Evaluation on the Level of Agricultural Informatization Development in Gansu Province during 2001 – 2010

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Abstract　According to the characteristics of agricultural informatization development in Gansu Province from 2001 to 2010, the evaluation indicator system for agricultural informatization development level is established for 20 indicators from 5 aspects, including information network construction, agricultural information technology application, agricultural information resources, agricultural information human resources, and agricultural informatization development environment. Indicator weight in indicator system is determined by analytic hierarchy process. Evaluation results of agricultural informatization development level in Gansu Province are obtained using weighted linear function. The difference of agricultural informatization development level is analyzed in different time periods in Gansu Province. According to the evaluation and analysis results, recommendations are put forward for promoting agricultural informatization development in Gansu Province.

Key words　AHP, Comprehensive evaluation, Agricultural informatization, Gansu

1 Introduction

Gansu is a major agricultural province where the issues concerning agriculture, countryside and farmers have loomed large. At the end of 2012, Gansu's poor population reached nearly 7 million, accounting for one-third of the rural population, and in terms of the poverty rate, Gansu was ranked second in China. It is less likely to improve farmers' living standards and increase farmers' income only by traditional agriculture, and the development of agricultural informatization is a major solution to the issues concerning agriculture, countryside and farmers. Since the 12th Five-Year Plan period, Gansu Province has introduced *Agricultural and Rural Informatization Action Plan in Gansu Province* (2010 – 2012) and *Opinions of Gansu Provincial Department of Agriculture and Animal Husbandry on Accelerating the Implementation of Agricultural Informatization* (2013). It also held Gansu's Information-based Work Conference on Strengthening Construction of Agricultural Informatization to Serve "Agriculture, Countryside and Farmers". However, due to economic backwardness and large poverty-stricken area, it is necessary to quickly and accurately find and address some urgent problems in the process of promoting Gansu's agricultural informatization in line with Gansu's needs for agricultural information-based construction in the new era. In this paper, we evaluate the level of agricultural informatization development in Gansu Province over a decade, and analyze the differences in different periods.

2 Methods for evaluation of agricultural informatization level

2.1 Determining the weight of the indicator system　There are two methods for the weight selection: one is subjective weighting method and the other is objective weighting method. However, both of them have different defects[1]. The analytic hierarchy process (AHP)[2] is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It has particular application in group decision making, and is used around the world in a wide variety of decision situations. The AHP helps decision makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. Therefore, this paper uses the analytic hierarchy process to determine the weight of evaluation indicators.

2.1.1 Establishing judgment matrix. The matrix formed by the pairwise comparison is called the judgment matrix. The judgment matrix has the following properties: a_{ij}; $a_j^i = \dfrac{1}{a}$; $a_{ij} = 1$. When there is transitivity in pairwise comparison judgment between elements, $a_{ij} = a_{ik} \cdot a_{kj}(i, j, k = 1, 2, \ldots, n)$.

Table 1　Scale table

Factor comparison	Quantized value
Equally important	1
Slightly important	3
Important	5
Very important	7
Extremely important	9
The intermediate value of two adjacent judgments	2,4,6,8

2. 1. 2   Calculating the relative weight. According to the judgment matrix, the square root method is used to calculate the eigenvector of the judgment matrix:

$$W = \sqrt[n]{\prod_{i=1}^{n} C_{ij}} \qquad (1)$$

It is normalized as follows:

$$W_i = \frac{W_i}{\sum_{i=1}^{n} W_i} \qquad (2)$$

where C_{ij} is the element of judgment matrix, $i = 1, 2 \cdots, n$.

2. 1. 3   Consistency test. The largest eigenvalue is calculated as follows:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{C_{ij} W^T}{n W_i} \qquad (3)$$

The consistency index is calculated as follows:

$$CI = (\lambda_{max} - n)/(n - 1) \qquad (4)$$

Finally, the random consistency ratio is calculated as follows:

$$CR = \frac{CI}{RJ} \qquad (5)$$

where n is the order of the judgment matrix; RI is the corrected value of the consistency index (Table 2); if CR is smaller than 0. 1 for each pair of judgment matrix, the consistency test of overall ranking can be passed.

Table 2   RI standard value of mean random consistency index

Matrix order	3	4	5	6	7	8	9
RI	0. 5149	0. 8931	1. 1185	1. 2494	1. 3450	1. 4200	1. 4616

2. 1. 4   Calculating the combined weight of various layers of indicators. On the basis of obtaining the weight of indicator at various levels relative to the indicator at upper level, in accordance with the hierarchy, the weight of the indicator at lower levels relative to the general goal is calculated, and the consistency test is conducted. The result obtained is the indicator weight of evaluation system[2].

2. 1. 5   Comprehensive evaluation. Finally, the weighted linear function processing is performed on the data to get the final evaluation result.

$$I_k = \sum_{i=1}^{n} X_{ki} W_i$$

where X_{ki} is the quantified value of indicator i in province or city k; W_i is the weight of indicator i.

2. 2   **Evaluation indicator system for agricultural informatization level**   The establishment of agricultural informatization indicator[3] is affected by economic, social, political, cultural and environmental factors, covering all aspects of agriculture, so based on the actual situation and development trend of agricultural informatization construction in Gansu Province, this paper follows the principles of scientificity, comprehensiveness and simpleness, and selects 20 indicators to measure the level of agricultural informatization development in Gansu (Table 3).

Table 3   Evaluation indicator system for agricultural informatization level

Criteria layer	Weight	Indicator layer	Weight
Information network construction (B_1)	0. 1992	Capacity of office switch per household (X_1)	0. 0423
		Capacity of long distance telephone exchange per household (X_2)	0. 0354
		Capacity of mobile telephone exchange per household telephone (X_3)	0. 0432
		Number of post office outlets every 10000 people (X_4)	0. 0363
		Length of rural delivery routes every 10000 people (X_5)	0. 042
Application of agricultural information technology (B_2)	0. 1941	TV ownership every 100 rural households (X_6)	0. 0346
		Fixed telephone ownership every 100 rural households (X_7)	0. 0291
		Mobile phone ownership every 100 rural households (X_8)	0. 0354
		Household computer ownership every 100 rural households (X_9)	0. 0307
		Proportion of rural Internet users (X_{10})	0. 0291
		Mobile SMS per capita (X_{11})	0. 0352
Agricultural information resources (B_3)	0. 2060	Number of agricultural information websites (X_{12})	0. 0536
		Per capita ownership of public library collections (X_{13})	0. 056
		Rural book, newspaper and magazine consumption index (X_{14})	0. 0454
Agricultural information human resources (B_4)	0. 1999	Proportion of scientific and technological personnel (X_{15})	0. 0995
		Proportion of agricultural information technology personnel (X_{16})	0. 1005
Development environment of agricultural informatization (B_5)	0. 2007	Per capita national education investment (X_{17})	0. 0459
		Investment in agricultural fixed assets every 10000 people (X_{18})	0. 044
		Per capita consumption expenditure on transportation and communication of rural households (X_{19})	0. 0348
		Number of ordinary colleges and universities every 10000 people (X_{20})	0. 0408

3   Comprehensive evaluation of agricultural informatization level in Gansu Province

3. 1   **Acquisition and processing of indicator data**   The indicator data come from *Gansu Development Yearbook* (2001 – 2009)[5] and *Gansu Yearbook* (2010, 2011)[6], and some data are from relevant statistics using the principle of minimum fuzziness.

Due to differences in definition, quantitative criteria, calculation methods and units between indicators, we can use the mean method to normalize indicator data:

$$x_i = \frac{x'}{\bar{x}}, \ \bar{x} = \frac{\sum_{i=1}^{n} x'_i}{n}, \ i = 1, 2, \ldots, n$$

where $\bar{x}$ is the mean of indicators.

The normalized indicator data can be shown in Table 4.

3.2 Comprehensive measurement model for agricultural informatization level The final results after comprehensive measurement can be shown in Table 5 and Fig. 1.

Table 4　Normalization results of the indicator data

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
X_1	0.598198	0.605725	0.659913	1.027336	1.124561	1.198904	1.223372	1.184051	1.139806	1.238138
X_2	0.000000	0.000000	0.000000	0.000000	1.339304	1.414955	1.754095	1.714215	1.764393	2.013038
X_3	0.371372	0.436035	0.465588	0.514516	0.510678	0.725079	1.201290	1.680646	1.830810	2.263988
X_4	0.444444	0.443142	0.442021	0.441273	0.626780	0.642816	1.831268	1.752274	1.762122	1.613863
X_5	1.001107	0.996005	0.995496	0.992777	0.979768	0.974869	0.979122	1.022590	1.032753	1.025514
X_6	0.895983	0.934203	0.979877	0.992681	1.013893	0.987808	1.030328	1.048292	1.061669	1.055267
X_7	1.103427	1.217409	1.349080	1.365765	1.237511	1.096794	0.877877	0.738165	0.569504	0.444467
X_8	0.044825	0.102201	0.267605	0.460801	0.709803	0.953875	1.223945	1.586355	2.131651	2.518939
X_9	0.092127	0.184255	0.251256	0.234506	0.335008	0.368509	0.929648	1.624791	2.278057	3.701843
X_{10}	0.390840	0.861040	0.560902	0.598541	0.919577	1.034872	1.258758	1.093176	1.563798	1.718474
X_{11}	0.000000	0.000000	0.000000	0.000000	0.000000	0.647590	1.064475	1.750568	2.876471	3.660895
X_{12}	0.245536	0.290179	0.468750	0.625000	0.669643	0.781250	1.294643	1.562500	1.875000	2.187500
X_{13}	0.892857	0.892857	0.922619	0.982143	1.011905	0.982143	0.982143	1.041667	1.071429	1.220238
X_{14}	0.971251	0.974165	0.982906	0.980963	0.988733	1.057692	1.015929	1.025641	0.998446	1.004274
X_{15}	1.172596	1.146982	0.980197	0.943055	0.897067	1.003766	0.922490	0.962276	0.961556	1.010029
X_{16}	0.776972	0.834191	0.878295	0.887812	1.042047	1.070323	1.101555	1.120434	1.116445	1.171880
X_{17}	0.397898	0.471267	0.495418	0.552044	0.641831	0.838821	1.069480	1.569752	1.887743	2.075746
X_{18}	0.467319	0.456065	0.510925	0.556304	0.614095	0.705721	0.920758	1.362475	1.885388	2.520948
X_{19}	0.400826	0.441740	0.684038	0.684038	0.969877	1.092308	1.164691	1.468235	1.488317	1.605931
X_{20}	0.800372	0.798029	0.987074	0.985458	1.047504	1.046777	1.077961	1.076830	1.075133	1.104540

Table 5　Evaluation results and growth rate of agricultural informatization in Gansu Province

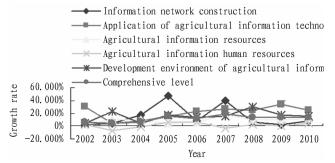| Year	Comprehensive level		First level indicators									
			B_1		B_2		B_3		B_4		B_5	
	Value	Growth rate %	Value	Growth rate %	Value	Growth rate %	Value	Growth rate %	Value	Growth rate %	Value	Growth rate %
2001	0.114		0.100		0.079		0.107		0.195		0.085	
2002	0.121	6.203	0.102	2.864	0.102	29.381	0.110	2.354	0.198	1.644	0.090	5.920
2003	0.127	4.625	0.106	3.425	0.107	4.497	0.121	10.598	0.186	−6.144	0.109	21.484
2004	0.135	6.279	0.123	16.541	0.115	7.827	0.133	9.571	0.183	−1.474	0.114	5.797
2005	0.157	16.274	0.181	46.634	0.133	15.862	0.137	3.317	0.194	5.968	0.133	0.786
2006	0.174	10.718	0.196	8.545	0.164	23.128	0.145	5.417	0.207	6.938	0.150	12.670
2007	0.207	18.986	0.273	39.170	0.207	26.253	0.171	17.683	0.202	−2.385	0.174	8.583
2008	0.236	13.884	0.290	6.070	0.257	24.164	0.189	10.633	0.208	2.892	0.227	21.444
2009	0.265	12.666	0.297	2.475	0.345	34.305	0.206	9.108	0.208	−0.227	0.265	17.104
2010	0.303	14.225	0.323	8.747	0.431	24.800	0.231	12.315	0.218	5.000	0.307	14.236

Fig. 1　The growth of agricultural informatization level in Gansu Province during 2001 – 2010

4　Analysis of agricultural informatization level in Gansu Province

From Table 5 and Fig. 1, it was found that the comprehensive level of agricultural informatization in Gansu Province showed a steady upward trend over a decade, but there were strong differences in the growth rate between indicators. For the five indicators in the criteria layer, the growth rate varied greatly, it showed a negative growth trend for some indicators, and the gap between the highest and the lowest growth rate was more than 20 times, indicating that the agricultural informatization level was not balanced in the province in different years. The growth of information network

construction (B_1) fluctuated considerably during 2001 – 2010. There was a stable development trend during 2002 – 2003; it showed an increasing trend from 2004, and peaked to 46.634% in 2005 and 39.170% in 2007; it slowly rose after 2008, indicating that from 2003, Gansu Province gradually stepped up the construction of information network, and especially in 2005 and 2007, it reached a peak. According to related statistics, Gansu implemented "village telephone project" from 2004, and the proportion of the province's administrative villages starting telephone call services increased from 89.94% at the end of 2003 to 99.5% in 2007; the rural mobile communication network covered 100% of towns, 99.68% of administrative villages and 96.54% of natural villages, which basically synchronized with Gansu's agricultural information network development[7]. The growth of application of agricultural information technology (B_2) and agricultural information resources (B_3) was relatively stable. The application of agricultural information technology (B_2) underwent dramatic changes during 2002 – 2004, and the initial growth trend was good, but due to delay in the process of applying agricultural technology, the growth rate dropped in 2003, and then rose steadily, indicating that with the large-scale application of agricultural information technology in Gansu Province, the agricultural informatization level was improved; the growth rate of agricultural information resources (B_3) was low in the early period, and increased significantly in 2007, which was inseparable from the information network construction. The growth trend of agricultural information talent resources (B_4) and agricultural information development environment (B_5) was not significant or even negative. The growth rate of agricultural information talent resources (B_4) fluctuated around 0, and there was an upward trend in 2010, but compared with other criteria layer indicators, the growth rate was low, indicating that the proportion of Gansu's agricultural science and technology personnel and workers increased slightly; the growth rate of agricultural informatization development environment (B_5) increased significantly in 2003, and the growth rate reached 30.39% in 2008, which was inseparable from national and local support for agricultural informatization. However, the growth rate began to decline after 2008, indicating that the development environment was highly correlated with national policies, and Gansu's investment advantage was not obvious.

5 Conclusions and recommendations

5.1 Conclusions
According to the characteristics of agricultural informatization development in Gansu Province from 2001 to 2010, the evaluation indicator system for agricultural informatization development level is established, and indicator weight in indicator system is determined by analytic hierarchy process. Evaluation results of agricultural informatization development level in Gansu Province are obtained using weighted linear function, in line with the actual level of vertical agricultural informatization development in Gansu Province.

5.2 Recommendations
(i) Playing the leading role of government, strengthening the practice promotion, increasing efforts to attract investment and promoting agricultural informatization development. Government departments should define roles, complement each other, adopt government-led and market-oriented building mode, combine government investment with market financing, and use various channels to raise funds and increase investment for information-based construction in rural areas[8]. (ii) Opening up channels of communication for agriculture and strengthening the information-based construction in rural areas. It is necessary to accelerate the construction of agricultural information infrastructure, increase the penetration rate of computer, integrate agricultural information websites, optimize network resources, strengthen supervision, promote the sharing of information resources, establish information collection, processing and release system, and integrate human resource, capital, technology, information and other resources. (iii) Intensifying personnel training and actively attracting talents. It is necessary to set up agricultural informatization major in colleges, and establish master's degree and doctoral degree in the pilot units; create a good employment environment and agricultural information-related employment opportunities, and attract agricultural information professionals; cultivate new farmers and rural brokers who can adapt to modern agricultural development needs, and make farmers know how to use information technology to improve operation and develop new markets[8]. (iv) Strengthening the construction of agricultural information environment to meet the diverse needs of rural information service[9]. Economic environment, social environment, human environment and natural environment are the basis of agricultural information environment. Agricultural informatization should not only focus on infrastructure construction, but also pay attention to farmers' needs and rely on government, enterprises, research institutions and universities to make agricultural informatization truly serve the people.

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