Relationships between Sustainable Campus Partial Renovation Project and Disaster Prevention Indices

Jhun-Iuan Kuo¹, Cheng Chuko², Huang Chih Tung¹, Wei-Cher Huang¹, Fang-Lin Chao²

¹ Department of Architecture and Urban Design, Chaoyang University of Technology, Taichung, 436, Taiwan.
² Department of Industrial Design, Chaoyang University of Technology, Taichung, 436, Taiwan.
E-mail: cchuko@cyut.edu.tw

Abstract. The relationship between sustainability and campus disaster prevention was investigated. From understanding the characteristics of campus, ecology, and energy, people can establish a diverse campus environment and create an eco-education demonstration zone. Descriptive statistics and one-way ANOVA were utilized to investigate the operation and money flow of "Sustainable Campus" by the Ministry of Education. Through comparing multiple criteria decision, we verified factors from "Instruction of Disaster Management for Campus." The results indicated: north Taiwan has the most ecology and health indicators, along with the most frequent natural water purification processing. Middle and south areas have the most permeable pavements, and the east region is notable for its multilayer ecological greening projects. By the result of the Delphi method questionnaire, we established six main applications for sustainability and disaster management: "building materials and natural resources," "permeable pavements." The global actions indicated more resourced placed on aspects of "indoor environment improvements" and "rainwater recycling."

1. Introduction

1.1. Natural disaster
Climate change and over-exploitation caused a natural disaster. Many rainfall-induced severe, large-scale landslides occurred during the last two decades in Taiwan [1]. Catastrophic landslides often happen without warning since the slight topographic creeping is hard to be detected. Recent studies have highlighted the ecological and geomorphological importance of wood debris to forested stream ecosystems [2]. People try to protect channels against the effect of erosion; biomaterials were installed on slopes, channel bed, and along river banks [3]. Vegetation based solutions were found to be more effective than the mechanical methods of streambank stabilization. Vegetation application on the flood-damaged bare ground also found to be very successful [4].

1.2. Environmental Education Act
The Legislative Yuan passed the Environmental Education Act in 2011 [5]. This law makes people are more environmentally conscious at school and society. People are required to attend four hours of environmental education each year in the form of lectures, discussions, internships, and group visits. Landslide is a significant natural and sociological event. Obtaining accurate landslide damage data and
outlines the need for reliable, standardized methods to evaluate landslide damage and associated restoration costs. The regional and local administrations can help community or school in the aftermath of a landslide event [6]. The person is familiar with the environmental problem, and its causes will act to lower the impact on the environment. People with pro-environmental attitudes are more likely to engage in protective behaviors. Some challenges facing humanity are climate change and future food security, and current dietary patterns are contributing significantly to these problems [7].

1.3. Instruction of Disaster Management for Campus in Taiwan
Sustainable Campus Innovation Education Sharing Platforms were built on social media. This platform also provided a sustainable campus participation team school and counseling group. Distribute experience to the several community-related green building, green building materials, campus and classroom ventilation, lighting, heat insulation, humidity control, and health. School is not a completely closed environment; the college may also be affected by the community disaster.

It is necessary to adjust the direction that how to re-quantify or determine individual schools in the community [8] from the disaster resilience. Among the three dimensions of disaster prevention literacy (knowledge, attitude, skills), the participants were highest on disaster prevention skills and lowest on disaster prevention knowledge [9]. Ministry of Education established a particular office to promote disaster prevention (Figure 1). The local government’s Education Bureau provides resources for counseling and basic renovation project. Through the connection between the local community and campus, the overall efficiency Increased by connecting with people and resources (Figure 2).

---

Figure 1. "Perpetual Campus Promotion Plan" planned by the Ministry of Education

Figure 2. Education bureau disaster prevention: counseling
2. Fuzzy Delphi method

Delphi is an essential method in policy science. It is based on expert judgment and uses the process of brainstorming to speculate on the phenomenon and sort out the opinions of the people. It has used in public policy, management, and other related fields. It used to select the list of essential decision-making factors within each perspective based on the decision-makers' opinion [10]. In this study, the fuzzy Delphi method used for factor screening, and the importance value given by experts was converted into a weighting factor to achieve better consensus convergence. When the degree of convergence set by the researcher reached a consensus. The fuzzy Delphi method reduces the number of investigations and reduces the time consumption, and the opinions of experts and scholars are also relatively complete. It established sustainable ecotourism indicators to address the vagueness and uncertainty of judgments in the group decision-making process [11].

2.1. Procedure

Method: Descriptive statistics and one-way ANOVA were utilized to investigate the operation and money flow of "Sustainable Campus" by the Ministry of Education. Through comparing multiple criteria decision, we verified factors from "Instruction of Disaster Management for All Levels of Campus." Based on campus improvement items and disaster sustainability association, we observed individual campus improvement proposals and plans. As shown in Figure 3, the disaster management points or factors summarized through the Fuzzy Delphi Questionnaire. Both paper and Internet expert questionnaires conducted through invited participants. The associated control factor selected through statistical data analysis. After the potential elements were selected, a cross-analysis provided between the number of times of application and investment resource amount. Based on the questionnaire and cross-analysis, the researchers established relevance and made policy and strategy recommendations.

![Figure 3. Study procedure](image)

2.2. Screening

With the definition of "sustainability" and "disaster prevention," reference is made to the sustainable development of the campus - the Ministry of Education's "Permanent Campus Partial Renovation Project" project and "Key Points of School Campus Disaster Management" to compare potentially related projects. The researchers collected the "Permanent Campus Partial Renovation Plan" and performed statistical analysis on the number of projects executed. Screening the potential correlation factors between the "Performance Campus Reconstruction Plan" and the "School Management Points of Schools at All Levels" with a high degree of consensus value, and creating a fuzzy Delphi expert questionnaire.

Use the double triangular fuzzy number to perform the screening work and establish the consensus value association project (Figure 4). After eliminating the non-reaching convergence project, the items with the convergence area (CP \( \geq 5 \)) are retained and ranked according to the CP value ranking weights. The researcher subdivided the partial transformation plan into four categories: "ecological indicator..."
subsystem," "energy-saving indicator subsystem," "reduction waste indicator subsystem," and "health indicator subsystem," and integrated the number of implementations and the flow of funds.

![Diagram](image)

**Figure 4.** Establish the consensus value association project

The questionnaire firstly reviewed by experts. After the reply, the researchers conducted the statistical analysis, comments of a formal one. The expert expresses the degree of association of the factors on the scale line segment. The correlation factor structure surface modified during the first questionnaire (pre-test). At this point, the panel of experts has increased to 32, and the idea of broad associations has broadened, which makes the evaluation indicator structure more complete. We take a sampling with a certain standard. The parent group of the expert group includes education administrators who are familiar with campus construction, spatial planning, and landscape environmental protection. The survey is limited to Taiwan, and the expert conditions are operational or teaching experience with both sustainability and disaster prevention.

A total of 36 questionnaires were collected. Among them, there are six professors, 14 associate professors, ten assistant professors, four lecturers, and two school administrators. A total of 31 questionnaires collected from the experts. The fuzzy Delphi questionnaire based on the 11-level scale (0-10). The higher the score, the more critical it is. The quantitative analysis first analyzes its implications for different views as a reference for deletion. Excel 2010 used to calculate the "double triangular fuzzy number," and the "grey zone" is used to test whether the expert's cognition reaches convergence.

The following data calculated, respectively: Minimum value in Omin-"most conservative cognition value," Om-geometric mean value, Omax-maximum value, and Zi-consensus value. Cmin - The minimum amount in the "most optimistic cognitive value," the Cm-geometric mean, and the Cmax-maximum. The researchers calculated the triangular number, the "most optimistic cognitive value." If it converges, the threshold value filtered (Figure 5). The Ai=(Cmin, Cm, Cmax), Cmax>Omin, and Zi<Gi indicate that the opinion is convergent and has a consensus.

\[
CP = \frac{C_{\text{max}} \times M_{\text{min}} - m_{\text{max}} \times O_{\text{min}}}{M_{\text{min}} - m_{\text{max}} + C_{\text{max}} - O_{\text{min}}}
\]

(1)
The high CP value indicates that the community has a high degree of consensus on the factor and also represents a high correlation with the project. The CP value takes the expert consensus value \( CP \geq 5.0 \) as the average association threshold; the final weight is obtained by sorting the CP value (Figure 5).

![Figure 5. Double triangle consensus fuzzy zone](image)

3. Results and discussion

3.1. Association factor screening
Among two catalogs, (a) Natural disasters: Eliminate wind disasters, earthquakes; preserve floods, earth-rock flows (combined hazards). (b) Human-made disasters: Eliminate traffic accidents, retain fires, toxic compounds, infectious diseases. The ecosystem subsystem contains:
- (1) Constructed wetland water circulation
- (2) Ecological landscape pool
- (3) Teaching farm
- (4) Symbiotic animal breeding
- (5) Water permeable pavement
- (6) Surface soil improvement

Energy-saving subsystems include Deciduous and kitchen waste composting, renewable energy applications. The waste reduction subsystem contains Resource recycling. The health subsystem includes: building materials and natural materials, indoor environment improvement, rainwater reclaimed water utilization, water recycling.

3.2. Resource allocation
The subsidy amount of primary school accounted for 78%. Among the total of 1,627 small households in 512 countries, the actual project amount sorted by water-permeable pavement, the maximum, indoor environment improvement, and the third was natural purified water circulation. The amount of subsidy divided into indicators: 38% for ecological groups, 35.5% for healthy, and 16% for energy-saving groups. Sub-item allocation: 17% for water-permeable pavement, 14% for indoor environment, 13% for rainwater reclaimed water, 9% for renewable energy applications, 7% for multi-level ecological deuteration, and 6% for other healthy building materials and natural materials. Energy conservation measures and affinity fences each accounted for 5%.
Table 1. Ranking of campus reconstruction and disaster management

| Rank subsystem | indicator | subsystem | disaster correlation factor | CP $\geq$ 5 |
|----------------|-----------|-----------|----------------------------|-------------|
| 1              | Health    | Healthy building materials and natural materials | Toxicants | 8.531 |
| 2              | Eco       | permeable pavement | Flood-earth flow | 7.390 |
| 3              | Health    | Indoor environment improvement | Toxicants | 7.201 |
| 4              | Eco       | constructed wetland natural purification water circulation treatment | Flood-earth flow | 6.563 |
| 5              | Health    | Rainwater Reclaimed Water Utilization | Flood-Earth Flow | 6.233 |
| 6              | Health    | Natural Purification Water Circulation | Flood - Earth and Rock Stream | 6.228 |
| 7              | Health    | Rainwater Reclaimed Water Utilization | Fire | 5.602 |

As shown in Table 1, the indicator subsystem and disaster correlation factor CP $\geq$ 5 were listed. The top rank is related to “Healthy building materials” and highly related to "Toxicants." Many items are similar to disaster “Flood-earth flow.” The “Earth and rock flow” implicated in the people’s living area, so it is a disaster with multiple effects. Naturally, it is the main factor in campus disaster prevention. The “Indoor environment improvement” is related to Toxicants; these factors related to human influence, so you can't think purely from the perspective of natural disasters. “Rainwater Reclaimed Water Utilization” and “Water Circulation” are essential to people's life and industrial production. This kind of problem requires a higher level of systematic planning, not from the school perspective. The observation revealed that:

(1) Fifty-two items remained after filtering by multiple criteria decision method from the original 144 related issues.

(2) By the result of the Delphi method questionnaire filtering out 52 associated subjects, we established six main applications for sustainability and disaster management: "building materials and natural resources," "permeable pavements."

(3) The six applications are all included in ecology and health indicators. The south area has more operations than the north area in "health-building materials," "natural resource," and "Indoor improvements." The actions indicated more resourced placed on aspects of "indoor environment improvements."

4. Conclusions
Knowledge structure need acquire from expert to extend the confidence of their correlation. The three elements of interaction (land, water, and forest) can spread to the existing relationship more precisely. Both small and medium-sized universities focus on ecological and health indicators. The water-permeable pavement has been the most applied, and the water circulation treatment, energy-saving,
and indoor environment have paid more attention. Planning time is short-term and financial constraints, and campus planning is usually based on the school's ability to master the resources of the project. The subsidy amount is the highest in the environmental group (38%), followed by healthy group (36%) and energy-saving (16%). When the expert is certified, the seven items with the CP associated value higher than five are retained, and the remaining six items. The related projects are: "Healthy Building Materials and Natural Materials" for Health Indicators, "Water Permeability Shop for Ecological Indicators," "Indoor Environment Improvement for Health Indicators," "Modified Wetland Natural Purification Water Circulation for Ecological Indicators," and Health Indicators. In the future, through the GPS information of the campus, it will evaluate the priority subsidies of the more likely disaster projects and strengthen the local transformation effect of the sustainable school.

5. References
[1] Chun-Hung Wu, Su-Chin Chen, Zheng-Yi Feng, Formation, failure, and consequences of the Xiaolin landslide dam, triggered by extreme rainfall from Typhoon Morakot, Taiwan. Landslides, vol.11-3, pp. 357 – 367, 2013.
[2] Chen, Su-Chin, Wu, Chun-Yi, Debris Flow Disaster Prevention and Mitigation of Non-Structural Strategies in Taiwan, Journal of Mountain Science, vol.11(2), pp. 308-322, 2014.
[3] Wu, H.L. and Feng, Z., Ecological Engineering Methods in Soil and Water Conservation of Taiwan, Ecological Engineering, vol. 28(4), pp. 333-344, 2006.
[4] Dhital, Yam Prasad, and Qiuhong Tang. Soil bioengineering application for flood hazard minimization in the foothills of Siwaliks, Nepal, Ecological Engineering, vol. 74, 458-462, 2015.
[5] [Online]. Available: http://law.moj.gov.tw/Eng/LawClass/LawAll.aspx?PCode=O0120001
[6] Donnini, Marco, et al. Impact of event landslides on road networks: a statistical analysis of two Italian case studies, Landslides, vol. 14.4, pp. 1521-1535, 2017.
[7] Stapp W B. The concept of environmental education, Environmental Education, vol.1(1), pp. 30, 2017.
[8] Ma, Kuo-Chen, Mo-Hsiung Chuang, and Chi-Tung Hung, Assessing the vulnerability and the resilience of campus for disaster management in response to climate change, EGU General Assembly Conference Abstracts, vol. 20, 2018.
[9] Chung, Sung-Chin, and Cherng-Jyh Yen, Disaster prevention literacy among school administrators and teachers: a study on the plan for disaster prevention and campus network deployment and experiment in Taiwan, Journal of Life Sciences, vol. 10, 2016.
[10] Lee, Sangwon, and Kwang-Kyu Seo, A hybrid multi-criteria decision-making model for a cloud service selection problem using BSC, fuzzy Delphi method and fuzzy AHP, Wireless Personal Communications, vol. 86.1, pp. 57-75, 2016.
[11] Ocampo, Lanndon, et al. Sustainable ecotourism indicators with fuzzy Delphi method–A Philippine perspective, Ecological Indicators, vol. 93, pp. 874-888, 2018.