Optimization of Agricultural Industrial Structure in Changping District of Beijing Based on Grey Relational Analysis

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Abstract In the economic development of Beijing, although the share of the total amount of agricultural industry in the overall economy is relatively low, it has an important impact on the daily life of residents, social stability and the development of other industries. Changping District, as an important agricultural production base of Beijing, its agricultural development has an indispensable strategic significance for the stability and growth of the entire regional economy. Therefore, it is very important to study the structure of agricultural industry in Changping District. Based on the detailed analysis of the agricultural industrial structure of Changping District, this paper uses the grey relation theory to analyze the different industries in the agricultural industrial structure of Changping District, including planting, forestry, animal husbandry, fishery and agricultural, forestry, service industries, in order to reveal the impact of these industries on the agricultural industrial structure of Changping District. Through this study, it comes up with specific and feasible suggestions for the optimization of agricultural industrial structure in Changping District, and provides valuable reference for the agricultural development of other areas in Beijing.

Key words Grey relation theory, Changping District, Agricultural industrial structure

1 Introduction

As an important agricultural production base in Beijing, Changping District plays a great role in ensuring the supply of agricultural products in Beijing and promoting regional economic development. Since 2008, with the gradual implementation of the national agricultural modernization strategy, the agricultural production capacity of Changping District has been significantly improved. According to the data of 2022, the total agricultural output value of Changping District reached 1.58 billion yuan, a significant increase of 30.6% compared with 1.21 billion yuan in 2008. Although agriculture in Changping District has made considerable progress, it still faces many problems, especially in the agricultural industrial structure. These problems greatly restrict the growth of total agricultural output value in Changping District, so it is urgent to carry out in-depth discussion, and find corresponding countermeasures to optimize the agricultural industrial structure and improve the total agricultural output value.

As a method for quantifying and evaluating the degree of correlation between different factors, grey relation theory plays an important role in understanding and optimizing the agricultural industrial structure. Domestic scholar Xu Jing[1] used grey relation theory to deeply analyze and study the relation between the four industries of agriculture, forestry, animal husbandry and fishery and the total output value of agriculture in Jilin Province, and put forward optimization suggestions. Based on grey relation theory, Wang Yan *et al.*[2] analyzed the correlation between the total agricultural output value of Shandong Province and the output value of various agricultural production departments, and put forward optimization suggestions in combination with other analysis. Sun Guangcai *et al.*[3] used grey relation theory to put forward optimization suggestions for the adjustment of agricultural industrial structure in Qujing City. Li Qianping *et al.*[4] used grey relation theory to put forward suggestions on optimizing the agricultural industrial structure of Jiangxi Province. Zhang Shuo *et al.*[5] used grey relation theory to analyze the relation between the three major forestry industries in Henan Province and the total output value, and then combined with other analysis and put forward optimization suggestions. In comparison, foreign scholars use grey relation theory from a macro perspective. Smith[6] studied the role of grey relation theory in agricultural policy decision-making, and studied the impact of different land management strategies on sustainable agricultural development through case studies. Hu *et al.*[7] revealed the correlation between the adjustment of agricultural industrial structure and national economic growth through grey relation theory, and made an in-depth analysis of the impact of different agricultural industry sectors on economic growth. Through the review of relevant literature[8-14] at home and abroad, it is found that these studies provide a theoretical support for understanding the relationship between local agricultural industrial structure and economic development. Therefore, we used grey relation theory to make an empirical analysis of the correlation between the agriculture-related industries and the total agricultural output value in Changping District, and combined with the statistical data of agricultural industry in Changping District from 2012 to 2022, to better guide the adjustment and optimization of the agricultural indus-

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trial structure in Changping District.

2 Analysis of agricultural industrial structure in Changping District of Beijing

2.1 Overview of total agricultural output value development in Changping District Since 2012, Changping District has vigorously developed industry and tertiary industry, and rural non-agricultural industries have emerged at the fore. In 2012, the total agricultural output value of Changping District was 2.59 billion yuan, and in 2022, the total agricultural output value of Changping District was 1.58 billion yuan, down 39% from the same period of the previous year; in 2012, the total economic output value of Changping District was 54.95 billion yuan, accounting for 4.7% of the total agricultural output value in the same period. In 2022, the total economic output value of Changping District was 134.08 billion yuan, accounting for 1.2% of the total agricultural output value in the same period, down 3.5% from the same period of the previous year. According to the above data (Table 1), the total agricultural output value of Changping District and its share in the GDP of the whole district showed a downward trend in the past 11 years.

Table 1 Total output value of agriculture and its share in GDP of Changping District

Year	GDP of changping district//10^8 yuan	Total output value of agriculture//10^8 yuan	Share//%
2012	549.5	25.9	4.7
2013	622.7	27.8	4.5
2014	693.6	25.8	3.7
2015	755.1	22.1	2.9
2016	815.4	20.7	2.5
2017	906.3	20.3	2.2
2018	997.9	17.9	1.8
2019	1 082.5	23.1	2.1
2020	1 151.8	20.2	1.8
2021	1 314.9	18.3	1.4
2022	1 340.8	15.8	1.2

Data source: *Statistical Yearbook of Agriculture and Rural Affairs Bureau of Changping District, Beijing 2013 – 2023*, the same below.

As to the share of agriculture-related industries, in the total agricultural output value of Changping District in 2012, planting accounted for 38.2%, forestry accounted for 22.8%, animal husbandry accounted for 35.5%, fishery accounted for 1.2%, and service industry for these sectors accounted for 2.3%. In 2022, the total agricultural output value of Changping District, planting accounted for 41.8%, forestry accounted for 37.3%, animal husbandry 19.6%, fishery 0.1%, and service industry for these sectors 1.3%. Through the comparison of the two years of data, it is found that the share of agriculture (planting) in the agricultural industrial structure of Changping District has remained almost unchanged in the past 11 years, the share of forestry has increased significantly, the share of animal husbandry has decreased significantly, the share of fishery has decreased significantly, but the value is too low and can be ignored, and the service industry for these sectors has declined (Fig. 1).

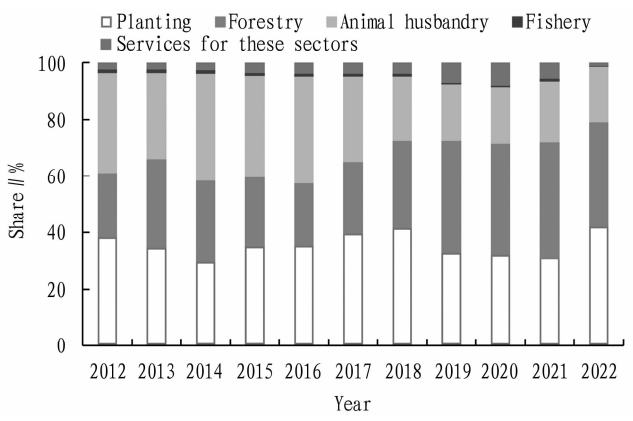

Fig. 1 Share of output value of agriculture, forestry, animal husbandry and services for these sectors

2.3 Overview of planting development in Changping District The change trend of grain cultivated land area and output value of planting industry in Changping District from 2012 to 2022 is shown in Fig. 2. It shows that the area of grain farmland in Changping District was about 3 700 ha in 2012, then reached 1 300 ha in 2016, and then reached the lowest value of 700 ha in 2020. By 2022, the area of grain farmland in Changping District increased to 2 100 ha. This development trend of first falling and then rising is closely related to the development of planting output value in Changping District.

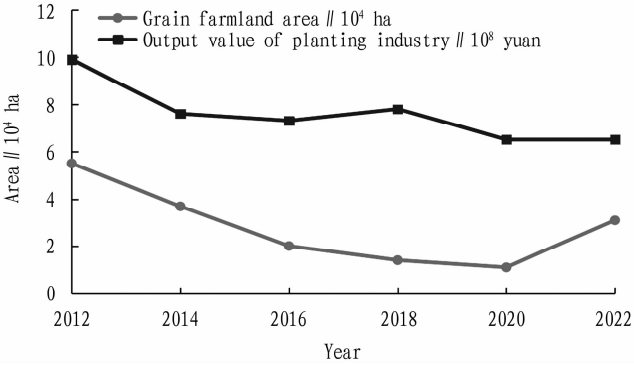

Fig. 2 Change trend of output value of planting industry and farmland area in Changping District

2.4 Overview of forestry development in Changping District From 2013 to 2017, Changping District completed nearly 8 700 ha of plain afforestation tasks in five years. In addition, Changping District also completed the afforestation work of 8 700 and 33.84 ha in 2020 and 2022, respectively. With the continuous expansion of forestry area, the forestry output value of Changping District also shows an upward trend (Fig. 3).

2.5 Overview of animal husbandry development in Changping District According to the statistical data of animal husbandry in Changping District from 2012 to 2022, we found that the total output of eggs and the annual output of pigs in Changping District showed a downward trend year by year. Specifically, the

total egg production was 9 000 t in 2012, decreased to 2 000 t in 2018, and further decreased to 1 000 t in 2022. Similarly, the annual output of live pigs dropped from 95 000 in 2012 to 10 000 in 2020, and rose to 26 000 in 2022 due to policy support. Such downward trend in egg production and annual pig production reflects the continuous decline in the output value of animal husbandry in Changping District. The change trend of egg production, annual live pig output and animal husbandry output value in Changping District in recent 11 years is illustrated in Fig. 4.

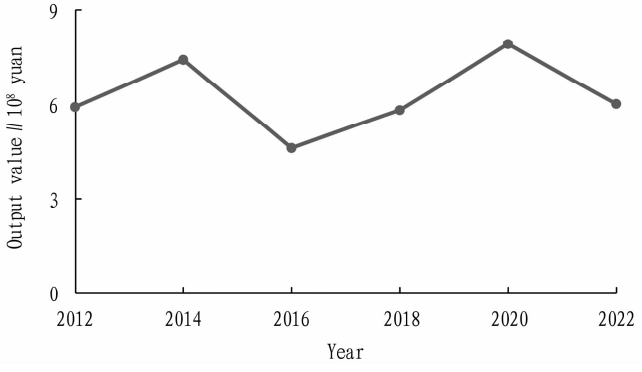

Fig. 3 Change trend of forestry output value in Changping District

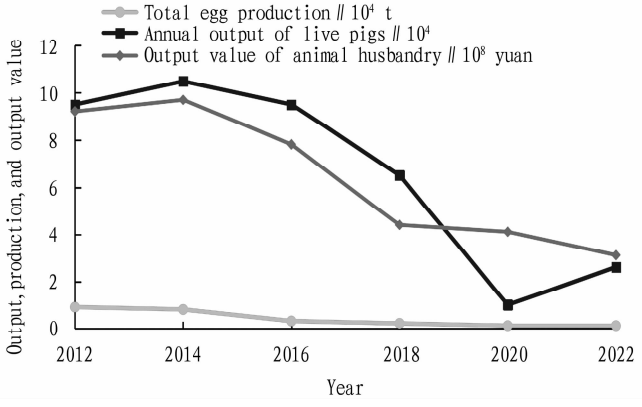

Fig. 4 Change trend of egg production, annual pig output and animal husbandry output value in Changping District

2.6 Overview of the development of fishery and service industries for agriculture, forestry, animal husbandry and fishery in Changping District Changping District is located in the inland, with many mountains and plains, and its geographical conditions are not suitable for the development of fisheries. Therefore, the fishery in Changping District is mainly concentrated in large reservoirs and lakes such as the Ming Tombs Reservoir, Shahe Reservoir and Changyucheng Reservoir. Due to the limited natural conditions, the development of fisheries in Changping District has been difficult, with low output value and lack of policy support. Leisure agriculture is the main form of service industries for agriculture, forestry, animal husbandry and fishery in Changping District. There were 199 agricultural sightseeing parks in 2017, 344 in 2018, 144 in 2020, and 114 in 2022. With the number of agricultural sightseeing parks increasing first and then decreasing, the output value of service industries for agriculture, forestry, animal husbandry and fishery in Changping District also showed a trend of increasing first and then decreasing (Fig. 5).

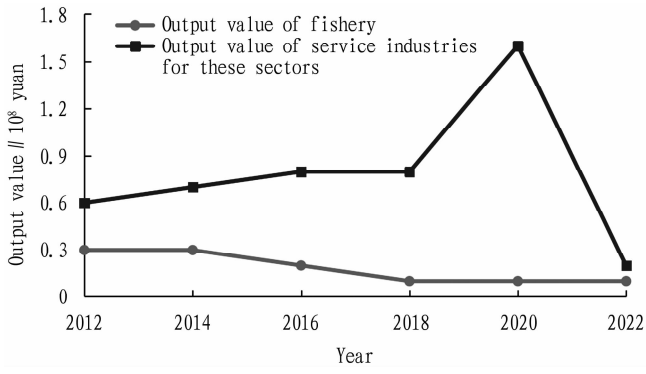

Fig. 5 Change trend of output value of fishery and service industries for agriculture, forestry, animal husbandry and fishery in Changping District

3 Analysis of grey relation model

3.1 Data selection We selected the output value data of planting, forestry, animal husbandry, fishery, and service industries for these sectors in Changping District from 2012 to 2022, as well as the total agricultural output value data of Changping District in the same period. The data were obtained from the *Statistical Yearbook* released by the Changping District Agriculture and Rural Bureau, as indicated in Table 2.

Table 2 Agricultural and related agricultural output value data of Changping District from 2012 to 2022

Year	Agriculture	Planting	Forestry	Animal husbandry	Fishery	Service industries for these sectors
2012	26.0	9.9	5.9	9.2	0.3	0.6
2013	27.8	9.6	8.7	8.5	0.3	0.7
2014	25.8	7.6	7.4	9.7	0.3	0.7
2015	22.1	7.7	5.4	7.9	0.2	0.8
2016	20.7	7.3	4.6	7.8	0.2	0.8
2017	20.3	8.1	5.3	6.1	0.2	0.8
2018	18.9	7.8	5.8	4.4	0.1	0.8
2019	23.2	7.6	9.1	4.7	0.1	1.6
2020	20.3	6.5	7.9	4.1	0.1	1.6
2021	18.3	5.6	7.5	4.0	0.2	1.0
2022	15.8	6.5	5.9	3.1	0.1	0.2

3.2 Model analysis In this study, we took the total output value of agriculture in Changping District as the reference series, with a span of 11 years, recorded as $x_s(t)$, and took the output value of planting, forestry, animal husbandry, fishery, and service industry for these sectors in Changping District as the comparative series, with a span of 11 years, recorded as $x_0(t)$. In order to facilitate the statistical results, we established an indicator system covering the agricultural industrial structure of Changping District: total agricultural output value $Y1$, planting output value $X1$, forestry output value $X2$, animal husbandry output value $X3$, fishery output value $X4$ and service output value $X5$. In order to ob-

tain the unified data of the unit, the original data under each indicator were dimensionless to avoid the influence of dimension on data processing. In this study, we used the mean value method.

$$x_{ij} = \frac{x'_{ij}}{\frac{1}{n}\sum_{j=1}^{n} x'_{ij}} \quad (1)$$

where x'_{ij} is the original data of each year and x_{ij} is the dimensionless data.

Using the formula (1), we obtained the non-dimensional matrix (Table 3).

Table 3 Non-dimensional matrix of output value of agriculture and related industries in Changping District from 2012 to 2022

Year	*X*1	*X*2	*X*3	*X*4	*X*5	*Y*1
2012	1.293 3	0.883 0	1.456 1	1.571 4	0.687 5	1.195 7
2013	1.254 2	1.302 0	1.345 3	1.571 4	0.802 1	1.278 4
2014	0.992 9	1.107 5	1.535 3	1.571 4	0.802 1	1.186 5
2015	1.005 9	0.808 2	1.250 4	1.047 6	0.916 7	1.016 3
2016	0.953 7	0.688 4	1.234 5	1.047 6	0.916 7	0.951 9
2017	1.058 2	0.793 2	0.965 5	1.047 6	0.916 7	0.933 5
2018	1.019 0	0.868 0	0.696 4	0.523 8	0.916 7	0.869 1
2019	0.992 9	1.361 9	0.743 9	0.523 8	1.833 3	1.066 9
2020	0.849 2	1.182 3	0.648 9	0.523 8	1.833 3	0.933 5
2021	0.731 6	1.122 4	0.633 1	1.047 6	1.145 8	0.841 6
2022	0.849 2	0.883 0	0.490 6	0.523 8	0.229 2	0.726 6

Next, we substituted the value $|x_0(t) - x_s(t)|$ obtained by subtracting each comparison series from the reference series into the grey relation coefficient formula (2) to obtain the grey relation coefficient matrix (Table 4).

$$e_i(k) = \frac{\min\limits_i \min\limits_j |x_0(t) - x_s(t)| + 0.5 \max\limits_i \max\limits_j |x_0(t) - x_s(t)|}{|x_0(t) - x_s(t)| + 0.5 \max\limits_i \max\limits_j |x_0(t) - x_s(t)|} \quad (2)$$

Table 4 Grey relation coefficient matrix of relevant indicators in Changping District from 2012 to 2022

Year	*X*1	*X*2	*X*3	*X*4	*X*5
2012	0.097 7	0.312 7	0.260 5	0.375 8	0.508 2
2013	0.024 3	0.023 6	0.066 9	0.293 0	0.476 3
2014	0.193 6	0.079 0	0.348 8	0.385 0	0.384 4
2015	0.010 4	0.208 1	0.234 1	0.031 3	0.099 6
2016	0.001 8	0.263 5	0.282 6	0.095 7	0.035 3
2017	0.124 7	0.140 3	0.031 9	0.114 1	0.016 9
2018	0.149 9	0.001 1	0.172 7	0.345 3	0.047 5
2019	0.074 0	0.295 0	0.323 0	0.543 1	0.766 4
2020	0.084 4	0.248 8	0.284 6	0.409 7	0.899 8
2021	0.110 0	0.280 9	0.208 5	0.206 1	0.304 3
2022	0.122 6	0.156 4	0.235 9	0.202 8	0.497 4

Finally, we put the correlation number into the formula (3), and obtained the relation degree between the output value of each agricultural industry and the total agricultural output value in Changping District: planting 0.844 5, forestry 0.735 5, animal husbandry 0.686 2, fishery 0.652 9, and service industries for these sectors 0.627 3.

$$q_i = \frac{1}{m}\sum_{j=1}^{m} e_i(j) \quad (3)$$

4 Conclusions and recommendations

4.1 Conclusions Using grey relation model analysis, we obtained the relation degree of each factor, and the specific relation degree ranking is as follows: $X1 > X2 > X3 > X4 > X5$. According to this, it can be concluded that the agriculture-related industries that influence the agricultural industrial structure of Changping District from large to small are planting, forestry, animal husbandry, fishery, and service industries for these sectors.

4.2 Recommendations

4.2.1 The planting industry should focus on the development of fruit and vegetable industry. As a key vegetable production area in Beijing, Changping District should focus on the development of fruit and vegetable industry based on the favorable natural environment. Firstly, it is recommended to continuously introduce and promote innovative agricultural technologies, including intelligent greenhouses, plant factories and UAV spraying systems, in order to improve the production efficiency and quality of fruit and vegetable products. Secondly, it is suggested that the quality of fruit and vegetable products should be further improved by selecting high-quality vegetable and fruit varieties, optimizing cultivation techniques and strengthening field management. Finally, it is suggested to increase the added value of agriculture and enhance its market competitiveness by increasing the planting proportion of characteristic fruits and vegetables and brand fruits and vegetables products.

4.2.2 Forestry should increase the planting proportion of economic forests and characteristic forests. Changping District is located in the northern mountainous area of Beijing and has favorable topography and landform for forestry development. Forestry is the second largest agricultural industry after planting. In order to optimize the forestry structure in Changping District, it is recommended that the planting of economic forests, such as walnut and other high value-added economic tree species, should be strengthened to improve the economic benefits of forestry products. Secondly, we propose to plant more characteristic forests, such as larch, in order to create characteristic gardens with local characteristics and cultural connotations. Finally, it is recommended to promote the development of environmentally friendly green economic forests, such as bamboo and fast-growing tree species, so as to enhance the sustainable utilization level of forestry resources.

4.2.3 Animal husbandry should strengthen support for livestock and poultry breeding. Animal husbandry is also one of the key areas of agriculture in Changping District. In order to optimize the development of animal husbandry, Changping District should strengthen the financial support for livestock and poultry breeding by providing subsidies or preferential subsidy policies. Secondly, it is suggested to carry out training courses, technical guidance and application of modern science and technology to improve the technical level of animal husbandry practitioners. Finally, it is suggested to strengthen the management of breeding environment, animal breeding and medication to ensure the production safety and product quality of livestock and poultry breeding industry.

4.2.4 Fishery should adopt intensive management strategy. Fishery is not the main economic industry in Changping District, but there are still some fishing activities because there are some lakes and reservoirs, such as Ming Tombs Reservoir and Xiaotangshan Reservoir. In order to optimize the development of fishery in Changping District, it is suggested to develop the aquaculture of famous, special and excellent aquatic products by adjusting the aquaculture varieties and modes. Secondly, Changping District should introduce and promote advanced aquaculture technology, such as recirculating aquaculture, to improve the efficiency of aquaculture. Finally, it is recommended to introduce diversified management modes such as fishery sightseeing and aquatic product processing to improve the added value and economic benefits of fisheries.

4.2.5 The service industry for these sectors should strengthen the development of leisure agriculture. The output value of planting, forestry, animal husbandry and fishery services in Changping District has increased, and the pulling effect of leisure agriculture is significant. According to the output value data recorded in Table 3, the output value in 2019 and 2020 was significantly higher than that in other years, because the development of leisure agriculture in Changping District was better in 2019 – 2020. Leisure agriculture reflects the versatility of agriculture, not only has the role of education and demonstration, but also can lead the development of science and technology. With the help of the location advantage of Changping District near the downtown of Beijing, it is recommended to strengthen the construction of surrounding infrastructure, such as tourist centers, experience facilities. Secondly, Changping District should pay attention to the innovation of leisure agricultural products and services, such as providing unique agricultural experience activities. Finally, Changping District should effectively use various marketing means, such as network marketing, social media promotion, *etc.*, to expand its visibility and influence.

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agricultural production, protects the ecological environment of agricultural production and reduces the adverse impact of agriculture on the environment.

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