Sustainable Agriculture and Food Production in Qinghai: Analysis based on grey correlation model

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Abstract—The sustainable development of agriculture requires continuous improvement of comprehensive agricultural capabilities on the one hand, and continuous improvement of land productivity on the other hand to ensure a sustainable increase in food production capacity. At present, China is facing the "tight balance" situation of supply and demand for food security in the medium and long term. The land productivity of agriculture in Qinghai is low, and the grain production capacity is difficult to guarantee the security of food supply in Qinghai Province. Based on the relevant theories of sustainable agricultural development, this article analyzes the factors affecting land productivity in Qinghai Province, and uses grey correlation analysis to analyze the correlation effects of sustainable agricultural development factors on land productivity. If only the sustainable development of agriculture is pursued, land productivity cannot be improved, which will lead to low grain production capacity and unsustainable development of supply level and quality. In the conclusion, this article puts forward relevant suggestions for improving food security in Qinghai Province.

1. INTRODUCTION
With the complex changes in the international situation, especially the outbreak of COVID-19 since 2020, the demand for food at home and abroad shows a trend of continuous growth. In the medium and long term, China is facing a "tight balance" between food supply and demand. As a country with a large population, food security has always been a hidden trouble in the development of national economy, which is related to the national economy and people's livelihood and is the foundation of survival. In the 14th Five-Year Plan of 2021, the comprehensive grain production capacity is clearly included in the constraint category of the main indicators. Food security was included in the plan for the first time, and the Law on the Guarantee of Food Security was formulated to ensure food security. Traditional grain production is the pursuit of the maximization of the total grain output, emphasizing development. However, the development of agriculture at the same time ignored the protection of the ecological environment, resulting in the continuous consumption of natural resources, ignoring the future development potential and sustainability of agriculture. The sustainable development of agriculture is based on reality, emphasizing the integration of existing resources to improve grain production capacity, while paying attention to the protection of the ecological environment, emphasizing the formation and maintenance of the infinite potential of development.

Agricultural sustainable development refers to the agricultural development mode which aims at maintaining ecological benefits while ensuring the improvement of agricultural economic and social benefits, is essentially the use of sustainable development thought in the field of agriculture, is the use of
advanced science and technology will be effective allocation of agricultural resources, improve the efficiency of the use of agricultural resources, makes possible the virtuous cycle of resource utilization, the agricultural production to meet the needs of modern people at the same time, for future survival and development of resources, is the change of traditional agricultural production mode. Considering the sustainable development of agriculture and food security as a whole is conducive to the rational use of agricultural resources, the protection of ecological environment and the improvement of food production capacity.

Qinghai province is located in the northwest in China, is a typical province of combination of agriculture and animal husbandry, farming land area is large, few and scattered agricultural cultivated land, and the natural environment is complex and ecological fragile, grain production capacity is low, lead to low comparative benefit of grain production, farmers with the increased number of migrant workers, gradually reduce the number of agricultural labor force, there is less investment in agriculture. In the past, Qinghai grain supply in good years, self-sufficiency, with the aid of external transfer, year-round food sales area. With the economic and social development of Qinghai Province, people's need for a better life makes the demand for grain in Qinghai Province increase continuously, resulting in rising supply pressure. Under the background of the national food security problem, how to improve the grain output of Qinghai Province, ensure the food security of Qinghai people and alleviate the national food security problem has become the problem of sustainable agricultural development in Qinghai Province.

In this paper, the theory of sustainable agricultural development is used to analyze the correlation between sustainable agricultural development and improving grain production capacity in Qinghai Province, aiming at the security problem of grain supply in Qinghai Province.

2. MATERIALS AND METHODS

2.1 General situation of grain production in Qinghai Province
Qinghai Province covers an area of 722,300 square kilometers. In 2021, the agricultural arable land area was 8.835 million mu, accounting for 0.8% of the province's total area, and the grain sown area was 4.203 million mu, accounting for 47.57% of the arable land area. The cultivated land area is small and relatively dispersed, and the crop planting areas are mainly distributed in the Yellow River Basin, Huangshui River Basin and Qaidam Basin. The crops are characterized by dry farming, and the main food crops are spring wheat, highland barley, broad beans, peas, potatoes and so on. The climate is plateau continental climate, with low temperature, large temperature difference between day and night, less and concentrated rainfall, sunshine for a long time and other characteristics. At present, the grain production capacity of Qinghai Province is relatively low, and it is a grain sales area throughout the year. In the case of abundant crops in the whole country, it relies on circulation to make up the gap of grain consumption, and the grain of urban residents mainly depends on the transfer from outside the province [2]. Qinghai Province although the land area is vast, but the arable land area is relatively low. To improve the grain production capacity of Qinghai province, it is necessary to improve its land productivity, ensure the comprehensive ability of agricultural production, and then improve its grain production capacity, which is of great significance to solve the grain security of Qinghai province and the whole country.

2.2 Factors affecting the food production capacity of Qinghai Province
According to the connotation of agricultural sustainable development, this paper takes agricultural land productivity as the dependent variable, and analyzes the factors that affect the grain production capacity of Qinghai Province from three aspects of economy, society and ecology. At the economic level, five indexes are selected, namely, gross agricultural product, grain planting structure, per capita income of agricultural families, level of agricultural mechanization and range of industrial structure adjustment. At the social level, the proportion of financial support to agriculture, the number of agricultural personnel and agricultural technology were selected as three indexes. At the ecological level, six indexes were selected as agricultural plastic film usage amount, agricultural chemical fertilizer application amount, arable land area, grain sown area, multiple cropping index and soil and water loss rate.
2.3 Gray correlation analysis

2.3.1 Model Selection and Data Source
The grey relational degree model is selected as the analysis model in this paper. This model is mainly used to analyze and investigate the close relationship between various factors, so as to obtain the factors that have an impact on land productivity. The main analysis process of the model is to compare and analyze relevant data and select the reference sequence as the benchmark, which can reflect the degree of internal correlation, which is manifested by comparing the similarity between the sequence and the reference sequence, and finally finding the factor with the greatest influence degree.

According to the gray correlation model to the original data at the request of the authenticity, continuity and comparability, the paper statistics from the Qinghai province statistics yearbook 2020, national statistical yearbook and China statistical yearbook of national statistics web site, select data from 2015 to 2019 in Qinghai province as the research data, analysis detailed in Table 1.

| TABLE 1 DATA ON AGRICULTURAL LAND PRODUCTIVITY IMPACT INDICATORS IN QINGHAI PROVINCE |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| factor                                         | 2015            | 2016            | 2017            | 2018            | 2019            |
| Agricultural land productivity                 | 1.77            | 1.78            | 1.74            | 1.75            | 1.79            |
| Economy                                       |                |                |                |                |                |
| The magnitude of agricultural structural adjustment | 1.39           | 0.48            | -1.3            | -2.91           | -1.8            |
| Per capita income of peasant families          | 7933.40         | 8664.40         | 9462.30         | 10393.30        | 11499.40        |
| Level of agricultural mechanization           | 53.81           | 54.56           | 54.86           | 57.56           | 60.60           |
| Total agricultural output                     | 319.27          | 338.80          | 364.10          | 405.93          | 454.35          |
| The structure of grain cultivation            | 50.21           | 51.04           | 50.88           | 50.47           | 50.62           |
| Society                                       |                |                |                |                |                |
| The proportion of financial support to farmers | 13.490          | 15.238          | 15.232          | 16.258          | 17.389          |
| Number of people engaged in agriculture       | 116.40          | 115.50          | 116.70          | 114.20          | 115.60          |
| The proportion of the agricultural labor force | 60.564          | 61.266          | 61.733          | 62.156          | 62.471          |
| Ecology                                       |                |                |                |                |                |
| Use of agricultural plastic film              | 0.7377          | 0.7943          | 0.8415          | 0.7556          | 0.7779          |
| The amount of fertilizer applied for agricultural use | 10.13          | 8.76            | 8.67            | 8.32            | 6.19            |
| Arable land                                   | 588.42          | 589.43          | 590.14          | 589.74          | 588.95          |
| The area where the crops are sown              | 558.39          | 557.75          | 555.31          | 557.25          | 553.54          |
| soil erosion                                   | 0.124           | 0.140           | 0.157           | 0.173           | 0.194           |

2.3.2 Analysis Calculations

First establish the data matrix to calculate the connection degree of land productivity and the sustainable influence factors of Qinghai province, the raw data in table 1 can be divided into reference data and compared the data sequences, select output data as reference sequence, and then to the original data dimensionless processing, also known as the normalized processing, is the most common initial value method, purpose is to reduce the absolute difference between the data, And reduce its value to an approximate range. In this part, the above influencing factors are analyzed and dimensionless processing is carried out. The results are shown in Table 2.
TABLE 2 DATA STANDARDIZATION RESULTS

| factor                                      | 2015   | 2016   | 2017   | 2018   | 2019   |
|---------------------------------------------|--------|--------|--------|--------|--------|
| Economy                                     |        |        |        |        |        |
| Agricultural land productivity              | 1.0000 | 1.0056 | 0.9831 | 0.9887 | 1.0113 |
| The magnitude of agricultural structural adjustment | 1.0000 | 0.3453 | -0.9353| -2.0935| -1.2950|
| Per capita income of peasant families        | 1.0000 | 1.0922 | 1.1928 | 1.3101 | 1.4496 |
| Level of agricultural mechanization         | 1.0000 | 1.0139 | 1.0195 | 1.0697 | 1.1262 |
| Total agricultural output                   | 1.0000 | 1.0726 | 1.1199 | 1.1672 | 1.2501 |
| The structure of grain cultivation          | 1.00001| 1.0133 | 1.0133 | 1.0052 | 1.0082 |
| Society                                     |        |        |        |        |        |
| The proportion of financial support to farmers | 1.00001| 1.1296 | 1.1291 | 1.2052 | 1.2890 |
| Number of people engaged in agriculture     | 1.0000 | 0.9923 | 1.0026 | 0.9811 | 0.9931 |
| The proportion of the agricultural labor force | 1.0000 | 1.0116 | 1.0193 | 1.0263 | 1.0315 |
| Ecology                                     |        |        |        |        |        |
| Use of agricultural plastic film            | 1.0000 | 1.0767 | 1.1407 | 1.0243 | 1.0545 |
| The amount of fertilizer applied for agricultural use | 1.0000 | 0.8648 | 0.8559 | 0.8213 | 0.6111 |
| Arable land                                 | 1.0000 | 1.0017 | 1.0029 | 1.0022 | 1.0009 |
| The area where the crops are sown           | 1.0000 | 0.9989 | 0.9945 | 0.9980 | 0.9913 |
| Multiple indices                            | 1.0000 | 0.9979 | 0.9916 | 0.9958 | 0.9905 |
| soil erosion                                | 1.0000 | 1.1290 | 1.2661 | 1.3952 | 1.5645 |

The reference sequence identified in Table 2 is, and \( x_i = [1.0000, 1.0056, 0.9831, 0.9887, 1.0113] \) the formula and calculation are calculated based on the two levels of maximum and minimum differences. The correlation coefficient of the corresponding elements of each comparison sequence and the reference sequence is calculated separately, according to the formula, which is the resolution coefficient, which is taken within 0 to 1, usually is the association coefficient between the first element of the comparison sequence and the first element of the reference sequence, which is used to reduce the effect of the difference on the calculation with the whole.

\[
\Delta_{\text{max}} = 3.0823 \quad \Delta_{\text{min}} = 0
\]

\[
\mu = 0.5, \quad \zeta_{k}(k) = \frac{\min \limits_{i=1}^{n} |x_i(k) - x_i| + \mu \max \limits_{i=1}^{n} |x_i(k) - x_i|}{\max \limits_{i=1}^{n} |x_i(k) - x_i|}
\]

Finally, the formula is calculated by the gray correlation

\[
r = \frac{1}{n} \sum_{i=1}^{n} \zeta_{i}(k),
\]

and you can get the degree of correlation between the sequences on the whole, such as Table 3. Get a gray correlation between the impact of sustainable agricultural development and land productivity from 2015.
### Table 3 Correlation Index

|          | 2015-2019 | 2016-2019 | 2017-2019 | 2018-2019 | Average Value |
|----------|-----------|-----------|-----------|-----------|---------------|
| \( r_1 \) | 0.7000    | 0.4455    | 0.3333    | 0.4006    | 0.5759        |
| \( r_2 \) | 0.9468    | 0.8802    | 0.8274    | 0.7786    | 0.8866        |
| \( r_3 \) | 0.9947    | 0.9769    | 0.9501    | 0.9306    | 0.9704        |
| \( r_4 \) | 0.9584    | 0.9184    | 0.8962    | 0.8658    | 0.9278        |
| \( r_5 \) | 0.9930    | 0.9807    | 0.9894    | 0.9980    | 0.9922        |
| \( r_6 \) | 0.5284    | 0.4873    | 0.3908    | 0.3333    | 0.5480        |
| \( r_7 \) | 0.9121    | 0.8767    | 0.9481    | 0.8843    | 0.9242        |
| \( r_8 \) | 0.9590    | 0.7930    | 0.7870    | 0.8731    | 0.8824        |
| \( r_9 \) | 0.7956    | 0.6370    | 0.8861    | 0.8649    | 0.8367        |
| \( r_{10} \) | 0.6625 | 0.6850 | 0.6230 | 0.4087 | 0.6759 |
| \( r_{11} \) | 0.9860 | 0.9330 | 0.9533 | 0.9638 | 0.9672 |
| \( r_{12} \) | 0.9760 | 0.9603 | 0.9676 | 0.9326 | 0.9673 |
| \( r_{13} \) | 0.9727 | 0.9702 | 0.9750 | 0.9301 | 0.9696 |
| \( r_{14} \) | 0.6915 | 0.4942 | 0.4049 | 0.3333 | 0.5848 |

Table 3 shows the correlation index of all factors on land productivity, which is further integrated as shown in Table 4. Finally, the overall average correlation degree of the three major indicators of economy, society and ecology to agricultural land productivity is obtained, as well as the correlation degree ratio of each indicator, as shown in Table 5.

### Table 4 Correlation Index of Economic, Social and Ecological Indicators

| Indicator |  | Average Correlation |
|-----------|---|---------------------|
| Economy   | The magnitude of agricultural structural adjustment | \( r_1 \) | 0.5759 |
|           | Per capita income of peasant families | \( r_2 \) | 0.8866 |
|           | Level of agricultural mechanization | \( r_3 \) | 0.9704 |
|           | Total agricultural output | \( r_4 \) | 0.9278 |
|           | The structure of grain cultivation | \( r_5 \) | 0.9922 |
|           | Overall average | \( r_6 \) | 0.8706 |
| Society   | The proportion of financial support to farmers | \( r_6 \) | 0.5480 |
|           | Number of people engaged in agriculture | \( r_7 \) | 0.9242 |
|           | The proportion of the agricultural labour force | \( r_8 \) | 0.8824 |
|           | Overall average | \( r_9 \) | 0.7849 |
| Ecology   | Use of agricultural plastic film | \( r_9 \) | 0.8367 |
|           | The amount of fertilizer applied for agricultural use | \( r_{10} \) | 0.6759 |
|           | Arable land | \( r_{11} \) | 0.9672 |
|           | The area where the crops are sown | \( r_{12} \) | 0.9673 |
|           | Multiple indices | \( r_{13} \) | 0.9696 |
|           | soil erosion | \( r_{14} \) | 0.5848 |
|           | Overall average | \( r_{15} \) | 0.8336 |
TABLE 5 ECONOMIC, SOCIAL AND ECOLOGICAL RELEVANCE

| Index   | Average correlation | Percentage |
|---------|---------------------|------------|
| Economy | \( r_e \) 0.8706    | 34.98%     |
| Society | \( r_s \) 0.7849    | 31.53%     |
| Ecology | \( r_z \) 0.8336    | 33.49%     |

3. RESULTS & DISCUSSION

According to Table 5, the degree of correlation between agricultural sustainable development factors and land is \( r_e(0.876) > r_z(0.8336) > r_s(0.7849) \). Among them, economic factors have the highest correlation with land productivity, indicating that economic factors have the greatest influence on land productivity. The average correlation degree between the grain planting structure and land productivity in the economic level index is 0.9922, indicating that the grain planting structure has a significant impact on the improvement of land productivity. In addition, the average correlation between agricultural mechanization and land productivity is 0.9704, the connection degree of agricultural mechanization level have been higher, the reason is that Qinghai is located in the Qinghai-Tibet Plateau, sparsely populated, improve the level of modern mechanical allow effective irrigation area of cultivated land increase, the mechanical seeding harvested area expands unceasingly, Labor and agricultural planting time is greatly saved, thus improving agricultural land productivity.

Ecological factors are the next most influential factors on land productivity, with a correlation proportion of 33.49%. Ecology is a barrier to economic and social development. Ecological index layer of the multiple crop index of land, cultivated land area and crop planting area associated with agricultural land productivity level is higher, refers to the multiple cropping index refers to a certain period (usually 1 year) on the same plot cultivated crops average number, namely years average number to plant crops on land, the value is equal to the ratio of the total sown area of crops to the cultivated area in the year. The multiple cropping index is an effective way to enlarge the sown area of crops, tap the potential of cultivated land utilization and increase the total yield of crops. Sustainable development of ecology is an important factor to promote sustainable development of agriculture.

Among the social factors, the number of agricultural personnel is an important factor affecting land productivity, which is because the current agricultural science and technology level in Qinghai is low, the agricultural infrastructure is poor, and land production mainly depends on labor.

Agricultural land productivity, investigate its fundamental factors such as natural resources, capital and labor to the input to agriculture after integration, reflects the difference of agricultural inputs and income, the improvement of grain production capacity is the direct reflection of land productivity, at the same time must take into account the concept of sustainable development of agriculture, will be a combination of these, Qinghai's policy calls for the development of a high-quality economy under the premise of giving priority to ecological and environmental protection. If only the pursuit of land productivity and ignore the ecological and sustainable development, ecological destruction at the same time, land, water, forests and other natural resources should be reduced, the essence of agriculture is the use of animal and plant growth and development of the law of the human labor and on it and get the corresponding agricultural industry, when damage to natural resources, the first problem we face is the survival and safety of human beings. Only by combining the thought of agricultural sustainable development with land productivity, can we guarantee the improvement of grain production capacity, thus ensuring the security of grain supply in Qinghai and lightening the burden of national grain security.

4. CONCLUSIONS

Food security is related to a series of problems such as national economic construction and social stability. In the medium and long term, the food security of Qinghai Province cannot be ensured. In order to improve land productivity, enhance comprehensive grain production capacity and ensure food security, we should start from the following four aspects:
4.1 Improve the efficiency of resource utilization
We will ensure the area sown to grain while keeping the red line of arable land unshaken. Develop water-saving agriculture and improve the agricultural irrigation efficiency of water resources. In order to further improve the utilization efficiency of agricultural land, we should transform the middle and low farmland, adjust grain structure, optimize crop varieties and improve the multiple cropping index of land according to local conditions.

4.2 We will improve the construction of agricultural infrastructure
We will accelerate the improvement of water conservancy facilities in agriculture and raise the effective irrigation rate of cultivated land. We will make great efforts to promote agricultural science and technology and information services, reduce risks in grain production and raise the yield and quality of grain per unit area.

4.3 Promote stable agricultural production
The main grain-producing areas should be regarded as the commercial grain base of Qinghai, and the incentive mechanism should be adopted to ensure the income of farmers in the main grain-producing areas, arouse their enthusiasm for grain planting and cultivate "professional" farmers.

4.4 Protect the agricultural ecological environment
According to soil fertility, rational application of chemical fertilizer, rational use of pesticides in combination with disease and insect pest control, recycling of residual film used in agricultural land, straw returning to the field, in the development of agriculture at the same time to protect soil and water, reduce soil erosion area.

ACKNOWLEDGMENT
Funding for this paper came from the National Social Science West Project No.: 13XJY006, Project Name: Study on Ecosystem Service Value and Sustainable Development in the Three-River Headwaters Region of Qinghai Province.

REFERENCES
[1] Yin K, Shang Q, Mi W. (2020) The coupling relationship between arable land productivity and food security in Ningxia and the trend forecast. Resources and environment in arid areas, 34 (07): 37-45.
[2] Liu Y. (2019) Thinking on the development and positioning of Qinghai grain industry. Qinghai Agricultural Technology Promotion, 3: 71-74-81.
[3] Zhou B, Zhai Y, Qian W, Yu Z. (2015) Analysis on the influencing factors of food security in China from the perspective of sustainable agricultural development: An empirical analysis based on structural equation model [J]. Rural Economy, 11:15-19.
[4] Wu Q, Qi Jian L, Chen X, Ding L, Zhu R (2020). Analysis of the impact of the development of agricultural modernization based on gray correlation on the yield rate of cultivated land- Take Yunnan Province as an example. World Tropical Agricultural Information, 11: 54-59
[5] Luo Q, Tang Q, Liu Y, Gao M, Ma L. (2017) Construction and Research of China's Agricultural Sustainable Development Evaluation Index System, 33 (27): 158-164
[6] Zhang M. (2020) Analysis of the influencing factors of China's total agricultural output value. Rural Economy and Science and Technology, 31 (21): 36-38.
[7] Li H D. Study on farmland fertility and grain productivity in Northeast China [D]. Shenyang Agricultural University,2016.
[8] Cheng S. The relationship between farmer land management scale and grain productivity [D]. China Agricultural University,2019.
[9] Zhou B, Zhai Y, Qian W, Yu Z. (2015) Analysis on the influencing factors of food security in China from the perspective of sustainable agricultural development: An empirical analysis based on structural equation model [J]. Rural Economy, (11):15-19.