Green Campus Community Management Using Fuzzy Analytic Hierarchy Process Evaluates in Taipei

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Abstract: Neihu Environment Awareness Group (NeihuEAG) aims to promote environmental awareness, saving energy architectural design and environmental education dissemination related to sustainable use of the campus in Taipei. From the viewpoint of urban heat island mitigation as well as energy efficiency, by field survey, the Fuzzy Analytic Hierarchy Process (FAHP) analysis technique has been applied for multivariable parameters while toward a green campus community. An empirical study was conducted to examine the FAHP of management evaluation model to effectively promote the quality of decision making that can be referenced for further related campus development researches. Results show that twenty- six low level dimensions can be deduced from three upper hierarchical levels. The six middle dimensions are: (1) preservative area and total greening building; (2) air quality and ventilation; (3) rain infiltration and storm mitigation design; (4) low sensible heat building; (5) natural resource utility; and (6) economic management and environmental education. The dimensions expressed by our expert group questionnaire data in the Neihu campus community of Taipei city can be ranked and weighted collectively for 23.70%, 20.60%, 19.70% 17.50%, 10.50% and 8.00 % for the six aforementioned dimensions, respectively. The method may be helpful to decision-makers for green campus community.

Key-words: FAHP, Green campus, saving energy, Low sensible heat building, Urban heat island mitigation

1. Introduction

Campus is an adequate place and example as a reality of environmental education and can enhance student concerning about sustainability [8]. Also, it can influence local residents and governor to think about strategies for determining how and whether a community campus could move toward sustainable development in today's fast deteriorating and changing environment. In order to construct campus buildings that promote sustainable development, several problems have to be addressed. One of the major problems is urban heat island mitigation by architectural design in campus building. Other problems, for instance energy use, green material use, involving issues such as natural ventilation, recyclable, waste minimization, and the impact on indoor air quality, are also important; but energy efficiency is the most single important factor. As energy use often has serious environmental impacts on urban heat island effect [14], both locally and globally [18]. Recently Taiwan is experiencing a regional scale heat island effect and diurnal temperature over Taiwan has decreased by about 1.1 degrees since 1950 [10]. These changes have been significantly induced by highly urbanization and its non-green architectural design, residents lacking of environmental concept etc. Thus, the impact of the urban climate in the subtropical Taipei city is alarming [11].

It is urgent and necessary to evaluate the energy use both for operation and for production and maintenance of the campus building during its lifetime. Well known of Taipei's dense population, the private and public buildings are rather crowed and mess. Among them campus buildings are less crowed and usually have more open space to be used by local residents.

Consequently, campus is an ideal field to promote sustainable concept that can provide and teach local residents good example of green building and further influences their houses, then extends to entire city. It means campus is an important transition place between single building (small size) and huge urban (big size) while we strive to reach a sustainable city. Nevertheless fulfilling the sustainability for community is very hard due to its nature of complication.

In reducing energy input planning research, Kumar et al. [9] stressed that through climate-responsive design, optimization of embodied energy by means of value engineering and life cycle costing. Lower environmental impact can be achieved through optimization of land use, maximizing landscape integration, recycling rain water, avoiding toxic materials, planning ecological pond, enhancing precipitation infiltration and minimizing pollutants emissions [3, 4, 12]. Huang et al. [5] pointed out that adaptation of the form, such as opened first floor building or shortening building length not only reduced the PM10 concentration for 80% but increased the average wind speed to 0.04 m/s on some spots.

Prianto et al., [16] revealed that air movements inside a building depend not only on external wind velocity, but also a number of architectural design element, and the effect of architectural design in naturally ventilated building can obtain thermal comfort in tropical humid regions. Furthermore, using the extensive photovoltaic (PV) arrays installed on the Ma Wan School can contribute to meet 10% of the School's annual electricity demand [7]. Karol [8] launched a project to raise their awareness of the complexity of addressing sustainable use of the campus and identified the potential influence of architect designed projects on the natural environment.

In this study we aim to select a case in Taipei city of Taiwan and try to find a systemic method [1] in order to provide managers in a more organized understanding with these problems and offer them more effectively management strategy toward sustainable campus. Among systemic methods, the Fuzzy Analytic Hierarchy Process (FAHP) is a more integrated application which breaks down a complex problem into simple hierarchical decision-making procession, and can be incorporated with fuzzy logic to show the relative strength of the factors in the corresponding criteria, thereby enable the construction of a fuzzy judgment matrix to facilitate decision-making in promoting sustainable community [19, 20]. However, FAHP has not been applied in a sustainable campus community study yet.

In this work we tried to apply it in a campus case in Neihu Community of Taipei city. The goals of this research are: (1) to study the three levels hierarchical indicators considered as management strategy by using FAHP analysis and by investigating campus in Neihu district of Taipei city; (2) to analyze benchmarks by questionnaire survey from expert and residents that would promote a sustainable campus community, and (3) to concern effective energy use and architectural design considered urban heat island mitigation.

2. Site and method

2.1 Site

Lifu elementary school campus is located at Neihu district where lies in the northeast corner of Taipei basin (Fig. 1). The total area of Neihu district measures approximately 31.6 square kilometers and is the third large district in Taipei. Moreover it is one of the administrative districts close to the mountain area in the Taipei. Recent decades the newly established Technology Park, a high-tech industrial center, and getting more population all make it more crowed and also deteriorating natural environment [13].

In 2007 Neihu Environment Awareness Group (NeihuEAG) is established by a group of volunteers at Department of Architecture, Taipei University of Technology in Taipei, Taiwan, who work together to promote awareness, activities and environmental education dissemination related to sustainable use of the campus community. This group was motivated by concerning the Lifu elementary school as a case study, where was built in a modern architectural style in its campus though located on a mountainous area.

After surveying this school campus, NeihuEAG identified many problems. For example, the site planning of campus is not benefit to urban heat urban mitigation, natural ventilation, and energy efficiency. Moreover, the entrance is rather closed, more close to road, and unfriendly for visitors due to its guarding consideration (Fig. 2), and there is not enough space in planting trees, greening building, infiltrating design, etc.; connections are not easily accessible to natural environment (mountainous area) from layout of classroom buildings. Two main problems existed when promoting to establish the community's campus sustainability: (1) it is not enough preserved in environmental ecology, greening planned, infiltration spaces, and saving energy sites; and (2) there is no clear plan for controlling campus preservative area as well as economical management.

This investigation that promotes a green campus in Lifu elementary school is the first attempt and will include other ones in all Niehu district of Taipei.

2.2 Method

We received 14 expert questionnaires from 15 issues, thus the recovery rate is 93.33%. A total of 12 valid questionnaires are adopted after CR value consistency test that used for the FAHP analysis. The procedures for this survey include three steps: (1) compute benchmarks for each hierarchy dimension to obtain the weights for each sustainable benchmark; (2) after crossing over each dimension and hierarchy benchmark weight value, the absolute weight value for each sustainable benchmark is obtained; and (3) benchmarks of relative importance and absolute importance can be ranked to derive the ranking importance based on the corresponding weight value and absolute weight value. Overall, this system established three levels: (1) upper level hierarchy; (2) middle level hierarchy; and (3) low level hierarchy including twenty-six sustainable benchmarks, as shown in Table 1. Then these benchmarks weighting values were computed for each of the hierarchy levels.

3. Weight value of low level hierarchy

The low level dimensions of this study were derived from the secondary benchmarks coming from the combination of the three upper level dimensions with the six middle level benchmarks. In other words, the sustainable campus community benchmark system is a "base level benchmark" which implies it is important for the base level dimensions. In this paper we analyzed the levels of the basic benchmarks that are not only similar to the upper level and middle level benchmarks, in terms of hierarchy, quality with finer quantitative degrees but are linked to a certain degree. For benchmarks in the same level, the effects of the different dimensions are minimal while the combination and complexity of the upper and middle levels are more complicated. Due to the large number of the benchmarks, the study investigated the corresponding dimensional weights and absolute weight dimensions of the low level benchmarks. Simultaneously, we focused on a basic and overall analysis of the three upper level dimensions.

Fig. 3. shows that 15 experts suggest the main three highly significant items of dilemma in promoting green Neuihu campus are: "lack of environmental concept", followed as "not actively promoted by government" and "not legislated by architectural law" in Taipei. Fig. 4 shows three upper level dimension that includes (１) energy efficiency dimension; (2) resource recycle utility dimension, and (3) economic management dimension. And six middle level dimension have: (1) preservative area and total greening building dimension; (2) air quality and ventilation dimension; (3) low sensible heat building (4) rain infiltration and storm mitigation design dimension; (5)natural resource utility dimension, and (6)economic management and environmental education.

3.1. Low level benchmark in energy efficiency dimension

In terms of the preservative area and total greening building dimension, the former is related to preserve original land, and is important and superior to do compared to the later.

3.1.1 Preservative area and total greening building

Reduced developed land is the highest at 37.3%. This means the related benchmarks to those include remain original natural land, limiting land use, etc. Because it is full of biodiversity and hydrological circulation in natural environment, and has high priority than greening after land used as buildings. Regarding to preservative area and total greening building dimension, the most important items are to increase the proportion of green cover over the land and improve the biological habitat and the sustainability of the ecological environment. Also, these not only are conducive for trees growth etc. but are beneficial for the micro-organisms in the land and organic production, enhancing local microclimate, and filtering noise. Most important, they absorb carbon dioxide, producing oxygen, replenishing the atmosphere, lowering heat island effect, preserving water and land, and cleaning the air. The effects are far reaching and effective in developing a sustainable community campus.

3.1.2 Air quality and ventilation dimension

The most important benchmark is interior natural ventilation at 30.65% in the dimension, and is closely related to use conventional design element as position and orientation of building, roof shape, balcony configuration, type and location of windows, partition and furniture arrangement. Changes in these elements can modify interior airflow magnitudes and patterns [2, 6, 15]. Overall, this dimension includes air quality and ventilation.

3.1.3 Low sensible heat building dimension

Concerning natural ventilation inside building is the highest at 37.62%. This means the related benchmarks to natural ventilation include keep a better layout and distance between different buildings, and building designed to emphasize outside and interior natural ventilation. Related literature also indicates that in terms of urban heat island mitigation, sensible heat flux low (reduction) for the layout of building, roof garden, surface serves as evaluation variables [17]. Consequently, sensible heat flux low building can be planned from architectural design that most concerns the heat island effect mitigation.

3.2 Low level benchmark in resource recycle utility

3.2.1 Rain infiltration and mitigating storm design dimension

In this rain infiltration and storm mitigation storm design dimension the most important benchmark is the site designed to can absorb storm rain at 40.85%. Generally effective conservation of water infiltration means we can spend less in installing to access them and simultaneously reduce impacting on natural resources. This dimension is important for constructing a sustainable campus community. The relationship between rain infiltration and land ecology is rather important. As the micro-organisms in the water and land are important elements, the water penetration rate not only affects on the organism activity in land and biological existence but also helps on hydrologic circulation and on decreasing runoff [3, 5, 19].

Water and land preservation is closely related to campus microclimate improvement. Good planning for water penetration is beneficial to the cycle of hydrology, animal, and plant organisms etc. thus lessens the loading on urban structures or urban heat island due to their negative impacting on ecological environment.

3.2.2 Natural resource utility dimension

The community-based natural resource management will promote planning more natural light, renewable energy, big trees in campus. The most important benchmark is a planned rain water reuse system at 26.73% in the dimension.

3.3 Low level benchmark in economic management

This level includes economic management and environmental education dimensions. The most important benchmark is to install simple saving energy equipment in the dimension.

4. Conclusion

This study uses sustainable campus community benchmarks to conduct expert surveys and adopts FAHP to analyze investigated data. The six middle dimensions are: (1) preservative area and total greening building; (2) air quality and ventilation; (3) rain infiltration and storm mitigation design; (4) low sensible heat building;

(5) natural resource utility; and (6) economic management and environmental education. The dimensions expressed by our expert group questionnaire data in the Neihu campus community of Taipei city can be ranked and weighted collectively for 23.70%, 20.60%, 19.70% 17.50%, 10.50% and 8.00 % for the six aforementioned dimensions, respectively. The major findings and recommendations of this study may be summarized as follows:

(1)Campus is a place represents a benefit environment and enjoying open space. Moreover, it is relatively easy to promote it toward a sustainable campus while comparing a sustainable urban in Taipei. Thus, many volunteer groups and individuals have been participating in sustainable community campus promotion projects to achieve our vision for Neihu as a beginning case of sustainable community campus.

(2) In terms of considering geography, city, and culture, the Neihu campus community can combine the natural green belt, parks, and natural environments with ecological characteristics, they will establish this campus community to have a green building feature in Neihu District. Moreover integrating to green community spaces, land, and related resources, community inhabitants and neighborhood structures, thus the surrounding green systems all will be harmoniously got along.

(3) For constructing community sustainability, the NeihuEAG can been involved to improve the professionalism of the community construction, such as promoting local campus managers and residents understanding green architectural design of campus sustainability in the campus community.

(4) 15 experts suggests the main three highly significant items of dilemma in promoting green Neuihu campus are: “lack of environmental concept”, followed as “not concerning energy saving” and “lack of good sample in sustainable building” in Taipei.

(5)After the awareness of environmental preservation has been raised local campus managers and residents can take the initiative and concern local problems actively in this campus community. Eventually local campus students and residents all can also been encouraged to serve as volunteers for campus, or their houses to concern planting trees, infiltration, saving energy, natural ventilation etc., thus they can have stronger awareness to protect their environment.

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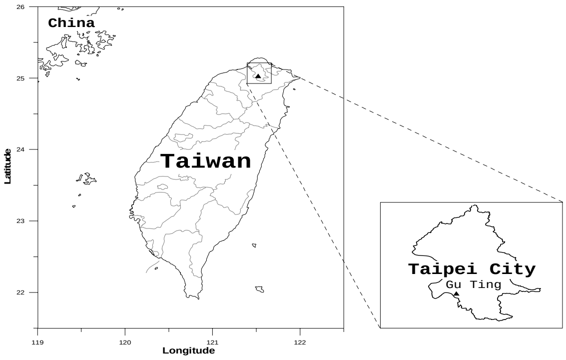

Fig. 1. Location of Lifu elementary school campus at Neihu district in Taipei city.

Fig. 2. Lifu elementary school designed in modern and high energy used building, where locates on mountainous area in Niehu district, Taipei.

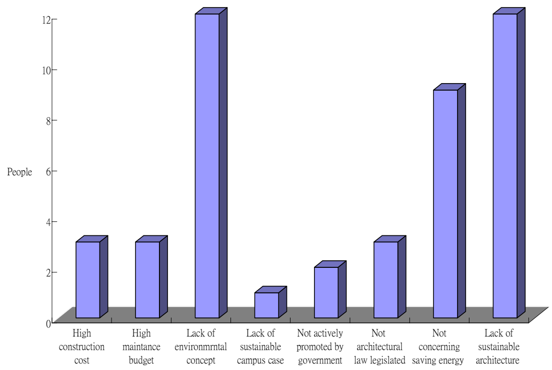

Fig. 3. The opinion indicating the most highly significant items of dilemma in promoting green Neuihu campus is "lack of environmental concept", "not concerning energy saving" and "lack of good sample in sustainable building" in Taipei. Y axis represents numbers of supports from 15 experts.

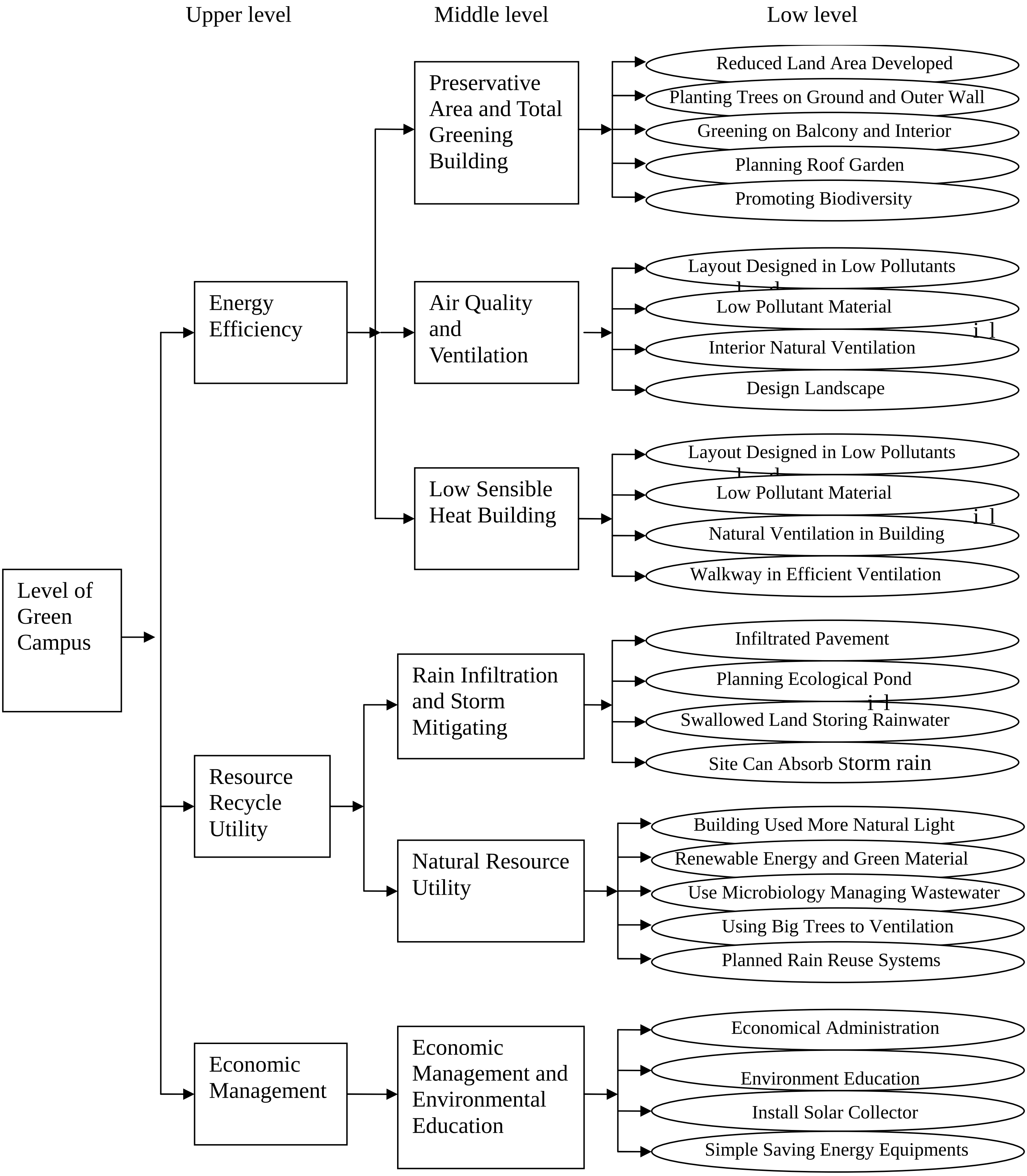

Fig. 4. Levels of toward a sustainable campus study using FAHB method in Taipei.

Table 1 Results of expert group decision evaluation using FAHP in campus in Taipei.

Low level Benchmarks				
Benchmark	Relative Weight	Relative Rank	Absolute Weight	Absolute Rank
1. Reduced Land Area Used	37.30	1	8.84	1
2. Planting trees on Ground and Outer Wall	17.80	3	4.22	10
3.Greening on Both Balcony and Interior	7.60	5	1.80	23
4. Planning Roof Garden to Improve Microclimate	15.00	4	3.56	13
5. Concerning Biodiversity	22.30	2	5.29	7
6. Layout Designed in Low Pollutants Accumulated	28.30	2	5.83	5
7. Low Pollutant Emission in Building Material Selected	19.97	4	4.11	11
8.Building Designed to Emphasizing Interior Natural Ventilation	30.65	1	6.31	4
9.Designed Landscape	21.98	3	4.53	9
10. Low Sensible Building	21.78	3	3.81	12
11. Wall Designed to Retard Sun	12.87	4	2.21	19
12. Concerning Natural Ventilation inside Building	37.62	1	6.58	3
13. Walkway in Efficient Ventilation	27.73	2	4.85	8
14. Infiltrated Pavement in campus	15.56	4	3.07	15
15. Planning Ecological Pond to clarify Water Quality	15.79	3	3.11	14
16. Swallowed land to storage rainwater	27.80	2	5.48	6
17. Site Designed to Can Absorb Storm Rain	40.85	1	8.05	2
18. Building Used More Natural Light	18.98	4	1.99	21
19.Using Renewable Energy and Green Building Material	19.30	3	2.03	20
20.Use Microbiology to Manage Wastewater	9.80	5	1.03	26
21. Using Big Trees to Ventilation	25.19	2	2.64	18
22. Planned Rain Reuse System	26.73	1	2.81	17
23. Economical Campus Administration	19.92	3	1.59	24
24. School Functioned As Good Sample of Environment Education	24.40	2	1.95	22
25. Installing Solar Collector	18.95	4	1.52	25
26. Installing Simple Saving Energy Equipments	36.73	1	2.94	16