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IDENTIFYING PUBLIC PREFERENCES FOR THE VALUE OF DAILY USED OPEN SPACES USING THE ANALYTIC HIERARCHY PROCESS – A CASE STUDY OF HANGZHOU CITY, CHINA

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ABSTRACT: Although much research exists on whether public open spaces are satisfactory with respect to users' perception, designers often neglect residents' preferences before a project is to be authorized. Especially when they design daily used open spaces that are located near or inside residential areas, the value of spatial environments is not paid enough attention to. This study applies the Analytic Hierarchy Process (AHP) to a field survey in order to compare the residents' perspectives concerning three general attributes (functional, aesthetic and ecological) and ten specific qualities of daily used open spaces. AHP is a methodology that assists respondents to make subtle trade-offs in unquantifiable attributes by means of measuring the relative preference of one attribute over another. Although this methodology is entirely different from other choice-based methods considering the cost-efficiency, the results of AHP offer a systematic method to examine the demands of those unheeded people. The results of the AHP application into data collected from the Chinese residents find that public preferences for daily used open spaces are stronger for the functional attribute, rather than the aesthetic attribute in the ancient Chinese tradition. Furthermore, comparisons of ten specific qualities show that the public prefers the open spaces that can be utilized conveniently and easily for group activities, because such spaces keep an active lifestyle of neighborhood communication, which also is seen to protect human-regarding residential environments.

Keywords: Public preference, open space, daily usage, Analytic Hierarchy Process (AHP)

INTRODUCTION

Growing Residences in China and Needs for Utilizable Open Spaces

Residence is the primary function that a city should serve for the public (CIAM IV, 1931). Nowadays, in China, a striking number of residential communities and college campuses are being constructed nationwide. As a result, improvement in the quality of residential environment is one of the most important goals of city policy and urban planning. Placements of open spaces in residential areas are predicated on their ability to deliver both a mechanism to maintain the viability of citizens' outdoor lives and a treatment to alleviate the high-density of urban constructions. What kinds of open spaces are desired by the masses? This question may be regarded as a valuable topic concerning residential environment. Especially, in China, a change in the system of university and college campuses has taken place during the past five years. The population of college students is increasing at an annual rate of 15% on a national level (Shi, 2005). More new campuses and buildings are changing the shape and formation of universities as well as students' daily lives. In the central cities, where most universities and colleges are located, the type of life on campus has become a crucial part of the urban residential lifestyle. College campuses are distinctive for their planning, which must incorporate learning, research, sports, leisure and residence, because most students live on campus. As a result, the campus is not only an educational zone in a city, but a multi-functional residence. In this study, ordinary communities and college campuses are both concerned in order to make a comparison analysis.

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Concepts of Designers and Public Preferences

In this paper, open spaces located near or in residential area call for much attention because of their convenience and humanism in the eyes of the masses. However, for years, research on the open space design has been concentrated on architectural formation, which favors the discussion on spatial relationship, material texture and architectural landscape (Marus and Francis, 1998). Consequently, large-scale open spaces, e.g. city plazas, pedestrian shopping streets and city parks occupy popular topics among architects and environmental designers. In contrast, the daily utilization of open spaces near the neighborhood, e.g. neighborhood parks and campus open spaces, is excluded from the mainstream of architectural forums. As such, public preferences for the value of daily used open spaces appeal to few designers' interest.

The popularity of open space projects undoubtedly also derives from their collateral benefits, including the provision of landscape, leisure places, and wildlife habitats. Open spaces, therefore, internalize some of the social benefits that go beyond the nominal boundary of the pricing system for real estate. In the aggregate, public preferences for the value of daily used open spaces may be characterized by three general attributes: functional, aesthetic, and ecological. Compared with some economic research in the field of real estate, the three attributes may be classified to the non-market value of open spaces.

Many studies have questioned whether the price-based models could effectively cover the value that the public truly requires on open spaces. Gardner (1977) argued that markets efficiently provide all these services, except perhaps open space and environmental amenities. This observation may highlight a serious disconnect between that which characterizes efficient policy and that which is actually being implemented by project managers. Kline and Wichelns (1994, 1998) agreed that the public's opinion of the non-market value is important in determining the cost effectiveness of an open space project. A cost-effective design, therefore, also relies on an appropriate specification of public demands for these non-market attributes. Herein, this paper seeks to illuminate the non-market side of the public's demands.

A Structured Multi-criteria Methodology to Examine Public Preferences

Developed by Saaty (1980), AHP is a flexible, yet structured, methodology which enables an individual or a group to define a specific problem and derive a solution based on the individual's (or the group's) own experience. As a widely used multi-criteria decision-making methodology, herein, the analytic hierarchy process (AHP) offers a tool at the hands of decision makers and researchers to compare the public's understanding of the value of open spaces, i.e. functional, aesthetic, and ecological attributes. Furthermore, some specific qualities, that explain the aforementioned attributes respectively, are also compared within each group. Unlike regression analysis (RA) of the satisfaction evaluation model of the residential environment in East China (Wu, 1995), principle component analysis (PCA) and cluster analysis (CA) of the preference of residential place choice in Saga, Japan (Ge and Hokao, 2004), or the Post–Occupancy Evaluation (POE) on various types of open space in USA (Marus and Francis, 1998), the AHP methodology in this paper employs a pair-wise survey and a statistical analysis.

Objectives

This study selected two different types of residential areas, so the groups of respondents are different. For the common community case, all the users who use the neighborhood open spaces were regarded as subjects in the survey. For the campus case, the college students become the subjects. The comparison between the two cases would confirm the diversity of public preference and find out the direction for future work.

As mentioned above, there are three worthwhile tasks for improvement in Chinese residential environment. They are: (1) to examine the difference between designers' concepts and residents' preferences regarding the value of daily used open spaces, and to offer designers with public opinion; (2) to investigate two main types of daily used open spaces in common residence and on campus, and to discover their common ground and diversity; (3) to propose a quantifiable

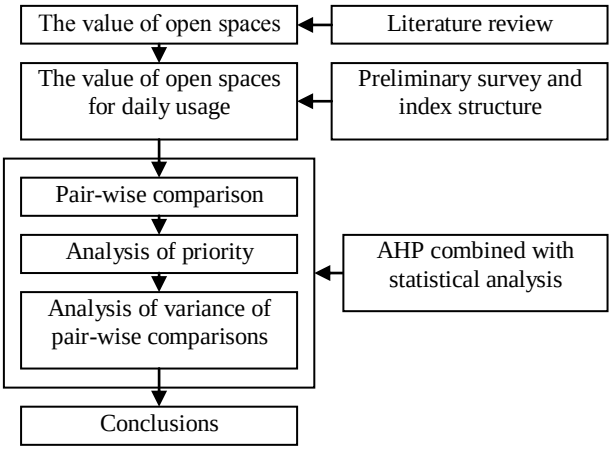

Fig. 1 Framework of the AHP applied into the value of open spaces for daily usage

framework of analytical factors regarding the value of daily used open spaces from the public side.

The survey scope of open space was defined inside the boundary of the communities and the campus. In China, the spatial boundary and spatial forms are quite clear by the enclosure of roads, rivers and walls.

The next section offers a review of previous studies and the third section describes the AHP conceptual model, exemplifying the responses from the masses and students of Hangzhou City, China. The fourth section then shows the quantification procedure of all factors' weights. The fifth section describes the survey procedure and reports the basic information of the samples. The sixth section discusses the analytical results of the AHP and the final section draws conclusions for the effectiveness of the application AHP to survey data regarding open spaces for daily usage (Fig.1).

LITERATURE REVIEW

Previous Research on the Value of Open Spaces

As an important garden designer of Ming Dynasty, China, Ji (1631) offered a classical design guideline for private gardens in Chinese style, discussing the basic principle for garden design. The non-native speaking reader is encouraged to refer to the English translation by Hardie (1988). Private gardens are regarded as the rudiment of daily used open spaces in China. Ji (1631) stressed that the value of gardens is to express designers' aesthetics and classified the design principles into six interdependent aspects: (1) field analysis, (2) building construction, (3) detail decoration, (4) horticulture, (5) rocks and water setting and (6) spatial interaction. At that time, the masses' demands for open spaces were out of designers' consideration. The philosophy of harmony between the nature and the master, i.e. the garden designer, was pursued as the supreme goal of gardens.

Until the 1990's, the utility of public open spaces was not highlighted in research on residential environment in China. With urban residential construction and social development, the Chinese city planners and designers refer to the western mode. Not only are large-scale parks and squares built recently at a high speed, but also neighborhood open spaces arise together with new residential zones nationwide.

Prior to the 1980s, research in this area classified the various types of value provided by open spaces and probed into the public's opinion concerning the value of those spaces. In a study of open space, Berry (1976) discussed six highly interdependent sources of value: utility, functional, contemplative, aesthetic, recreational, and ecological. Berry's (1976) work, in effect, distinguished active value (e.g. recreational value) from passive value (e.g. aesthetic value) and nonuse value (e.g. contemplative value). Effort is also made to distinguish ecological value that is readily valuable to humans (related to functional value) from that which is not (related only to natural environment).

Cybriwsky (1999) reviewed trends in the design of urban public spaces in Japan and USA by examining their changing patterns in how they are used. A comparison indicates that both cities have quite a few new public spaces that enhance the quality of urban life and add aesthetic appeal, but that also reflects certain social problems and divisions as the following common trends: (1) increasing privatization of spaces that were once clearly in the public domain; (2) increasing surveillance of public spaces and control of access in order to improve security; and (3) increasing use of design themes that employ "theme park" simulations and break connections with local history and geography. As far as the differences between the two cities, in the Tokyo area there is also a curious trend to create large, landscaped open areas near new development projects that few people use. They can be called "planned wastelands" or "new urban deserts". New York City, on the other hand, has succeeded in having more people come together for enjoyment in parts of the city that were once all but abandoned.

The comparison studies have used several methods to measure public preferences for preserved open spaces, especially agricultural land, on a county or town level. Kline and Wichelns (1994) used an indirect approach employing referenda data in Rhode Island and Pennsylvania to distinguish three attributes of preserved open space, including environmental, agricultural, and growth control (open space was included in the environmental attribute). In a study most directly motivating the research presented in this paper, Duke and Rhonda (2002) used a general population survey to develop a list of four attributes and eight qualities of preserved open space in Delaware. Both Kline and Wichelns (1994, 1998) and Duke and Rhonda (2002) suggest that any open space program must consider, at minimum, public preferences for the joint provision of non-market value.

A hint deriving from the above studies is that the non-market value of open spaces should be given more consideration in an open space project, i.e. functional, aesthetic and ecological attributes, because they endow open spaces with abundant appeal for citizens and the whole society.

Public Evaluation on Residential Open Spaces

In China, much research in residential environment evaluation focuses on the general evaluation system at a city level, which is mainly related with the subjective satisfaction evaluation. Wu (1995) and Xu, Yang (1996) conducted general surveys of residential environments in Southeast China and Shanghai City respectively. In fact, residential environment is closely connected with concrete components, e.g. building quality, shopping convenience, transportation and open spaces, influencing people's daily lives. As a result, it is necessary to deepen the residential environment evaluation of some specific topics. In this paper, daily used open spaces located in residential areas will be examined. In the limited literature on this type of open space, the focus is mainly on the spatial formation, cultural atmosphere and landscape. Zhu and Wu (2002) built up a multi-level evaluation model considering building quality, transportation, landscape and so on. Wang (1996) and Wu (2002) examined the relationship of human perception of satisfaction and utilization of facilities of parkways in Taiwan. Previous research mainly applies satisfaction evaluation into public preferences. In this paper, the AHP is used as a central method to study the public's preferences for the value of daily usage open spaces located in residential zones and campuses. The purpose is to offer a supporting tool for open space designers who will understand the masses' demands for their works.

Previous Applications of AHP

Analytic Hierarchy Process (AHP), since its invention, has been a tool at the hands of decision makers and researchers; and it is one of the most widely used multiple criteria decision-making tools. Many outstanding works have been published based on AHP: they include applications of AHP in different fields such as planning, selecting a best alternative, resource allocations, resolving conflict, optimization, etc., and numerical extensions of AHP (Zahedi, 1986; Vargas 1990;Vaidyaa and Kumar, 2004; http://www.expertchoice.com).

Vaidyaa and Kumar (2004) review and critically analyze the Analytic Hierarchy Process as a developed decision making tool. This review of the AHP applications covers more than 150 papers, and clearly supports the claim that the AHP is being adopted as a widely used research tool. They highlight the application areas in each of the chosen themes. It is observed that AHP is being predominantly used in the themes of selection and evaluation. As far as the area of application is concerned, most of the times AHP has been used in engineering, personal and social categories. This review brings out an interesting observation that in the earlier phase of usage, AHP was used as a stand-alone tool. As the confidence of the researchers grew with the AHP usage, they started experimenting the combination of AHP with other techniques. Realizing the need to refine their results, the researchers then used modified versions of AHP combined with other tools like linear programming, artificial neural network, fuzzy set theories, etc. It does not mean that AHP is not used as a stand-alone tool anymore. Many researchers are, in fact, joining the ever-growing group of people successfully using AHP as a stand-alone tool (Al Harbi, 2001). The data analysis regarding the number of the reviewed papers indicates the growth in the use of AHP over the years (Vaidyaa and Kumar, 2004). What it means is that AHP as a tool comes with a natural flexibility that enables it to be combined with so many different techniques effectively. This flexibility is obvious from the fact that some authors have even converted the Saaty's nine-point scale to a convenient five-point scale or even a 100-point scale. Moreover, recent studies apply AHP into general population survey data (Duke and Rhonda, 2002), while previous AHP studies tend to interview a relatively small number of experts, professional managers or role-playing participants in an interest group (Peterson, 1994; Alho and Kangas, 1997).

Applications of AHP in Daily Used Open Space

In fact, there exist relatively few applications of AHP to residential open spaces, especially for daily usage. The main extension of the present paper is to apply AHP to a general survey with a good number of respondents in order to investigate public preferences for daily places, by means of revealing the relative weights on the functional, aesthetic, and ecological attributes of the value of open spaces. The AHP is also used to identify the relative weights on the specific qualities within each of the three general attributes. The data of the survey are then compared between two different groups of respondents according to their demographic attributes and social conditions (one is the group of common residents and the other is the group of college students). This study provides some basic information and attempts to examine the current public opinions on daily used open spaces in Chinese cities.

THE HIERARCHY OF THE VALUE OF DAILY USED OPEN SPACE

Analysis of Problem with a Structured Hierarchy

How can people best deal with complexity? Herbert Simon (1960), Nobel laureate and expert of Artificial Intelligence, writes: " Large organizations are almost universally hierarchical in structure. That is to say, they are divided into units which are subdivided into smaller units, which are, in turn, subdivided and so on. An organization will tend to assume hierarchical form whenever the task environment is complex relative to the problem-solving and communicating powers of the organization members and their tools. Hierarchy is the adaptive form for finite intelligence to assume in the face of complexity."

Developed by Saaty (1980), Analytic Hierarchy Process is a multiple criteria decision-making tool, which facilitates choosing among alternative action courses or designs in order to achieve a final goal and main/ subordinate objectives (Fig. 2).

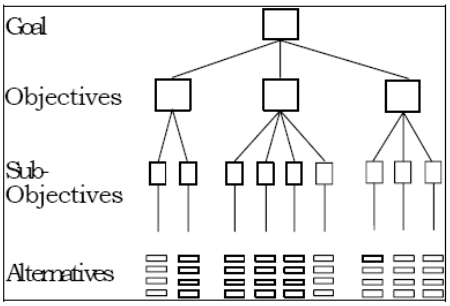

Fig. 2 A demonstration of hierarchical structure

Analysis of the Value of Daily Used Open Space

As mentioned in the section of introduction, the value of open spaces in urban area is based on their ability to deliver both a mechanism to maintain the viability of citizens' outdoor lives and a mechanism to alleviate the high-density of urban constructions. It becomes the focus of this research to clarify the composition of the value with a view of the public preferences. In existing studies presented above, there shows a lack of attention to open spaces for daily usage. Hence, in this paper, the value of daily used open spaces is to be structured by means of

Table 1 Comparison of frequently mentioned attributes between designers, common residents and students

Sequence No.	Designers		Common residents		College students	
	Description	Percentage	Description	Percentage	Description	Percentage
1	Landscape formation	19.4% (188:970)	Facility for group activity	20.3% (301:1485)	Facility for group activity	21.0% (211:1003)
2	Architectural style	18.1% (176:970)	Landscape formation	17.8% (265:1485)	Facility for public activity	17.9% (180:1003)
3	Biologic diversity	15.9% (154:970)	Facility for individual activity	15.8% (234:1485)	Landscape formation	14.4% (144:1003)
4	Community culture	13.5% (131:970)	Service buildings	13.7% (203:1485)	Aural amenity	12.3% (123:1003)
5	Facility for group activity	12.1% (117:970)	Tactual amenity	11.3% (168:1485)	Biologic diversity	9.2% (92:1003)
6	Microclimate	8.4% (81:970)	Microclimate	7.7% (115:1485)	Facility for individual activity	8.3% (83:1003)
7	Facility for individual activity	6.1% (59:970)	Aural amenity	5.7% (84:1485)	Campus culture	5.6% (56:1003)
8	Water-soil retention	2.3% (22:970)	Biologic diversity	3.9% (58:1485)	Water-soil retention	4.9% (49:1003)
9	Facility of service	1.3% (13:970)	Facility for public activity	2.2% (32:1485)	Service buildings	3.2% (32:1003)
10	Others	3.0% (29:970)	Others	1.7% (25:1485)	Others	3.3% (33:1003)

Note: Percentage denotes the percentage of mentioned terms among all terms. The former number in the bracket denotes the times of mentioned terms; the latter number denotes the total times of all terms.

using the AHP method to examine public preferences.

In order to cover the facets and levels of the value of daily used open spaces, it is necessary to broaden the objectives of the problem or consider all factors and its outcome. As discussed in the section of review, the value can be understood from different viewpoints in terms of the interest of different people. For example, traditional garden artists showed an appreciation of spatial and architectural aesthetics; land and estate agents express an anxiety of the cost-benefit optimization; meanwhile the masses call for a more humanistic open space to enjoy life. Therefore, a preparative interview or survey is absolutely required.

Before the AHP survey, some useful information was collected at Hangzhou City, concerning the citizens' perspectives on open spaces they use daily near their residences. In order to acquire a general consciousness, both common residents and college students were selected around Hangzhou City for this case study. The objectives evaluated by those respondents consist of two types of open spaces in residential area, i.e. the open space in mass communities and that on campus respectively. The preparative interview was conducted in 6 communities and 4 campuses that are in different locations and distinct social background (Shi, 2006). In the preparative interview with 31 designers, 45 residents and 25 students, the respondents were asked what kinds of attributes made up the value of daily used open spaces. We obtained the following information (Table 1):

(1) Generally, the value of daily used open spaces includes three aspects, which are: available places of leisure activities; landscape amenity; and ecological conditioners.

(2) There are some differences between the residents and designers. The residents mention the leisure value frequently, while the designers put the landscape, especially visual amenity on the first consideration.

(3) The factors mentioned by residents are more general than those by designers. Residents' perspectives almost cover all the aspects concerning open space, while designers argue that there are some factors which can not be dealt with through design. For example, environmental cleanness, fresh air, creature inhabitability, activity, harmful gas, garbage disposal and fire accident.

(4) There are some differences between campus and common community. On campus, students consider both group activities and public activities, while the residents in community mainly consider about individual and small group activities, and exclude large public activities.

A Structured Hierarchy of the Value of Daily Used Open Space

According to the AHP, the problem can be structured with a hierarchy of different levels constituting goal, objectives, sub-objectives and alternatives. Based on the above interview we structure a hierarchy of the indices constituting the value of open spaces for daily usage. The hierarchical structure is decomposed of two levels, i.e. general attributes and specific qualities, underlying the total goal (Fig.3). The general attributes include functional, aesthetic, and ecological factors; and the specific qualities are described as follows.

The functional attribute: Facilitating users' leisure activities

According to users' behavior, there are three categories of leisure activities in open spaces. The first one is individual activities, e.g. strolling, reading, musing, fishing and so on. The second one is interactive activities in a group, e.g. chatting, discussing, sports

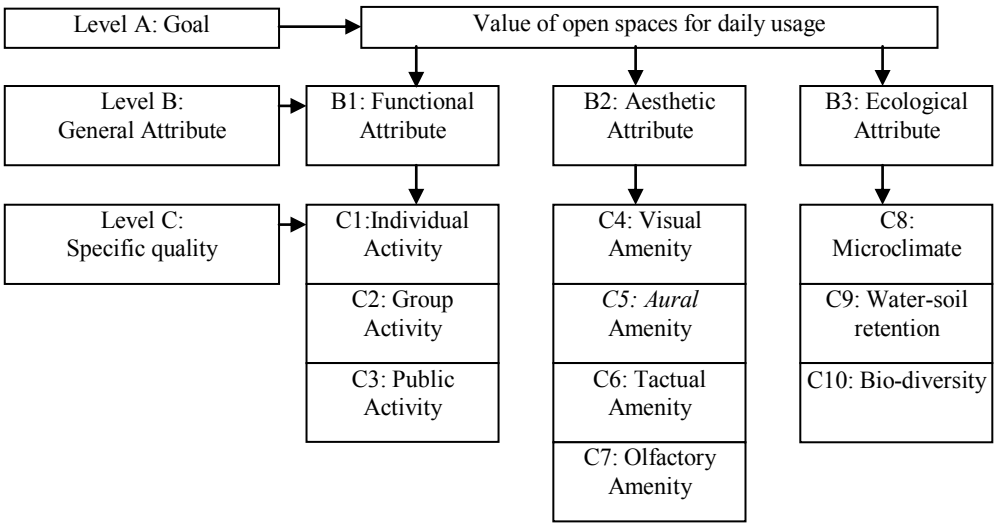

Fig. 3 The structured hierarchy of the indices regarding the value of daily used open space

game, party, picnic and so on. The third one is interactive activities in crowds, e.g. speech listening, exposition, flea market and so on.

Correspondingly, an open space is subjected to the requirement of the three categories of activities. They are defined as three specific qualities, i.e. facilitating individual, group and public activities. Proper location, space, and facilities are required to provide material conditions for residents' daily usage.

The aesthetic attribute: providing amenity of landscape

Conventionally, the concept of landscape is mainly relative to visual perception. With the development of the research on landscape design and environmental psychology, some new concepts, e.g. sound-scape, are introduced frequently to understand comprehensively human perception of surrounding environment. In this research, we defined the amenity of landscape as the properties that offer comfortable perception for residents in open spaces.

There are four specific qualities of the amenity of landscape. The first one is visual amenity, e.g. architectural styles, natural scenery and so on. The second one is aural amenity, e.g. human songs and voice, wind or rain sound, creatural songs and so on. The third aspect is tactual amenity, e.g. sunshine, wind flick, material sense of benches, water surface, and vegetal contiguity and so on. The fourth one is olfactory amenity, e.g. fresh air, aroma, smell of picnic food, outdoor tea or coffee and so on.

Correspondingly, an open space near a residence is subjected to the requirement of these four qualities. Designers should create beautiful buildings, plantation, and natural environment to meet residents' daily aesthetics.

The ecological attribute: preserving local ecology

Although much research has highlighted the ecological significance of open spaces for local environment, especially wetland at the urban fringe and rural green land, most residents underrate, not ignore, the ecological attribute of open spaces for their daily life.

For residents, there are three specific qualities of open spaces for local ecology. The first aspect is creatural diversity, e.g. planting various vegetation and attracting more birds and insects with a livable habitat. The second aspect is the improvement in microclimate, e.g. diluting density of buildings and increasing sunlight rate. The third aspect is preservation of natural resource, e.g. conserving a natural pond or creek and keep a vacant land from occupied by buildings.

Correspondingly, an open space near a residence is subjected to the requirement of these three qualities. Sufficient space, plantation and natural surface features are required to alleviate the intensity of ecological impact imposed by the construction.

Table 2 Demonstration comparison of general attributes

	B1: Functional	B2: Aesthetic	B3: Ecological
B1: Functional	1	5	7
B2: Aesthetic	1/5	1	3
B3: Ecological	1/7	1/3	1

Table 3 The AHP pair-wise comparison scale

Degree of importance	Definition
1	Both attributes equally important
3	Very slight importance of one attribute over the other
5	Moderate importance of one attribute over the other
7	Very importance of one attribute over the other
9	Absolute importance of one attribute over the other
2, 4, 6, 8	Intermediate value between two adjacent judgments

QUANTIFICATION OF THE WEIGHTS

A Demonstration of Pair-wise Comparisons

In this paper, we are trying to establish a normalized set of weights to be used when comparing future alternatives (designs) using the above hierarchy of attributes and qualities. Analytic Hierarchy Process applies an eigenvalue approach to the pair-wise comparisons matrix. It also provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances. The scale ranges from 1/9 for 'least valued than', to 1 for 'equal', and to 9 for 'absolutely more important than' covering the entire spectrum of the comparison (Saaty, 1980). When used in the systems engineering process, AHP can be a powerful tool for comparing alternative design concepts.

For simplicity, we exemplify a respondent's comparisons among the 3 general attributes: B1, B2, and B3 (Table 2). The AHP operates the comparisons of each element in the corresponding level and calibrates them

Table 4 Random Indices (*RI*)

N	1	2	3	4	5	6
RI	0.00	0.00	0.58	0.90	1.12	1.24

on the numerical scale. This requires n×(n-1)/2 comparisons (the dark cells in Table 2), where n is the number of elements with the considerations that diagonal elements are equal or '1' and the other elements will simply be the reciprocals of the earlier comparisons. Table 3 details the pair-wise comparison scale universally used in the AHP. Four main axioms underlie the theoretical validity of the comparison matrix (Saaty, 1986). For this example, the weights of B1, B2, and B3 would be 72.4%, 19.3% and 8.3% respectively.

Consistency Test

Normalized weights for each attribute can be calculated according to the maximum eigenvalue (λ max). Meanwhile, the consistency index (*CI*) and the consistency ratio (*CR*) test the consistency of the whole matrix. Complete consistency in rating alternatives is rarely the case when subjectivity is involved. Saaty (1980) proposed the right eigenvector method that constructs the vector of priority weights and facilitates testing for inconsistency. Saaty (1980) proved that λ max is bigger than *n*, which enables AHP to test the degree of inconsistency in a respondent's ratings. The quantity of λ max-n measures the degree of inconsistency within the *n*×*n* matrix. The consistency index (*CI*) for an *n*×*n* comparison matrix with largest eigenvalue, λmax, is

$$CI = {\lambda_{\max} - n}/{n-1} \quad (1)$$

Denote the consistency index for a randomly generated *n*×*n* matrix as *RI* (random index, Table 4). Using the *CI* and *RI* indexes, Saaty (1980) defined the consistency ratio as *CR*=*CI*/*RI*. Value of *CR* are desired to be smaller that 0.1. Higher *CR* value imply an unacceptable level of inconsistency and respondents would be asked to revise their pair-wise comparison ratings till these value lie in a desired range. If the maximum eigen-value, *CI*, and *CR* are satisfactory then decision is taken based on the normalized value. For this example, λ max=3.066, *CI*=0.033, *CR*=0.057.

Synthesis of the Value

The a_{ij} value are quantitative measures of each respondent's judgment concerning the relative degree of importance of attribute *i* over attribute *j*. In this study, the decision maker is actually a group of 425 randomly selected survey respondents in Hangzhou City. In a case of group decision making, Duke and Rhonda (2002) suggest the geometric mean as a method of calculating the overall average comparison rating across all respondents. Given m survey respondents, a composite judgment of their a_{ij}* value is the geometric mean of the aij value, which is defined as

$$a_{ij}^{*} = \sqrt[m]{\prod_{k=1}^{m} a_{ij}^{k}} \quad (2)$$

Aczel and Saaty (1983) proved that the geometric mean is consistent and upholds the four axioms underlying the AHP process. Using the geometrically averaged a_{ij}* value, a set of numerical weights w_1, w_2,…, w_n were computed to represent the relative degree of importance of the qualities within each general attribute. These numerical weights represented a vector of relative importance weights with Σw_i=1. The AHP was processed using Excel and was checked for inconsistent comparisons at the aggregate level.

In this way, AHP helps to incorporate a group consensus. Generally this consists of a questionnaire for comparison of each factor and geometric mean to arrive at a final solution of all the factors' weights.

DATA COLLECTION

Survey Procedures

After structuring the hierarchy of three general attributes and ten specific qualities, 301 residents living in common residential communities and 124 college students in Hangzhou City were interviewed to reveal their collective preferences for open spaces (Shi, 2006). One of the disadvantages of the AHP is the difficulty how to make those respondents understand the comparison judgment on each pair of items. The enumerators solicited the participation of respondents and then offered a clear statement for respondents to understand the meanings of the three key concepts (i.e. open space, daily usage, and pair-wise comparison) and the hierarchical structure of all the attributes/ qualities.

At all times, the enumerators attended to the respondent and answered any questions. When respondents were familiar with the context, the enumerators asked them to make pair-wise comparisons and rank the intensity of their preferences: the three general attributes and then the ten specific qualities. The survey concluded with several demographic and opinion questions. The surveyor recorded the respondents'

Table 5 Sample selection statistics

	Male				Female				Total			
	PT	VR	Total	PT (%)	PT	VR	Total	PT(%)	PT	VR	Total	PT (%)
Common residence	59	138	147	42.8%	51	140	154	36.4%	110	278	301	39.6%
Campus residence	40	69	72	58.0%	35	51	52	68.6%	75	120	124	62.5%
Total	99	207	219	47.8%	86	191	206	45.0%	185	398	425	46.5%

Note: PT denotes consistency-test-passed respondent; VR denotes valid respondent; PT (%) denotes percentage of consistency-test-passed respondent in valid respondent.

comparison ratings via pencil and paper. All necessary pair-wise combinations of attributes and qualities were presented to each respondent for comparison. The order in which the pairs of attributes and qualities were presented for comparison was the same for all respondents (i.e. all respondents took the exact same survey).

Building upon recent categorizations in the literature (Kline and Wichelns, 1998), the sub-factors were intended to represent their parent factor, and to be as independent of one another as possible. Herein, the functional attribute was characterized by a desire to enjoy an outdoor lifestyle, to communicate with the neighborhood, and to participate in public activities. The aesthetic motivation includes the wish of keeping some natural places surrounding daily lives, the value of preserving scenic quality. The ecological motivation arises from a desire to control the density of buildings and population, to mitigate the environmental impact and to experience space with other living beings. Therefore, each respondent provides 15 pair-wise comparisons with intensity rankings: 3 comparisons among the general

Table 6 AHP results and priority rankings in terms of the community type

Valuable attribute		Weight of Priority							
Level B: General attribute	Level C: Specific quality	Common residence				Campus residence			
		Within group		Total (rank)		Within group		Total (rank)	
B1: Leisure activity			Rank	0.512*	**1***		Rank	0.449*	**1***
(Functional attributes)	C1: Individual activity	0.371	2	0.190	2	0.335	2	0.150	2
	C2: Group activity	0.546	1	0.280	1	0.384	1	0.172	1
	C3: Public activity	0.083	3	0.042	9	0.281	3	0.126	4
B2: Landscape amenity				0.343*	**2***			0.397*	**2***
(Aesthetic attributes)	C4: Visual amenity	0.375	1	0.129	3	0.375	1	0.149	3
	C5: Aural amenity	0.268	2	0.092	4	0.292	2	0.116	5
	C6: Tactual amenity	0.137	4	0.047	8	0.106	4	0.042	9
	C7: Olfactory amenity	0.220	3	0.075	5	0.227	3	0.090	7
B3: Ecology				0.145*	**3***			0.154*	**3***
(Ecological attributes)	C8: Microclimate	0.333	2	0.048	7	0.293	2	0.045	8
	C9: Water-soil retention	0.196	3	0.028	10	0.098	3	0.015	10
	C10: Biological diversity	0.471	1	0.068	6	0.609	1	0.094	6
Total				1.000**				1.000**	

Note: ** denotes the total value is the sum of the above value with the * mark.

attributes at Level B and 12 total comparisons at Level C.

Basic information of respondents in the sample

A sample of 398 valid responses from the total 425, resulting in 5970 usable pair-wise comparisons (15 comparisons per respondent), was obtained in the spring of 2005 by a questionnaire survey at Hangzhou City, China. Table 5 shows the descriptive statistic data resulted from the survey.

In this survey, most of the questionnaires were answered with a face-to-face interview. The percentage of valid respondents is approximately 90%. During the interviews, the enumerators attended to the respondent and answered their questions. As a result, the percentage of the respondents without inconsistency in all the valid respondents is approximately 50%.

According to the consistency test, some responses were eliminated because of inconsistency. The other responses did not find inconsistency and were used in the geometrical average. All of the geometrically averaged comparison matrices passed the test for consistency. Thus, the aggregated comparison matrices will not demonstrate inconsistency.

RESULTS AND DISCUSSIONS

Overall, the local residents are demanding all the aspects of daily used open spaces. Nonetheless, marked preferences exist for the functional attribute regarding the capability of facilitating leisure activities. The AHP result is presented in terms of the type of the survey areas in Table 6. The users' demand can be examined by the results of the AHP. The weight value of each item stands for the degree of users' demand.

Table 6 also offers the comparison of the priority ranking of the general and specific qualities. To reinforce a point in the modeling, the geometric mean-derived AHP results are to be interpreted as an expression of public preferences in Hangzhou City. As such, the planning and design policy concerning open spaces, especially those used daily, that meets public demands would be efficient and satisfactory.

Weight Rankings of Public Preferences

The results in terms of the community type (i.e. common residential zones and campus residences) correspond to expectations, given the diverse patterns of social conditions across the city. As an important tourism city, until 2002, Hangzhou City had been one of the geographically smallest, but highest-densely populated provincial cities in China. After the administrational amalgamation of Hangzhou City and a few satellite counties, it is also the fastest growing city in East China, with the residential floor area increasing 184% from 2002 to 2004 (Hangzhou Bureau of Statistics, 2005).

In this case study, respondents living in common residences allocated 51.2% of their preferences to the functional attribute. The aesthetic attribute was weighted

Table 7 Analysis of variance between group

	No./	Comparison group	Average comparison of Common residence	Average comparison of Campus residence	F	Sig.
Level B	1	B1:B2	1.493	1.131	1.050	0.306
	2	B1:B3	3.531	2.916	2.214	0.187
	3	B2:B3	2.366	2.578	1.262	0.279
Level C	4	C1:C2	0.679	0.872	1.005	0.645
	5	C1:C3	4.470	1.192	6.441	0.021*
	6	C2:C3	6.578	1.367	11.593	0.000**
	7	C4:C5	1.399	1.284	1.355	0.257
	8	C4:C6	2.737	3.538	2.502	0.159
	9	C4:C7	1.705	1.652	0.362	0.747
	10	C5:C6	1.956	2.755	4.113	0.045*
	11	C5:C7	1.218	1.286	0.255	0.856
	12	C6:C7	0.623	0.467	0.796	0.352
	13	C8:C9	1.699	2.990	5.287	0.024*
	14	C8:C10	0.707	0.481	3.890	0.046*
	15	C9:C10	0.416	0.161	6.219	0.013*

Note: * denotes the Sig. is not more than 0.05; ** denotes the Sig. is not more than 0.01

middle (34.3%), whereas the ecological attribute was the least important (14.5 % merely). Almost on the scale of common residences, campus residences have been experiencing an extensive relocation from the city center to the suburban areas in recent years (Shi, 2005). Campus residents also rank the functional attribute as the most important (44.9%), followed by the aesthetic (39.7%) and (15.4%) ecological attributes.

Hence, across the city, the functional attribute seems to be the most important, carrying approximately half the weight in the total balance. Following in importance is the aesthetic attribute with a little more than one-third weight, and only one-seventh weight is on the ecologic attribute. In contrast with the traditional perspective regarding the Chinese classical theory of the garden design (Ji, 1631), the approximate ratio of 7:5:2 (functional: aesthetic: ecological) proves there exists a change of public preferences for open spaces that residents utilize daily. The rapid development of urbanization is invading the land used for open spaces so that human outdoor leisure is losing its indispensable supports of places and facilities.

The sharpness of the AHP results is marked; assuming one believes that the sample is sufficiently large and representative of Hangzhou City, then the results show, for instance, that the public is almost 3.5 times as interested in the functional services of open spaces as the ecological effects. In general, the two results closely correspond to the current trend regarding public preferences for open spaces. The results of the AHP show the weights when users consider a livable or satisfactory open space environment inside their residences for daily usage. The prior items have higher weight values, which means they are more important in the users' evaluation.

A fuller picture emerges, however, from the results on the relative importance of the various attributes and qualities of daily used open spaces. By multiplying the specific weight by the general weight, an overall weight for each specific quality emerges. The sample places the most importance on (1) providing places for group activities (28%, 17.2%), keeping neighborhood communication as a part of daily lives, and (2) providing places for individual activities (19%, 15%), an outdoor environment where people can relax. The sample expressed the least interest in water-soil retention (2.8%, 1.5%). The top three qualities (group activity, individual activity and visual amenity) contribute 59.9% (the common case) and 47.1% (the campus case) of the overall weight, while the bottom three qualities account for only 11.7% (the common case) and 10.2% (the campus case).

Analysis of Variance between Common Residence and Campus Residence

Each survey respondent made three pair-wise comparisons of the three general attributes. Although AHP is not statistically based, testing for statistically significant differences (at the α=0.05 level) in mean pair-wise comparison ratings between the two groups of respondents offer additional insight into preference variation by the characteristics of respondents. Statistically significant differences in these ratings suggest that the average intensity of preferences in one group is different than the other; however, differences do not suggest shortcomings with the AHP application. On the contrary, the differences between groups distinguish inequitable environments and diverse people. This test was statistically significant in 6 of 15 pairs of instances (3 general-attribute comparisons and 12 specific-quality comparisons between 2 groups) (Table 7). These differences support prior expectations.

First, the common group is statistically more intense than the campus group in its mean comparison ratings of C1, C2 (individual, group activity) over C3 (public activity). Communicating activities among small groups dominate in common residential communities, such as chatting with neighbors, playing chess, going for a walk with family and so on; while college students pay more attention to public activities, such as oral presentation, sports games, pageants, exhibitions and so on.

Second, the common group is statistically less intense than the campus group in its mean comparison rating of C5 (sound-scape) over C6 (tactual amenity). The aged and children are the majority of the users in open spaces of common residential zones. Most residents express more preference than college students for comfortable interfaces of facilities, e.g. wooden benches and clean grass. Meanwhile, the acoustic environment in common residential open spaces lacks in diversity of campus sound-scape, so residents does not have the same understanding as college students. Therefore, they expect aural amenity with less importance than those on campus.

Third, the common group is statistically less intense than the campus group in its mean comparison ratings of (1) C8, C10 (microclimate, biological diversity) over C9 (water-soil retention) and (2) C10 over C8. As known from Table 6, public preference for microclimate is little difference in the average marks, and the influence derives from the change of public preferences for water-soil retention and biological diversity. Commonly, a campus open space is much larger than a neighborhood park or open space, accommodating more wildlife with habitats. Because main campuses in Hangzhou City are

now located at the suburban areas, the natural environment surrounding them is protected satisfactorily. Therefore, college students show intense interest in biological diversity over water-soil retention. It may be discussed in another topic since the ecological attributes are also diverse in different open spaces, while this paper just focused on the general comparison and the two different types of survey areas.

CONCLUSIONS

Importance of the Functional Attribute

As a whole, the public is demanding many valuable attributes from daily used open spaces. The importance of the functional attribute is consistent between common residents and college students. A potentially problematic implication of the AHP study involves where to place it in the toolbox of designers. The results suggest that the public is less interested in several ecological services of open spaces, including the provision of microclimate, wildlife habitat and water-soil retention, which are usually provided via other types of open spaces planned for forestland and wetland. This result is unlikely to be robust across all open space programs because of the diversity of residents. These results tend to prove that planning policy for open spaces—in China, at least—ought to include at least two approaches, one for common residential areas and one for other special areas, e.g. campuses. The AHP results clearly suggest that the public demands more from their open spaces than non-market services and reinforce Marus, and Francis (1998)'s argument that open space programs should focus on criteria associated with leisure activities in open spaces over visual landscape. Further research on public preferences for activity-supporting functions is needed.

Applicability of the AHP Concerning Open Spaces

This study used AHP to identify the attributes and qualities of the value of daily used open spaces demanded by the public. Previous studies estimated people's preferences for the value of open spaces by using satisfaction evaluation and comparing the relative importance of open space characteristics through statistical analysis of survey and referenda data. The AHP application presented here provides clear and direct results on the relative importance of the attributes of the value of open spaces, though perhaps relying heavily on assumptions about the reliability of the sample. In combination with other methods, AHP is a useful technique for characterizing the demand side of open space programs.

The survey enumerators and supplementary materials continually reinforce the meaning of the rating scale and other survey elements in order to minimize subjective interpretation of the decision problem. Bias may still remain in the ratings data, however. The results of this test are well under the accepted inconsistency threshold (Saaty, 1980). Finally, many more respondents are sampled for this analysis than what had been done in the typical AHP literature. As a result, the potential of any individual bias to impact inordinately aggregate preference is reduced.

Potential Application of the AHP into Design Process

Users' demands and their evaluation on open space are the basis of environmental design. Designers should consider their designs according to the demands of users and improve the designs to increase the users' evaluation. The interview survey suggested that the concepts of designers diverge, in a way, from the public's demands on daily used urban spaces.

The users' demands and evaluation derive from their subjective perception, while the designers deal with the controllable objective factors. The AHP results offer designers the useful information: what kinds of attributes and qualities are important in public opinion. In the process of environmental design, alternative designs can be compared with each other according to weighted marks of all items. For example, when local authorities and experts of a panel evaluate the design presentation for a land development project or an open space, the preparative AHP results can provide the public opinions concerning what issues and qualities of residential environments are significant for their daily life. The weight values of all the factors are a useful achievement from the public participation. That is able to constitute to the final policy choice or decision.

Future Work

Evidence is now accumulating that the public demands many services from daily used open spaces. Clearly, human open spaces will not emerge from the designs that mainly target visual impression or that appeal more to house purchasers, while giving only slight credit to the functional attributes. More work is needed to reconcile the public's demands from visual appeals to the functional attributes. Such a recommendation has been made before; Marus and Francis (1998) argued that behavior modes in leisure activities show diversity of the public's demands. As a

consequence, it is necessary to examine specific and concrete actions, behaviors, and preferences of different people before formulating a design policy. Efficient administration of open space programs requires that the varied benefits should be balanced.

In fact, this study is only an exploration research on public perception for future work. The methods and details regarding design process using the AHP still need further attempt in citizen participation.

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