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Water Conservancy Science and Technology Promotion Project Based on AHP-DEA Model Evaluation

Zhang Ning
Professor, Hangzhou Dianzi University, Zhejiang province, China
Muzaffar Rakhimboyev
Assistant professor, Karakalpak State University, Uzbekistan

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ABSTRACT

This paper studies the economic, technical, social as well as ecological benefits of the farmland water conservancy science and technological promotion project of Zhejiang Province by using AHP-DEA Model and survey data and section of 9 related cities from 2009 until 2012. Moreover, the research illustrates that there is an observable regional difference between the comprehensive benefits of Zhejiang Province Water Conservancy Science and technology project; the investment and annual water supply conservancy are the main factors which is causing the regional difference. Furthermore, social benefits have gained an outstanding effect while the economic benefits achieved not so obviously. Therefore, improving the investment of the project and increasing the farmer employment, reducing the farming burden, cultivating new socialist farmers in relatively undeveloped areas are the best way to contribute and improve the social benefits and promote the harmonious and stable development of rural society.

INTRODUCTION

Water is the lifeline of national economy. Thus, In order to promote and apply the distribution of water science and techmology, Zhejiang Provincial Finance Department set up a special fund about water science and technology promotion from 2009 until 2012. Zhejiang province has invested 1725 million yuan, and this program also attracted local financial inputs about 4814.5 million yuan. The whole investment contained 118 projects and 40 new technologies. The project involved more than four different environmental areas, such as: disaster prevention and mitigation, water resources and soil conservation, water disinfection and channel excavation and so on. Moreover, the project was successful that it covered almost the whole areas of Zhejiang Province. It has been found that those views were focused on ecological and economic aspects of domestic and foreign scholars; as the main research scholars, it needs to be stated Boqing Wu (1), Rui Zhang (2), Ping Wang (3), Sun Yue (4), Dong Xu (5), and others. According to the domestic and foreign scholars on the project evaluation, the research also combines the AHP and DEA models to analyze the social, economic, ecological and technical benefits of Water Conservancy Science and Technology Promotion Project of Zhejiang Province and the model donated 9 related cities which are ranking results about the development of this special project as it has been proposed practical policy recommendations to Zhejiang authority.

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THEORETICAL MODELS AND RESEARCH METHODS

Theoretical models

Currently, the usage of the post evaluation of the project is much more common in the country, such as: analytic hierarchy process (AHP), data envelopment analysis (DEA), principal component analysis. Among them, AHP results are clear and simple but also a little rough ranking. When the correlation and coefficient of the evaluation index are high, Principal component analysis be capable of eliminating the index information to overlap the problem. However, this method does not take into account the relative importance of indexes. The method of data envelopment analysis based on the actual input and output index data of the decision-making unit and it has a little influence on subjective factors, but can not reflect the preferences of the decision maker. Evaluating water conservancy projects and comprehensive assessment will be more reasonable If AHP-DEA be capable of using to influence Zhejiang provincial water conservancy projects.

Data envelopment analysis (DEA) is an evaluation method of multi-input and output. Its analysis based on the actual input and output index data of the decision-making unit to clarify whether DMU is effective or not (6-11). From the input and output budget perspective C^2R (12) model is chosen.

The main steps for analytic hierarchy process method are as follows: 1) To establish the hierarchical structure; 2) To establish judgment matrix of each level according to the scaling criterion and Delphi; 3) To calculate the weight of each factor; 4) To check the consistency; 5) To calculate the relative importance of each factor index ranking. CI is one of the consistencies of indicators and CR is the consistency ratio, CR=CI/RI, It can be said the judgment matrix with satisfactory consistency When CR<0.1.

Research methods

On the evaluation index system of water conservancy project research with reference to Han Aijin (2012) (13), Jin Lianghai (15) Zhejiang Province Water Conservancy Science and technology promotion project were practically combined. The research also established the evaluation index system (table 1).

Table 1. Comprehensive evaluation index system of water conservancy projects

Target layer (0)	Criterion layer (F_j)	Index layer (X_i)	Meaning of indicators
The comprehensive benefit evaluation of water conservancy projects	Economic benefits (F1)	The utilization water resources (X_1)	The total volume percent of water resources
		Agricultural production (X_2)	The output of farm products
		The increase in farmers' income (X_3)	Income of farmers
		The ratio of input to output (X_4)	The total investment of water and agricultural income ratio
	Ecological benefits (F_2)	The area of soil and water loss every year (X_5)	The area of soil and water loss
		An annual increase of vegetation coverage (X_6)	The area of vegetation cover
		Every year new land areas (X_7)	New land area

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		The improved conditions of agricultural products (X_8)	Easy access to irrigation water
	Social results (F_3)	Public satisfaction (X_9)	Farmers' water satisfaction
		The number of benefits farmers (X_{10})	Water function zone
		The incidence rate of water (X_{11})	Flood disaster and water disputes
	Technical benefits (F_4)	Safety and stability (X_{12})	Reservoir dangerous rate, workers' safety
		Maintenance (X_{13})	Workers' number and time
		Popularizing degree (X_{14})	Using area and service life

Hierarchical structure model of water conservancy projects

According to the principle of AHP, The hierarchical structure model of Zhejiang Province water conservancy projects has been established in nine cities, which includes target layer, criterion layer O, standard layer F, Index layer X and plan layer (the detailed structure shown in figure 1)

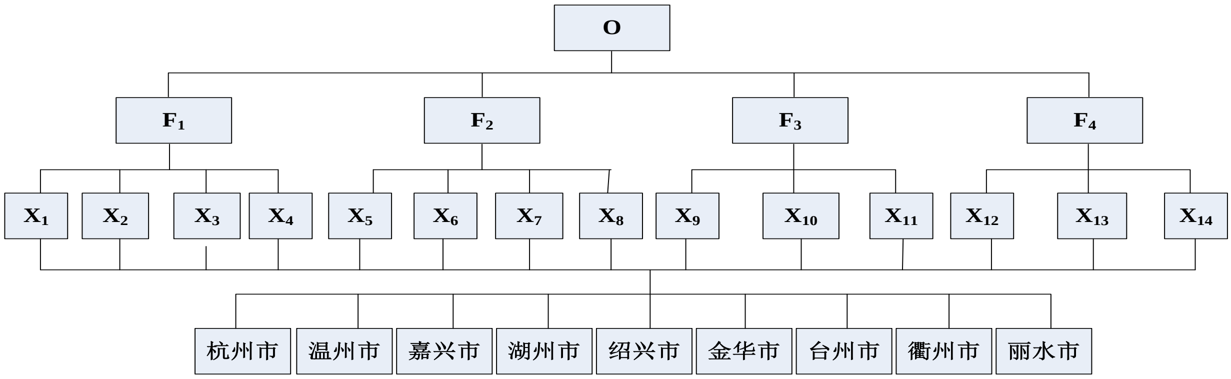

Figure 1. The hierarchical structure model of Zhejiang province water conservancy projects related to nine cities.

The integrated model of AHP and DEA

The value of AHP model can reflect the slanted preferences of decision-makers, and the value of DEA model can reflect the actual effectiveness of DMU input and output, thus using the combination linear weighted the two methods. The real situation of comprehensive benefits can be revealed more objectively. The calculation formula is as follows:

$$A = \alpha y + (1 - \alpha)\theta^*$$

In the formula is *A* being the comprehensive evaluation value; *y* is the value of AHP model; α is the subjective coefficient and $0 \leq \alpha \leqq 1$, and the specific value are given by the decision-makers according to their preferences; $1 + \alpha$ is the objective preference coefficient and θ^* is the evaluation value of DEA model.

THE DATA SOURCE AND DESCRIPTION

The data of the public satisfaction index come from the questionnaires completed by the author and five graduate students during the summer in 2013. The survey chose 16 households from every village randomly that selected from 9 related cities. Afterward, the questionnaire was

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completed in the form of an interview. Totally 260 questionnaires and 233 valid questionnaires were picked up, and the recovery rate was around 89.6% (table 2).

Table 2. Basic situations of respondents and sample households

Type	Options	The number of samples (people and households)	Proportions (%)	Type	Options	The number of samples (people and households)	Proportions (%)
Gender	Male Female	176 57	75.54% 24.46%	Education	Primary school and below	47	20.17%
Annual Household Income (million)	< 1 1-2 2-3 3-4 < 4	23 109 49 31 21	9.87% 46.78% 21.03% 13.31% 9.01%		Middle school	99	42.49%
					High school	81	34.76%
					Above senior	6	2.58%
				Age	Below 35 36-45 46-55 Above 55	10 39 119 65	4.29% 16.74% 51.07% 27.90%

RESULTS AND ANALYSIS

The results and analysis of AHP

Based on the actual situation of each prefecture of cities, the experts give the two comparisons of all indexes of the layer. As a result, five judgment matrixes and the level of total ordering index layer (X_i) are constructed by the experts (Table 3).

Table 3. Weights of the index layer

	F_1	F_2	F_3	F_4	Total weight sorting
	0.4236*	0.2271*	0.1223*	0.2270*	w_j
X_1	0.3499	0	0	0	0.1482（1）
X_2	0.3090	0	0	0	0.1309（2）
X_3	0.1094	0	0	0	0.0463（9）
X_4	0.2317	0	0	0	0.0981（4）
X_5	0	0.1839	0	0	0.0418（11）
X_6	0	0.2426	0	0	0.0551（8）
X_7	0	0.1732	0	0	0.0393（12）
X_8	0	0.3123	0	0	0.0709（5）
X_9	0	0	0.2826	0	0.0350（13）
X_{10}	0	0	0.1428	0	0.0175（14）
X_{11}	0	0	0.5710	0	0.0698（6）
X_{12}	0	0	0	0.5223	0.1186（3）

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X_{13}	0	0	0	0.1998	0.0454（10）
X_{14}	0	0	0	0.2779	0.0631（7）

Note: the number in parentheses represents the importance ranking of each index in the 14 indicators; the data marked with a * represents the weight values of the criteria layer.

The Brief analysis and Evaluation results of DEA

The brief results of DEA select the total investment of regional water conservancy promotion project (x1/million), the effective irrigation area (x2/a thousand hectares), the annual increase of vegetation (y2/HA), and rural standard population of drinking water safety (y3/million) as an output index of decision-making units (table 4) to attain the relative efficiency value $\theta^*$of the prefecture-level city water conservancy projects (table 5).

Table 4. Input and output data of water conservancy projects of 2012

DMU	Input index			Output index		
	x_1 million	$x_2$thousand hectares	$x_3$million cubic meters	$y_1$million	y_2HA	$y_3$million
Hangzhou	1314.2	163.74	435.364	236.77	890	352.51
Wenzhou	315	126.44	203.962	107.88	695	568.53
Jiaxing	1184.22	199.21	218.461	142.8	1138	263.65
Huzhou	689.233	135.34	139.988	116.22	96	159.65
Shaoxing	215.7	160.47	189.284	72.1	603	207.4
Jinhua	553.1	156.93	237.018	125.43	852	347.29
Taizhou	673.1	128.26	191.77456	189.25	662	167.6
Quzhou	813.98	94.22	127.2959	76.15	1091	184.21
Lishui	1085.18	88.82	190.4222	72.62	1001	216.84

Analysis and evaluation results of AHP-DEA

The comprehensive evaluation value can be calculated according to the results of AHP and DEA models. Dimensionless treatment of the data is significant, shown in table 5.

Table 5. Comprehensive benefit results and ranking of AHP and DEA projects

	Hangzhou	**Wenzhou**	**Jiaxing**	**Huzhou**	**Shaoxin**	**Jinhua**	**Taizhou**	**Quzhou**	**Lishui**
A value	0.8142	0.6823	0.7761	0.4782	0.6045	0.7600	0.7451	0.6346	0.6431
A ranking	1	5	2	9	8	3	4	7	6
θ^*	1	1	0.8777	0.9224	1	0.8966	1	1	1
A-D value	0.9071	0.8412	0.8269	0.7003	0.8023	0.8283	0.8726	0.8173	0.8216
A-D ranking	1	3	5	9	8	4	2	7	6

This table indicates that both AHP analysis ranking and Comprehensive ordering are all shown that Hangzhou, Jinhua, Taizhou as a top-four, Huzhou and Shaoxing have been in the last two places. AHP model with a certain confidence level is also demonstrated. There is an obvious regional difference comprehensive benefits of water conservancy science and technology projects in Zhejiang Province. The main factors causing the difference are the total investment of

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regional water and the annual water supply. The social benefits have the best influence, and the economic achievement is not so obvious.

CONCLUSION

The research established the comprehensive evaluation index system of Zhejiang Water Conservancy Science and technology projects, and make full use of the subjective experience judgment analysis ability of AHP model and the data envelopment analysis of DEA model, combined the two methods to form the evaluation of AHP-DEA methods of water science and technology promotion project, and by analysis, the evaluation of the comprehensive benefit of 2009-2012 of Zhejiang water conservancy science and technology promotion project we get the results of above, and in view of this, this paper suggests there are many aspects to take to improve the comprehensive benefits of water conservancy science and technology promotion project. Because of the capital strength is insufficient of economically less developed areas and the financial income is not so enough so that places need the government to put more efforts, therefore, this is suggested that there are more investment needed to put into these relatively underdeveloped areas to help to improve the overall comprehensive benefits, what's more, not only the amount of investment but also the size of irrigation area, the amount of water supply and the local actual situation also have some effects on the comprehensive benefit are need to be aware. As it is not easy to distinguish the proportion of economic and ecological benefits are improved by Zhejiang Water Conservancy Science and technology projects or other water projects, and in the light of water conservancy projects have achieved good results in social benefits and technical efficiency, and it has a certain popularization value, so this paper recommendation to increase the power of technical obvious projects to get better technical and social benefits.

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