# The Research on Eco-campus Evaluation Index System and Weight

Xinpei Jiang
Hebei University of Engineering
Guangming South Street 199, Handan, Hebei, China
CHINA
Jangxinpei2007@163.com

Bao Zheng
Hebei University of Engineering
Guangming South Street 199, Handan, Hebei, China
CHINA
zhengbaobigboy@163.com

Haifeng Wang
Hebei University of Engineering
Guangming South Street 199, Handan, Hebei, China
CHINA
jiuliushuili@sohu.com

*Abstract:* - At present so many universities in China are working hard on eco-campus construction. This paper reviewed the research on eco-campus in china and established the eco-campus evaluation index system on the basis of summarizing ecological building, green building, sustainable building and energy-saving building and consulting data of a conference. Then Analytical Hierarchy Process (AHP) is used to design questionnaires, check the questionnaire consistency and calculate the weight of eco-campus evaluation index system. This research used AHP expert decision-making software Expert Choice 11.5 to make the consistency check and calculate the weight, which avoids complex calculations and saves a lot of time. The main goal of this thesis is to list the priorities that affect planning and construction of eco-campus to provide basis and reference for eco-campus construction and eco-campus sustainable development.

*Key-Words:* - Sustainable development, Eco-campus, index system, weight, AHP

## 1 Introduction

During the united Nations Earth Summit held by the United Nation Environment Programme (UNEP) in Rio de Janeiro(1992), a sustainable development was defined as “improving the quality of human life while living within the carrying capacity of supporting eco system”. This definition has an impact on the economic, social and environmental development. It was later be formally adopted worldwide. At the 2005 World Green Building Council Congress, the mayors of fifty of the world’s largest cities signed an agreement that all new municipal buildings will be subjected to green building rating systems by 2012. 178 countries in the world has signed and agreement on acceptance and implementation of sustainable development and has accepted to implement the Agenda 21. It was reconfirm in Johannesburg in 2002[1]. Implementing sustainable development is a profound transformation, which changes people's world outlook, values, ethics, and behaviors. Facing China's severe environmental problems, how to implement the strategy of sustainable development and the strategy of developing the country through science and education and how to handle relationship between the rapid economic growth and sustainable development in the process of high-speed economic development is the new historic mission for universities in the 2l century. Experts pointed out: in order to achieve such a transformation, sustainable development education and environmental education must be implemented, enhance sustainable development education and construct virtuous circle of ecological environment campus is one of the important measures about the basic national policy of environmental protection and sustainable development. So many universities in China are

working hard on eco-campus construction. Constructing eco-campus and carrying out ecological education are necessary requirements of implementing the strategy of sustainable development, developing the country through science and education, technology reformation of higher education and spiritual civilization.

There is an important issue, which is the construction of eco-campus evaluation index system and weight distribution of the index in the whole system in the process of building eco-campus. At present, the theory and construction of eco-campus are still at the exploratory stage in China and abroad and not yet a mature and detailed assessments of eco-campus system for reference [2]. For the construction of eco-campus evaluation index system and the selection of the weight, different scholars have proposed different theories and ideas and come to different conclusions and results. Michael[3] analyzed the sustainability of the recent higher education cross-agency measurement, reviewed 11 kinds of cross-agency assessment tools, summed up evaluation parameters to achieve sustainability in higher education, including the reduction of output, synchronous tracking and systematic changes, took sustainable education as a core part of curriculum and worked hard on cross-functional and cross-agency, Chen Yuetang etc [2] took Hunan Agricultural University as an example, proposed ecological comprehensive indexes as goal, structure, function, structure, function, coordination as first-level indexes, a number of factors as second-level indexes, which constitute the eco-campus evaluation system, he weight of indexes are obtained by consulting experts ; Zhang Guozhen [4] proposed five levels of ecological evaluation indexes and a number of factors under the five levels about primary schools in Taiwan, at last AHP was used for evaluation ; Li etc[5]proposed that the ecological footprint is an effective practice tool can compare and reflect environmental impact of campus, and ecological footprint analysis (EFA) was used to evaluate Northeastern University, considering energy consumption, food consumption, waste disposal, water supply, transport and paper consumption and other factors, concluded that the ecological footprint of Northeastern University is 24787hm2,needs 25000hm2 Ecological productive land to support consumption and waste disposal, meanwhile, energy consumption is up to 68% ,sharing the largest footprints percentage ; Cui Meng etc[6] proposed four part evaluation contents mainly based on environmental indexes: environmental impact, environmental quality, environmental education, service facility, and a number of factors under all levels composed eco-campus evaluation system, at last Analytical Hierarchy Process (AHP) was used for ecological evaluation on a campus in the north of china ; Chu Dong sheng[7]proposed eco-campus evaluation indexes system, contained structure, function, self-discipline as first-level indexes, and a number of factors were selected to form second、third-level indexes ; Wang Yuan etc [8] proposed eco-campus evaluation indexes system, contained ecological landscape, ecological comfort, ecological technology, ecological management, ecological culture five levels, and fuzzy comprehensive evaluation method was used for the old campus of Tian Jin Poly Technic University evaluation.

Ecological indicator system ( EIS ) is an effective method and tool used to monitor, assess and manage ecological system, which consists of a series of a certain hierarchy indexes, used to represent the link between composition, structure and function of the complex ecological system and reflect the hierarchy and integrity of ecological system[9-11]. For any multi-index evaluation system, the mutual importance of each evaluation index, namely the index weight is different from each other, different weights corresponding to different evaluation results, therefore, determining reasonable indexes weights for any evaluation system is very important[12].

This paper will use AHP as theoretical framework for analysis, and construct eco-campus evaluation index system on the basis of summarizing ecological building, green building, sustainable building and energy-saving building and consulting the conference of saving campus in Hebei Province in August 2009 sponsored by Hebei Province Office of Housing and Urban and Rural Construction, Hebei Province Department of Education, and delphi questionnaire is designed under the principle of AHP, finally, the weights of eco-campus evaluation index system are calculated by using Expert Choice software, obtaining relevant factors in the process of constructing eco-campus and the priority of selection.

## 2 Research Advances on Eco-Campus

Facing the deteriorating ecological environment, the international community reached a consensus, namely, improve environmental awareness through publicity and education.

Foundation for Environmental Education (FEEE) in Europe in 1994 first proposed a Europe-wide

"eco-schools scheme", also called "green schools". China issued 《The National Environmental Propaganda and Education Program(1996-2010)》 by the National Environmental Protection Agency, the State Education Commission, and the Central Propaganda Department in 1996.And the connotation of green schools is given, its construction includes many aspects as ecological campus, ecological education, ecological technology, ecological environment etc. This paper mainly explores and studies on ecological campus.

At present the domestic and international research on eco-campus is still in the initial stage, and the concept of ecological campus is also under discussion. Judging from the time of literature published, the research on the eco-campus mainly started from the middle 1990s, when 21st century coming, related literatures are increasing year by year. Europe and America began to do the research of ecological planning from 20 century 50 ~ 60 years, and early introduced the ecological concept to school construction. Taking EI database for example, by searching green campus, ecological campus, sustainable campus and other entries, we found the earliest related literatures are published in 70 years, throughout the 20th century 70~ 90 years, the number of relevant literatures are limited. Since the mid 90's, the related research gradually increased, especially after the 21st century, eco-campus is gradually becoming a hot academic research. From geographical distribution of the researcher, the English literature search results show that current research on the ecological campus mainly concerned in the developed countries, especially the U.S. scholars, as shown in the table 1[13].

Table 1 The country of literature author distribution (articles) in EI database

| Search Entries | Green Campus | Ecological Campus | Sustainable Campus | Total |
|---|---|---|---|---|
| America | 24 | 45 | 71 | 120 |
| England | 3 | 3 | 7 | 13 |
| Japan | 2 | 3 | 0 | 5 |
| Australia | 1 | 4 | 7 | 12 |
| Spain | 2 | 2 | 6 | 10 |
| India | 4 | 3 | 4 | 11 |
| China | 1 | 5 | 4 | 10 |

In China the concept of eco-campus during school construction is mentioned the most widely in recent years. But the research on eco-campus has not yet formed a complete theoretical system covered both construction and management. Today most domestic scholars proposed the definition of eco-campus from the standpoint of construction, agreed with the basic principles and methods of ecology, regarded the campus as artificial ecological system for research, some scholars thought that university has five elements of community composition as well, take it as a special ecological community of the city for research[14]. Meanwhile, Zang Shuliang etc defined eco-campus on the view of construction: Eco-campus is an artificial ecological system with harmonious relations between man and nature, reasonable species distribution and structure, excellent quality environment, material, energy, and information efficiently used, and environmentally friendly function of study, work, activities, leisure that uses the basic principles and methods of ecology to plan, design, construct, manage and operate [15]. In the research content, scholars stressed that the eco-campus construction takes sustainable concept as a guidance and builds natural ecology and human together.

Our country is paying more attention to the construction of eco-schools at the beginning of this century, nearly 2000 green schools are built at present, which are mainly for kindergartens, primary and secondary schools. But the voice of eco-campus construction in the university is very weak, most remain in the simple greening and beautification, lack of understanding of the ecological construction.

# 3 Determination of Eco-campus Evaluation Index System and Weight

## 3.1 Construction of Eco-campus Evaluation Index System Hierarchy Structure

The creation of eco-campus is taking eco-campus as a value to pursue, makes eco-campus of expectation and ideal come true, therefore, before and after the creation of eco-campus should make ecological assessment. The evaluation index system establishment is the basis for ecological evaluation, and is also a comprehensive reflection of ecological level of the university. Construction of evaluation system is selecting several factors as first-level indexes according to certain principles, each first-level index is divided into a number of second-level

indexes, and continue to decompose until each index can be measured.

This paper constructed eco-campus evaluation index system on the basis of summarizing ecological building, green building, sustainable building and energy-saving building and consulting the conference of saving campus in Hebei Province in August 2009 sponsored by Hebei Province Office of Housing and Urban and Rural Construction, Hebei Province Department of Education , and based on the sustainable development theory as guidance, constructed in the principle of comprehensive, representative, hierarchy, rationality and reality, mainly selected indexes of planning, design, construction and management constituted goal, first-level index, second-level index. The goal is eco-campus, the first-level index are consisted of Ecological Planning, Ecological Technology, Ecological Comfort, Ecological Management, Ecological Education. Ecological planning level is consisted of Base Location Selection, Landscape Planning, Environmental Improvement, Energy Planning, New Architecture Planning. Ecological Technology level are consisted of Energy Effciency and Energy Utilization, Water Saving and Utilization, Material Saving and Utilization, Ecological Comfort level are consisted of Indoor Air Quality, Acoustic Environment, Lighting Environment, Thermal and Humidity Environment, Wind Environment, Ecological Management level are consisted of Operation and Maintenance Technology, Intelligent System, Ecological Education level are consisted of Course and Lecture, Research and Practice, Propaganda and Popularization.

## 3.2 Establishment of Eco-campus Evaluation Index Weight

### 3.2.1 Analytical Hierarchy Process Theory

The AHP, which was developed by Professor Saaty in the early 1970s, is a subjective tool with which to analyze, based on a crisp 9-point scale, the qualitative criteria needed to generate alternative priorities and preferences[16] .

The weight sets are determined by AHP can be written in the following form[17]:

$$A = \{A1, A2, \cdots, An\} \quad (1)$$

With: $An$—The matrix of criteria level n.

The major step of determination of weight sets:

Step 1 Design Delphi expert questionnaire, through questionnaires at each level, the indexes of the layer-by-right comparison, the structure matrix of pairwise comparison judgments are:

$$A = (a_{ij})_{n\times n} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (2)$$

Suppose there are factors: $x_1 x_2 \cdots x_n$ , and take two factors: $x_i$ and $x_j$ each time. $a_{ij}$ is the ratio of the importance of $x_i$ and $x_j$ ,determined by the Saaty's 1-9 scale [19] in Table 1.

Table.1 Number scale and its description

| scale | compare factor i and j |
|---|---|
| 1 | Equal Importance |
| 3 | Moderate Importance |
| 5 | Essential or strong Importance |
| 7 | Very strong Importance |
| 9 | Extreme Importance |
| 2, 4, 6, 8 | Intermediate value of the comparison |
| reciprocal | If the comparison value is aij,aji=1/aij |

The judgement matrix(A) is a reciprocal metrix with $aij > 0, aij = 1/aji, aii = 1$ . The nature of it determines that we only need to obtain upper(or lower)triangula $n(n-1)/2$ factors of n×n judgemen matrixor analysis.That is to say we only need $n(n-1)/2$ judgments.

Step 2 Test the consistency of each matrix .

Matlab software can be used to calculate the largest eigenvalue $\lambda_{\max}$ by using function $[v, d] = eig(a)$ .

Consistency Index( $C.I.$ ):

$$C.I. = \frac{\lambda \max - n}{n-1} \quad (3)$$

Consistency Ratio( $C.R.$ ):

$$C.R. = \frac{C.I.}{R.I.} \quad (4)$$

Where $R.I.$ is the average random consistency index, its value can be obtained by look-up table. As shown in Table 2.

Table 2 Average Random Index

| Matrix order | 1 , 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| $R.I.$ | 0 | 0.52 | 0.89 | 1.12 | 1.26 | 1.36 | 1.41 |
| Matrix | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

| order | | | | | | | |
|---|---|---|---|---|---|---|---|
| $R.I.$ | 1.46 | 1.49 | 1.52 | 1.54 | 1.56 | 1.58 | 1.59 |

$$\text{If } C.R.\begin{cases} < 0.1 & \text{accept abl e} \\ \geq 0.1 & \text{unaccept abl e} \end{cases} \quad (5)$$

When $C.R$ is unacceptable, you should rectify the matrix appropriately

Step 3 Solve judgment matrix and calculate the weight vectors

The eigenvector (wi) results from the maximum matrix eigenvalue, translates the priority order of the factors and can be calculated through equation (6)[18].

$$wi = \frac{(\prod_{j=1}^{n} a_{ij})^{1/n}}{\sum_{k=1}^{n} (\prod_{j=1}^{n} a_{kj})^{1/n}} \quad (6)$$

We can normalize w to obtain a new weight vector as follows:

$$W = (w_1, w_2, \cdots, w_n)^T \quad (7)$$

Step 4 Calculate complex weight

The complex weight is calculated from top to bottom, and then test the consistency of the synthesis matrix(The test method is the same as step 2)

### 3.2.2 Questionnaire Consistency Check

The factors of each level made paired comparison under the previous level as assessment benchmarks and let decision-makers or decision-making group members fill questionnaires under 1 to 9 scale. The questionnaire of expert A is taken as an example to illustrate the relative importance of each comparison matrix as shown in Table 2.

similarly, the questionnaire design of the second-level indexes under ecological planning, ecological technology, ecological comfort, ecological management, ecological education are also the same

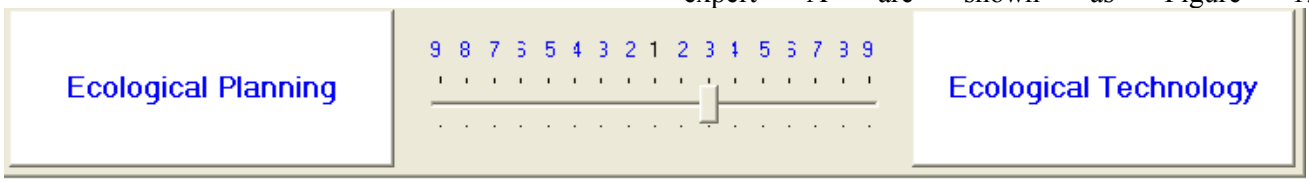
Tab.2 Sample of questionnaire design

| Assessment elements | 9:1 | 7:1 | 5:1 | 3:1 | 1:1 | 1:3 | 1:5 | 1:7 | 1:9 | Assessment elements |
|---|---|---|---|---|---|---|---|---|---|---|
| Ecological Planning | | | | | | √ | | | | Ecological Technology |
| Ecological Planning | | | | | | | √ | | | Ecological Comfort |
| Ecological Planning | | | | | √ | | | | | Ecological Management |
| Ecological Planning | | | √ | | | | | | | Ecological Education |
| Ecological Technology | | | | | | √ | | | | Ecological Comfort |
| Ecological Technology | | | √ | | | | | | | Ecological Management |
| Ecological Technology | | √ | | | | | | | | Ecological Education |
| Ecological Comfort | | √ | | | | | | | | Ecological Management |

| | | | |
|---|---|---|---|
| Ecological Comfort | √ | | Ecological Education |
| Ecological Management | | √ | Ecological Education |

as the sample above. The questionnaires issued, including the following four major groups: ecology experts, architecture experts, relevant government agency person, 20 questionnaires were sent by post and e-mail, the feedback of questionnaires are seven represented by expert A,B,C,D,E,F,G and the response rate is 35%.

This study applied Expert Choice AHP software to test the consistency of each dual matrix. The first-level indexes questionnaire responds and tests of expert A are shown as Figure 1.




Compare the relative importance with respect to: Goal:Construction of Eco-campus Evaluation Index System

| | Ecological | Ecological | Ecological | Ecological | Ecological |
|---|---|---|---|---|---|
| Ecological Planning | | 3.0 | 5.0 | 1.0 | 5.0 |
| Ecological Technology | | | 3.0 | 5.0 | 7.0 |
| Ecological Comfort | | | | 7.0 | 9.0 |
| Ecological Management | | | | | 3.0 |
| Ecological Education | Incon: 0.05 | | | | |

Fig.1 Questionnaire responds and tests of expert A

Figure 1 is the first-level indexes questionnaire of expert A. The 3.0 with red colour under the index of ecological technology in the Expert Choice matrix represents the weight of ecological planning and ecological technology pairwise comparison judgments is 1 / 3(ecological technology is more important than ecological planning). On the other hand, the meaning of black and red is opposite. Inconsistency rate( $incon$ ) at left bottom is equal to $C.R.$. $incon$ =0.05 < 0.1 means questionnaire of this level is acceptable.

The structure matrix of pairwise comparison judgments about Fig.1 is:

$$A=\begin{bmatrix} 1 & 1/3 & 1/5 & 1 & 5 \\ 3 & 1 & 1/3 & 5 & 7 \\ 5 & 3 & 1 & 7 & 9 \\ 1 & 1/5 & 1/7 & 1 & 3 \\ 1/5 & 1/7 & 1/9 & 1/3 & 1 \end{bmatrix}$$

Priorities with respect to goal of the first-level indexes can be obtained by Expert Choice software, as shown in Figure 2.

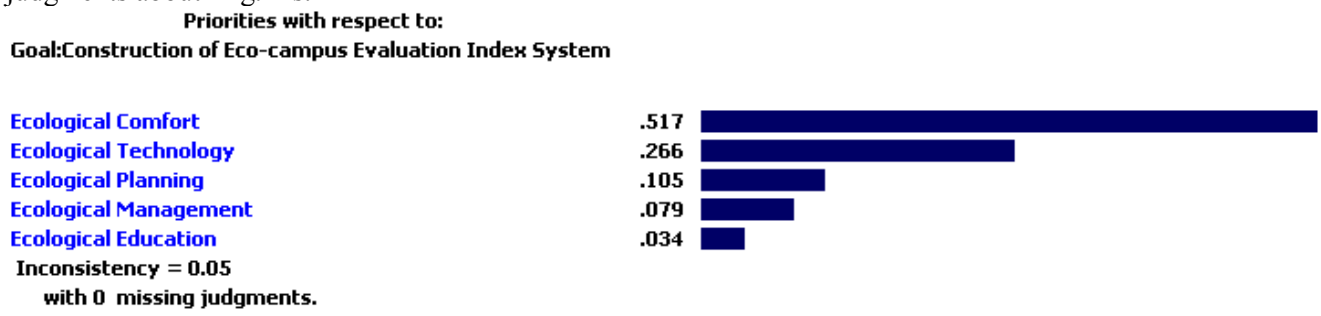



Fig.2 Priorities with respect to goal

If $C.R$ is unacceptable, analyze the questionnaire and find out the reason of $incon$ , feedback to expert until the questionnaire is acceptable.

Similarly, the operate mode of the second-level indexes under ecological planning, ecological technology, ecological comfort, ecological management, ecological education are also the same as above.

Finally Synthesis with respect to goal and test overall inconsistency, shown as figure 3.

Overall inconsistency=0.03 < 0.1means this questionnaire is acceptable。If overall inconsistency is unacceptable, analyze the questionnaire and find out the reason, and feedback to expert until the questionnaire is acceptable.

### 3.2.3 Synthesize Questionnaire and Determine Weight

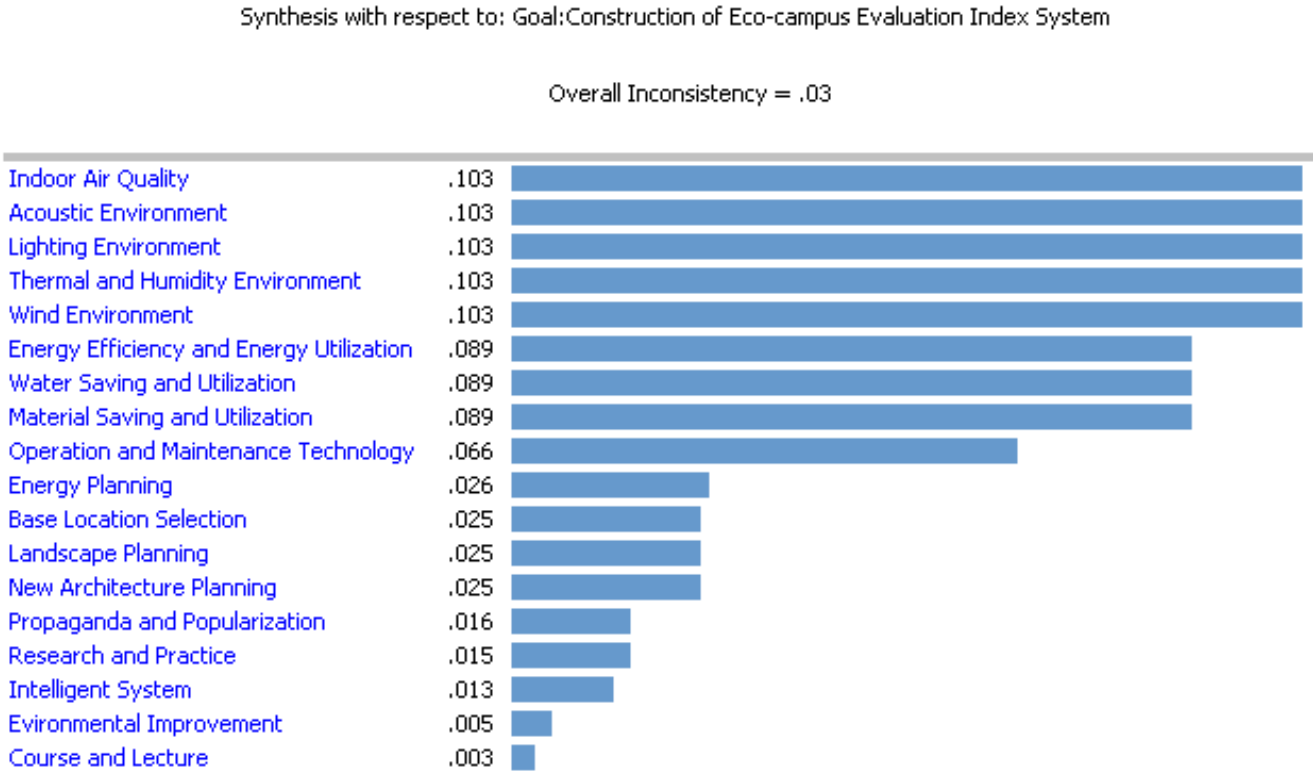



Fig.3 Synthesis with respect to goal

Through the above steps, the consistency of experts A, B, C, D, E, F, G questionnaires are tested, make each expert's questionnaire accepted. At last make dynamic sensitivity analysis using Expert Choice software, take expert A as an example, shown as figure 4.

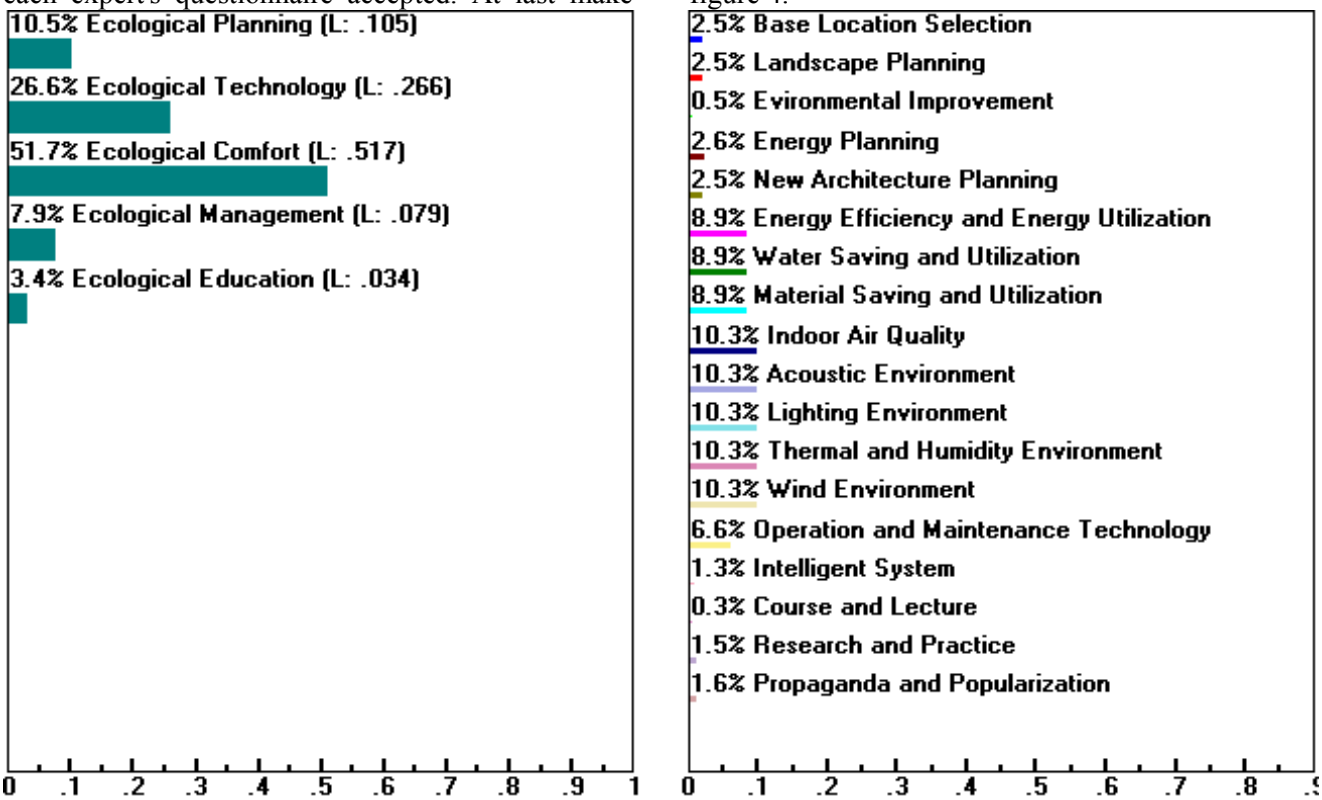



Fig.4 Dynamic sensitivity for nodes below goal

From figure 4, we can see that the highest assessment in the first-level is ecological comfort (51.7%), the next is ecological technology, ecological planning, ecological management, ecological education. In the second-level, Indoor Air Quality, Acoustic Environment, Lighting Environment, Thermal and Humidity Environment, Wind Environment, each of which occupies the largest proportion(10.3%).

The final results of weight determination of other experts are the same with expert A as shown in Figure 5. After completing the weight calculation of each expert, this paper used geometric mean to calculate the average weights of each index related to the goal, obtained the final weight and priorities of eco-campus evaluation index system as shown in Table4.

Table.4 The weight and priorities of eco-campus evaluation index system

| Target level | Criteria level | weight | Rank | Scheme level | weight | Rank |
|---|---|---|---|---|---|---|
| Constructio Of Eco-campus Evaluation Index System | Ecological Planning | 26% | 1 | Base Location Selection | 4.7% | 8 |
| | | | | Landscape Planning | 1.8% | 15 |
| | | | | Environmental Improvement | 4.7% | 8 |
| | | | | Energy Planning | 8.9% | 2 |
| | | | | New Architecture Planning | 5.7% | 6 |
| | Ecological Technology | 21% | 3 | Energy Effciency and Energy Utilization | 8.9% | 2 |
| | | | | Water Saving and Utilization | 5.2% | 7 |
| | | | | Material Saving and Utilization | 7.3% | 4 |
| | Ecological Comfort | 24% | 2 | Indoor Air Quality | 8.1% | 3 |
| | | | | Acoustic Environment | 2.9% | 13 |
| | | | | Lighting Environment | 3.2% | 12 |
| | | | | Thermal and Humidity Environment | 3.4% | 11 |
| | | | | Wind Environment | 6.5% | 5 |
| | Ecological Management | 13% | 5 | Operation and Maintenance Technology | 8.9% | 2 |
| | | | | Intelligent System | 3.5% | 10 |
| | Ecological Education | 16% | 4 | Course and Lecture | 4.2% | 9 |
| | | | | Research and Practice | 2.6% | 14 |
| | | | | Propaganda and Popularization | 9.5% | 1 |

From table analysis above, the final results of geometric mean show that the experts give the highest evaluation on ecological planning, is 26%. The next is ecological comfort 24%, ecological technology is 21%, ecological education is 16%, ecological management is 13%.

In the scheme level, the experts give the highest evaluation on Propaganda and Popularization 9.5%, the next are Energy Planning 8.9%, Energy Effciency and Energy Utilization is 8.9%, Operation and Maintenance Technology is 8.9%.

In recent years, environmental awareness is becoming focus in China. Since the 20th century 80 years, 《Green Campus》 was published in Malaysia, all over the world has gradually paid more attention on the application of ecological thinking and environmental protection on school, construction of eco-campus is a goal for every universities.

Campus has heavy responsibility for training high-level management talents, technology talents, education talents for the country. Undergraduates are decision-makers, managers and executors of sustainable development in the 21st Century [20], so improving undergraduates environmental awareness is extremely important, ecological education and propaganda and popularization are essential contents in the process of eco-campus construction, and the concept of eco-campus goes deep into undergraduate's awareness is the most important. At the same time, accelerating the construction of resource-saving and environmental friendly society is a major strategic decision made by Central Committee and State Council in the new situation, developing thoroughly eco-campus energy-saving and energy rational utilization, not only helps college students set up awareness of energy saving and environmental protection and master the skills of energy saving and environmental protection, but also has an important impact on China's economic and social. Builders also make a choice according to the size of weight of each factor in the process of eco-campus construction.

## 4 Conclusion and Recommendation

This paper highlighted the goal of eco-campus and took the concept of eco-campus and sustainable development as contact point, established eco-campus evaluation index system on the basis of summarizing ecological building, green building, sustainable building and energy-saving building and consulting the conference of saving campus in Hebei Province in August 2009 sponsored by Hebei Province Office of Housing and Urban and Rural Construction, Hebei Province Department of Education, which integrated environment, landscape design, urban planning, economics and management, and humanities indexes is comprehensive assessment system. Although our index system selected various indexes that fully characterized the campus ecological level, when involved various aspects of the situation, more in-depth analysis need to be investigated and researched.

The eco-campus evaluation index system weight is constructed by using AHP expert decision-making software Expert Choice, the results show that ecological planning is the important thing in the process of building eco-campus, at the same time, focuses on propaganda and popularization, energy planning and energy saving, and the operation and maintenance have to be put into practice as well, bounded by policies. It not only provides basis and reference for eco-campus construction, but also lays foundations for constructing eco-campus information management system standard. But the eco-campus evaluation index system weight of this paper is not the ultimate weight, the campus in different areas need to add or screen indexes and modify according to concrete conditions.

The utilization of Expert Choice software in the process of the research avoids complex calculations and saves a lot of time, the method is simple and effective and the results are clear and concise

*References:*


[1] Zuhairuse Md Darus, Abdul Khalim Abdul Rashid,Nor Atikah Hashim, Zaidi Omar, Masran Saruwono, Noraziah Mohammad, Development of Sustainable Campus: Universiti Kebangsaan Malaysia Planning and Strategy, *WSEAS Transaction on Environment and Development*, Vol.5, No.3, March 2009, pp. 273-282.

[2] CHEN Yuetang and GAO Zhiqiang. The Analysis of ec-ocmpus Evaluation Index System, *China Agricultural Education*, 2004, pp.43-45.

[3] Michael S. Institutional assessment tools for sustainability in higher education, strengths, weaknesses, and implications for practice and theory. *Higher Education Policy*, Vol.15, No.2, 2002, pp. 153-167.

[4] ZHANG Guozhen, Construct Eco-campus Evaluation System and Index weight, Ph D Thesis, *Shanghai: Shanghai Tongji University*, 2006

[5] Li GJ, Wang Q, Gu X W. etal. Application of the componential method for ecological footprint calculation of a Chinese university campus. *Ecological Indicators*, Vol.8, No.1, 2007, pp. 75-78.

[6] CUI Meng, ZHANG Hongwei and WANG Yuan, Assessment System of Eco-campus Based on Analytical Hierarchy Process, *Journal of Tianjin Polytechnic University*, Vol.26, No.4, 2007, pp.81-85.

[7] CHU Dongsheng, GAN Zuowei, MA Dingwei. The Research on Eco-campus and Its Standard, *Contemporary Education Forum*, Vol.4, No.7, 2008, pp.95-98.

[8] WANG Yuan and LU Youhao, Reseach on Assessment System of Eco-campus, *Journal of Inner Mongolia Agricultural University(Social Sciences)*, Vol.10, No.3, 2008, pp.134-135.

[9] Cairns J, McCormick P V, NiederlehnerB R. A proposed framework for the developing indicators of ecosystem health. *Hydrobiologia*, 1993,PP:1-44.

[10] Karr J R. Assessment of biotic integrity using fish communities. *Fisheries* , 1981,16,21- 27.

[11] Virginia H D , Suzanne C Beyeler. Challenges in the development and use of ecological indicators. *Ecological Indicators* , 2001 , 1 : 3-10

[12] PANG Yanjun, LIU Kaidi, ZHENG Bowen. The Method of Determining the Objective Index Weight in the Synthetic Evaluation System.Systems. *Engineering-Theory and Practice*, No.8, 2001.8, pp.37-43.

[13] ZHANG Lei,LIU Jianmin. The overseas research and constructing of ecological campus, *JOURNAL of SHANDONG JIANZHU UNIVERSITY* ,Vol.22, No.6, 2008, pp.501-506

[14] LI Yi, ZHANG Yujun. Discussion on the Construction Models of Ecological Campus, *ENVIRONMENTAL SCIENCE AND MANAGEMENT*, Vol.32, No.10, 2007, pp.143-147

[15] ZANG Shu2liang and TAO Fei. Discussion and Analysis on Ecological Campus, *Journal of*

*Liaoning University (Philosophy and Social Sciences Edition)*, Vol.32, No.4, 2004, pp.21-25

[16] Saaty. T.L The analytic hierarchy process. *New York:McGraw-Hill*,1980.

[17] Xinpei Jiang Bao Zheng , Liying Wang, The Coupled Method Fuzzy-AHP Applys to Solve Multi-criteria Decision Making Problems, *WSEAS Transactions on Mathematics*, Vol.11, No.8, November 2009, pp. 657-666

[18] Antonio A. L. S. Duarte,Gisela M. C. Rodrigues, Rui A. R. Ramos,A global service quality index to evaluate the performance and sustainability in water supply utilities, *WSEAS Transaction on Environment and Development*, Vol.5, No.12, December 2009, pp. 759-769

[19] CHEN Changjun, WANG Ziwen, Analytic Assessing Environmental Impact of Construction Project Using Analytic Hierarchy Process, *Environmental Science and Technology*, Vol.29, 2006,pp.108-110.

[20] ZHANG Zhansheng,The Research on Environmental Indicator System of City Well-off Society, Ph D Thesis, *Jilin: Jilin University,* 2004.5.