Survey on Campus Landscape Construction and Study on Suitability Comprehensive Evaluation

Based on the Perspective of the Sustainable Development of Green Campus in China's Urbanization Process

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Abstract. Scientific and rational designing and construction of green infrastructure is an important part of the sustainable urbanization of China. In view of this, deeper insights into the actual condition of campus landscape construction in China's urbanization process were gained by investigating 10 primary and secondary schools on the spot and interviewing 20 experts and scholars. A 12-experts panel Delphi questionnaire survey on the evaluation indexes of Campus Landscape was conducted, and the suitability comprehensive evaluation index system was established. By the division of suitability grade, the set pair analysis theory was applied to the suitability comprehensive evaluation of Campus Landscape. Finally, taking the Zundao School in Mianzhu as an example, the school ground suitability comprehensive evaluation was made.

Keywords: Primary and secondary schools · Campus environmental landscape · Urbanization · Ecological civilization · Suitability · Evaluation

1 Introduction

China is known as one of the countries experiencing fastest urbanization development, and the statistic from National Bureau of Statistics shows that the urbanization rate rose from 51.27 % in 2011 to 52.57 % in 2012 and then to 53.73 % in 2013. Experts predict that the urbanization rate will arrive at 80 % in 2030 [1]. Despite having made significant achievements, urbanization also suffers a lack of ecological civilization [2]. The problems such as the out-of-control land use, the lower quality of regional environment, and the ecological destruction in urbanization construction, etc. [3], have posed a severe challenge to the sustainable and healthy development of cities.

The urbanization of China must consist with China's national condition and the concept of sustainable development, since it is the inevitable choice in the path toward ecological civilization. As a result of this, the development of urban green infrastructures is thought of as a significant measure to address urbanization problems and relevant urban problems by Chinese governments at all levels and the workers of

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landscape architecture, who have achieved remarkable effects through the successive implementation of landscaping projects as well as the protection and utilization of scenic spots [4].

Campus green space is the second largest green space in cities behind park. Notwithstanding the smaller area, campus is likely to make greater ecological contributions than the park as a habitat because cities are always brimming with a large quantity of homogeneous and scattered campuses. Provided campus landscape is properly built as a friendly habitat and connected through ecological corridor to shape an ecological network where living beings can shuttle between different habitats, it is inevitable that campus will play an irreplaceable role in protecting urban ecological safety, highlighting urban characteristics, and guaranteeing urban sustainable development.

The construction of eco-friendly campus landscape not only helps to maintain campus biodiversity, but also takes into account campus beautification and greening. Besides offering the teaching materials required by the education of natural science as the ideal place of outdoor teaching, campus landscape can contribute to physical and mental health of children. The outdoor experiential education can motivate children to learn, and involve them in the significant learning in campus learning habitat regarding new knowledge and skills to broaden their vision. Campus landscape can enable children to become aware of the life value, understand and respect universal living beings in learning process, develop their outlook on ecology and fully realize the beauty of nature. In this way, children will endeavor to strive for an agreeable environment in the future.

2 Survey on Campus Landscape Construction of Primary and Secondary Schools

2.1 Investigate Primary and Secondary Schools on the Spot

In order to gain deeper insights into the actual condition of campus landscape construction in China's urbanization process, the researcher has devised a biological habitat questionnaire, made a field survey on 10 local schools (see Table 1), and used the result obtained as the reference for Delphi method questionnaire.

- As shown by the field survey, the floor space of these schools ranges from 10,000 to 40,000 m^2, with over 50 % of the ground made up of hard pavement.

Table 1. 10 Local schools

School Name	Location
Daxijie Elementary School, Ziyan Elementary School, Zundao School, Xiaode Secondary school	Mianzhu, Sichuan
Xiaoquan National Primary School, Deyang Experimental Primary School, Deyang High School	Deyang, Sichuan
Wenchuan First Primary School, Wenchuan Yanmen school, Wenchuan First Secondary school	Aba Prefecture

- 60 % of campuses are adjacent to streets, and a lower number of biological species and living beings are allowed to enter campus from outside. However, a minority of schools neighbor uncultivated land or agricultural land, but the enclosure cannot stop the living beings from jumping into campus. As a result, the uncultivated land or agricultural land naturally becomes the heartland of schools, and besides, biodiversity is also raised as the living beings shuttle between school and outside environment.
- While designing and constructing a building, few schools take into consideration biological channels. In view of this, the researcher carries out an investigation into campus road system, finding that only 30 % of schools take advantage of natural materials. The footpath paved by Xiaoquan National Primary School with abandoned stones, for instance, shows distinct characteristic, whereas most of primary schools tend to make use of asphalt or cement, which is adverse to the activity of organisms in campus.
- In terms of plants selection, the researcher finds that 40 % of schools incline to grow native plants, and others prefer growing plants based on visual landscape. Though such plants are not ecologically meaningless, schools are heavy with landscape streets, which have obviously occupied the survival space of native plants.
- In order to maintain the beauty of campus, 90 % of schools assign weeding task to special person regularly, 70 % of them resorting to pesticide.
- Though 70 % of schools are equipped with a pool, none of them has built a creek. The bottom of the pool is made of cement and tile, without pores or side slopes for organisms, thus going against the requirements of ecological pool.

2.2 Interview with the Workers of Environmental Education Affairs

An interview with the management experts and environmental education workers of the schools above is conducted, and their working experience has educated the researcher about the concept and methods of campus landscape construction. According to the analysis on the identical and different views of the interviewees, the consistent opinions and conclusions are included in Delphi method questionnaire as reference. The interviewing result is summarized as follows:

- The interviews believe that campus biodiversity can contribute to building a new less-polluted Chinese town on the way to sustainable development.
- 60 % of interviewees argue that campus should be equipped with the habitats such as tree, grassland, and pond to attract varieties of organisms, whereas the remaining interviewees insist that there is no need to classify habitats, and the campus should be let develop naturally to attract the organisms.
- In terms of management, human intervention in organisms should be lessened, and the environment should be let develop naturally within permission limit. For instance, there is a need to sweep the fallen leaves, as well as reduce the weeding frequency and the use rate of pesticide. Besides, schools are supposed to arrange

special person or group to protect and monitor school's ecological environment so as to guarantee the sustainability of the biologically diverse campus environments.

- The interviewees hold that campus landscape construction requires multiparty participation. Administrative director is of great importance, since campus management is in the charge of administrative director. Additionally, a group of like-minded teachers are required to make environmental plan and design the course with joint efforts for the sake of the education about natural ecology. Besides, to seek the sponsorship of relevant units is also of vital significance; otherwise, it will be difficult to carry out the education of natural ecology based on a utopian scheme. While establishing the habitat design course, campus could provide an environment more suitable for learning if experts offer consultation service and assistance.
- The eco-friendly campus landscape is usually beneficial to environmental teaching, since teachers and children can often see the ecological natural phenomena such as about natural evolution, survival of the fittest, and the law of the jungle. Besides, the eco-friendly campus landscape can realize the functions such as life education, ecological teaching, and design of teaching situation.

3 Methods of Suitability Comprehensive Evaluation

3.1 Building of Evaluation Index System

As an outdoor learning place, campus landscape can inspire children to make discoveries, explorations, interactions, and individual communications in environment, and enhance the relationship with environment and the sense of ownership. To evaluate campus landscape is of vital practical significance [5, 6]. Suitability evaluation, frequently used in environmental planning, is primarily applied to urban construction land, agricultural land, natural reserves or tourism land, regional planning and landscape planning, project site, and environmental influence, etc. [7–9]. Considering that campus landscape is a combination of humanistic education, social economy, and eco-environmental system, the quality of environmental landscape construction is judged by means of suitability evaluation.

According to the information obtained through the field survey on the schools above and the interview with the workers of environmental education, this study complies the candidate index list for the comprehensive evaluation on campus landscape suitability as well as the Delphi method questionnaire. Then, 12 experts are invited to participate in the questionnaire survey until the questionnaire survey result converges. Afterwards, a statistical analysis is performed to build an evaluation index system.

Comprehensive Evaluation Index System of Campus Landscape Suitability includes four grades. Grade-I Index is comprehensive evaluation on campus landscape suitability. Grade-II Indexes are Inclusivity, Natural Environment, Place and Property, Flexibility and Changes. The Grade-II Index Weight corresponding respectively are A1 (0.285), A2 (0.222), A3 (0.358), A4 (0.135). The Grade-III Index and Grade-IV Index are shown in Table 2.

Table 2. Comprehensive evaluation index system of campus landscape suitability

Grade-III Index (Weight)	Grade-IV Index (Weight) – Case Evaluation Result
Universality A11 (0.063)	universality of users q1 (0.018) - Suitable
	fairness of campus landscape use q2 (0.018) - Highly suitable
	multicultural element utilization q3 (0.015) - Suitable
	embodiment of school history and background q4 (0.012) - Unsuitable
Accessibility A12 (0.08)	no use limitation on the disabled q5 (0.015) - Suitable
	the offering of route and location map q6 (0.015) - Highly Suitable
	the design of a proper space based on the frequency and size of children activity q7 (0.018) - Highly Suitable
	the dynamic flow and the requirement of silent children group q8 (0.018) - Suitable
	the selection of multi-functional facilities q9 (0.014) - Suitable
Participation A13 (0.069)	the participation of teachers and children in design and construction q10 (0.018) - Suitable
	the openness of participatory process to interest group q11 (0.018) - Suitable
	the role and function of children participation q12 (0.015) - Suitable
	the representativeness and reasonable operation of corresponding participating organizations q13 (0.018) - Suitable
Interaction A14 (0.073)	different types of interactive space q14 (0.022) - Suitable
	corresponding interactive space for different age groups q15 (0.018) - Suitable
	interactive space suitable for group size q16 (0.018) - Suitable
	space for self-expression and observation q17 (0.015) - Suitable
Biodiversity A21 (0.088)	different plant arrangements q18 (0.022) - Suitable
	the preservation and integration of existing plants to the largest extent q19 (0.018) - Highly Suitable
	the integration of natural elements into artificial environment q20 (0.018) - Suitable
	the offering of the habitat suitable for animals q21 (0.015) - Suitable
	the construction of an entire ecosystem with regional section jointly q22 (0.015) - Highly Suitable
Soil Conservation A22 (0.04)	topsoil conservation q23 (0.012) - Suitable
	topsoil conservation and reuse q24 (0.008) - Suitable
	excavation and filling q25 (0.008) - Suitable
	reduction of soil erosion risk q26 (0.012) - Suitable
Microclimate A23 (0.045)	the offering of natural sheltering to the largest extent q27 (0.015) - Suitable
	the reduction of cement pavement q28 (0.015) - Suitable
	maximization of greening area q29 (0.015) - Suitable
Water Resource A24 (0.049)	the collection of site water q30 (0.012) - Unsuitable
	the collection of water resource for site greening q31 (0.009) - Unsuitable
	the reduction of landscape water wastage q32 (0.012) - Suitable
	purification and drainage of surface water q33 (0.008) - Unsuitable
	the integration of campus landscape with site water design q34 (0.008) - Unsuitable
Landscape Environment A31 (0.075)	the combination of shelter, color and space q35 (0.015) - Suitable
	emotional design and expression q36 (0.015) - Suitable
	the creation of location awareness and sense of ownership q37 (0.018) - Suitable
	readability, diversity and graphic expression of guiding system q38 (0.015) - Highly Suitable
	the reasonable allocation of trees, and the requirement for shelter and light q39 (0.012) - Suitable

(*Continued*)

Table 2. (*Continued*)

Grade-III Index (Weight)	Grade-IV Index (Weight) – Case Evaluation Result
Outdoor Learning A32 (0.057)	the use of campus site in combination with teaching activity and course q40 (0.018) - Suitable
	the support and encouragement for outdoor learning q41 (0.015) - Suitable
	the seamless transition and convenient pass between indoor and outdoor environment q42 (0.012) - Suitable
	the integration of new technologies into campus site and its application q43 (0.012) - Suitable
Activity A33 (0.1)	the satisfaction of children's requirement for outdoor exercise q44 (0.032) - Highly Suitable
	children's gender, age, and confidence level q45 (0.025) - Suitable
	formal sports exercise space and affiliated facilities q46 (0.025) - Suitable
	the safety of children's outdoor play and sports field q47 (0.018) - Suitable
Silence And Reflection A34 (0.024)	the region of self-recovery and reflection in campus q48 (0.012) - Suitable
	space for children's pressure alleviation q49 (0.012) - Suitable
Display A35(0.054)	reasonable display of school image in campus q50 (0.015) - Highly Suitable
	the openness and hospitality expression of campus q51 (0.015) - Suitable
	opportunities for the display of children's achievements and skills q52 (0.012) - Suitable
	the influence of display site and pass way on school order q53 (0.012) - Highly Suitable
Safety A36 (0.048)	good visual field for monitoring q54 (0.018) - Suitable
	avoidance of hidden space resulting from greening q55 (0.015) - Suitable
	well-defined sign and clear control over entrance and exit and traffic route q56 (0.015) - Suitable
Space Requirement A41 (0.03)	the satisfaction of the requirement for spatial function and use in campus site q57 (0.018) - Suitable
	individual space size q58 (0.012) - Suitable
Multi-Purpose A42 (0.07)	the recognition of surrounding communities and sense of ownership q59 (0.015) - Highly Suitable
	monitoring over free access and activity safety of community members q60 (0.012) - Unsuitable
	the opportunities of children's class activities, after-class activities and weekend activities q61 (0.016) - Suitable
	the benefit for the exchange and interaction between children and adults q62 (0.015) - Unsuitable
	the utilization of campus site as community resources q63 (0.012) - Unsuitable
Functional Diversity A43 (0.035)	the satisfaction of current and future diversity requirement of teachers and students q64 (0.015) - Suitable
	serving the activities such as about teaching, sports, exchange and festival q65 (0.012) - Highly Suitable
	the use of non-exclusive space q66 (0.008) - Suitable

3.2 Set Pair Analysis

Set pair analysis (SPA) is a systematic analysis method that processes identical-discrepant-contrary quantitative analysis in the indeterminate system. Set pair analysis, proposed by Zhao Keqin-a Chinese scholar-in 1989, performs an analysis on the system from identical, discrepant and contrary angles, as well as studies the mutual transformation among them. The comprehensive evaluation on campus landscape suitability faces varieties of uncertainties, which can be effectively eliminated by means of set pair analysis.

The basic thinking of set pair analysis is: in the face of a certain question, two correlated sets X and Y are given to form a set pair (X, Y), and then, an analysis is performed on the set pair to figure out N characteristics, with S characteristics shared by the two sets X and Y, P characteristics contrary between the two sets X and Y, and F = N-S-P characteristics unclear (they are neither contrary nor commonly owned). S/N is defined as the identical degree H(X,Y), denoted by a; F/N is defined as discrepant degree or uncertain degree H(X,Y), denoted by b; P/N is defined as contrary degree H(X,Y), denoted by c. The correlation degree [10] of every different characteristic weight is expressed as follows:

$$\mu = a + bi + cj = \sum_{k=1}^{S} \omega_k + \sum_{k=S+1}^{S+F} \omega_k i + \sum_{k=S+F+1}^{N} \omega_k j \quad (j = -1, i \in [-1, 1], a + b + c = 1) \tag{1}$$

Where $\omega_k \left[k = 1, 2, \cdots, N, \sum_{k=1}^{N} \omega_k = 1 \right]$ refers to weight of characteristic. In this paper, the weight of each index in the comprehensive evaluation index system of campus site suitability in urban primary and middle schools is determined by means of AHP [11].

3.3 Grading of Suitability

The evaluation has three grades, namely, highly suitable, suitable, and unsuitable. When the weights of all the indices at the same grade are added together, the suitability evaluation result of the campus site can be obtained through Eq. (1) and denoted by correlation degree μ. As shown by Eq. (1), j = −1, and the value of i is obtained from [−1,1]; according to principle of equipartition, i = 0. Since the value range of the normalized correlation coefficient μ is [−1,1], the suitability grade corresponding to correlation coefficient can be seen in Table 3.

Table 3. Grading standard of suitability

Grade	Unsuitable	Suitable	Highly Suitable
Correlation Coefficient	$-1 \leq \mu \leq -0.333$	$-0.333 < \mu \leq 0.333$	$0.333 < \mu \leq 1$

In suitability evaluation, i has different values, which can reflect not only the suitability of campus site, but also the design, construction, and management level of this site. When i = 1, μ corresponds to the highest suitability of the site; when i = −1, μ corresponds to the lowest suitability of the site. The parties of campus site planning, construction, and management may on the one hand find out the vulnerabilities and non-sustainable factors according to the evaluation result of each index in index system, and on the other judge the grade of site suitability and work out the suitability degree of the campus site according to the value range of μ. On this basis, they can upgrade the suitability of the site through corresponding measures.

When $c \neq 0$ in μ = a + bi + cj-the equation of correlation degree, a/c-the ratio of the identical degree a to contrary degree c means the set pair trend against the background of a specific question, i.e., shi (H) = a/c. The order of the set pair trend that is arranged according to a/c value is termed as set pair trend order, with the relationship between the grade and order of set pair trend shown in Table 4 [12]. The set pair trend has revealed the development trend of site suitability, which has provided a direction for the parties of campus site planning, construction, and management.

Table 4. Relationship between grade and order of set pair trend

Grading	Relationship	Set Pair Trend (Meaning)
Equipollence	a = c, b > a	Slight Equipollence (The identical trend is equal to contrary trend in the system)
	a = c, b = a	Weak Equipollence (The identical trend is equal to contrary trend in the system)
	a = c, a > b>0	Strong Equipollence (In the system, though the identical trend is equal to contrary trend, but they are uncertain)
	a = c, b = 0	Quasi-Equipollence (In the system, though the identical trend is equal to contrary trend, but they are weak)
Identical Trend	a > c, b = 0	Quasi-Identical trend (The system has a certain identical trend)
	a > c, c > b	Strong Identical trend (The system is dominated by identical trend)
	a > c, a > b>c	Weak Identical trend (The system has a weak identical trend)
	a > c, b > a	Slight Identical trend (The system has a very weak identical trend)
Contrary Trend	a < c, b = 0	Quasi-Contrary trend (The system has a certain contrary identical trend)
	a < c, 0 < b<a	Strong Contrary trend (The system is dominated by contrary trend)
	a < c, b > a, b < c	Weak Contrary trend (The system has a weak contrary trend)
	a < c, b > c	Slight Contrary trend (The system has a very week contrary trend under the influence of uncertainties)

4 Case Study

Mianzhu Zundao School is a nine-year compulsory education school, and Zundaochang Town is 8 km away from the west of Mianzhu City. The 5.12 Wenchuan Earthquake in 2008 has delivered a heavy blow to Zundao School, 99 % of the teaching building turned into dilapidated building, all teaching facilities destructed. Following the urbanization of China after disaster, the renowned real estate company China Vanke donated a large sum of money to Zundao School for the sake of rebuilding. Covering a floor space of 35,666.67 ㎡ and a built-up area of 11,793.00 ㎡, the campus is equipped with web-based teaching facilities suitable in the 21st century, and the buildings are constructed with the advanced earthquake-proof technique that can resist against the seismic magnitude up to 9 degree. Meanwhile, the campus, near the mountain and by the river, highlights environmental landscape and comes out as a representative new urbanized school. Characterized by beautiful environment, modernization, humanistic care, and safety, the campus develops into the paradise where children learn knowledge (see Fig. 1).

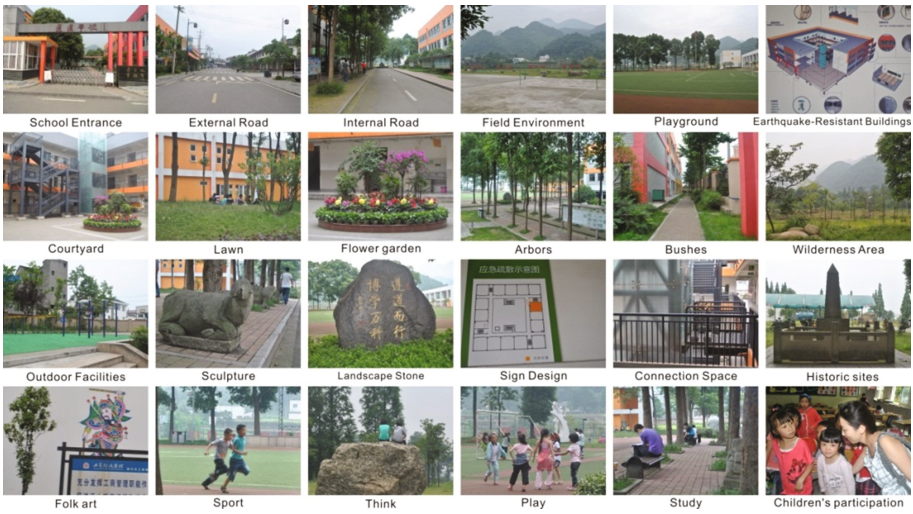

Fig. 1. Environmental Landscape of Manzhu Zundao School (Source: Author)

This study carries out a comprehensive evaluation on the suitability of this campus site by means of the abovementioned suitability evaluation system, with the evaluation result shown in Table 2.

According to the evaluation method above, the correlation degree can be figured out through Eq. (1):

$$\mu = 0.185 + 0.727i + 0.088j \quad (2)$$

When i = 0, μ = 0.097; the grade of environmental landscape suitability of Mianzhu Zundao School will be suitable, as shown in Table 3.

When i = 1 and i = −1, μ1 = 0.824 and μ2 = −0.63, respectively, with the value range of μ being [−0.63, 0.824]. This suggests that the campus site will be most suitable when μ1 = 0.824, and its grade will be highly suitable; however, the parties of campus site planning, construction and management should not feel satisfied with the present suitability degree of the campus site, but find out the vulnerabilities and identify the non-sustainable factors according to the unsuitable evaluation index and then upgrade the comprehensive level of campus site suitability with corresponding measures.

Analysis on set pair trend: in Eq. (2), a/c = 2.10, a > c, and b > a, which suggests that the system has a very weak identical trend; that is, the campus site is at suitable grade, but there is a very weak highly suitable trend. Additionally, b has a high value, which means that the index weight of suitable grade accounts for a large proportion. However, these indexes, which are seemingly suitable, will face grade decline as the campus site requirements and evaluation requirements increase; therefore, to avoid the unsuitable grade, there is a need to check these indices carefully and take corresponding measures to attain the highly suitable grade.

5 Conclusion

By investigating present construction situation, it was found that the Campus Landscape which was consistent with biodiversity and suitable for environmental education should possess the following 4 conditions: (1) building the comprehensive landscape site; (2) building the diverse biotopes environment; (3) implementing environmental education; (4) taking multi-participative construction and management measures.

Comprehensive evaluation index system of campus landscape suitability was conducted. There were 66 indicators involved in 4 categories being built: (1) inclusivity; (2) natural environment; (3) place and property; (4) flexibility and changes. In accordance with the Analytic Hierarchy Process and Set Pair Analysis, a scientific and objective platform was created for green campus decision-making operability in China's urbanization process.

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