Evaluation of Cultivated Land Fertility in Cultivated Land Area of Lingdong in Hulunbeir City

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Abstract

In this paper, according to the cultivated land situation of the three banner cities in the cultivated land area of Lingdong in Hulunbeir city, this paper uses fuzzy comprehensive evaluation method and analytic hierarchy process on the basis of ARCGIS to evaluate the research area.Using Delphi method to evaluate the factor screening chose 12 indicators, using the analytic hierarchy process (ahp) to determine the weight value of each factor, according to the degree of each evaluation factor's influence on farmland soil fertility to determine the membership function model of each evaluation factor, and the evaluation index to make use of GIS spatial interpolation and superimposed analysis, obtained the hulun buir ridge east farmland productivity distribution of cultivated land area.Finally, the grade I land accounts for 10.10% of the total area;The grade II land accounts for 27.74% of the total area;The grade III land accounts for 27.74% of the total area;The grade IV land accounts for 37.65% of the total area;The grade V land accounts for 6.96% of the total area.The result shows that the arable land fertility in the study area is relatively good on the whole.

Keywords

Cultivated Land; Farmland Productivity; Evaluation Factor; Cultivated Land Area of Lingdong.

1. Introduction

The evaluation of cultivated land fertility is a comprehensive evaluation of the basic soil fertility and production capacity of cultivated land[1]. It is a process of evaluating the production potential and land suitability of cultivated land. The evaluation of cultivated land fertility can fully understand the quality of cultivated land.To understand the quality of cultivated land, we can understand the cultivated land mode and its effect on the regional scale to a certain extent, so as to provide valuable Suggestions and theoretical basis for the adjustment of cultivated land mode and land use planning.At the same time, the farmland productivity evaluation is the foundation of cultivated land protection, and to evaluate farmland productivity level, to protect cultivated land resources, regional cultivated land resource reasonable configuration, agricultural structure adjustment, such as to provide basic data, also can promote the sustainable development of agriculture, so the research on farmland productivity evaluation has strong practical significance and scientific value.

In this paper, on the basis of ARCGIS, fuzzy comprehensive evaluation method and analytic hierarchy process are used to evaluate the cultivated land fertility of the cultivated land related to the cultivated land rotation in lingdong cultivated land area of Hulunbuir city in 2018, and the cultivated land fertility of the study area is divided to provide a theoretical basis for scientific and reasonable utilization of cultivated land.

2. Overview of the Research Area

2.1 Basic Information of the Research Area

In this paper, the study area is cultivated land area of Lingdong in Hulunbeir city ,mainly including zhalantun, Arun Banner and MoQi three flag city, located in the piedmont plain to the piedmont region of songnen plain, where is mainly used for farming in agricultural economic zone, the main

crops for upland crops such as soybean, corn, potato.The low hills and hills at the eastern foot of the Greater Hinggan Mountains basically belong to the continental monsoon climate of the middle temperate zone. The frost-free period (minimum daily temperature ≥2℃) is relatively short, about 100 ~ 130d;The average annual rainfall is 280mm, concentrated in the summer;The number of windy days is relatively large, which is generally 25 ~ 45d throughout the year;The cultivated soil is mainly black soil, dark brown soil and meadow soil.

The cultivated land area of the study area is about 1.13 million hectares, accounting for 61% of the city's total cultivated land area.And dry farming is the main form of agriculture in the study area, with 81.5% of the cultivated land occupied.

2.2 The Layout of Monitoring Points

In this paper, the factors such as administrative division, soil type, climatic conditions and management level are considered comprehensively, and then srtting up the cultivated land quality monitoring points in the study area.There are 40,000 hectares of cultivated land in the study area. According to the requirement of setting up one monitoring point for every 667 hectares of cultivated land, there are 60 rotation monitoring points in the study area, covering four soil types: black soil, dark brown soil, meadow soil and marsh soil.

2.3 The Data Source

The data of this study are mainly from Land consolidation Center of Hohhot, Soil fertilizer station of Hohhot and Statistical Yearbook of Inner Mongolia Autonomous Region.

The data include the climatic conditions, physical properties and soil nutrient data of each monitoring site.Among them, the data of climatic conditions include effective accumulated temperature (≥0℃, ≥10℃), frost-free period, perennial rainfall, etc.Physical properties include geomorphic type, topographic position, altitude, slope, effective soil layer thickness, surface layer thickness, parent material, bulk weight, texture, etc.Soil nutrient data include organic matter, pH value, available phosphorus, available potassium, available zinc, slow available potassium, exchangeable calcium, exchangeable magnesium, available sulfur, silicon, iron, manganese, copper, zinc, boron, molybdenum, and so on.Other data include the study of regional administrative zoning and land use status maps.

3. The Results and Analysis

3.1 Determine Evaluation Unit

According to the relevant requirements of The Technical Regulations for Survey and Quality Evaluation of Cultivated Land Fertility and Classification of Cultivated Land Types and Cultivated land Fertility of China, the evaluation unit was determined by comprehensive analysis method, and the cultivated land fertility of Hulunbuir city was comprehensively evaluated with lingdong cultivated land area of Hulunbuir city as the evaluation unit[2-5].

3.2 Determine Evaluation Factors

There are various factors affecting cultivated land fertility, including climate, site conditions, profile characters, physical and chemical properties of surface layer, nutrient status of surface layer, obstacle factors and soil management, etc. According to these seven aspects, evaluation factors suitable for cultivated land fertility in Hulunbuir city were selected[5, 6].Finally, 11 indexes of climate, site conditions, physical and chemical properties of topsoil and nutrient status of topsoil are determined: effective accumulated temperature ≥10℃, landform type, altitude, slope, effective soil layer thickness, texture, organic matter, pH value, effective phosphorus, available potassium and effective zinc.

3.3 Determine Index Weight

The impact of each evaluation index on the cultivated land fertility is different, the importance of the impact of the index can be expressed by assigning different weights to each index, and the analytic hierarchy process is used to determine the weight value of the index[7] .Each indicator and the corresponding evaluation matrix are determined according to the constructed hierarchy structure, and

the comprehensive score is given to determine the comprehensive weight of each indicator.The specific process of AHP is as follows:

(1) Building a Hierarchy

According to the evaluation objectives and the selected evaluation factors, the target layer, criterion layer and index layer were constructed to form the cultivated land fertility evaluation system of Hulunbuir city. See Table 1 for the specific hierarchical structure [8].

Table 1 hierarchy of cultivated land capacity evaluation indexes in Hulunbuir City

Target layer	Criterion level	Index level
Land capacity evaluation G	Climate C_1	Frost-free seasonA_1
		Effective accumulated temperature ≥10℃A_2
	Site Conditions C_2	Geomorphic typeA_3
		ElevationA_4
		GradientA_5
	Physicochemical property C_3	Effective soil thicknessA_6
		Character A_7
		Organic matterA_8
		PH valueA_9
	Nutrient status C_4	Olsen-P A_{10}
		Olsen-K A_{11}
		DTPA-Zn A_{12}

(2) Construction of Judgment Matrix

The judgment matrix is constructed to assess the relative importance of each factor at this level to an element at the higher level, and it is mainly used to make judgments based on the experience and knowledge of experts [8]. And according to the 1 ~ 9 scaling method compared to fill out two evaluation factors constitute the judgment matrix, get the rule layer and index layer judgment matrix [5, 8].

(3) Weight Determination and Consistency Test

After the hierarchical structure and judgment matrix were constructed, the analytic hierarchy process (Table 2) was obtained, and the consistency test was carried out. The CR values were all less than 0.10, and the calculated results fully met the consistency condition.

If the consistency ratio CR<0.10 is a satisfactory consistent result; Otherwise, the judgment matrix needs to be adjusted. The consistency ratio (CR) is calculated as follows:

$$CR=CI/RI \qquad \text{(Formula 3-1)}$$

Where: CI is the consistency index; RI is a random index.

3.4 Standardization of Evaluation Indicators

In order to ensure the reliability of the results, it is necessary to standardize the original index data. Through statistical analysis of data characteristics and consultation with experts, the corresponding membership degree of qualitative data is given directly by Delphi method.For quantitative data, Delphi method and membership function were used to determine the membership function of evaluation factors [4].

According to the technical Rules for The Investigation and Quality Evaluation of Cultivated land, the relationship between the selected evaluation index and cultivated land production capacity in this evaluation can be divided into four types of subjection functions: ring-up function, ring-down function, peak-type function and conceptual type function.The original data value of each evaluation factor is substituted into the corresponding membership function, and the original value with irregular

distribution, unit, quantitative or qualitative description is converted into the membership degree distributed from 0 to 1 with no dimensional difference [7].

The membership functions of each evaluation factor of cultivated land fertility are shown in Table 3.

Table 2 Results of hierarchical analysis

Hierarchical A	Hierarchical C				Combination weight
	Climate C1	Site Conditions C2	Physicochemical property C3	Nutrient status C4	
	0.1403	0.2665	0.3431	0.2501	
Frost-free season A_1	0.5455				0.0765
Effective accumulated temperature ≥10℃A_2	0.4545				0.0638
Geomorphic type A_3		0.2497			0.0665
Elevation A_4		0.3979			0.1060
Gradient A_5		0.3524			0.0939
Effective soil thickness A_6			0.1650		0.0568
Character A_7			0.2184		0.0749
Organic matter A_8			0.2669		0.0916
PH valueA_9			0.3497		0.1200
Olsen-P A_{10}				0.2577	0.0644
Olsen-K A_{11}				0.3395	0.0849
DTPA-Zn A_{12}				0.4028	0.1007

Table 3 membership function of evaluation factors

Type of Function	Item	Subordinate Function	c	ut
On the Ring Type	Frost-free season	$Y=1/[1+0.0044(u-c)^2]$	130	ut<95
	Effective accumulated temperature ≥10℃	$Y=1/[1+4.444\times10^{-5}(u-c)^2]$	2350	ut<1900
	Effective soil thickness	$Y=1/[1+0.000625(u-c)^2]$	80	ut<10
	Organic matter	$Y=1/[1+0.0004(u-c)^2]$	100	ut<10
	Olsen-P	$Y=1/[1+0.00016(u-c)^2]$	120	ut<4
	Olsen-K	$Y=1/[1+8.16\times10^{-6}(u-c)^2]$	600	ut<70
	DTPA-Zn	$Y=1/[1+0.1111(u-c)^2]$	5	ut<0.5
Under the Ring Type	Gradient	$Y=1/[1+0.1111(u-c)^2]$	1	ut>13
Ridge Type	PH value	$Y=1/[1+11.11(u-c)^2]$	6.1	ut1=5，ut2=7.8
Conceptual	Geomorphic type	Flatland 1，Hill 0.8，mountainous region 0.5		
	Character	Black soil1, Meadow soil 0.8, Dark brown earth0.6, Boggy soil0.4		
	Elevation	<230 is 1,230~270 is 0.9,270~320 is 0.85,320~370is0.65,>370 is 0.4		

3.5 Results of Comprehensive Index of Cultivated Land Fertility

By using the index scores standardized by membership functions and the weight values of each factor index obtained by analytic hierarchy process, the comprehensive scoring method USES the following formula (Formula 3-2) to comprehensively score the arable land fertility of Hulunbuir [7].

$$IFI = \sum_{i=1}^{n} P_j X_{ij} (i = 1,2,3\ldots\ldots n,\ j = 1,2,3\ldots\ldots \mathrm{m}) \qquad \text{(Formula 3-2)}$$

Where, IFI (Integrated Fertility Index) is the comprehensive index of cultivated land fertility, n is the total number of evaluation factors, P_j is the weight of the j-th evaluation index, and Xij is the membership degree of the evaluation unit on the j-th evaluation index.The value range of IFI is 0.10 ~ 1.00, and the higher the value, the higher the contribution rate of each evaluation factor to the cultivated land fertility [9].

The calculation result of IFI value is shown in Fig.1. It can be seen from the figure that the comprehensive index range of soil fertility in the cultivated land rotation fallow area in Hulunbuir city is 0.40~0.79. The IFI value is higher in the south-central part of Moqi, the south and north part of Arong Banner and the southeast part of Zhalantunshi, indicating that the cultivated land quality is higher in these areas.

Natural discontinuities segmentation method for classification standard are used to get the hulun buir city, arable land, crop rotation fallow farmland productivity level, and according to the national farmland type, the farmland productivity hierarchy ", natural discontinuities classification method is used to change the hulun buir city, farmland productivity of arable land, crop rotation fallow area are classified into five grades, classification results are shown in table 4.Among them, the first level takes up 10.10%, mainly distributed in the south of Moqi and The south of Arun Banner;The secondary area, accounting for 17.55%, is mainly distributed in the central part of Mo Qi and the northeast part of Arun Banner.The third level, accounting for 27.74%, is mainly distributed in the central part of Arun Banner and the central and northern part of Moqi.The fourth level is 37.65%, mainly distributed in the north of Moqi, the west of Arun Banner, and the middle and west of Zalantun.Grade five occupies 6.96%, mainly in the north of Zalantun.It can be seen that, among the three counties of Zarantun, Arun Banner and Moqi, Arun Banner had the best farmland land overall, followed by Moqi and Zarantun.

Table.4 Comprehensive index classification table of cultivated land productivity

Soil Fertility Levels	The ComprehensiveLand Power Index' Ievel
Level 1	＞0.68
Level 2	0.64-0.68
Level 3	0.60-0.64
Level 4	0.56-0.60
Level 5	＜0.56

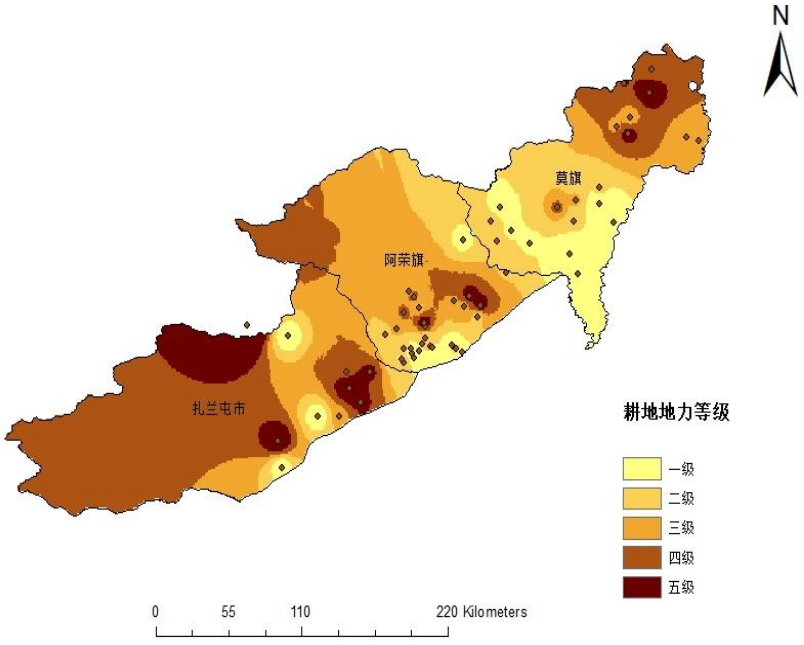

Fig.1 IFI value distribution diagram of cultivated land fertility comprehensive index in the research area

4. Conclusion

The cultivated Land Area of Lingdong in Hulunbeir city as the research area, including zhalantun, Arun Banner and MoQi, through the establishment of cultivated Land Area of Lingdong in Hulunbeir city of cultivated land fertility evaluation system, to determine the index weight and membership function model of each index factor in the study area in 2018, through analyzing the cultivated land quality, finally obtained the study area of farmland productivity as a result, the farmland productivity in the study area is divided into five, among them, the grade I land accounts for 10.10% of the total area; The grade II land accounts for 27.74% of the total area; The grade III land accounts for 27.74% of the total area; The grade IV land accounts for 37.65% of the total area; The grade V land accounts for 6.96% of the total area. Finally we can conclude that the arable land fertility in the study area is relatively good on the whole.

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