land

Article

The Coupling Coordination between the Competitiveness Level and Land Use Efficiency of Green Food Industry in China

Zhongming Li [1], Wei Fu [1,*], Mingcan Luo [1] and Jiancheng Chen [2]

[1] College of Economics and Management, Southwest Forestry University, Kunming 650224, China
[2] College of Economics and Management, Beijing Forestry University, Beijing 100083, China
* Correspondence: fuw@swfu.edu.cn; Tel.: +86-15987197775

Abstract: With the development of the green food industry, land conflicts are gradually escalating, and the coordinated development of competitiveness level and land use efficiency is crucial to the green food industry. The competitiveness level of China's green food industry at the provincial level between 2011 and 2020 was measured by constructing an index system using the entropy method and VlseCriterion Optimisation and Compromise Resolution (VIKOR) method, and then the land use efficiency was evaluated using the super efficiency Slacks-based Measurement (SBM) model, and the coupling coordination degree was analyzed using the coupling coordination model based on the results of both measurements. The results showed that the competitiveness level of the green food industry was "high in the west and low in the east"; most provinces and cities were with the middle competitiveness level. Land use efficiency generally showed a trend of rising and then falling and leveling off, and the average value of the three regions was ranked as eastern (1.13) > western (0.84) > middle (0.63). The mean value (0.82) of the overall coupling coordination in China floated at the boundary of high-quality coordination, and all three regions showed a trend of rising and then falling and leveling off, and the number of provinces and cities in high-quality coordination in China was shifting from the north to the south during 2011–2020. This study can provide theoretical support for the coordinated development between industrial development and land use, and provide feasible suggestions for the intensive and efficient use of resources.

Keywords: coupling coordination model; green food industry; competitiveness; land use efficiency

check for updates

Citation: Li, Z.; Fu, W.; Luo, M.; Chen, J. The Coupling Coordination between the Competitiveness Level and Land Use Efficiency of Green Food Industry in China. *Land* **2022**, *11*, 2116. https://doi.org/10.3390/land11122116

Academic Editor: Hossein Azadi

Received: 29 September 2022
Accepted: 22 November 2022
Published: 24 November 2022

1. Introduction

Along with the rapid economic growth in China, consumers are increasingly concerned about food quality and safety [1]. Many Chinese households are increasingly concerned about their health, pursue a high-quality lifestyle, focus on environmental protection and food safety, and prefer to purchase safe and green foods [2,3]. Green foods are becoming a viable option due to the growing interest of the population in quality food, health, and sustainable living [4].

In China, the food certification system is divided into three levels, indicating the stringency of the relevant standards, namely safe food, green food, and organic food [2]. Since the 1990s, green food has been one of the most successful eco-labeling innovations in the Chinese food production industry [5]. First introduced by the Chinese Ministry of Agriculture in 1990, green food refers to a unique Chinese food certification scheme that indicates that food is produced according to sustainable development principles, with standard operating procedures applied throughout the industry chain and designated by the China Green Food Development Center (CGFDC) [6]. Green foods are defined as foods that originate from a high-quality environment and are produced using specific technologies with strict production quality process controls that ensure safety for human consumption [7]. In the application for a green food license, mainly in accordance with the "Green Food Mark Management Measures" to carry out the relevant work, an audit is also needed to manage and follow up the inspection. The object of the license and the quality and safety of the relevant products of green food is subject to the regulation of the "Food Safety Law of the People's Republic of China" and the "Quality and Safety Law of the People's Republic of China for Agricultural Products". Green food labeling review procedures and technical specifications continue to supplement and revise; the annual inspection of green food enterprises, product sampling, market surveillance, risk warning, elimination and withdrawal of post-certification regulatory system has been fully established and implemented to green food labeling management as the core of the institutional system has been basically established [8]. There are two different standards for green foods, including Grade A and Grade AA. Grade A allows food producers to use limited chemical pesticides, chemical fertilizers, and other chemical inputs. Grade AA has more stringent standards that are equivalent to the Chinese organic food production standards [9]. Moreover, 36 provincial-level green food working agencies, 325 municipal-level working agencies, and 2076 county-level working agencies have been established in China, covering 97.6% of prefectures and 72.7% of cities nationwide [10]. In addition, green food-designated environmental monitoring institutions and product quality testing institutions have been set up to achieve quality supervision of the entire industrial chain of green food from origin to product.

The green food industry is growing rapidly in China [11]. The belief that green foods are healthier than conventionally produced foods is an important reason for the growing interest in green foods worldwide [12]. At the same time, the growing demand for green foods reflects consumers' concerns about the destructive nature of traditional agriculture and people's health environment [13,14]. Therefore, there is a wealth of current research related to green foods, especially consumer preferences for green foods. However, the development of the green food industry is closely related to natural conditions, such as land, but few studies have analyzed this association [15].

Land resources are not only the spatial carriers of social and economic development but also the carriers of environmental and ecological services. In the case of limited land stock, improving land use efficiency is an important step to promote rational land use and achieve sustainable development [16]. Academic research on land use efficiency originated from the theory of market allocation efficiency in neoclassical economics in the 1870s [17]. The application of ecological location theory in the 1920s further enriched the study of land use efficiency. Many scholars have conducted numerous empirical studies on land use change [18], efficiency measurement and assessment [19], and optimization modeling strategies [20]. Land use efficiency is a concept that embodies sustainable development and is driven by natural, economic, and social impacts. Previous research on land use efficiency focused on two aspects. On the one hand, it explored the land use values of specific land use types, the spatial differences, saving potential and influencing factors of arable land [21], industrial land [22], and urban construction land [23]. On the other hand, the relationship between land use values was discussed, looking at socio-economic development, environmental constraints, and economic transition formation from the perspective of resource use [24]. Land use is an objective law formed by the interaction and influence of different land use types. This shows that different land use structures can provide different production materials and services that meet the needs of human activities [25]. Land use types have two relationships, including competition and cooperation. In the competitive relationship, depending on their comparative advantage, an increase in one type implies a decrease in the other type. In a cooperative relationship, the two land use types are interdependent and increase together [26]. Under natural conditions, the value of land use contribution to ecosystem services is closely related to the area of regional land use and the degree of interaction of other natural elements [27]. In the past few years, local governments in China, motivated by economic growth and a political impetus, have challenged regional sustainable development by increasing the scale of land transfers for investment projects, which has led to many problems, such as the reduction in arable land and inefficient land use [28]. Currently, there are various forms of land use conflicts in China, such as conflicts between urban expansion and arable land protection, conflicts between protected land and productive land (e.g., arable land and construction land), and conflicts between overuse of land and land degradation [29]. It predicted that China's total demand for arable land, total demand for pastureland, and total demand for forest land will continue to grow from 2011 to 2050. Total land demand in China is expected to continue to grow without sufficient improvements in production efficiency, and the pressure posed by dietary changes on land resources related to food supply will remain high in the future [30]. At the same time, at the provincial level, the higher the population density, the higher the intensity of land use conflicts, and it is imperative for China, as the world's most populous country, to improve the efficiency of agricultural land use [29].

Growing population and consumption led to increased demand for food, which increased competition for land and thus affected the ability to produce food, while plant-based products replaced non-renewable energy sources, leading to a growing demand for land [31]. The expansion and intensification of agricultural land have become one of the major threats to environmental degradation and biodiversity conservation [32]. At the same time, along with industrialization, soil degradation has become an urgent ecological problem and an important threat to sustainable food production [33]. Rwanda is the most densely populated country in Africa, and this denseness makes land one of the key resources in the country, with the majority of the working population relying on it for their livelihoods, and Rwanda's food security problems have been attributed to land scarcity and inadequate policies [34]. In addition to this, a study in Bangladesh indicated that more than half of the surveyed households experienced a decrease in crop land and an increase in tree plantations over the last 30 years [35]. The quantity and quality of land are closely related to national food security, sustainable agricultural production, and public health [36]. Widespread changes in land use worldwide caused by human activities have affected human health and ecosystems [37]. Land use is one of the determinants of future food demand and supply [38]. Food production is the most basic and concrete example of human dependence on land [32]. The Swedish government issued the Green Public Procurement (GPP) policy in 2006, stating that the public sector should increase organic food consumption to 25% in order to achieve the national environmental goal of 20% organic farmland by 2010. In 2017, a new, more ambitious policy stated that by 2030, the public sector food consumption of organic share would reach 60%, and the share of organic farmland would reach 30% [39]. Against the backdrop of increasing human concern for their own health and growing land use problems, it is significant to explore the degree of the coupling coordination between the level of competitiveness and land use efficiency of China's green food industry.

The competitiveness level of China's green food industry, land use efficiency, and the coupling coordination between them were focused on. After the existing studies, it was predicted that the competitiveness of China's green food industry was at a high level, the land use efficiency of China's green food industry showed a decreasing trend, and the coupling coordination between the two was good. Firstly, this study measured the competitiveness level of China's green food industry during 2011–2020 by constructing an index system firstly using the entropy method and VlseCriterion Optimisation and Compromise Resolution (VIKOR) method, and then evaluated the current land use efficiency of the green food industry in each province and city through super-efficient Slacks-based Measurement (SBM) model. Based on the above two results combined with the coupling coordination model, the coupling coordination between the competitiveness level and land use efficiency of China's green food industry was evaluated and analyzed from both time and space perspectives. By studying the coupling coordination of competitiveness level and land use efficiency of the green food industry in China, it had certain theoretical significance for expanding the research horizon of agricultural land and realizing regional targeted development of the industry. At the same time, studying the coupling coordination of competitiveness level and land use efficiency of the green food industry was of great significance for optimizing the industrial structure and promoting healthy, sustainable, stable, and efficient development of the green food industry. It provided theoretical and methodological support for the government to formulate industrial policies, development strategies, and investment decisions of relevant stakeholders. It also had reference significance for the solution of land contradiction problems in the green food industry in various provinces and cities in China.

2. Mechanism of Action

The green food industry has the characteristics of a highly connected and driven industry. Improving its competitiveness not only has a direct impact on land use efficiency but also can indirectly affect land use efficiency through infrastructure construction, industrial structure adjustment, and other factors, and the mechanism of action is shown in Figure 1, where the solid line indicates direct impact and the dashed line indicates indirect impact.

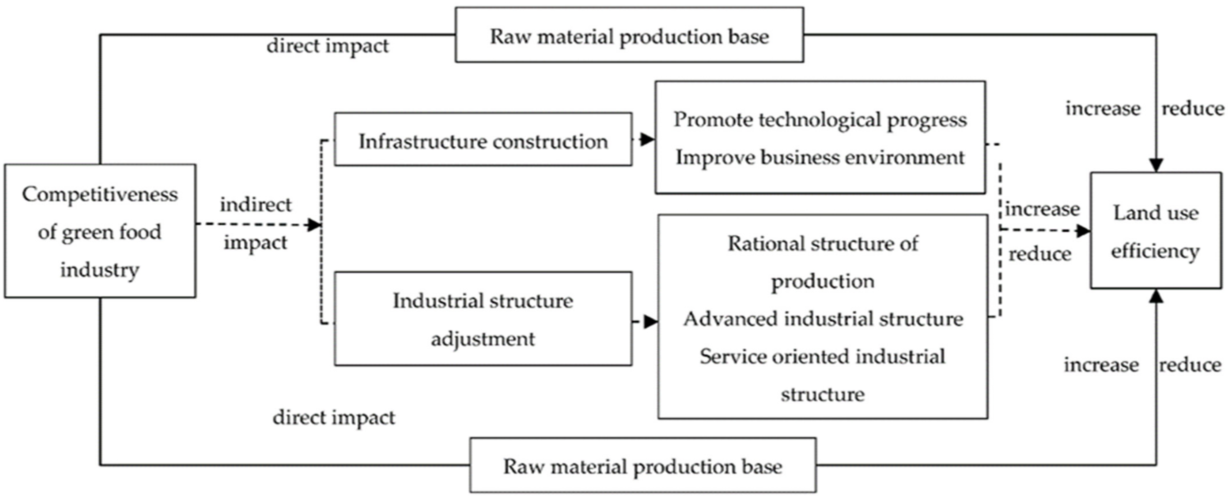

Figure 1. Mechanism of the competitiveness of green food industry on land use efficiency.

2.1. Direct Impact

Enhancing the competitiveness of the green food industry is an important path to serve rural revitalization and promote farmers' income and prosperity. Green food industry production and processing are inseparable from land resources, but due to soil degradation and other reasons, enhancing the land-use efficiency of the green food industry becomes a more feasible method. At the same time, the development of the green food industry revitalizes the idle labor force in rural areas, enriches the function of land, and promotes the intensive use of land resources. However, the current vague concept of land use in the green food industry and the lack of corresponding land use classification guidance have reduced the efficiency of land use and increased the downward pressure on land use efficiency.

2.2. Indirect Impact

China's green food industry is weak in processing, especially in livestock products and aquatic products, which are mostly sold in the form of raw materials. The green food industry involves both agricultural and industrial land, and as an industry that closely depends on land development, it should increase the construction of infrastructure to promote technological progress and drive economic benefits through infrastructure on the one hand, and improve the business environment and contribute to the premium of surrounding land on the other. The higher the land revenue, the stronger the attraction to the concentration of economic factors, the more intensive the economic activities it carries, and the higher the degree of intensive land use.

The development of the green food industry promotes the rationalization, advanced, and service evolution of regional industrial structure, which in turn has a profound impact on land use efficiency. Firstly, spatial planning guides the rationalization of industrial layout promotes inter-industry and intra-industry synergy and correlation effects, accelerates the formation of industrial clusters, and realizes the improvement of land use efficiency. Secondly, in order to enhance regional competitiveness, the industrial structure further evolves to an advanced level on the basis of rationalization, realizes regional total factor productivity enhancement, promotes technological progress, and improves land output efficiency. Thirdly, the servitization of industrial structure realizes land value-added by increasing industrial value-added, but the trend of economic servitization may reduce total factor productivity and thus affect land use efficiency. Fourthly, as the industrial structure is optimized and upgraded, the competition among industries will become more intense, and when the crowding effect is greater than the agglomeration effect, land use efficiency will also decline.

3. Data and Methods

3.1. Study Area

China is a vast territory and has rich natural resources and a variety of green food raw materials [40]. After decades of development, the green food industry has a certain scale. At present, China's green food products are mainly agricultural, forestry, and processed products, mainly concentrated in vegetables and fresh fruits. As recorded by "Green Food Statistical Report (2020)", a total of 8075 units and 16,863 products were certified in 2020 in China, with a total area of 156 million acres of origin testing environment. One hundred and seventy-one million acres of land were applied to green food cultivation in 2020 in China, an increase of 5 million acres compared with 2019, and annual domestic sales in 2020 amounted to CNY 507.565 billion; when compared with 2019, there was also certain increase. At the same time, as a major raw material country, China's green food exports in 2020 were up to USD 3.678 billion. The green food industry, as a new industry with great development potential, has received much attention from many sides, bringing great benefits from economic, social, and ecological aspects. In order to promote the competitiveness of the green food industry, the planting area of green food raw materials in China also needs to continue to expand, but the increase in the area of origin inevitably brings about changes in the structure, quantity, and extent of land use, and problems such as the contradiction between human and land are gradually highlighted.

At the same time, as China's cities continue to expand, urban construction land has increased dramatically. In 2012, China's per capita arable land was far below the world average [41]. In 2019, China's built-up area was as high as 60,312.45 square kilometers. In the early 1990s, China began to strengthen land use management, including guarding arable land resources and restraining the growth of built-up areas [42]. At present, the Chinese government has implemented many land management policies, such as the relevant plans for urban and rural construction land [43]. How to identify effective land use strategies to balance economic growth and land resources is a key issue.

Therefore, the evaluation of the coupling coordination between the competitiveness level of China's green food industry and land use efficiency is not only important for the development of China's green food industry but also beneficial for the improvement of the spatial allocation efficiency of land resource elements and the intensive and efficient use of resources.

3.2. Indicator System Construction

3.2.1. Green Food Industry Competitiveness Level Measurement Index System

This is based on the core meaning of industrial competitiveness and the principles of index selection and is combined with the existing research results [44]. In combination with Figure 1, the mechanism between the competitiveness and land use efficiency of the green food industry, five secondary indicators of production efficiency, product quality, economic efficiency, social efficiency, and ecological efficiency were selected to build a green food industry competitiveness level measurement index system, as shown in Figure 2.

Primary indicator	Secondary indicators	Tertiary indicators	Indicator interpretation
Green food industry competitiveness level measurement index system	Production efficiency	Green food industry water consumption	Green food industry total water consumption / sown area (10,000 m³ / ha)
		Productivity of agricultural land	Total output value of green food industry / farmland area (10,000 yuan / ha)
		Economic output per labor force in green food industry	Total output value of green food industry / number of employees in green food industry (10,000 yuan / person)
		Area of green food raw material standardized production base	Area of green food raw material standardized production base (10,000 ha)
	Product quality	Intensity of pesticide use	Total pesticide use / sown area (tons / ha)
		Fertilizer application intensity	Total fertilizer application / sown area (tons / ha)
		Number of green food certified units	Number of green food certified units (home)
		GDP output value of green food industry per unit area	Total output value of green food industry / sown area (10,000 yuan / ha)
	Economic efficiency	The proportion of the number of employees in the green food industry to the	The number of employees in the green food industry / total employment (%)
		The proportion of labor force employment in the green food industry	Number of employees in green food industry / number of rural labor force employment (%)
		Green food industry structure index	Total output value of green food industry / total output value of primary industry (%)
		Total output value index of green food industry	Total output value index of green food industry (%)
	Social efficiency	Per capita disposable income of rural residents	Per capita disposable income of rural residents(yuan)
		Effective irrigation coefficient	Effective irrigation area / farmland area (%)
		Green food industry waste resource utilization level	Green food industry waste sulfur dioxide gas production / farmland area (tons / ha)
		Green food industry renewable resource utilization level	Green food industry construction sun room area / farmland area (%)
	Ecological efficiency	Forest coverage rate	Forest coverage rate (%)
		Water resources per capita	Total water resources / total population (10,000 m³ / person)
		Farmland area per capita	Farmland area / total population (ha / person)
		Soil erosion control intensity	Soil erosion control area / land area (%)

Figure 2. Green food industry competitiveness level measurement index system.

3.2.2. Land Use Efficiency Evaluation Index System

With reference to the existing literature, in combination with Figure 1, the mechanism between the competitiveness and land use efficiency of the green food industry, land use efficiency is measured in two dimensions, input and output [45]. The construction and development of provinces and cities depend on the inputs of land, capital, labor, and other factors. In terms of output indicators, along with the current economic transformation in China, more and more attention is paid to environmental protection, and the expected output and non-expected output in the process of urban land use are included in the measurement system at the same time. The expected output mainly consists of economic, social, and ecological benefits, and the non-expected output considers the ecological losses generated in the land use process.

By regarding input factors combining land, capital, and labor as the three basic factors of production, land input, capital input, and labor input were selected. Regarding the land input index, the sown area reflects the input of green food production in terms of land. Regarding the capital input index, the investment in rural fixed assets is an important source of basic capital required for green food production, which is an important pavement for the future development of green food. Regarding the labor input index, talents are the source of industrial development, and the employees of agriculture, forestry, animal husbandry, and fishery are the main force for the development of the green food industry.

Regarding the expected output, the evaluation of land use efficiency should take into account the economic benefits generated by the land use process while taking into account the benefits of social welfare, ecological civilization, and other parties, so the expected output indicators of land use efficiency were selected from three aspects: economic benefits, social benefits, and ecological benefits. Regarding the indicators of economic benefits, the value added of primary industry, as an important indicator reflecting the level of national economic development, the greater its contribution to domestic GDP, the higher the level of advanced industrial structure and economic development. Regarding the indicators of social benefits, the per capita disposable income is an important indicator measuring the living standard of residents and has significant and direct social benefits. Regarding the indicators of ecological benefits, the forest coverage rate, as an important indicator measuring regional ecological security, is conducive to revealing the level of regional green development.

Regarding the non-desired output, the emissions of wastewater and exhaust gases were selected as a direct manifestation of the negative externalities of the economic and social activities of the green food industry on the environment, which can characterize the ecological losses generated in the process of economic development, as shown in Figure 3.

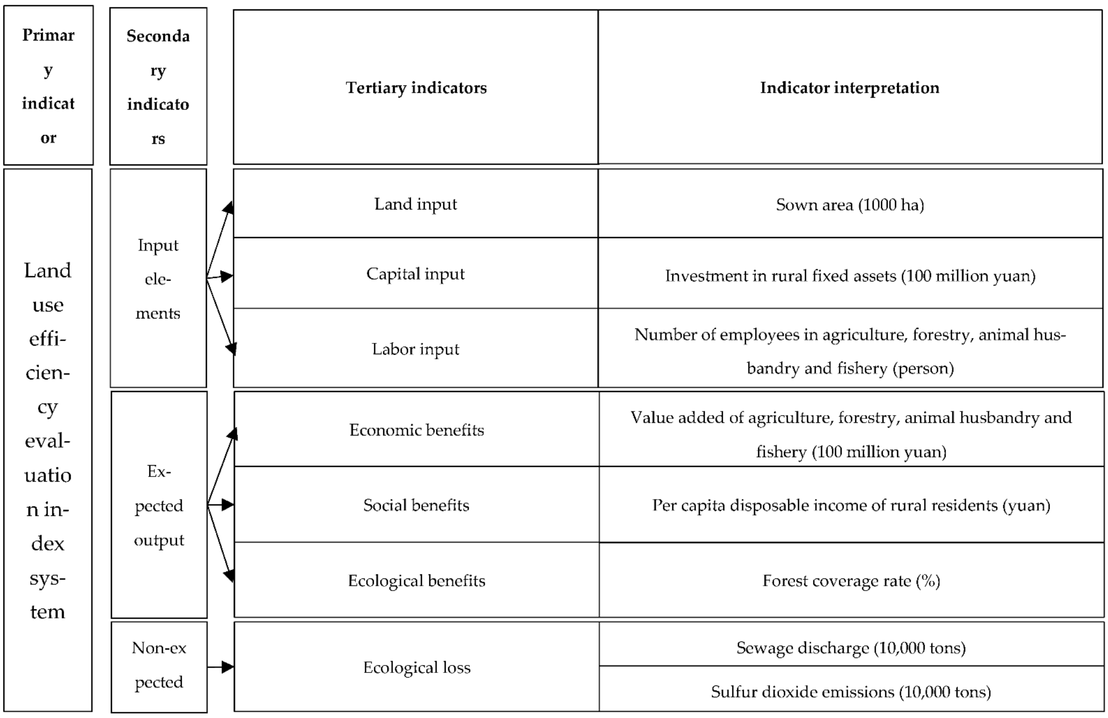

Figure 3. Land use efficiency evaluation index system.

3.3. Data Sources

The original data for the years 2011–2020 were mainly obtained from the "*China Statistical Yearbook*", "*China Rural Statistical Yearbook*", "*Green Food Statistical Report*", and provincial statistical yearbooks and other official data, based on which the data were processed to study the coupling coordination between the competitiveness level of China's green food industry and land use efficiency.

Moreover, based on the division in the "*China Statistical Yearbook*", 31 Chinese provinces and cities (excluding Hong Kong, Macao, and Taiwan) are divided into three regions based on their geographical locations, eastern, middle, and western, as shown in Table 1.

Table 1. Coverage of the three major regions in China.

Region	Scope
Eastern	Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan
Middle	Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan
Western	Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang

3.4. Methods

3.4.1. Entropy Method

The entropy method calculates the objective information amount of each indicator by analysis and thus weights the indicators, and the indicators with high weights have a large impact on the comprehensive evaluation [46]. The calculation process is standardizing the original data, calculating the ratio and entropy value of indicators, finding the coefficient of variability, and calculating the weights.

3.4.2. VIKOR Method

The VIKOR method is proposed by Opricovic and Tzeng et al. [47]. The VIKOR method is a multi-attribute decision-making method based on a compromise solution, which analyzes the maximization of group utility and minimization of individual regret based on a special measure of "closeness" and incorporates the subjective preferences of multiple decision-makers to make the evaluation results more reasonable and reliable. The standardized data and weights calculated by the entropy method are used to calculate the VIKOR value by calculating the positive ideal solution and negative ideal solution on this basis.

Assuming that there are m competitiveness level indicators, n is the number of years in the data sample, and X_{ij} denotes the i-th competitiveness level indicator value in year j; the standardized attribute values are:

$$f_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} {X_{ij}}^2}}, i = 1, 2, \cdots m; j = 1, 2 \cdots n \tag{1}$$

Afterward, the positive and negative ideal solutions are calculated, the maximum and minimum values of each indicator of the competitiveness level are found for each year:

$$f_i^* = \{max_j f_{ij}\} \tag{2}$$

$$f_i^- = \{min_j f_{ij}\} \tag{3}$$

f_{ij} is the assessed value of indicator i in year j after standardization, f_i^* is the maximum value of indicator i in each year, and f_i^- is the minimum value of indicator i in each year.

$$S_j = \sum_{i=1}^{n} \frac{w_i(f_i^* - f_{ij})}{f_i^* - f_i^-} \tag{4}$$

$$R_j = Max\left[\frac{w_i(f_i^* - f_{ij})}{f_i^* - f_i^-}\right] \tag{5}$$

where S_j denotes the weighted distance from the evaluated value of the j-th year to the positive ideal solution, and R_j denotes the weighted distance from the evaluated value of the j-th year to the negative ideal solution.

$$Q_j = \frac{v(S_j - S^*)}{S^- - S^*} + \frac{(1 - V)(R_j - R^*)}{R^- - R^*} \tag{6}$$

where Q_j denotes the VIKOR value of the competitiveness level in the j-th year. Where $S^* = minS_j$, $S^- = maxS_j$, $R^* = minR_j$, $R^- = maxR_j$, S^* is the maximum utility of the competitive level group, R^* is the minimum regret of the competitive level group, and v is the maximum group utility weight. When $v < 0.5$, it means that the solution is approved by the majority of the group, and when $v > 0.5$, it means that the solution is rejected by the majority of the group. Therefore, to simultaneously pursue the maximization of group utility and the minimization of individual regret, v is set to 0.5.

3.4.3. Super-Efficient SBM Model

Data Envelopment Analysis (DEA) is a non-parametric method that can be used to deal with the efficiency problem between multiple inputs and multiple outputs, and the efficiency value of the evaluated unit is measured based on the frontier surface composed of input and output indicators of all evaluation units. The super-efficient SBM model is based on the traditional DEA model, and the slack variables are directly put into the objective function to solve the input–output slackness problem [48]. Additionally, when the super-efficient SBM model is in the calculation of efficiency values, the effective research unit efficiency values can be further decomposed so that it is greater than 1. The model is set as follows:

$$U = \frac{1 + \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{ik}}}{1 - \frac{1}{s_1+s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{rk}^g} + \sum_{r=1}^{s_2}\frac{s_r^b}{z_{rk}^b}\right)} \tag{7}$$

$$s.t.\begin{cases} x_k \geq X\lambda - s^- \\ y_k^g \leq Y^g\lambda + s^g \\ z_k^b \geq Z^b\lambda - s^b \\ s^- \geq 0, s^g \geq 0, s^b \geq 0, \lambda \geq 0 \end{cases} \tag{8}$$

where U is the land use efficiency value to be calculated; m, s_1, and s_2 are the number of input, desired output, and undesired output factors, respectively; s^-, s^g, and s^b are the slack of input, expected output, and non-expected output; x, y^g, and z^b are the value of the input, expected output, and non-expected output, respectively; λ is the weight vector; X, Y^g, and Z^b are the matrices composed of input, expected output, and non-expected output, respectively.

3.4.4. Coupling Coordination Model

The coupling coordination model is used to analyze the relationship between the level of industrial competitiveness and land use efficiency. It is often used to measure the degree of coordinated development of different systems and is widely used in urbanization, industrial development, and ecological environment systems. The coupling degree reflects the degree of synchronization between two systems [49], while the coupling coordination degree takes into account the development level of the two systems and the coordination degree between the two systems at the same time, the coupling coordination degree reflects the degree of synchronization of the two systems and their development level as a whole [50].

$$C = 2\left[\frac{Q \times U}{\prod(Q+U)}\right]^{\frac{1}{2}} \tag{9}$$

$$T = aQ + bU \tag{10}$$

$$D = \sqrt{C \times T} \tag{11}$$

where C is the coupling degree, T is the development degree, and D is the coupling coordination degree. Referring to the existing grading criteria and combined with the calculation results, the coupling coordination degree is divided into seven levels, as shown in Table 2 [51]. a and b are parameters to be determined, which indicate the relative importance of two subsystems to the total system. Therefore, $a = b = 0.5$ in this paper, as both are equally important.

Table 2. Coupling coordination degree taking value and grading.

Range of Values	Coupling Coordination Level
$0 \leq D < 0.3$	Severe disorder
$0.3 \leq D < 0.4$	Major disorder
$0.4 \leq D < 0.5$	Mild disorder
$0.5 \leq D < 0.6$	Primary coordination
$0.6 \leq D < 0.7$	Moderate coordination
$0.7 \leq D < 0.8$	Good coordination
$D \geq 0.8$	High-quality coordination

4. Empirical Analysis

4.1. Competitiveness Level of Green Food Industry by Provinces and Cities in China

By using the entropy method to determine the index weights, the competitiveness levels of the green food industry in 31 provinces and cities (excluding Hong Kong, Macao, and Taiwan) in China during 2011–2020 were calculated separately by the VIKOR method. During the period of 2011–2020, the competitiveness level of China's green food industry is stronger in the west than in the middle and the east, that is, "the west is higher than the east is lower", mainly because of the obvious advantages of Gansu, Qinghai, Ningxia, and Xinjiang four provinces in the northwest of China. The middle region and the eastern region scores are similar; the difference is small, as shown in Table 3.

Based on the measurement results of the competitiveness level of the green food industry in each province and city in China from 2011 to 2020, grading results were defined in a hierarchical manner by system clustering through SPSS 26.0. Based on the results of systematic cluster analysis and existing studies, the 31 provinces and cities (excluding Hong Kong, Macao, and Taiwan) are divided into three categories, including high competitive regions, medium competitive regions, and low competitive regions.

The first category of high competitive areas includes five provinces and cities, Tianjin, Gansu, Qinghai, Ningxia, and Xinjiang. The above five provinces and cities in China's green food industry competitiveness level measurement ranking for a long time during 2014–2020 are in the forefront. Qinghai, Xinjiang, and Gansu, respectively, ranked first, second, and third in China's green food industry competitiveness level; it can be seen that the above three provinces for green food industry competitiveness advantage are obvious. Take Qinghai, which has the most significant advantages, as an example, the soil, air, and water resources in Qinghai are less affected by pollution; the temperature difference between day and night is large; the light radiation is strong; and the good ecological environment is beneficial to the planting and cultivation of green food, which lays a solid foundation for the development of green food industry in Qinghai. At the same time, the Qinghai provincial government supported the idea of the green food industry; in 2006, it already put forward the "General Office of Qinghai Provincial People's Government on accelerating the development of pollution-free agricultural and livestock products green food organic agricultural and livestock products opinions". As a leading model province in China's green food industry competitiveness, the development experience of Qinghai's green food industry is worthy of reference and promotion.

The second category of medium competitive areas includes Beijing, Hebei, Liaoning, Guangdong, Shanxi, Jilin, Anhui, Henan, Hubei, Hunan, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, seventeen provinces and cities. There are more provinces and cities in the middle level of competitiveness of China's green food industry, which also reflects the current situation of competitiveness of China's green food industry; that is, the advantages and disadvantages are not obvious and are mostly located in the middle level. Among them, Shanxi, Tibet, and Beijing show growth from 2020 onwards, all due to the significant increase in the number of employees in the green food industry and the area of green food production bases, which promote the positive development of the industry. In contrast, Guizhou and Yunnan were in first place in 2013 but gradually declined in the following years, inextricably related to the reduction in production base area and effective irrigation area.

Table 3. Green food industry competitiveness level of each province and city in China during 2011–2020.

Provinces and Cities	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beijing	0.47	0.46	0.87	0.48	0.48	0.52	0.55	0.49	0.50	0.53
Tianjin	0.73	0.70	0.82	0.65	0.66	0.70	0.71	0.57	0.58	0.59
Hebei	0.42	0.38	0.81	0.48	0.51	0.51	0.50	0.47	0.49	0.51
Liaoning	0.47	0.45	0.91	0.47	0.48	0.49	0.46	0.44	0.47	0.44
Shanghai	0.36	0.37	0.55	0.36	0.37	0.41	0.48	0.38	0.52	0.55
Jiangsu	0.46	0.46	0.63	0.33	0.40	0.38	0.31	0.32	0.24	0.27
Zhejiang	0.24	0.26	0.79	0.26	0.33	0.32	0.35	0.34	0.35	0.33
Fujian	0.31	0.32	0.00	0.31	0.34	0.35	0.38	0.36	0.39	0.37
Shandong	0.33	0.28	0.71	0.38	0.48	0.39	0.39	0.35	0.36	0.38
Guangdong	0.44	0.45	0.94	0.46	0.49	0.49	0.50	0.46	0.49	0.47
Hainan	0.33	0.34	0.87	0.36	0.36	0.39	0.41	0.38	0.37	0.36
Eastern average	0.42	0.41	0.72	0.41	0.44	0.45	0.46	0.41	0.43	0.44
Shanxi	0.61	0.60	0.93	0.57	0.61	0.62	0.58	0.55	0.57	0.56
Jilin	0.43	0.48	0.97	0.50	0.53	0.53	0.51	0.49	0.50	0.52
Heilongjiang	0.15	0.16	0.67	0.16	0.16	0.16	0.16	0.16	0.21	0.16
Anhui	0.48	0.44	0.87	0.50	0.55	0.52	0.48	0.49	0.47	0.43
Jiangxi	0.32	0.31	0.93	0.35	0.36	0.38	0.37	0.34	0.38	0.39
Henan	0.51	0.49	0.85	0.54	0.55	0.58	0.58	0.54	0.53	0.51
Hubei	0.46	0.49	0.89	0.43	0.48	0.47	0.47	0.44	0.48	0.48
Hunan	0.43	0.42	0.86	0.42	0.43	0.44	0.42	0.41	0.43	0.43
Middle average	0.43	0.42	0.87	0.44	0.46	0.46	0.45	0.43	0.45	0.44
Inner Mongolia	0.29	0.38	0.92	0.36	0.38	0.38	0.38	0.35	0.35	0.32
Guangxi	0.42	0.41	0.97	0.43	0.44	0.46	0.47	0.43	0.46	0.43
Chongqing	0.55	0.53	0.92	0.51	0.43	0.54	0.53	0.48	0.48	0.45
Sichuan	0.48	0.46	0.94	0.50	0.54	0.53	0.49	0.47	0.51	0.52
Guizhou	0.56	0.54	0.98	0.50	0.50	0.51	0.49	0.43	0.47	0.45
Yunnan	0.45	0.43	0.97	0.41	0.43	0.44	0.46	0.42	0.43	0.44
Tibet	0.45	0.46	0.75	0.48	0.49	0.53	0.53	0.52	0.56	0.56
Shaanxi	0.46	0.46	0.94	0.48	0.48	0.50	0.50	0.48	0.51	0.48
Gansu	0.72	0.69	0.87	0.71	0.75	0.74	0.71	0.74	0.74	0.73
Qinghai	0.98	0.98	0.94	0.95	0.95	0.95	0.95	0.97	0.97	0.97
Ningxia	0.72	0.70	0.95	0.65	0.67	0.67	0.61	0.58	0.60	0.55
Xinjiang	0.87	0.84	0.85	0.86	0.89	0.88	0.88	0.87	0.89	0.86
Western average	0.58	0.57	0.92	0.57	0.58	0.59	0.58	0.56	0.58	0.56
National average	0.48	0.47	0.83	0.48	0.50	0.51	0.50	0.47	0.49	0.48

The third category of low competitiveness areas mainly includes Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Hainan, Heilongjiang, Jiangxi, and Inner Mongolia, which are nine provinces and cities. The above nine provinces and cities have relatively backward comprehensive scores and rankings, and the level of competitiveness of the green food industry needs to be improved for different reasons. For example, Inner Mongolia and Heilongjiang have a better ecological environment, but there are problems such as low employment and slow technological progress, while Shanghai, Hainan, and other provinces and cities have a limited ecological environment, which limits the development of the industry. However, the competitiveness level of Shanghai's green food industry has greatly improved in the decade of 2011–2020, rising from 24th place in 2011 to 9th place in 2020, and its per capita disposable income of rural residents and the number of green food certified units have increased exponentially, indicating that Shanghai is continuously reducing the competitiveness level gap with other provinces and cities based on its developed economic environment and policy support. In general, the low, competitive regions should look to the high competitive regions in multiple dimensions to improve the development level of the green food industry in the province and city from all aspects, as shown in Figure 4.

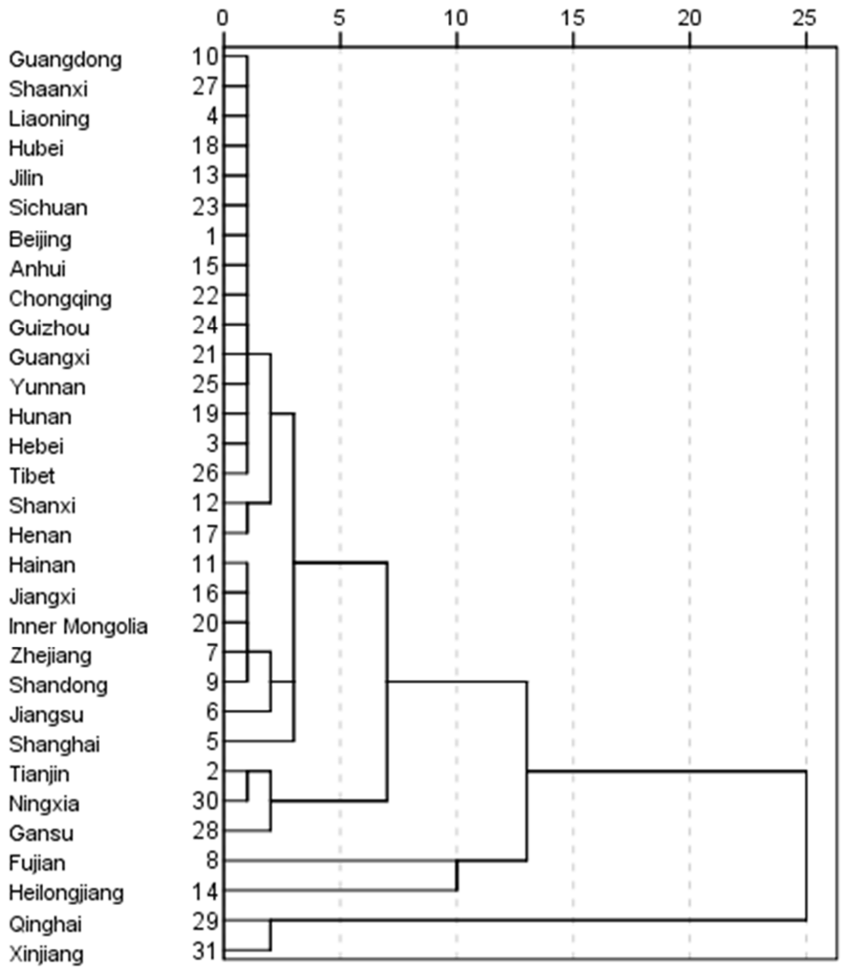

Figure 4. Clustering spectrum of competitiveness level of green food industry in 31 provinces and cities (excluding Hong Kong, Macao, and Taiwan) in China.

4.2. Land Use Efficiency of Green Food Industry by Provinces and Cities in China

The super-efficient SBM model was used to evaluate the land-use efficiency of the green food industry in each province and city in China (excluding Hong Kong, Macao, and Taiwan), and the results are shown in Table 4, and the average values of land use efficiency in the three major regions and the whole country are shown in Figure 5.

According to Table 4 and Figure 5, it can be seen that the land use efficiency of China's three major regions and overall green food industry generally showed a rising and then declining trend from 2011 to 2020, peaking in 2016 and showing a rebounding trend in 2020. The specific reasons are that the sulfur dioxide emissions of all provinces and cities in 2016 have significantly decreased, indicating the importance of the ecological environment for land use. The input indicators of all provinces and cities, that is, sown area, investment in rural fixed assets, and the number of people employed in agriculture, forestry, animal husbandry, and fishery, generally increased to different degrees in 2020, while the sulfur dioxide emissions of all provinces and cities again show a significant decrease, indicating that the development of China's green food industry depends on the investment of government funds and the introduction of talents.

In Figure 5, the average land-use efficiency of the green food industry in the three major regions is ranked as eastern > western > middle, and the middle and western are lower than the national average in most years. Regarding the land-use efficiency of China's green food industry, the eastern leads significantly, while the development of the green food industry in the middle and western may be constrained by the land-use efficiency.

The land use efficiency of the green food industry in 31 Chinese provinces and cities (excluding Hong Kong, Macao, and Taiwan) was classified into four categories, intensive use, moderate use, low use, and rough use, by using systematic clustering through SPSS 26.0, as shown in Figure 6.

Table 4. Land use efficiency of green food industry in China by provinces and cities in 2011–2020.

Provinces and Cities	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beijing	1.29	1.28	1.31	1.42	1.43	1.43	1.46	1.51	1.55	1.48
Tianjin	1.14	1.15	1.16	1.24	1.36	1.16	1.23	1.15	1.07	1.15
Hebei	1.00	0.66	1.00	1.02	1.00	1.04	0.65	1.00	0.50	0.62
Liaoning	0.35	0.40	0.28	0.38	0.37	0.92	0.31	0.30	0.33	0.37
Shanghai	2.08	2.06	1.94	1.89	1.82	1.64	1.60	1.18	1.18	1.25
Jiangsu	1.02	1.04	1.05	1.05	1.06	1.09	1.06	1.05	1.02	1.04
Zhejiang	1.28	1.43	1.38	1.50	1.64	1.79	1.66	1.54	1.19	1.14
Fujian	1.08	1.11	1.05	1.12	1.11	1.16	1.07	1.06	1.11	1.18
Shandong	1.03	1.03	1.08	1.08	1.06	1.00	1.06	1.10	1.04	1.02
Guangdong	0.70	0.59	0.64	1.00	1.01	1.10	1.02	1.01	1.03	1.01
Eastern average	1.13	1.10	1.13	1.19	1.21	1.26	1.14	1.12	1.04	1.07
Hainan	1.47	1.35	1.53	1.37	1.41	1.52	1.45	1.46	1.46	1.45
Shanxi	0.34	0.32	0.36	0.36	0.35	0.37	0.31	0.32	0.27	0.25
Jilin	0.47	0.47	0.30	0.47	0.48	1.03	0.34	0.32	0.39	0.46
Heilongjiang	0.15	0.19	0.17	0.22	0.24	1.04	1.07	1.05	1.06	1.05
Anhui	0.62	0.53	0.49	0.53	0.50	0.64	0.63	0.58	0.37	0.43
Jiangxi	0.49	0.42	0.46	0.56	0.55	1.04	0.58	0.53	0.46	0.47
Henan	0.48	0.42	0.43	0.53	0.75	1.02	1.05	1.06	1.05	1.09
Hubei	1.01	0.66	0.34	1.01	0.70	1.03	1.01	0.38	0.33	1.02
Hunan	1.03	1.06	1.06	1.06	1.05	0.89	1.03	1.03	0.83	1.00
Middle average	0.57	0.51	0.45	0.59	0.58	0.88	0.75	0.66	0.60	0.72
Inner Mongolia	1.00	1.05	1.01	0.30	0.31	0.61	0.28	0.25	0.50	0.40
Guangxi	0.72	0.62	0.43	0.76	0.72	1.09	1.00	1.00	0.52	1.03
Chongqing	1.18	1.14	1.15	1.13	1.10	1.10	1.15	1.21	1.19	1.25
Sichuan	1.02	1.03	1.02	1.01	1.02	0.81	1.02	1.02	1.03	0.69
Guizhou	1.09	1.06	1.06	1.07	1.14	1.11	1.23	1.24	1.17	1.12
Yunnan	0.58	0.67	0.48	1.01	0.61	0.49	0.51	0.49	0.52	0.76
Tibet	1.35	1.36	1.31	1.31	1.41	1.97	1.25	1.25	1.25	1.26
Shaanxi	1.02	1.02	1.01	1.02	0.76	0.62	0.75	0.77	0.54	0.57
Gansu	1.01	1.02	0.29	1.01	0.50	0.61	0.36	0.29	0.38	0.51
Qinghai	1.10	1.12	1.08	1.12	1.09	1.07	1.04	1.05	1.08	1.08
Ningxia	0.48	0.63	0.45	1.03	1.07	1.13	1.07	1.08	1.03	1.10
Xinjiang	0.07	0.07	0.05	0.05	0.06	0.22	0.06	0.09	0.16	0.27
Western average	0.89	0.90	0.78	0.90	0.82	0.90	0.81	0.81	0.78	0.84
National average	0.89	0.87	0.82	0.92	0.89	1.02	0.91	0.88	0.83	0.89

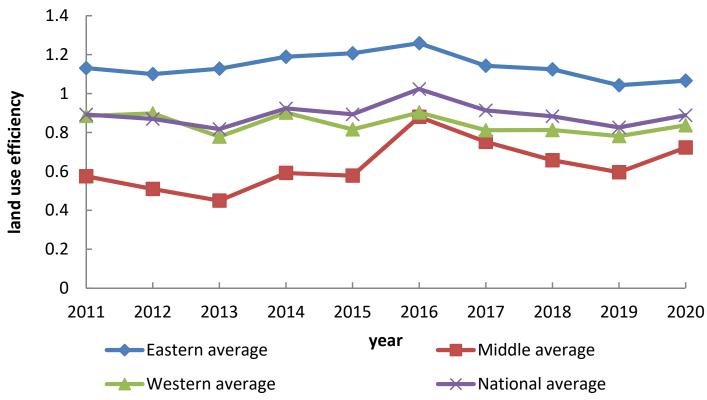

Figure 5. Average land-use efficiency of the green food industry in the three major regions of China and the country from 2011 to 2020.

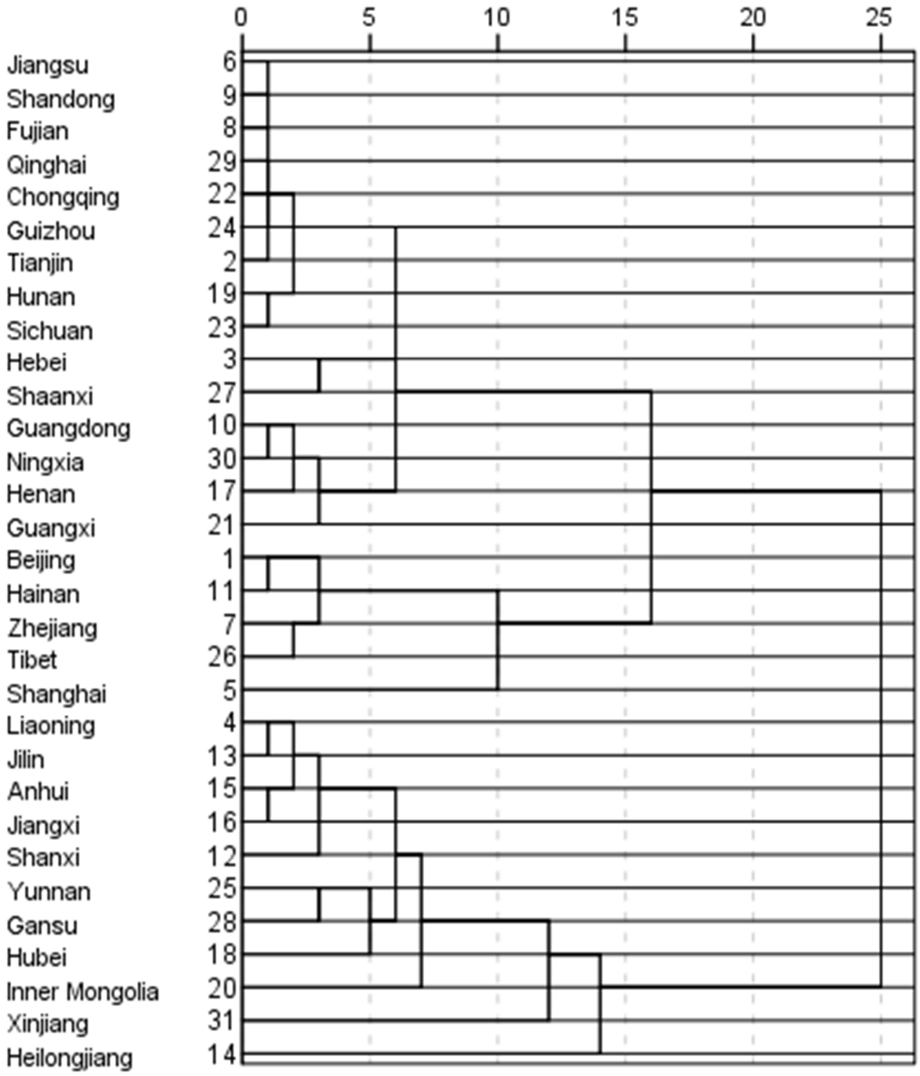

Figure 6. Clustering spectrum of land use efficiency of green food industry in 31 Chinese provinces and cities.

The first category, intensive use, contains five provinces and cities, Beijing, Shanghai, Zhejiang, Hainan, and Tibet. The above five provinces and cities have the highest land use efficiency in the green food industry all year round for different reasons. Beijing and Shanghai mainly rely on the higher economic level and ecological environment of local residents. Zhejiang mainly relies on the local government's investment in the green food industry and the higher income level of residents. Hainan has a better natural resource environment, and Tibet has more employees in the green food industry, while the government attaches importance to waste water and waste gas emission reduction.

The second category, moderate use, contains fifteen provinces and cities in Tianjin, Hebei, Jiangsu, Fujian, Shandong, Guangdong, Henan, Hunan, Guangxi, Chongqing, Sichuan, Guizhou, Shaanxi, Qinghai, and Ningxia. The land-use efficiency of China's green food industry is located in more provinces and cities with medium utilization, indicating that the overall land-use efficiency of China's current green food industry is at an intermediate level. Among them, Guangdong, Henan, Guangxi, and Ningxia all had more obvious improvements in land use efficiency during the decade. Guangdong's fixed asset investment, industrial added value, and per capita disposable income are higher, indicating that Guangdong's higher land use efficiency mainly relies on an economic level. Henan's sown area, fixed asset investment, and industrial added value are higher, indicating that Henan mainly relies on production level and economic level. Guangxi's production level, economic level, and ecological environment are all in an advantageous position. Ningxia's ecological environment is the green food industry's important advantageous factor for land use efficiency.

The third category, low use, contains ten provinces of Liaoning, Shanxi, Jilin, Anhui, Jiangxi, Hubei, Inner Mongolia, Yunnan, Gansu, and Xinjiang. During 2011–2020, the trend of lower land use efficiency is more obvious in Anhui, Inner Mongolia, and Gansu, and there are different reasons for the inhibition in each province. In Anhui, the main reason is that the number of employees in the green food industry is low, and the loss of talent is the main reason for inhibiting the land-use efficiency of the green food industry in Anhui. In Inner Mongolia, the focus is on economic and ecological reasons, and although the number of local employees is high, it is not strongly supported by the government. In Gansu, the values of all indicators are lower than the national average, indicating that the land use efficiency of the green food industry in Gansu has more serious problems. The values of all indicators in Gansu are lower than the national average, indicating that Gansu's green food industry has serious problems in land use efficiency and needs to be improved in all aspects.

The fourth category, rough use, contains one province of Heilongjiang. Fixed asset investment and per capita disposable income are the main reasons that inhibit the land-use efficiency of the green food industry in Heilongjiang, and economic factors have a greater impact on Heilongjiang. However, Heilongjiang's green food industry is highly competitive and has a good production level and natural resource environment, so since 2016, the land use efficiency of Heilongjiang's green food industry has seen a relatively large increase.

From the perspective of three major regions, there are six provinces and cities in the middle region for rough use and low use, four in the western region, and only one in the eastern region; there are nine and eight provinces and cities in the eastern region and western region for moderate use and intensive use, respectively, with little difference, but there are only three in the middle region. By combining Table 4 and Figure 5, it can be seen that the current land use efficiency of the green food industry in the three regions has formed obvious differences.

4.3. Coupling Coordination between the Competitiveness Level and Land Use Efficiency of Green Food Industry by Provinces and Cities in China

4.3.1. Temporal Characteristics

(1) The average value of coupling coordination between the competitiveness level and land use efficiency of China's green food industry from 2011 to 2020 floats at the boundary of high-quality coordination, indicating that the competitiveness and land use efficiency of China's green food industry develop in a more coordinated manner. All three regions show a rising and then declining and leveling-off trend, with the eastern and western remaining in high-quality coordination over the decade and the middle being good coordination except for 2012, when it was moderate coordination, as shown in Figure 7. In 2013, the coupling coordination between the competitiveness level and land use efficiency in all three regions reached a peak. The main reason is that the number of employment and fixed asset investment in China's green food industry in 2013 was significantly higher compared to 2012 and 2014, indicating that the development of the green food industry in China's provinces and cities was on the rise in 2013, attracting more labor to join the green food industry. The government also actively supported the green food industry, and governments at all levels increased their investment in fixed assets for the green food industry. At the same time, national urbanization accelerated in 2013; the reverse of urban space expansion caused a decrease in the production base area of the green food industry, resulting in an increase in the land use efficiency of the green food industry in that year and an increase in the coupling coordination of all regions to varying degrees:Coordinated development of the eastern region.

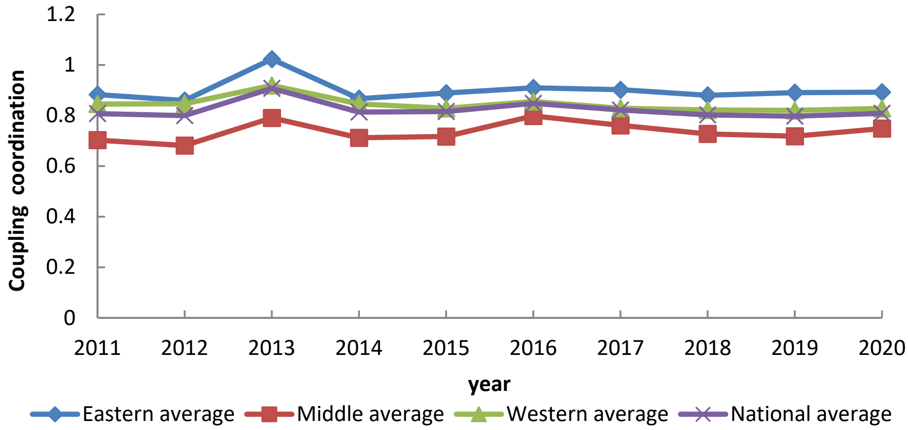

Figure 7. Trend of the average of the coupling coordination degree between competitiveness and land use efficiency of green food industry in three major regions and the whole country of China from 2011 to 2020.

The eastern maintained high-quality coordination during the decade, and the average value of coupling coordination is higher than that of the western and middle, taking the lead. Firstly, there are more developed cities in the eastern of China, covering the capital Beijing, Shanghai, Zhejiang, and other provinces and cities with better economic development and higher population density, and the residents generally have better economic strength, cultural quality, environmental awareness, and health consciousness. People are more in pursuit of green and healthy life. Secondly, most of the eastern are coastal provinces and cities, and with the advantages of location and transportation, they attract many high-tech industries and projects to land, increase the expenditure in technology, promote the improvement of land use efficiency by enhancing the innovation ability, and accelerate the pace of development of green food industry. Thirdly, most enterprises in the eastern are mainly in secondary and tertiary industries, which is more convenient to promote the formation of an integrated chain with the green food industry. Fourthly, the eastern region is a monsoon climate zone, regulated by the ocean, rain, and heat in the same season, light and temperature with good cooperation, conducive to the growth of a variety of crops and the implementation of a multi-crop system.

(2) Stable development in the west.

Although the coupling coordination in the western is slightly inferior to that in the eastern, it is still high-quality coordination in all ten years, which is inseparable from the vast land area and good ecological environment in the western. Although there is a gap between the economic development of the western and the eastern, resulting in a lower population density in the west, it has also become an important reason for the good development trend of the green food industry in the west. Because of the low population, the ecological environment in the west is relatively less polluted, and the light and temperature are beneficial to the growth of agricultural products, so it has a more suitable environment for the growth of green food. The northwest region is a temperate or alpine continental climate, dry and with little rain, and mainly grassland. The southwest region includes the southwest plateau area and the southeast Tibetan Chuanxi region, with annual precipitation between 500 and 1000 mm, and a subtropical, warm temperate humid or sub-humid climate, for the year two maturity system. At the same time, the land area in the west is more extensive, which can be used to build a well-regulated green food production base. In addition to the good natural conditions, the government of the west also intends to cultivate the green food industry as an advantageous industry; for example, the government of Yunnan Province proposed “three green cards”, including the “green food card”. With the policy support, along with the implementation of initiatives such as the growth of science and technology expenditure and the adjustment of industrial space layout, the competitiveness of the green food industry in the west has been in a leading position in recent years.

(3) Uneven development in the middle.

Among the three major regions, the middle has the lowest coupling coordination in all ten years. In recent years, China's export-oriented economy has entered a rapid development stage while most of the provinces and cities in the middle have less favorable natural conditions than those in the west, so they are more inclined to develop high-end, modern manufacturing and service industries, resulting in problems such as an insufficient number of employees in the green food industry. At the same time, the process of industrialization in the middle provinces and cities has encroached on a large amount of arable land, resulting in ecological damage and imbalance in urban and rural development. In addition, the focus on building small towns has dispersed the construction resources of the green food industry and reduced land-use efficiency, resulting in a low degree of coupling coordination between the competitiveness and land-use efficiency of the green food industry in the middle region.

4.3.2. Spatial Characteristics

According to the calculated specific values of the coupling coordination degree between competitiveness and land use efficiency of the green food industry in each province and city of China from 2011 to 2020, the graphs were made by ArcGIS 10.6 based on the grading method of coupling coordination degree in Table 2. The four years of 2011, 2014, 2017, and 2020 were selected at every two-year interval to analyze the spatial evolution characteristics of the coupling coordination degree of competitiveness level and land use efficiency of China's green food industry from 2011 to 2020, as shown in Figure 8.

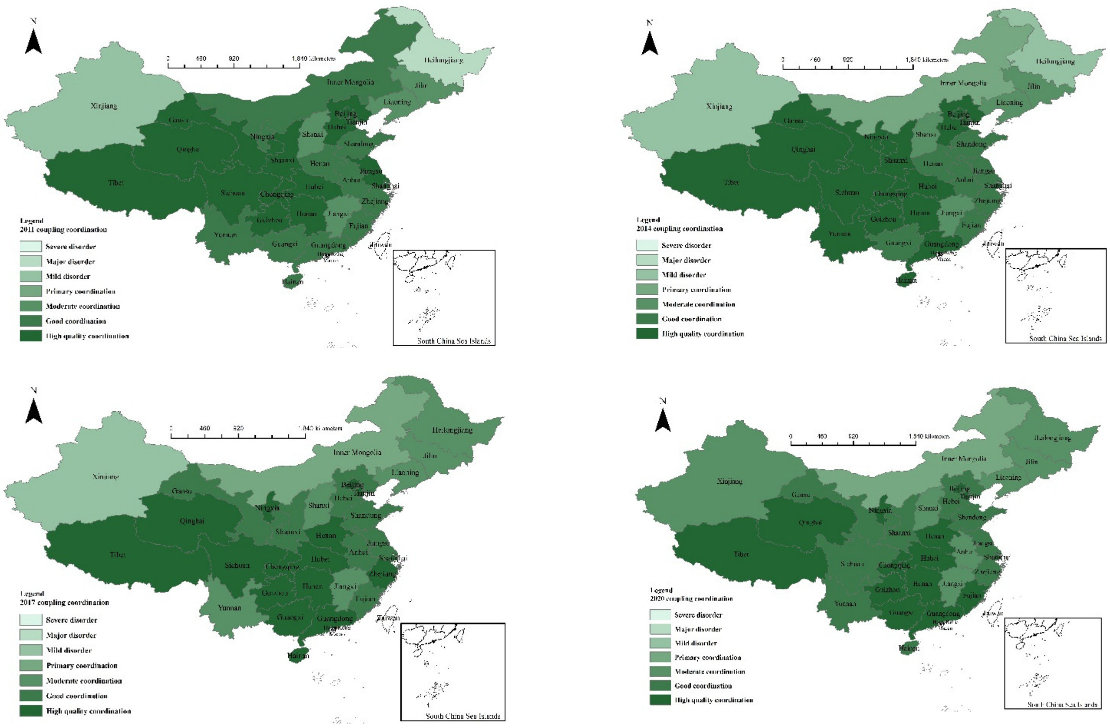

Figure 8. Spatial distribution of the coupling coordination between competitiveness and land use efficiency of green food industry in China from 2011 to 2020.

As can be seen from Figure 8, the overall high-quality coordination between the competitiveness and land use efficiency of the green food industry in China (excluding Hong Kong, Macao, and Taiwan) shows a shift from the north to the south, which is reflected in the following three aspects:

(1) The eastern is centered on the economic belt.

In 2011, all the provinces and cities in the eastern, except Liaoning, were high-quality coordination or good coordination and were in the leading position nationwide. Among them, high-quality coordination is mainly concentrated in Beijing, Hebei, Zhejiang, and Guangdong, closely relying on the three economic belts of Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta, indicating that the development of the green food industry in the eastern is highly related to the local economic level. Through the excellent land, sea, and air transportation conditions, the gathering effect, radiation effect, and technology leading effect of the urban economic belt, the core competitiveness of the green food industry in the eastern is successfully enhanced. Additionally, the high-quality coordination provinces and cities in the eastern as a whole are shifted from northern China to the southeast. Fujian, the nearest geographically located province, also rose from good coordination to high-quality coordination in 2020 under the economic radiation effect of Guangdong.

(2) The western gap decreases and tends to be intermediate.

According to the measurement results, the majority of provinces and cities in the west in 2011 were in high-quality coordination, individually in good coordination, and only Xinjiang was mild disorder, indicating that the development gap between provinces and cities in the west is large and the advantages and disadvantages are more prominent. The number of provinces in high-quality coordination is gradually decreasing from the north to the south, mainly because the land area of provinces in the northwest is generally higher than that in the southwest. However, from 2017, the overall situation in the west has changed significantly, with the number of provinces and cities in high-quality coordination decreasing on the one hand and the provinces and cities in high-quality coordination being shifted from the north to the south on the other hand. Additionally, in 2020, although the number of provinces and cities with high-quality coordination decreased, the dynamics of provinces such as Xinjiang increased, which has been in disorder for a long time, changing from mild disorder to moderate coordination, the gap between provinces gradually decreases, and the overall trend is toward the intermediate dynamic.

(3) The middle is in good shape and actively developing.

In 2011, most of the provinces in the middle were in moderate coordination, among which Heilongjiang was in major disorder, and the overall coupling coordination in the middle was low. The middle has the important role of "bearing the east and enlightening the west", obviously as a "bridge" between the more developed and less developed areas of the Yellow River Basin, and is subject to radiation from the eastern, while at the same time, it has to bear the responsibility of transferring talents, technology, and other resources for the development of the west. However, the low degree of coupling coordination in the middle indicates that the middle has not yet fully transformed its resource advantages into an intrinsic driving force for coordinated regional development. Moreover, soil erosion disasters, water shortage, and unscientific land use have also hindered the development of the middle. However, with the change in time, the overall situation in the middle is good, and the green food industry is actively developing. Heilongjiang, which was a major disorder, rose to moderate coordination; Henan, which was good coordination, rose to high-quality coordination; and the remaining provinces did not change significantly. The advantageous location is stable and does not shift significantly.

5. Discussion

With the improvement of people's living standards, the consumer concept of safety, health, and environmental protection has become increasingly popular. As the world's largest developing country and one of the world's largest agricultural countries, the Chinese government has proposed to vigorously develop green agricultural products and try out policies to promote the development of the green food industry, such as the conformity certificate system for edible agricultural products. On this basis, the planting area of green food raw materials also needs to be expanded continuously, but the increase in the area of origin inevitably brings about changes in the structure, quantity, and degree of land use, and problems such as the contradiction between humans and land are gradually highlighted. This study provides theoretical support for solving the land conflicts caused by the green food industry by analyzing the coupling coordination between the competitiveness level and land use efficiency of the green food industry in China. Unlike previous studies, this study contains the following three main aspects: (1) Although China has a good environment for green food growth, the green food industry has developed late, and the land use problem has not been paid attention to yet; the research related to the land use of the green food industry is enriched. (2) The index system for measuring the competitiveness level of the green food industry is constructed, which fully considers the complete process from the production of raw materials of green food to the three major benefits of economy, society, and ecology brought by industrial development. (3) The land utilized by the green food industry is the object of land use efficiency evaluation, concentrates on agricultural land, and avoids the influence of other industrial lands on the measurement results.

This study first evaluated the competitiveness level and land use efficiency of China's green food industry separately and then conducted a specific analysis of the coupling coordination degree based on the evaluation results. Firstly, according to the evaluation results of the competitiveness level of China's green food industry, the provinces and cities with higher competitiveness levels are mainly based on good natural conditions and policy support, while the reasons for lower competitiveness vary, mainly focusing on the number of employment, ecological environment, and technology level. Secondly, the evaluation results of land use efficiency show that the land use efficiency of the green food industry in all provinces and cities in China will be significantly improved under the condition that the sown area, investment in rural fixed assets, the number of people employed in agriculture, forestry, animal husbandry, and fishery industry are significantly increased, and the emission of sulfur dioxide is significantly reduced. Finally, the coupling coordination degree was analyzed from the perspective of time, and both the eastern and western rely on good economic development and superior natural environment are in high-quality coordination all year round; from the spatial perspective, the number of provinces and cities in high-quality coordination is shifting from the north to the south, because the economic environment of the southern provinces and cities in China is generally better than that of the north at present, and they drive industrial development among each other and play the role of economic radiation. The above research results show that the coupling coordination between the competitiveness level and land use efficiency of China's green food industry is mainly influenced by five aspects, including economic environment, talent introduction, technology investment, financial support, and natural conditions. From the perspective of the economic environment, the economic development of provinces and cities not only depends on the green food industry but also requires the cooperation of the government, enterprises, and residents. The green food industry can reverse the regional economy by strengthening the integration with secondary and tertiary industries and strengthening brand building and publicity. From the perspective of talent introduction, form a professional recruitment team and improve the internal welfare treatment of enterprises, including basic salary, social security, and holiday benefits. From the perspective of technical investment, encourage green food enterprises and technical personnel to innovate technology, implement clear and specific incentive programs, and cooperate with related industries to innovate, so as to reduce the duplication and waste of funds. From the perspective of financial support, select food production and processing enterprises, foreign marketing enterprises, and human resource guarantee enterprises as the main recruitment targets guarantee and strengthen the basic elements of green food. From the perspective of natural conditions, the ecological environment of each province and city has great differences, and the crops suitable for growth should be cultivated according to the natural conditions of the region and can be combined with rural tourism, crop picking, and other industries according to the local environment. In addition, all provincial and municipal governments should strengthen the quality supervision of green food production and processing to effectively ensure the health effects of green food.

6. Conclusions

This study evaluates the competitiveness level and land use efficiency of China's green food industry during 2011–2020 by constructing an index system using the VIKOR method and the super-efficiency SBM model, respectively, and analyzes the coupling coordination degree using the coupling coordination model based on the measurement results. The main conclusions are as follows:

(1) The competitiveness level of China's green food industry shows a trend of "high in the west and low in the east", with a small gap between the competitiveness level of the middle and the eastern. Highly competitive provinces are concentrated in the northwest, and most Chinese provinces and cities are in the middle of competitiveness.
(2) The land use efficiency of China's green food industry generally showed a trend of rising and then falling and peaked in 2016. The average value of land use efficiency of the green food industry in the three regions is ranked as eastern > western > middle, and the middle and western are lower than the national average in most years.
(3) The average value of coupling coordination between the competitiveness level and land use efficiency of China's green food industry floats at the boundary of high-quality coordination, with all three regions showing a rising and then declining trend and leveling off and peaking in 2013. The eastern and western are in high-quality coordination all year round, and the middle is in good coordination most years. The number of provinces and cities in high-quality coordination in China is shifting from the north to the south in terms of geographic location, with the eastern relying on the development of the three major economic belts, the western having a smaller gap between provinces and cities, and the middle having an overall positive posture.

There are still some limitations in this study. Firstly, since part of the current green foods is privately cultivated by farmers and part of them are planted in national standard production bases, it will lead to some missing information. Secondly, the grading method of this study on coupling coordination combines the empirical results of this study and the studies of related experts and scholars, but there is still some subjectivity. Thirdly, this study concentrates on macro analysis from the perspective of the green food industry, ignoring the growth characteristics of green food itself and other factors that may affect the accuracy of the results. In addition, this study divides China into three regions, east, middle, and west, on the basis of which regional subdivision can be compared in the future, and the influencing factors can be further refined and analyzed.

Author Contributions: Conceptualization, Z.L.; methodology, W.F.; software, Z.L. and W.F.; data collection, Z.L.; resources, M.L.; writing—original draft preparation, Z.L.; writing—review and editing, Z.L., W.F., M.L. and J.C.; language, W.F.; funding acquisition, W.F. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by the National Natural Science Foundation of China "Research on the spatial and temporal evolution and driving mechanisms of indirect carbon emissions from household consumption in western China from a heterogeneous perspective" (No. 72264035), Yunnan Provincial Philosophy and Social Science Planning Project "Research on the competitiveness measurement and spatial distribution pattern of forest green food industry in Yunnan" (NO. YB2020054) and Yunnan Provincial Education Department Scientific Research Fund Project "Research on the measurement of high-quality development level and spatial distribution trend of forest green food industry in Yunnan province" (NO. 2022Y622).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data sets provided in the study are included in the article materials. For further inquiries, please contact the corresponding author.

Acknowledgments: This study would like to thank Wei Fu, Mingcan Luo, and Jiancheng Chen for giving a lot of advice and ideas.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Xu, J.; Zhong, J.; Zhang, B.; Li, X. Green labelled rice shows a higher nutritional and physiochemical quality than conventional rice in China. *Foods* **2021**, *10*, 915. [CrossRef] [PubMed]
2. Yu, X.; Gao, Z.; Zeng, Y. Willingness to pay for the "Green Food" in China. *Food Policy* **2014**, *45*, 80–87. [CrossRef]
3. Ayyub, S.; Wang, X.; Asif, M.; Ayyub, R.M. Antecedents of trust in organic foods: The mediating role of food related personality traits. *Sustainability* **2018**, *10*, 3597. [CrossRef]
4. Shaqiri, F.; Vasa, L.; Arben, M.; Ymeri, P. Evaluating consumer behavior for consumption of milk and cheese in Gjilan Region, Kosovo. *Ann. Agrar. Sci.* **2019**, *17*, 375–382.
5. Paull, J. Green food in China. *Elem. J. Bio-Dyn. Tasman.* **2008**, *91*, 48–53.
6. Qi, X.; Ploeger, A. Explaining consumers' intentions towards purchasing green food in Qingdao, China: The amendment and extension of the theory of planned behavior. *Appetite* **2019**, *133*, 414–422. [CrossRef]
7. ul Hassan, M.; Wen, X.; Xu, J.; Zhong, J.; Li, X. Development and challenges of green food in China. *Front. Agric. Sci. Eng.* **2020**, *7*, 56–66. [CrossRef]
8. Zhang, Z.; Yu, H.; Li, X.; Liu, B.; Tian, Y. Research on the development strategy of green food industry in China. *Chin. J. Agric. Resour. Reg. Plan.* **2015**, *36*, 35–38. (In Chinese)
9. Qi, X.; Ploeger, A. Explaining Chinese consumers' green food purchase intentions during the COVID-19 pandemic: An extended Theory of Planned Behaviour. *Foods* **2021**, *10*, 1200. [CrossRef] [PubMed]
10. Liu, B.; He, Q. Impact factors and promotion countermeasures on regulatory effectiveness of green food in China. *Qual. Saf. Agroproducts* **2017**, *6*, 49–52. (In Chinese)
11. Xu, J.; Zhang, Z.; Zhang, X.; Ishfaq, M.; Zhong, J.; Li, W.; Zhang, F.; Li, X. Green food development in China: Experiences and challenges. *Agriculture* **2020**, *10*, 614. [CrossRef]
12. Yadav, R.; Pathak, G.S. Intention to purchase organic food among young consumers: Evidences from a developing nation. *Appetite* **2016**, *96*, 122–128. [CrossRef] [PubMed]
13. Meemken, E.M.; Qaim, M. Organic agriculture, food security, and the environment. *Annu. Rev. Resour. Econ.* **2018**, *10*, 39–63. [CrossRef]
14. Jeyakumar Nathan, R.; Victor, V.; Popp, J.; Fekete-Farkas, M.; Oláh, J. Food innovation adoption and organic food consumerism—A cross national study between Malaysia and Hungary. *Foods* **2021**, *10*, 363. [CrossRef]
15. Sun, C.; Huang, D.; Li, H.; Chen, C.; Wang, C.; Li, M.; Wang, Z. Green Food Industry in China: Spatial Pattern and Production Concentration Drivers. *Front. Environ. Sci.* **2021**, *9*, 665990. [CrossRef]
16. Su, Q.; Jiang, X. Evaluate the economic and environmental efficiency of land use from the perspective of decision-makers' subjective preferences. *Ecol. Indic.* **2021**, *129*, 107984. [CrossRef]
17. Fei, R.; Lin, Z.; Chunga, J. How land transfer affects agricultural land use efficiency: Evidence from China's agricultural sector. *Land Use Policy* **2021**, *103*, 105300. [CrossRef]
18. Assandri, G.; Bogliani, G.; Pedrini, P.; Brambilla, M. Beautiful agricultural landscapes promote cultural ecosystem services and biodiversity conservation. *Agric. Ecosyst. Environ.* **2018**, *256*, 200–210. [CrossRef]
19. Kuang, B.; Lu, X.; Zhou, M.; Chen, D. Provincial cultivated land use efficiency in China: Empirical analysis based on the SBM-DEA model with carbon emissions considered. *Technol. Forecast. Soc. Change* **2020**, *151*, 119874. [CrossRef]
20. Kang, W.; Kang, S.; Liu, S.; Han, Y. Assessing the degree of land degradation and rehabilitation in the Northeast Asia dryland region using net primary productivity and water use efficiency. *Land Degrad. Dev.* **2020**, *31*, 816–827. [CrossRef]
21. Yerseitova, A.; Issakova, S.; Jakisheva, L.; Nauryzbekova, A.; Moldasheva, A. Efficiency of using agricultural land in Kazakhstan. *Entrep. Sustain. Issues* **2018**, *6*, 558–576. [CrossRef] [PubMed]
22. Xie, H.; Chen, Q.; Lu, F.; Wu, Q.; Wang, W. Spatial-temporal disparities, saving potential and influential factors of industrial land use efficiency: A case study in urban agglomeration in the middle reaches of the Yangtze River. *Land Use Policy* **2018**, *75*, 518–529. [CrossRef]
23. Chen, J.; Gao, J.; Chen, W. Urban land expansion and the transitional mechanisms in Nanjing, China. *Habitat Int.* **2016**, *53*, 274–283. [CrossRef]
24. Liu, J.; Jin, X.; Xu, W.; Gu, Z.; Yang, X.; Ren, J.; Fan, Y.; Zhou, Y. A new framework of land use efficiency for the coordination among food, economy and ecology in regional development. *Sci. Total Environ.* **2020**, *710*, 135670. [CrossRef] [PubMed]
25. Zhao, Y.; Zhang, M.; Cui, J. Land-use transition and its driving forces in a minority mountainous area: A case study from Mao County, Sichuan Province, China. *Environ. Monit. Assess.* **2022**, *194*, 688. [CrossRef]
26. Zhu, G.; Xu, X.; Ma, Z.; Xu, L.; Porter, J.H. Spatial dynamics and zoning of coastal land-use change along Bohai Bay, China, during 1979–2008. *J. Coast. Res.* **2012**, *28*, 1186–1196.
27. Chen, H.; Chen, Y.; Chen, X.; Zhang, X.; Wu, H.; Li, Z. Impacts of Historical Land Use Changes on Ecosystem Services in Guangdong Province, China. *Land* **2022**, *11*, 809. [CrossRef]

28. Jiang, X.; Lu, X.; Liu, Q.; Chang, C.; Qu, L. The effects of land transfer marketization on the urban land use efficiency: An empirical study based on 285 cities in China. *Ecol. Indic.* **2021**, *132*, 108296. [CrossRef]
29. Jiang, S.; Meng, J.; Zhu, L.; Cheng, H. Spatial-temporal pattern of land use conflict in China and its multilevel driving mechanisms. *Sci. Total Environ.* **2021**, *801*, 149697. [CrossRef]
30. Jiang, L.; Guo, S.; Wang, G.; Kan, S.; Jiang, H. Changes in agricultural land requirements for food provision in China 2003–2011: A comparison between urban and rural residents. *Sci. Total Environ.* **2020**, *725*, 138293. [CrossRef] [PubMed]
31. Redlichová, R.; Chmelíková, G.; Blažková, I.; Svobodová, E.; Vanderpuje, I.N. Organic food needs more land and direct energy to be produced compared to food from conventional farming: Empirical evidence from the czech republic. *Agriculture* **2021**, *11*, 813. [CrossRef]
32. Paz, D.B.; Henderson, K.; Loreau, M. Agricultural land use and the sustainability of social-ecological systems. *Ecol. Model.* **2020**, *437*, 109312.
33. Underwood, T.; McCullum-Gomez, C.; Harmon, A.; Roberts, S. Organic agriculture supports biodiversity and sustainable food production. *J. Hunger. Environ. Nutr.* **2011**, *6*, 398–423. [CrossRef]
34. Chigbu, U.E.; Ntihinyurwa, P.D.; de Vries, W.T.; Ngenzi, E.I. Why tenure responsive land-use planning matters: Insights for land use consolidation for food security in Rwanda. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1354. [CrossRef]
35. Ahammad, R.; Stacey, N.; Sunderland, T. Assessing land use changes and livelihood outcomes of rural people in the Chittagong Hill Tracts region, Bangladesh. *Land Degrad. Dev.* **2021**, *32*, 3626–3638. [CrossRef]
36. Liu, H.; Zhou, Y. Urbanization, land use behavior and land quality in rural china: An analysis based on pressure-response-impact framework and sem approach. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2621. [CrossRef]
37. Mohammady, M. Land use change optimization using a new ensemble model in Ramian County, Iran. *Environ. Earth Sci.* **2021**, *80*, 780. [CrossRef]
38. Yawson, D.O.; Mohan, S.; Armah, F.A.; Ball, T.; Mulholland, B.; Adu, M.O.; White, P.J. Virtual water flows under projected climate, land use and population change: The case of UK feed barley and meat. *Heliyon* **2020**, *6*, e03127. [CrossRef]
39. Lindstrom, H.; Lundberg, S.; Marklund, P.O. How Green Public Procurement can drive conversion of farmland: An empirical analysis of an organic food policy. *Ecol. Econ.* **2020**, *172*, 106622. [CrossRef]
40. Li, Z.; Fu, W.; Udimal, T.B.; Luo, M.; Chen, J. The measurement of competitiveness of forest green food industry in Yunnan Province. *PLoS ONE* **2021**, *16*, e0261133. [CrossRef] [PubMed]
41. Yu, J.; Zhou, K.; Yang, S. Land use efficiency and influencing factors of urban agglomerations in China. *Land Use Policy* **2019**, *88*, 104143. [CrossRef]
42. Qian, Z. Land acquisition compensation in post-reform China: Evolution, structure and challenges in Hangzhou. *Land Use Policy* **2015**, *46*, 250–257. [CrossRef]
43. Liu, Y.; Fang, F.; Li, Y. Key issues of land use in China and implications for policy making. *Land Use Policy* **2014**, *40*, 6–12. [CrossRef]
44. Zhang, R.; Lu, J. Spatial–Temporal Pattern and Convergence Characteristics of Provincial Urban Land Use Efficiency under Environmental Constraints in China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 10729. [CrossRef]
45. Bao, C.; Xu, M.; Sun, S. China's Land Uses in the Multi-Region Input–Output Framework. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2940. [CrossRef]
46. Zhang, M.; Wang, J.; Zhou, R. Entropy value-based pursuit projection cluster for the teaching quality evaluation with interval number. *Entropy* **2019**, *21*, 203. [CrossRef]
47. Opricovic, S.; Tzeng, G.H. Extended VIKOR method in comparison with outranking methods. *Eur. J. Oper. Res.* **2007**, *178*, 514–529. [CrossRef]
48. Zhao, X.; Long, L.; Sun, Q.; Zhang, W. How to Evaluate Investment Efficiency of Environmental Pollution Control: Evidence from China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 7252. [CrossRef] [PubMed]
49. Cheng, K.; Yao, J.; Ren, Y. Evaluation of the coordinated development of regional water resource systems based on a dynamic coupling coordination model. *Water Supply* **2019**, *19*, 565–573. [CrossRef]
50. Li, R.; Ding, Z.; An, Y. Examination and Forecast of Relationship among Tourism, Environment, and Economy: A Case Study in Shandong Province, China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 2581. [CrossRef]
51. Han, L.; He, T.; Yang, Y. Coupling Coordination Evaluation of High Quality Development and Land Use Efficiency of Urban Agglomeration——Empirical Analysis of Seven Urban Agglomerations in the Yellow River Basin. *J. Henan Norm. Univ. (Philos. Soc. Sci.)* **2021**, *48*, 95–101. (In Chinese)