces accounted for 40%. In 2015, the grain yield of southern provinces accounted for 56% of the total, while that of northern provinces accounted for 44%. Second, grain production by regions of the country is "shrinking in the east but expanding in the central regions," meaning that grain production in eastern coastal provinces has decreased significantly, while that in the central region has expanded. The proportions of the nation's total grain production from the eastern, central and western regions were 38%, 36% and 26%, respectively, in 1980. These had changed to 27%, 46%, and 27%, respectively, in 2015. Third, the spatial centralization of grain production has increased. The total grain yield of 13 major grain-producing provinces and regions in the country accounted for 69.27% of nation's total in 1980, and it had reached 76.18% in 2015, showing that the impact of major grain-producing areas on national food security has increased. The influence of rapid urbanization on grain production areas shows remarkable regional differences. As the level of urbanization has increased, build-up land occupies a large number of high-quality farmland, especially in east coastal provinces and thus the grain planting area decreased obviously. The effect of dietary structure changes on grain production patterns was evident in two ways. On the one hand, as dietary diversity has increased, total grain consumption has decreased. The reduction in the proportion of planting area for grain crops to total crop planting area dropped from 82% in 1980 to 68% in 2015, making this change in total grain consumption evident. On the other hand, the ratio of grain for human consumption declined as the ratio of grain consumed by animals increased. The reduction in the proportion of rice and wheat grown and an increase in the proportion of feed grain production (mostly maize) from 20% in the 1980s to 36% in 2015 makes this change in grain production and consumption evident. In the future, with the establishment of national functional areas for grain production, the spatial pattern of grain production will return, while the demand for feed grains will continue to increase but with the space for expansion limited.

Key words: grain production; spatial patterns; urbanization; dietary structure; China

1 Introduction

Grain production security is an important guarantee of national food security and relies on a reasonable production

layout. Therefore, changes in grain production patterns have been the focus of many studies over a long period of time (Huang, 1995; Lu and Lv, 1997; Wu, 2000; Gao, 2005; Yin

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et al., 2006; Lu and Mei, 2007; Deng et al., 2013).

Existing studies have shown that China's spatial pattern of grain production has changed from the traditional "transferring grain production from the south to the north" to "transferring grain yields from the north to the south". The center of grain production has shifted from the south to the north and from the eastern region to the middle and western regions (Guo, 1992; Cheng and Zhang, 2005; Wang and Liu, 2009). Changes in spatial patterns of grain production are influenced by many factors, such as differences in regional comparative advantages, the structural transformation of agriculture, the impact of economies of scale on grain production (Li, 1996a; Li, 1996b), per capita arable land resources, the total number of agricultural laborers and their education levels, and inputs of fertilizer and agricultural machinery (Wu, 2000; Gao, 2005; Yin et al., 2006; Lu and Mei, 2007). Increasing regional centralization of grain production is another change in the spatial pattern change of China's grain production (Tan et al., 2012; Zhou and Cheng, 2015; Chai and Zhu, 2016). The regional centralization of wheat production is the greatest, while that of rice and corn production has undergone a U-shaped change process. Does this mean that China's regional specialization process of grain production is accelerating or that it is affected by other factors?

Whether it is a "northbound shift" or "westward expansion", China's grain production pattern shows a spatial disparity with the suitability of the country's natural conditions for agricultural production. This disparity has increased the pressure on water resources in the northern and mid-western regions and exacerbated the risk to grain production safety while causing serious ecological problems (Liu et al., 2007).

Since the 21st century began, China's grain production capacity has been steadily increasing and so has the scale of grain production, which together have enabled the nation to achieve an overall balance of food supply and demand. However, with the increase in urbanization and as the dietary structure of urban and rural Chinese becomes more diverse, China's grain market cannot meet the demand for diversified consumption, leading to the phenomenon referred to as "simultaneous increase in three volumes" (i.e., production volume, import volume and inventory volume). The mismatch of "surplus" and "deficiency" reflects the imbalance in China's grain production supply and consumption demand, and indicates a profound structural problem. Analyzing the characteristics of and the factors driving the change in China's grain production pattern from the supply side is conducive to understanding the causes of the change.

China's urbanization has been a major event affecting human society in the 21st century. Its development in the last 30 years has competed with the urbanization process of Western countries that occurred over the last several hundred years. China's urbanization level increased from 17.92% in 1978 to 56.10% in 2015. The impact of rapid

urbanization on China's food security has attracted international attention. In the 1990s one American scholar Lester argued that the development of industrialization and urbanization would cause farmers to lose sizable amounts of land and water resources, resulting in decreased grain production. At the same time, the demands for food to satisfy the production and living needs of Chinese people would increase explosively, leading inevitably to food shortages in China (Brown, 1995). Christiansen argued that although China's grain yield had increased in recent years, its per capita grain production and consumption were still low, while industrialization and urbanization, loss of arable land, and agricultural labor force reductions were seriously impeding the steady growth in grain production capacity and output in China (Christiansen, 2009). Some Chinese scholars have also examined the impact of urbanization on grain production and grain security from various perspectives (Huang, 2004; Wang and Leng, 2008; Chen and Wu, 2015; Yao et al., 2016). There have, however, been few studies to date of regional differences in China's urbanization and the impact these differences have on grain production patterns.

This study focuses on the pattern change of China's grain production and its influencing factors mainly including urbanization and dietary structure. Our intent is to reveal the effect of China's urbanization on spatial patterns of grain production and the impact of dietary structure on grain production structure with the goal of providing support for China's supply-side reforms and grain production planning in the future.

2 Data sources and research methods

National and provincial grain production data were obtained mainly from editions of *China Statistical Yearbook* for the years 1980 to 2016 (National Bureau of Statistics, 2016).

In this study, we use the proportion of total grain yield (or the area of grain crops planted) of a certain province or region in a given period of time to the country's total yield to represent the grain crop production situation of the province or region. This indicator is also known as the grain production centralization degree. It indicates the basic situation with respect to changes in regional grain production patterns, both horizontal and vertical, for each province or region (Lu and Mei, 2007). We use this indicator to evaluate the change in China's grain production pattern.

3 Results analysis

3.1 Spatio-temporal changes in China's grain production pattern

3.1.1 The presence of a significant "northward shift"

Since the reform and opening-up began, China's grain yield has increased significantly, from 320 million tons in 1990 to 450 million tons in 1996, 500 million tons in 1996, and 510 million tons in 1998. After 1998, grain production decreased

steadily, dropping to 430 million tons in 2003. It then began increasing year after year and was over 600 million tons in 2013 (Fig. 1). While the grain yield continued to grow, the spatial pattern of grain production also changed significantly.

Southern China’s good quality soils and ample water and heat resources have made this region the nation’s traditional granary, forming a historical pattern reflected in the expression “transferring grain production from the south to the north.” However, during the past 30 years, the grain production relationship between north and south in China has undergone significant changes. In 1980, the proportion of total grain yield in China’s southern provinces relative to the nation’s total was 60% and that of China’s northern provinces relative to the nation’s total was 40%. After 1990, grain production in the south declined, and by 2005, the north-south grain production relationship had reversed itself in terms of scale, and the yield in the north surpassed that in the south for the first time. In 2015, the proportion of total grain yield in China’s northern provinces relative to the nation’s total reached 56% and that of China’s southern provinces had decreased 16 percentage points from its earlier high to 44% (Fig. 1). In terms of volume, this decreased percentage in 2015 represented a reduction of 100 million tons of grain production in southern China, indicating an obvious “northward shift” in the grain production center.

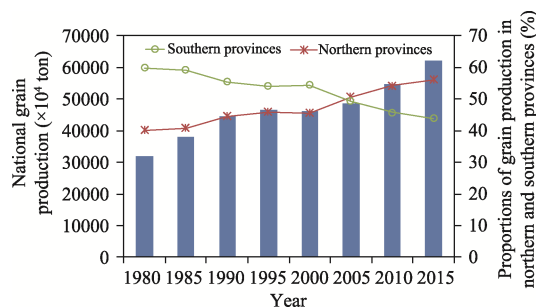


Fig. 1 Changes in grain yield and the proportions of total production for the northern and the southern provinces

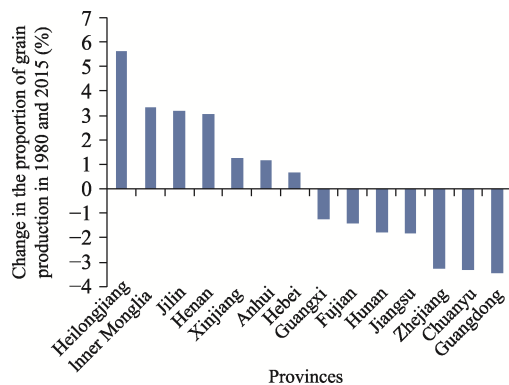


Fig. 2 Provinces with significant changes in grain production between 1980 and 2015

The distribution of provinces and regions with significant changes in the proportion of grain production in 2015 relative to that in 1980 is shown in Fig. 2. The proportions of grain production in northern provinces such as Heilongjiang, Inner Mongolia, Jilin and Henan increased while proportions in southern provinces and regions such as Guangdong, Sichuan and Chongqing (combined in this study for consistency), Zhejiang, Jiangsu and Hunan decreased significantly. The northward shift in grain production to the Northeast Plain was particularly noticeable. The share of China’s three northeastern provinces in national grain yield increased from 11% in 1980 to 19% in 2015. The rice yields of these provinces increased from less than 4 million tons to 32.97 million tons, and their proportion relative to the nation’s total rice yield increased from 3% to 16%, leading to the area being designated the New Northeast Major Rice Producing Zone. The scale of corn production in the three northeastern provinces also increased significantly, and its proportion relative to the nation’s total increased from less than 27% in the 1980s to over 34% in 2015. The scale of wheat production in Henan Province, located in the Huang-Huai-Hai Plain, increased significantly, and its proportion of China’s total wheat production jumped from 16% to 27%. These changes indicate that the center of China’s grain production has shifted away from the important producing areas in the south (e.g., the Yangtze River Basin and the Pearl River Delta) to the Northeast and the Huang-Huai-Hai Plain.

3.1.2 The presence of “decrease in the east but expansion in the central region”

Over the past 30 years, the grain production patterns in the eastern, central and western regions of China have changed significantly. Grain yields in the eastern, central and western regions accounted for 38%, 36% and 26%, respectively, of nation’s total in 1980 and for 27%, 46% and 27%, respectively, of nation’s total in 2015 (Fig. 3). The proportion of grain production in the eastern region relative to the nation’s total decreased by 11% between the years 1980 and 2015. This is equivalent to a reduction of 68.36 million tons of grain in 2015, compared to 1980. The dynamic changes in grain production patterns in the eastern and central regions has become increasingly pronounced, with grain production in the eastern coastal provinces dropping significantly while that in the central regions has exhibited an upward trend.

Both Inner Mongolia and Xinjiang are located in China’s western region and both showed an upward trend in grain production. The proportions of grain production in Inner Mongolia and Xinjiang relative to the nation’s total were 1.24% and 1.21%, respectively, in 1980 and reached 4.55% and 2.45%, respectively, in 2015. For Inner Mongolia, the increase was caused mainly by the scaling up of corn production; corn yields increased from less than 1.4 million tons in 1980 to 22.5 million tons in 2015, and proportion of corn produced in Inner Mongolia relative to the country’s

total increased from 2% to 10%. The share of wheat production in Xinjiang relative to the country's total increased from 3.86% to 5.36%. Overall, grain production in the eastern, central, and western regions of China showed an obvious pattern of “decrease in the east but expansion in the central region.”

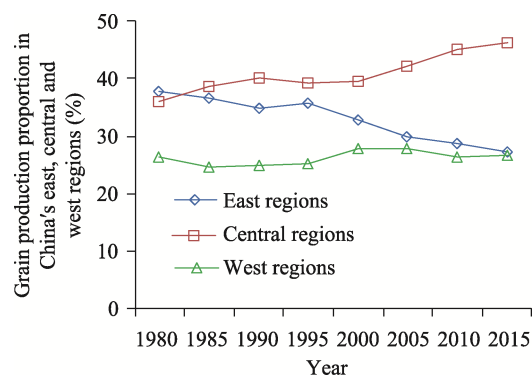


Fig. 3 Changes in the proportion of grain production in the eastern, central and western regions of China

3.1.3 Increase of spatial centralization of grain production
In terms of the centralization of grain production, the main grain-producing provinces in China went through major changes from 1980 to 2015. Prior to 2000, the grain production centralization levels for Sichuan, Shandong, Jiangsu, and Henan were the highest, all over 7%, while those for

Guangdong and Zhejiang were also over 3%. However, after 2000, the proportions of grain production in Guangdong and Zhejiang decreased steadily.

According to the *Opinions on a Number of Policy Measures to Reform and Improve Comprehensive Agricultural Development* issued by the Ministry of Finance in 2003, thirteen provinces (regions), i.e., Heilongjiang, Liaoning, Jilin, Inner Mongolia, Hebei, Jiangsu, Anhui, Jiangxi, Shandong, Henan, Hubei, Hunan and Sichuan, were designated China's main grain-producing areas. In 2015, Heilongjiang and Henan, two provinces with the highest production volume, each had a total grain yield of over 120 million tons; Liaoning Province, which had the lowest grain yield among the 13 main grain-producing areas, produced more than 20 million tons. The 13 main grain-producing areas produced more than 76% of the nation's yield in 2015, an increase of six percentage points over their proportion of total yield in 1980 (Table 1).

These data indicate that the spatial centralization of China's grain production has increased and that the production centralization level of the main producing areas has also increased. The grain production situation in the main grain-producing areas determines whether the national food supply is stable. This means that as the centralization level has increased, the influence of the main grain-producing areas on national food security has become more pronounced.

Table 1 Centralization levels for China's 13 major grain-producing provinces (regions) (%)

Main provinces	1980	1985	1990	1995	2000	2005	2010	2015
Heilongjiang	4.56	3.77	5.18	5.47	5.51	6.39	9.17	10.18
Henan	6.70	7.15	7.40	7.43	8.87	9.47	9.95	9.76
Shandong	7.44	8.28	7.52	9.10	8.30	8.09	7.93	7.58
Jilin	2.68	3.23	4.5 9	4.27	3.54	5.33	5.20	5.87
Jiangsu	7.54	8.25	7.24	7.04	6.72	5.86	5.92	5.73
Anhui	4.54	5.72	5.51	5.53	5.35	5.38	5.64	5.69
Sichuan	10.72	10.10	9.56	9.35	7.30	6.63	5.90	5.54
Hebei	4.75	5.19	5.10	5.87	5.52	5.37	5.45	5.41
Hunan	6.63	6.63	5.94	5.77	5.99	5.53	5.21	4.83
Inner Mongolia	1.24	1.59	2.18	2.26	2.69	3.43	3.95	4.55
Hubei	4.79	5.85	5.55	5.28	4.80	4.50	4.24	4.35
Jiangxi	3.87	4.05	3.72	3.44	3.49	3.63	3.58	3.46
Liaoning	3.81	2.57	3.35	3.05	2.47	3.61	3.23	3.22
Total	69.27	72.38	72.84	73.87	70.55	73.23	75.36	76.18

3.2 Effects of urbanization and changes in dietary structure on grain production patterns

Urbanization affects grain production patterns from both the supply side and the demand side. On the supply side, urbanization affects various grain production input factors, such as the quantity and quality of available arable land and

rural labor and these in turn affect grain production patterns. On the demand side, given the differences in the dietary structures of urban and rural residents, as the size of China's urban population increases, the overall changes in dietary structure that lead to changes in grain demand, and these affect grain production patterns. Changes to dietary structure are the outcome of advanced urbanization and higher

levels of social and economic development that provide improved quality of life for both urban and rural Chinese.

3.2.1 Effect of urbanization on spatial patterns of grain production

Rapid urbanization has led to the fast growth of China's urban population, which has increased from less than 200 million in the 1980s to 770 million currently. The rapid expansion of urban population centers has decreased the amount of quality land resources on the peripheries of cities and towns. China's built-up urban area, which accounted for 7438 km² in 1981, had reached 52102 km² in 2015, a seven-fold increase representing a net increase in construction land area of 4.466 million ha. In 2000–2010, China's urban land area expanded by 18377 km², of which 12620 km² was arable land (accounting for 68.7% of the total expansion). In 1990–2000, urban land only expanded by 9602 km², of which 5130 km² was arable land (accounting for 53.4%) (Wang et al., 2012). The total area of urban expansion in China during 2000–2010 was 1.91 times greater than it was during 1990–2000, and took 2.46 times more of the country's arable land (Yao et al., 2016). The decrease in arable land resources resulting from urban sprawl is one of the important factors driving the change in China's grain production patterns.

The urbanization levels in the eastern, central, and western regions of China stood at 27%, 22%, and 17%, respectively, in 1980. By 2015, these regional levels had reached 68%, 53%, and 48%, respectively. From 1980 to 2015, as urbanization levels increased, the proportion of grain crop planting area in the eastern region relative to the nation's total decreased from 31% to 25% and that in the central region increased from 37% to 44%, while that in the western region remained unchanged at approximately 30% (Fig. 4). With the expansion of cities and towns, the built-up land occupies a large number of high-quality farmland and thus the grain planting area has been significantly reduced in the eastern region due to the limited farmland resources.

3.2.2 Impact of changes in dietary structure on grain production patterns

Rapid economic development and the increase in urbanization levels have caused significant changes in the dietary structure of both urban and rural Chinese. The proportion of meat, egg, and milk consumption to total consumption has increased while direct grain consumption has declined. This has driven ongoing adjustments to the agricultural planting structure, leading to a steady decrease in the proportion of grain planting area relative to the country's total planting area, from 82% in 1980 to 68% in 2015 (Fig. 5). In the eastern coastal provinces of Guangdong, Zhejiang and Fujian, the decrease in the proportion of grain planting area relative to the total crop planting area was even larger, dropping 33% in Fujian and 24% in Guangdong. Regional changes in

grain planting area has driven changes in China's grain production patterns.

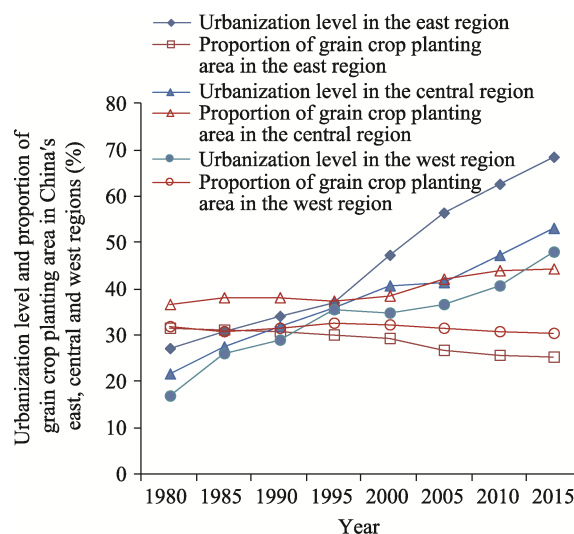


Fig. 4 Changes in urbanization levels and the proportion of grain planting area in the eastern region of China

Changes in dietary structure also had an impact on the grain production pattern. As the meat and egg consumption by humans increased, the consumption of feed grains by livestock and poultry steadily increased while the consumption of rice and wheat rations, exhibited a declining trend. After 1980, the proportion of grain ration production relative to the nation's total grain yield decreased from its highest level of 67% in 1986 to approximately 54% in 2015. This was mainly because rice production in the south declined and wheat production remained stable, while the proportion of corn production (used as feed grain) increased from 20% in 1980 to 36% in 2015 (Fig. 6). In 2012, the volume of corn production surpassed that of rice production for the first time, and corn became China's number one grain crop. Spatially, the range of corn production has steadily expanded; in the northeastern, southwestern, and northwestern regions of China, corn production has been expanding.

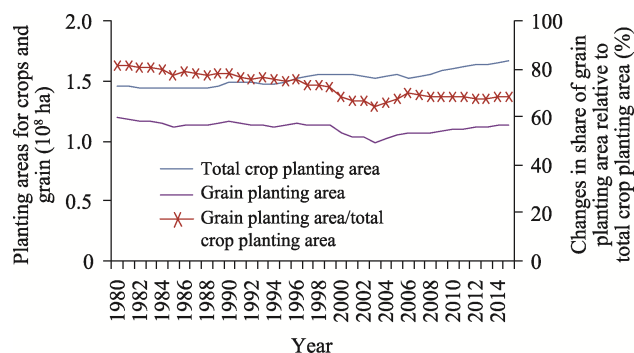


Fig. 5 Changes in planting area and the proportion of crops and grain crops

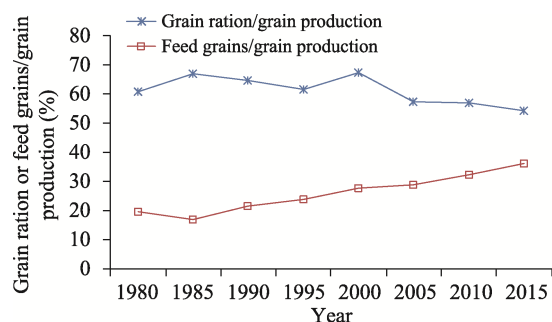


Fig. 6 Changes in the proportion of grain ration production and feed grains in grain output

3.3 Change trends for future grain production patterns

3.3.1 The designation of functional areas for grain production will facilitate the return to reasonable grain production patterns

The phenomenon in China's grain production pattern described by the expression "shift toward the north and central regions" has been caused mainly by increased grain production in the Northeast and the Huang-Huai-Hai Plain. This represents a market-driven outcome resulting from objective, historically inevitable differences in China's regional social and economic development. However, water resources in the Huang-Huai-Hai Plain have been seriously overexploited, and the consumption of water resources provided by the Hai River and the Yellow River has exceeded the available amount of water resources. Moreover, in the West Liaohe River Basin in northeastern China and along the Heihe River and Tarim River in northwestern China, the overexploitation of water resources has also been severe. The change in China's grain production pattern represented by the shift toward the north and central regions has exacerbated the shortage of water resources and exposed an enormous risk to China's future food security.

In the recently introduced *Guiding Opinions of the State Council on Establishing Functional Zones for Grain Production and Protected Zones for the Production of Major Agricultural Products* (No. 24, 2017), 900 million mu of functional zones for grain production were proposed, with the Yangtze River basin and southeastern coastal areas identified as key regions. Acreage for grain production is to be guaranteed at the county level and various preferential policies are to be formulated and implemented to safeguard grain production. It is possible that the construction of functional areas for grain production will result in expanded grain production in the Yangtze River basin and southeastern coastal areas in the future. By better matching production with available soil and water resources, this development could result in a return to a reasonable grain production pattern, helping to alleviate the of overexploitation and overuse of water resources in China's northern regions to a certain extent.

3.3.2 Demand for feed grain continues to increase, but the potential to expand feed grain production is limited

Because increases in urbanization levels and changes in dietary structure are expected to continue into the future, China's demand for feed grain will continue to increase. While the current demand for feed grain is 326 million tons, supply capacity is only 274 million tons, resulting in a deficit of 52 million tons and a feed grain security level of 84.15%. By 2030, when China's population is expected to peak, the demand for feed grain will be 345 million tons. If supply capacity is maintained at the current level, the supply deficit will be 71 million tons and the feed grain security level will be 79.41%. Thus, it is necessary to continue to increase the scale of feed grain production.

Among the factors affecting the increase in corn production in China since 2000, the contribution of increased planting area has accounted for over 80% of the increase. Relative to the area for planting corn in 2000, current corn production areas in Heilongjiang, Inner Mongolia, Jilin, and Henan have increased by 223.5%, 162.46%, 72.94% and 51.90%, respectively. At the same time, the areas for planting soybeans, oilseed, potatoes and wheat in these provinces have decreased, indicating that the expansion of corn production has squeezed out the production of other agricultural products. This suggests that the space for continued expansion of feed grain production is very limited.

4 Discussion and conclusions

4.1 Discussion

Grain production in China has shifted from its traditional center in the southern and eastern regions of the country to the northern and central regions. The impact of the northern and central regions on national grain production has become greater. However, this change is at odds with the spatial distribution of water resources in China, and has exacerbated the water shortage in the northern, central and western regions of the country. It has exposed the sustainability of China's grain production and food security to great risk. Therefore, the establishment of a reasonable pattern of grain production that is compatible with resource endowments is urgently needed.

The effect of urbanization on China's grain production patterns is closely related to regional differences in the level of economic development in China. The eastern region has industrialized rapidly and has the highest level of urbanization in the nation, and compared to industrial enterprises of all kinds, the grain farming oriented towards grain production lacked comparative advantages, leading to a decline in the enthusiasm of farmers for growing grain crops and thus a decline in grain production. As urbanization levels increased, the proportion of grain planting areas in the central region increased significantly, and this was associated with the limited development of secondary and tertiary industries in the central region, simple economic structure in rural ar-

eas, and limited income sources for farmers. Incentives offered through various national grain subsidy policies encouraged farmers to opt for increasing their grain planting area to increase household revenue. The proportion of grain planting area in the central region remained stable as the level of urbanization increased steadily because in this region, water and soil resources were limited and there was only very limited land available for the expansion of grain production.

In the future, with the establishment of functional zones for grain production, the scale of grain production in the eastern region, which is rich in water resources, will expand to some degree. The use of water and land resources for grain production in China will, therefore, be more coordinated, and the spatial distribution will be more reasonable. As the level of urbanization increases, the scale of China's feed grain demand will continue to increase, but there is only limited space available to expand feed grain production. Moreover, the main corn-producing area is currently in the north, while the eastern coastal provinces are the main consumption area. This spatial dislocation of production and marketing patterns has increased the cost of corn production, while the inversion of domestic and foreign corn prices has caused excessive domestic stocks. Optimizing the structure and regional distribution of feed grains is a challenge that must be addressed to ensure future grain supplies.

4.2 Conclusions

Our analysis of China's grain production patterns over the past 30 years, based on an assessment of the proportions of provincial grain production and production area relative to the nation's totals and the changes to these proportions, has come to the following conclusions:

(1) Driven by the laws of nature and economics, China's grain production in the past 30 years has exhibited a spatial change indicative of a "shift to the north and expansion in the central region." In terms of northern and southern regions, the area devoted to grain production has shifted toward the north, especially to China's northeast and the Huang-Huai-Hai Plain. Viewing the overall situation in the eastern, central and western regions, grain production in eastern coastal areas has decreased while that in the central region has expanded.

(2) Since 2003, when major grain-producing provinces and regions were set, the proportion of grain production in the major grain-producing areas has increased from 69.27% to 76.18%, indicating that the spatial centralization of grain production in China has increased and that the influence of the major grain-producing areas on national food security has increased. The increase in the contribution of the major grain-producing areas to the country's grain production has facilitated the designation of functional areas for grain production. This allows for the formulation and implementation of more effective grain production policies to ensure the

country's food security.

(3) There are significant regional differences in the impact of urbanization on China's grain production patterns. During the years 1980 to 2015, as urbanization levels increased, the proportion of grain planting area in the northern region increased by 8%, and correspondingly, that in the southern region decreased by 8%. In the eastern, central and western regions of China, as urbanization levels increased, the proportion of grain planting area in the eastern region decreased by 7%, while that in the central region increased by 7% and that in the western region remained stable.

(4) The impact of changes in dietary structure on grain production patterns are evidenced in two ways. First, direct human consumption of grain decreased, and the proportion of grain planting area relative to the nation's total crop planting area decreased as well from 82% in 1980 to 68% in 2015. and the decrement in the proportion of grain planting area in the eastern coastal provinces was even larger. Second, the production volume of feed grains expanded, and the proportion of corn production increased from 20% to 36%, with corn becoming China's largest grain crop.

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中国粮食生产格局演变及城镇化与膳食结构变化的影响

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摘 要: 粮食生产格局是国家粮食安全的基础。自从 1978 年改革开放以来, 中国社会经济的快速发展推动城市化进程不断加快, 城乡居民的膳食结构亦发生了显著变化。在这样的背景下, 粮食生产格局也发生了较大变化。一是传统的粮食生产南北格局发生变化, “北移”特征明显。1980 年南方省区粮食产量占比 60%, 北方省区占比 40%, 到 2015 年北方省区占比 56%, 南方省区下降为 44%; 二是东中西部粮食生产呈现“东缩中扩”特征, 东部沿海省区粮食生产明显萎缩, 中部粮食生产呈扩大态势。1980 年东中西部粮食占比分别为 38%、36%和 26%, 到 2015 年则为 27%、46%和 27%; 三是粮食生产空间集中度增大。1980 年全国 13 个粮食主产省区的总产量占比为 69.27%, 到 2015 年达到 76.18%, 粮食主产区对国家粮食安全的影响力增强。城市化快速发展对粮食播种面积的影响具有显著的区域差异。随着城市化水平提高, 东中部和南北方粮食播种面积此消彼长, 增减幅度在 7%–8%之间。膳食结构变化对粮食生产格局的影响表现在两个方面, 一方面粮食消费总量减少, 粮食播种面积占农作物播种面积比重从 1980 年的 82%下降为 2015 年的 68%; 另一方面, 粮食消费结构发生变化, 人口直接消费的粮食减少, 动物消费的饲料粮扩大。表现为稻谷和小麦种植面积占比下降, 饲料粮(主要是玉米)种植面积占比从 1980 年代的 20% 增大到 36%。未来随着国家粮食生产功能区的建立, 粮食生产的空间格局将合理回归, 饲料粮需求持续增加但生产扩大的空间有限。

关键词: 粮食生产; 时空格局; 城镇化; 膳食结构; 中国