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Research Article

The Building of Indicators of Forest Farm's Sustainable Development Based on Entropy-AHP

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Abstract: This study establishes evaluation indicators for sustainable forest farm management referring to a large number of literatures on the previous study. Then using AHP-entropy and index weighting method to carry out the forestry sustainable development comprehensive evaluation. The result shows that the comprehensive index of sustainable management was 0.4084 in 2001, while the comprehensive index was 0.7321 in 2011. Ecological sustainable comprehensive index was 0.3552 in 2001, being in a sustainable state, while it was 0.9157 in 2011, being in a fully sustainable state; Sustainable economic index was 0.4570 in 2001, while it was 0.5845 in 2011, being in the weak sustainable state; Social sustainability index was 0.4324 in 2001, being in the weak sustainable state, while it was 0.7210 in 2011, being in the basic sustainable state. The result shows that the evaluation results is consistent with the actual situation, the index system is reasonable, which has certain scientific nature and feasibility.

Keywords: Development, entropy-AHP, forest farm, indicators, sustainable

INTRODUCTION

Sustainable development is a major problem which is concerned around the world. Forestry is the important foundation of economic and social sustainable development and is the main art of the ecological construction. Forestry sustainable development has the particular status (China Forestry Net, 2011). Forest farm's sustainable development is the foundation of realizing forestry sustainable development (Yao, 2008).

Nowadays, all countries are studying and researching criteria and indicators for sustainable forestry management system, while only few studies focus on the forest farm's sustainable development. On this basis, this article takes Ming Xi state-owned forest farm in Fujian as the research object, collects data of forest farm from 2001-2011 and combines previous research results of forestry sustainable development evaluation index, finally establishes evaluation indicators for sustainable forest management referring to a large number of literatures on the previous study. Secondly, using AHP-entropy and index weighting method to carry out the forestry sustainable development comprehensive evaluation, which has extremely important and practical significance to scientifically determine the region forestry farm management, reasonable plan sustainable forest management measures and promote local forestry sustainable development and sustainable management.

MATERIALS AND METHODS

Profile of the study area: MingXi state-owned forest farm was founded in 1959, which is located in southeast of Wuyi mountain, E116°37′-117°35, N26°8′-26°39. Forest farm distributes in Mingxi seven towns and 38 villages, forest farm management and timber production are very convenient. It is located in the low mountain hilly terrain and belongs to subtropical monsoon climate. Class I and II land account for 58.9% with superior natural conditions and it is suitable for building timber basis with Cunninghamia Lanceolata, Pinus Massoniana, Schima Superba etc. The total forestry land area is nearly 6600 hm^2, including public welfare forest area of 6266.7 hm^2.

Data source: Through field investigation, collecting Fujian province "twelfth five-year" forestry development planning, MingXi survey data of forest resource planning and design in 2001-2011, annual summary of MingXi state-owned forest farm in 2001-2011, development plan, work plan and other legal data.

Method of evaluation indexes:

The construction of evaluation indexes: The state-owned forestry farm sustainable management evaluation indicators is divided into 4 layers: target layer, system layer, state layer and index layer 4 (Table 1). Target layer describes the operation of the state-owned forest sustainable management trend on the

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Table 1: The evaluation index of forest farm's sustainable development

Target layer	System layer	State layer	Index layer	Target value	Standardized value 2001	Standardized value 2011	Entropy weigh	AHP	Entropy-AHP	Evaluation value 2001	Evaluation value 2011
The evaluation index of forest farm sustainable development A	Ecological sustainability indicatorsA1	B1. forest resources sustainability	C1 forestry category structure	87.4:12.6:0①	0.183	0.816	0.107	0.116	0.1115	0.0204	0.0910
			C2 forest age structure: (%)	50②	1	1	0.037	0.050	0.0435	0.0435	0.0435
			C3 woodland utilization rate (%)	87.4①	0.784	0.935	0.047	0.082	0.0645	0.0506	0.0603
			C4 the ability to resist inspects (%)	1②	0.071	0.153	0.039	0.064	0.0515	0.0037	0.0079
		B2. ecological benefits sustainability	C5 forest coverage rate (%)	65.5①	0.749	1	0.043	0.043	0.0430	0.0322	0.0430
			C6 proportion of ecological public welfare forest area (%)	80②	0.830	1	0.015	0.046	0.0305	0.0253	0.0305
			C7. volume of forestry (billion M^3)	1.38③	0.584	1	0.032	0.028	0.0300	0.0175	0.0300
			C8 survival rate of trees planted (%)	85③	0.800	1	0.013	0.013	0.0130	0.0104	0.0130
			C9 forestland volume per unit area (m^3/hm^2)	79.1③	0.607	0.671	0.009	0.010	0.0095	0.0058	0.0064
	Economic sustainability indicators A2	B3. social level sustainability	C10 forest farm total value (10000 Yuan)	500①	0.800	0.900	0.033	0.038	0.0355	0.0284	0.0320
			C11 asset-liability ratio (%)	1②	0.400	0.417	0.093	0.040	0.0665	0.0266	0.0277
			C12. forest output value (m^3)	4000①	0.750	0.850	0.069	0.024	0.0465	0.0349	0.0395
			C13 sell rate of forest products (%)	1②	0.850	0.974	0.064	0.011	0.0375	0.0319	0.0365
			C14 the output value per area (Yuan/hm^2)	1130③	0.182	0.466	0.008	0.008	0.0080	0.0015	0.0037
		B4. social benefits sustainability	C15 average salary per year of workers (Yuan/people)	38989③	0.180	0.301	0.098	0.098	0.0980	0.0176	0.0295
			C16 utilization rate of the investment (%)	1②	0.700	0.850	0.043	0.054	0.0485	0.0340	0.0412
			C17 Engel's coefficient (%)	45②	0.788	0.970	0.047	0.029	0.0380	0.0299	0.0369
	Social sustainability indicators A3	B5. living standard sustainability	C18 network density index ($km/km^{2)}$	54.67③	0.232	0.728	0.057	0.051	0.0540	0.0125	0.0393
			C19 coverage rate of communication tools (%)	80.2②	0.333	0.595	0.018	0.023	0.0205	0.0068	0.0122
		B6. social progress sustainability	C20 forest farm criminal rate (%)	1②	1	1	0.018	0.040	0.0290	0.0290	0.0290
			C21 average education year of workers (year)	9②	0.456	0.840	0.019	0.033	0.0260	0.0119	0.0218
			C22 forest are per people (m^2/per)	27.756②	0.522	0.784	0.036	0.060	0.0480	0.0251	0.0376
		B7 teconology management sustainability	C23 echnology level (%)	50③	0.400	0.680	0.032	0.016	0.0240	0.0096	0.0163
			C24 forest investment (Yuan/hm^2)	4500③	0.230	0.419	0.023	0.024	0.0235	0.0054	0.0098

①: Planning values; ②: The sustainable development requirements or affluent society reference value; ③: The local average value in 2011

Table 2: The level division of sustainable development

Comprehensive score	Sustainable development level	Description
0.90~1	I	Fully or strong sustainable development stage
0.80~0.90	II	Sustainable development stage
0.60~0.80	III	Basic sustainable development stage
0.40~0.60	IV	Weak sustainable development stage
Below 0.40	V	None-sustainable development stage

whole aspect; System layer includes 3 subsystems, which respectively are: A1 ecological sustainability indicators; A2 economic sustainability indicators; A3 social sustainability indicators; State layer B decides the main steps of each subsystem and key components,; Index layer C uses the available measured indicators to do direct measurement to performance and intensity of state level. State-owned forest sustainable management index system are shown in Table 1.

Construction of evaluation model: The index weighting evaluation model is used to calculate comprehensive evaluation value of forestry farm sustainable development at all levels of indicators. The model expression is:

$$A = (P_1^{W1} * P_2^{W2} * ....P_n^{Wn})^{\frac{1}{\sum Wi}}, i = 1,2,...n \qquad (1)$$

where in, A is the integrated evaluation index of one factor in this layer, n is the numbers the factor includes, wi is the weight of index i and Pi is the evaluation value of index i. For the total evaluation value, it is judged according to the standard of Table 2 (Zhou, 2007).

Indexes standardization processing: Standardizing the indexes to use target value index method and target value can be decided according to Table 1. In this study, Z represents index evaluation value, P represents the actual value, S represents the reference value. For positive indicators, evaluation value Z = P/S, when the index value is greater than the target value, then Z = 1; Regarding the negative indexes, Z = S/P, when the index value is less than the target value, Z = 1.

Weighting calculation: By adopting the combination of subjective and objective entropy-AHP method for weight assignment (Zhou, 2007; Gao and Wang, 2005; Zhang and Shang, 2009).

Using the improved analytic hierarchy process to determine the subjective weight: AHP is a kind of decision-making method which is to break the elements related to the decision into some layers, such as objectives, principles, scheme and make qualitative and quantitative analysis (Thompson and Strict, 2001). But there were some shortage in deciding weight during the past study, improvement is needed. Volume method is adopted when determine the weight.

Using entropy weight method to determine the objective weight: In the comprehensive evaluation, the traditional entropy weight method has been widely used in natural resources sustainable development, such as animal and plant resources, land resources, because of its high credibility to determine weight value (Zhang and Shang, 2009).

Using entropy-AHP method to determine the final weight: To overcome the defects of AHP method subjective randomness, using the entropy weight W_{ij} to fix the weight coefficient obtained from AHP method. Its formula is:

$$w_j = \alpha(w_j') + (1-\alpha)(w_j''), (0 \le \alpha \le 1) \qquad (2)$$

where in, w_j' is the weight determined by improved AHP method and w_j'' is the weight determined by entropy weight method. The combination weight changes along with the change of α. When α = 1, it corresponds to AHP method; while α = 0, it corresponds to entropy weight method. How to reasonably define the value of α, there are many discusses. By comprehensive consideration, α = 0.5 (Liang *et al*., 2010).

Comprehensive evaluation results of four state-owned forest sustainable management:

State-owned forest farm sustainable operating each index value analysis: According to the weight value and evaluation value of Table 1, during MingXi state-owned evaluation indicators for sustainable management, the major influence factors include: forestry category structure, asset-liability ratio, forest farm total output, forestry production, the worker's average wage income, output value per woodland area, etc. Among them, the value of forestry category structure changes bigger, from 0.0204 in 2001 to 0.0910 in 2011; the index value of ability to resist diseases and insect pests is low in 2001 and 2011, which should be focused on improving. The index value of Forest volume is varied; output value per woodland area in 2001 and 2011 is low, which is the key to improve; average wages of worker per year has a large gap compared with the local average value, which does not change significantly between 2001 and 2011; network density index changes significantly, from 0.232 in 2001 to 0.728 in 2011; Forest investment spending in 2001 and 2001 is lower, which should focus on improving.

Table 3: The comprehension evaluation value of forest farm sustainable development

Contents		Weigh Entropy	AHP	Entropy-AHP	Evaluation value 2001	2011
State layer	B1	0.230	0.311	0.2705	0.3614	0.8789
	B2	0.112	0.140	0.1260	0.3421	1
	B3	0.267	0.121	0.1940	0.5910	0.6739
	B4	0.188	0.181	0.1845	0.3487	0.5032
	B5	0.075	0.073	0.0740	0.2563	0.6887
	B6	0.073	0.134	0.1035	0.7386	0.8543
	B7	0.055	0.040	0.0475	0.3042	0.5351
System layer	A1	0.342	0.451	0.3965	0.3552	0.9157
	A2	0.455	0.302	0.3785	0.4570	0.5845
	A3	0.203	0.247	0.2250	0.4324	0.7210
Comprehension	2001	2011				
Evaluation value	0.4084	0.7321				

Comprehensive evaluation results of MingXi state-owned forest farms state layer: Forest resources index was 0.3614 in 2001, being in a non-sustainable state, while it was 0.8789 in 2011, being in a state of sustainable development; Ecological benefit index was 0.3412 in 2001, while it was 1 in 2011, being in a fully sustainable state; Economic level index was 0.5910 in 2001, being in non-sustainable state, while it was 0.6739 in 2011, being in the weak sustainable state; Economic benefit index was 0.3487 in 2001, in a sustainable state, was 0.5032 in 2011, in the weak sustainable state; Living standard index was 0.2563 in 2001, being in a non-sustainable state, while it was 0.6887 in 2011, being in the basic sustainable state; Social progress index was 0.7386 in 2001, being in the basic sustainable state, while it was 0.8543 in 2011, being in the strong sustainable state; Technical management index was 0.3042 in 2001, being in a sustainable state, while it was 0.5351 in 2011, in the weak sustainable state.

Comprehensive evaluation results of MingXi state-owned forest farms system layer: According to the formula (1), it is calculated that A1 ecological sustainable comprehensive index was 0.3552 in 2001, being in a non-sustainable state, while it was 0.9157 in 2011, in a fully sustainable state; A2 Sustainable economic index was 0.4570 in 2001, while it was 0.5845 in 2011, being in the weak sustainable state; A3 Social sustainability index was 0.4324 in 2001, in the weak sustainable state, while it was 0.7210 in 2011, in the basic sustainable state.

Comprehensive evaluation results of MingXi state-owned forest farm sustainable management: State-owned forest sustainable management comprehensive index was 0.4084 in 2001, while it was 0.7321 in 2011. According to the calculation result, it shows that Ming Xi state-owned forest farm was in the weak sustainable state in 2001; while it was in the basic sustainable state in 2011 (Table 3).

RESULTS

MingXi state-owned forestry farm sustainable management evaluation system consists of four levels and 24 indicators. This article establishes evaluation indicators for sustainable forest farm management referring to a large number of literatures on the previous study. Then using AHP-entropy and index weighting method to carry out the forestry sustainable development comprehensive evaluation. The result shows that the comprehensive index of sustainable management was 0.4084 in 2001, while the comprehensive index was 0.7321 in 2011. Ecological sustainable comprehensive index was 0.3552 in 2001, being in a sustainable state, while it was 0.9157 in 2011, being in a fully sustainable state; Sustainable economic index was 0.4570 in 2001, while it was 0.5845 in 2011, being in the weak sustainable state; Social sustainability index was 0.4324 in 2001, being in the weak sustainable state, while it was 0.7210 in 2011, being in the basic sustainable state.

The evaluation result is consistent with the specific management condition from investigation to Ming Xi Forest farm, which shows that the index system is reasonable and has a certain scientific nature and feasibility. Moreover, according to the weight value and evaluation result, in MingXi state-owned sustainable forest management evaluation indicators, the major influence factors include: forest forestry category structure, asset-liability ratio, forest farm total production value, forestry output value, the output value per unit woodland area, average wage income of workers per year, etc. Thus, to improve the state of forest farm sustainable management, it should emphasize from the above several aspects.

The reasons for the improvement of sustainable management condition of MingXi state-owned forest farm mainly have the following aspects:

- The implementation of the natural forest protection project, the six major afforestation and soil and water conservation engineering, makes the forest farm management have transition from mainly on economic construction to ecological construction. The importance of forestry soil and water conservation, oxygen supplement and forest tourism have been paid attention, which makes the ecological function of the MingXi state-owned forest farms greatly enhanced.

- Under the support from the national and local government, population development and compulsory education policy have been gradually implemented, which makes the education level of forest farm workers and level of forestry science and technology improved obviously.

REFERENCES

China Forestry Net, 2011. Meaning of Forestry Sustainable Development. Retrieved form: http:// sbj. forestry. gov.cn.

Gao, R.X. and F.Y. Wang, 2005. Forestry sustainable development evaluation system and evaluation. J. Forest. Sci., 4: 42-44.

Liang, H.M., S.K. Peng and W.L. Zi, 2010. Forestry Farm sustainable development evaluation based on AHP method. J. Ning. Jing Forestry Univ., 34(3): 9.

Thompson, A. and A.J. Strict, 2001. Strategic Management: Concepts and Cases. McGraw Hill Co. Inc., New York.

Yao, D.S., 2008. Requirement and Implement to state-owned forest farm. J. Forestry Agric. Res., (1): 10-14.

Zhang, X. and J.P. Shang, 2009. The land sustainable development evaluation based on entropy method. J. Land Resour. Res., 4: 33-35.

Zhou, C.L., 2007. Economics development research based on AHP method. Da Lian Science University, D. Da Lian.