EVALUATING CRITERIA FOR SUSTAINABLE CAMPUS IN FENG CHIA UNIVERSITY

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Abstract- The initiative of sustainable campus has attracted great attention from both the universities and the society themselves. Therefore it needs to set up a resource evaluation circulation mechanism, especially in university campuses. This paper proposes a framework of a more suitable approach to evaluating campus sustainability. We used the Analytic Network Process (ANP) to figure out each weight that influences the criteria during the decision of sustainable campus, and further to provide decision-makers and designers a reference index guiding school authorities in the policy planning or architectural design by these quantitative data. The result of the survey indicated that the materiality level between dimensions "resource use efficiency", "resource recycling", and "discharge of pollutant" are the same, and among the eleven criteria for evaluation, "resource recycling system", "resource supervise and control", and "management of sewage systems" is the most important impacting criterion. The finding can function as a reference for Feng Chia university which aim to assess the level of their sustainability in terms of campus in their organization.

Index Terms- Sustainable campus, Evaluation criteria, Analytic network process (ANP)

I. INTRODUCTION

The sustainability issues in higher educational organization had fascinate an increasingly level of attention from both public and policy decision makers during the past decades (Stephens & Graham, 2010). In nowadays universities also can be regarded as 'small cities' due to their size, population, and the various complicated activities taking place in campuses, which have some critical direct or indirect impacts on the environment and resource utilization[1]. As a result, a large number of applications of sustainable development criteria for campuses as small cities can be found in research.

We can see the development of guidelines actions mainly in the United States and Great Britain, which have set out to evaluate the efficiency of institutes of universities. Measuring their effectiveness had to be carried out on two levels, firstly in focusing on the relations universities maintain with their environment and secondly in highlighting the effectiveness of their internal operations [2]. And then, a large number of academic works have straighten out on experiments carried out in many country and have center upon the reasons which have led universities to apply such approaches, on the methodology used, on the difficulties they have confront as well as on the criterions they have chosen [3]. Like many other countries in the world, Taiwan has been emphasized sustainable development issues and have been allocated a significant amount of resources in this field. However, there are humble discussions about green university (GU) not to mention sustainable campus (SC). Basically, green university and sustainable campus is different in nature. Environmental issues are becoming more complex, the traditional practices and regulations of addressing environmental issues have become highly inefficient and cannot guarantee sustainability. Multidimensional and interconnected and environmental sustainability by its very nature requires an integrated and systematic approach to decisions making, investments and management[1]. Therefore, there is need for a professional and systematic environmental management approach to reducing the consumption of resources and negative impacts of the various campus utilizations and encouraging campus sustainability.

In developing the idea, we study past and on-going initiatives in the field of sustainable campus and green university and their respective evaluation criterias to demonstrate that not only is a set of criterias needed for efficient evaluating, but also consider sustainable recycle utilization of resources and carbon reduction, therefore, this paper proposes a more suitable integrated approach to achieving campus sustainability. Specifically, we propose using Analytic Network Process (ANP), it could remedy the limitations of the current environmental management practices in universities and ensures more sustainability through the integration of three strategies, resource use efficiency, resource recycling, and discharge.

II. REVIEW OF SUSTAINABLE CAMPUS EVALUATION SYSTEM

Sustainability affects every sphere of a university, from the classrooms and laboratories, to housing, transportation and other services, and to the entire campus. There is a common understanding in the

literature that a sustainable university campus implies a better balance between economic, social and environmental goals in policy formulation as well as a long-term perspective about the consequences of today's campus activities [4]. For a city or an organization to be sustainable, it requires conservation and enhancement of its resources base, an elimination of poverty and deprivation of its inhabitants, broadening of the concept of development so that it covers not only economic growth but also social and cultural development [5].

A. The existing sustainability discussions in universities

The work of green campus in foreign countries more focuses on spreading the idea, publicity and education. As early as in 1972, the conception of green school was put forward in the Stockholm Conference on the Human Environment, asking for the attention on the education of environment protection [6]. In 1990, over 300 university administrators in over 40 countries have signed the Talloires Declaration, a 10-point action plan for incorporating sustainability and environmental literacy in teaching, research, operations and outreach at colleges and universities. In 1992, the UN conference on Environment and Development was held in Rio, Brazil. In 1994, UNESCO put forward that the concept of sustainable development should be integrated in the education, and conducted the EPD (Education for Environment population and Sustainable Development) project, which aimed to accelerate the environment improvement, population quality uplift and social sustainable development, by the environment education, population education and sustainability education of adolescent and the whole society [6].

Compared with the foreign mode in which the foreign universities spontaneously pay more focuses on the idea spread, publicity and education, and have relatively weak enforcement of energy efficient technology application projects, the sustainable campus development in Taiwan begun with the demonstration of greening university and administrative management from the government. This led to a “green university” sustainability policies to promote the construction of green buildings and greening facilities, such as green street networks (by planting all available footpath locations with trees), planting trees in unused spaces, replacing pavement with trees and planted landscapes, and promoting the use of green roofs and cool roofs on campus buildings. It focus on environment greening and green building design.

B. Historical development of sustainable campus in Taiwan

In the early stage of campus energy conservation work, although the concepts of green schools, eco-campus, Green University have already been put forward at home and abroad, it has been difficult to be implemented due to the lack of specific approaches and concrete measures, so most of them just remained in the eco-awareness education level. In Taiwan, the government has a program named “green schools” (GS), which began from 1998 was the important turning point, and really opening up the pathway that leaded to the development of sustainable campus in Taiwan.

It was expect that the crucially criterias in GU practices can be identified and hence relevant administrative, operational, or educational policies can be implemented with scientifically determined priorities. The typical procedures for establishing sustainable development criterias were employed. That is, the essential issues regarding campus sustainability in university campuses were reviewed and examined and thus the primary content and structure of the evaluation system were designed. A total number of 19 candidate criterias and 44 subcriterias were proposed, which were classified into three major components, “environmental system”, “environmental management”, and “environmental education”. These criterias can then be used for self-appraisal or cross-university comparison [7].

But the Ministry of Education green university evaluation system has some problem, for example: Plan is a means to achieve the goals, it is a method but not a evaluation criteria. The sub-indicator "Research and develop plan of school disaster prevention and response" can’t be quantified, it is not suitable as an evaluation index. In the same situation, the subindication "Enforcement of green purchasing regulations" also can’t be quantified. We suggest it can be changed into "The proportion of procurement Green Mark products". In summary, we need to establish a more suitable evaluation criteria frame for sustainable campus.

C. The evaluation system of sustainable campus

To construct the evaluation framework, there were two working stages. In the first stage, the essence and important issues with regard to GU or sustainable campus were reviewed and analyzed. Rules for selecting criteria were also set up so that the primary content and structure of the framework can be determined. Tasks in this stage are basically consulted from literature. After finishing the draft of candidate criterias, the research will proceed to the second stage in using ANP to calculate and rank the weight of criterions.

As many criterions that represent the many elements and factors in all aspects for sustainable campus need to be included, we need to be classified and integrated so that a systematic picture can be viewed. The three basic components, “resource use efficiency”, “resource recycling”, and “discharge of pollutant” that contain major perspectives related to sustainable campus..

The definition of the criteria clusters and nodes or elements (sub-criteria) is essential when ANP is applied to support decision-making processes since the rank of the alternatives is based on such elements. Thus, based on previous studies and taking into

account the scenario defined for this study, a balanced set of criteria that provides a holistic assessment was chosen for evaluating the experts' preferences towards sustainable campus[1], [6], [7],[8], [9], [10], [11], [12].

Following the ANP nomenclature, the problem has been broken down into three clusters and fourteen nodes as follows (see Fig. 1):

Resource use efficiency

Represents the efficiency associated with the sustainable campus of the resource use management. It involves three nodes:

a1. Facilities management practices (FMP): We should design appropriate management practices according to the facilities life time. And according to the practices perform regular maintenance of the facility

a2. Monitoring the water, energy and air quality (MWEA): The target is to have better water use efficiency, energy control, improved ventilation and indoor air quality which contribute to healthy environments by reducing the dangerous air-pollutants that cause respiratory disease in campus buildings.

a3. Monitoring the waste (MW): This criteria provide college decision makers with a detailed understanding of a waste stream and enable waste management programs to be tailored to local needs.

Resource recycling

It represents the cycle utilization of the campus resource.

b1. Storage and treatment facilities of water resource (STFWR): means the university has embarked on water saving techniques using rain water harvesting water recycling or ground water extraction.

b2. Renewable energy facilities (REF): means making facilities physical changes such as energy supply side approaches increase the efficiency of providing the same level of services and reduce the use of energy that does not provide services or waste.

b3. Reuse, recycle and recovery of waste (RRRW): is a set of activities that include the following: collection, transport, treatment and disposal of waste; control, monitoring and regulation of the production, collection, transport, treatment and disposal of waste.

b4. Repurposing of unused space (RUS): It is talking about how to make good use of the campus derelict space to facilitate the learning activities and create the new activity space and atmosphere for community residents.

Discharge of pollutant

Refers to the “environmental pollution” of the campus environment in terms of resources used, emissions and quality.

c1. Sewage treatment facility (STF): the goal of this indication "Sewage treatment facility" has extended from protecting receiving water and human health to improving the environment sustainability.

c2. Waste electrical and electronic equipment (WEEE) treatment facility (WEEETF): means an integrated recycling system is proposed to realize WEEE high recycling rate for future WEEE recycling.

c3. Evaluation of volatile organic compounds (VOCs) emissions (EVoc): The main objective of this criteria is to quantify the volatile organic compounds (VOCs) emissions at the campus of the Universidad and to evaluate improvement scenarios associated with those activities making the greatest contribution in order to reduce campus emissions.

c4. Hazardous waste management (HWM): The objective of Hazardous waste management is to ensure safe, efficient and cost effective collection, transportation, treatment and disposal of wastes.

The decision problem was structured as a network integrated by the clusters and nodes previously defined as it is shown in Fig.1 It illustrates that the criteria clusters are interconnected with outer dependencies and the environmental and social clusters also have inner dependencies.

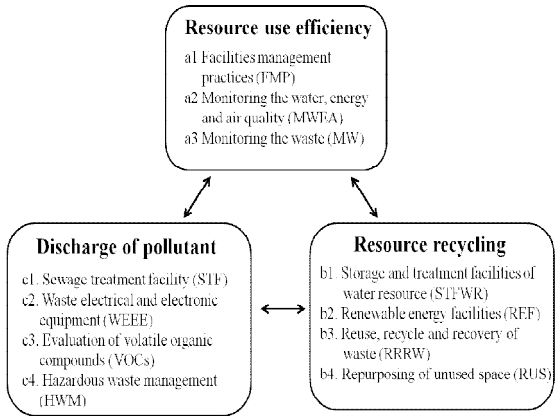


FIG.1 Network structure for the analysis of the sustainable campus evaluation frame in the ANP model

III. METHODOLOGY

In the context of evaluating criteria for sustainable campus, the ANP methodology is a useful tool since it allows modelling the problem as a network of criteria and alternatives (which are called elements), grouped in clusters [13]. All the elements in the network can be related in any possible way, considering feedback and interrelationships within and between clusters. According to[14] and [13], the ANP is comprised of the following main steps:

Step 1 Structuring the problem as a network

The problem should be stated clearly and be broken into clusters — including the alternative cluster — which are made up of various elements or nodes. Then, the relationships between nodes and clusters must be identified. Thus, it models a network which has cycles connecting its nodes and loops that connect components to themselves. The network structure can be obtained by decision-makers through brainstorming or other appropriate methods The whole complex of interrelationships should be represented through a matrix of interfactorial domination. The absence or presence of the influence between the corresponding

elements is displayed by zero—one entries, respectively.

Step 2 Conducting a pairwise comparison on the elements

To establish the relative importance of the different elements, with respect to a certain component of the network, experts and stakeholders are individually asked to respond to a series of pairwise comparisons. The comparisons are made using Saaty's Fundamental Scale which is a 9-point scale where a score of one represents equal importance between the two elements and a score of 9 indicates the extreme importance of one element compared to the other one [14].

Because the comparisons are carried out through personal judgement, it is essential to verify their consistency in order to guarantee that the judgments are reliable. Saaty in 1980 defined the consistency index (CI) and the consistency ratio (CR) as follows[15]:

$$CI = \frac{\theta_{max} - n}{n - I} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

where CI is the consistency index; θmax is the maximum eigenvalue; n is the number of elements in the judgement matrix; CR is the consistency ratio and; RI is the consistency index of a randomly generated reciprocal matrix from the 9-point scale, with forced reciprocals.

The CR is a measure of how a given matrix compares to a purely random matrix in terms of the CI. For matrixes larger than 3×3, a value of the $CR \leq 0.1$ is considered acceptable while larger values of the CR require the decision-maker to revise their judgements .

Pairwise comparisons between the applicable elements are used as the input to calculate the weighted priority vector which corresponds to the main eigenvector of the comparison matrix.

Step 3 Supermatrix formation

To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix, known as a supermatrix. It is a partitioned matrix where each sub-matrix is composed of a set of relationships between and within the levels. In the first step, an unweighted supermatrix is obtained which contains all the eigenvectors that are derived from the pairwise comparison matrices of the model. Subsequently, to obtain the weighted supermatrix, the eigenvector obtained from a cluster level comparison with respect to the control criterion (i.e. selection of the most appropriate evaluation criteria) is applied to the unweighted supermatrix as a cluster weight. If there is interdependence among clusters in a network, as usually happens, the columns of the supermatrix sum to more than one. Hence, the supermatrix must be transformed to make it stochastic.

Step 4 Final priorities

Finally, the weighted supermatrix is converged to obtain a long-term stable set of weights. In doing so, the weighted supermatrix is raised to the power of 2k, where k is an arbitrarily large number. The outcome of such process is called the limit supermatrix [15]. By normalizing each block of the limited supermatrix, the final priorities of all the elements in the matrix can be obtained. Because the weighted supermatrix usually covers the whole network, the priority weights of alternatives can be found in the column of alternatives in the normalized supermatrix. The alternative with the largest overall priority should be selected as it is the best alternative as determined by the calculations made using matrix operations.

IV. RESULTS AND DISCUSSION

FCU has a history of more than half a century. Over the next 50 years, an environmentally friendly, green campus will be constructed. In the design of its new Shuinan campus, sustainability concepts will be incorporated to complement the development of the Taichung Gateway District and College Town. The goal is to become a campus with low carbon emissions, thereby fulfilling FCU's environmental and conservation responsibilities.

This study, set up the specific objective of incorporating green concepts and Sustainability to create a blueprint for the Future. This task was given to the decision makers of this article for whom research primarily focuses on designing sustainable development indicators relating to other issues, which carrying out a comprehensive evaluation of progress made in the area at the level of the university as a whole.

A team of 20 evaluators from the academic, research and student fields were asked to fill out a thoughtfully designed questionnaire to collect evaluators' preferences. The objective of involving members from three networks was to have a balanced and representative panel of evaluators.

A questionnaire is designed in the form of a pair-wise comparison based on the ANP model described above (see Fig. 1). As an example, evaluators make pair-comparisons among sub-criteria under perceived advantages with respect to the sub-criteria peer influence under perceived external influence (see Appendix B for an example of the ANP questionnaire). An ANP questionnaire format (nine-point rating scale) indicates the dependence relationships and interactions among sub-criteria. After 20 evaluators finished their assessments of relative importance among sub-criteria, the geometric mean was used to aggregate the pair-wise comparison matrix.

Tab.1 Unweighted supermatrix of the ANP model.

	FMP	MWEA	MW	STFWR	REF	RRRW	RUS	STF	WEEETF	EVoc	HWM
FMP	0	0	0	0.31081	0.4	0.16342	0.53961	0.29696	0.31081	0.29696	0.31081
MWEA	0	0	0	0.49339	0.4	0.29696	0.29696	0.53961	0.1958	0.53961	0.1958
MW	0	0	0	0.1958	0.2	0.53961	0.16342	0.16342	0.49339	0.16342	0.49339
STFWR	0.31562	0.52874	0.28768	0	0	0	0	0.41549	0.25363	0.28632	0.13959
REF	0.14422	0.16514	0.15207	0	0	0	0	0.18495	0.17664	0.182	0.18441
RRRW	0.48142	0.23431	0.49311	0	0	0	0	0.29259	0.47628	0.43478	0.60019
RUS	0.05874	0.07181	0.06714	0	0	0	0	0.10697	0.09345	0.09 69	0.07581
STF	0.39052	0.39052	0.19526	0.45822	0.39052	0.39052	0.39052	0	0	0	0
WEEETF	0.13807	0.27614	0.27614	0.24038	0.19526	0.13807	0.13807	0	0	0	0
EVoc	0.27614	0.19526	0.13807	0.18512	0.13807	0.27614	0.27614	0	0	0	0
HWM	0.19526	0.13807	0.39052	0.11628	0.27614	0.19526	0.19526	0	0	0	0

The CR of all pairwise comparison matrices was found to be less than 0.1. Hence, there was consistency between all experts' opinions. In order to facilitate computations and enhance the accuracy in scoring, ANP application was developed through the use of the specific Superdecision software.

Tab2 Cluster weight matrix.

Dimention	Weight	Ranking
Resource use efficiency	0.333	1
Resource recycling	0.333	1
Discharge of pollutant	0.333	1

Tab3 Weighted supermatrix of the ANP model.

	FMP	MWEA	MW	STFWR	REF	RRRW	RUS	STF	WEEETF	EVoc	HWM
FMP	0	0	0	0.1554	0.2	0.08171	0.26981	0.14848	0.15541	0.14848	0.15541
MWEA	0	0	0	0.2466	0.2	0.14848	0.14848	0.26981	0.0979	0.26981	0.0979
MW	0	0	0	0.0979	0.1	0.26981	0.08171	0.08171	0.24669	0.08171	0.24669
STFWR	0.1578	0.2643	0.1438	0	0	0	0	0.20775	0.12682	0.14316	0.06979
REF	0.0721	0.0825	0.0760	0	0	0	0	0.09247	0.08832	0.091	0.09221
RRRW	0.2407	0.1171	0.2465	0	0	0	0	0.1463	0.23814	0.21739	0.30 01
RUS	0.0293	0.0359	0.0335	0	0	0	0	0.05348	0.04672	0.04845	0.0379
STF	0.1952	0.1952	0.0976	0.2291	0.19526	0.19526	0.19526	0	0	0	0
WEEETF	0.0690	0.1380	0.1380	0.1201	0.09763	0.06904	0.06904	0	0	0	0
EVoc	0.1380	0.0976	0.0690	0.0925	0.06904	0.13807	0.13807	0	0	0	0
HWM	0.0976	0.06904	0.19526	0.05814	0.13807	0.09763	0.09763	0	0	0	0

Tab4 Limit supermatrix of the ANP model.

	FMP	MWEA	MW	STFWR	REF	RRRW	RUS	STF	WEEETF	EVoc	HWM
FMP	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098
MWEA	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
MW	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
STFWR	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
REF	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
RRRW	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136
RUS	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
STF	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124
WEEETF	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
EVoc	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
HWM	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069

The unweighted supermatrix was non-stochastic by columns because different nodes from different clusters have influences on one element. Hence, using the cluster pairwise comparison matrices and considering the cluster weights matrix (Table2), the weighted supermatrix was generated (Table3). Subsequently, the weighted supermatrix was raised to sufficiently large power until convergence occurred. The outcome is the limit supermatrix which is column stochastic and represents the final eigenvector (Table 4).

In Table 5, the priority weight of criteria (local weights of criteria) is equal to sum of its sub-criteria weights. The priority weights of sub-criteria within their clusters (local weights of sub-criteria) are calculated by normalizing their priority weights in the related criteria.

The result of the survey indicated that the materiality level between dimensions “resource use efficiency”, “resource recycling” and “discharge of pollutant” are the same. This outcome shows that for a campus sustainable development these three dimensions are equally important.

Tab.5 Weights and ranking of criteria and sub-criteria.

Dimention	Weight	Ranking	Criteria	Weight	Ranking
Resource use efficiency	0.333	1	FMP	0.098	6
			MWEA	0.129	2
			MW	0.106	5
Resource recycling	0.333	1	STFWR	0.114	4
			REF	0.056	10
			RRRW	0.136	1
			RUS	0.027	11
Discharge of pollutant	0.333	1	STF	0.124	3
			WEEETF	0.070	8
			EVoc	0.071	7
			HWM	0.069	9

In different dimensions, different indicators with varying degrees of influence. Three dimensions and 11 factors under them contribute to the environmental sustainability. Table5 shows the priorities of the criteria under environmental sustainability. First of all, according to the result of Resource use efficiency dimension, The most important factors are Reuse, recycle and recovery of waste (RRRW) and Storage and treatment facilities of water resource (STFWR). The factors Repurposing of unused space (RUS) and Evaluation of volatile organic compounds (VOCs) emissions (EVoc) are insignificant for environment sustainability. This indicates that in order to improve campus environment sustainability, more focus should be invested in Reuse, recycle and recovery of waste (RRRW) and Storage and treatment facilities of water resource (STFWR).

The relative importance of resource recycling for campus sustainability is Monitoring the water, energy and air quality (MWEA), and the factor waste electrical and electronic equipment (WEEE) treatment facility (WEEETF) is insignificant for environment sustainability. This demonstrates that better environmental sustainability performance of the cycle utilization retrofit is mainly driven by better monitoring the water, energy and air quality, improvement in the reducing negative impacts on environmental degradation.

All the factors in Cluster 1 project organization have a higher priority than other factors. The most important factor is RRRW and MWEA. The factors RUS was insignificant with respect to discharge of pollutant, indicating that environmental pollution performance of the campus is mainly decided by RRRW and MWEA, such as improve resource recovery or reduce the water use rate.

Eventually, relative weights for each criteria was found out as shown in Table5, The 6th criteria (RRRW) is preferred as the most eligible partner since it has the greatest relative weight of 0.136. The rest of the candidate criterions are ranked as MWEA (0.129), STF (0.124), STFWR (0.114), MW (0.106), FMP (0.098), EVoc (0.071), WWWETF (0.07), HW (0.069), REF (0.056), RUS (0.027).

CONCLUSIONS

The opinion that a sustainable university campus should be a healthy campus environment, with a prosperous economy through energy and resource conservation, waste reduction and an efficient environmental management, and promotes equity and social justice in its affairs and export these values at community, national and global levels[1].

From university managers and campus planners perspective, this study involves several implications. While the final solution of our assessment would be very useful for them, it should be noted that the methodological approach followed to support the decision making process might be also of great usefulness. It has been illustrated that ANP method provides significant practical benefit in its ability to structure the overall decision making process and to identify the importance of the different assessment criteria based on their dependencies. Moreover, as articles pointed out, ANP allows the decision makers to evaluate projects ex-ante but also ex-post. In this situation, it is assessed whether the intuition of the decision makers was correct. The flexibility of the methodological approach followed in this study is also an important benefit for managers and policy makers. Thus, different cluster, criteria and alternatives can be introduced in the assessment. It means that the decision making process can be accommodated to different size and scale dimensions of the project to be evaluated and also that the perceptions and knowledge of the stakeholders can be introduced in the assessment.

This paper analyzed an ANP model for evaluating criteria for sustainable campus in Feng Chia University, which is valuable to decision-makers engaged with the complexities inherent in the sustainable evaluation system. Three dimensions for sustainable campus and 11 criteria of the evaluation mechanism were identified in previous research. In this research, the final priorities and relationships between CSFs and KPIs were revealed by adopting an ANP approach. The final result of the ANP model indicates that sustainable campus in Feng Chia University under the evaluation mechanism is mainly determined by reuse, recycle and recovery of waste, monitoring the water, energy and air quality and Sewage treatment facility. Decision makers should dedicate more attention to these aspects. Weightings and relative importance of all the critical success factors were also identified in this paper.

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