

Appraisal of Agricultural Production Suitability Based on RS and GIS

-- Taking Xiahe County as an Example

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Abstract: Based on the natural environment and land use status of agricultural production, the research on the suitability evaluation of agricultural production can provide a theoretical basis for the scientific spatial planning. This paper takes Xiahe County as the research area, based on RS and GIS, through the analysis of agricultural production in terms of water resource abundance, terrain, soil fertility, light and heat conditions, meteorological disaster risk, land concentration and contiguousness, etc., to improve the suitability evaluation of agricultural production System, carry out the suitability evaluation of agricultural production, and on this basis, scientifically evaluate the sustainable development of agriculture, and provide scientific basis for the sustainable and sustainable development of agriculture in Xiahe County.

Keywords: Evaluation of agricultural production suitability; CASA model; Xiahe County; Agricultural resources.

1. Preface

China is a country with agricultural production as the basis of its national economy. The main agricultural land, such as cultivated land and garden land, accounts for nearly 15% of the land area [1]. Therefore, optimizing the spatial distribution of agricultural production is an important measure closely related to the national food security strategy. However, in the process of industrialization and urbanization, the scale of land use in small towns has expanded rapidly, resulting in the compression of cultivated land and ecological land in small towns [2] [3]. Under the requirements of the state to put forward policies related to land space planning, the land space suitable for agricultural production is delineated, and the reasonable scale of agricultural production is proposed through the evaluation of the suitability and carrying capacity of agricultural production, which is of very important for optimizing the agricultural production space layout, the coordination of the relationship with other functional spaces, as well as the determination of the amount of cultivated land and the area of permanent basic farmland protection are of great significance.

The suitability for agricultural production, that is, the suitability of land for agriculture, refers to the suitability for planting crops on a specific land space or land. The suitability of agricultural production is one of the important links in determining agricultural planting methods, planting types, and planting scales. It is also commonly used together with concepts such as land productivity and land use potential in agricultural regional development, management, and planning [4] [5]. Agricultural production not only depends on the characteristics of the crop itself, but also is affected by external factors such as water, soil, topography, weather, and land use. Therefore, it is commonly used to evaluate the suitability of regional planting production or animal husbandry production by using geographic information system (GIS), remote sensing (RS) technology and comprehensive analysis methods of indicators, and by analyzing conditions such as terrain, climate, soil, irrigation and land use. Research methods [6].

Xiahe County is part of an important ecological security barrier in my country. Its ecological environment construction attributes put forward stricter requirements for land planning, protection and utilization. Therefore, it is necessary to carry out regional land space planning and do a good job in the suitability evaluation of agricultural production. Based on this, this paper takes Xiahe County as the research area, using GIS and RS, makes the analysis of agricultural production from water resource abundance, topography, soil fertility, light and heat conditions, meteorological disaster risk, land concentration and contiguousness, etc., to improve agricultural production suitability evaluation system, carry out the evaluation of the suitability of agricultural production, and on this basis, scientifically evaluate the sustainable development of agriculture, and provide scientific basis for the sustainable development and sustainable development of agriculture in Xiahe County.

2. Data Sources and Research Methods

2.1. Overview of the study area

Xiahe County is located in the southwest of Gansu Province, the northwest of Gannan Tibetan Autonomous Prefecture, and the northeast is close to the Qinghai-Tibet Plateau. It is located between 34°32'~35°34' north latitude and 101°54'~103°25' east longitude. It is under the jurisdiction of Gannan Tibetan Autonomous Prefecture. The study area is adjacent to Hezuo City and Zhuoni County in the east, Luqu County in the south, Zeku County in Qinghai Province in the west, Linxia Prefecture, Xunhua County and Tongren County in Qinghai Province in the north. The total area is 6267.08km². Located on the eastern edge of the Qinghai-Tibet Plateau, the transition zone between the Gannan Plateau and the Loess Plateau, there are high mountains and canyons, bounded by Tumen Pass, the Loess Plateau in the north, and the obvious plateau landform in the south. The altitude of most areas is between 3000 and 4200m, and the terrain slopes from northwest to southeast. It belongs to the cold humid climate, and the characteristics of plateau continental climate are more obvious. The river network in

Xiahe County is densely distributed, with the Daxia River system in the north and west, and the Taohe River system in the south and east. Both the Daxia River and Tao River are important tributaries of the upper reaches of the Yellow River. Soil types mainly include alpine meadow soil, subalpine meadow soil, chernozem, gray cinnamon soil, etc. At the end of 2018, the resident population was 90,300, the per capita disposable income of urban residents reached 24,574 yuan, and the per capita disposable income of farmers and herdsmen was 7,598 yuan.

2.2. Data sources

The data used in this paper include meteorological data,

remote sensing data, disaster data, digital elevation model data, data from the third national land survey of Xiahe County, and the 2018 Statistical Yearbook of Xiahe County. The data mainly come from online public data downloads or obtained from relevant departments.

Because the study area is a county-level unit, the research scope is small, and the data sources are complicated, and the unit sizes are different, to facilitate unified calculation, all spatial data are unified to a resolution of 30m, which is used as the basic evaluation unit of Xiahe County; Based on the national geodetic coordinate system (CGCS2000_3_Degree_GK_Zone_34N), it unifies various types of spatial data projection coordinate systems.

Table 1. Data source

name	type	resolution	Data Sources	Specific data required
Meteorological data	text	—	China Meteorological Science Data Sharing Service Network	Multi-year daily average precipitation and wind speed data of each station
remote sensing image	grid	30m	Geospatial Data Cloud	Landsat8-OLI data
disaster data	Maps	—	Xiahe County Natural Resources Bureau	Disaster point data
Digital Elevation Model	grid	30m	Geospatial Data Cloud	Extract terrain factors such as slope and elevation
Data from the Third National Land Survey of Xiahe County	vector	—	Xiahe County Natural Resources Bureau	Maps of land types, administrative boundaries at all levels, roads, water systems, residential areas, etc.
Statistical Yearbook	text	—	Xiahe County Bureau of Statistics	Population, Industrial Economy, etc.

2.3. Research Methods

2.3.1. Comprehensive index method

The comprehensive index method was used to evaluate the suitability of crop production in Xiahe County. Combined with the characteristics of Xiahe County's own development, according to the three principles of coordination, scientificity

and feasibility, and centering on the core goal of planting production suitability, the water resource abundance, topography, soil fertility, light and heat conditions, meteorological disaster risk, Starting from the 6 second-level index layers of land concentration and contiguosness, 16 third-level index evaluation factors are established.

Table 2. Evaluation index system of crop production suitability

Suitability for crop production	Water abundance	precipitation
		surface runoff
	terrain	terrain relief
		slope
		Aspect
		altitude
	soil fertility	Soil texture
		Effective soil thickness
		Soil organic matter content
		Soil pH
	Photothermal conditions	Annual accumulated temperature
		Total annual solar radiation
		Average annual temperature
	Meteorological Disaster Risk	Disaster-forming environment
		Hazardous factors
		Hazardous body
Concentration of land contiguosness	—	

2.3.2. CASA model

The CASA model is a typical NPP estimation model that

integrates the effects of environmental factors and plant factors on light energy use efficiency. This model is

determined by the effective radiation of photosynthesis absorbed by plants and the utilization coefficient of light energy [7], namely:

$$NPP(x, t) = APAR(x, t) \times \varepsilon(x, t)$$

APAR refers to the solar radiant energy involved in the photosynthesis process of vegetation, which is jointly determined by the total solar radiation and the absorption ratio of photosynthetically active radiation by vegetation, namely:

$$APAR(x, t) = SOL(x, t) \times FPAR(x, t) \times 0.5$$

Light energy efficiency refers to the efficiency with which vegetation converts absorbed solar radiation energy into organic carbon, and it has a certain relationship with the temperature and humidity conditions in the environment. Right now:

$$\varepsilon(x, t) = T_{\varepsilon_1}(x, t) \times T_{\varepsilon_2}(x, t) \times W_{\varepsilon_1}(x, t) \times \varepsilon_{\max}$$

3. Evaluation Results of Agricultural Production Suitability

3.1. Suitability of crop production

3.1.1. Evaluation process

(1) Abundance of water resources

The abundance of water resources refers to the amount of potential value carried by all natural precipitation, surface water and groundwater that can be used for production or living. The spatial distribution of water resource abundance in Xiahe County is uneven, decreasing from south to north. In terms of precipitation, from the perspective of spatial distribution in Xiahe County, Xiahe County has 2426.97 hectares of arable land with rich water resources, accounting for 13.37% of the total arable land, mainly distributed in Amu Quhu Town and Bola Town; The area of cultivated land is 10,979.29 hectares, accounting for 60.48% of the total area of cultivated land, mainly distributed in Amu Quhu Town, Bola Town and Jicang Township; the area of cultivated land not rich in water resources is 4747.78 hectares, accounting for 26.15% of the total area of cultivated land, mainly Distributed in Ganga Town, Madang Town and Zhayou Township, the higher the abundance of water resources, the more suitable for planting production.

(2) Terrain

Terrain flatness is represented by four indicators of terrain relief, slope, aspect and altitude, all of which are calculated based on DEM digital elevation data. The Xiahe County study area has a relatively large flat area, and the planting industry has high adaptability. The fragmentation of regional uneven areas is randomly distributed throughout the county, and there is no contiguous uneven area. Xiahe County has 4452.09 hectares of relatively flat cultivated land, accounting for 24.66% of the total cultivated land, mainly distributed in Bola Town and Zhayou Township; 5918.50 hectares of uneven cultivated land, accounting for 32.78% of the total cultivated land, mainly Distributed in Amu Quhu Town, the flatter the terrain, the more suitable for planting production.

(3) Soil fertility

Soil fertility is evaluated through single-factor evaluation and comprehensive analysis and evaluation through the four

indicators of effective soil layer thickness, soil texture, soil pH, and soil organic matter content to obtain the quality distribution of soil fertility. The area of cultivated land with the highest soil fertility in Xiahe County is 1,735.26 hectares, accounting for 9.55% of the total area of cultivated land in the county, mainly distributed in Ganga Town, Madang Town and Labrang Town; 41.19% of the total area is mainly distributed in Bola Town, Madang Town and Zhayou Township; the area of arable land with average soil fertility capacity is 8949.39 hectares, accounting for 49.26% of the total arable land area, mainly distributed in Amu Quhu Town and Jicang Township.

(4) Light and heat conditions

In the process of evaluating the suitability of agricultural climate, light and heat conditions are very important indicators. It mainly uses the active accumulated temperature with daily average temperature $\geq 0^{\circ}\text{C}$ to reflect the support of natural climate conditions such as light and heat for agricultural production. level [8]. The results show that there are 5531.56 hectares of cultivated land in Xiahe County with better light and heat conditions, accounting for 33.49% of the total cultivated land area in the county, mainly distributed in Amu Quhu Town, Ganga Town and Labrang Town; The area of cultivated land is 6827.79 hectares, accounting for 41.34% of the total area of cultivated land in the county, mainly distributed in Bola Township, Zhayou Township and Jicang Township; the area of cultivated land with poor light and heat conditions is 4158.53 hectares.

(5) Meteorological disaster risk

Meteorological disaster risk mainly studies the sensitivity of disaster-forming environment, the vulnerability of hazard-bearing bodies and the risk of hazard-causing factors. Among them, the risk of disaster-causing factors includes three meteorological disaster indicators of drought, rainstorm and freezing damage, the sensitivity of disaster-forming environment is represented by the river network density factor, and the vulnerability of disaster-affected bodies includes the factor of cultivated land area index.

The high-risk area of comprehensive meteorological disaster risk in Xiahe County is mainly located in the north, and the overall meteorological disaster risk index decreases from north to south. Among them, Xiahe County has 6,052.64 hectares of cultivated land with meteorological disaster risk in the high-risk area, accounting for 33.32% of the total cultivated land, mainly distributed in Madang Town, Ganga Town, Wangertang Town and Tang Gaang Township; The area of cultivated land in the risk area is 10,077.05 hectares, accounting for 55.48% of the total area of cultivated land, mainly distributed in Bola Town, Amu Quhu Town and Jicang Township; the area of cultivated land in the low-risk area is 2,034.97 hectares, accounting for 11.20% of the total area of cultivated land %, mainly distributed in Amuquhu Town, Bola Town and Zhayou Township.

(6) Concentration and contiguity of land

Landscape coherence is a concept proposed from the perspective of landscape ecology, which is generally divided into structural coherence and functional coherence. The concentration of cultivated land is an important factor affecting agricultural production, while the dispersion and fragmentation of cultivated land have a greater impact on agricultural production. The areas with high contiguity in Xiahe County are mainly distributed in the southeastern part of the county, which is consistent with the actual cultivated land area. Among them, Xiahe County has 4,616.94 hectares of arable land with relatively good land

concentration and contiguousness, accounting for 25.40% of the total arable land area, mainly distributed in Amu Quhu Town and Jicang Township; the area of relatively average land concentration and contiguousness is 3344.98 hectares, accounting for 18.40% of the total cultivated land area, mainly distributed in Bola Town and Madang Town; the area of cultivated land with poor land concentration and contiguousness is 10216.11 hectares, accounting for 56.20% of the total cultivated land area, mainly distributed in Bola Town, Ganga Town and Zhayou Township.

3.1.2. Comprehensive evaluation of planting production suitability

The suitability of planting production can be obtained from the analysis of water resource abundance, topography, soil fertility, light and heat conditions, meteorological disaster risk, and land concentration and contiguousness. The results show that the total area suitable for planting production in Xiahe County is 13933.31 hectares, accounting for 2.20% of the total land area of the county. Distributed in 11 towns and townships in the county, Amu Quhu Township is the most distributed, accounting for 3727.13 hectares, accounting for 23.09% of the total area suitable for planting, followed by Bola Town, with 3488.40 hectares, accounting for 21.62% of the total planting production area; Wangertang Township, Qu'ao Township, and Tanggaang Township's current cultivated land and cultivated land reserve resource areas are all in suitable areas for planting. The unsuitable areas for planting production in Xiahe County are mainly distributed in Ganga Town, with an area of 468.52 hectares, accounting for 2.90% of the total area of unsuitable areas for planting production. There are no suitable areas for planting production in Sangke Town and Kecai Town.

3.2. Suitability of animal husbandry production

3.2.1. Evaluation process

(1) Vegetation Net Primary Productivity NPP

The CASA model was used to calculate the vegetation net primary productivity NPP. The vegetation coverage in Xiahe County shows a decreasing trend from south to north. Among them, the area of high coverage is 297,178.39 hectares, accounting for 47.43% of the total area of Xiahe County, mainly distributed in Sangke Town, Kecai Town and Amu Quhu Town; The coverage area is 250,231.15 hectares, accounting for 39.93% of the total area of Xiahe County, mainly distributed in Sangke Town, Ganga Town and Kecai Town; the general coverage area is 79,188.11 hectares, accounting for 12.64% of the total area of Xiahe County, They are mainly distributed in Ganga Town, Madang Town and Wangertang Town. From the perspective of spatial distribution, the high-coverage area in the south has good lighting conditions, sufficient precipitation, and grassland is the main ecosystem type, and its water conservation capacity is good, while some areas with general coverage in the north are frequently disturbed by urban construction and human activities. The spatial pattern of the distribution of low NPP values of local vegetation in the north was formed.

(2) Grassland forage production capacity

Grassland forage production capacity is expressed by annual hay production per unit area. Hay production refers to the total production of pasture dry matter produced in a certain period of time in a certain area. The calculation results are shown in Figure 1.

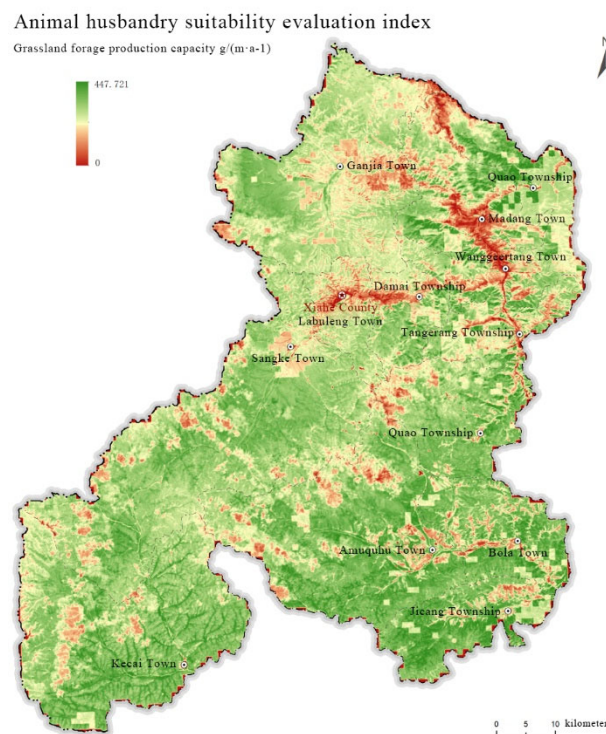


Figure 1. Evaluation results of grassland forage production capacity

3.2.2. Comprehensive evaluation of animal husbandry production suitability

The evaluation results show that the area suitable for animal husbandry production in Xiahe County is 371,474.83 hectares, accounting for 67% of the total land area of the county. The suitable area accounts for 14% of the total area, followed by Amu Quhu Town and Kecai Town in the south. This area has high forage production capacity, low risk of meteorological disasters, and flat terrain. It is an excellent pastoral area in Xiahe County. Labrang Township and Damai Township in the central part are less suitable for animal husbandry production due to the high risk of meteorological disasters, low terrain flatness, and broken ground.

4. Suggestions on Utilization of Agricultural Resources in Xiahe County

4.1. Reasonably adjust the agricultural structure and strengthen investment in land consolidation

In the process of urbanization, due to the accelerated process of urbanization, the development and utilization of rural land resources has been greatly affected. However, the land resources in our country, especially the arable land resources are very scarce at present, and the original extensive agriculture can no longer meet people's needs. The key to solving this problem is to realize the intensive use of land, so as to improve the efficiency of land use. Further improve the quality of cultivated land and enhance the population carrying capacity of land resources. Improve the quality of cultivated land in towns such as Amuquhu Town, Bola Town and Jicang Township, improve soil fertility, prevent the degradation of cultivated land, increase the construction of farmland water conservancy facilities, strengthen the intensity of land

reclamation, improve the basic facilities of farmland, and consolidate the productivity of cultivated land, to increase the productivity of cultivated land.

4.2. Actively promote green ecological agriculture and vigorously promote the development of ecological industries

Actively promote the development of green ecological agriculture, and use the livestock and poultry breeding belt as a link to carry out a number of planting and breeding projects, highland barley bases, Chinese herbal medicine bases, harmless treatment of livestock and poultry (including professional cooperatives), resource recycling, and standardized slaughterhouses project. Vigorously develop and develop the local economy, and support the development of distinctive and advantageous agriculture in all counties and districts.

4.3. Scientific and rational use of grassland resources to promote the healthy development of animal husbandry

Take technical measures such as banning grazing and resting grazing, returning grazing to grassland, controlling grassland pests and rodents, reseeding, fertilizing and other technical measures to comprehensively control degraded pastures. Delineate the grazing layout, stipulate strict rotational grazing and rest grazing time, realize "determining livestock by grass", and form a scientific grazing system. Xiahe County is one of the key animal husbandry counties in Gansu Province. The plateau characteristic ecological animal husbandry, mainly yaks and Tibetan sheep, is the rich people's industry and the first industry in Xiahe County. Strengthening grassland protection, realizing high-efficiency breeding, quality fattening, scientific breeding, precise management, promoting marketing, ensuring the safety of livestock products, and improving production conditions are the only ways to improve the management level and realize the scientific and healthy development of animal husbandry.

5. Conclusion

This paper evaluates the suitability of agricultural production in Xiahe County based on GIS and RS, evaluates the suitability of planting production based on the comprehensive index method, evaluates the suitability of animal husbandry production based on the CASA model, and evaluates the agricultural resources and environment of Xiahe County based on the evaluation results. On this foundation, the paper puts forward reference suggestions for the utilization and development of agricultural resources and environment in Xiahe County. Through the research of this paper, the following conclusions are obtained:

(1) The total area suitable for planting production in Xiahe County is 13,933.31 hectares, accounting for 2.20% of the county's total land area. It distributed in 11 townships in the county. The unsuitable areas for planting production in Xiahe County are mainly distributed in Ganga Town, with an area of 468.52 hectares, accounting for 2.90% of the total area of

unsuitable areas for planting production. There are no suitable areas for planting production in Sangke Town and Kecai Town.

(2) The area suitable for animal husbandry production in Xiahe County is 371,474.83 hectares, accounting for 67% of the total land area of the county. The areas with high suitability are mainly distributed in Sangke Town in the west of the county, followed by Amu Quhu Town in the south, Kecai Town, this area has high forage production capacity, low risk of meteorological disasters, and flat terrain. It is an excellent pastoral area in Xiahe County. Labrang Township and Damai Township in the central part are less suitable for animal husbandry production due to the high risk of meteorological disasters, low terrain flatness, and broken ground.

(3) Based on the evaluation results of the suitability of agricultural production in this paper, the following suggestions are put forward for the utilization of agricultural resources in Xiahe County: ① Adjust the agricultural structure Reasonably and strengthen investment in land consolidation. ② Actively promote green ecological agriculture and vigorously promote the development of ecological industries. ③ The scientific and rational use of grassland resources to promote the healthy development of animal husbandry.

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