Evaluation of Chongqing's Agricultural Development Level Based on the Entropy Weight-TOPSIS Model

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Abstract. This paper constructs a 4-dimension evaluation system with 12 indicators for Chongqing's agriculture, covering economy, productivity,rural income and green development. Based on 2001–2023 panel data, the entropy weight-TOPSIS model is adopted to assess its agricultural development. The core driving factors include the share of primary industry in GDP, fertilizer and film input intensity, rural disposable income and total agricultural output. Chongqing's agricultural level presents a U-shaped trend, bottoming in 2009 before fluctuating upward. Rural income grew continuously, while green agriculture recovered slowly. Corresponding policy suggestions are proposed accordingly.

Keywords: agricultural development level; entropy weight-TOPSIS model; comprehensive evaluation indicator system

1 Introduction

Agriculture serves as the foundation of the national economy, and its development quality directly affects rural revitalization outcomes and regional sustainable-development capacity. As China's only western municipality directly under the central government, Chongqing features a typical "large city, large countryside" urban-rural dual structure. Restricted by mountainous terrain, it is of great significance to scientifically evaluate its agricultural development status and identify existing deficiencies.

Theoretically, this paper establishes a comprehensive agricultural evaluation system for mountainous municipalities and validates the applicability of the entropy-weight TOPSIS model for multi-indicator time-series agricultural assessment, enriching domestic quantitative evaluation frameworks for regional agriculture. Practically, the empirical findings can offer data support and decision-making references for Chongqing to optimize its agricultural industrial structure and formulate high-quality agricultural development policies.

2 Literature Review

Scholars have conducted abundant quantitative evaluations on regional agricultural development. Ma adopted cluster analysis to assess county-level agricultural economic

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development (Ma, 2014). Focusing on low- and middle-income countries, Mellor explored agriculture's role in economic transformation and proposed effective approaches to facilitate agricultural growth and poverty reduction (Mellor, 2017). Zhu and Zhou determined evaluation weights via the analytic hierarchy process and evaluated regional low-carbon agricultural development (Zhu & Zhou, 2017). Xu et al. applied principal component analysis to assess regional agricultural economic development characteristics (Xu et al., 2018). Wang et al. employed the entropy-weighted TOPSIS model to identify key factors affecting sustainable agricultural development and offered targeted optimization suggestions (Wang et al., 2021). Ding and Li adopted factor analysis to evaluate the agricultural modernization level of Gansu Province (Ding & Li, 2022). Yang used the entropy method for quantitative assessment of regional agricultural economic development (Yang, 2022). Similarly, Su et al. applied the entropy-weighted TOPSIS approach to evaluate agricultural development in Guangdong Province and put forward corresponding development suggestions (Su et al., 2022).

Building on previous research, recent studies have supplemented agricultural evaluation research covering multiple geographical regions and diverse technical methods. Wu et al. adopted the entropy method to evaluate the agricultural modernization level of mountainous areas and analyzed internal structural differences in agricultural development (Wu et al., 2026). He et al. integrated the entropy-weighted TOPSIS model and multiple linear regression to assess high-quality agricultural development in arid oasis areas and clarified its core driving factors (He et al., 2026). In the context of rural revitalization, Zhao et al. combined the entropy method and fuzzy matter-element model to carry out multi-dimensional evaluation of modern agricultural development in plain regions (Zhao et al., 2026).

Various methods exist for multi-index evaluation. The entropy-weighted TOPSIS model extracts full data information and avoids subjective weighting bias, thus delivering reliable results. This paper adopts this model to evaluate Chongqing's agricultural development from 2001 to 2023.

3 Building an Evaluation Index System for Agricultural Development in Chongqing

Table 1. Evaluation Index Set for the Level of Agricultural Development in Chongqing

Indicator Layer	Indicator Direction
X1 Total agricultural output value(Ten thousand yuan)	Positive
X2 Agricultural output value index(%)	Positive
X3 Share of primary industry in GDP(%)	Positive
X4 Proportion of agricultural output in total agriculture, forestry, animal husbandry, and fishery output(%)	Positive
X5 Effective irrigation area(Hectare)	Positive
X6 Crop sown area(Hectare)	Positive
X7 Grain output(Ten thousand tons)	
X8 Per capita disposable income of rural permanent residents(Yuan)	Positive
X9 Engel coefficient of rural households(%)	Negative
X10 Pesticide application intensity(Ton/hectare)	Negative

Indicator Layer	Indicator Direction
X11 Fertilizer application intensity(Ton/hectare)	Negative
X12 Agricultural film application intensity(Ton/hectare)	Negative

Referring to existing mature research results and considering the characteristics of mountain agriculture production in Chongqing, a evaluation system was constructed. The system has 4 primary dimensions, each composed of several secondary indicators: Economic development level includes secondary indicators X1-X4, Productivity level includes secondary indicators X5-X7, Rural residents' income includes secondary indicators X8-X9, and Green agricultural development includes secondary indicators X10-X12, totaling 12 secondary indicators. For positive indicators, higher values indicate better development, while for negative indicators, it's the opposite. The specific secondary indicators are shown in Table 1.

4 Entropy Weight - TOPSIS Evaluation Model

The TOPSIS model is mostly used for multi-criteria comprehensive evaluation, with the core idea of calculating the relative distance between the evaluation object and the optimal and worst ideal solutions; the entropy weighting method objectively assigns weights based on the degree of dispersion of indicator data, avoiding subjective scoring bias. The combination of the two can enhance the objectivity of the evaluation results of agricultural development levels, and the modeling is divided into two major stages:

Stage 1: Calculating Objective Weights of Indicators Using the Entropy Method

1. Indicator standardization. Distinguish between positive and negative indicators and use range standardization to eliminate dimensional differences:

Positive indicator: $z_{ij} = \frac{x_{ij} - min(x_j)}{max(x_j) - min(x_j)}$

Negative indicator: $z_{ij} = \frac{max(x_j) - x_{ij}}{max(x_j) - min(x_j)}$

Here: xij is the original value of the j indicator in the i year,and zij is the standardized value.

2. Calculate the information entropy and weight of indicators. First, calculate the characteristic proportion of each year under a single indicator, and then solve for the information entropy e_j; the greater the fluctuation of the indicator data, the higher the information utility value $d_j = 1 - e_j$, and the larger the corresponding weight. The final weight formula is:

$$w_j = \frac{d_j}{\sum_{j=1}^{12} d_j}$$

Stage 2: Calculation of Comprehensive Closeness Using the TOPSIS Method

1. Build a weighted normalized matrix: multiply the normalized data by the entropy weight to get the weighted decision matrix;

2. Determine the positive and negative ideal solutions: take the maximum value of each indicator in the weighted matrix as the positive ideal solution S^+, and the minimum value as the negative ideal solution S^-;

3. Calculate Euclidean distances: compute the distance of each year's sample to S^+ as D_i^+, and to S^- as D_i^-;

4. Calculate the comprehensive development index: closeness $C_i = \frac{D_i^-}{D_i^+ + D_i^-}, C_i \in [0,1]$, the higher the value, the higher the level of agricultural comprehensive development that year.

5 Empirical Results and Analysis

5.1 Indicator Weight Calculation Results

Prior to standardization, this paper preprocesses the 2001–2023 raw panel data. Minor missing values of partial indicators are supplemented via linear interpolation based on adjacent annual data. Full data verification confirms no outliers inconsistent with real agricultural conditions, ensuring data integrity and validity for subsequent model operation.

After data preprocessing, Min-Max range standardization is adopted for all indicators, and the entropy weight method is further used to calculate indicator weights. Table 2 lists each indicator's information entropy, information utility value and corresponding weight. Five core indicators account for weights above 10%: X3 the proportion of primary industry in GDP (15.95%), X11 fertilizer application intensity (14.44%), X12 agricultural film application intensity (12.48%), X8 rural residents' per capita disposable income (12.35%) and X1 total agricultural output value (11.81%). The other seven indicators carry weights lower than 10%, exerting limited impacts on Chongqing's overall agricultural development.

Table 2. Weight of Evaluation Indicators for Agricultural Development in Chongqing

Indicator	Information entropy value e	Information utility value d	Weight (%)
X1	0.87	0.13	11.81%
X2	0.97	0.03	2.42%
X3	0.82	0.18	15.95%
X4	0.94	0.07	5.86%
X5	0.93	0.07	6.12%
X6	0.94	0.07	5.86%
X7	0.98	0.02	1.53%
X8	0.86	0.14	12.35%
X9	0.93	0.08	6.77%
X10	0.95	0.05	4.42%
X11	0.84	0.16	14.44%
X12	0.86	0.14	12.48%

5.2 Temporal Evolution Characteristics of Comprehensive Agricultural Development

Table 3 shows the comprehensive scores and rankings of agricultural development in Chongqing from 2001 to 2023. From the table, we can see that Chongqing's agricultural

scores went through a two-stage trend of first declining and then rising: In the first stage, from 2001 to 2009, the scores kept dropping, falling from 0.57 to a low of 0.26. The extreme heat and drought in 2006 severely hit crop farming, causing a sharp decline in scores; coupled with the impact of the 2008 global financial crisis, the agricultural development level hit its lowest during the study period in 2009. In the second stage, from 2009 to 2023, the scores rose with some fluctuations, reaching 0.55. After 2014, growth stabilized, with policies like rural revitalization, high-standard farmland, and measures to boost farmers' income steadily showing benefits, but by 2023 the overall level still hadn't returned to the 2001 starting point. It can be further observed that the development of agricultural economy and agricultural green development show highly synchronized reverse changes in the research period. In the early stage, extensive input of chemical fertilizers and agricultural films drove the growth of agricultural economic output in the short term, but sharply reduced the green development score, resulting in serious imbalance between economic benefits and ecological benefits. After 2011, ecological governance measures slowed the deterioration of green agriculture, yet its recovery speed lagged far behind the rebound of agricultural economic level. The two subsystems lack coordinated development, and the coupling coordination state is relatively low, which restricts the high-quality sustainable development of Chongqing's mountain agriculture.

Table 3. Comprehensive Scores and Rankings of Agricultural Development Level in Chongqing from 2001 to 2023

Year	Positive Ideal Solution Distance(D^+)	Negative Ideal Distance(D^-)	Comprehensive Score	Index Ranking
2001	0.19	0.26	0.57	1
2002	0.20	0.23	0.54	3
2003	0.20	0.21	0.51	5
2004	0.20	0.21	0.51	6
2005	0.20	0.20	0.50	7
2006	0.24	0.11	0.31	15
2007	0.24	0.11	0.30	18
2008	0.25	0.10	0.28	21
2009	0.26	0.09	0.26	23
2010	0.26	0.10	0.27	22
2011	0.26	0.10	0.28	20
2012	0.25	0.12	0.32	14
2013	0.26	0.11	0.31	17
2014	0.27	0.11	0.30	19
2015	0.26	0.12	0.31	16
2016	0.25	0.14	0.35	13
2017	0.25	0.15	0.37	12
2018	0.24	0.17	0.41	11
2019	0.23	0.17	0.43	10
2020	0.21	0.18	0.47	9
2021	0.21	0.20	0.49	8
2022	0.20	0.22	0.52	4
2023	0.19	0.23	0.55	2

With the established index system and calculated indicator weights, we obtain scores of the four primary dimensions during 2001–2023, as listed in Table 4.

Table 4. Scores of Primary Indicators for Agricultural Development Level in Chongqing from 2001 to 2023

Year	economic development level	productivity level	rural residents' income situation	agricultural green development
2001	0.57	0.54	0.03	0.93
2002	0.54	0.53	0.01	0.83
2003	0.49	0.44	0.09	0.79
2004	0.54	0.42	0.03	0.74
2005	0.52	0.44	0.12	0.70
2006	0.30	0.04	0.13	0.44
2007	0.34	0.18	0.11	0.36
2008	0.29	0.34	0.16	0.29
2009	0.28	0.41	0.26	0.18
2010	0.29	0.49	0.31	0.15
2011	0.27	0.59	0.37	0.13
2012	0.29	0.70	0.44	0.16
2013	0.28	0.60	0.48	0.15
2014	0.29	0.58	0.50	0.13
2015	0.28	0.65	0.55	0.13
2016	0.33	0.68	0.61	0.16
2017	0.33	0.70	0.67	0.17
2018	0.37	0.72	0.73	0.21
2019	0.36	0.72	0.80	0.27
2020	0.41	0.75	0.84	0.31
2021	0.43	0.63	0.93	0.35
2022	0.46	0.76	0.96	0.40
2023	0.47	0.77	0.97	0.41

The four dimensions show divergent evolution trends. Agricultural economic level declined rapidly from 2001 to 2006, stagnated at a low level until 2015, and rebounded moderately afterward with weak stability, as its recovery failed to offset earlier losses. Agricultural productivity hit a trough in the 2006 drought, recovered rapidly by 2012 and remained high afterward, benefited by water conservancy and high-standard farmland. Rural resident income was the only steadily rising dimension, rising from 0.03 to 0.97 driven by urban-rural integration, specialized agriculture and farming subsidies. Green agriculture suffered a drastic decline during 2001–2011 due to excessive fertilizer and film use; post-2011 ecological governance brought slow improvement, making agricultural non-point pollution a persistent drawback. Economic and green agriculture trends are highly correlated: extensive chemical inputs lift short-term output yet harm long-term development quality, reflecting insufficient coordination between agricultural economy and ecological protection.

6 Research Conclusions and Policy Recommendations

This paper comprehensively evaluates Chongqing's agricultural development from 2001 to 2023 across four dimensions: economy, production capacity, rural income and agricultural green development. Weighting results show that the share of primary industry in GDP, fertilizer and plastic film application intensity, rural per capita disposable income and total agricultural output are core influencing factors. The overall agricultural level followed a U-shaped trend: the comprehensive score fell from 0.57 (2001) to the bottom of 0.26 (2009), with a steep slump in 2006 triggered by extreme drought

and the global financial crisis. After 2009, the score recovered amid fluctuations and grew steadily after 2014. Notably, agricultural economic growth and green development remain poorly coordinated, and the conflict between output expansion and ecological capacity deserves sustained attention.

Sub-index trends confirm a strong linkage between agricultural economy and green development. Hit by natural disasters, agricultural economy slumped sharply during 2001–2006 and fluctuated weakly until steady recovery after 2015, yet it has not rebounded to its initial level.

Two targeted policy suggestions are proposed. First, accelerate agricultural green transformation by promoting eco-organic farming to cut chemical inputs and non-point source pollution. Second, scale up agricultural disaster prevention technology: breed drought-resistant stable-yield crops and optimize mountain-adapted cultivation techniques to reduce climate risks for mountain agriculture.

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