EVALUATION ON COMPREHENSIVE BENEFIT OF LARGE-SCALED CONSTRUCTION PROJECT BASED ON FUZZY THEORY: A CASE STUDY OF GUANGZHOU IN CHINA

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ABSTRACT

With the implementation of "The Belt and Road" policy and increasing investment, there will be a large number of large-scaled construction projects (LSCP) in China. However, the comprehensive benefit of most LSCP is not satisfactory because of concerning more about the economic benefits. It makes the sustainability of LSCP concerned about. In order to ensure the sustainable development, the evaluation of the comprehensive benefit of LSCP should be carried out. Based on comprehensive literature review and content analysis, 30 influence factors of comprehensive benefit evaluation for LSCP are identified. The evaluation index system of 17 factors containing three subsystems of social, economic and environmental benefit is established through factor analysis. Entropy method is used to determine weights of each indicator, and then synthetic evaluation model is put up. This paper selects a practical case, Lieder Village reconstruction in Guangzhou, to calculate the synthetic evaluation value using fuzzy theory. The evaluation results are satisfactory and in line with reality. It shows that the evaluation index system and synthetic evaluation model has a certain reference value for analysis of comprehensive benefit and can help for enhancing the construction and management level of LSCP and promoting the sustainable development of LSCP.

KEYWORDS

Comprehensive benefit; Large-scaled construction project; Index system; Fuzzy synthetic evaluation; Construction management; Case study

INTRODUCTION

With more than 30 years of opening-up, Chinese economy experienced rapid development. It is the material base for the investment and construction of large-scaled projects. In recent year, with the implementation of "The Belt and Road" policy and increasing investment, it can be foreseen that there will be a large number of large-scaled construction projects (LSCP) in China.

However, LSCP is often a sacrifice of precious ecosystems and land losses to meet the needsof urban development, which will make our cities face serious social, economic and environmental problems [1]. Moreover, most of LSCP only focus on economic benefit and ignore
the social or environmental factors. The construction management model of high input, low efficiency and high energy consumption is often formed, which make the sustainability of LSCP more concerned. Therefore, combined with the concept of sustainable development, the objective of this paper tries to establish a scientific and comprehensive evaluation index system of comprehensive benefit and construct a fuzzy synthetic evaluation model to analyse the comprehensive benefit of LSCP.

LITERATURE REVIEW

The concept of sustainable development was put forward in 1970s, but it was not used in LSCP until 1990s [2]. Some researchers believed that sustainable development had three pillars: society, economy and environment [3]. One of the key features of LSCP is that the costs are far more than normal projects because they are built at one time, with huge and long-term impact [4]. LSCP is regarded as a good way to solve social problems, environmental impact and economic development [5-7]. More studies are trying to research LSCP from different perspectives. Tam believed that sustainable building should take into consideration three aspects of society, economy and environment, and integrated it into the practice of construction industry [8]. Wang pointed out that in order to promote the sustainable development of projects, engineering construction projects should strengthen sustainable standards in the scheme selection, green technologies used in construction and operation phases, public participation mechanism of project [9]. Abidin believed that sustainable development of LSCP was an important component of sustainable development of construction industry and it was an important way to achieve sustainable development of construction industry [10]. Tang analyzed the distribution of the benefit in a LSCP of PAZHOU Village reconstruction [11]. Catalina analyzed some factors influencing sustainable development of LSCP [12].

The sustainability of LSCP can be reflected by the comprehensive benefit of project. The specific performance is to realize the harmony of social repercussions, the rationality of economic benefit and the adaptability of the natural environment. It has been widely acknowledged on the importance of evaluating comprehensive benefit of LSCP [13]. Adopting appropriate evaluation methods and constructing reasonable evaluation model can effectively evaluate and promote the decision-making for sustainable development of LSCP [14]. There are some researches on assessing the LSCP. Hemphill put forward a hierarchical model, used Delphi method to evaluate and analyze the sustainability of large-scaled public project [15]. Tam put forward a sustainability assessment approach for environmental problems based on organizational behavior [16]. Lee used AHP method and constructed an evaluation model to evaluate sustainable development of some LSCP in Hong Kong [17]. Deng constructed a hierarchical model of urban renewal sustainability evaluation, and applied it to case study [18]. Liu designed a comprehensive assessment system of sustainable LSCP and put forward five measures to obtain the comprehensive benefit of sustainable development [19].

After researching LSCP, many scholars advocated using index system as the dominant evaluation method, because indicators are the most common and popular tools to measure sustainability and comprehensive benefit [20]. To evaluate the comprehensive benefit, some sustainability indicators should be chosen. Some international organizations proposed a large number of sustainability indicators. UN Commission on Sustainable Development(CSD), United Nations(UN) and Ministry of Housing and Urban-Rural Development of the People's Republic of China(MOHURD) [21-23] published most indicators, covering many aspects of sustainable development such as society, economic development, ecological environment, institution, public security and resource conservation, etc. Shen [3] integrated those different sets of indicators and proposed a new list of sustainability indicators, which contains 37 categories of 115 indicators. Singh [24] found that there were 12 categories and more than 60 indicators reflecting sustainable development from different perspectives. Many evaluation indicators were proposed by some other researchers [19-20] [25-26]. These have been used as references for many countries and communities to develop their own evaluation index systems. The selection of indicators should not be the collection of information about all indicators, but rather the selective analysis of those which are more basic in nature [3]. Scholars agree that the evaluation indicators need to be more representative and more in line with the values of the local people [24]. After conducting the literature review and content analysis, through consulting many scholars and professionals, 30 influence factors of comprehensive benefit evaluation associated with LSCP are identified, see Table1.

Tab. 1 - Influence factors of comprehensive benefit evaluation associated with LSCP

NO.	Factors	CSD [21]	UN [22]	MOHU RD[23]	Shen [3]	Singh [24]	Tasaki [25]	Zhao [26]	Liu [19]	Total Number
L01	Traffic improvement status	*	*	*	*	*	*		*	7
L01	Social harmony and stability	*		*	*	*	*	*	*	7
L03	Clean, safe and belonging community	*		*		*	*		*	5
L04	The inheritance of history, culture and urban styles	*	*	*	*	*	*		*	7
L05	Improvement of living and recreation	*	*	*	*	*	*		*	7
L06	Improvement of living conditions	*	*	*	*	*	*	*	*	8
L07	Social welfare improvement	*	*	*	*	*	*	*	*	8
L08	Improvement of public infrastructure	*		*	*	*	*	*	*	7
L09	Development potential after project construction		*	*			*	*	*	5
L10	The degree of public participation	*		*	*	*	*		*	6
L11	Improvement of									

	reputation and income of corporate		*				*	*	*	4
L12	Project construction cycle			*			*	*	*	4
L13	Project construction cost					*	*	*	*	4
L14	Land revenue status		*		*			*	*	4
L15	Per capita disposable income	*	*	*	*	*	*	*		7
L16	Compensation and resettlement cost			*			*	*	*	4
L17	The level of rental income				*	*		*	*	4
L18	Cultural and educational improvement	*	*	*	*		*	*	*	7
L19	Financial internal rate of return (FIRR)				*		*	*	*	4
L20	Dynamic Investment Payback Period		*	*				*	*	4
L21	Financial Net Present Value (FNPV)		*		*		*	*		4
L22	Rate of return on investment (ROR)		*		*		*	*		4
L23	Loan repayment period			*			*	*	*	4
L24	Environmental quality improvement status	*	*	*	*	*	*		*	7
L25	Land use rate	*	*	*	*	*	*		*	7
L26	Land use intensity		*	*	*	*		*	*	6
L27	The impact on ecological environment	*	*	*	*	*	*	*	*	8
L28	Urban landscape function improvement	*	*	*	*	*	*	*	*	8
L29	Building energy efficiency level	*	*	*	*	*	*			6
L30	The coordination degree of new and old buildings	*		*	*		*		*	5

METHODS

The method employed in this research was based on questionnaire survey, factor analysis, entropy method, fuzzy theory and case study. Questionnaire survey is a systematic method of collecting data based on sample. For this study, a questionnaire survey was carried out to investigate the importance of various factors affecting comprehensive benefit of LSCP. Most of evaluation method are expert-driven and need for a greater inclusion of citizen's opinion in the application of evaluation indicators [27]. The questionnaire involved government, enterprises and institutions, stakeholders, the public, experts and scholars.

Factor analysis

Factor analysis (FA) is a reducing dimension method to simplify the data. It refers to a variety of statistical techniques whose common objective is to represent a set of variables in terms of a smaller number of hypothetical variables [28]. Factor analysis model is as follows:

$$C_i = l_{i1}F_1 + l_{i2}F_2 + \cdots + l_{im}F_m + \varepsilon_i \tag{1}$$

C_i is the comprehensive factor, l_{ij} is the factor load, F_j is the common factor, ε_i is the unique factor.

Entropy method

Entropy method is an objective method to calculate the weight of evaluation factors for multi-objective decision-making and it acquires the effective and available information by measuring the data [29]. The basic calculating steps are as follows:

1) To construct matrix $X = (x_{ij})_{m\times n}$ of the original evaluation data according to evaluation objects and indicators;

2) To normalize matrix X . The original evaluation data can be normalized by:

$$y_{ij} = \frac{\max_j(x_{ij}) - x_{ij}}{\max_j(x_{ij}) - \min_j(x_{ij})} \tag{2}$$

$$y_{ij} = \frac{x_{ij} - \min_j(x_{ij})}{\max_j(x_{ij}) - \min_j(x_{ij})} \tag{3}$$

For small indicators, it can use Equation 2. For maximum indicators, it can use Equation 3.

3) To calculate the entropy value E_j of each indicator, if $p_{ij} = 0$, $\lim_{p_{ij}\to 0} p_{ij} \ln p_{ij} = 0$

$$E_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{4}$$

Where m is the number of evaluation objects, n is the number of evaluation indicators,

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \tag{5}$$

4) To calculate the weight and obtain entropy weight vector $W = \{w_1, \quad w_2, \quad \ldots, \quad w_m\}$.

$$W_j = \frac{1 - E_j}{k - \sum_{j=1}^{k} E_j} \tag{6}$$

Fuzzy synthetic evaluation

Fuzzy theory has been proven to be an effective multi-criteria decision-making method, which is one of the most popular methods because of its ease use and taking uncertainty into account. It has been adopted in many fields, such as in engineering, economic, environmental, social, medical, and management applications [30-33]. These previous studies demonstrate that fuzzy synthetic evaluation has the advantage of handling complicated evaluation with multiple factors and layers. In fact, the use of the fuzzy methodology helps to capture the ambiguity of human appraisal when uncertain and imprecise data is used. Fuzzy synthetic evaluation method is considered as an effective method for the evaluation of comprehensive benefit of LSCP. It requires the following four elements:

1) A set of basic factors $U = \{u_1,\ u_2,\ \ldots,\ u_m\}$, u_i standing for the evaluation factor i;

2) A set of grades alternatives $V = \{v_1,\ v_2,\ \ldots,\ v_n\}$, v_j being the evaluation grade j;

3) A set of weight vectors $W = \{w_1,\ w_2,\ \ldots,\ w_m\}$, w_i denoting the weighting of evaluation factor i;

4) A fuzzy evaluation matrix $Q = (q_{ij})_{m\times n}$, $q_{ij}\,(i = 1,2,\cdots,m;\ j = 1,2,\cdots,n)$ represents the percentage of respondents who choose v_j for their satisfaction level concerning the factor u_i.

Determination of the membership function for each common factor

Given that the set of grade alternatives for selection are defined as $V = \{1,3,5,7,9\}$, where "1" = very dissatisfied; "3" = dissatisfied; "5" = basically satisfied; "7"= satisfied; and "9" = very satisfied. For each common factor u_{ik}, the membership function can be computed by[33] :

$$Z_{u_{ik}} = \frac{P1_{u_{ik}}}{\text{very dissatisfied}} + \frac{P3_{u_{ik}}}{\text{dissatisfied}} + \frac{P5_{u_{ik}}}{\text{basically satisfied}} + \frac{P7_{u_{ik}}}{\text{satisfied}} + \frac{P9_{u_{ik}}}{\text{very satisfied}}$$

$$= \frac{P1_{u_{ik}}}{1} + \frac{P3_{u_{ik}}}{3} + \frac{P5_{u_{ik}}}{5} + \frac{P7_{u_{ik}}}{7} + \frac{P9_{u_{ik}}}{9} \tag{7}$$

Where u_{ik} represents the k^{th} evaluation factor i; $Z_{u_{ik}}$ denotes the membership function of the evaluation factor u_{ik}; and $Pt_{u_{ik}}$ (t =1,3,5,7,9) is the percentage of respondents who choose t for their satisfaction level concerning the factor u_{ik}. Alternatively, the membership function of u_{ik} can also be written as $\left(P1_{u_{ik}}, P3_{u_{ik}}, P5_{u_{ik}}, P7_{u_{ik}}, P9_{u_{ik}}\right)$, where $0 \le Pt_{u_{ik}} \le 1$ and $\sum_{1}^{9} Pt_{u_{ik}} = 1$.

RESULTS

Data statistics

The statistics come from 202 participants selected from government departments, the public around the Lieder Village, people participating in the reconstruction, relevant stakeholders as well as the experts who have urban renewal experience. In Table 2 is shown that the 30 to 49 years old account for 73.26%, university degree and above account for 83.66%, people with construction and management experience account for 84.8%. It shows that participants who filled out questionnaires have higher education and rich work experience.

Tab. 2 - Background information of the respondents

1) Age of survey respondents					
Category	20~29 years old	30~39 years old	40~49 years old	50~59 years old	Above 60 years old
Percentage	9.41	42.08	31.18	11.39	5.94
2) Education level of survey respondents					
Category	Below bachelor	Bachelor		Master and above master	
Percentage	16.34	58.42		25.24	
3) Work unit of survey respondents					
Category	Administrative departments	Enterprise	Higher school	Research institutions	other
Percentage	22.77	32.18	13.86	15.35	15.84
4) Urban renewal experience of survey respondents					
Category	None	1~2 years	3~4years	5~6years	Above 6 years
Percentage	15.2	26.3	22.7	17.2	18.6

Data analysis

Before adopting FA for the calculated impact, several tests were conducted to determine the appropriateness of using it.

(1) Reliability analysis was performed to evaluate the internal consistencies of the extracted factors. The value of Cronbach coefficient of social benefit, economic benefit and environmental benefit were calculated to be 0.908, 0.887 and 0.854 respectively, indicating that the questionnaires had a high level of uniformity [34].

(2) Bartlett test of Sphericity (Table3): the value of Bartlett Test of Sphericity was calculated to be 5561.960, 4857.940 and 5503.496 with an associated significance level of 0.000. This suggested that the correlation matrix is not an identity matrix [35].

(3) Kaiser–Meyer–Olkin (KMO): the value of KMO was calculated and shown in Table 3, a value above 0.8 indicating that the collected data would be suitable for factor analysis [35].

(4) Explained variance (EV): to determine how many factors were required to represent 30 evaluation factors, the total percentage of variance explained by each factor was examined. In this study, principal factor extraction with varimax rotation was performed through the SPSS to generate factor loadings for the number of factors to be exacted from a sample of 202 respondents, see Table 4.

Tab. 3 - Cronbach's Alpha coefficient and KMO test analysis of various dimensions' benefit

Aim	Dimension	Question number	Cronbach's Alpha	A sufficient degree of sampling KMO	Bartlett's spherical test		
					Approximate chi-square distribution	DOF	Significance
Comprehensive Benefit	Social Benefit	1-30	0.908	0.890	5561.960	435	0.000
	Economic Benefit	1-30	0.887	0.868	4857.940	435	0.000
	Environmental Benefit	1-30	0.854	0.820	5503.496	435	0.000

Extracting common factor and construction of evaluation index system

According to the results of FA in max orthogonal rotation, the common factors of social benefit, economic benefit and environmental benefit were extracted. The details of the extracted factors, their factor loading and variables contained in each common factor are shown in Table 4. According to Tabachnick [36], maximum load factor (MLF) could be considered to represent the vast majority of the information about the integrated factor. So selecting the factor with maximum load in each principal component to represent the common factors can build the synthetic evaluation index system of LSCP, which contains three levels of target layer, criterion layer and index layer, see Table 4.

Tab. 4 - Synthetic evaluation index system of social, economic, environmental benefit

Target Layer	Criterion layer	Index Layer (common factors)	Load (MLF)	Percentage of EV	Including Variable factor(number)
Com-prehen-sive Benefit	Social Benefit	Improvement of public infrastructure	0.796	46.426	L20,L19,L14,L13,L16, L21,L23
		The degree of public participation	0.838	11.035	L12,L02,L22,L17,L15,L06
		The inheritance of history, culture and urban styles	0.852	5.645	L05,L03,L11,L18,L07
		Urban landscape function improvement	0.777	4.821	L24,L27,L01
		Development potential after project construction	0.678	3.969	L30,L29,L25,L26
	Econo-mic Benefit	Traffic improvement status	0.809	40.865	L30,L28,L24,L08,L27,L23 ,L26
		Project construction cost	0.739	10.093	L12,L19,L21,L22,L16
		Land use rate	0.739	6.830	L14,L15,L29,L20
		Social welfare improvement	0.857	4.975	L17,L05,L10
		Social harmony and stability	0.762	4.341	L03,L09,L06
		Improvement of reputation and income of corporate	0.704	3.981	L18,L04
	Environ-mental Benefit	Land revenue status	0.818	44.246	L13,L16,L21,L20,L19,L23
		Improvement of living conditions	0.835	9.551	L15,L17,L22,L07
		Clean, safe and belonging community	0.668	6.477	L29,L09,L08,L02
		Environmental quality improvement	0.779	4.940	L28,L27,L30,L25
		Land use intensity	0.681	4.576	L12,L01,L10
		Cultural and educational improvement	0.707	3.590	L04,L05,L11

Development of weighs for social, economic and environmental benefit

This research selected sixty-three experts with rich experience in LSCP to judge the importance of society, economy and environment for comprehensive benefit by using a five-point Likert scale (“1”= least important, while “5”=most important). Original results evaluation matrix of each index is as follows:

$$X=\begin{bmatrix}0 & 5 & 16 & 23 & 19\\ 2 & 5 & 16 & 22 & 18\\ 1 & 4 & 15 & 25 & 18\end{bmatrix}^T \qquad p_{ij}=\begin{bmatrix}0.000 & 0.079 & 0.254 & 0.365 & 0.302\\ 0.302 & 0.079 & 0.254 & 0.349 & 0.286\\ 0.016 & 0.063 & 0.238 & 0.397 & 0.286\end{bmatrix}^T$$

To calculate the entropy and weights of social, economic and environmental benefit:

$$E=\begin{bmatrix}0.79 & 0.86 & 0.81\end{bmatrix} \qquad W=\begin{bmatrix}0.39 & 0.26 & 0.35\end{bmatrix}$$

Determine the weight of indicators in index layer

The data was collected from 202 questionnaires. It was to assess the importance of each factor in index layer for comprehensive benefit of LSCP from social, economic, environmental benefit. By using Equation 2 to 6, the weight of each indicator was calculated and then a synthetic evaluation models can be obtained, as shown in Figure 1.

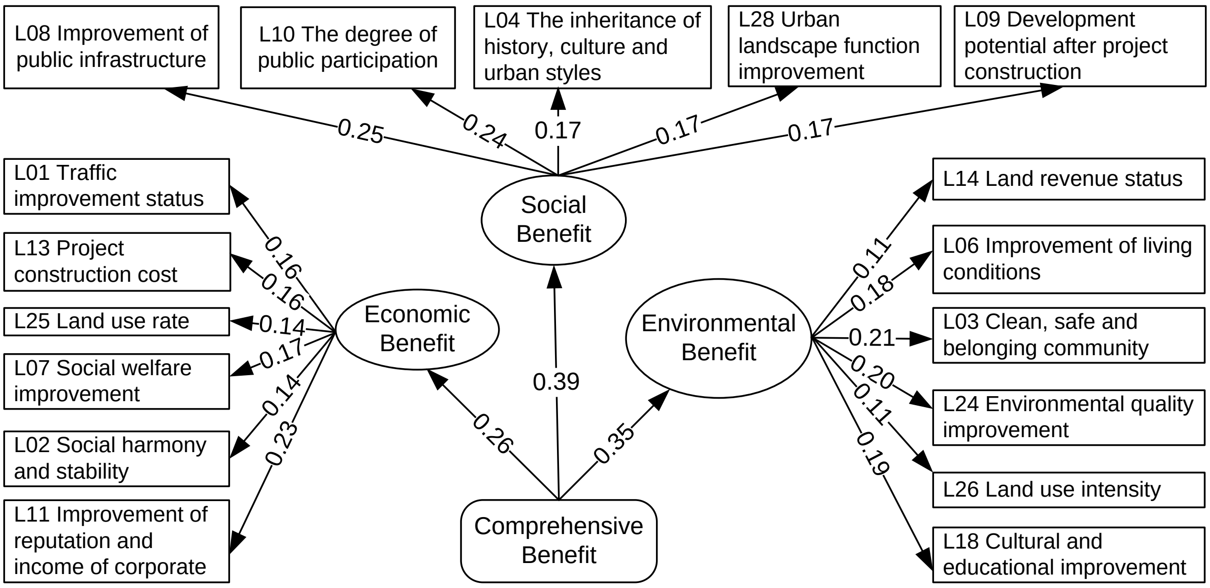

Fig. 1- Synthetic evaluation model of social, economic, environmental benefit

CASE STUDY AND ANALYSIS

With the rapid pace of urbanization, city of Guangzhou continues to expand and produces a large number of urban renewal projects. All urban renewal projects cover an area of about 399.52 square kilometers, in which the area of urban village is about 219.59 square kilometers. To solve the problem of urban village determinate whether urbanization can be carried out successfully and whether can achieve urban sustainable development.

Project background

Lieder Village has a history of over 800 years, which is located in the CBD of Guangzhou. The reconstruction of Lieder Village is the first pilot project of urban village renewal in Guangzhou and it is also a first successful case of urban village renewal by selling land for getting the reconstruction money. According to statistics, Lieder Village land area for reconstruction is about 235,000 m^2, the building floor area of 600,000 m^2. The Lieder Village is divided into three areas to implement the reconstruction program: Eastern land is for resettlement of residents. There are 37 high buildings which is about 5662 set house to meet the villagers living themselves and nearly 4,000 sets can be rented; Southwestern land is mainly for the construction of star hotel, creating collective economic income; Western land is sold to developers of 4.6 billion Yuan, equivalent to the floor price of 8095.3 Yuan/m^2, for the construction of commercial and office. It can be said Lieder Village reconstruction is a LSCP.

Determination of the membership function

As mentioned earlier, a total of 17 common factors were identified for assessing the comprehensive benefit of LSCP. Eighty-nine evaluators participating in the Lieder Village reconstruction, stakeholders, and experts or scholars were invited to assess each indicator of synthetic evaluation model through a questionnaire. For example, the survey results on the Improvement of public infrastructure of social benefit indicated that 0% of the respondents opined the importance of this common factor for social benefit as very dissatisfied, 0% as dissatisfied; 18% as basically satisfied; 28% as satisfied; 54% as very satisfied. Therefore, the membership function of Improvement of Public Infrastructure is given by Equation 7.

$$Z_{C1}=\frac{0.00}{\text{very dissatisfied}}+\frac{0.00}{\text{dissatisfied}}+\frac{0.18}{\text{basically satisfied}}+\frac{0.28}{\text{satisfied}}+\frac{0.54}{\text{very satisfied}}$$
$$=\frac{0.00}{1}+\frac{0.00}{3}+\frac{0.18}{5}+\frac{0.28}{7}+\frac{0.54}{9}$$

It can also be written as (0.00, 0.00, 0.18, 0.28, 0.54). Similarly, the membership functions of all common factors can be derived in the same way, see Table 5.

Tab. 5 - The membership function of all common factors for LSCP

No.	Common factors	Weight	Membership function of Level 3	Membership function of Level 2
C1	Improvement of public infrastructure	0.25	(0.00, 0.00, 0.18, 0.28, 0.54)	(0.01, 0.01, 0.19, 0.27, 0.52)
C2	The degree of public participation	0.24	(0.00, 0.01, 0.20, 0.28, 0.51)	
C3	The inheritance of history, culture and urban styles	0.17	(0.01, 0.02, 0.21, 0.29, 0.46)	
C4	Urban landscape function improvement	0.17	(0.00, 0.01, 0.18, 0.23, 0.58)	
C5	Development potential after project construction	0.17	(0.01, 0.02, 0.20, 0.26, 0.51)	
C6	Traffic improvement status	0.16	(0.00, 0.01, 0.15, 0.21, 0.63)	(0.01, 0.02, 0.16 ,0.28, 0.53)
C7	Project construction cost	0.16	(0.01, 0.03, 0.14, 0.28, 0.54)	
C8	Land use rate	0.14	(0.00, 0.02, 0.17, 0.26, 0.55)	
C9	Social welfare improvement	0.17	(0.00, 0.02, 0.16, 0.30, 0.52)	
C10	Social harmony and stability	0.14	(0.02, 0.03, 0.17, 0.37, 0.41)	
C11	Improvement of reputation and income of corporate	0.23	(0.00, 0.01, 0.17, 0.27, 0.55)	
C12	Land revenue status	0.11	(0.01, 0.02, 0.19, 0.29, 0.48)	(0.01, 0.01, 0.17, 0.30, 0.51)
C13	Improvement of living conditions	0.18	(0.01, 0.00, 0.11, 0.29, 0.60)	
C14	Clean, safe and belonging community	0.21	(0.00, 0.00, 0.14, 0.31, 0.55)	
C15	Environmental quality improvement	0.20	(0.00, 0.01, 0.14, 0.29, 0.56)	
C16	Land use intensity	0.11	(0.02, 0.04, 0.21, 0.35, 0.38)	
C17	Cultural and educational improvement	0.19	(0.00, 0.02, 0.24, 0.30, 0.44)	

Taking the social benefit as an example, its membership function is as follows.

$$(0.25\times0.00+0.24\times0.00+0.17\times0.01+0.17\times0.00+0.17\times0.01, 0.25\times0.00+0.24\times0.01+0.17\times0.02+0.17\times0.01+0.17\times0.02,$$
$$0.25\times0.18+0.24\times0.20+0.17\times0.21+0.17\times0.18+0.17\times0.20, 0.25\times0.28+0.24\times0.28+0.17\times0.29+0.17\times0.23+0.17\times0.26,$$
$$0.25\times0.54+0.24\times0.51+0.17\times0.46+0.17\times0.58+0.17\times0.51)=(0.01,0.01,0.19,0.27,0.52)$$

Tab. 6 - The results of fuzzy synthetic evaluation for comprehensive benefit of LSCP

No.	Critical factors	Weight	Membership function of Level 2	Membership function of Level 1
B1	Social benefit	0.39	(0.01, 0.01, 0.19, 0.27, 0.52)	(0.01，0.01，0.18，0.28，0.52)
B2	Economic benefit	0.26	(0.01, 0.02, 0.16 ,0.28, 0.53)	
B3	Environmental benefit	0.35	(0.01, 0.01, 0.17, 0.30, 0.51)	

After deriving the membership function of Level 1, the fuzzy evaluation value (FEV) of social benefit, economic benefit, environmental benefit and comprehensive benefit can be calculated using Equation 7:

$$Z_{B1} = 0.01\times1 + 0.01\times3 + 0.19\times5 + 0.27\times7 + 0.52\times9 = 7.56$$

$$Z_{B2} = 0.01\times1 + 0.02\times3 + 0.16\times5 + 0.28\times7 + 0.53\times9 = 7.60$$

$$Z_{B3} = 0.01\times1 + 0.01\times3 + 0.17\times5 + 0.30\times7 + 0.51\times9 = 7.58$$

$$Z_{A1} = 0.01\times1 + 0.02\times3 + 0.16\times5 + 0.28\times7 + 0.53\times9 = 7.58$$

To have an in-depth analysis, the fuzzy evaluation value of each common factor can also be calculated using the same method. The results are shown in Table 7.

Fuzzy evaluation analysis

The empirical research finding (Table 7) shows that the fuzzy evaluation value of social, economic and environmental benefits are 7.56, 7.60 and 7.58 respectively. The value is very close, showing that it basically balances the benefit of the three critical factors. So it reflects the comprehensive benefit is 7.58, which can be regarded as between “satisfied” and “very satisfied”. In addition, the survey respondents perceived that “Urban landscape function improvement” in the evaluation index of social benefit is the most CF, with the value equal to 7.76; with “The inheritance of history, culture and urban styles” being the last, with the value

equal to 7.29. In the evaluation index of economic benefit, “Traffic improvement status” is the first, with the value equal to 7.92; “Social harmony and stability” the last, with the value equal to 7.24; For the environmental benefit, “Improvement of living conditions” is the higher, with the value equal to 7.99; and “Land use intensity” the lower, with the value equal to 7.06. These research findings revealed that the LSCP of Lieder Village completed the construction of urban infrastructure, beautified the environment, promoted economic development and inherited cultural heritage. However, the density of new building is too large. On the other hand, during the period of construction, especially for the problem of demolition compensation, some conflicts occurred among different stakeholders. Moreover, although some historical and cultural buildings were rebuilt, it has little regrets for the old buildings in the overall demolition and reconstruction of old Lieder Village. But in whole, the fuzzy results are line with the reality and Lieder Village reconstruction is satisfactory.

Tab. 7 - The membership function of all common factors for LSCP

No.	FEV	No.	Critical factors	FEV	No.	Common factors(CF)	FEV
A1	7.58	B1	Social Benefit	7.56	C1	Improvement of public infrastructure	7.72
					C2	The degree of public participation	7.58
					C3	The inheritance of history, culture and urban styles	7.29
					C4	Urban landscape function improvement	7.76
					C5	Development potential after project construction	7.48
		B2	Economic Benefit	7.60	C6	Traffic improvement status	7.92
					C7	Project construction cost	7.62
					C8	Land use rate	7.68
					C9	Social welfare improvement	7.64
					C10	Social harmony and stability	7.24
					C11	Improvement of reputation and income of corporate	7.72
		B3	Environmental Benefit	7.58	C12	Land revenue status	7.37
					C13	Improvement of living conditions	7.99
					C14	Clean, safe and belonging community	7.82
					C15	Environmental quality improvement	7.80
					C16	Land use intensity	7.06
					C17	Cultural and educational improvement	7.32

CONCLUSIONS

(1) This research has developed a comprehensive, objective, reliable, and practical evaluation model for assessing the comprehensive benefit of LSCP using Entropy method and fuzzy synthetic evaluation approach. In the synthetic evaluation model, the weights of social, economic and environmental benefit are 0.39, 0.26 and 0.35 respectively. It perceives that social benefit is most important. To achieve social benefit of LSCP is the key to maintain social harmony and stability, which can help to complete the LSCP smoothly and successfully.

(2) The synthetic evaluation model this paper constructs reflects the basic elements of sustainable development. The result of using this model to evaluate the Lieder Village reconstruction is satisfactory and in line with reality. The developed model provides an objective basis for assessing the comprehensive benefit of LSCP.

(3) The development of evaluation index system not only enhances the understanding of government and investors in implementing a successful LSCP, but it also provides reference for construction managers to measure, evaluate and improve the current performance of LSCP. It can be seen from the evaluation index system that LSCP should pay attention to the construction of public infrastructure, public participation, the inheritance of historical, cultural and

urban styles, community's cleanliness and safety, environmental quality improvement, the interests of enterprises and social security of residents.

(4) This research enables manager to better understand what the comprehensive benefit should be assessed for LSCP. It also assists manager in planning and control for LSCP. An automated system for the fuzzy comprehensive benefit evaluation model of LSCP could be developed in the future. By doing so, a practical comprehensive benefit evaluation tool for LSCP could be used for benchmarking purposes.

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