Study on the Farmland Evaluation Index System through the Construction of Mathematical Models and Big Data

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Abstract. Basic farmland is the essence of cultivated land. To completely solve China’s food security problems and achieve stable growth of agricultural production in China, it is one of the most effective ways to build high-standard basic farmland. Therefore, this paper evaluates the high standard basic farmland. This paper evaluates the natural quality of basic farmland through the construction of mathematical models. The total cultivated land area in the hilly area of Faku County is 153061.02 hm2, while the natural quality score of cultivated land in the hilly area of Faku County is between 51 and 86. Among the equal-valued intervals, the maximum cultivated land area between ≥60-70 is 129110.25 hm2, accounting for 84.35% of the total cultivated land in the hilly area of the county, followed by the area between ≥70-80, which is 9069.44 hm2. The total area of cultivated land in the hilly area of the county is 5.92%, followed by the interval of ≥80 points, <60 interval, the area is 8095.61 hm2, and the ratio of 6787.72 hm2 accounts for 5.29% and 4.43% of the total cultivated land in the hilly area of the county. In general, the natural quality of cultivated land in the hilly area of Faku County is moderate.

1. Introduction
Land is the carrier of all things, and as an important resource for the sustainable development of society and economy, it is an important foundation for the survival of human life. With the continuous acceleration of the process of urbanization in my country, under the dual pressure of the rapid development of the national economy and the growing population, the contradiction between man and land has become more and more prominent, and other types of land affected by it have increased and decreased significantly to varying degrees, especially It is cultivated land with a large change [1-2]. my country has a large population base and a small amount of cultivated land per capita. The contradiction between man and land is very prominent. The threats to ecological security and food security are gradually increasing, mainly because of the decline in the quantity and quality of arable land resources.
Therefore, a major issue related to the steady and rapid development of my country's economy and whether food security can be guaranteed has been raised: alleviating the contradiction between man and land, and cherishing and protecting arable land resources. The measures of land improvement and the construction of high-standard basic farmland have created a brand-new method to ensure the continuous increase in the amount of arable land and at the same time to ensure the various types of construction land required for social development. In order to realize the sustainable development of arable land resources, the use of land improvement and high-standard basic farmland projects to improve land production capacity is also of great significance to the prominent problems of human-land contradiction in our country [3-4]. The sustainable development model is gradually being valued under the background of the new era. The important starting point of my country's land use development will also fall on the sustainability of the high-standard basic farmland projects of land remediation.

This article summarizes the theories and practices of high-standard basic farmland construction at home and abroad, based on the basic connotation of high-standard basic farmland and the characteristics of space-time development, using Faku County as the research area, and high-standard basic farmland within the county. Based on the actual situation of the construction project, the quality and potential of the cultivated land of the high-standard basic farmland in Faku County will be evaluated and analyzed, in order to provide reference and reference for the construction of the high-standard basic farmland.

2. Data sources and status quo analysis

2.1. Map data
Faku County standard plot distribution map, Faku County arable land classification map, Faku County arable land use classification map, Faku County land use coefficient map, Faku County land economic coefficient map. Socio-economic data: 2006-2010 Statistical Yearbook of Faku County. Text data: Faku County's 2011 grading results technical report and Faku County's 2011 grading results work report. In this study area, Faku County is taken as an example, the evaluation unit is mainly land, and the evaluation unit is obtained by screening according to the results of agricultural land grading.

2.2. Land use status in the study area
The whole area of Faku County is 228855 hm², of which the proportion of mountains and hills is 34%, and the proportion of waters is 4%. As of 2007, the total agricultural land in Faku County was 188,879 hm², accounting for 82.53% of the total area of Faku County. Among them, arable land is 136462 hm², accounting for 59.63% of the total area of Faku County; woodland is 34939 hm², accounting for 15.26% of the county's area; garden land is 3646 hm², accounting for 1.59% of the parcel area, and pasture land is 1574 hm², accounting for the total land area. 0.68%; other agricultural land is 12259 hm², accounting for 5.34% of the county's total land area. The construction land in Faku County is 24142 hm², accounting for 10.55 percent of the total area, of which rural homestead and industrial and mining land are 18,954 hm², accounting for 8.28% of the total area; the traffic water utilization land is 4770 hm², accounting for 2.08% of the total area; other construction land is 418 hm², accounting for 0.18% of the total land area in Faku County. The area of unused land is 15,834 hm², accounting for 6.92% of the land area of Faku County. The total area of cultivated land under investigation in the county in 2011 was 156006.54 hm², of which: paddy field area was 5773.46 hm², irrigated land area was 458.09 hm², and dry land area was 149774.99 hm². In Faku County, the dry land area accounts for 96% of the total cultivated land area, the paddy field area accounts for 3.7% of the total cultivated land area, and the irrigated land area accounts for 0.3% of the total area. Therefore, the main type of cultivated land in Faku County is dry land, followed by paddy fields, and finally irrigated land. The pattern of land use is clear, with obvious differences. The terrain of Faku County is dominated by low mountains and hills, with undulating hills and plains.
3. Establishment of Cultivated Land Natural Quality Evaluation Index System

3.1. Analysis and Quantification of Cultivated Land Natural Quality Factors

According to the meaning of high-standard basic farmland construction and its construction characteristics, high-standard basic farmland should have the characteristics of concentration and contiguous, supporting facilities, high yield and stable production, good ecology, strong disaster resistance, stable form, and adaptability to modern agricultural production and management methods [5]. Following the principle of evaluation indicators, in Faku County, hills and plains are undulating, so according to the divided plains and hills, the factors that determine the natural quality of the basic farmland are selected respectively. Soil texture, soil organic matter content, soil pH, barrier layer There are 5 evaluation indexes of depth from the ground surface and terrain slope. Due to the different utility of each evaluation index, the degree of impact on the natural quality of high-standard basic farmland is also different. When quantifying the evaluation index, the evaluation index changes within a certain range and is classified as the same category, and the same score is assigned in a certain section. According to the "Agricultural Land Quality Grading Regulations", the high-standard basic farmland natural quality evaluation index is determined Graded assignment.

| Evaluation index | Weights | First level | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|------------------|---------|-------------|--------|--------|--------|--------|--------|
| Degree of barrier layer from ground surface (cm) | 0.1 | 60~90 | 10 | 0 | 30~60 | 80 | <30 | 60 | - | - | - | - | - | - |
| Topsoil texture | 0.5 | Loam | 10 | 0 | clay | 80 | sand | 60 | Gravel soil | 40 | - | - | - | - |
| Soil organic matter content (%) | 0.24 | ≥4 | 10 | 0 | 4~3 | 90 | 3~2 | 80 | 2~1 | 70 | 1~0.6 | 60 | <0.6 | 45 |
| Soil pH | 0.16 | 6.0~7.9 | 10 | 7.9~8.5 | 90 | 5.0~5.5 | 80 | 4.5~5.5 | 60 | <4.9 | 0~9.5 | 30 | ≥9.5 | 10 |

According to the "Agricultural Land Quality Grading Regulations", in the natural quality evaluation index of the plain area, the barrier layer is divided into 3 levels from the ground surface depth, and each level is assigned. The first index level is 60-90cm, and 100 points are assigned. The second index level
30-60cm is assigned 80 points, and the third index level is less than 30cm, assigned 60 points; the surface soil texture is divided into four levels, and points are assigned to each level. The first index level loam is assigned 100 points. The second index level clay is assigned 80 points, the third index level gravel soil is assigned 60 points, and the fourth index level gravelly soil is assigned 40 points; the soil organic matter content is divided into 6 levels, and the first index level is greater than or equal to 4%, giving 100 points, the second index level is content 4-3%, giving 90 points, the third index level is content 3-2%, giving 80 points, the fourth index level is content 2-1%, giving 70 points, the fifth index level is content 1-0.6%, giving 60 points, the sixth index level is content less than 0.6%, giving 45 points; soil pH is divided into 6 index levels, the first index level is 6.0-7.9, with 100 points, the second index level is 5.5-6.0, 7.9-8.5, and 90 points are assigned, the third index level is 5.0-5.5, 8.5-9.0, and 80 points are assigned, the fourth index level is 4.5-5.5, and 60 points are assigned, the fifth index level is <4, 9.0-9.5, 30 points are assigned, and the sixth index level is ≥9.5, and 10 points are assigned.

Table 2. Hilly natural quality evaluation score

| Evaluation index | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|------------------|--------|--------|--------|--------|--------|--------|
| Terra in slope (°) | 0.24   | <2     | 100    | 2~5    | 90     | 5~8    |
| Tops soil texture | 0.15   | Loam  | 100    | clay   | 80     | sand   |
| Soil organic matter content (%) | 0.38   | ≥4     | 100    | 4~3    | 90     | 3~2    |
| Soil pH          | 0.23   | 6.0~7.9| 100    | 5~6.0, | 90     | 5~5.5, |

According to the "Agricultural Land Quality Grading Regulations", in the natural quality evaluation index of hilly areas, the surface soil texture is divided into four levels, and points are assigned to each level. The first index level is loam, and the second index is assigned 100 points. Grade clay is assigned 80 points, the third index level gravel soil is assigned 60 points, and the fourth index level gravelly soil is assigned 40 points; the soil organic matter content is divided into 6 levels, the first index level is 4% or more, giving 100 points, the second index level is 4-3% content, giving 90 points, the third index level is 3-2% content, giving 80 points, and the fourth index level is content 2-1%, giving 70 points, the fifth index level is content 1-0.6%, giving 60 points, the sixth index level is content less than 0.6%, giving 45 points; soil pH is divided into 6 index levels, the first index level is 6.0~7.9, 100 points are assigned, the second index level is 5.5~6.0, 7.9~8.5, 90 points are assigned, the third index level is 5.0~5.5, 8.5~9.0, 80 points are assigned, and the fourth index level is 4.5~5.5, assigned 60 points, the fifth index level is <4, 9.0~9.5, assigned 30 points, the sixth index level is ≥9.5, assigned 10 points; the
terrain slope is divided into 5 levels, the first index level For terrain slope <2°, 100 points are assigned, the second index level is 2°-5°, 90 points are assigned, the third index level is 5°-8°, 70 points are assigned, and the fourth index level is 8°-15°, 50 points are assigned, and the fifth index level is ≥15°, 30 points are assigned [6-8].

3.2. Determination of Natural Quality Evaluation Model

The natural quality evaluation result is obtained from the comprehensive evaluation of the scores and weights of each evaluation factor, and can be calculated by the geometric average method. The calculation formula is as follows:

\[
S_{ij} = \sum_{j=1}^{m} w_{ij} \cdot f_{ij}
\]  

In the expression: \(S_{ij}\) represents the natural quality score of the grading unit; \(i\) represents the grading unit number; \(j\) represents the evaluation factor number; \(m\) represents the number of evaluation factors; \(f_{ij}\) represents the index score of the j-th evaluation factor in the i-th grading unit, with a value of (0-100]; \(w_{ij}\) represents the weight of the j-th evaluation factor in the i-th grading unit.

Calculate the natural quality score of cultivated land according to the above formula, and divide the natural quality of high-standard basic farmland into equivalence intervals according to the method of equal intervals. The plains are divided into 3 equivalence intervals, that is, less than 80 divisions, and greater than or equal to 80-85 points. The interval is greater than or equal to 85 partitions; the hilly area is divided into 4 partitions, which are less than 60 partitions, greater than or equal to 60-70 partitions, greater than or equal to 70-80 partitions, and greater than or equal to 80 partitions. Among them, the weight of farmland quality evaluation factors refers to the degree of influence on the evaluation results, and the weight in the farmland quality evaluation is determined according to the "Agricultural Land Quality Grading Regulations" and the Delphi method [9].

3.3. Natural quality evaluation results

According to the evaluation model, the area of each equivalent area is counted with the township as a unit. Create a map of the natural quality scores of cultivated land in the plains and hills of Faku County.

| Segmented total area(hm²) | <80 | ≥80-85 | ≥85 |
|--------------------------|-----|--------|-----|
| 2945.52                  | 283.12 | 2102.92 | 559.48 |

Through statistical analysis of the evaluation results of the natural quality of the high-standard basic farmland, the total area of cultivated land in the plain area of Faku County is 2945.52 hm², while the natural quality scores of the high-standard basic farmland in the plain area of Faku County are distributed between 76 and 88. Among the equivalence interval of ≥80-85, the area of arable land is the largest, 2102.92 hm², accounting for 71.39% of the total arable land area of the county’s plains, followed by the interval ≥85, 559.48 hm², accounting for arable land in the plains of the county 18.99% of the total area, the last is the interval of <80 points, which is 283.12 hm², accounting for 9.62% of the total area of the plain area of the county. On the whole, the natural quality of cultivated land in the plains of Faku County is above average, which is related to the topography of Faku County. The topography of Faku County is dominated by low mountains and hills, with undulating hills and plains.
Table 4. Faku county area of farmland natural quality score table

| Segmented total area(hm²) | <60 | ≥60-70 | ≥70-80 | ≥80 |
|---------------------------|-----|--------|--------|-----|
| 153061.02                 | 6787.72 | 129110.25 | 9067.45 | 8095.61 |

Through the statistical analysis of the evaluation results of the natural quality of cultivated land, the total cultivated land area in the hilly area of Faku County is 153061.02 hm², while the natural quality scores of cultivated land in the hilly area of Faku County are distributed between 51 and 86, which are divided into various equivalence intervals. The largest area of arable land between ≥60-70 divisions is 12,9110.25 hm², accounting for 84.35% of the total cultivated area of the county’s hilly areas, followed by the area between ≥70-80 divisions, which is 9067.44 hm², accounting for the total area of arable land in the county’s hilly areas. The area is 8095.61 hm², and 6787.72 hm² accounts for 5.29% and 4.43% of the total cultivated area in the hilly area of the county respectively. On the whole, the natural quality of cultivated land in the hilly area of Faku County is medium.

4. Conclusion and Discussion

The high-standard basic farmland construction project is a complex project with comprehensive consideration of land use planning, field supporting facilities, economic benefits and ecological benefits. Through scientific planning and adjustment of regional land, land leveling projects, irrigation and drainage projects, road projects, and farmland protection projects, it is a requirement for regional cultivated land to meet high standards, providing necessary conditions for agricultural modernization, especially agricultural mechanization, and integrating the agricultural industry. The development layout of the country, exploring the land consolidation and utilization model serving the characteristic agriculture. Through the construction of the evaluation index system, combining the actual conditions of the project area and the specific construction goals, fully taking into account the characteristics and general laws of the region’s land remediation, and combining the current status of the regional land use, the evaluation results are scientific and feasible in application. Sex. This article applies theoretical analysis and literature reading methods, with ArcGIS software as the technical support, combined with model construction to conduct an empirical analysis of the natural quality of the high-standard basic farmland in Faku County, and concludes that the natural quality of the cultivated land in the plain area of Faku County is above average. It is related to the topography of Faku County. The topography of Faku County is dominated by low mountains and hills, with undulating hills and plains.

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