The Comprehensive Benefits about Under-forest Economy in Shijiazhuang City

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Abstract Based on the relevant domestic and foreign theories, we establish the evaluation indicator system for the comprehensive benefits about under-forest economy. Using the data from 2010 to 2014, we employ AHP to measure the comprehensive benefits of under-forest economy, and convert the comprehensive benefits into the data that can be used for analysis and comparison. It is found that the comprehensive benefit index of under-forest economy in Shijiazhuang City continued to increase from 2010 to 2014 (0.223, 0.515, 0.523, 0.698 and 0.956, respectively). This further indicates that the under-forest economy in Shijiazhuang City shows a good trend towards the goal of high quality and efficiency, so it is a correct model of development. Based on the results and the problems during the research process, some policy recommendations are brought forward for the development of under-forest economy.

Key words Under-forest economy, AHP, Comprehensive benefits, Shijiazhuang City

1 Introduction

In recent years, due to the excessive focus on economic growth rate, part of the woodland is destroyed for land reclamation, ecological destruction combined with air quality has become the weakest link in economic development, and the livability index is declining. In this context, the model of under-forest economy has been gradually emphasized, because under-forest economy is a green model focusing on harmonious development of forest protection and output growth, which can not only protect woodland and improve ecology, but also increase farmers' income, and promote agricultural development and harmonious society building. The purpose and significance of this paper lies in building comprehensive evaluation indicator system and using AHP for qualitative and quantitative comprehensive evaluation of comprehensive benefits about under-forest economy. The concept of "under-forest economy" is not used abroad, and the concept that has been widely used abroad is agroforestry. The overseas theoretical study of agroforestry began in the 19th century, and Japan's study on crop use of light energy and the US agro-ecological research have made outstanding contribution to the theory of agroforestry. However, the study of the agroforestry system as a whole is relatively rare. The domestic study on the model of under-forest economy started late, and in recent years, more and more domestic scholars are emerging to study the under-forest economy. In terms of the study on composite degree of under-forest economy, Wang Hu (2010) uses principal component analysis to assess the composite degree of under-forest economy in Beijing, and concludes that if the composite degree is positive, the development of under-forest economy is in a dominant position, and if the composite degree is not positive, it is in a weak position. In terms of the study on project development of under-forest economy, Yuan Jun and Shi Bin (2015) discuss the business model of under-forest economy from the technical level, and explore the ways to effectively combine under-forest economy with economic forest industry. In summary, in the domestic and international research, most scholars take the ecological benefits as the main subject of research, and the comprehensive benefits about under-forest economy are rarely evaluated. Meanwhile, the domestic scholars' focus on the model of under-forest economy based on region and resource endowment is not quite similar, and there is no predecessor conducting systematic study on under-forest economy in Shijiazhuang City. Therefore, the estimation of comprehensive benefits about under-forest economy in this paper will help to scientifically assess and guide the model of under-forest economy.

2 Current development of under-forest economy in Shijiazhuang City

Currently, there is 6800000 mu of woodland in Shijiazhuang, including about 3400000 mu of fruit trees, and more than 60% of woodland has the conditions for the development of forest economy, with enormous output potential. In 2014, 14 new demonstration bases of under-forest economy and 10 large-scale under-forest farms were built, with agroforestry output value exceeding 750 million yuan. Five key areas of under-forest economy were planned: western mountain ecological forest area; hill and plain economic forest area; plain fast-growing forest area; green channel area; ecological forest farm area. In 2015, the city's operating area of under-forest economy increased to 80000 mu, and the output value reached 800 million yuan; by 2020, the operating area of under-forest economy is expected to exceed 900000 mu, and output value will reach 900 million yuan. During the field survey in Gaocheng District and Xinji County, it is found that more than 90% of re-

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spondents are based on single-family operation, never forming large-scale production. It is relatively fragmented, and the ability to resist risks is weak. Many villages have rich under-forest resources and good market prospects, but the imperfect local roads, communications and other related facilities have restricted the development of under-forest economy, leading to the outflow of rural labor and other social issues.

3 Definition of concept and analysis methods

3.1 Under-forest economy Based on the existing forest resources or shade advantages, under-forest economy is a three-dimensional forestry business model which combines under-forest planting, under-forest breeding, forest landscape use and under-forest product processing, without affecting tree growth.

3.2 Comprehensive benefits The system of under-forest economy is a system in which agro-ecosystem is intertwined with agro-economic system, so the comprehensive benefits based on under-forest economy mean the a full range of benefits taking into account economic, ecological and social benefits.

3.3 AHP The analytic hierarchy process (AHP) 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. Rather than prescribing a "correct" decision, 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.

3.4 Hierarchical model It is the comprehensive evaluation indicator system in this paper, including four layers: goal layer; criteria layer; indicator layer; alternative layer. Through the most reasonable and most efficient model of development, the under-forest economy achieves the best comprehensive benefits, namely the goal layer; economic, ecological and social benefits are the criteria layer.

4 Data sources and analysis principle

4.1 Data sources The data in this paper are mainly from *Statistical Analysis Table of Shijiazhuang Forestry* (2010 – 2014), and *Shijiazhuang Statistical Yearbook* (2010 – 2014). Part of the missing data are provided by the local agricultural committee and forestry departments, so this paper's data effective.

4.2 Analysis principle AHP includes the following steps[8]: (i) establishing hierarchical model, including goal layer, criteria layer and indicator layer; (ii) in accordance with the actual situation of the application, determining several different levels of indicators on the basis of the survey, and establishing the comprehensive evaluation indicator system; (iii) by constructing judgment matrix, calculating the weight of various factors and indicators in the criteria layer, and conducting consistency test, to rule out the judgment arbitrariness; (iv) normalizing the original value, and comparing the indicator values of various factors at the level of [0, 1] to directly reflect the difference in the benefits; (v) based on the comprehensive benefit analysis about weight and standard value, given that the weight and standard value of indicator layer are known, calculating the final weighted comprehensive benefit score (the higher the score, the higher the comprehensive benefits).

5 Analysis and results

5.1 Indicator and data selection The following data are the data about under-forest economy in Shijiazhuang City during 2010 – 2014, and due to the data missing of number of enterprises engaged in under-forest economy, we select the number of enterprises in Gaocheng District of Shijiazhuang City. Specific data are shown in Table 1.

Table 1 The indicators concerning under-forest economy

Indicators and value \ Year	2010	2011	2012	2013	2014
Total output value of forestry economy//10^8 yuan	62.1	69.1	72.9	81.1	85.2
Output value of under-forest economy//10^8 yuan	6.40	6.83	7.11	7.38	7.62
Forest farmers' income//yuan	5977	7563	8993	9540	10780
Forest coverage//%	28.96	29.42	30.18	32.21	34.00
Woodland area//10^4 mu	564	580	633	670	712
Air quality rate//%	11.81	10.16	11.70	19.45	31.20
Number of the farmers engaged in under-forest economy	430	800	1200	1900	2800
Number of enterprises engaged in under-forest economy	2	3	3	4	5
Number of tourists//10^4	90	127	145	276	686

Data source: *Shijiazhuang Statistical Yearbook* (2011 – 2015).

5.2 Establishment of comprehensive evaluation indicator system The comprehensive benefits about under-forest economy are affected by three criteria of economic, ecological and social benefits. Based on the ecological status of Shijiazhuang, we believe that the three criteria are equally important, and the maximum eigenvalue of eigenvector $W = [1/3, 1/3, 1/3]$ is 3. At the same time, we select three indicator layer factors having the greatest impact on the criteria layer, and establish the following com-

prehensive evaluation indicator system.

Table 2 Comprehensive evaluation system for under-forest economy

Goal layer	Criteria layer	Weight	Indicator layer	Weight
Comprehensive benefits about under-forest economy	Economic benefits	1/3	Total output value of forestry economy (A_1)	W_1
			Output value of under-forest economy (A_2)	W_2
			Forest farmers' per capita income (A_3)	W_3
	Ecological benefits	1/3	Forest coverage (B_1)	W_4
			Woodland area (B_2)	W_5
			Air quality rate (B_3)	W_6
	Social benefits	1/3	Number of the farmers engaged in under-forest economy (C_1)	W_7
			Number of enterprises engaged in under-forest economy (C_2)	W_8
			Number of tourists (C_3)	W_9

5.3 Construction of judgment matrix Based on the 1 – 9 scaling method, we construct the judgment matrix. In the processing and testing of the matrix, the following formula is used:

$$CI = (\lambda_{max} - n)/(n-1);\ CR = CI/RI$$

where CI represents consistency index; CR represents consistency ratio; λ_{max} represents the maximum characteristic root of eigenvector.

If CR is less than 0.1, this judgment matrix passes the consistency test, with satisfactory consistency. As for 1 – 9 order judgment matrix, when n is 1 – 9, the corresponding RI value is 0; 0; 0.58; 0.90; 1.12; 1.24; 1.32; 1.41; 1.45. From Table 3, it can be found that the eigenvector of economic benefits $w_A = (0.331, 0.140, 0.529)^T$, and the maximum characteristic root of eigenvector $\lambda_{max} = 3.05$; $CI = 0.025$; $RI = 0.58$; $CR = CI/RI = 0.043$, less than 0.1, successfully passing the consistency test. The eigenvector of ecological benefits $w_B = (0.231, 0.121, 0.648)^T$, and the maximum characteristic root of eigenvector $\lambda_{max} = 3.003$; $CI = 0.0015$; $RI = 0.58$; $CR = CI/RI = 0.003$, less than 0.1, successfully passing the consistency test. The eigenvector of social benefits $w_C = (0.735, 1.122, 0.143)^T$, and the maximum characteristic root of eigenvector $\lambda_{max} = 3.04$; $CI = 0.02$; $RI = 0.58$; $CR = CI/RI = 0.034 < 0.1$, successfully passing the consistency test. The evaluation indicator values are made dimensionless, and the formula $X_{ij}^* = X_{ij} \sum_{i=1}^{n} x_{ij}$ is used to facilitate the comparison of all indicator values at the level[0, 1], and facilitate the subsequent weighting (Table 4).

Table 3 Judgment matrix of benefit indicators

Economic benefit indicators	A_1	A_2	A_3
A_1	1	3	1/2
A_2	1/3	1	1/3
A_3	2	3	1
Ecological benefit indicators	B_1	B_2	B_3
B_1	1	2	1/3
B_2	1/2	1	1/5
B_3	3	5	1
Social benefit indicators	C_1	C_2	C_3
C_1	1	5	3
C_2	1/5	1	1/3
C_3	1/3	3	1

Table 4 Dimensionless treatment of evaluation indicator values

Weight \ Year	2010	2011	2012	2013	2014
$W_1 = 0.331$	0.167	1.187	0.197	0.219	0.230
$W_2 = 0.140$	0.181	0.193	0.201	0.208	0.215
$W_3 = 0.529$	0.139	0.176	0.210	0.223	0.252
$W_4 = 0.231$	0.187	0.190	0.195	0.208	0.220
$W_5 = 0.121$	0.179	0.184	0.200	0.212	0.225
$W_6 = 0.648$	0.140	0.120	0.139	0.231	0.370
$W_7 = 0.735$	0.060	0.112	0.168	0.266	0.393
$W_8 = 0.122$	0.118	0.760	0.176	0.235	0.294
$W_9 = 0.143$	0.068	0.096	0.110	0.208	0.518

Note: Some data are calculated using Matlab software.

5.4 Results and analysis Linear weighting method is used for comprehensive evaluation. It is calculated as follows:

$$y = \sum_{i=1}^{n} wixi$$

where y is the comprehensive evaluation value; w_i is the weight coefficient of the evaluation indicator x_i, $w_i \in [0, 1]$, $\sum_{i=1}^{n} w_i = 1$.

The comprehensive benefit index of under-forest economy (y) in Shijiazhuang City during 2010 – 2014 is calculated to be 0.223, 0.515, 0.523, 0.698 and 0.956, respectively. The results show that during 2010 – 2014, the comprehensive benefits about under-forest economy in Shijiazhuang City continued to rise, and the overall growth was fast.

6 Conclusions and recommendations

6.1 Conclusions Based on the relevant domestic and foreign theories, we establish the evaluation indicator system for the comprehensive benefits about under-forest economy. Using the data from 2010 to 2014, we employ AHP to measure the comprehensive benefits of under-forest economy, and convert the comprehensive benefits into the data that can be used for analysis and comparison. It is found that the comprehensive benefit index of under-forest economy in Shijiazhuang City continued to increase from 2010 to 2014 (0.223, 0.515, 0.523, 0.698 and 0.956, respectively). This further indicates that the under-forest economy in Shijiazhuang City shows a good trend towards the goal of high quality and efficiency, so it is a correct model of development.

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rely on rural credit cooperatives, and innovate upon financial products, to realize breakthrough in financing.

5.4 Strengthening rural infrastructure construction It is recommended to make overall plan for urban and rural infrastructure construction according to plan and distribution of urban farms, take various modes, cooperate with project owners in building water conservancy, traffic, electrical power, and network infrastructure, and improve development environment of urban farms. Urban farm project owners should attach great importance to comprehensive control and development and use of ecological environment, and put an end to damage of traditional production mode and urban development to agricultural ecological system. Besides, it is commended to promote courtyard reconstruction, water conservation transformation, clean production and clean energy application, to energetically develop agricultural and rural economy. In addition, competent authorities should formulate urban farm service quality standards and star level rating criteria, to attract citizens and tourists with beautiful environment, high quality products, and excellent services.

5.5 Strengthening construction of talent team It is recommended to energetically develop rural adult education and vocational and technical education, strengthen talent training and introduction, and build a talent team with reasonable structure and excellent quality for urban farms. Besides, it is recommended to consolidate and cultivate a team of specialized talents good at planting and breeding technologies, market information analysis, agricultural product development, recreational service design, and special food research badly needed for urban farms.

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6.2 Recommendations (i) Accelerating the construction of specialized cooperation organizations about under-forest economy. Most of farmers are based on single-family operation, never forming large-scale production. The ability to resist risks is weak in the fickle market, so it is necessary to accelerate the development of farmers' under-forest cooperatives, and unite the scattered farmers, so as to effectively enhance the ability to withstand risks and increase forest farmers' income. In the comprehensive evaluation model, forest farmers' income accounts for 52.9% of economic benefits, thereby enhancing the comprehensive benefits of the entire under-forest economy. (ii) Taking actions that suit local circumstances, highlighting features and avoiding blind following. Due to differences in natural conditions and resource endowments, it is necessary to build the under-forest economy model suitable for local areas. It is found in the survey that some villages blindly follow others to plant mushroom but finally fail to achieve the desired benefits. From the hierarchical model, it is the driving of under-forest economy, and the weight is 0.735, having a crucial impact on the social benefits and final comprehensive benefits about the entire under-forest economy. Therefore, it is necessary to highlight features and avoid blind following to develop under-forest economy. (iii) Promoting competitiveness with quality and improving multiplicity. The companies and farmers engaged in the production of under-forest products must continue to improve the quality of under-forest products, and enhance product differentiation under the premise of quality and safety, so as to enhance the competitiveness of products. During the development of under-forest economy, there is a need to change the single crop output, and increase the ornamental, science and service projects to enhance the multiplicity.

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