The Comprehensive Assessment of Planting Elements Based on Analytic Hierarchy Process

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Abstract. There were many factors having an effect on planting development, this paper designed an indicator system for planting assessment, mainly including three kinds of essential sub-system elements, they were resource sub-system, information and energy sub-system and social-economic sub-system, the detailed indicator system involved in 8 concrete indicators from the three sub-systems. In the way, a set of reasonable indicator system of planting assessment was proposed on township/town scale, there was the characteristics involved in rural areas and agriculture information introduced in the case of indicator system. Based on it, the paper constructed the hierarchical structure model of the planting elements assessment, the weight of each indicator was calculated through AHP method. The study results showed that the planting elements development level from the comprehensive assessment was Juzhen township, Fangsi town, Shizhong subdistrict office, Xinzhai town, Xindian town, Zhangzhuang town, Liangjia town, Anren town, Lunzhen town, Shiliwang township and Litun township. Obviously, the comprehensive assessment model had preferable operability and practicability, it not only combined subjective evaluation with objective appraisal, but also qualitative with quantitative study, and fully considered of each assessment factor. Therefore, AHP method is scientific and reasonable and suit to be used to evaluate the level of planting elements assessment.

Keywords: Indicator system, planting elements assessment, the analytic hierarchy process.

1 Introduction

Planting was the foundation of agriculture and a special place in agriculture, which only related to the overall situation of national food security. It was also an important income source of the farmers, its value was more than 50% of the total agricultural value. A total of 66 articles were retrieved in the Chinese journal of literature since 2011 as a summary of the key word “planting evaluation”. Retrieval results showed that Gaojun “the high military cropping systems in the suburbs of Beijing ecological security assessment and technical countermeasures – take the case of Shunyi District,

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Beijing", Shi Chenyang, etc. "The Study of the Technology Path of the Efficient Using Water of the Piedmont of Mt. Taihang Mountain in Hebei Province", Zheng Yalian "Cultivated Land Fertility Evaluation and Planting Industry Layout in Tongzhou District of Beijing" and Liu Tian-sen "research on the application of comparative advantage theory in Chinese regional farming" were retrieved in database. The less literature study and the weak quantitative study related to planting evaluation were presented in the retrieval contents. It was necessary to establish a set of scientific indicator system on township/town scale for the comprehensive assessment of planting elements. Among evaluation methods, the analytic hierarchy process (AHP) can use opinions of experts to construct the judgment matrix, so it was meaningful. So the objective of the study was develop the quantitative evaluation of planting elements on town/township scale in Yucheng city, and the article regarded the rural areas and agriculture information as the evaluation indicator, a set of reasonable indicator system of planting assessment was proposed on township/town scale, and the system provides a visual way for users to do all the works of AHP, so the study presented academic significance[1,2,3,4]. In some correlated research, the quantitative studies were developed by fuzzy method and other methods as the above research, but the planting elements assessment had the less study from the correlation literatures and the study did not involve in the country level, and AHP method was scientific and reasonable and suit to be used to evaluate the level of planting elements assessment, so the method was selected in the article.

2 Material and Methodology

2.1 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) was developed by A.L.Saaty. AHP method was a multi-objective decision analytical method that combines qualitative with quantitative analysis and also a kind of optimization techniques, so it could be used to calculate the weight of each indicator. The essence of the process was decomposition of a complex problem into a hierarchy with goal (objective) at the top of the hierarchy, criterions and sub-criterions at levels and sub-levels of the hierarchy, decision alternatives at the bottom of the hierarchy. Elements at given hierarchy level were compared in pairs to assess their relative preference with respect to each of the elements at the next higher level. The verbal terms of the Saaty's fundamental scale of 1–9 was used to assess the intensity of preference between two elements. The number of 1 indicates equal importance, 3 moderately more, 5 strongly more, 7 very strongly and 9 extremely more importance. The numbers of 2, 4, 6, and 8 were allotted to indicate compromise values of importance. The method computed and aggregated their eigenvectors until the composite final vector of weight coefficients for alternatives was obtained. The entries of final weight coefficients vector reflected the relative importance (value) of each alternative with respect to the goal stated at the top of hierarchy. During the AHP process, the steps were as follows: Form assessment indicator set. Establish stepped hierarchical construction. Ascertain the weight of the indices. Construct comparison judgment matrix and monolayer weights order. Consistency test and comprehensive assessment of AHP[4].

2.2 Construction of Indicator System of Planting Elements Assessment

Construction of indicator system was the premise of planting elements evaluation, so we constructed the indicator system according to the following principles: (1) Comprehension: The factor must reflect each side of the appraised object, study its connotation and extension deeply in the process of construction, making every effort to fully and actually manifest it. (2) Operability: Weight of each indicator should be determined and the evaluation method stresses on availability of indicator data. (3) Guidance : Prospective and tendency factors should be introduced to guide the direction of planting development. (4) Connection: The indicator system should link up with regional planting index system and reflect the development characteristic of planting itself. (5) Comparability: The general targets should be introduce in the system indicator[5].

We selected 8 indicators from the above principles to develop the comprehensive assessment of planting elements, the detailed contents referred to Table 1. In the indicator system, agriculture information indicator was introduced firstly in information and energy sub-system in the AHP model. The core content of planting elements assessment included 3 mutually and closely contacted planes: resource sub-system, information and energy sub-system and social-economic sub-system.

Table 1. Contents of Indicator System based on AHP

	Indicator name	Indicator content and significance
B_1:Resource sub-system	C_1:Fertilizer consumption per sown area	Fertilizer consumption/crop sown area
	C_2:Pesticide consumption per sown area	Pesticide consumption/ crop sown area
	C_3:Farmland plastic Film consumption per sown area	Farmland plastic film consumption/ crop sown area
B_2:Information and energy sub-system	C_4:Agriculture information status	Synthesis weight for infrastructure information of agriculture and production information of agriculture
	C_5:Total agricultural machinery power and energy information	The weight included the total agricultural machinery power, main energy and power consumption information
B_3:Social-economic sub-system	C_6:Agricultural scale management	Arable land/ The number of rural labor force
	C_7: effective irrigation capacity	Mechanical and electrical drainage and irrigation area/ crop sown area
	C_8:output ratio of planting industry	Output value of the planting industry/ agricultural output value

Selection principle of indicator AHP model, combined with the indicator system of planting elements Assessment in Yucheng city, hierarchy construction schematic diagram was shown in Fig.1. The graded hierarchical construction model of planting elements assessment included four layers on regional scale, target layer, rule layer, measure layer and object layer.

Where, the parameter meaning of B1,B2,B3 C1,C2,C3,C4,C5,C6,C7,C8 referred to Table.1, S1, S2, S3, S4, S 5, S 6, S 7, S 8, S 9, S10 and S11 respond to the Shiliwang township, Anren town, Lunzhen town, Juzhen township, Litun township, Fangsi town, Xinzhai town, Xindian town, Zhangzhuang town, Liangjia town and Shizhong subdistrict office in Yucheng city.

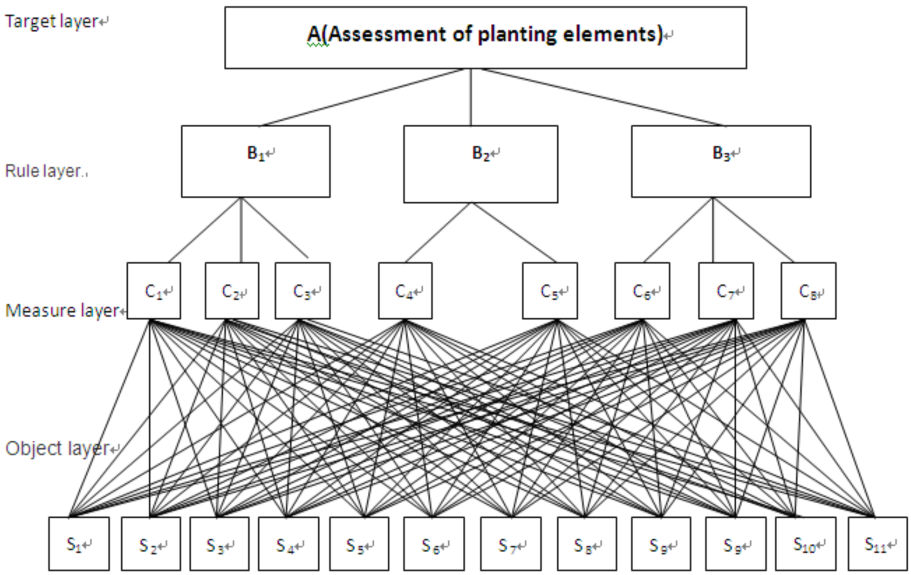

Fig. 1. Hierarchy Construction of planting elements assessment in Yucheng city

3 Results and Analysis

By pairwise comparing elements of the same layer in accordance with certain upper factor, each element of the judgment matrix was able to be defined. The relative importance of each element followed 1-9 proportion evaluation scale. Several judgment matrixes can be established based on the scores that experts provided. The importance that each element of No.(k+1) layer relative to No.k layer was ordered according to the judgment matrix. The weights of judgment matrix of AHP model were shown in Table 2. and Table 3.

Table 2. Comparison Judgment Matrix of Eigen Vector

Eigen Vector of A-B matrix	Eigen Vector of B_1-C matrix	Eigen Vector of B_2-C matrix	Eigen Vector of B_3-C matrix
0.694	**0.458**	**0.500**	**0.429**
0.132	**0.126**	**0.500**	**0.143**
0.174	**0.416**		**0.429**

Table 3. Comparison Judgment Matrix of Eigen Vector

C_1–D matrix	C_2–D matrix	C_3–D matrix	C_4–D matrix	C_5–D matrix	C_6–D matrix	C_7–D matrix	C_8–D matrix
0.037	**0.029**	**0.076**	**0.123**	**0.121**	**0.042**	**0.070**	**0.032**
0.020	**0.080**	**0.113**	**0.076**	**0.123**	**0.032**	**0.181**	**0.026**
0.056	**0.068**	**0.019**	**0.102**	**0.023**	**0.050**	**0.062**	**0.257**
0.270	**0.049**	**0.278**	**0.022**	**0.068**	**0.182**	**0.020**	**0.193**
0.022	**0.028**	**0.034**	**0.020**	**0.023**	**0.102**	**0.028**	**0.018**
0.088	**0.236**	**0.145**	**0.287**	**0.186**	**0.088**	**0.108**	**0.058**
0.075	**0.200**	**0.044**	**0.043**	**0.034**	**0.225**	**0.273**	**0.060**
0.145	**0.176**	**0.023**	**0.022**	**0.051**	**0.039**	**0.041**	**0.123**
0.144	**0.032**	**0.028**	**0.037**	**0.024**	**0.157**	**0.035**	**0.145**
0.110	**0.063**	**0.057**	**0.062**	**0.061**	**0.058**	**0.153**	**0.067**
0.034	**0.041**	**0.184**	**0.208**	**0.285**	**0.023**	**0.029**	**0.023**

To ensure the monolayer weights order was correct, the judgment matrix should be dealt with consistency test. Consistency should be tested as follows: Computing consistency index CI (CI = lmax – n/n-1), where: lmax was the eigenvalue of maximum, n represents for the number of the order of judgement matrix. If CR<0.1, the consistency of the judgement matrix can be satisfied and so the order weights accepted.

Calculating consistency ratio CR:$CR=$ CI/RI, the final results of AHP were validated by the random consistency ratio CR. If CR<0.1, the results can meet the requirements. The values of $\lambda_{max,}$ CI and the values of CR are shown in the Table 4, the values of CR are all less than 0.1, so the consistency test of the parameters was passed.

Table 4. λ_{max} of Judgement Matrix and Corresponding Consistency Test

	λ_{max}	C.I.	C.R.
A-B Matrix	**3.080**	**0.040**	**0.069**
B_1-C Matrix	**3.009**	**0.005**	**0.009**
B_2-C Matrix	**2.000**	**0.000**	**0.000**
B_3-C Matrix	**3.000**	**0.000**	**0.000**
C_1-D Matrix	**11.710**	**0.071**	**0.047**
C_2-D Matrix	**11.969**	**0.097**	**0.064**
C_3-D Matrix	**11.750**	**0.075**	**0.049**
C_4-D Matrix	**11.853**	**0.085**	**0.056**
C_5-D Matrix	**11.915**	**0.091**	**0.060**
C_6-D Matrix	**11.509**	**0.051**	**0.034**
C_7-D Matrix	**11.587**	**0.059**	**0.039**
C_8-D Matrix	**11.667**	**0.067**	**0.044**

Based on the assessment factor matrix and the monolayer weights matrix, the value of comprehensive assessment of the planting elements can be determined, the validation parameters (C.I.= 0.075 , R.I=1.52, C.R.= 0.049<0.1) were passed in the model, the results were shown in the Table 5.

Table 5. The Total order Weight Value of Hierarchy in AHP of 11 town/townships

Target Layer	Criterion Layer	Weight	Measure Layer	Object Layer	Total weight	Total Layer
	Resource sub-system	0.694	Fertilizer consumption per sown area	Shiliwang township	0.060	10
				Anren town	0.068	8
			Pesticide consumption per sown area	Lunzhen town	0.062	9
planting elements assessment			Farmland Plastic Film consumption per sown area			
	Information and energy sub-system	0.132	Agriculture information Level	Juzhen township	0.205	1
			Total Agricultural Machinery Power and energy information	Litun township	0.032	11
	Social-Economic sub-system	0.174	effective irrigation capacity	Fangsi town	0.135	2
			output ratio of planting industry	Xinzhai town	0.087	4
			Agricultural scale management	Xindian town	0.086	5
				Zhangzhuang town	0.084	6
				Liangjia town	0.078	7
				Shizhong subdistrict office	0.104	3

There was no doubt that AHP provided a scientific measure for analysis and decision making. Juzhen township, Fangsi town, Shizhong subdistrict office, Xinzhai town, Xindian town, Zhangzhuang town, Liangjia town, Anren town, Lunzhen town, Shiliwang township and Litun township, the weight above 11 townships/towns is 0.205, 0.135, 0.104, 0.087, 0.086, 0.084, 0.078, 0.068, 0.062, 0.060, 0.032 respectively, the weight value indicated that the planting elements dominance of 11 towns/townships is 0.205, 0.135, 0.104, 0.087, 0.086, 0.084, 0.078, 0.068, 0.062, 0.060 and 0.032, respectively.

4 Conclusions and Discussion

In a word, we drew conclusions that a set of reasonable indicator system in planting elements assessment was proposed on the township/town scale in this paper, it was suitable for processing by computers and was worth promoting. Furthermore, using AHP model, the paper constructed the hierarchical structure model of the planting elements assessment and calculated the factor weight of resource sub-system, information and energy sub-system and social-economic sub-system. Based on it, the planting elements dominance from the comprehensive assessment was Juzhen township, Fangsi town, Shizhong subdistrict office, Xinzhai town, Xindian town, Zhangzhuang town, Liangjia town, Anren town, Lunzhen town, Shiliwang township and Litun township. Obviously, the comprehensive assessment model of planting elements had preferable operability and practicability. It not only combined subjective evaluation with objective appraisal, but also qualitative with quantitative study, and fully considered of each assessment factor in system evaluation. Therefore, AHP method was scientific and reasonable to be used to evaluate the level of planting elements on country level.

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