IASDR07
INTERNATIONAL ASSOCIATION OF SOCIETIES OF DESIGN RESEARCH
THE HONG KONG POLYTECHNIC UNIVERSITY
12TH TO 15TH NOVEMBER 2007

THE SUSTAINABLE VALUE OF URBAN DESIGN

Yufeng Ho[1], Hsiaolin Wang[2] and Rongsheng Lee[2]

[1]Graduate School of Architecture and Urban Design, Chaoyang Unviersity of Technology, Taiwan, hyfarch@ms32.hinet.net

[2]Department of Landscape, Tunghai University, Taichung, Taiwan, Wang1435@hotmail.com

ABSTRACT:

Taiwan's rapidly increasing urban population has outstripped the ability of urban public infrastructure, regional resources and the surrounding environment to support it. This has led to social problems such as overcrowding, congestion, energy shortages, excessive building density, lack of green space, excessive waste volume, environmental population and crime. These have had a negative impact not only within cities but upon their surrounding areas as well. The larger a city becomes the greater the severity and scope of its impact on the surrounding environment becomes; the massive injection of energy and resources into the city's ecological system at the same time also results in a high concentration of energy, resources and wastes, creating serious consequences for the quality of living within the city. The purpose of this study is therefore to devise an evaluation indicator system for regional environment, economy and social values in urban planning. By approaching the issues in urban planning from a sustainable development and urban planning perspective, to provide a scientific basis for improving the quality of the urban environment.

Keywords: Urban Design, Sustainable Indicators, Fuzzy Delphi Method, Fuzzy Analytic Hierarchic Process Method

1. INTRODUCTION

A city is composed of physical and non-physical environments. To improve the quality of the urban environment, it should possess clearly defined urban spaces and structures, convenient transportation systems as well as a complete and highly efficient public service infrastructure. At the same time, the urban environment should reflect the social consciousness, economic values and public interests. The co-existence and acceptance of diversity, richness, group and individual values are therefore also a basic value that contributes to the quality of the urban environment. Sustainable urban design is where the shape of the urban environment is arranged in ways that are logical and artistic while remaining within the load limits of the ecology. Its main goal is to improve the nature of the urban environment to enhance the quality of life for citizens. Its values are measured according to its goal orientation so are based on environmental, economic, social, political and diversity issues. By realizing the decisions in physical form, it serves as a reflection of the city's values and social ideals during its modernization process. Sustainable urban design is therefore a controllable, goal-oriented, identifiable and economic force for realization. To implement sustainable urban design during policy development, a set of evaluation indicators that can be controlled is required. In this study, problems in urban design are examined from the perspective of sustainable development and urban design to establish an evaluation index system for the local environment, economy and sustainable social values in Taiwan's urban design. The evaluation system for the sustainable values in urban design is examined using the Fuzzy Delphi Method, Fuzzy Analytic Hierarchy Process and case studies to provide a reference for urban designers.

2. RESEARCH METHOD

Creating an evaluation index system for sustainable values in urban design is a relatively complex system engineering effort. It contains social and economic factor indicators as well as environmental indicators, with all combined to form a multi-layered, multi-indicator and multi-factor evaluation index system for urban design. Due to the complexity and fuzziness of the system, this study used theories and methods of fuzzy mathematics to construct the evaluation index system. Fuzzy Set Theory was initiated and developed by L. A. Zadeh (Zadeh, 1965) with following definition:

Let X be a universal set. A fuzzy set $\tilde{A}$ in X is a set of ordered pairs:

$$\tilde{\mathrm{A}} = \{(x, \mu_{\tilde{A}}(x)) | x \in \mathrm{X}\}$$

$\mu_{\tilde{A}}(x)$ is the membership function or degree of truth of x in $\tilde{A}$ which maps X to the membership space [0,1] denoted by $\mu_{\tilde{A}}(x)$ where

$$\mu_{\tilde{A}} : \mathrm{X} \to [0,1] \text{ with } x \to \mu_{\tilde{A}}(x)$$

Therefore, if $\mu_{\tilde{A}}(x) = 1, \forall x,$ it is an ordinary set and we call it Crisp Set for differentiation.

Besides, a fuzzy set can also be denoted by

$$\tilde{A} = \frac{\mu_{\tilde{A}}(x_1)}{x_1} + \frac{\mu_{\tilde{A}}(x_2)}{x_2} + \ldots = \sum_{i=1}^{n} \frac{\mu_{\tilde{A}}(x_i)}{x_i}$$

From the personal point of view one may notice that the expression of one's preference such as "quite far", "little closer", and "much closer" are linguistic terms, However, how for is "quite far" and how closer is "little closer" are very fuzzy and really a matter of degrees which are subjective to one's perceptions and preference. When numeric data are assessed, a membership function can be adopted to define the degrees of closeness to a reference point. However, when linguistic data are given, the induced membership functions are defined on a set instead of point value. The concept of Fuzzy Set and the related issues have then been adopted to develop a type of methods called "Fuzzy evaluation system for the sustainable value of urban design". It is this paper we are going to discuss about.

An explanation of the research method is provided below:

2.1. FUZZY DELPHI METHOD (FDELPHI)

The process developed by Ishikawa et al. (1993) to combine expert opinions into fuzzy numbers using the concepts of cumulative frequency distribution and fuzzy integrals is referred to as the Fuzzy Delphi Method. The Fuzzy Delphi Method (FDM) is divided into three steps: (1) Establish the set of influencing factors; (2) Collect the opinions of the decision-making body; (3) Use FDM to calculate the rate scores, set the threshold value and make the final decision. Two methods have been developed to carry out the calculations: Max-Min and Fuzzy Integration.

(1) Establish the fuzzy triangular functions based on the rate scores from the survey.

First, establish separately the cumulative frequency function F1 for the "maximum acceptable value" and the cumulative frequency function F2 for the "minimum acceptable value". Then calculate separately the quartiles (C1, D1) for F1, the quartiles (C2, D2) for F2 and the medians M1 and M2 for F1 and F2. Next, connect (C1, M1, D1) and (C2, M2, D2) to find the membership functions for the "maximum acceptable value" and the "minimum acceptable value". Where the two membership functions intersect is then the predicted value X. (Fig. 1)

(2) Selection of Evaluation Factor

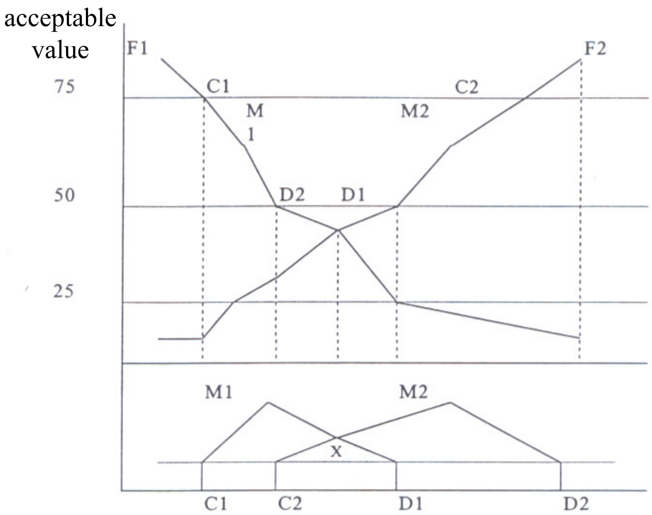

Figure 1: Max-Min Predicted Value Figure (Ishikawa et al., 1993)

Using triangular fuzzy functions, select the evaluation factors by setting the threshold value (S) as required for the research objective.

If XA≧S then accept evaluation factor A;

If XA＜S then reject evaluation factor A;

2.2. FUZZY ANALYTIC HIERARCHY PROCESS METHOD (FAHP)

The FAHP Method is where the characteristics are compared in pairs with the expert entering a fuzzy number between the two. Geometric means are then used to combine the expert opinions. Due to the large number of factors to consider in the evaluation index system for sustainable values in urban design, how to determine the importance of each factor and whether the planning factors are properly considered becomes important issues. When defining the factors, as humans can't compare more than 7 things at once, when dealing with complex problems it can be broken down into a hierarchical structure to facilitate comparison. This study therefore chose the FAHP method to analyze the evaluation factors' weighting. The flowchart for the operation of FAHP is shown in figure 2.

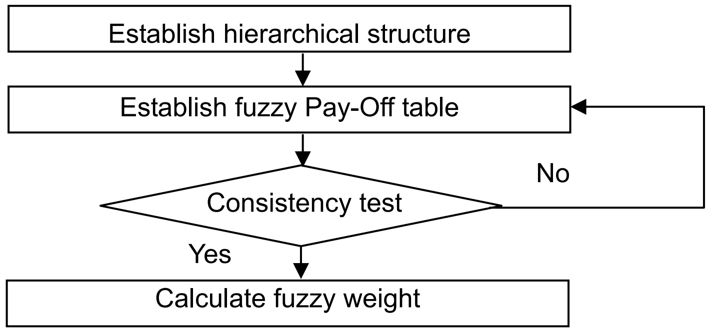

Figure 2: Flowchart for FAHP

2.3. SIMILARITY AGGREGATION METHOD

In a group multiple decision-making problem an expert's subjective rating for a particular proposal based on a certain principle can be expressed as a fuzzy number. The problem is how to combine the fuzzy numbers from multiple experts. This study therefore used the similarity aggregation method. This method is where the expert's own importance and other experts' level of agreement with their rating is calculated using an agreement matrix and average level of agreement to derive the relative level of agreement. The rating thus derived is then used as the weighting for each expert's rating score. (Hsu & Wu, 1995). The flowchart for the operation of similarity aggregation method is shown in figure 3.

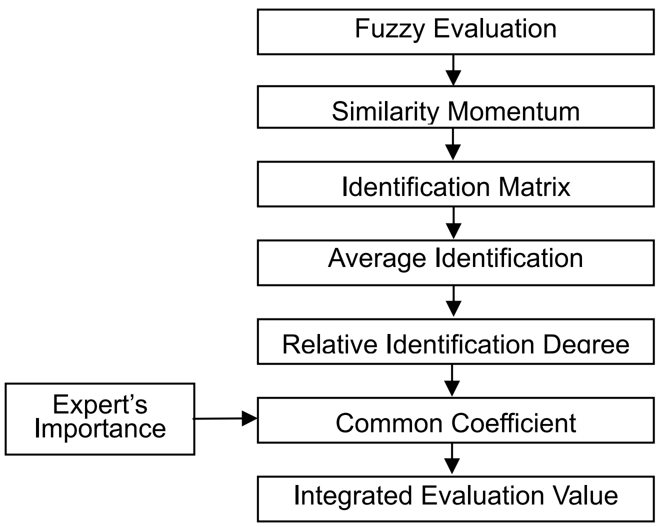

Figure 3: Flowchart for similarity aggregation method (Hsu & Wu,1995)

3. ESTABLISHING THE EVALUATION INDICATORS

3.1. ESTABLISHING THE INITIAL EVALUATION INDICATORS

This study reviewed the research on sustainable development indicators (Ishikawa et al, 1993; Mitchell et al, 2000; Smith et al, 2003l Bonaiuto et al, 2003; Ng & Hills, 2003; CABE, 2004; Ho & Wang, 2006; Zakaria & Imam, 2006) and after considering Taiwan's urban construction and actual experience, proposed an evaluation index system for sustainable values (Fig. 4). Layer 1 contained 3 environmental indicators, layer 2 contained 7 indicators including the urban landscape while layer 3 contained 24 evaluation factors including urban landscape continuity.

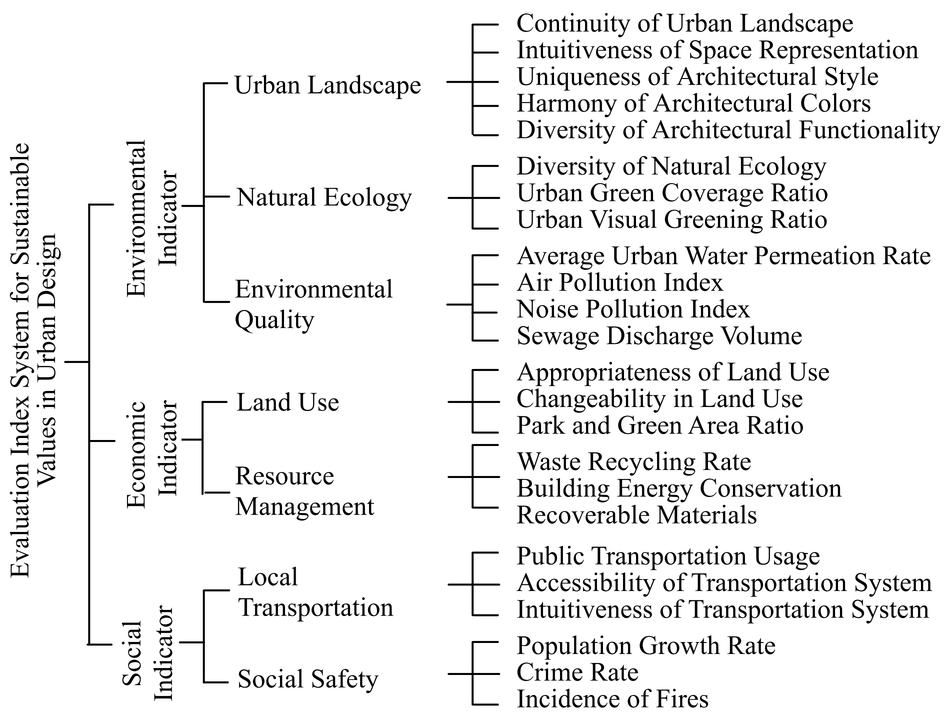

Figure 4: Evaluation index system for sustainable values in urban design

3.2. ANALYSIS OF SURVEY RESULTS

This study invited experts in urban design, urban planning, architecture design, landscape design, environment & culture, economics and social science to participate in the survey. 30 questionnaires were distributed for the phase 1 survey with 26 recovered and 22 effective samples; 22 questionnaires were distributed for the phase 2 survey with 22 recovered and 19 effective samples; through the phase 1 fuzzy Delphi questionnaire and fuzzy calculations a threshold value of 7 was derived, reducing the evaluation indicators from 33 to 24, or 72.72% of the total. The results are shown on Table 1. The weightings of the evaluation factors were derived using the phase 2 fuzzy Delphi hierarchical survey and are as shown in Table 2.

3.3. DEFINITION OF EVALUATION CRITERIA

Based on past literature and the relevant city regulations, the evaluation criteria devised by this study assigned a score of 1/5 to 5/5 points for ranks 1 to 5. If the total product at the target layer was lower than the threshold value of 0.6, this meant it did not reach the standard of urban sustainability. The product of the scores and the factor weighting from the expert survey gave the rank of sustainability in the urban design; the strengths and weaknesses in each evaluation category was then analyzed to provide suggestions for improvements (Table 3).

4. CASE STUDY

4.1. SITE ANALYSIS

The case study used was the Tianshi Block of Taichung City's new government center as shown in Fig.5. The Block is situated at the junction of Shihjhen North 1st Rd. and Hueimin Rd. as shown in Fig.6. Its dimensions are 165m in the north-south direction and 185m in the east-west direction. Total surface area is 3.025 hectares, building coverage ratio 50% and the floor area ratio 350%.

4.2. EVALUATION RESULTS

Table 1 Results from the Phase 1 Fuzzy Delphi Survey

Factor	Maximum	Rating	Minimum
Intuitiveness of Space Representation	10	7.9961≧7	1
Uniqueness of Architectural Style	10	7.7886≧7	2
Harmony of Architectural Colors	10	7.6453≧7	2
Diversity of Architectural Functionality	10	7.2439≧7	2
Urban Density	10	6.8298≦7	1
Diversity of Natural Ecology	10	7.8467≧7	2
Nativeness of Natural Vegetation	10	6.7316≦7	1
Urban Green Coverage Ratio	10	8.4191≧7	2
Urban Visual Greening Ratio	10	8.2121≧7	2
Average Urban Water Permeation Rate	10	8.0904≧7	3
Air Pollution Index	10	7.3515≧7	1
Waterway Pollution Index	10	5.9773≦7	1
Noise Pollution Index	10	7.0552≧7	2
Sewage Discharge Volume	10	7.5731≧7	1
Appropriateness of Land Use	10	8.8733≧7	2
Appropriateness of Land Use	10	7.3043≧7	2
Completeness of Local Development	10	5.4134≦7	1
Park and Green Area Ratio	10	8.5681≧7	3
Waste Recycling Rate	10	7.4265≧7	1
Building Energy Conservation	10	8.6312≧7	2
Recoverable Materials	10	7.8570≧7	2
Renewable Energy Sources	10	6.2113≦7	1
Importance of Cultural Assets	10	7.4815≧7	1
Uniqueness of the local industry	10	6.7710≦7	1
Contribution to Local Industry	10	5.3502≦7	1
Public Transport Usage	10	7.9840≧7	1
Urban Car Ownership	10	6.0275≦7	1
Accessibility of Transportation System	10	8.3440≧7	2
Intuitiveness of Transportation System	10	7.2669≧7	1
Population Growth Rate	10	7.2061≧	1
Crime Rate	10	7.2226≧7	1
Incidence of Fires	10	7.2189≧7	1

Table 2 Results from the Phase 2 FAHP Method Survey

Target Layer	Layer 1	Layer 2	Layer 3	Rank
Evaluation Index System for Sustainable Values in Urban Design 1	Environmental Indicator 0.6253	Urban Landscape 0.0231	Continuity of Urban Landscape 0.0066	21
			Intuitiveness of Space Representation 0.0068	20
			Uniqueness of Architectural Style 0.0029	23
			Harmony of Architectural Colors 0.0045	22
			Diversity of Architectural Functionality 000023	24
		Natural Ecology 0.3649	Diversity of Natural Ecology 0.1753	1
			Urban Green Coverage Ratio 0.1155	2
			Urban Visual Greening Ratio 0.0759	4
		Environmental Quality 0.2372	Average Urban Water Permeation Rate 0.0925	3
			Air Pollution Index 0.0411	10
			Noise Pollution Index 0.0452	8
			Sewage Discharge Volume 0.0583	5
	Economic Indicator 0.1948	Land Use 0.1257	Appropriateness of Land Use 0.0493	7
			Appropriateness of Land Use 0.0210	17
			Park and Green Area Ratio 0.0554	6
		Resource Management 0.0691	Waste Recycling Rate 0.0224	15
			Building Energy Conservation 0.0309	13
			Recoverable Materials 0.0158	19
	Social Indicator 0.1799	Local Transportation 0.0650	Public Transport Usage 0.0212	16
			Accessibility of Transportation System 0.0275	14
			Intuitiveness of Transportation System 0.0163	18
		Social Safety 0.1149	Population Growth Rate 0.0391	11
			Crime Rate 0.0425	9
			Incidence of Fires 0.0333	12

Table 3 Table of Assessment Rank Classification

Continuity of Urban Landscape	Rank 1: No landscape continuity Rank 2: Low landscape continuity Rank 3: Normal landscape continuity Rank 4: High landscape continuity Rank 5: Intense landscape continuity
Spatial Ideology	Rank 1: Diverse uses, lack of explicitness. Rank 2: Weak spatial ideology Rank 3: Spatial ideology formed Rank 4: Formed spatial ideology with molding in process Rank 5: Maintains and manages explicit spatial ideology
Architectural Uniqueness	Rank 1: Architecture with no particular style Rank 3: Architecture with style Rank 5: Architecture with strong characteristics
Architectural Color Harmony	Rank 1:1/3 of the area complies with or creates specifications Rank 3:2/3 of the area complies with and creates specifications Rank 5:The entire area complies with color specifications.
Versatility of Architectural Functions	Rank 1: Architecture situated in Type 1 residential/commercial area Rank 3: Architecture situated in Type 2 and 3 residential/ commercial areas Rank 5: Architecture situated in Type 4 residential/commercial area
Ecological Versatility	Rank 1: Less than 3 to 4 species Rank 3: 5 to 6 species Rank 5: More than 7 species
Urban Ratio of Green Cover	Rank 1:15% < Ratio of Green Cover< 30% 。 Rank 3:30% < Ratio of Green Cover< 65% 。 Rank 5: Ratio of Green Cover< 65%
Urban Green Visibility Ratio	Rank 1:15% < Green Visibility Ratio< 30% 。 Rank 3:30% < Green Visibility Ratio< 65% 。 Rank 5: Green Visibility Ratio< 65%
Urban Average Permeability	Rank 1: Area with no permeability Rank 2:0% < permeability< 25% Rank 3:25% < permeability< 50% Rank 4:50% < permeability< 75% Rank 5:75% < permeability< 100%
Air Pollution Index	Rank 1: Polluting day/year > 40 Rank 2: 30<Polluting day/year <40 Rank 3: 20<Polluting day/year <30 Rank 4: 20<Polluting day/year <10 Rank 5: Polluting day/year <10
Noise Pollution Index	Rank 1: Polluting day/year > 40 Rank 2: 30<Polluting day/year <40 Rank 3: 20<Polluting day/year <30 Rank 4: 20<Polluting day/year <10 Rank 5: Polluting day/year <10
Wastewater Discharge	Rank 1: Wastewater Discharge >85,000CMD Rank 2:65,000CMD< Wastewater Discharge< 85,000CMD Rank 3:45,000CMD< Wastewater Discharge< 65,000CMD Rank 4:25,000CMD< Wastewater Discharge< 45,000CMD Rank 5: Wastewater Discharge< 25,000CMD

Rationality of Land Use	Rank 1: Conformity of land use zoning < 25% Rank 3: 25% < Conformity of land use zoning < 50% Rank 5: Conformity of land use zoning < 50%
Variability of Land Use	Rank 1: Land development> 80% Rank 2: 60% < Land development < 80% Rank 3:40% < Land development < 60% Rank 4:20% < Land development < 40% Rank 5: Land development < 20%
Ratio of Park/Green Cover	Rank 1: Park/Total area < 5% Rank 3:5% < Park/Total area < 10% Rank 5:10% < Park/Total area < 15%
Recycling Ratio for Waste Resources	Rank 1: No sorting at all, once a week with individual disposal Rank 2: No sorting or volume reduction; once every 1－3 times with individual disposal Rank 3: No sorting or volume reduction, collected for recycling; once every 1－3 times with individual disposal Rank 4: Sorted and collected; once every 1－3 times with individual disposal Rank 5: Wastes sorted, volume-reduced, and collected for recycling and reuse with toxic substances removed; treated daily.
Normal architecture energy efficiency	Rank 1: Meet with 1 item of energy saving principles. Rank 3: Meet with 2 energy saving principles. Rank 5: Meet with 3 energy saving principles.
Recoverable materials	Rank 1: Architecture within the area < 30% 。 Rank 3:30% < Architecture within the area < 60% 。 Rank 5: Architecture within the area < 60% 。
MRT trips per person per day	Rank 1: < 2.5 trips per person per day Rank 3: 2.5< trips per person per day < 5 Rank 5: 5< trips per person per day < 10
Availability of Transport System	Rank 1: Including Class-5 roads Rank 2: Including Class-4 and Class-5 roads Rank 3: Including roads of Class-3, 4 and 5 Rank 4: Including roads of Class-2, 3, 4 and 5 Rank 5: Including roads of Class 1 through Class-5
Transport System Infrastructure	Rank 1: Having secondary roads Rank 3: Having primary and secondary roads Rank 5: Having primary, secondary and community roads
Population Growth Rate	Rank 1:Population Density < 500/km^2 Rank 2:500/km^2< Population Density < 1000/km^2 Rank 3:1000/km^2< Population Density < 1500/km^2 Rank 4:1500/km^2< Population Density < 2000/km^2 Rank 5:2000/km^2< Population Density < 2500/km^2
Security System	Rank 1: No burglary prevention measures Rank 3: With burglary prevention and security force Rank 5: With burglary prevention, security force, and community patrol
Fire Control System	Rank 1: No provision for escape exit; mostly flammable materials Rank 2: No provision for escape exit; mostly non-flammable or flame-resistant materials Rank 3: No provision for escape exit; all materials are non-flammable or flame-resistant Rank 4: With escape exits; mostly non-flammable or flame-resistant materials Rank 5: With escape exits; all materials are non-flammable or flame-resistant

One of the evaluation sheets of the Tianshi Block in Taichung new Government Center are as shown in Fig 7 and the evaluation results are as shown in Table 4.

Figure 5: – Case study Area

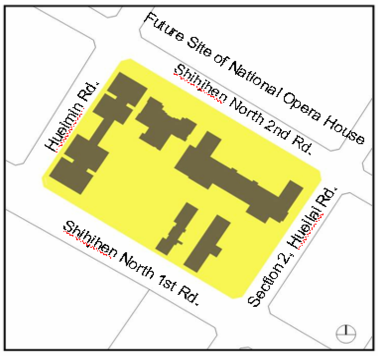

Figure 6: – Tianshi Block Layout

Figure 7 Survey of Urban Landscape Continuity

Environmental Indicator	Urban Environment
Evaluation Factor	Continuity of Urban Landscape
Factor Description	
Refers to the influence of landscape continuity in parks and open spaces. This is affected by park landscaping and the number of spatial interruptions. Fewer interruptions result in the higher continuity of urban landscape, if the opposite occurs then the continuity of landscape is reduced. The green coverage ratio, visual greening ratio and vegetation distribution in green parkland and open spaces are also considered.	
Current Status of Case Study	
	
Hueimin Rd.	Shizheng North 1st Rd.
	
Hueilai 2nd Rd.	Shizheng North 2nd Rd.

Survey of Case Study		
The road system around the site is clearly defined with planned pedestrian areas and tree-lined sidewalks used to create an overall city landscape space. The result is a neat streetscape, a clear visual axis and a high level of landscape continuity.		
Grading Criteria		Evaluation Grade
Level 1: No continuity of landscape. Level 2: Continuity of landscape is low. Level 3: Continuity of landscape is average. Level 4: Continuity of landscape is high. Level 5:Continuity of landscape is very high.		1. 1/5 2. 2/5 3. 3/5 4. 4/5 5 5/5
Evaluation Grade	Level 4: Continuity of landscape is high.	
Weighting	0.0066 x 4/5 = 0.0058	
Remarks		

Table 4 – Evatuation Results of Tianshi Block

Layer 1	Rating	Layer 2	Rating	Layer 3	Rating	Rank	Review of Inspection Results
Environmental Indicator 0.6253	0.3908	Urban Environment 0.0231	0.0191	Continuity of Urban Landscape 0.0066	0053	4	The landscaping features large continuous expanses of green areas and lack unique belt spaces.
				Intuitiveness of Space Representation 0.0068	0068	5	High level of intuitiveness in the overall architectural space and the spatial structure was complete as well. The representation for the entrance was a little weak.
				Uniqueness of Architectural Style 0.0029	0029	5	The building mass used simple lines to connect with the terrain. The architecture possesses a unique local style.
				Harmony of Architectural Colors 0.0045	0027	3	Color planning emphasized warm colors to create a comfortable and harmonious sense of space.
				Diversity of Architectural Functionality 0.0023	0013	3	Spatial functionality composed of residences, commercial spaces and arts spaces. It is however lacking in spaces with a leisure function.
		Natural Ecology 0.3649	0.2493	Diversity of Natural Ecology 0.1735	1041	3	Plenty of hinterland preserved and has great plant diversity. Habitat space is however lacking so animals not suitable for long-term habitation.
				Urban Green Coverage Ratio 0.1155	0693	3	Includes legally required green area. Up to 35% used for plantings but aesthetics of scenery are lacking.
				Urban Visual Greening Ratio 0.0759	0759	5	Green space planned for with the brushwood and low flowering bushes connected to give a high level of visual greening.

		Environmental Quality 0.2372	0.1224	Average Urban Water Permeation Rate 0.0925	0555	3	Legally required green area means 25% of the overall space is water permeable surfaces. Some surfaces are not designed for permeability.
				Air Pollution Index 0.0411	0164	2	Construction in the surrounding area and pollution from traffic threatens residents' environmental quality.
				Noise Pollution Index 0.0452	0271	3	Construction in the surrounding area and noise from traffic threatens residents' living environment.
				Sewage Discharge Volume 0.0583	0233	2	Only some of the household sewage is treated before discharge. Gray water recycling system recommended.
Economic Indicator 0.1984	0.1377	Land Use 0.1257	0.1131	Appropriateness of Land Use 0.0493	0493	5	Passed urban design reviews and land use meets urban planning regulations. Urban land development effectively controlled.
				Appropriateness of Land Use 0.0210	0084	2	Over 60% of land developed.
				Park and Green Area Ratio 0.0554	0554	5	Parks have high level of continuity, making up 40% of the overall area. This allows balanced use by urban residents.
		Resource Management 0.0691	0.0246	Waste Recycling Rate 0.0224	0089	2	Building owner committees collects community residents' rubbish for centralized sorting and disposal, enhancing recycling rate.
				Building Energy Conservation 0.0309	0062	1	Surrounding buildings conform to 1 or more building energy conservation indicators. Only a few buildings meet the energy saving standard.
				Recoverable Materials 0.0158	0095	3	New buildings mainly use steel and remanufactured materials, reducing consumption of resources.
Social Indicator 0.1799	0.1184	Local Transportation 0.0650	0.0480	Public Transport Usage 0.0212	0042	1	Most use cars or motorcycles for transportation. Lacking in public transportation system.
				Accessibility of Transportation System 0.0275	0275	5	Located within Taichung City's main area of development with excellent accessibility to a wide range of transportation systems.
				Intuitiveness of Transportation System 0.0163	0163	5	External and internal transportation systems feature trunk, secondary and neighborhood roads, giving the transportation system a high level of intuitiveness.
		Social Safety 0.1149	0.0703	Population Growth Rate 0.0391	0078	1	Population growth data over the past 5 years from the household registry office's data show that there's net population growth.

				Crime Rate 0.0425	0255	3	Communities have comprehensive security and management measures but lack neighborhood watch patrols and digital surveillance systems.
				Incidence of Fires 0.0333	0333	5	Emergency exists provided are built from fire-resistant materials.
Note: The total combined score was 0.609 out of a maximum of 1.0000 (this weighting table includes relative weighting and absolute weighting. The relative weighting is indicated by parentheses)							

This study carried out on-site inspections and interviews with residents to apply the 24 evaluation factors to the case study and assigned them weighting according to their level. The sustainable value results of the environmental, economic and social indicators were then analyzed. This study suggests the following improvements:

(1) Environmental Indicator

- Urban Landscape: The planned urban environment provides a good quality residential space, completeness in overall architecture and open space representation, high level of intuitiveness and harmony in colors. The planting of greening vegetation improved the landscape aesthetics to create the appearance of a local town. There is however a preponderance of artificial landscaping so this should be improved by increasing areas with natural ecologies.
- Natural Ecology: Rich diversity in vegetation planned for greening, good green coverage ratio, good continuity between bushes and brushwood forming a continuous visual landscape space. Some of the vegetation is overgrown however so better maintenance and management is recommended.
- Environmental Quality: Continuous green open spaces, high-rise building developments and centralized treatment of household sewage has increased ground water content and reduced the impact of noise, improving living quality for residents. Nearby construction however is posing threats to the environment due

to air and water pollution. A public transportation system is recommended and residents should be encouraged to use natural detergents.

(2) Economic Indicator

- Land Use: The land has been properly planned to create continuous open spaces, parks, varied residential environments and different local building styles while increasing the overall living quality. The real estate prices in the area have continued to rise from 2003 to 2007, increasing from 200,000 to 450,000 NTD per ping – an increase of 52%. The launching of the Central Taiwan Science Park is also driving the commercial potential of the area. These all have economic value generated through the use of urban design.
- Resource Management: Buildings are constructed mostly from reusable steel girders and stainless steel with the exterior façade providing insulation and moderation of solar radiation. Community recycling centers support recycling. The power consumption from lighting and air-conditioning systems are however too high. Infra-red sensing systems are recommended.

(3) Social Indicator

- Local Transportation: The grid-based layout of the roads helps identify their status and structure, enhancing travel between areas. The high frequency of car and motorcycle use however calls for the addition of bus stops.
- Social Safety: The high quality living environment generated by urban design has attracted many residents. The new neighborhoods have sound security systems and comprehensive firefighting facilities, enhancing their safety.

5. CONCLUSIONS AND RECOMMENDATIONS

(1) Based on urban design literature this study drafted evaluation indicators for sustainable values in urban design. Using Fuzzy Delphi and Fuzzy AHP, an multi-layered and multiple indicator evaluation system was constructed. By using the Fuzzy Aggregation Theory method, the opinions of experts and academics can be expressed in an objective manner.

(2) This study determined that there are a total of 24 evaluation factors for sustainable value. The 5 major indicators were (1) Diversity of natural ecology; (2) Urban green coverage ration; (3) Average urban water permeation rate; (4) Urban visual greening rate; (5) Sewage discharge volume.

(3) Empirical analysis showed that the urban neighborhood evaluated had major deficiencies such as buildings with poor energy-saving performance, low utilization of public transportation, fast population growth, high air pollution index, high sewage discharge volume and low recycling rate. These should be improved at once to ensure the sustainability of the neighborhood.

(4) Future studies can draw upon the theory of urban ecology to explore further the influence of the urban environmental factors on residents' health indicators. This can then be extended to propose policies that can help to improve people's quality of life.

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