A FRAMEWORK ON THE DIVERSITY OF RESIDENTS' PREFERENCE AND BEHAVIOR IN RESIDENTIAL OPEN SPACE --- BASED ON THE CAMPUS CASE

September, 2006

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ABSTRACT AND KEY WORDS

ABSTRACT:

The rapid urbanization of Chinese cities has been resulting to the degradation of urban residential environments. As a representative of green areas, residential open spaces play key roles to balance the needs for both conservation and development. To provide insights for satisfactory planning of open space, the translation of intangible recreational value of open space into concrete value is necessary. In order to achieve the goal of public benefits, this study attempts to integrate public preference from residents to reflect the demands of the community that is the main stakeholders, who consume open space service in the form of recreational opportunities and amenities. Study of behavior and evaluation of residents may lead for action to interrelate the local view into planning process. Moreover, the relationship between spatial features and subjective perception was also examined based on the case study of Hangzhou City.

Human perception to the surrounding environment is diverse, and consequently the expression of residents deriving from perception can be observed through their behavior mode. As a result, this reaction of stimulus and feedback produces a new concept of interrelationship among subjective evaluation, behavior and human socio-demographic attributes. Herein the concept was concluded as lifestyle concerning residential open space. With consideration of its complexity, it is significant to classify the typical variations of residents' lifestyle in residential open space.

The study concentrated on the satisfaction indices and the preference ranking that influence the behavior of residents. The new quantification framework was developed through the interaction of behavior approaches together with subjective evaluation approaches by proposing a method to explore the interaction between residents' opinion and behavioral dynamics. As to behavior approaches, this study established an unconventional determinant factor to enable the examination of temporal regulation, spatial distribution and activity category of residents' behavior through the Behavior Entropy Index (BEI).

Satisfaction and Preference

With regard to open space users' evaluation: Satisfaction Index and Preference Weight, this study established the conventional methods to verify the consistency of residents' subjective perception to physical environments. The results of satisfaction and preference evaluation revealed the following information:

(i) the comprehensive satisfaction is significantly related to open space properties of

openness, greenness and facilities.

(ii) the comprehensive satisfaction is effectively influenced by applicability, amenity, community sequentially with both cases of the common residences and the campuses. Moreover, the applicability is evaluated as the more important aspect to influencing the satisfaction.

(iii) The functional attribute was evaluated as the most powerful weight within the three attributes that represent residents' preference of both the common case and the campus case.

Behavior

With regard to open space users' behavior: Behavioral Entropy Index, this study established the unconventional methods to examine the complexity of residents' reaction to physical environments. The results of behavior assessment revealed the following information:

(i) It is insufficient to examine the behavioral characteristics only by simply population count. The index of complexity constitutes to clarify the relationship between the temporal, spatial and categorical dynamics.

(ii) The balance of the temporal, spatial and categorical probability is significant to increase the efficiency of open space utilization; and more options and opportunity for outdoor life are important to increase the complexity of outdoor behavior.

(iii) The weather conditions hold the balance of outdoor behavior, which provides important information for designers that it is sound to set up more hemi-open spaces connected directly with open spaces.

(iv) The school schedule also influences the balance of outdoor behavior, which provides important information for students' leaders and university organizers that it is considerable to set up more activities not only during off days but also working days.

Lifestyles

With regard to open space users' lifestyles: Lifestyle Classification Model, this study established the unconventional methods to extract the diversity (or variations) of residents' lifestyles in residential open space. The results of lifestyle classification revealed the following information:

(i) There are existing the differences of preference, satisfaction, behavior and socio-demographic characteristics among the sample of respondents.

(ii) Three principal components represent the main impact factors of residents' preference, labeled (1) Ecology - Group activity, (2) Landscape, and (3) Individual - Public activity.

Four principal components represent the main impact factors of students' preference, labeled (1) Landscape + Microclimate, (2) Ecology - Group activity, (3) Non-visual landscape, and (4) Individual activity.

(iii) Eight types of lifestyles for the common case are described as (1) Aged exercisers, (2) Chatterers, (3) Private nursers, (4) Chess-card fans, (5) hydro-intimates, (6) Youths and (7) Lovers and (7) Mid-aged strollers. Six types of lifestyles for the campus case are described as (1) Sportsmen, (2) Talkers, (3) Landscapists, (4) Scholars, (5) hydro-intimates, and (6) Lovers.

Information for Improvement

This reasonable finding revealed the useful result due to the reason that daily usage is synthetically influenced by passive (compulsory) purpose and active (optional and social) purpose. Due to the potential of several determinants development, not only behavior and preference of open space users can be examined but also the interaction of open space users' behavior and preference can lead to the very useful information in order to monitor the change effect to the dependent side. The specific recommendations are as follows:

(i) The result of satisfaction evaluation shows that it is a suitable way to improve Applicability and Amenity of open space, in order to increase residents' satisfaction;

(ii) Correlation between satisfaction evaluation and physical factors shows that it is a suitable way to provide green space, attractive facility and good maintenance inside open spaces;

(iii) Spatial-Temporal BEI result shows that it is a suitable way to activate unused spaces and vacant land as more as possible, in order to improve the spatial balance for residents' utilization;

(iv) Spatial-Temporal BEI result also shows that it is a suitable way to provide more semi-open spaces connected directly with open spaces;

(v) Categorial-Temporal BEI result shows that it is a suitable way to organize special events during working days.

Some information for environmental improvement is also acquired based on the correlation analysis of spatial influence on satisfaction and behavior.

(i) According to the influence on people's activity, the first and second factors of spatial featuers may be defined as the Landscape + Usage Factor and the Communication Factor.

(ii) Applicability is influenced by the Principal Factor 1 (Landscape + Usage Spatial Factor). Amenity is also influenced by the Principal Factor 1. Community is influenced by the Principal Factor 2 (Communication Spatial Factor). Total Satisfaction is also influenced by the Principal

Factor 1.

(iii) Temporal BEI is influenced by the accessibility of small plots for students' activities, the ratio of semi-open space and plaza, and the number of facilities. On the contrary, the excessive openness and greenness seems to break the balance of people stay there, although the number of people increases. The categorial BEI is influenced by the accessibility of small plots, the ratio of semi-open spaces and plazas, and the number of benches and lights. Population ratio is influenced by the ratio of water area and the number of facilities.

In sum, this study examined the diversity of users' evaluation and behavior in the context of residential open space utilization. The results are expected to link residents' desire of open space improvement, professionals' interest in human subjective evaluation, and physical conditions of open space. The samples can be hopefully extended to reasonably represent the overall situation of Yangtze River Delta, China, so that it is possible to use the data for further analysis in this region, and to provide a valuable reference for other regions of China.

KEY WORDS:

Residential Open Space, Lifestyle, Satisfaction, Preference, Behavior

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CHAPTER 1:

INTRODUCTION

1.1. BACKGROUND

Increase of metropolitan population and residence

As economy develops and technology progresses, many regions in China have become industrialized and urbanized. Compared with main countries in the world, China is the representative of the most crowded and the most vigorous countries, in terms of population density and GDP increment (UN Statistics Division, 2005). The accompanying urbanization has resulted in detrimental and even dehumanizing outcomes due to the excessive exploitation of land resources, especially for the economic-leading region of Yangtze River Delta, East China (National Bureau of Statistics, China, 2005).

In addition to the prospect of a burgeoning population, metropolitan areas of Yangtze River Delta are using more land for residences than the case a few decades ago (Hangzhou Bureau of Statistics, 2005). Sustainable policies and effective programs should be required to stem the increasing tide of land-consumptive development and to reserve adequate livable spaces for local residents.

Daily usage of residential open space

Amérigo and Aragonés (1997) addressed that life satisfaction is closely related to residential satisfaction. Urban residential environment plays a vital role in the local society since it is directly relevant to human daily lives. One aspect of the urban residential environment is concerned with open space (Gehl, 1987). Since it provides many diverse benefits and opportunities to people's relaxation that constitutes to mitigating the pressure on urbanites. Consequently, open spaces have been given great importance as one of the indicators of quality of urban environments. People can gain direct benefits from open space service that are related to physical health as well as improved mental health. At the same time, open spaces also contribute indirect benefits to local communities in terms of social, economic and cultural levels.

As mentioned above, herein, much attention of this study is paid to residential open space.

1.2. PROBLEM STATEMENT

Residents' desire

Why do people prefer outdoor space to interior space in leisure time? In order to support the great importance of open space to people who live in urban areas. A preliminary survey concerning the first choice on leisure places was conducted in Hangzhou City, the capital of Zhejiang Province, China. The situation regarding residents' demands and the current barrier of open space are examined (Appendix A, page 87). The results show that most people choose to stay in exterior space during their leisure time rather than go outdoors. However, they also express the eagerness to open space as long as it is improved to be suitable for daily utilization. *In other words, the current performance of residential open space needs further improvement to meet residents' desire of leisure.*

Professionals' interest

Professionals such as planners, designers, and environmental researchers contribute to build up living spaces for residents. As to open space, traditional planning and design approaches mainly focus on spatial forms and building styles with a viewpoint of visual aesthetics. In addition, local authorities introduce environmental impact assessment into planning and design processes. *As with the development of related research in the recent years, some professionals and experts have begun to convert part of attention to users' subjective evaluation* (Wu, 1995; Xu and Yang, 1996; Zhu and Wu, 2002).

At present, Chinese environmental planners and designers also regard their clients' demands and environmental sustainability. Nonetheless, the great amount of construction projects and programs push them into a dilemma: pursuing the maximum monetary profit or realizing the maximum social profit. Especially, the latter outcome is latent after a long-term post occupancy and utilization of factual users, who usually have no decisive power when alternative designs or programs are decided before (Zhao and Ge, 2004).

Generally speaking, the models of residents' evaluation and behavior in open space are still desired by Chinese planners, designers and local authorities. There is a lack of comprehensive data of residents' evaluation and behavior concerning residential open space.

Limitation of the current design process

The above retrospection concerning Chinese residential open space elicits an implication (Yu,

2006) that:

(i) the traditional top-down approach in residential open space planning and implement should be integrated with scientifically based methods;

(ii) the functions of the current residential open spaces were mainly provision of green cover, with insufficient concern for human uses such recreational uses. Recreational uses should be considered and integrated into existing and planned residential open spaces;

(iii) the recently invoked "city beautiful", or cosmetic approach to residential open space planning and implementation should be stopped ; and

(iv) Residential open spaces should be planned as a critical strategic element of ecological infrastructure at both the regional and urban scale during current rapid and extensive urbanization occurring in China.

Residential areas and university campuses

What kinds of residential open space should be considered? Is it enough if only common residential communities? In fact, there is a reason to extend the research by including campuses into a whole study. Unlike the US, Europe or Japan, the long-term planned economy system of China has formed the distinctive planning policy of university campuses. Most students live on campus as same as residents who live in a neighborhood community. In some regionally central cities, the population of college students is a considerable number. For example, there are more than 600,000 college students in Beijing City, 500,000 in Shanghai City and 300,000 in Hangzhou City, China (National Bureau of Statistics, China, 2005). *In other words, university campuses should be regarded as a specific type of residential area in China. However, the synthetic consideration of common residences and campuses is still insufficient while related research selects the study areas.* As a result, this study makes a comparison and comprehensive consideration on both sides.

In a word, this study is rooted in the above four aspects of Chinese current situation, including residents, professionals, process and category concerning residential open space.

1.3. OBJECTIVES OF STUDY

The main goal of the study is to provide an effective evaluation system toward environmental improvement, which can advance design and management of residential open space for daily usage. The evaluation system is composed of the following aspects (Table 1.3.).

Table 1.3. Explanation of the Evaluation System concerning Residents' Behavior

Component	Description
Valuator	Users in residential open space (local residents and college students)
Way	Interview, Questionnaire, Observation, Record
Technique	RA (Regression Analysis), AHP (Analytic Hierarchy Process), Entropy, PCA (Principal Component Analysis), CA (Cluster Analysis).
Output	How well open space has satisfied the users; Preferences of the users; Diversity of residents

Some specific objectives of the study are listed as follows.

(i) To construct the evaluation structure and indices system for residential open space. To set up satisfaction and preference evaluation models and to explain the referred meanings in real world.

(ii) To classify human satisfaction and preference of urban open space, to grasp behavior mode and lifestyle in residential open space.

(iii) To offer a framework and useful information to support design according to the analysis results.

1.4. AREA OF STUDY

Residential open spaces in Hangzhou City, China are selected as the study area in this paper. Although there are also other types of open spaces, such as city parks and city plazas, they are not considered directly within this research. More concretely, the focus of this research is on some specific spaces that are daily utilized by the users for their recreational purpose, including: neighborhood open spaces, and university campuses.

The selected residential areas and campuses in Hangzhou city are depicted in Figure 1.4. *(Details and reasons of the area selection are mentioned in Chapter 3.2., Page 15)*

Figure 1.4. Study Area, Hangzhou City (Rectangle: Residence, Circle: Campus)

1.5. CONTRIBUTION

This research intends to propose a conceptual framework to examine user's viewpoints through *the linkage of residential open space users' evaluation and behavior*. Compared with existing research on residential satisfaction evaluation (Yang and Xu, 1995; Wu, 1995; Amerigo and Aragones, 1997), this method can highlight the role of main stakeholders of residential open space *in a comprehensive way*, especially in order to *interrelate the public preference to the satisfaction and behavior, not only for common residences but also for university campuses*. Under this expectation, some specific research contributions are described as following.

(i) (As to methodology, Chapter 4) The factors that influence the diversity of residents' evaluation and behavior can be identified through the *several model developments* of evaluation approaches and behavior approaches, which lead to *some valuable information from each model for future practical implication on open spaces*.

(ii) (As to models, Chapter 5) By *correlating residential open space users' perception* in terms of satisfaction evaluation and preference evaluation *to a few physical characteristics*, the study can lead to more understanding of residents' subjective

evaluation as well as the underlying factors, while existing research (Zhu, 2003; Skjaeveland and Garling, 1997) mainly applies unattached techniques such as Regression Analysis and Principal Component Analysis. This study attempts more useful techniques in a proactive manner to hold the promise of effective planning and maintenance of open spaces in the community.

(iii) (As to models, Chapter 6) *The synthesis of residents' preference and satisfaction* through the classification of the sample respondents showed a valuable tool for local government policymakers and environmental designers to place suitable plans of residential open space service in association with the evaluation, preference and behavior of the community. *With the extraction of the concept of Residential Open Space Lifestyle* (see Chapter 2), it assists public agencies and stakeholders in multiple uses of residential open spaces to delineate the perception and behavior related to environmental programs. *It is more concrete and pellucid than the abstract concept of lifestyle or residential lifestyle* (Burchard, 1991; Munoz, 2003; Van Eck, 2005; Ge and Hokao, 2004).

(iv) (As to models, Chapter 7) The assessment of residential open space users' behavior based on the *behavioral dynamics model* provides a method to observe and *examine the intrinsic relationship between temporal, spatial and categorical levels*. Based on the entropy theory (Shannon, 1948; Wilson, 1980), this method develops the concept of entropy in the field of environment-behavior, for enhancing outdoor space performance by incorporating the behavioral complexity, differently with the conventional method of population count (Sisiopiku and Akin, 2003).

(v) (As to findings, Chapter 8) The comparison among the common case and the campus case *examines the differences in terms of spatial scale and property*. Moreover, the correlation analysis and the regression analysis clarify the influence of spatial factors on residents' evaluation and behavior.

Role of this study

Since open space is one kind of public facility that is provided to maximize social benefit to the community, *it becomes significant to link the professional side with common people*. This study aims to clarify residents' perception to open space by integration of evaluation approaches and behavior approaches. *It is expected to provide valuable information for professional practice*. In fact, different open spaces provide different opportunities to different groups of people, which format different evaluation and behavior. In this study, three types of common cases and two types of campuses were compared concerning the satisfaction evaluation and preference, and *the*

results was defined as a concept of Residential Open Space Lifestyle. More details of the definition are discussed in Chapter 2, page 9 and page 10.

1.6. DISSERTATION OUTLINES

This dissertation consists of seven chapters as shown in Figure1.6.

It begins with **Chapter 1**, explanation on the background of the study together with the problem statement of research. Moreover, the objective and the area of study are also introduced in this chapter.

Followed by **Chapter 2**, the reviews of literatures related to this dissertation are illustrated and the lack of consideration from other studies is given in detail.

Chapter 3 traces the history and changes of planning and design of Chinese residential open space. And the social and spatial features of the study areas are also present in this chapter.

After the above parts of guidance, **Chapter 4** describes the framework of analysis and deduces the concept of Residential Open Space Lifestyle. The model development and analysis are discussed in the following parts, including Chapter 5, 6, and 7.

Chapter 5 is mainly focused on the evaluation model development and the result of analysis on residents and students' satisfaction evaluation from the questionnaire data. The preference is also examined and compared between the two cases afterwards.

Chapter 6 illustrates the procedure to incorporate the evaluation and the first choice on activity, and demonstrates the diversity of residential open space lifestyles through the empirical study.

Chapter 7 applies the concept of entropy to capture the behavior of open space users and establishes the model to quantify the behavior in terms of temporal, spatial and categorical levels.

Chapter 8 examines the spatial influence on the evaluation and behavior of the common cases and the campus cases, in order to clarify the relationship between spatial features and subjective evaluation.

Finally, the conclusions of dissertation are drawn in **Chapter 9** as the last chapter, related

recommendations and future work are also mentioned.

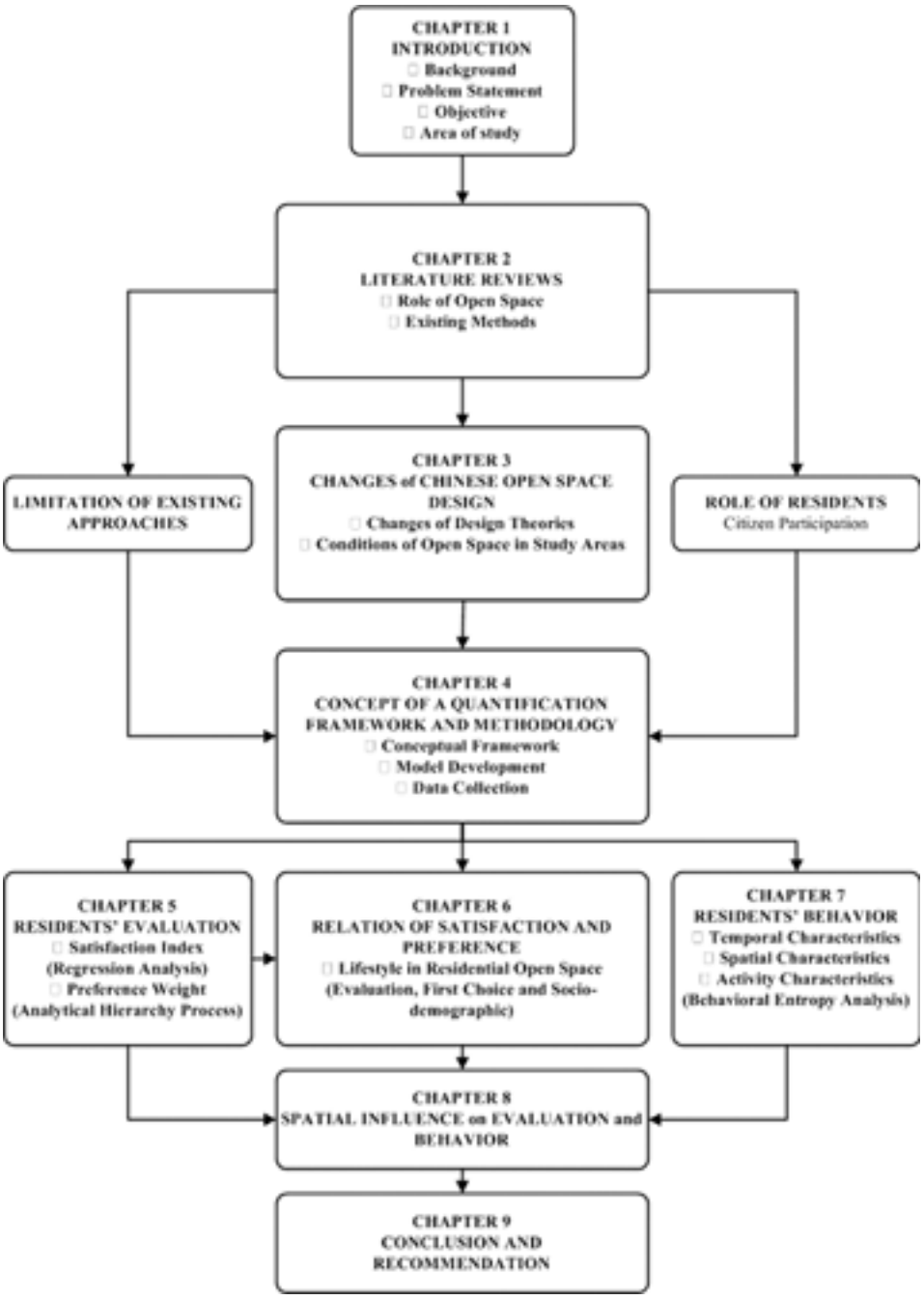

Fig. 1.6. The Flow Chart of the Dissertation and Main Methods

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CHAPTER 2:

LITERATURE REVIEW

2.1. OVERVIEW

2.1.1. Definition of Residential Open Space

Open Space is an open area of land that allows for the free flow of air, the unconstrained movement of people and natural exposure to the elements. It is typically seen as uncovered land in its natural state that can include washes, arroyos, view-sheds and trails. Open Space can also be a landscaped plaza in the middle of a busy downtown that provides areas for relaxing, sitting and strolling. The size can range from a pedestrian mall to a regional park to miles of river levee to an entire mountain range. The purpose is to preserve natural areas, provide public gathering places and supply a balance to urban development. There is no easily identifiable standard for open space but every opportunity to protect natural, historic, archeological and scenic resources should be attempted in order to guide urban development to appropriate areas and preserve resources for the health and welfare of the community (City of Yuma, 2002).

Further concretely, open spaces for people usage can be classified differently by size, service area, and purpose as described as follows (Marcus and Francis, 1998):

(i) Urban Plazas;
(ii) Neighborhood Parks;
(iii) Mini-parks and Vest-pocket Parks;
(iv) Campus Outdoor Spaces;
(v) Outdoor Spaces in Housing for the Elderly;
(vi) Children Care Outdoor Spaces;
(vii) Hospital Outdoor Spaces.

In one word, the related research has put forward a primary definition of open space. Consequently, this study is based on it and proposes a specific definition of residential open space: *that is an open (uncovered) land located at residential areas, allowing for the free flow of air, the unconstrained movement of residents and natural exposure to the elements.* Since this study is concerned with residential areas, neighborhood parks and campus outdoor spaces (ii, iv) are considered as the objects to survey.

2.1.2. Necessary on Residential Open Space

Several studies have identified that urban open space are potential to improve the quality of life of all citizens (Burgess, et al., 1988). The increase in demand on recreational activity results to the rise of demand on residential areas. Kraus (1971) summarized the causes that led to the growth of the recreational movement as follows:

(i) Growth of Leisure;
(ii) Increasing Affluence;
(iii) Higher Level of Education;
(iv) Urbanization and Suburbanization;
(v) Expanding Population;
(vi) Mobility of Population;
(vii) Advances in Modern Technology;
(viii) Cultural explosion;
(ix) Expansion of social welfare; and
(x) Professional development in Recreation.

During the past twenty years, most of the above trends (especially Increasing Affluence, Higher Level of Education, Expanding Population, Advances in Modern Technology, and Expansion of social welfare) have taken place in Chinese cities and stimulated more demands on open space not only for economic reasons but also for social development.

2.1.3. Definition of Target Groups

It can be seen that not only a variety function of green spaces provided to service the community but also a range of stakeholders are involved through out the environmental planning process. Leitmann (1999) classified in different groups of stakeholders as follows:

(i) Affected: Concerned residents and community-based organizations;
(ii) Decision-makers: Environmental protection agencies; politicians; sector agencies; private and informal-sector enterprises.
(iii) Experts: Planning agencies; the professional news media; the scientific and academic community; external sources of support/expertise.

In this study, *useful information is to be drawn out from the side of the concerned residents and provided to the other side of decision-makers and experts.* It includes residents' perception (evaluation and preference) and their reaction (behavior) to open spaces. Finally, this information

is to be concluded with a concept of lifestyle.

2.1.4. Definition of Residential Open Space Lifestyle

Lifestyle is such an abstract complicated concept that it is difficult to describe with a precise definition. According to a dictionary explanation (American Heritage Dictionary, 4th.Edition), lifestyle is a way of life or style of living that reflects the attitudes and values of a person or group. When lifestyle began to gain wide currency a generation ago, a number of critics objected to it as voguish and superficial, perhaps because it appeared to elevate habits of consumption, dress, and recreation to a primary basis of social classification. Nonetheless, the word has proved durable and useful, as Americans commonly invoke in explaining social values and social behavior, whether appropriately or not.

A concept of residential lifestyles as well as their structure and components was proposed in existing research (Ge and Hokao, 2004). Residential lifestyle is defined here as the way of life related to residence associated with the consumption of time, space and money.

Derived from the related research, the Residential Open Space Lifestyle is considered from two pairs of counterpoints, such as Subjectivity (evaluation) verse Objectivity (space), as well as Actuality (behavior) and Ideality (preference), all of which are directly related to open space. A tentative definition is as follows: *Residential Open Space Lifestyle is a way of outdoor lives that reflects the attitudes and values of a person or group who daily and regularly use open spaces surrounding residences.*

2.2. METHODS ON OPEN SPACE

2.2.1. Subjective Evaluation

Satisfaction Evaluation of Residential Environment

In the research concerning residential environment, the evaluation model is one of the basic and most important topics. Most of the research dealt with a general evaluation model by considering the common conditions. Amérigo, M. and Aragonés, J. I. (1997) discussed theoretical and methodological approaches on residential satisfaction. Asami (2001) concluded the main methods and theories for residential environment evaluation. Xu and Yang (1996) conducted a general survey of residential environments in Shanghai City, China. Ge and Hokao

(2004) explored residential environments in Saga City, Japan. The existing research in residential environment evaluation focuses on the general evaluation system at a city level. In fact, environment evaluation is closely connected with the different types of residents' characteristics and their residential lifestyles. As a result, it is necessary to deepen the residential environment evaluation of some specific residential groups. In this paper, the campus residential environment evaluation considering campus lifestyles will be examined.

Campus Environment

In the limited literature on campus environment, the focus is mainly on spatial forms, cultural atmosphere and landscape. Lin and Hu (1992) introduced the cognitive map into campus environment design, focusing mainly on visual image from an architectural viewpoint. Zheng (2001) emphasized the influence of the evaluation system in the process of campus planning. Zhu and Wu (2002) built up a multi-level evaluation model considering building quality, transportation, landscape and so on. However, existing research on campus environment stresses the apparent factors of campus environment only, neglecting psychological factors, such as residential preferences and lifestyle.

Yamaguchi, K. and Taniguchi, H. (2003) attempted to grasp the characteristics of outdoor spaces in the national university campuses by using the sky factor and the vertical direct daylight factor. The sky factor shows an openness of the outdoor space, and the vertical direct daylight factor shows a lighting condition. They computed both indexes about 100 campuses and compared it with the rate of building to site and the rate of floor to site. As for 12 campuses, it was examined about the influence which a change in the building arrangement exerted on both indexes and the building density indexes. The results are as follows; 1) Average of sky factor is closely related to the rate of building to site and the rate of floor to site. 2) Average of sky factor and vertical direct daylight factor are useful indexes which can show characteristics of arrangement of buildings.

Al-Homoud and Abu-Obeid (2003) found that a student grouping is affected by the space boundaries that it occupies in educational settings. Enclosure of space affects in-group interactions and seclusion. The hypothesis of the present study is that students' social interaction within the group is affected by increasing spatial enclosure, and seclusion is affected by exposure to increasing pedestrian flow in outdoor spaces on university campuses. The reported study included visual manipulations of two natural zones in an open courtyard at the Jordan University of Science and Technology Campus in the city of Irbid, Jordan. Analysis of the variance showed that perception of seclusion decreased when pedestrian flow took place and increased when

spatial enclosure occurred, whereas perception of interaction increased with increasing pedestrian flow compared to that of spatial enclosure occurrence. Vitality was affected by the location of the individual subjects. Implications suggest that a closer look at public outdoor spatial layouts should take place in terms of locating functions that affect pedestrian flow such as kiosks and enclosure formation in settings where healthy social interactions and friendship formation are of concern, such as in educational institutions.

Decision Support System:

Satty (1980, 1986) and Aczel (1983) integrated public participation in decision-making, and incorporation of human preferences, needs and perceptions in management. The method focused on the quantification of the human opinion, preferences and perceptions, and consequently the investigated results could be the inputs of the treatment method, such as the analytic hierarchy process (AHP). Seely (2004) developed this decision-making procedure of multi-criteria. The expected utility method (EUM) and compromise programming (CP) were used to assign the appropriate weights and ranked according to their importance to the interest groups, the issues to be studied, and the alternative management plans. The alternatives were also evaluated by assessing their sustainable character. The decision support systems, DSSs were modeled as a framework designed to project and/or interpret the consequences of different management activities and designed to address issues at multiple spatial and temporal scales that have increasingly employed a framework of hierarchically linked or nested models.

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).

However, 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).

2.2.2. Objective Evaluation of Open Space

Environmental Impact Analysis

Sankoh (1996) and Atkinson (2006) discussed on Environmental Impact Analysis in developing and developed countries. Community environmental impact assessment provides a systematic process for identifying, describing and evaluating community natural and human resources in order to improve decisions about their management. Choosing to assess the community environment does not imply that all identified resources must be preserved or protected. It does imply that the community must be knowledgeable about its resources, so that development decisions reflect the range of community values, not just economic values. An environmental impact assessment facilitates community planning by assisting local government officials, community leaders, and citizens:

(i) identify valuable environmental resources in the community and surrounding area that may be affected by a proposed development;

(ii) evaluate the community's capacity for additional development given environmental protection priorities;

(iii) identify the deficiencies or tradeoffs between possible development alternatives or courses of action and the environmental impacts associated with each alternative;

(iv) determine which groups in the community may be directly or indirectly affected by the project or action.

Entropy Analysis

Shannon and Weaver (1948) introduced Boltzmann's Heat Entropy into the application of information science. Wilson (1970) examined urban development using the entropy theory. Parrott (2005) applied spatially explicit entropy models in ecology to permit the investigation of population dynamics in both space and time. The resultant spatiotemporal dynamics is often irregular and patchy, giving rise to intricate spatial patterns that can be difficult to characterise. The question of how to characterise the spatiotemporal dynamics of simulated populations is addressed and a method of quantifying the complexity of patchy vegetation dynamics is proposed. The method is inspired by information-based measures of complexity and entropy and can distinguish between ordered, disordered (random) and complex (patchy) spatiotemporal mosaics. The method is demonstrated using data generated by the individual-based, multi-species model WIST.

Let X be a random vector taking values in Rd with probability density function f(x), then its differential entropy is defined by

$$H(f) = -\int f(x) \ln f(x) dx:$$

It is assumed that H(f) is well-defined and is finite. The concept of differential entropy was introduced in Shannon's original paper (1948). Since then, entropy has been of great theoretical and applied interest. The basic properties of differential entropy are described in Chapter 9 of Cover and Thomas (1991). Verdugo Lazo and Rathie (1978) provide a useful list containing the explicit expression of H(f) for many common univariates. Ahmed and Gokhale (1989) calculated H(f) for various multivariate.

The differential entropy has some important extremal properties:

(I) If the density f is concentrated on the unit interval [0; 1] then the differential entropy is maximal; if f is uniform on [0; 1], and then H(f) = 0.

(II) If the density is concentrated on the positive half line and has a fixed expectation then

the differential entropy takes its maximum for the exponential distribution.

(III) If the density has fixed variance then the differential entropy is maximized by the Gaussian density.

Kaimanovich and Wolfgang (2002) studied the Poisson boundary (representation of bounded harmonic functions) of Markov operators on discrete state spaces that are invariant under the action of a transitive group of permutations. This automorphism group is locally compact, but not necessarily discrete or unimodular. The main technical tool is the entropy theory which they develop along the same lines as in the case of random walks on countable groups, while, however, the implementation is different and exploits discreteness of the state space on the one hand and the path space of the induced random walk on the non-discrete group on the other. Various new examples are given as applications, including a description of the Poisson boundary for random walks on vertex-transitive graphs with infinitely many ends and on the Diestel–Leader graphs.

Song Chun Zhu, Ying Nian Wu, David Mumford (1997) proposed a general theory and methodology, called the minimax entropy principle, for building statistical models for images (or signals) in a variety of applications. This principle consists of two parts. The first is the maximum entropy principle for feature binding (or fusion): for a given set of observed feature statistics, a distribution can be built to bind these feature statistics together by maximizing the entropy over all distributions that reproduce them. The second part is the minimum entropy principle for feature selection: among all plausible sets of feature statistics, the authors choose the set whose maximum entropy distribution has the minimum entropy. Computational and inferential issues in both parts are addressed; in particular, a feature pursuit procedure is proposed for approximately selecting the optimal set of features. The minimax entropy principle is then corrected by considering the sample variation in the observed feature statistics, and an information criterion for feature pursuit is derived. The minimax entropy principle is applied to texture modeling, where a novel Markov random field (MRF) model, called FRAME (filter, random field, and minimax entropy), is derived, and encouraging results are obtained in experiments on a variety of texture images. The relationship between our theory and the mechanisms of neural computation is also discussed.

GIS-Based Multi-Criteria Decision Making Approach

Phua and Minowa (2004) applied multi-criteria decision making in the forest conservation planning that implies a process of assigning values to alternatives that are evaluated along multi-criteria. Multi-criteria decision making could be divided into two broad classes of multi-attribute decision making and multi-objective decision making. Both multi-attribute decision making and multi-objective decision making problems can be single-decision-maker problems or group decision problems. Based on the GIS based multi-criteria decision making approach, the preferences of conservation groups can be derived and incorporated in prioritizing forest areas for conservation with different indicators at a landscape scale for the criteria covering the interests of the conservation groups. The preferences and indicators could then be combined to generate potential conservation areas. The potential conservation areas serve as the basis for delineation of potential new protected area.

2.2.3. Synthesis of Evaluation: P.O.E.

Integrated by Wolfgang (1988), Post-Occupancy Evaluation (POE) is the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time. POEs focus on building occupants and their needs, and thus they provide insights into the consequences of past design decisions and the resulting building performance. This knowledge forms a sound basis for creating better buildings in the future. POEs' objects mainly refer to the performance of buildings. There are many kinds of buildings from which specific performance is expected. So are the different occasions and locations in or out of buildings.

In a hotel room, for example, conversations taking place next door may be overhead. In the case the acoustical performance of the building is being assessed. The room temperature, the quality of lighting, storage, finishes, and even the esthetic quality of the view from the hotel window are also informally evaluated. Similarly, those waiting for an elevator may judge the waiting time to be excessive. The criteria used in this case come from expectations that are based on previous experiences with elevators.

Depending on the objectives of the client organization and the time frame involved, POEs have uses and benefits over the short, medium, and long term, using three POE process models. indicative POE, investigative POE, and diagnostic POE. The methods include:

(i) archival and document evaluation;
(ii) performance issues;

(iii) walk – through;

(iv) interview;

(v) questionnaires;

(vi) surveys;

(vii) observations;

(viii) physical measurements;

Its goal is the correlation of physical, environmental, and behavioral performance measures, thus providing a better understanding of the relative significance of various performance criteria.

As a result, Diagnostic POEs are usually applied on large-scale projects, involving many variables. Often the attempt is made to develop results that indicate relationships among variables. It uses sophistication in both data collection and analysis techniques exceeding that of the two former kinds of POEs.

2.2.4. Factors and Values of Outdoor Space

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.

Matsuda, et al. (2002) clarified the collective form of buildings and outdoor spaces, such as courtyards and streets, in Manek Chowk area in Ahmedabad, western India. The streets in this area have hierarchical tree system forming block pattern called Pol. In this study, the collective form of buildings and outdoor spaces is described to three phases such as house/group/Pol. As the result they found the two collective systems. One is the supplement system of the outdoor space between court-yard and street the other is the nesting system of each phases.

Elena G. Irwin (2002) tested the marginal values of different open space attributes, using a hedonic pricing model with residential sales data from central Maryland. The identification problems that arise due to endogenous land use spillovers and unobserved spatial correlation are addressed using instrumental variables estimation with a randomly drawn subset of the data that omits nearest neighbors. Results show a premium associated with permanently preserved open space relative to developable agricultural and forested lands and support the hypothesis that open space is most valued for providing an absence of development, rather than for providing a particular bundle of open space amenities.

Charles, J. and Fausold, Al. (1999) addressed that communities increasingly face development pressures that can irreversibly alter open space lands. While the monetary costs and benefits of development are typically known, the corresponding values of natural lands are complex and difficult to measure. This paper reviews different concepts of economic value in relation to open space, describes methods for quantifying these values, and presents examples of each from published literature. Open space benefits accruing to citizens as market values or consumers' surplus include market and enhancement values, production values, natural systems value, use and nonuse values, and various intangible values. Economic impacts that open space lands have on local communities and economies include fiscal impacts on municipal budgets, expenditures from open space-related activities, and impacts from employment and tax revenues. These values are not universally present within a given community, nor are they quantitatively additive. However, a comprehensive consideration of the multiple values of open space will better inform community decisions about land conservation and development.

Thompson (2002) asked what should be demanded from urban open space in the 21st century. It explores the social and spatial implications of new lifestyles, values, attitudes to nature and sustainability, and the models for future city life and the patterns of urban open space that might accommodate these. One vital role that urban parks play is providing space for the expression of diversity, both personal and cultural; this raises issues of democratic provision for and access to public open space. It suggests that the role of the urban street as public space may need to be re-thought. The social and cultural values of open space include attitudes towards nature and the desire for contact with it; contemporary understandings of ecology offer new insights into ways to serve both human needs and the broader ecological framework of urban open space structures. It has been suggested that the urbanity of public open space is threatened by the increase in 'virtual' transactions, obviating the need for real, social interaction, but there is also evidence that use of new communications technology can increase and enhance use of public open space; this may include engagement in the productive aspect of our landscape. A more flexible approach to

open space definition and usage is proposed, recognising 'loose-fit' landscapes which allow opportunities for the socially marginalised and the ecologically shifting within a dynamic framework of urban structures and networks.

In "the welfare economics of city bigness", George Tolley asserts that the virtual price of amenities can be used to judge the efficiency of a urban spatial land use patterns. Expanding this test to open space amenities is not straightforward because those amenities are especially difficult to characterize. Bockstael and Irwin (2000) suggest that open space amenities and their virtual prices depend on whether surrounding land uses are fixed or adjustable. Smith, V. Kerry, Christine Poulos, and Hyun Kim. (2002) estimates hedonic price functions over nearly 30 years to evaluate, whether the distinctions between fixed and adjustable land uses help in measuring the value of open space amenities.

Bates L.J.; Santerre R.E. (2001) concluded that at both the state and national levels, public policies are being designed to stimulate the demand for locally owned open space. Yet very little is known about the factors that influence the demand for open space and the sensitivity of demand to price and income. To fill the void, this study uses data for Connecticut cities and towns to estimate the public demand for open space. The empirical results suggest that the demand for open space is relatively insensitive to changes in price but highly responsive to changes in income. The findings also show that federal and state open space may tend to crowd out locally owned open space and that locally owned open space represents a highly congestable good. Finally, the analysis indicates that privately owned open space is not a good substitute for locally owned public open space.

Wu, J. and AJ Plantinga. (2003) found that there is widespread public support for open space provision and for efforts by government to limit sprawl. They demonstrate that open space policies should not be viewed as independent of—or necessarily compatible with—growth management goals. They examine the impacts of open space designation on the urban landscape in a spatial city model with two important and empirically-relevant features: (1) residents prefer to live close to open space and (2) open space amenities attract migrants to the city. Our main findings are that open space designation can produce leapfrog development when it is located outside of the city; the effect of open space on the total area of developed land in the city is ambiguous; the location, size and configuration of open space can all affect development densities throughout the city. Our analysis identifies the key factors that determine the impacts of open space and yields insights into the design of effective land-use policies.

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.

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CHAPTER 3:

REVIEW OF RESIDENTIAL OPEN SPACE IN CHINA

3.1. CHANGES OF CHINESE RESIDENTIAL OPEN SPACE

This section traces on the evolution of planning and implementation of residential open space in China, and provides a historical and social context to the concept of residential open space.

3.1.1. General Review

Although the concept (literal definition) of Residential Open Space was an adaptation from the western countries (Massachusetts Office of Coastal Zone Management, 2005; Department of Planning and Development, Seattle City, 2005; Planning Department of Midland City, Michigan, 2005), the Chinese have a history of more than 2000 years of residential open space planning and implementation. Chinese residential open spaces have been called various names and were planned for various reasons (Ji and Hardie, 1988; Peng, 1986; Wang, 2000).

In history, urban open space concerned with residential lives includes civil cartilage, downtown streets, and bazaars, while royal parks and aristocratic gardens are controlled and exclusive to common citizens.

The long history of residential open space planning and implementation in China was mainly a “top-down” approach, which, while very effective under a centralized administrative system, often lacked a scientific basis and significant public participation (Yu, 2006).

3.1.2. Recent 100-Year History of Residential Open Space Design

Relevant to this study, residential open spaces in China are discussed chronologically and in three stages (Zhang, 2003), which are *the classical (traditional) stage*, *the compact stage* and *the modern (landscape) stage*, shown as Table 3.1.2. (a, b):

Table 3.1.2. (a) Stage of Recent 100-Year History of Residential Open Space in China

Stage	Year	Description	Type of Open Space	Facility	Scale (M2)
1	Before 1949	Traditional community	Classical garden, multi-purpose street	Tree, pond, bench, light, porch, gloriette, street,	100-400
2.1	1949-1978	Compact community	Space between buildings	Tree, bench, light, road,	100-1000
2.2	1979-1992	Improved Compact community	Central parks, space between buildings	Tree, pond, bench, light, porch, gloriette, instrument, road,	1000-3000
3	1993-	Landscape community	Central parks, space between buildings	Tree, pond, bench, light, porch, gloriette, instrument, road,	1000-5000

Table 3.1.2. (b) Stage of Recent 50-Year History of Campus Open Space in China

Stage	Year	Description	Type of Open Space	Facility	Scale (M2)
2	1952-	Compact Campus	Central green area, space between buildings	Tree, pond, bench, light, porch, gloriette, instrument, road	1000-10000
3	2000-	Landscape Campus	Central landscape area, space between buildings	Tree, pond, bench, light, porch, gloriette, instrument, road,	1000-40000

(1) Stage 1 (Classical private garden and multi-purpose street): Until the New Culture Movement in 1919, the mainstream of residential open space design had been concerned with classical private gardens. Elegance, exclusion and delicacy composed the spirit of design and construction. The scale of private gardens was within a scope of 100 square meters to several thousand (Fig. 3.1.2.1.).

From the early 20th century, Chinese universities were also founded at several big cities. The area of campus was much less than that of current campuses, and the population of students was also much fewer than today. The campus locations were usually selected in old-system schools. The style and feature retained the Qing Dynasty's traditions.

From 1919 to 1949, there was a break of design theory and implementation due to the civil war and the world war.

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Fig. 3.1.2.1. (a) Open space of Song Dynasty's Urban Street

Fig. 3.1.2.1. (b) Map of Liu-Yuan
（中国明代蘇州留園）

Fig. 3.1.2.1. (c) Open space of Liu-Yuan
（中国明代蘇州留園）

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.1.2.1. (d) Open space of Q-H-F
（中国杭州清代・民国清河街）

Fig. 3.1.2.1. (e) Open space of Q-H-F
（中国杭州清代・民国清河街）

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(2) Stage 2 (Compact community): Influenced by the planned economics system and the financial tension from 1949 to 1992, open spaces in community were laid out around the whole community at a low quality level. The green ratio and facilities were both insufficient. The residents were assigned their residences without a free choice right, but a stark top-down mechanism of assignment. During this stage, there are two sub-stages, where one is from 1949-1978 (Stage 2.1) and the other is from 1979-1992 (Stage 2.2). In the former stage, most communities have higher dense buildings and fewer available open spaces for leisure usage than the latter case (Fig. 3.1.2.2.).

From the foundation of the People's Republic of China, Chinese universities were constructed nationwide. The area of campus was less than that of current campuses, and the population of students was also much fewer than today. The campus locations were usually selected near sub-centers of the city. The style and feature adopted the eclecticism of the Russian mode and national traditions.

Fig. 3.1.2.2. (a) An old community in Hangzhou City

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.1.2.2. (b) An old community in Hangzhou City

Fig. 3.1.2.2. (c) An old campus in Hangzhou City

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.1.2.2. (d) An old campus in Hangzhou City

(3) Stage 3 (Landscape community): Since the extension of the nationwide economic reformation in 1992, the system of house ownership has changed into the mode of money market. The estate agents began to control the decision of site plan, open space design and building design. In order to appeal to clients and potential house-buyers, the visual attractiveness of open space takes the second place next to the price-distance index. More facilities and natural components are introduced into open space design (Fig. 3.1.2.3.).

As with the combination movement of universities and colleges from 1998, Chinese universities began to be moved, re-constructed and constructed nationwide. The area of campus is enlarged, and the population of enrolled students is also increasing. The campus locations are usually selected outside of urban area. The style and feature adopted the modern style from the west countries.

As residential open spaces have evolved in China, they reflect changes in ideology, utilization and scale; from green space protection or beautification to ecological and multiple uses, and from small-scale fragments to a systematic community network. The development of economics, the involvement of city policy and the influence of technology all play an important role in the evolution of residential open spaces in China.

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.1.2.3. (a) A new community in Hangzhou

Fig. 3.1.2.3. (b) A new community in Hangzhou

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.1.2.3. (c) A new campus in Hangzhou

Fig. 3.1.2.3. (d) A new campus in Hangzhou

3.1.3. Change of Design Methods

3.1.3.1. Community Case

(1) Stage 1 (Classical private garden and multi-purpose street):

Stage 1 –A: ***Classical private garden***

Principle of Open Space Design: The classical private garden emphasizes imagining the greatness from the small scale space. Various methods are used to create abundant open space within a limited area, such as open courtyard with abundant scenery, small yard designed elaborately and fringe space used subtly. Many elements are used to divide space, such as buildings, scenical walls, plants, hills and stones.

Spatial Scale: Most private gardens is within a scope of 100 square meters to several thousand, where many places are properly assigned, such as dwelling, receiving, lie fallowing, reading and so on. The buildings are almost traditional wood structure with one or two floors.

Facility: It is a main characteristic of the classical private garden that scenery changing along with the place. Plenty of facilities are provided in it, including wood chairs around booths and corridors, tables and chairs inside booths and some chairs beside ponds, road and under big trees. The plant scheme goes in for the harmonious combination of flower, color, smell, shape and the seasonal attribute. The disposal of hills and stones emphasizes nature shape and artistic conception. Waterscape design emphasizes the harmoniousness with plants, hills, stones and buildings, its shape is regular or freedom.

Transitional space: The buildings in the classical private garden are almost timberwork, with grille windows and doors. Corridors are usually set outside or between buildings, which enhances the relation between inner and outer space. Scenical walls and hollow windows are also the common way to add the space levels. Open booths are usually used as the place for communion and viewing.

Road: Most roads in classical private garden are devious, one-meter width. Its important action is leading people to view the scenery.

Stage 1 –B: ***Multi-purpose Traditional Street***

Principle of Open Space Design: Because the space spreads linearly along with the boundary of the road, the kinds of open spaces are simplex. Only some irregular small spaces appear at the offset of the road. Usually, various performances of traditional handicraft occur on the road, through which the road is divided into several recessive open places.

Spatial Scale: The space scale of the road is kindness and amenity. Only walkers can pass through it. The main road is 7－10 meters width and the spur track is 1－3 meters width. The most buildings beside the road are wood or brick structure with two to three floors.

Facility: That toriis, lighting walls and carves are disposed at the entry of the road, and various steles, couplets, facias and camouflages are fixed on the buildings beside the road. Landscape opusculums, such as sculptures and chairs, are placed at the irregular small spaces. Plants and water are very deficient for the limited area.

Transitional space: At the ground floor, the business spaces are almost open wide, and the frontage shops are almost open to the road in business time, which enhances the relation between inner and outer spaces. At the same time, most buildings set shoulder corridors at the second floor, which perform the same function.

Folk-custom activity: At the feast, various folk-custom activities are performed, such as opera, kid show, handicraft show and so on, which is one magnetic cultural landscape.

The selected study case: Qing-He-Fang Community.

(2) Stage 2 (Compact Community):

Stage 2 –A: ***Old Compact Community***

Layout: Most communities located at the old city center with limited area and compact pattern. Most buildings are six to seven floors. Considering the basic requires of function, the buildings are disposed to stiff tessellation.

Principle of Open Space Design: The real public open space is very few. The places between buildings are formed according to the demands of sunlight time, which are the main open spaces. The shapes of most open spaces are regular and single.

Scale: Only a small quantity of open spaces with limited area can be found in the community.

Facility: The sports facilities are seriously deficient. Only a few small setting-up equipments are fixed at a little big space between the buildings. There is not enough rest and parking facilities, and the problem of parking on the road is ubiquity.

Road: The road system takes a dendritic pattern with a stiff form, People and cars all can transit through it.

Plant: there isn't centralized greenbelt, only some small greenbelt dispersed between houses, without special designed.

Water: Water is very little for the limited area.

The selected study case: Qiu-Shi Community.

Stage 2 –B: Improved Compact Community

Layout: Most improved compact communities locate at the city sub-center with limited area. Most buildings are six to seven floors. Considering the demand of sunlight time, the buildings are disposed to tessellation or courtyard.

Principle of Open Space Design: The kinds of open spaces increase as the community center park and the group greenbelts becoming the important elements of the community. While the places between buildings still act as the common open spaces.

Scale: Usually, there is a community center park with a scope of 500 square meters to several thousand, which is the main open space. According to the scale of the community, two or three group greenbelts are setup with a scope of 100 to 200 square meters. They are the assistant open spaces for the limited quantity and simple facility.

Facility: Many facilities are disposed at the community center park, such as booths, corridors, bridges, chairs and small setting-up equipments. The corridors, chairs and small squares are also placed at the group greenbelt. The sports facilities are deficient, and the problem of parking on the road is ubiquity for the short of parking facilities.

Road: Flexural shape is taken in the design of the main road, in order to limiting the vehicle

speed and improving the visual image. The subordinate roads still take a dendritic pattern, People and cars all can transit through it.

Plant: Special plant design is taken in the community center park and the group greenbelts. The harmony is emphasized when combining two or more elements together, such as arbors and shrubs, lawns and squares, lianas and corridors.

Water: The regular or freedom waters become an important element of the community center park. Usually the whiff areas are disposed beside the bank, and the facilities, such as booths, bridges, chairs and so on, are located over the water surface.

The selected study case: Cui-Yuan Community and Cai-He Community

(3) Stage 3 (Landscape community):

Layout: Most landscape communities are constructed nearby the city sub-center in recent years. The distribution emphasizes the aesthetics of composition and form, pursuing the free or geometry pattern instead of tessellation. The building highness is strewing at random.

Principle of Open Space Design: From the entry to the public greenbelt, square and courtyard, the continuous and multi-level open space system is formed. At the same time, various available spaces are elaborately designed. For example, amenity space is created through setting booths, chairs, scenical walls and plants beside the residential fastigium. The shapes of open space are abundant, such as circle, sector, echelon and other free forms.

Spatial scale: The combination of the center park and the chamber becomes the center of the community public space. The scale of the group space and courtyard is largening, as the building layers become increasingly high. They become the main places of resident activities and the keystone of landscape design.

Facility: Various facilities are setup according to the ages, occupations and customs of residents, such as greenbelts, physical disabilities ramps, children paradises, healthy footpaths, natatoriums, tennis courts, chess and cards booths. The facilities for rest and parking are sufficient.

Road: Based on the satisfied function requires, the road scheme emphasizes aesthetic form and free shape. The character of the general space distribution is presented with the road form, such

as curve, folded line, freeness and geometry.

Plant: The plant scheme emphasizes the diversity of the kinds and levels, pursuing the harmonious disposal of arbors, shrubs, herbages and liana. For example, the shrub and the herbage act as the main elements at the greenbelt between the buildings, the arbor should be the main object planted on the sideway, the cooperation of arbors, shrubs and herbages should be carefully considered at the small pleasance. Meanwhile, the seasonal attributes also should be skillfully utilized.

Water: The waterscape becomes important at the community. Most natural waters are utilized after properly modified and some facilities and environmental art are disposed in them. The forms of most artifical waters are viewing pond, paddle pond and natatorium. Usually, fishes and hydrophytes are placed in them.

The selected study case: Wen-Xin Community and Xia-Sha Community

3.1.3.2. Campus Case

(1) Stage 2 (Compact Campus):

Symmetrical Axis: The utilization of axes and courtyards is considered as the main character of the campus scheme. Usually, the entry is regarded as the start of the axes, emphasizing the vigor of the entry plaza. The statuary of chair mao is setup as the visual focus, giving prominence to the coherence of the entry and the footprint direction. The library or the teaching building with big bulk is usually regarded as the end-point of the axes. The courtyard surrounded with teaching buildings and office buildings is the center of the whole campus, with a regular shape and majesty vigor.

Spatial scale: Most campuses located at the old city center with a compact pattern and limited area. the building density is high.

Facility: A small quantity of chairs are usually placed in the shady woods, the sports facilities are deficiency and short of convenience for the centralized distribution. The pitching mode of square and road are simplex.

Principle of Open Space Design: Teaching center is prominent in the distribution of open spaces. The courtyards or plazas surrounded with several large buildings are the main places of

plant scheme. Commonly, the large lawns are taken as the background and the big trees, hedges and sculptures are considered as the decorations, which emphasizes the widen but ignores privacy. At the same time, only less open spaces are placed at the living area, assistant teaching area and sports area, even so, the scanty open spaces are still used as distributing place of the given area without enough plants and facilities.

Transitional space: The buildings are occlusive with limited communication between inner and outer spaces, and short of diverse visual image for the stiff shape.

Road: The road system takes a regular pattern with a stiff form, spreading along with the principal axis of the campus and connecting the function areas. People and cars all can transit through it.

Water: The waters are usually undersize and less, most of them are artifical ponds except owning natural waters. The shapes of ponds are regular, and fountains and sculptures are usually placed in them.

The selected study case: Yu-Quan Campus and Xi-Xi Campus (Zhejiang University)

(2) Stage 3 (Landscape Campus):

Layout: The general distribution emphasizes aesthetics of the composition and the form, breaking through the routine rectangle plan and tessellation, pursuing the freedom and geometry pattern. The space forms are more abundant, such as circle, sector, echelon and other free shapes.

Spatial Scale: The campus is moved from city center to the city edge with a scope of several square kilometers to decades. The functions of campus are citilized and the building distribution is comparatively dispersive, so the density is greatly falling.

Facility: The pattern of the centralized and the dispersed are adopted together in the distribution of sports area, as giving attention to the utilization in break and peacetime. The fields with great noise are setup solely and centralized at the place keeping a certain distance from the teaching area and living area. The small sports fields, such as badminton courts，pingpong courts，single and parallel bars courts, are located at the empty place between the teaching buildings and the living building, so as to the students can expediently utilize them. Simultaneously, proper quantity chairs are placed with plant and opusculums at the roadsides, under the trees, inner the

hall and on the corridors, where the teachers and the students pass by daily. Either the squares designed elaborately or the hardpans all can attain enough light and wind, and sufficient chairs are placed in them.

Principle of Open Space Design: The open spaces with various scales and forms are interspersed among the campus. Including not only small greenbelts at the roadside, small squares designed elaborately and hardpans with beautiful colors, but also the open and comfortable public spaces, such as the entry plaza, the center square, the plazas front the public buildings (library and auditorium etc) and the recreational greenbelt provided for a mass of persons to swing. The plant scheme emphasized the harmonious combinations between arbors and shrubs, lawns and flowers, plants and squares.

Transitional space: The building images is diversiform, and the transitional spaces, such as the corridors outside or between buildings, halls for communion and flat roofs, are setup to enhance the relation between inner and outer spaces, in order to providing more probability for activities.

Road: The road scheme emphasizes the effect of visual image, avoiding single traffic function and stiff form. The design of roads pursues the combination of point, line and face, beeline and curve, tessellated line and bias.

Water: Utilized the nature lake or digged the artificial pound, the waterscape becomes the important character of campus. The large area waters usually take free banks cooperating with plants and roads, and the small scales are designed to regular shapes and collocated borders, fountains and small squares etc.

The selected study case: Zhejiang Gongshang Univeristy Campus and Zi-Jin-Gang Campus (Zhejiang University)**.**

3.2. SELECTION OF SURVEY AREA AND THE CURRENT CONDITIONS

Based on the design stages mentioned in the previous section, ten residential areas (six common residences and four campuses) in Hangzhou City, China, were chosen as the sample areas (Fig. 3.2. and Table 3.2.(a) & (b)), and a questionnaire survey was conducted in the fall of 2005. This is from the reason that it is necessary to perform case study on different functions of destination that affect on different behavior of open space users.

Fig. 3.2. The Selection of Study Areas

Table 3.2.(a) Description of the Six Common Residences in Hangzhou City

Community Name	Length (years)	No. of Residents	Location	Type	Facility
No.3. Qing-He-Fang	50-100 Stage 1 Traditional	2300	East to the Lake	B: Scenic	1. Historic street 2. Museum 3. City plaza
No.4. Qiu-Shi	30-50 Stage 2.1 Modern	7800	West to the Lake	B: Scenic	1. Super market 2. University 3. Library 4. Sports center 5. Park
No.1. Cui-Yuan	20 Stage 2.2		Located in the city north center.	A: Shopping	1. Super market 2. Amusement center
No.2. Cai-He	Stage 2.2 Improved Modern		Located in the city east center.	A: Shopping	1. Super market 2. Amusement center
No.5. Xia-Sha	5 Stage 3	56500	Located in the eastern suburb.	C: Suburban	1. Super market 2. University

Table 3.2.(b) Description of the Four Campuses in Hangzhou City

Campus Name	Length (years)	No. of Students	Area (Ha)	Floor Area (M^2)	Type	Description
No.7. ZJU-YQ	52 Stage 2	10,000	120	700,000	A: Urban	Near the West Lake and the Plant Park
No.8. ZJU-XX	Stage 2 Modern (old)		70	500,000	A: Urban	Near the travel sites: the Yellow Dragon Cave and the Gem Hill.
No.9. ZJU-ZJG	5 Stage 3	13,000	200	600,000	B: Suburban	Located in the northwest suburb of the city.
No.10.	4	12,000	100	350,000	B: Suburban	Located in the estern

3.2.1. Surrounding Environments of the Study Areas

Common Residential Community (Common Case)

The study area is composed of six Common Residential Communities, which are located around Hangzhou city. Locations and surrounding conditions are chosen as the criteria for classifying these areas (Table 3.2.(a)).

Type A may be named Shopping Type, which is near the district center. Cui-Yuan (No.1) and Cai-He (No.2) are located in the northern and eastern shopping center of the city respectively, characterized by a dense population and complete shopping facilities. Both communities are more than 20 years old and the buildings are mostly old and densely located.

Type B may be named Scenic Type, which is near the landscape area. Qing-He-Fang (No.3) and Qiu-Shi (No.4) are located around the West Lake, the famous tourism area noted for its beautiful natural and cultural landscape. Both communities are more than 50 years old; most buildings are old and densely located.

Type C may be named as Suburban Type, which is located on the outskirts of the city. Xia-Sha (No.5) and Wen-Xin (No.6) are located on the eastern edge and northwest edge of the city respectively, both of which are new cultural and educational areas. At present, there is a lack of municipal facilities and the population is sparse.

As mentioned above, the six communities are located around the urban area of the city,

representing general conditions with an overall consideration of the history, economic development, and natural conditions as well.

University Residential Community (Campus Case)

The study area is composed of four campuses, which are located around Hangzhou city. They are: Yu-Quan Campus, Xi-Xi Campus and Zi-Jin-Gang Campus of Zhejiang University (abbr. ZJU-YQ & ZJU-XX & ZJU-ZJG); Xiasha Campus of Zhejiang Gongshang University (abbr. ZJGSU). According to their different geographic, natural and social features, we can classify them into two types (Table 3.2.(b)). Although influential factors concerning the campus environment are numerous, we chose location and surrounding condition as the criteria for classifying these four campuses.

Type A may be named Urban Type, which is located in the city center and near the landscape area. ZJU-YQ (No.7) and ZJU-XX (No.8) are located in the Xi-Hu District, the famous tourism district area noted for its beautiful natural and cultural landscape. The two campuses are more than 50 years old; some buildings are new but densely located.

Type B may be named as Suburban Type, which is located on the outskirts of the city. ZJU-ZJG (No.9) and ZJGSU (No.10) are located on the eastern edge and northwest edge of the city respectively, both of which are new cultural and educational areas. At present, there is a lack of municipal facilities and the population is sparse.

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3.2.2. Features of the communities and open space

Qing-He-Fang Community (historic area)

The south of Hangzhou City was the cradle of old Hanzhou's prosperity and the center of politics and economy in the ancient time. Qing-He-Fang Street is also located there, to the south of the palace (damaged), and to the north of Wu Mountain. So it was once one of the most developed regions in the city (Fig. 3.2.2.1.).

This block was ever a commercial downtown area, where many old shops and institutions with a century history (approximately 80 years or more) were distributed, such as Hu-Qing-Yu-Tang Drugstore. Although this block has been declining since the 1950's, these old buildings remain today. After the protection program (Shi, 2006), this area continues to serve the local residents and foreign visitors.

Along with the promotion of people's living quality, tourism and leisure have become an indispensable index to assess residential environment. Fortunately, the rich legacy of this area may meet this demand, such as the unique architectural features and spatial forms, especially the legends and historic figures remaining during the long history. This immaterially cultural legacy contains the attractiveness that modern landscape can not provide.

Quite a few dynasties have alternated during the past thousand years. In this area, a lot of folk houses, shops and restaurants place densely in rows.

The cultural features of Qing-He-Fang consist of the architectural styles and the life styles. The architectural elements are two-story buildings, sloping roofs, wooden components, Chinese ornaments, wells, white walls, dark tiles, and red doors. The daily activities are teatime chat, snack party, souvenir deal, street show, and handicraft exhibition.

The open spaces include courts between buildings, shopping streets, and semi-open spaces orts (Table 3.2.2.1., Fig. 3.2.2.1.).

Table 3.2.2.1. Description of Open Space in Qing-He-Fang

Name	Surface	Facility	Area (M^2)	Location
Court	Grass, Pavement	Bench, light, tree,	2,100	Located in the central land and between buildings
Street	Pavement,	Light, Bench	5,500	Across the whole community

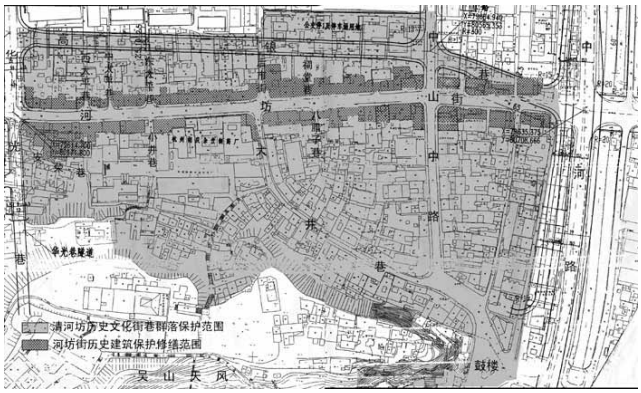

Fig. 3.2.2.1. (a) Area of Q-H-F Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.1. (b) A green court of Q-H-F Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.1. (d) a street corner of Q-H-F Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.1. (f) a snack lane of Q-H-F Community

Fig. 3.2.2.1. (c) A resting place of Q-H-F Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.1. (e) A semi-court of Q-H-F Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.1. (g) Shops in Q-H-F Community

Qiu-Shi Community (old area)

The community is located near Yu-Quan Campus of Zhejiang Univerity, and some parts were founded in 1952. At present, the residents are mainly the university staffs and some lessees. Due to the compact land and high density of buildings, the community lacks of a large-scale central open space. The green ratio and available patches of open spaces are also insufficient (Fig 3.2.2. 2. (a)-(e)). In addition, the buildings are unadorned and old. Only a few playing facilities sustain children's activities. As to the aged, there is almost nothing to provide.

The open spaces include roadsides, grass land and mini playing grounds (Table 3.2.2.2., Fig. 3.2.2.2.).

Table 3.2.2.2. Description of Open Space in Qiu-Shi Community

Name	Surface	Facility	Area (M^2)	Location
Playing ground	Pavement	Bench, light, porch,	800	Located in small plots between buildings
Green land	Grass	Tree, bench, light	2,300	Located between buildings
Roadside	Pavement,	Light	2,000	Along the roads.

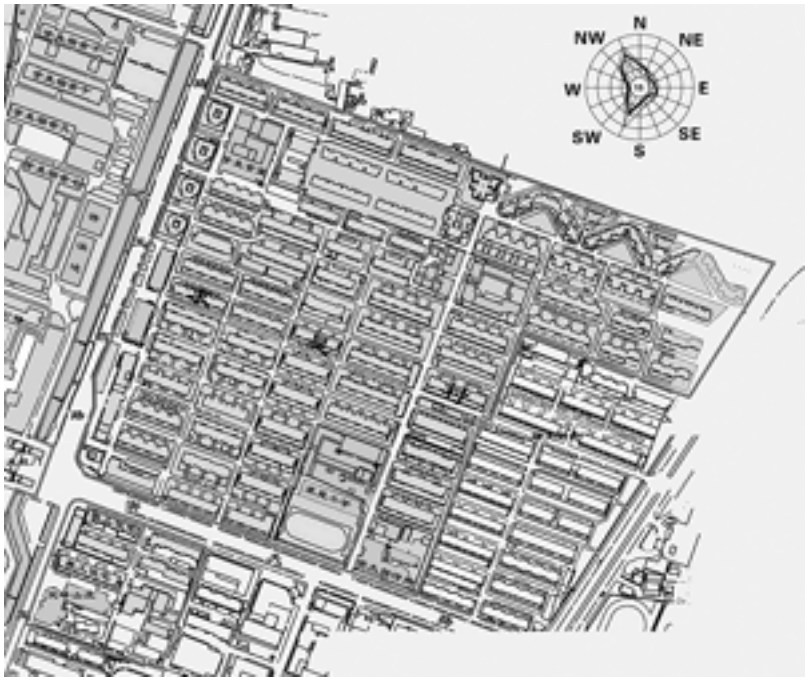

Fig. 3.2.2.2. (a) Area of Qiu-Shi Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.2. (b) Green areas of Qiu-Shi Community

Fig. 3.2.2.2. (c) Playing grounds of Qiu-Shi Community

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Fig. 3.2.2.2. (d) Green areas of Qiu-Shi Community

Fig. 3.2.2.2. (e) Playing grounds of Qiu-Shi Community

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Fig. 3.2.2.2. (f) A resting place of Qiu-Shi Community

Fig. 3.2.2.2. (g) Green areas of Qiu-Shi Community

Cui-Yuan Community (northern center area)

The community is located at the northern center of Hangzhou, and main parts were founded in 1986-1990. At present, the residents are multiple occupations. Due to the low economic level in the 1980's, the buildings are unadorned and old. Fortunately, influenced by some new design principles, the designers considered to provide a large-scale central open space and some small plots for residents' outdoor lives. The green ratio and available patches of open spaces are more than the old communities (Fig 3.2.1. (f)-(g)). In addition, some facilities sustain the aged and children's activities.

The open spaces include a central park, small plots between buildings, and mini playing grounds (Table 3.2.2.3., Fig. 3.2.2.3.).

Table 3.2.2.3. Description of Open Space in Cui-Yuan Community

Name	Surface	Facility	Area (M^2)	Location
Small plots	Pavement	Bench, table, light, tree	2,000	Between buildings.
Park		Bench, light, tree, instrument, pond, bridge, instrument	3,500	Located in the community center.

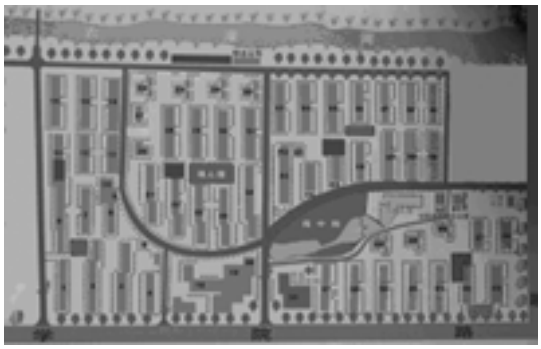

Fig. 3.2.2.3. (a) Area of Cui-Yuan Community

Fig. 3.2.2.3. (b) A bridge of Cui-Yuan Park

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.3. (c) A pond of Cui-Yuan Community

Fig. 3.2.2.3. (d) A bridge of Cui-Yuan Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.3. (e) A green way of Cui-Yuan Community

Fig. 3.2.2.3. (f) A resting place of Cui-Yuan Community

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Fig. 3.2.2.3. (g) A semi-open space of Cui-Yuan Community

Fig. 3.2.2.3. (h) A resting place of Cui-Yuan Community

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Fig. 3.2.2.3. (i) A square of Cui-Yuan Community

Fig. 3.2.2.3. (j) A semi-open space of Cui-Yuan Community

Cai-He Community (eastern center area)

The community is located near the train station, and main parts were founded in 1984. At present, the residents are multiple occupations. It is almost as same as Cui-Yuan Community, except that the density of buildings is higher and the age is older.

The open spaces include a central park, small plots between buildings, and mini playing grounds (Table 3.2.2.4., Fig. 3.2.2.4.).

Table 3.2.2.4. Description of Open Space in Cai-He Community

Type	Surface	Facility	Area (M^2)	Location
Small plots	Pavement	Bench, table, light, tree	2,500	Between buildings.
Park		Bench, light, tree, instrument, pond, bridge, instrument	3,100	Located in the community center.

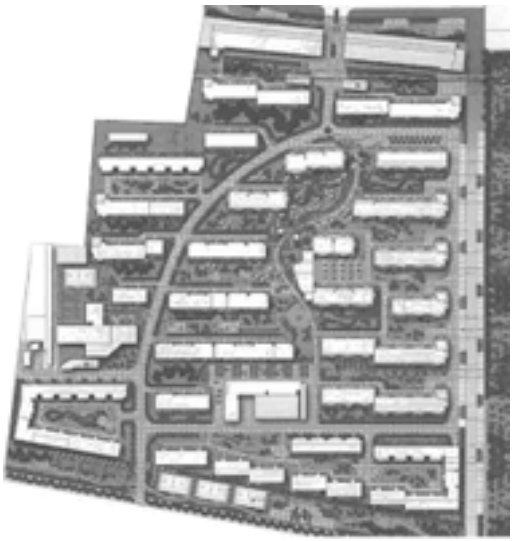

Fig. 3.2.2.4. (a) Area of Cai-He Community

Fig. 3.2.2.4. (b) A central park of Cai-He Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.4. (c) A mini-playing field of Cai-He Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.4. (d) A resting placeof Cai-He Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.4. (e) A water space of Cai-He Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.4. (f) A semi-open space of Cai-He Community

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Xia-Sha Community (northern suburban area)

The community is located at the eastern suburban of Hangzhou, and main parts have been constructed since 2001. At present, the residents are multiple occupations. Due to the fast economic development in the 2000's, the buildings are adorned and new. Influenced by the estate market competition, the designers paid much attention to provide a large-scale central open space and some small plots for residents' outdoor lives. The green ratio and available patches of open spaces are sufficient (Fig 3.2.1. (j)-(k)). In addition, some facilities sustain the aged and children's activities. It is noted that Xia-Sha is very far from the main body of Hanghzou, almost 25 kilometers, so the house price and environmental quality do not reach a high level compared with the following community.

The open spaces include a central park, small plots between buildings, and mini playing grounds (Table 3.2.2.5., Fig. 3.2.2.5.).

Table 3.2.2.5. Description of Open Space in Xia-Sha Community

Type	Surface	Facility	Area (M^2)	Location
Small plots	Pavement	Bench, table, light, tree	3,200	Between buildings.
Central open space		Bench, light, tree, instrument, pond, bridge, instrument	4,600	Located in the community center.

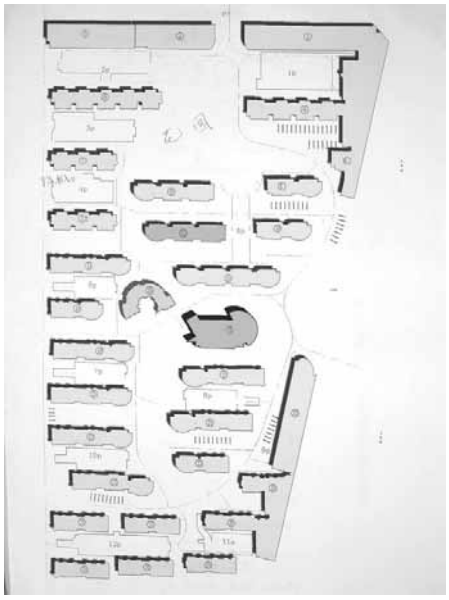

Fig. 3.2.2.5. (a) Area of Xia-Sha Community

Fig. 3.2.2.5. (b) A central open space of Xia-Sha Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.5. (c) A green space of Xia-Sha Community

Fig. 3.2.2.5. (d) A resting place of Xia-Sha Community

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Fig. 3.2.2.5. (e) A water stream of Xia-Sha Community

Fig. 3.2.2.5. (f) A resting place of Xia-Sha Community

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Fig. 3.2.2.5. (g) A resting place of Xia-Sha Community

Fig. 3.2.2.5. (h) A water space of Xia-Sha Community

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Wen-Xin Community (eastern suburban area)

The community is located at the western suburban of Hangzhou, and main parts have been constructed since 1999. At present, the residents are multiple occupations. Due to the fast economic development in the 2000's, the buildings are adorned and new. Influenced by the estate market competition, the designers paid much attention to provide a large-scale central open space and some small plots for residents' outdoor lives. The green ratio and available patches of open spaces are sufficient (Fig 3.2.2. (l)-(m)). In addition, some facilities sustain the aged and children's activities. Most importantly, this area is located between the city center, the West Lake and the National Park of Xi-Xi Wetland. The distance is acceptable, approximately 10 kilometers, so that the house price and environmental quality are the highest among the city.

The open spaces include a central park, small plots between buildings, and mini playing grounds (Table 3.2.2.6., Fig. 3.2.2.6.).

Table 3.2.2.6. Description of Open Space in Wen-Xin Community

Type	Surface	Facility	Area (M^2)	Location
	Pavement	Bench, table, light, tree	5,000	Between buildings.
Park or green space		Bench, light, tree, instrument, pond,	4,000	Located in the community center.

Fig. 3.2.2.6. (a) Area of Wen-Xin Community

Fig. 3.2.2.6. (b) Sports fields of Wen-Xin Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.6. (c) A green Space of Wen-Xin Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.6. (d) Sports fields of Wen-Xin Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.6. (e) A semi-open space of Wen-Xin Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.6. (f) A plaza of Wen-Xin Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.6. (g) A central green space of Wen-Xin Community

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.6. (h) A water space of Wen-Xin Community

Yu-Quan Campus of Zhejiang University

Yuquan Campus is the headquarter of Zhejiang University, where administration offices are located. Currently, administration offices of the following nine colleges are located in this campus, covering from science, engineering to economics, MBA. This campus was constructed from 1952. Open space area is compact and building density is high. The facilities are also insufficient.

The open spaces include small plazas, waterfront, green areas, semi-open spaces and sports fields (Table 3.2.2.7., Fig. 3.2.2.7.).

Table 3.2.2.7. Description of Open Space in Yu-Quan Campus

Name	Surface	Facility	Area (M^2)	Location
Small plaza	Pavement	Bench, light, tree	5000	Near the office building and library
Waterfront		Bench, light, tree	3,000	Along the campus boundary

Fig. 3.2.2.7. (a) Area of Yu-Quan Campus


Fig. 3.2.2.7. (b) A square of Yu-Quan Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.7. (c) A resting place of Yu-Quan Campus

Fig. 3.2.2.7. (d) Green areas of Yu-Quan Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.7. (e) A pond of Yu-Quan Campus

Fig. 3.2.2.7. (f) A pond of Yu-Quan Campus

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Fig. 3.2.2.7. (g) A plaza of Yu-Quan Campus

Fig. 3.2.2.7. (h) A plaza of Yu-Quan Campus

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Fig. 3.2.2.7. (i) Tennis fields of Yu-Quan Campus

Fig. 3.2.2.7. (j) A soccer field of Yu-Quan Campus

Xi-Xi Campus of Zhejiang University

Xi-Xi Campus is another campus of Zhejiang University, where some administration offices are located. Currently, administration offices of the following nine colleges are located in this campus, covering from art, humanities and environment. This campus was also constructed from 1952. Open space area is compact and building density is high. The facilities are also insufficient.

The open spaces include small plazas, waterfront, green areas, semi-open spaces and sports fields (Table 3.2.2.8., Fig. 3.2.2.8.).

Table 3.2.2.8. Description of Open Space in Xi-Xi Campus

Name	Surface	Facility	Area (M^2)	Location
Small plaza	Pavement	Bench, light, tree	4,300	Near the teaching building and the central part of campus
Waterfront		Bench, light, tree	2,100	Located in the central part

Fig. 3.2.2.8. (a) Area of Xi-Xi Campus


Fig. 3.2.2.8. (b) Green Space of Xi-Xi Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.8. (c) A green plot of Xi-Xi Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.8. (d) Tennis fields of Xi-Xi Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.8. (e) A plaza of Xi-Xi Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.8. (f) A square of Xi-Xi Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.8. (g) Green space of Xi-Xi Campus

Fig. 3.2.2.8. (h) A green way of Xi-Xi Campus

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Zi-Jin-Gang Campus of Zhejiang University

The Zijingang Campus is located at the northwest suburban of the city and just 6 km away from the Yuquan Campus, accommodating the University's 13,000 junior students. In the future, the campus will be 550 Ha and accommodate more than 40,000 students.

Having a great amount of land and natural conditions, this campus is designed in a fashionable way. The dorms are located in the northern district and the teaching buildings are located in the southern district with many landscapes. There is the sports area between dorms and teaching buildings. The open spaces include small plazas, waterfront, green areas, semi-open spaces and sports fields (Table 3.2.2.9., Fig. 3.2.2.9.).

Table 3.2.2.9. Description of Open Space in Zi-Jin-Gang Campus

Name	Surface	Facility	Area (M^2)	Location
Small plaza	Pavement	Bench, light, tree	20,000	Near the teaching building and the central part of campus
Waterfront		Bench, light, tree	100,000	Across the whole campus and located around.

Fig. 3.2.2.9. (a) Bank of Zi-Jin-Gang Lakefront

Fig. 3.2.2.9. (b) Plaza of Zi-Jin-Gang Lakefront

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

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Fig. 3.2.2.9. (c) Green Space of Zi-Jin-Gang Dorm Area

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.9. (e) Area of Zi-Jin-Gang Campus

Fig. 3.2.2.9. (d) Pond of Zi-Jin-Gang Teaching Area

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.9. (f) Sports Field of Zi-Jin-Gang Campus

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ZJGSU Campus

Zhejiang Gongshang University offers the total number of full time students has reached over 13,000. Among its over 8,400 staff members and workers, there are over 1,100 professors and 2,400 associate professors. This campus is located in the east suburban district for higher educational institutions. The new campus is close to the Qiantang River. It neighbors on students' living area in the north and is connected with staff's living area in the south.

The open spaces include small plazas, waterfront, green areas, semi-open spaces and sports fields (Table 3.2.2.10., Fig. 3.2.2.10.).

Table 3.2.2.10. Description of Open Space in ZJGSU Campus

Name	Surface	Facility	Area (M^2)	Location
Small plaza	Pavement	Bench, light, tree	5000	Near the office building and library
Waterfront		Bench, light, tree	10,000	Along the central horizontal roads

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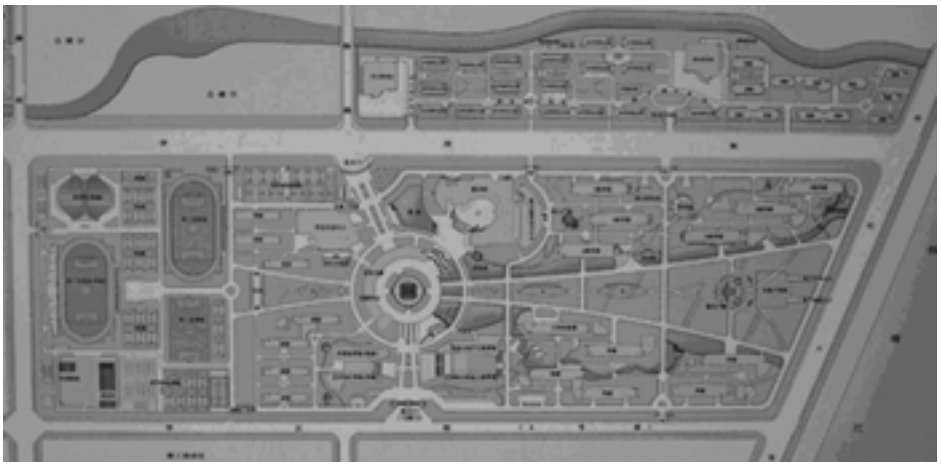

Fig. 3.2.2.10. (a) Area of ZJGSU Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.10. (b) Semi open space of ZJGSU Campus

Fig. 3.2.2.10. (c) water space of ZJGSU Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.10. (d) green space of ZJGSU Campus

Fig. 3.2.2.10. (e) dorm open space of ZJGSU Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.10. (f) Pond of ZJGSU Campus

Fig. 3.2.2.10. (g) dorm water space of ZJGSU Campus

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Note: Due to the volume limitation of Saga Univeristy Library, the total dissertation must be less than 5 M. As a result, some auxiliary pictures are reduced, and available from the print versions kept in the Graduate School of the University.

Fig. 3.2.2.10. (f) Sports fields of ZJGSU Campus

Fig. 3.2.2.10. (g) Sports fields of ZJGSU Campus

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CHAPTER 4:

CONCEPT & METHODOLOGY

4.1. CONCEPTUAL FRAMEWORK

(the related concepts are mentioned in Chapter 2.1.1., page 9, and Chapter 2.1.4., page 11)

Aiming to develop this framework to reflect residents' viewpoint towards livable open space supply to the community. This study offers a new approach to strengthen the weak position of open space in the context of current planning and design efforts to improve the quality of life for residents. It is assumed that the major factors influencing residents' lifestyle comprise two major related factors, which are residents' *evaluation and behavior*. The consideration on the variables affects the quantification of lifestyle, so it can be drawn as shown in the followings figure:

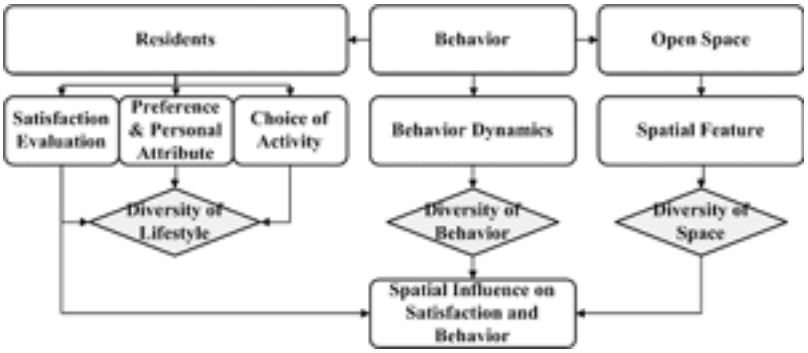

Figure 4.1. (a) The Conceptual Framework of Diversity of Open Space Residents

Based on this concept, this study proposed a framework to capture environmental evaluation and behavior of residents in the linkage of the relationship between open space users' perception on and reaction to their living environment. This framework was developed and based on the key concept of *lifestyle* that residents play a significant role during interaction with relative elements. Consequently, the several models were established to quantify the evaluation and behavior of residents and assess their linkage based on the following diagram:.

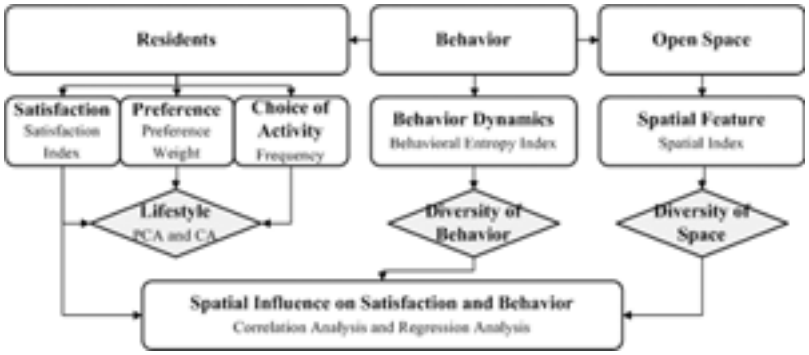

Figure 4.1. (b) The Index Model of Residential Open Space Lifestyle

The structure as demonstrated in Figure 4.1. (b) consists of two main aspects that are *evaluation approaches and behavior approaches*.

Firstly, as to evaluation approaches, residents tend to express their perception on environmental quality how much getting pleasure from open space with different participation and recreation in enjoying open space. Therefore, the perception that includes *satisfaction* and *preference* characteristics could be utilized to examine the extent how well users evaluate the effectiveness of all levels of public goods and service, and how much users expect the value of ideal open space. It can be considered as a comprehensive consideration to estimate open space benefit. In detail, the satisfaction evaluation could be examined compared with a method of Mean Comparison as well as Regression Analysis. *Satisfaction Index* evaluates the non-market benefits of open space based on residents' perceived reflection to existing environmental conditions. An Analytical Hierarchy Process method was also applied into providing the useful idea on the preference concerns. The result of *Preference Weight* estimates the non-market benefits of open space based on residents' perceived expectation to future environmental conditions.

Secondly, as to behavior approaches, it can be illustrated that this study attempted to capture the behavior of residents by the application of *behavioral dynamics model* to quantify the *temporal, spatial and categorical characteristics* of residents in a variety of daily utilization of residential open space. This is from the reason that major factors that influence the residents' behavior could be represented by timing, location and content of activity selection decision. These three aspects were defined as behavioral temporal, spatial and categorical dynamics by examining *temporal, spatial and categorical Behavioral Entropy Index*.

Finally, by using this rational result, this study also developed the framework to determine the relationship between evaluation and behavior of residents, in order to classify *Residential Open*

Space Lifestyle. Through the *Principal Component Analysis*, principal factors of preference were extracted by using the *Preference Weight* results. Then, through the *Cluster Analysis*, the residents were classified into several groups. The Analysis of Variance examined the difference of Satisfaction Index, Preference Weight, Behavioral Entropy Index, and the socio-demographic attributes between the groups of residents. As a result, a classification of the *Residential Open Space Lifestyle* can be examined through this linkage of quantified evaluation and behavior.

4.2. STEPS OF STUDY

To support the advantage of this framework, the proposed process is developed step by step in order to achieve the goal of this study is organized as follows:

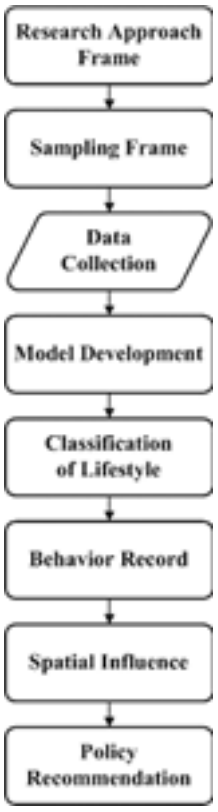

Figure 4.2. The Process of Study

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4.3. MODEL DEVELOPMENT

To establish the quantification framework, several models need to calibrate the relationship with the explanatory variables of residents' evaluation and their behavior, and consequently it can lead to the way to combine the results of related factors as illustrated by the following approaches:

4.3.1. Evaluation Approach

4.3.1.1. Satisfaction Evaluation (Mean Comparison, Correlation Analysis, Regression Analysis)

On the one hand, the perception of residents to open space includes level of satisfaction that was applied as rates given by the residents on the quality of open space. The aggregation of the satisfaction score was performed by employing the idea of similarity distance to be normalized and consequently obtained the *satisfaction index* as shown by Equation 4.3.1.1..

$$SI = \alpha + \sum_{j=1}^{n} \beta_j SI_j \qquad \text{[Equation 4.3.1.1.]}$$

where SI is total (general) Satisfaction index

SI_j is Satisfaction index on the j^{th} evaluation item,

n is No. of evaluation items.

4.3.1.2. Preference Evaluation (Analytical Hierarchy Process)

On the other hand, the perception of residents to open space also includes preference that was applied as rates given by the residents on the value of open space. The aggregation of the preference weight was performed by employing the idea of Analytical Hierarchy Process using pair-wise comparison as shown by Equation 4.3.1.2.(a).

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{12} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \qquad \text{[Equation 4.3.1.2.(a)]}$$

where A is the comparison matrix,

a_{ij} represents the pair-wise comparison rating for attribute i and attribute j,

n is No. of items.

Consequently obtained the *Preference Weight* as shown by Equation 4.3.1.2.(b).

$$W = \frac{A^k e}{e^T A^k e} \qquad \text{[Equation 4.3.1.2.(b)]}$$

where *W* is the final weight vector of comparison matrix,

e=(1, 1,…, 1),

k is No. of iteration which the weighted values finally converge on,

4.3.2. Behavior Approach (Entropy Analysis)

The behavior of residents in open space includes three levels of characteristics: temporal, spatial, and categorical characteristics. The variety of the behavior was performed by employing the idea of Entropy, shown as Equation 4.3.2..

$$BEI = \frac{-\sum_{j=1}^{n} p_j \log_2(p_j)}{\log_2(n)} \qquad \text{[Equation 4.3.2]}$$

where *BEI* is the Behavioral Entropy Index,

p_j is the relative frequency (probability) of the j^{th} behavioral option.

n is the number of behavioral options.

Division by $log_2(n)$ serves to normalize the measure into 0-1.

4.3.3. Synthesis of Evaluation and Behavior

This study also developed the framework to determine the relationship between evaluation and behavior of residents, in order to classify *Residential Open Space Lifestyle.* Through the *Principal Component Analysis*, principal factors of preference were extracted by using the *Preference Weight* results. Then, through the *Cluster Analysis*, the residents were classified into several groups. The Analysis of Variance examined the difference of Satisfaction Index, Preference Weight, Behavioral Entropy Index, and the socio-demographic attributes between the groups of residents. As a result, a classification of the *Residential Open Space Lifestyle* can be

examined through this linkage of quantified evaluation and behavior.

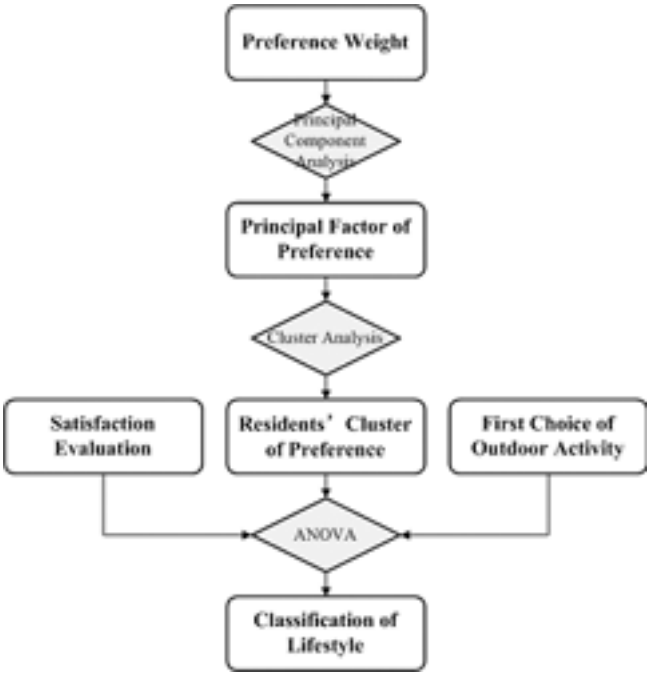

Figure 4.3.3. A Streamline to Explore Residents' Lifestyle in Open Space: Synthesis of Evaluation and Behavior

4.4. DESIGN OF QUESTIONNAIRE

In order to obtain raw data on open space users' characteristics of the study area, a questionnaire form should be designed by containing all the required data.

Data Requirement

The required data can be classified regarding to socioeconomic and characteristics of residents, evaluation and behavior of open space users. The following table illustrates the required data in this study that can be classified into four main categories:

Table 4.4.1. Data Structure of Questionnaire for Model Development

	Question Contents	No. of Question
SOCIO-DEMO ATTRIBUTE	Age, Sex, Occupation (Major), Family (Dorm) structure, Residential period, Hobby, etc.	6
Activity First Choice	Frequency, Timing, Place, Action, Duration, Accompany, etc.	6
Satisfaction Evaluation on Open Space Quality	Convenience	3
	Amenity	3
	Healthy	4
	Safety	3
	Community	2
Preference on Open Space Value	Function	3
	Aesthetics	4

Samples

600 residents living in common residential communities and 800 college students in Hangzhou City, China, were delivered a questionnaire to reveal their collective satisfaction and preference on residential open spaces. 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. residential open space, daily usage, satisfaction and pair-wise comparison) and the hierarchical structure of all the attributes/ qualities.

In this survey, approximate half of the questionnaires were answered with a face-to-face interview and others were received through the community office. The percentage of valid respondents is approximately 78.9%. 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 61.9%. Table 4.4.2. illustrates the descriptive statistic data resulted from the survey.

Table 4.4.2. Samples and Response of the Questionnaire

Subject	Name of Residence	No. of Distributed	No.of Valid Response	Response Rate (%)	No.of Pass CI	Pass Rate (%)
Common Case	No.1.Cui-Yuan		74		51	68.9
	No.2.Cai-He	100	59	59.0	32	54.2
	No.3.Qing-He-Fang	100	55	55.0	30	54.5
	No.4.Qiu-Shi	100	70	70.0		64.3
	No.5.Xia-Sha	100	82		59	72.0
	No.6.Wen-Xin	100	59			
	Total of Common	600	399			
Campus Case	No.7.ZJU-YQ	200	162	81.0	101	62.3
	No.8.ZJU-XX	200	155	77.5	97	
	No.9.ZJU-ZJG	200	176	88.0	114	64.8
	No.10.ZJGSU	200	183	91.5	103	56.3
	Total of Campus	800	676	84.5	415	61.4
Overall		1400	1075	78.9	665	61.9

Pass CI denotes the response data passed the Consistence Index Test of AHP.
Pass Rate denotes the ratio of No. of passed CI to No. of valid response.

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CHAPTER 5:

EVALUATION OF SATISFACTION & PREFERENCE

5.1. RESIDENTS' ATTITUDE ON RESIDENTIAL OPEN SPACE

This study attempts to identify the perception of park users on residential open space from two aspects of environmental evaluation. The first one examined the direct relationship between open space quality and residents' satisfaction; and the second one used the indirect means concerned with the preference on the value of ideal open space to serve people. In addition, the main objective of this chapter is to construct two models which:

(i) reflect empirical findings on the relationship between residents' satisfaction and open space quality;
(ii) summarize and suggest strategies or policy development to appeal to more residents.

5.1.1. Determinants of Residents' Satisfaction

In order to comprehensively analyze the factors influencing residential open space, 15 sub-items on residential open space qualities were set up according to five principal items, which were applicability, amenity, health, safety and community. WHO (World Heath Organization) first presented the four concepts of residential environment to satisfy the basic living requirements of human beings in 1961, which were safety, health, convenience and amenity. The five items originally derived from the rudimentary research (Ge and Hokao, 2004) which were almost same as the concepts presented by WHO, and one more concept of "Community" was added, standing for the spiritual needs of community beyond the basic material needs of residential environment. In order to apply this model into residential open space, the item of convenience should be replaced by the concept of applicability. According to this result and also by interviewing experts, officials and citizens for revision of indexes, the hierarchical multi-attribute index system for subjective residential evaluation was established with three levels as described in Fig. 5.1.1.

In this system, Total Environmental Quality (level A) depends on satisfaction with "Applicability", "Amenity", "Health", "Safety" and "Community" (level B). Attributes of level 2 are assumed to depend on satisfaction with 15 attributes (C1 to C15) of level C.

Besides, the questionnaire included such question as: “Are there any other items not mentioned in the questionnaire that also affect the open space quality?” Almost all of the answers considered that the items presented could explain well the residential open space quality.

As such, the satisfaction evaluation was concerned with five aspects of residential open space. In this study, the environmental quality of residential open space was assessed with the following structure (Fig. 5.1.1.).

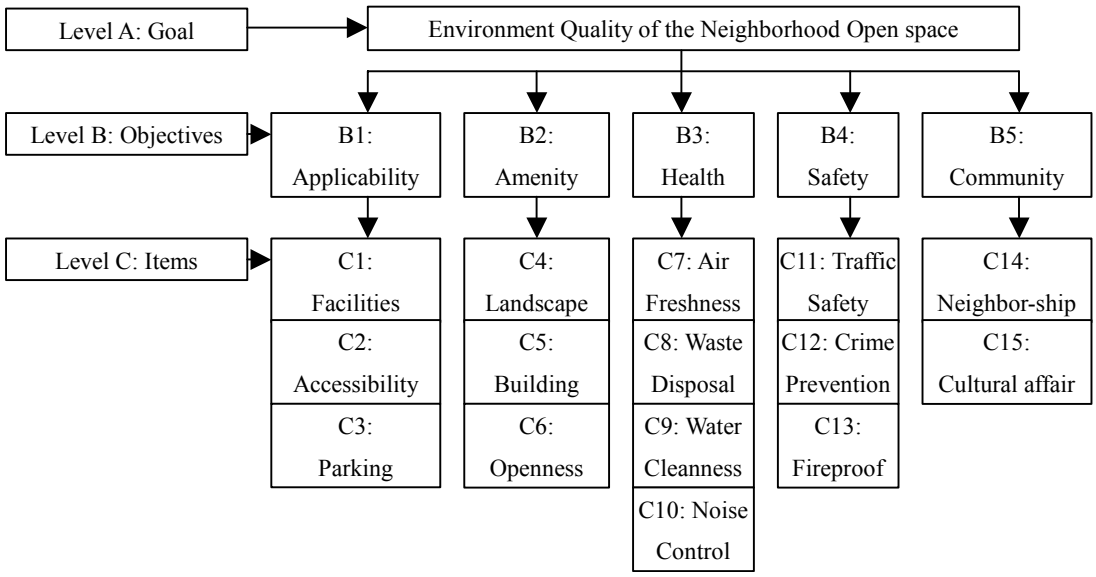

FIG. 5.1.1. THE FRAMEWORK OF THE INDEX SYSTEM FOR SATISFACTION EVALUATION

(i) Applicability (B1) stands for the degree how the open space provides suitable places and facilities for people’s utilization;

(ii) Amenity (B2) stands for the degree how the open space provides beautiful landscape, building appearance and openness sense for people’s appreciation;

(iii) Health (B3) stands for the degree how the open space provides healthy environments for people’s daily lives;

(iv) Safety (B4) stands for the degree how the open space provides proper control to prevent dangerous sense;

(v) Community (B5) stands for the degree how the open space provides more opportunity for people’s communication;

5.1.2. Determinants of Residents' Preferences

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.

Through a pre-survey at Hangzhou City, the factors of residents' preference on the value of open space were collected from two sides (residents and designers). More details is mentioned in Section 5.3.2., page 40.

The hierarchical structure is decomposed to two levels, i.e. general attributes and specific qualities, underlying the total goal (Fig. 5.1.2.). The general attributes include functional, aesthetic, and ecological factors; and the specific qualities are described as follows.

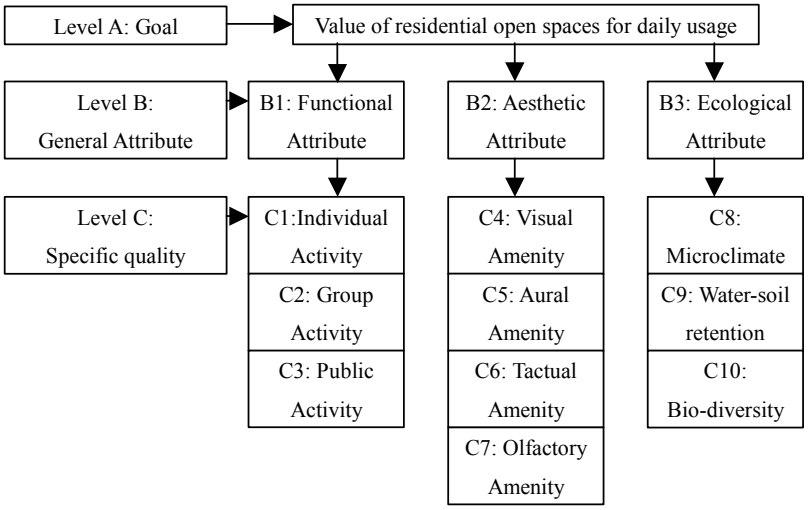

Fig. 5.1.2. The framework of the index system for preference evaluation

(i) The functional attribute stands for 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 game, party, picnic and so on. The third one is interactive activities in crowds, e.g. speech listening, exposition, flea market and so on.

(ii) The aesthetic attribute stands for providing amenity of landscape. 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.

(iii) The ecological attribute stands for preserving local ecology. 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.

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5.2. SATISFACTION ON RESIDENTIAL OPEN SPACE

5.2.1. Concepts of Satisfaction Index (SI) Model

A concept of satisfaction measurement allows for a variety of attitudes regarding open space service to be determined. It reflects their perception of the benefits derived from their recreation and amenity from open space visitation relative to their expenditure and time spend for both travel and activity in site. The preference on open space visit can be described their attitudes regarding open space service since it was assumed that their attitude can be measured by different criteria to evaluate open space service. On the other hand, by using rational decision, users who spend a longer time to travel and higher expenditure should tend to spend more time and cost in their activity inside open spaces. As well as, they should be willing to pay more fees for maintenance quality of open space service. Nevertheless, it is not always the case that some users do not always have their rational choice. This study employed this rational relationship to propose the unconventional method to identify the relationship between behaviors of open space utilization by capturing the real satisfaction value of open space users. The satisfaction of open space service was measured according to five different criteria that the preference was quantified from the level of satisfaction that was applied to rate the quality of open space service on five different criteria in terms of:

- Applicability of open space,
- Amenity of open space,
- Health of open space,
- Safety of open space,
- Community of open space,

Together with the quality score of score five levels of

- 5=excellent
- 4=good
- 3=fair
- 2= very poor

 1=must be improved,

Furthermore, it was assumed that the higher satisfaction means the higher value that would be reflected to the higher participation value. On the other hand, the level of satisfaction on open space service can be derived from different perceptual qualities of the sites. Consequently, to obtain the perception index, the average score of satisfaction need to be determine as a representative of the integration of the normalized value as shown by the following:

$$SI_{i,j} = \frac{E_{i,j} - r_j}{R_j - r_j} \qquad \text{[Equation 5.2.1.(a)]}$$

where E_j is a raw satisfaction score on the jth evaluation item,

r_j = Minimum level of the jth evaluation item (R_i=1 in this study).,

R_j= Maximum level of the jth evaluation item (R_j=5 in this study).

n = No. of satisfaction items.

However, there should be some interaction between the satisfaction of service and the participation value on public works for maintenance and management program. Therefore, this study attempted to quantify this index as it would be useful to be used to determine the overall preference effect resulted to the behavior of open space users. Thus, the satisfaction index of open space users can be assessed and evaluated in the next section.

$$SI = \alpha + \sum_{j=1}^{n} \beta_j SI_j \qquad \text{[Equation 5.2.1.(b)]}$$

where SI_j is Satisfaction index on the jth evaluation item,

n is No. of evaluation items.

5.2.2. Results of Satisfaction Index (SI) Model

The present study examined public satisfaction on different criteria concerning residential open space as shown in the following.

Table 5.2.2. (a) Satisfaction Index of Six Common Communities

Name	Applicability	Amenity	Health	Safety	Community	Total SI
Cui-Yuan	0.71	0.44	0.36	0.64	0.81	0.65
Cai-He	0.67	0.39	0.45	0.58	0.68	0.61
Q-H-F	0.19	0.54	0.26	0.16	0.87	0.35
Qiu-Shi	0.17	0.05	0.42	0.60	0.52	0.23
Xia-Sha	0.53	0.45	0.20	0.33	0.09	0.32
Wen-Xin	0.85	0.78	0.82	0.67	0.59	0.77
Mean	0.52	0.44	0.42	0.50	0.59	0.49
St.D.	0.26	0.22	0.21	0.19	0.25	0.21

Table 5.2.2. (b) Satisfaction Index of Four Campuses

Name	Applicability	Amenity	Health	Safety	Community	Total SI
ZJU-YQ	0.28	0.19	0.54	0.35	0.32	0.41
ZJU-XX	0.37	0.22	0.58	0.41	0.44	0.47
ZJU-ZJG	0.72	0.92	0.83	0.62	0.54	0.75
ZJGSU	0.53	0.74	0.76	0.49	0.46	0.67
Mean	0.47	0.52	0.68	0.47	0.44	0.58
St.D.	0.17	0.32	0.12	0.10	0.08	0.14

5.2.3. Analysis of Satisfaction Evaluation

5.2.3.1. Comparison of Mean

Through the comparison between the mean values of satisfaction indices, Wen-Xin Community (SI=0.77) takes the first rank within the common group and Zi-Jin-Gang Campus (SI=0.75) leads the ranking of the campus group. On the contrary, Qiu-Shi Community and Yu-Quan Campus are both on the bottom of the groups.

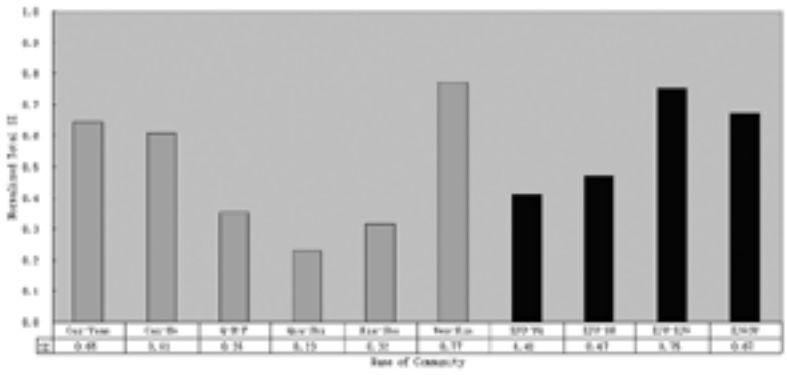

Fig. 5.2.3.1. Comparison of Mean between six common communities and four campuses

5.2.3.2. Regression Analysis

Following the mean comparison, a regression analysis was performed as Table 5.2.3.2., using the results of normalized Satisfaction Indices.

The results from the multiple regression analysis could be regenerated into the regression equations as follows.

For the common case, $r^2 = 0.756$,

$$Satisfaction = 0.362Applicability + 0.290Amenity + 0.165Health + 0.134Safety + 0.183Community - 0.032$$

For the campus case, $r^2 = 0.701$,

$$Satisfaction = 0.374Applicability + 0.248Amenity + 0.125Health + 0.103Safety + 0.146Community + 0.035$$

The relative impact weight of each attribute was given by standardized regression coefficient β . Satisfaction with "Applicability" appeared to be the most powerful factor (β =0.362, 0.374, respectively). Following that, the attributes of "Amenity" (β =0.290, β =0.248, respectively) and "Community" (β =0.183, β =0.146, respectively). The fifth attribute of "Safety" seemed not to affect residential satisfaction much (β = 0.134, 0.102, respectively).

Table 5.2.3.2. Regression Analysis of Satisfaction Evaluation

Common Case				Campus Case			
	Coef.	**t**	**Sig.**		**Coef.**	**t**	**Sig.**
Applicability	.362	13.204	.000	*Applicability*	.374	10.367	.000
Amenity	.290	11.287	.000	**AMENITY**	.248	8.461	.000
Health	.165	3.159	.003	***Health***	.125	2.744	.004
Safety	.134	2.171	.006	***Safety***	.103	1.025	.008
Community	.183	1.778	.001	***Community***	.146	2.013	.002
Constant	-.032	7.552	.000	***Constant***	.035	6.375	.000

5.3. PREFERENCES ON RESIDENTIAL OPEN SPACE

5.3.1. Concepts of Preference Weight (PW) Model (Analytical Hierarchy Process)

This study employs the well-known technique for decision-making that is called the Analytic Hierarchy Process (AHP). Satty and Vargas (2001) stated that AHP are applied to pairs of homogeneous elements that need a hierarchy or a network structure to represent that problem as shown in Figure 5.3.1.

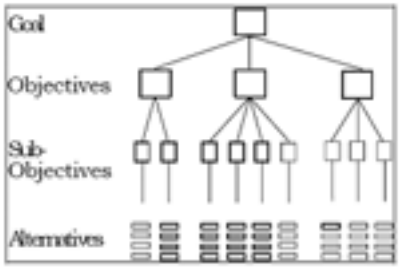

Figure 5.3.1. A demonstration of hierarchical structure

In the discrete case these comparisons lead to dominance matrices and in the continuous case to kernels of Fredholm Operators, from which ratio scales are derived in the form of principal eigenvectors, or eigen functions. These matrices, or kernels, are positive and reciprocal, e.g., $a_{ij} = 1/a_{ji}$. In particular, special effort has been made to characterize these matrices.

However, Satty and Vargas (2001) also mentioned that there is an infinite number of ways to derive the vector of priorities from the matrix a_{ij}. The emphasis on consistency leads to the eigenvalue formulation $Aw = nw$. The priorities can be assumed to be $w = (w_1, \ldots w_n)$ with respect to a single criterion are known. The matrix of ratio comparisons and multiplication to obtain nw can be form as follows:

$$\begin{pmatrix} \left(\frac{w_1}{w_2}\right)\left(\frac{w_1}{w_2}\right) & \cdots & \left(\frac{w_1}{w_2}\right)\left(\frac{w_1}{w_2}\right) \\ \left(\frac{w_1}{w_2}\right)\left(\frac{w_1}{w_2}\right) & \cdots & \left(\frac{w_1}{w_2}\right)\left(\frac{w_1}{w_2}\right) \\ \vdots & & \vdots \\ \left(\frac{w_1}{w_2}\right)\left(\frac{w_1}{w_2}\right) & \cdots & \left(\frac{w_1}{w_2}\right)\left(\frac{w_1}{w_2}\right) \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix}$$

If a_{ij} represents the importance of alternative *i* over alterative *j* and a_{jk} represents the importance of alternative *j* over alternative *k* and a_{ik}, the importance of alternative *i* over alterative *k*, must equal $a_{ij}\, a_{ik}$ or $a_{ij}\, a_{ik} = a_{ik}$ for the judgments to be consistent. The precise values of w_i/w_j depend on the scaling that the solution is obtained by raising the matrix to a sufficiently large power then summing over the rows and normalizing to obtain the priority vector $w = (w_1, \ldots w_n)$. the process is stopped when the difference between components of the priority vector obtained at the *k*th power and at the (*k*+1)st power is less than some predetermined small value.

The simple was to obtain the exact value (or an estimate) of λ_{max} when the exact value (or an estimate) of *w* is available in normalized form is to add the columns of A and multiply the resulting vector by the priority vector *w*. It is interesting to note that $(\lambda_{max} - n)(n\text{-}1)$ is the variance of the error incurred in estimating a_{ij}. This can be shown by writing $a_{ij} = (w_i / w_j)\ \varepsilon_{ij}$, $\varepsilon_{ij} > 0$, $\varepsilon_{ij} = 1 + \delta_{ij}$, $\delta_{ij} > -1$, and substituting in the expression for λ_{max}. It is δ_{ij} that concerns us as the error component and its value $|\delta_{ij}|<1$ for an unbiased estimator.

The measure of inconsistency can be used to successively improve the consistency of judgments. The consistency index of a matrix of comparisons is given by C.I. = $(\lambda_{max} - n)(n\text{-}1)$. The consistency ratio (C.R.) is obtained by comparing the C.I. with the appropriate one of the following set numbers each of which is an average random consistency index derived from a sample of randomly generated reciprocal matrices using the scale 1/9, 1/8, …,1,…, 8, 9. If it is not less than 0.10, study the problem and revise the judgments. And inconsistency of 10 percent or less implies that the adjustment is small compared to the actual values of the eigenvector entries.

Table 5.3.1. Average Random Consistency Index (R.I.) , Satty and Vargas (2001)

N	1	2	3	4	5	6
Random Consistency Index (R.I)	0	0	0.58	0.90	1.12	1.24

Satty and Vargas (2001) also suggested that in order to make comparison possible, the work should go down from the goal as far as one can and then should work up from the alternatives until the levels of the two processes are linked. Thus, AHP is to assist people in organizing their thoughts and judgments to make more effective decisions.

This study employs this concept to understand open space users' preference by inferring judgments from the weight comparisons, in order to present more information for future design and planning.

5.3.2. Collection of Preference Items

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. 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 5.3.2.):

(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.

Table 5.3.2. Comparison of frequently mentioned attributes

Ranks	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.

5.3.3. Result of Preference Weight Model

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 5.3.3..

Table 5.3.3. 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.

Table 5.3.3 AHP results and priority ranking

Valuable attribute Level B: General attribute	Level C: Specific quality	Weight of Priority 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: Biologic 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.

5.3.4. Analysis of Preference Weights

5.3.4.1. Priority of Preference Weights

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 to 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 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.

Further, a fuller picture emerges from the results on the relative importance of the various attributes and qualities of daily used open spaces between the common case and the campus case. 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).

5.3.4.2. ANOVA of Preference Weights between the common case and the campus case

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 5.3.4.2.). 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.

Table 5.3.4.2. Analysis of variance between group

	No./	Comparison group	Average comparison of Common residence	Average comparison of Campus residence	F	Sig.
Level	1	B1:B2	1.49	1.13	1.050	0.306
	2	B1:B3	3.53	2.92	2.214	0.187
	3	B2:B3	2.37	2.58	1.262	0.279
Level C	4	C1:C2	0.68	0.87	1.005	0.645
	5	C1:C3	4.47	1.19	6.441	0.021*
	6	C2:C3	6.58	1.37	11.593	0.000**
	7	C4:C5	1.40	1.28	1.355	0.257
	8	C4:C6	2.74	3.54	2.502	0.159
	9	C4:C7	1.70	1.65	0.362	0.747
	10	C5:C6	1.96	2.75	4.113	0.045*
	11	C5:C7	1.22	1.29	0.255	0.856
	12	C6:C7	0.62	0.47	0.796	0.352
	13	C8:C9	1.70	2.99	5.287	0.024*
	14	C8:C10	0.71	0.48	3.890	0.046*
	15	C9:C10	0.42	0.16	6.219	0.013*

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

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 5.3.4.2, 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.

CHAPTER 6:

SYNTHESIS OF PREFERENCE AND SATISFACTION

6.1. CONCEPT OF THE EVALUATION-BEHAVIOR MODEL

As mentioned in Chapter 2 (page 10) and Chapter 4 (page 49, 50), one objective of this study is to clarify the current main *Residential Open Space Lifestyles*, in order to offer a comprehensive panorama over the object, which may be at a city level, or only focus on a type of space or a community (Figure 6.1..)

The key to solve the problem is how to differentiate people from the total samples into several sub-groups within which the members are similar to each other. Herein, the value preference on residential open space was selected as the criteria, because the satisfaction evaluation depends too much on physical conditions, instead of human perception. In other words, satisfaction is suitable to classify a sample of open spaces. The value preference is an accumulative outcome from a given environment, distinctive culture and some intangible traditions. The preference characteristics would influence the person on many important decisions.

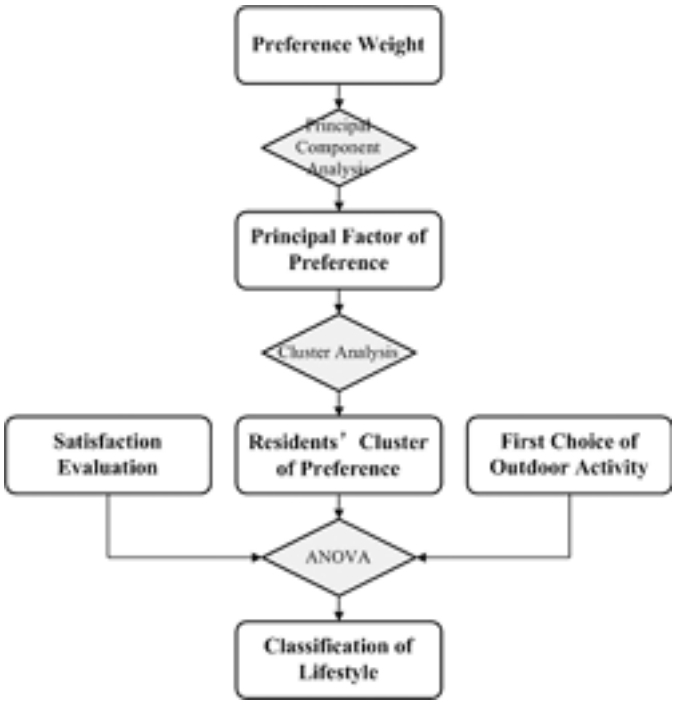

Figure 6.1. A Streamline to Explore Residents' Lifestyle in Open Space: Synthesis of Evaluation and Behavior

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6.2. Principal Component Analysis of Preference

In order to examine the variations of public preferences for both cases, a dimension-reducing process was performed by the principal component analysis (PCA). Based on the AHP results of Chapter 4.4. (n=250 for the common case; n=415 for the campus case, Table 4.3.2., page 31), the ten variables of weights (i.e. C1 to C10) representing public preferences were submitted to the PCA. Further more, the residents/students were classified into several groups in terms of individual scores on the extracted factors with the Cluster Analysis in Section 6.3..

6.2.1. PCA on the Common Case (250 Samples of Six Areas)

The PCA solution (Table 6.2.1.) extracted four components labeled (1) Ecology – Group activity, (2) Landscape, and (3) Individual – Public activity. This solution yielded ten communalities ranging from 0.620 to 0.932.

Table 6.2.1. PCA solution for the Common case (250 responses)

Rotated Component Matrix	Factor 1	Factor 2	Factor 3	Communality
Ecology – Group activity †				
C10: Biological diversity	.934	-.039	.071	.879
C9: Water-soil retention	.915	.000	.309	.932
C2: Group activity	-.846	-.386	-.100	.875
C8: Microclimate	.778	.248	-.423	.846
Landscape†				
C5: Aural amenity	.015	.925	.193	.893
C4: Visual amenity	.031	.831	-.252	.756
C7: Olfactory amenity	.473	.803	-.156	.893
Individual activity – Public activity †				
C3: Public activity	-.144	-.290	-.812	.764
C1: Individual activity	.148	-.277	.722	.620
C6: Tactual amenity	-.296	-.545	.646	.802
Eigenvalue	3.386	2.862	2.011	
% of Variance	33.863	28.621	20.113	
Cumulative %	33.863	62.484	82.597	

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.† denotes the definition of each factor are assigned by the author.

The items in the first factor mainly referred to various ecological qualities of microclimate, water-soil retention, and biologic diversity inside or in the immediate surroundings of the residence, whereas negatively referred to the group activity. The second factor referred to manifestations of landscape amenity, except olfactory amenity. The third factor contained items referring to positively individual activity and negatively public activity. The cumulative percentage of variance showed that the above three principle factors explained residents' preferences quite well, with a cumulative explanation of 82.6%, in which the first two factors had 62.5%.

Table 6.2.2. PCA solution for the CAMPUS case (415 responses)

Rotated Component Matrix	Factor 1	Factor 2	Factor 3	Factor 4	Communality
Landscape + Microclimate †					
C7: Olfactory amenity	.921	.251	-.047	.172	.943
C4: Visual amenity	.876	-.135	-.048	-.414	.968
C8: Microclimate	.829	.152	.372	-.285	.930
C3: Public activity	-.614	-.243	-.598	-.280	.872
Ecology - Group activity†					
C10: Biological diversity	-.034	.978	.052	-.166	.987
C9: Water-soil retention	.140	.935	-.120	.102	.919
C2: Group activity	-.483	-.629	-.217	-.014	.676
Non-visual landscape†					
C6: Tactual amenity	.149	.024	.971	-.102	.977
C5: Aural amenity	-.071	-.090	.850	.484	.970
Individual activity†					
C1: Individual activity	-.116	-.047	.136	.967	.970
Eigenvalue	2.974	2.401	2.249	1.579	
% of Variance	29.738	24.01	22.489	15.795	
Cumulative %	29.738	53.747	76.236	92.031	

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.† denotes the definition of each factor are assigned by the author.
† denotes the definition of each factor whose names are assigned by the authors.

The items in the first factor mainly referred to visual and olfactory aesthetic qualities and the microclimate quality regulated by open spaces in the vicinity of the residence. The second factor referred to two ecological qualities of water-soil retention and biologic diversity inside or in the immediate surroundings of the residence, whereas negatively referred to the group activity. The third factor referred to manifestations of the aural and tactual aesthetic qualities of open spaces. The fourth factor contained items referring to individual activity. The cumulative percentage of variance showed that the above four principle components explained residents' preferences quite well, with a cumulative explanation of 92.0%, in which the first two components had 53.7%.

6.2.3. Comparison of PCA Results between the common case and the campus case

As mentioned above, a PCA solution extracted three factors of the common case, labeled (1) ecology - group activity, (2) Landscape, (3) individual activity – public activity. The other similar PCA was performed for the campus case, extracting four components labeled (1) landscape + microclimate, (2) ecology - group activity, (3) non-visual landscape, and (4) individual. The result clarified the similarity and differences between the two cases.

The components of ecology, group activity and non-visual landscape can be regarded as the shared components that explain perceptional differences among the eight groups (the common case) and among the six groups (the campus case). That means that the designers should consider the diversity of public demands on ecology, group activity and non-visual landscape, whether for common residential zones or for university campuses.

On the other hand, the two cases show some differences of the preferences on individual activity, public activity and microclimate. That means that the designers may treat their works differently for common residential open spaces and for campus open spaces, in terms of the mentioned aspects above.

6.3. CLUSTER ANALYSIS OF RESIDENTS

In order to classify the respondents in terms of their preference, the four scores of the principal factors (components) were used as the data for the Cluster Analysis.

6.3.1. Cluster Analysis on the Common Case (Total 250 samples of six areas)

For the common case, therefore, the 250 pairs of scores on the four components were taken as

the data variables for use in the subsequent cluster analyses (CA), in order to classify the residents according to individual preferences. The CA results showed that eight groups of residents have been clusters among all the 250 samples. To illustrate the cluster distribution clearly, the scatter plot in terms of the scores on the first and second factors is shown as Fig 6.3.1.. The name of each cluster is defined from the following results of Section 6.4..

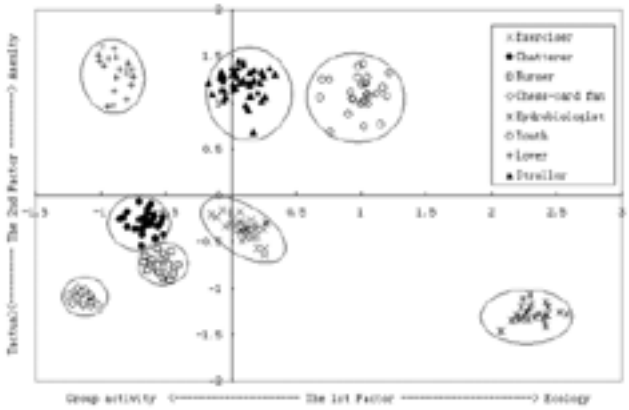

Fig. 6.3.1. The scatter plot of common residents' clusters in terms of PCA scores

6.3.2. Cluster Analysis on the Campus Case (Total 415 samples of four areas)

For the campus case, therefore, the 415 pairs of scores on the four components were taken as the data variables for use in the subsequent cluster analyses (CA), in order to classify the residents according to individual preferences. The CA results showed that six groups of residents have been clustered among all the 415 samples. To illustrate the cluster distribution clearly, the scatter plot in terms of the scores on the first and second factors is shown as Fig 6.3.2.. The name of each cluster is defined from the results of Section 6.4..

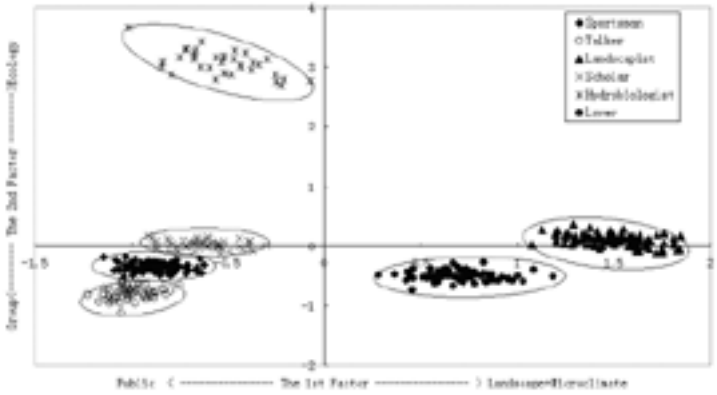

Fig. 6.3.2. The scatter plot of students' cluster in terms of PCA scores

6.3.3. Comparison of the lifestyles between the two cases

As mentioned above, a CA solution extracted eight groups of the common case, labeled (1) aged exercisers, (2) chatterers, (3) private nursers, (4) chess-card fans, (5) hydro-intimates, (6) youths, (7) lovers, and (8) middle-aged strollers. The other similar PCA was performed for the campus case, extracting six groups labeled (1) sportsmen, (2) talkers, (3) landscapist, (4) scholars, (5) hydro-intimates, and (6) lovers.

The results clarified the similarity and differences between the two cases. On the one hand, the groups of exercisers (sportsmen), chatters (talkers), hydro-intimates, lovers and strollers (landscapist) are the similar types in both cases. These five types can be regarded as the mutual lifestyles among residential open space users. On the other hand, the two cases show some different lifestyles. For example, the common case has two types (nursers and chess-card fans) that are out of the campus cases; and the campus case has one lifestyle of scholars that is out of the common case.

Hence, it is confirmed that the lifestyles are diverse in both cases and that the diversity of the lifestyles of the common case are more extensive than those of the campus case.

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6.4. ANOVA AND CLASSIFICATION OF RESIDENTIAL OPEN SPACE LIFESTYLES

Through the analysis of variance between groups in terms of personal demographic attributes and behavioral features, it showed that three aspects are different with significance, including gender, age, first choice of activity and so on. Consequently, the corresponding characteristics of the eight (or six) groups are described as follows.

6.4.1. ANOVA and Classification of Lifestyles of the Common Case

6.4.1.1. ANOVA OF THE COMMON CASE (250 SAMPLES OF SIX AREAS) The ANOVA result (Table 6.4.1.1.(a)) confirmed that there are differences between the eight clusters on all the five indices and the comprehensive satisfaction.

The middle-aged and aged people evaluate their residential open space with a high level, while the lovers and the waterfront people contrastively undervalue it. This seems to inform designers that current conditions should be improved with *a kind consideration on relative privacy (for lovers' communication) in open space, and availability of water spots as well.*

Also, other information should be paid much attention to, e.g. health for chatterers and safety for private (family) nursers who take care of children, enjoying outdoor life.

Table 6.4.1.1. (a) Comparison of Satisfaction Indices of the Common Case

Cluster Name	Application	Amenity	Heath	Safety	Community	Total
Aged exercisers	0.57	0.53	0.44	0.56	0.77	0.52
Chatterers	0.52	0.45	0.23*	0.59**	0.74	0.50
Private nursers	0.53	0.57**	0.54	0.40*	0.67	0.51
Chess-card fans	0.57	0.41	0.51	0.55	0.84**	0.51
Hydro-intimates	0.22*	0.34*	0.28	0.41	0.41	0.43
Youths	0.62**	0.44	0.51	0.49	0.34	0.49
Lovers	0.37	0.39	0.33	0.44	0.30*	0.36*
Middle-aged strollers	0.72	0.41	0.55**	0.55	0.71	0.59**
ANOVA Test						
F	11.896	5.354	7.371	2.667	18.258	5.039
Sig.	0.000	0.000	0.000	0.021	0.000	0.000

The ANOVA result (Table 6.4.1.1.(b)) confirmed that there are differences between the eight

clusters on all the ten indices of preference, especially on C2 (group activity), C3 (public activity), and C9 (water-soil retention).

On the above three attributes, the clusters of chess-card fans, aged exercisers and hydro people express strong speciality. *It is a valuable pursuit for group places of chess-card fans, public places of aged exercisers, and water places.*

Table 6.4.1.1. (b) Comparison of Preference Weights of the Common Case

See Page 34	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exerciser	0.092	0.288	0.224 **	0.107	0.058	0.011*	0.067	0.072	0.010*	0.071
Chatterer	0.241	0.318	0.067	0.097	0.065	0.077**	0.051	0.041	0.006	0.036
Nurser	0.089	0.455	0.040	0.117	0.041	0.076	0.021	0.043	0.027	0.091
Chess-card	0.150	0.557 **	0.069	0.033	0.042*	0.061	0.021*	0.023*	0.013	0.033
Hydro-inti	0.282 **	0.057 *	0.025	0.029*	0.046	0.055	0.057	0.070	0.173 **	0.207 **
Younger	0.079*	0.184	0.021*	0.156	0.116	0.032	0.102**	0.094**	0.093	0.124
Lover	0.252	0.257	0.034	0.099	0.163**	0.045	0.078	0.032	0.019	0.022*
Mid-aged strollers	0.108	0.245	0.028	0.195**	0.108	0.020	0.080	0.052	0.059	0.105
ANOVA TEST										
F	795.912	1436.241	2621.532	819.008	800.901	1120.361	640.526	632.363	2290.165	1122.419
Sig.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The ANOVA result (Table 6.4.1.1.(c)) confirmed that there are differences between the eight clusters on socio-demographic characteristics and especially on the activity choice. It is necessary for designers to consider diverse scenarios of residents' daily life.

Table 6.4.1.1. (c) Comparison of Socio-demographic Characteristics and the First Choice

Type Name	Socio-demo			First Choice			
	Gender (% of Male)	Age	Occupation	Frequency (Weekly)	Timing	Duration (Per time)	Accompany (No.)
Exerciser	0.514	63.1	retired	6.14	dawning	40.3 (min)	13.6
Chatterer	0.367	58.4	housewife	10.28	multi	51.9 (min)	4.93
Nurser	0.000	20.7	maid	5.86	multi	34.0 (min)	2.65
Chess-card	0.703	56.6	multi	3.85	multi	73.3 (min)	6.49
Hydro-inti	0.760	50.3	multi	4.76	multi	114.1 (min)	1.78
Youth	0.464	16.5	student	0.81	afternoon	37.2 (min)	2.55
Lover	0.526	26.2	multi	1.62	evening	44.4 (min)	1.00
Mid-aged strollers	0.469	44.8	multi	3.19	multi	17.0 (min)	0.83
ANOVA Test	(Chi-Square)						
F	42.049	8.954		31.286		25.397	17.330
Sig.	0.000	0.000		0.000		0.000	0.000

6.4.1.2. Classification of Lifestyles of the Common Case (250 samples of six areas)

According to the above results, the following classification are concluded to characterize the residents who daily consume their open spaces as individual preference and feed back on their evaluation in diversity.

(1) Type 1 mainly refers to aged exercisers (35 respondents, 14.0%). Their average age is 63.1 and the gender is balanced. They utilize small squares in neighborhood parks to take exercise every morning, with the duration of approximately 40 minutes. The weight on C3 (public activity) is assigned 22.4%, with the highest rank among the eight types. On the contrary, the weights on C6 (tactual amenity) and C9 (water-soil retention) are assigned 1.1% and 1.0% respectively, with the lowest and second lowest rank among the eight types (next only to Type 2: aged chatterers).

(2) Type 2 mainly refers to aged chatterers (30 respondents, 12.0%). Their average age is 58.4 and the female is the majority. They utilize various spaces of neighborhood parks for chatting or gossiping from 9:00 to 11:00 AM or from 3:00 to 5:00 PM with the duration of approximately 50 minutes each time. The weight on C6 (tactual amenity) is assigned 7.9%, with the highest rank among the eight types. On the contrary, the weight on C9 (water-soil retention) is assigned 0.6%, with the lowest rank among the eight types.

(3) Type 3 mainly refers to private nursers (27 respondents, 10.8%). Their average age is 20.7 and all are female. They utilize grassland and paths inside neighborhood parks for playing, basking in the sunlight or viewing landscape from 9:00 to 11:00 AM or at about 5:00 PM with the duration of approximately 30 minutes, 5-6 times per week. The weight on C2 (group activity) is assigned 44.9%, with the second highest rank among the eight types (next only to Type 4: chess-card fans). On the contrary, the weight on C1 (individual activity) is assigned 8.9%, with the second lowest rank among the eight types (next only to Type 6: youngers). In addition, C5 (aural amenity) and C7 (olfactory amenity) are assigned 4.1% and 2.1% respectively, with the second lowest rank among the eight types (both next only to Type 2: aged chatterers).

(4) Type 4 mainly refers to chess-card fans (37 respondents, 14.8%). Their average age is 56.6 and the male is the majority. They utilize playrooms inside neighborhood parks and small corners between buildings for intellective games from 12:00 to 1:00 PM or from 3:00 to 5:00 PM with the duration of approximately 70 minutes, 3-4 times per week. The weight on C2 (group activity) is assigned 55.8%, with the highest rank among the eight types. On the contrary, the weights on most of the aesthetic and ecological qualities (C4,

C5, C7, C8 and C10) are assigned low values, with the lowest or second lowest rank among the eight types.

(5) Type 5 mainly refers to the people who are intimate to water, named hydro-intimates (25 respondents, 10.0%). Their average age is 50.3 and the male is the majority. They stay around waterfronts in the vicinity of the neighborhood for fishing and walking with a birdcage from 8:00 to 11:00 PM or from 1:00 to 5:00 PM with the duration of approximately 120 minutes, 4-5 times per week. The weights on C1 (individual activity), C9 (water-soil retention) and C10 (bio-diversity) are assigned 28.6%, 16.7%, and 20.8% respectively, with the highest rank among the eight types. On the contrary, the weights on C4 (visual landscape) are assigned 2.9%, with the lowest rank among the eight types.

(6) Type 6 mainly refers to young students and workers (28 respondents, 11.2%). Their average age is 16.5 and the gender is balanced. They usually utilize grassland inside neighborhood for reading, talking and viewing landscape with friends after the lunch or at about 3:00 PM. with the duration of approximately 30 minutes, less than 1 time per week. The weights on most of the aesthetic and ecological qualities (C4, C5, C7, C8, C9 and C10) are assigned high values, with the highest or second highest rank among the eight types. On the contrary, the weights on C1 (individual activity) and C3 (public activity) are assigned 7.8% and 0.2% respectively, with the lowest rank among the eight types.

(7) Type 7 mainly refers to lovers (19 respondents, 7.6%). Their average age is 26.2 and the gender is balanced. They usually utilize shady places under trees inside neighborhood for intimate amorism from 3:00 to 4:00 PM or after the supper, with the duration of approximately 45 minutes, 1-2 times per week. The weights on C5 (aural amenity) and C1 (individual activity) are assigned 15.9% and 25.6% respectively, with the highest and second highest rank among the eight types (next only to Type 5: hydro-intimates). On the contrary, the weights on C10 (bio-diversity) and C8 (microclimate) are assigned 2.2% and 3.1% respectively, with the lowest or second lowest rank among the eight types (next only to Type 4: chess-card fans).

(8) Type 8 mainly refers to middle-aged strollers (49 respondents, 19.6%). Their average age is 44.8 and the gender is balanced. They usually pass through the neighborhood park for meeting neighbors off duty or stroll along walkways after the supper, with the duration of approximately 15 minutes, 3-4 times per week. The weights on C4 (visual amenity) and C7 (olfactory amenity) are assigned 19.7% and 8.0% respectively, with the highest or second highest rank among the eight types. On the contrary, the weight on C5 (aural amenity) is assigned 2.1%, with the second lowest rank among the eight types

(next only to Type 1: aged exercisers).

6.4.2. ANOVA and Classification of Lifestyles of the Campus Case (415 samples)

Table 6.4.2.1. (b) Comparison of preference weights of the Campus Case

See Page 34	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Sportsmen	0.126	0.189	0.371**	0.092	0.042*	0.016*	0.052	0.030	0.008*	0.075
Talker	0.101	0.298**	0.152	0.125	0.093	0.082	0.047*	0.030	0.010	0.064
Landscapist	0.071*	0.103	0.025*	0.304**	0.073	0.087	0.100**	0.098**	0.026	0.114
Scholar	0.226	0.120	0.028	0.052*	0.212**	0.133**	0.061	0.059	0.011	0.099
Hydro-inti	0.150*	0.085	0.061	0.069	0.068	0.051	0.082	0.045	0.097**	0.292**
Lover	0.243**	0.191	0.044	0.159	0.111	0.044	0.092	0.047	0.023	0.046*
ANOVA TEST										
F	977.201	1184.087	7825.992	2858.304	2432.827	2327.108	630.729	1542.951	4741.351	3564.776
Sig.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6.4.2.1. (a) Comparison of satisfaction indices of the Campus Case

Type Name	Application	Amenity	Heath	Safety	Community	Total
Sportsmen	0.55	0.57	0.81**	0.55**	0.59	0.67**
Talker	0.64**	0.49	0.74	0.42	0.64**	0.64
Landscapist	0.47	0.65**	0.66	0.49	0.25*	0.59
Scholar	0.54	0.53	0.58	0.48	0.29	0.56
Hydro-inti	0.24*	0.47	0.70	0.52	0.36	0.47*
Lover	0.40	0.43*	0.57*	0.39*	0.53	0.53
ANOVA TEST						
F	10.561	14.322	3.083	1.023	3.135	5.045
Sig.	0.000	0.000	0.000	0.000	0.000	0.000

Similar to the common case, the ANOVA result (Table 6.4.1.1.(b)) also confirmed that there are differences between the six clusters on all the ten indices of preference, especially on C3 (public activity), C9 (water-soil retention), and C10 (water-soil retention).

On the above three attributes, the clusters of sportsmen and hydro intimates express strong speciality. *It is a valuable pursuit for public places and water places.*

The ANOVA result (Table 6.4.2.1.(c)) confirmed that there are differences between the six clusters on socio-demographic characteristics and especially on the activity choice. It is necessary for designers to consider diverse scenarios of students' daily life.

Table 6.4.2.1. (c) Comparison of Socio-demographic Characteristics and the First Choice

Type Name	Socio-demo			First Choice			
	Gender (% of Male)	Age	Major	Frequency (Weekly)	Timing	Duration (Per time)	Accompany (No.)
Sportsmen	0.716	21.5	multi	4.2	Dawning, p.m.	37.3 (min)	11.2
Talker	0.541	21.9	multi	17.3	multi	9.1(min)	2.49
Landscapist	0.198	21.0	multi	3.1	multi	48.5 (min)	1.42
Scholar	0.571	19.8	multi	3.9	multi	38.6 (min)	0.25
Hydro-inti	0.639	21.3	multi	1.77	multi	45.9(min)	1.14
Lover	0.518	23.2	multi	5.54	evening	85.8 (min)	1.00
ANOVA	(Chi-Square)						
F	53.920	3.207		12.658		61.432	20.334
Sia.	0.000	0.025		0.000		0.000	0.000

6.4.2.2. Classification of Lifestyles of the Campus Case (415 samples of four areas)

(1) Type 1 mainly refers to sportsmen (88 respondents, 21.2%). Their average age is 21.5 and the male is a little more than 70%. They utilize playgrounds to take exercise every morning, with the duration of approximately 20 minutes, 5-6 times per week. Moreover, they are fond of ball games in the afternoon, with the duration of approximately 50 minutes, 3-4 times per week. The weight on C3 (public activity) is assigned 36.8%, with the highest rank among the six types. On the contrary, the weights on most of the aesthetic and ecological qualities (C5, C6, C7, C8 and C9) are assigned low values, with the lowest or second lowest rank among the six types.

(2) Type 2 mainly refers to talkers (61 respondents, 14.7%). Their average age is 21.9 and the gender is balanced. They utilize various spaces in the vicinity of classrooms for chatting or discussion at about 10:00 AM and 3:00 PM with a short break of approximately 10 minutes per time. The weights on C2 (group activity) and C3 (public activity) are assigned 30.5% and 14.9% respectively, with the highest and second highest rank among the six types (next only to Type 1: sportsmen). On the contrary, the weights on C1 (individual activity), C7 (olfactory amenity) and all the ecological qualities are assigned low values, with the lowest or second lowest rank among the six types respectively.

(3) Type 3 mainly refers to the students who like landscapes, named landscapist (91 respondents, 21.9%). Their average age is 21.0 and the female is majority. They usually utilize grassland or scenery-facing ground on campus for reading and viewing landscape alone in the afternoon, with the duration of approximately 50 minutes, 3-4 times per week. The weights on C4 (visual amenity), C7 (olfactory amenity) and C8 (microclimate)

are assigned 30.0%, 10.1%, and 9.8% respectively, with the highest rank among the six types. On the contrary, the weights on C1 (individual activity) and C3 (public activity) are assigned 7.0% and 2.5% respectively, with the lowest rank among the six types.

(4) Type 4 mainly refers to the students who enjoy outdoor studying, named scholars (56 respondents, 13.5%). Their average age is 19.8 and the gender is balanced. They utilize (semi) open spaces with a good seating environment on campus for reading and studying, from 9:00 to 11:00 AM and from 2:00 to 4:00 PM with the duration of approximately 40 minutes, 3-4 times per week. The weights on C5 (aural amenity) and C6 (tactual amenity) are assigned 21.0% and 13.2% respectively, with the highest rank among the six types. In addition, the weight on C1 (individual activity) is assigned 23.0%, with the second highest rank among the six types (next only to Type 6: lovers). On the contrary, the weights on C2 (group activity), C3 (public activity) and C4 (visual amenity) are assigned low values, with the lowest or second lowest rank among the six types respectively.

(5) Type 5 mainly refers to the people who are intimate to water, named hydro-intimates (36 respondents, 8.7%). Their average age is 21.3 and the male is the majority. They stay around waterfronts on campus for fishing and boating from 1:00 to 5:00 PM. with the duration of approximately 50 minutes, 1-2 times per week. The weights on C9 (water-soil retention) and C10 (bio-diversity) are assigned 9.8% and 29.0% respectively, with the highest rank among the six types. On the contrary, the weights on C2 (group activity), C4 (visual amenity) and C5 (aural amenity) are assigned low values, with the lowest or second lowest rank among the six types respectively.

(6) Type 6 mainly refers to lovers (83 respondents, 20.0%). Their average age is 23.2 and the gender is balanced. They usually utilize ulterior places, e.g. marginal or isolated sections on campus for intimate amorism after the supper, with the duration of approximately 90 minutes, 5-6 times per week. The weights on C1 (individual activity) and C2 (group activity) are assigned 24.5% and 19.1% respectively, with the highest and second highest rank among the eight types (next only to Type 2: talkers). In addition, the weights on most of the aesthetic qualities (C4, C5 and C7) are assigned high values, with the second highest rank among the six types. On the contrary, the weights on C10 (bio-diversity) and C6 (tactual amenity) are assigned 4.6% and 4.4% respectively, with the lowest or second lowest rank among the six types (next only to Type 1: sportsmen) respectively.

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CHAPTER 7:

RESIDENTS' BEHAVIORAL DYNAMICS

7.1. CHARACTERISTICS OF RESIDENTS' BEHAVIOR

7.1.1. Temporal Characteristics

People visit open spaces in different timings according to their own preference and willingness, which can be observed hourly, daily, weekly, seasonally, annually, even with a whole lifetime. In this study, a period throughout 12 weeks was taken as the sample of behavioral data. The regulation at daily and hourly levels confirmed the diversity of temporal characteristics.

7.1.2. Spatial Characteristics

The distribution of people's activities is also different in terms of their own demands. For example, children like sand grounds and sports instruments, students often gather on a plot of lawn, while the aged usually prefer a seat under a tree. In fact, the spatial characteristics are closely connected to the category of activity.

7.1.3. Categorial Characteristics

Open space provides a mixture of opportunities to visitors, not only the direct benefit to the pleasure of sensory contact with nature but also contribute to the social and cultural meanings to the people in the community. As the results, there are varieties of activities that visitors could perform at site. Greatly simplified, Gehl (1980) categorized the different activities in open space into *necessary, optional and social* activities. Following that, in general, a variety of activities can be grouped to be three types of activities that can be described as Table 7.1.3:

Table 7.1.3. Category of Activity

Category of Activity	Description & Example
Necessary	**Description:** *Necessary activities* include those that are more or less compulsory. Because of necessity, the incidence is influenced only slightly by the physical conditions. These activities will take place throughout the year, under nearly all conditions, and are more or less independent of the exterior environment. The participants have no choice. **Example:** going to school or to work, shopping, waiting for a bus or a person, running errands, distributing something.
Optional (Individual)	**Description:** *Optional activities are* those pursuits if there is a wish to do so and if time and place make it possible. These activities take place only when exterior conditions are optimal, when weather and place invite them. This relationship is particularly important in connection with physical planning because most of the recreational activities that are especially pleasant to pursue outdoors are found precisely in this category of activities. These activities are especially dependent on exterior physical conditions.
Studying	**Example:** Reading a book or newspaper, or writing something.
Viewing	**Example:** standing or sitting and sunbathing, enjoying life.
Rambling	**Example:** taking a walk to get a breath of fresh air.
Social	**Description:** Social activities are all activities that depend on the presence of others in public spaces. Social activities occur spontaneously, as a direct consequence of people moving about and being in the same spaces. This implies that social activities indirectly supported whenever necessary and optional activities are given better conditions in public spaces.
(Group)	there are a limited number of people with common interests or because people "know" each other, or they often see one another.
Talking	**Example:** greetings and conversations, communal activities
Playing	**Example:** Play game, such as chess, card or a physical game
Party	**Example:** Gathering with food, drinks
(Public)	In city streets and city centers, social activities will generally be more superficial, with the majority being passive contacts - seeing and hearing a great number of unknown people. But even this limited activity can be very appealing.
Sports	**Example:** exercising, playing ball with known or unknown people.
Performing	**Example:** making a performance, presentation, lecture or speech.
Assembling	**Example:** dealing at a flea market, a public affair,

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7.2. METHOD OF BEHAVIORAL DYNAMICS MODEL (BEHAVIORAL ENTROPY ANALYSIS)

Since people's behavior in open space is diverse in terms of temporal, spatial and categorical dimensions, it can be regarded as a kind of complex system that consists of multiple forms. How to characterize the distribution of daily activities in campus open spaces calls for much attention of designers and planners. It seems natural to assume that, if an open space system is a complex system, any internal changes will be reflected in established measures of the complexity of the system (where ''complexity'' is seen as a system attribute capturing one or more aspects of the system's structure, function or dynamics) (Parrott, L., 2005). How to measure "complexity" has become a common practice for describing spatial structural properties in the fields of urban geography and landscape ecology. One common approach to characterizing complexity is to use information-based measures such as Shannon entropy and its relatives to classify a data set according to its degree of order or randomness.

The Shannon entropy (Shannon, 1948), Hs, of a binary sequence is thus computed as follows:

$$H_s(L) = -\sum_{i=1}^{N} p_{L,i} \log_2 p_{L,i} \qquad \text{[Equation 7.2.1]}$$

where $p_{L,i} \log 2\ p_{L,i} = 0$ for $p_{L,i} = 0$. For a random sequence, all words are equally probable (all pL,i are equal), and the maximum value of Hs = log N is obtained. The minimum value, Hs = 0, occurs when one $p_{L,i} = 1$ and the others are all zero (maximally ordered string).

The behavior of residents in open space includes three levels of characteristics: temporal, spatial, and categorical characteristics. The dynamics of the behavior was examined by employing the idea of Entropy, as shown by Equation **7.2.2**.

$$BEI = \frac{-\sum_{j=1}^{n} p_j \log_2(p_j)}{\log_2(n)} \qquad \text{[Equation } \mathbf{7.2.2}\text{]}$$

where *BEI* is the Behavioral Entropy Index,

p_j is the relative frequency (probability) of the j^{th} behavioral option.

n is the number of behavioral options.

Division by $log_2(n)$ serves to normalize the measure into 0-1.

According to the definition of the behavior entropy, the value of BEI stands for the diversity of people's behavior.

At the temporal dimension, the value becomes 1 if all the periods of the day and night can be used by outdoor activities, and the population distribution is evenly balanced. On the contrary, the value becomes 0 if the outdoor population congregates into only one period or nobody outdoors. As a medium, the value of conditional random becomes approximately 0.78 if the daytime periods from 6:00 to 18:00 are used in balance.

At the spatial (section) dimension, the value becomes 1 if all the sections of the community or campus can be used by outdoor activities, and the population distribution is evenly balanced. On the contrary, the value becomes 0 if the outdoor population congregates into only one section or nobody outdoors. As a medium, the value of conditional random becomes approximately 0.85 if the 75% sections are used in balance.

At the categorial dimension, the value becomes 1 if all the categories of the activity can be taken by outdoor people, and the population distribution is evenly balanced. On the contrary, the value becomes 0 if the outdoor population congregates into only one category or nobody outdoors. As a medium, the value of conditional random becomes approximately 0.80 if the 70% categories are used in balance.

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7.3. RESULTS OF BEHAVIORAL DYNAMICS MODEL

(A Case Study of Zi-Jin-Gang Campus and Xi-Xi Campus of Zhejiang University)

The comparison between the common case and the campus case on the preference and satisfaction would be conducted in Chapter 6 (Section 6.2.3., 6.4.3.). The results show that there are generally mutual characteristics among residents and students' evaluation on residential open spaces. Campus open space can be regarded as a research base and a receivable representative case to examine the behavioral characteristics in residential open space.

Due to the limitation of data collection, only two campuses were selected as the study case of behavioral survey. As the largest campus and a multiversity campus in Hangzhou City, however, Zi-Jin-Gang Campus and Xi-Xi Campus are suitable to be the typical objects. The former is a representative of the new fashionable type located in the suburban area, and the latter is a representative of the old type located in the central area of the city.

7.3.1. General Information of Zi-Jin-Gang Campus and Xi-Xi Campus

Zi-Jin-Gang Campus

The campus of Zi-Jin-Gang is the new territory of Zhejiang University and is to be the future main body of the university. At present, the total land area is approximately 2 million square meters, where approximately 13,000 students are studying and living. The campus was founded in the year of 2000 and is still being built. According to the planning transportation system and the current situations in the survey (Fig. 7.3.1.), the campus is divided into 4 sections (A, B, C, D) and 11 sub-sections (A1, A2, A3, A4, B1, B2, B3, C1, C2, C3, D1). The partition considered the functions of land, the road level (width) and the traffic control. Section A is the living area (dorm area), Section B is mainly the sports area, and Sections C and D are the study area (Table 7.3.1.).

Table 7.3.1.(a) Area of the Sections of Zi-Jin-Gang Campus

	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D1
Total Area (HA)	24.91	10.67	10.44	15.38	8.26	13.79	16.50	17.35	47.43	19.38	14.17
Open Area	0	8.00	0	12.46	8.02	12.27	15.02	15.26	42.69	16.67	0

Fig. 7.3.1. (a) Partition of Zi-Jin-Gang Campus

The students' dormitories are all located in the northern part of the campus, with a relatively high density of buildings and more service facilities. The main types of open space comprise the roadside plots with good pavement, and the green courtyards enclosed or partially enclosed by buildings with good plantation.

The sports facilities are all located between the dormitory area and the teaching area, with a relatively low density of buildings and more sports instruments. The main types of open space comprise the sports fields with good pavement or grass, and the green areas with excessive woods.

The teaching buildings are all located in the central and southern parts of the campus, with a beautiful landscape of buildings and waterscape. The main types of open space comprise the small plots and semi-open spaces with good pavement and facilities near the buildings, and the lawn along the waterfront..

Xi-Xi Campus

The campus of Xi-Xi is one of the old areas of Zhejiang University and was founded since 1952. At present, the total land area is approximately 0.41 million square meters, where approximately 10,000 students are studying and living. According to the planning transportation system and the current situations in the survey (Fig. 7.3.1. (b)), the campus is divided into 3 sections (A, B, C) and 13 sub-sections (A1, A2, A3, A4, B1, B2, B3, C1, C2, C3, C4, C5, C6). The partition considered the functions of land, the road level (width) and the traffic control. Section A is the living area (dorm area), Section B is mainly the sports area, and Sections C is the study area (Table 7.3.1. (b)).

Table 7.3.1. (b) Area of the Sections of Xi-Xi Campus

	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**
Total Area (HA)	5.27	1.84	3.02	8.47	1.48	2.42	1.71
Open Area	2.72	1.05	1.88	5.14	1.48	2.35	1.36
Description	Dorm	Dorm	Dorm	Dorm	Field	Field	Gym
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	
Total Area	2.54	2.45	2.20	3.77	2.70	3.24	

Fig. 7.3.1. (b) Partition of Xi-Xi Campus

7.3.2. Results of Temporal Behavioral Dynamics Index

The population of the students who appear in the campus open space could be examined and compared at a temporal level (dimension) as Fig. 7.3.2.(a) & (b).

On the one hand, from the daily frequency dynamics (Fig. 7.3.2.(a)), the *weather* variation influences the population change with a serious extent, since the population in open space would descend to a trough (valley) as a result of rainfalls. In addition, the *special affairs or incidents* stimulates the population to a great increment. For example, the apex appears on the seventh day, the Chinese traditional holiday, when people go outdoors to enjoy the moon light and family ties (friendship).

On the other hand (Fig. 7.3.2.(b)), from the hourly temporal dynamics, the outdoor population ratio rises to the wave crest at *p.m. 17 to 18*, and the *morning period nearly to lunch* is also observed many populations. As the common sense, night is not a sound timing for outdoor life and consequently the outdoor population ratio declines to zero.

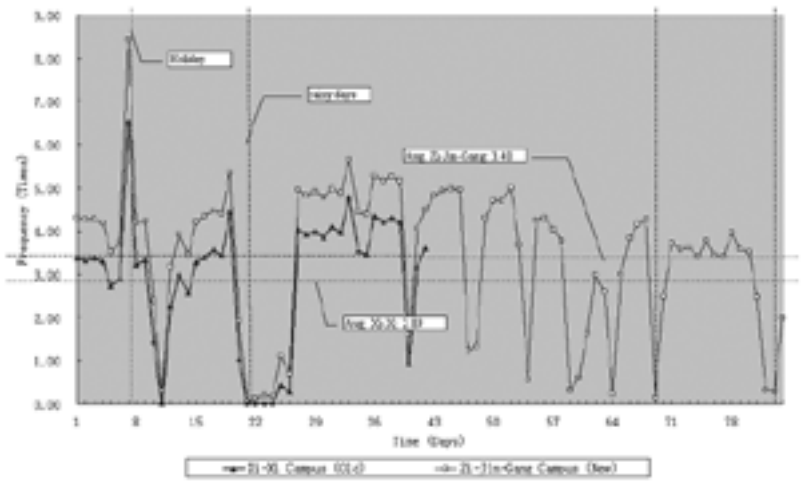

Fig. 7.3.2. (a) Average frequency dynamics within a 12-week (6-week) period, measured as the ratio of daily accumulative number of students outdoors to all the samples.

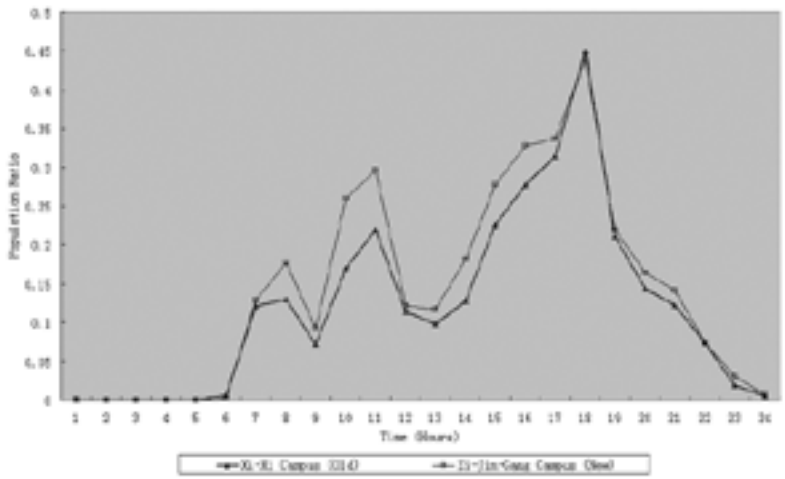

Fig. 7.3.2. (b) Hourly population ratio dynamics within a 12-week (6-week) period, measured as hourly accumulative number of people in campus open spaces. Note: the temporal point stands for the end of the hour period, e.g. 12 means the span from 11:00 to 12:00.

With a comparison between the old campus and the new campus, it shows that the population in the new campus open space is more prominent at the temporal dimension than that in the old campus.

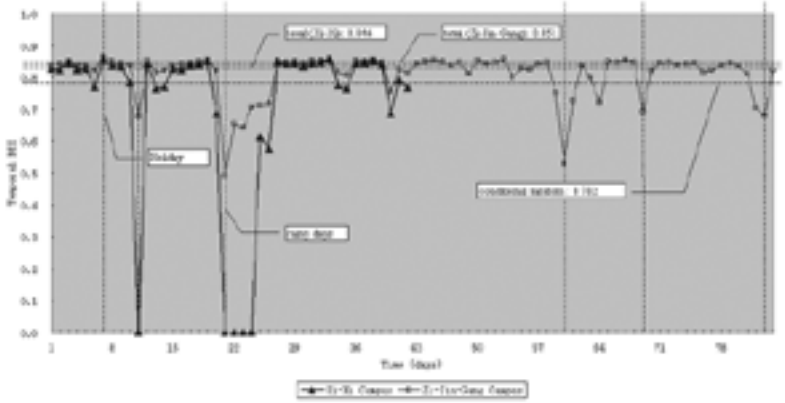

Fig. 7.3.2. (c) Total temporal dynamics throughout a 12-week (6-week) period; the daily temporal BEI is measured as hourly accumulative number of people presence on campus.

However, the simple dynamics of population provide insufficient information of students' behavior. It is necessary to explore further into the complexity of students' behavior. The results of a temporal behavioral entropy index revealed that (Fig. 7.3.2.(c)):

(i) Although special *affairs or incidents* arises the temporal behavioral complexity on the seventh day, the extent should be assessed carefully, instead of only comparing the simple number of population.

(ii) The *weather conditions* still influence the temporal behavioral complexity, because rain cuts down the opportunity for outdoor life.

Note:

$$BEI = \frac{-\sum_{j=1}^{n} p_j \log_2(p_j)}{\log_2(n)} \qquad \text{[Equation 7.3.2]}$$

where *BEI* is the Behavioral Entropy Index,

p_j is the relative frequency (probability) of the j^{th} behavioral option.

n is the number of behavioral options.

Division by $log_2(n)$ serves to normalize the measure into 0-1.

(The above function is also used in all the BEI calculations)

Daily Temporal BEI = f (x_i),

where x_i = hourly accumulative population during the day, i = 1, 2, 3, …, 24.

Total Temporal BEI = f (x_i),

where x_i = hourly accumulative population during the 12 weeks (or 6 weeks), i = 1, 2, 3, …, 24.

Temporal BEI of Conditional Random = f (x_i),

where x_i = 1/12, i = 6, 2, 3, …, 18;

x_i = 0, i = 1, 2, 3, 4, 5, 19, 20, 21, 22, 23, 24.

7.3.3. Results of Spatial Behavioral Dynamics Index

Like the temporal case, the population of the students who present in the campus could be examined and compared at a spatial level (dimension) as Fig. 7.3.3 (a). On the one hand, from the spatial dynamics, the *location* influences the population changes with a serious extent, since the population in open space would converge at the sports field and the study area with *a good landscape view*, where are laid out *large numbers of open spaces* with *facilities*. The areas under construction is inaccessible for outdoor activities.

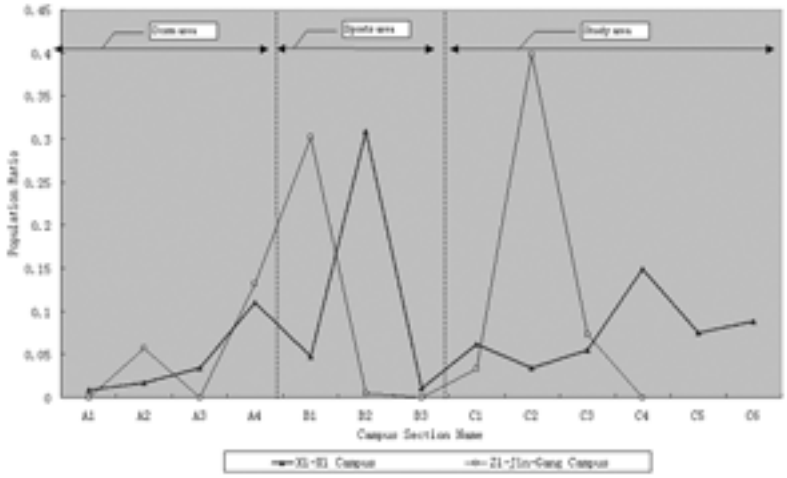

Fig. 7.3.3. (a) Spatial population dynamics within a 12-week (6-week) period, measured as accumulative number of people presence in each section of campus open spaces.

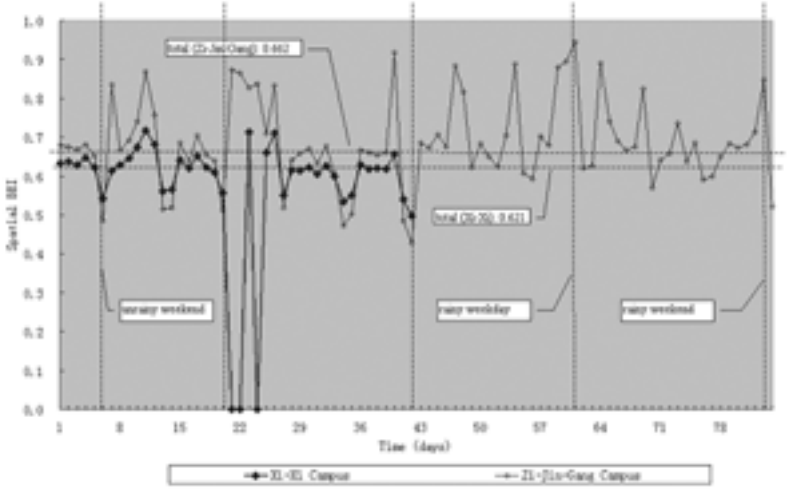

Fig. 7.3.3. (b) Total spatial dynamics throughout a 12-week (6-week) period; the daily BEI is measured as hourly accumulative number of people in campus open space.

As mentioned above in the temporal section, the results of a spatial behavioral entropy index (Fig. 7.3.3. (b)) revealed that:

(i) Contrasted with the few population and the low temporal BEIs in rainy days, the spatial BEIs rises. The contrastive results imply that spatial behavioral complexity could not be simply examined by population. In other words, *more population does not absolutely bring out more complexity.*

(ii) The *weather conditions* still seriously influence the complexity of spatial behavior, because rain cuts down the opportunity for some given open spaces, e.g. the sports space. As a result, the complexity of location decision increases. It is also confirmed by the BEIs of unrainy weekends that are very low as the class is off, the sports and leisure decision increases. The choice of place becomes simple.

Note:

$$BEI = \frac{-\sum_{j=1}^{n} p_j \log_2(p_j)}{\log_2(n)} \qquad \text{[Equation 7.3.2]}$$

where *BEI* is the Behavioral Entropy Index,

p_j is the relative frequency (probability) of the j^{th} behavioral option.

n is the number of behavioral options.

Division by $log_2(n)$ serves to normalize the measure into 0-1.

Daily Spatial BEI = $f(x_i)$,

where x_i = hourly accumulative population in the sub-section, on that day, i = A1, A2, …, C6.

Total Spatial BEI = $f(x_i)$,

where x_i = hourly accumulative population throughout the 12 weeks (or 6 weeks), i = A1, A2, …, C6.

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7.3.4. Results of Categorial Behavioral Dynamics Index

Similarly, the population of the students who present in the campus could be examined and compared at a categorial level (dimension) as Fig. 7.3.4 (a). From the categorial dynamics, the *category of activity* influences the population changes with a serious extent, since the population in open space would converge at *sports* and *talking*, while holding a party or assembly seems not to take an important place among daily life.

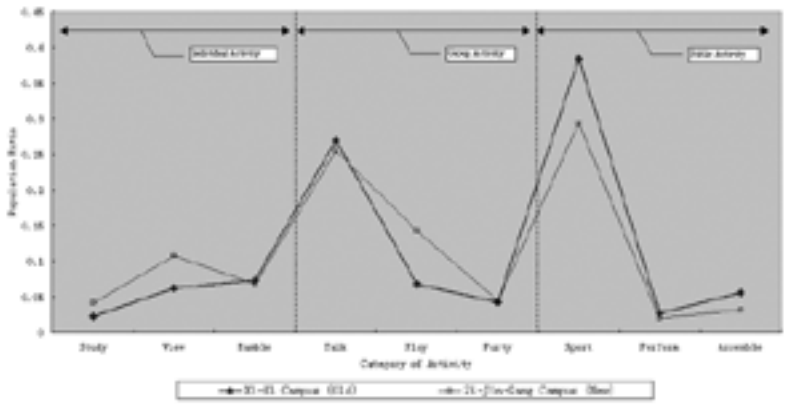

Fig. 7.3.4. (a) Categorial population dynamics within a 12-week (6-week) period, measured as accumulative number of people in each section of campus open space.

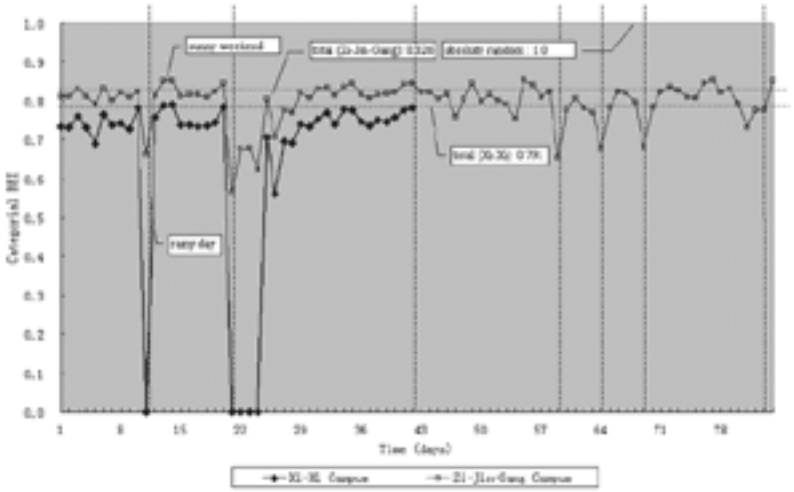

Fig. 7.3.4. (b) Total categorial dynamics within a 12-week (6-week) period; the daily BEI is measured as hourly accumulative number of people in campus open spaces.

As mentioned above in the previous sections, the results of a categorial behavioral entropy index (Fig. 7.3.4.(b)) revealed that:

(i) Contrasted with the similarly equivalent temporal BEIs in unrainy days whether weekdays or weekends, the categorial BEIs of sunny weekends rise. The contrastive results imply that categorical behavioral complexity is subject to some compulsory schedule. For example, students must spend more time in study on weekdays so that other activities are cut down.

(ii) The *weather conditions* still seriously influence the categorial behavioral complexity, because rain cuts down the opportunity for some given activity, e.g. parties, performance or assembles. As a result, the complexity of activity decision increases. It is also confirmed by the BEIs of unrainy weekends that are very high as almost all activities could be held so that the choice of activity content becomes diverse.

Note:

$$BEI = \frac{-\sum_{j=1}^{n} p_j \log_2(p_j)}{\log_2(n)} \qquad \text{[Equation 7.3.2]}$$

where *BEI* is the Behavioral Entropy Index,

p_j is the relative frequency (probability) of the j^{th} behavioral option.

n is the number of behavioral options.

Division by $log_2(n)$ serves to normalize the measure into 0-1.

Daily Categorial BEI = f (x_i), where x_i = hourly accumulative population of the activity category, on the day, i = Study, View, Ramble, Talk, Play, Party, Sports, Perform, Assembly.

Total Categorial BEI = f (x_i), where x_i = hourly accumulative population during the 12 weeks (or 6 weeks), i = Study, View, Ramble, Talk, Play, Party, Sports, Perform, Assembly.

Categorial BEI of Absolute Random = f (x_i), where x_i = 1/9, i = Study, View, Ramble, Talk, Play, Party, Sports, Perform, Assembly..

7.4. Analysis of Interaction between Behavioral Dynamics Indices

7.4.1. Analysis of Temporal-Spatial Behavioral Dynamics Indices

(i) Temporal-Spatial

The relation between time and space was checked with a temporal-spatial behavioral index (Fig.7.4.1.(a)). The behavioral complexity reaches the peaks *at 14:00 and 19:00, when the activities are distributed in all the campus sections as a relatively even balance*. But they are seriously uneven in the early morning and the suppertime.

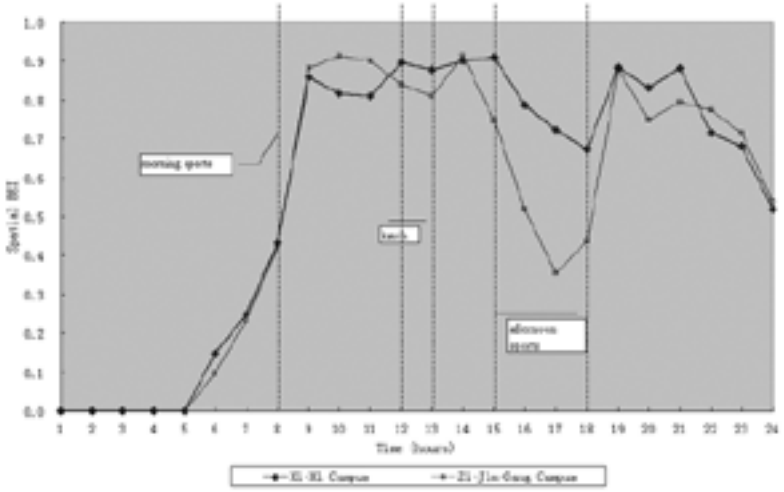

Fig. 7.4.1. (a) Temporal-spatial dynamics at a 24-hour scale; the BEI is measured as hourly accumulative number of people presence in campus open space.

(ii) Spatial - Temporal

The relation between time and space was also checked with a spatial-temporal behavioral index (Fig.7.4.1.(b)). The behavioral complexity at the temporal dimension reaches the peaks *at the Dorm Areas and followed by the Teaching Areas*. But they are seriously uneven in the sports areas.

The results imply the positive impacts of distance to dorm, facilities (light and bench), waterscape, small plot and semi-open space on the spatial-temporal BEI. It is an implication that more provision of these physical factors should increase the behavioral complexity and consequently improve the utilization efficiency of open space at the temporal dimension.

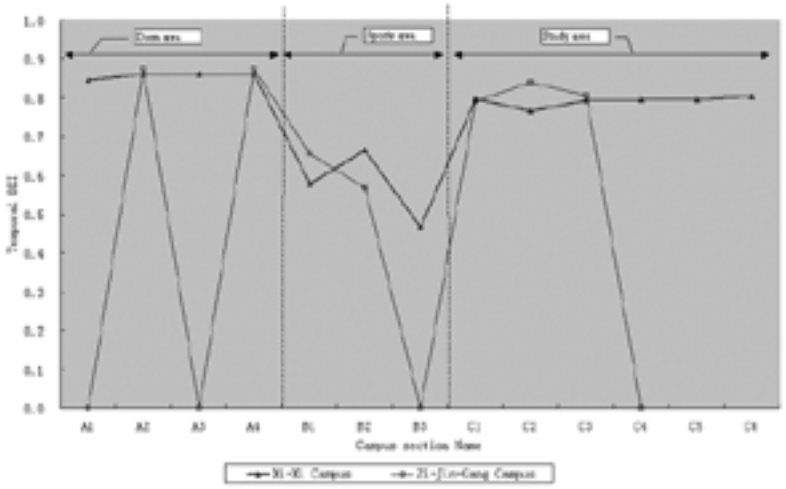

Fig. 7.4.1. (b) Spatial-temporal dynamics at an 11-section (13-section) scale; the BEI is measured as hourly accumulative number of people presence in campus open spaces.

7.4.2. Analysis of Temporal – Categorial Behavioral Dynamics Indices

(i) Temporal – Categorial

The relation between time and category was checked with a temporal-categorial behavioral index (Fig.7.4.2.(a) &(b)). The behavioral complexity reaches the peaks *at 14:00 and 19:00, when the category of activities is diverse as a relatively even balance*. But they are seriously uneven in the early morning, the dinner time and after 20:00.

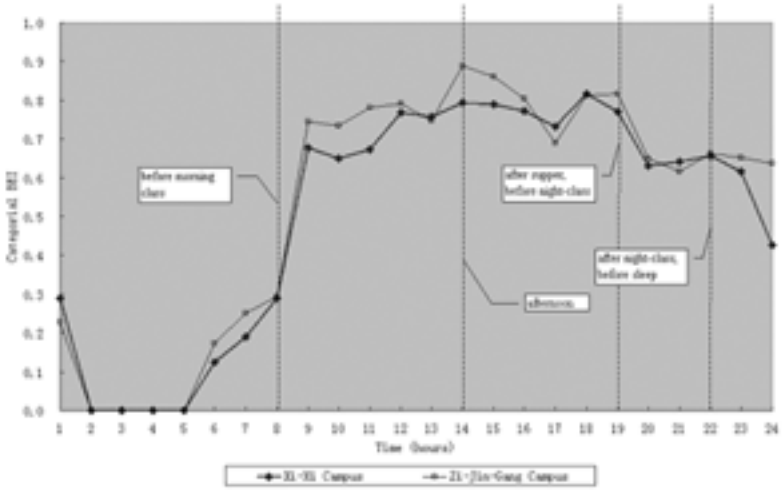

Fig. 7.4.2. (a) Temporal-categorial dynamics at a 24-hour scale; the daily BEI is measured as hourly accumulative number of people presence in campus open spaces.

(ii) Categorial - Temporal

The Categorial - Temporal index shows that there are two categories of activities are taken extensively in a whole day, i.e. individual rambling and group talking. On the contrary, public activities are taken place only during fewer timing.

Moreover, there is an obvious difference between the two campuses. The viewing activity of Zi-Jin-Gang Campus (the new campus) is taken much more extensive than Xi-Xi Campus (the old campus) at the temporal dimension. That confirms that the landscape in Zi-Jin-Gang Campus is more beautiful and extensively distributed than Xi-Xi Campus.

Hence, designers should improve the old campus with more landscape elements not only for the teaching areas but also for the dormitory areas or the sports areas.

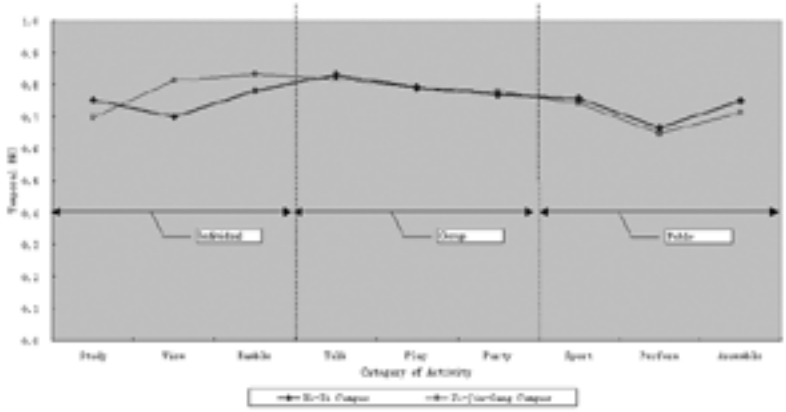

Fig. 7.4.2. (b) Categorial-Temporal dynamics at a 9-category scale; the daily BEI is measured as hourly accumulative number of people presence in campus open spaces.

7.4.3. Analysis of Spatial – Categorial Behavioral Dynamics Indices

(i) Spatial – Categorial

The relation between time and category was checked with a temporal-categorial behavioral index (Fig.7.4.3.(a) &(b)). The behavioral complexity reaches the peaks *at C1, C2 and C3, espetially C2, the central study area of Zi-Jin-Gang Campus*, where diverse activities are taken place. But fewer category is held at B1 (the sports field), and none at the three under-construction sections of Zi-Jin-Gang Campus (A1, A3, D1 (C4)).

The results imply the positive impacts of facilities (light and bench), waterscape, small plot and semi-open space on the spatial-categorial BEI. It is an implication that more provision of these physical factors should increase the behavioral complexity and consequently improve the utilization efficiency of open space.

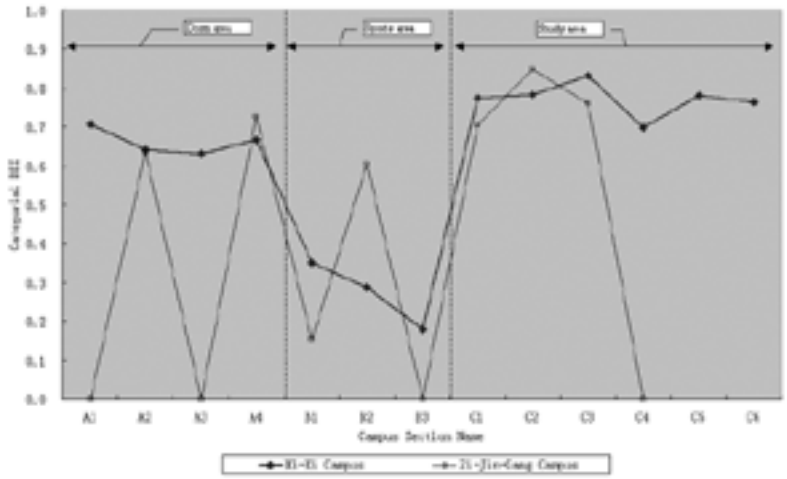

Fig. 7.4.3. (a) Spatial-categorial dynamics within an 11-section (13-section) scale; the daily BEI is measured as hourly accumulative number of people presence in campus open spaces.

(ii) Categorial - Spatial

The Categorial - Temporal index (**Fig. 7.4.3. (b)**) shows that there are two categories of activities are taken extensively on campus, i.e. individual rambling and group talking. On the contrary, sports is taken place only in one or two locations. The results mean that some activities are diversely distributed around the campus sections, while others converge into a few specific sections.

Some useful information may be extracted from the above results that:

(i) For individual rambling and group talking, designers should consider to provide more physical conditions at most locations.

(ii) If possible, designers may complement some small-scale sports fields inside the dorm areas and the teaching areas. That constitute to students' sports activity on the spot.

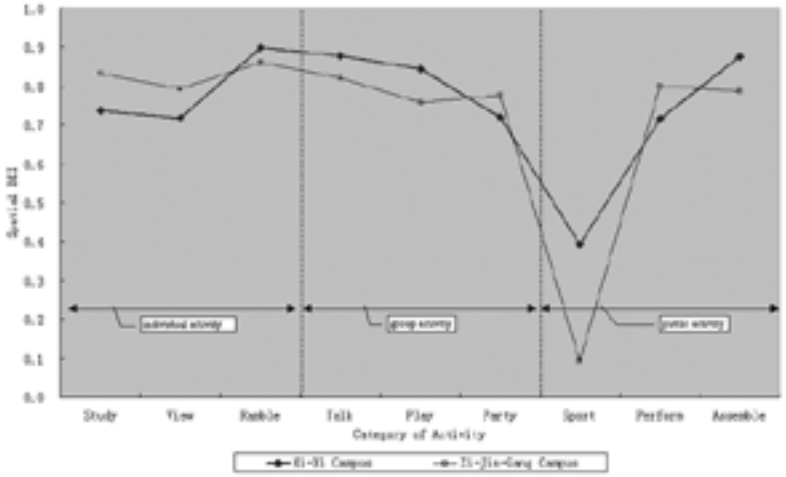

Fig. 7.4.3. (b) Categorial-Spatial dynamics at a 9-category scale; the daily BEI is measured as hourly accumulative number of people presence in campus open spaces.

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CHAPTER 8:

SPATIAL INFLUENCE ON EVALUATION & BEHAVIOR

8.1. STRUCTURE OF SPATIAL FACTORS

8.1.1. Structure of Spatial Factors

In order to examine the relation between spatial characteristics and subjective evaluation, the index system of spatial factors should be structured in accordance with the subjective index system. With a correlation analysis of satisfaction scores and possible objective data, the spatial factors were selected as Table 8.1.1.(a).

Table 8.1.1.(a) Structure of spatial index system

Satisfaction		*Spatial Factors*		
		Related Spatial Index	***Definition***	**Formula**
Applicability	***Facility***	**Light Index**	No. of lights per 100 square meters (No./ha.).	$Light = \frac{No.}{OpenArea} \times 100$
		Bench Index	No. of benches per 100 square meters (No./ha.).	$Bench = \frac{No.}{OpenArea} \times 100$
		Instrument Index	No. of Instruments per 100 square meters (No./ha.).	$Instrument = \frac{No.}{OpenArea} \times 100$
		Semi-open Index	Ratio of semi-open area to total open space area	$SemiOpen = \frac{SemiOpenArea}{OpenArea}$
	Accessibility	**Neighborhood Park Accessibility Index**	Reciprocal of average distance between house and park (/km).	$ParkAccess = \frac{1}{Distance}$
		Small Playing Plot Accessibility Index	Reciprocal of average distance between house and plot (/m).	$PlotAccess = \frac{1}{Distance}$
		Sports Field Accessibility Index	Reciprocal of average distance between dorm and sports field (/km).	$SportsAccess = \frac{1}{Distance}$
	Parking	**Car parking Index**	Ratio of car parking spaces to total land area	$CarParking = \frac{CarSpace}{TotalArea}$
		Bike parking Index	Ratio of bike parking spaces to total land area	$BikeParking = \frac{BikeSpace}{TotalArea}$
Amenity	***Landscape***	***Green Index***	Ratio of green area to total open space area	$Green = \frac{GreenArea}{OpenArea}$
		Water Index	Ratio of water area to total open space area	$Water = \frac{WaterArea}{OpenArea}$
		Display Index	No. of display items (show window) per 100 square meters (No./ha.).	$Display = \frac{No.}{OpenArea} \times 100$
	Building appearance	***Unavailable now***	Concerned with aesthetical consideration	
	Openness	**Openness Index**	Ratio of open space area to total land	$Openness = \frac{OpenArea}{}$

Table 8.1.1.(a)(continued) Structure of spatial index system

Subjective aspect		*Spatial aspect*		
		Related Spatial Index	**Definition**	**Formula**
Health	**Air Freshness**	**Road Index**	Ratio of main road (bi-way) area to total land area	$Road = \frac{RoadArea}{TotalArea}$
		Openness Index	Ratio of open space area to total land area	$Openness = \frac{OpenArea}{TotalArea}$
	Waste Disposal	**Unavailable now**	Concerned with community management	
	Water Cleanness	**Unavailable now**	Concerned with community management or natural conditions	
	Noise Control	***Road Index***	Ratio of main road (bi-way) area to total land area	$Road = \frac{RoadArea}{TotalArea}$
Safety	***Traffic Safety***	**Road Index**	Ratio of main road (bi-way) area to total land area	$Road = \frac{RoadArea}{TotalArea}$
	Crime Prevent	**Light Index**	Reciprocal of average distance between lights (No./m).	$Light = \frac{1}{Distance}$
		Blind Index	Ratio of dead angle area to total open area	$Blind = \frac{BlindArea}{OpenArea}$
	Fireproof	**Water Index**	Ratio of water area to total open space area	$Water = \frac{WaterArea}{OpenArea}$
		Fire Engine Index	Cover rate of fire engine accessible area to total open area	$FireEngine = \frac{EngineAccessArea}{OpenArea}$
Community	**Neighbor Tie**	***Semi-open Index***	Ratio of semi-open area to total open space area	$SemiOpen = \frac{SemiOpenArea}{OpenArea}$
		Shop Index	No. of shops per 100 square meters (No./ha.).	$Shop = \frac{No.}{OpenArea} \times 100$
		Small Playing Plot Accessibility Index	Reciprocal of average distance between house and plot (/m).	$PlotAccess = \frac{1}{Distance}$
	Cultural Affairs	***Plaza Index***	Ratio of plaza (square) to total open area	$Plaza = \frac{PlazaArea}{OpenArea}$

Based on the above corresponding connection, some influential spatial factors were classified according to two stages of spatial planning and design (Table 8.1.1.(b)).

Firstly, *Layout Plan* mainly refers to (1) the allocation of buildings and the road structure, (2) the ratio of open spaces, green areas and water areas, and (3) the abundance of parking.

Secondly, *Detail Design* mainly refers to (1) the equipment of facilities, (2) the provision of social communication places, and (3) the natural surveillance.

Table 8.1.1.(b) Structure of spatial index system

Design Stage	*Involved Spatial Factors*	*Unit*
1. Layout Plan	**1.1. Neighborhood Park Accessibility Index**	**1/km**
	1.2. Small Playing Plot Accessibility Index	**1/m**
	1.3. Sports Field Accessibility Index	**1/km**
	1.4. Green Index	**(ratio)**
	1.5. Water Index	**(ratio)**
	1.6. Road Index (Bi-way motor vehicle)	**(ratio)**
	1.7. Openness Index	**(ratio)**
	1.8. Car parking Index	**(ratio)**
	1.9. Bike parking Index	**(ratio)**
	1.10. Fire Engine Index	**(ratio)**
2. Detail Design	**2.1. Bench Index**	**No./100M^2**
	2.2. Light Index	**No./100M^2**
	2.3. Instrument Index	**No./100M^2**
	2.4. Display Index	**No./100M^2**
	2.5. Shop Index	**No./100M^2**
	2.6. Semi-open Index	**(ratio)**
	2.7. Plaza Index	***(ratio)***

Explanation (Why this index system excludes other items)

Besides the mentioned items above, the external environments surrounding the community, e.g. the distance to a factory or to a city road, also influence on the internal open space quality.

In addition to the quantitative consideration of spatial factors, there are still some potential qualitative factors, that is to say, aesthetical judgment on the style of building appearance, detail decoration, and so on.

Moreover, the management and maintenance of the community environment also change the usage and quality of open space, e.g. traffic control, cleaning frequency, and so on.

In this study, those external factors, qualitatively aesthetical involvements, and management factors are not concerned with the research focus.

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8.2. SPATIAL INFLUENCE ON SATISFACTION

8.2.1. Spatial Influence on Satisfaction of Common Case

With a comparison of *Spatial Indices* and *Satisfaction Indices* within the six communities (Table 8.2.1. (a)), a conclusion could be drawn that the satisfaction is significantly correlated to the spatial properties of residential open space. In other words, the relatively new built communities are generally evaluated higher than the old ones. The last community, Xia-Sha Community, should be noted since it is evaluated unexpectedly low although the spatial qualities are not worse. It confirmed the previous hypothesis that the open space is also influenced by some external conditions, instead of spatial characteristics. The community of Xia-Sha is located far from urban area, almost more that one-hour drive distance so that people have no abundant leisure time to enjoy open space, which decreases the attractiveness and neighborhood communication. Moreover, many factories are located in the surrounding area. As a result, health of open space is deteriorated on the air, noise and so on.

Table 8.2.1. (a) Comparison of Spatial factors and satisfaction of Common Case

		Name of Community					
		Q-H-F	**Qiu-Shi**	**Cai-He**	***Cui-Yuan***	***Wen-Xin***	***Xia-Sha***
Spatial Index	**1.1. Park Accessibility**	0.00	0.00	6.06	7.13	7.65	7.01
	1.2. Small Plot Accessibility	0.11	0.01	0.05	0.06	0.05	0.02
	1.3. Sports Accessibility	0.00	0.00	3.14	4.87	9.23	8.35
	1.4. Green	0.09	0.21	0.29	0.32	0.39	0.35
	1.5. Water	0.01	0.00	0.02	0.03	0.04	0.03
	1.6. Road	0.02	0.08	0.05	0.04	0.04	0.05
	1.7. Openness	0.28	0.55	0.62	0.65	0.75	0.68
	1.8. Car parking	0.01	0.00	0.11	0.14	0.35	0.23
	1.9. Bike parking	0.01	0.06	0.08	0.10	0.26	0.21
	1.10. Fire Engine	0.46	0.84	0.91	0.93	1.00	1.00
	2.1. Bench	0.07	0.01	0.12	0.13	0.15	0.11
	2.2. Light	0.31	0.25	0.26	0.28	0.35	0.30
	2.3. Instrument	0.00	0.01	0.04	0.05	0.06	0.03
	2.4. Display	0.08	0.01	0.03	0.04	0.10	0.06
	2.5. Shop	0.09	0.04	0.06	0.07	0.05	0.01
	2.6. Semi-open	0.12	0.01	0.05	0.06	0.03	0.01
	2.7. Plaza	0.09	0.02	0.05	0.06	0.05	0.02
	2.8. Blind	0.04	0.01	0.02	0.01	0.00	0.00
tisfaction dex	***Applicability***	0.19	0.17	0.67	0.71	0.85	0.53
	Amenity	0.54	0.05	0.39	0.64	0.78	0.45
	Health	0.26	0.42	0.36	0.45	0.82	0.20
	Safety	0.16	0.60	0.58	0.64	0.67	0.33
	Community	0.87	0.52	0.68	0.81	0.59	0.09

With a correlation analysis of *Spatial Indices* and *Satisfaction Indices* within the six groups (Table 8.2.1.(b)), it shows that the satisfaction is significantly correlated to the spatial properties of residential open space.

Applicability is influenced by the accessibility of the neighborhood (community) park, the ratio of green area and water area, the number of benches and instruments, and the parking of cars.

Amenity is influenced by the accessibility of small plots for residents' activities, the ratio of green area and water area, the number of benches and display devices, and the parking of cars.

Health is influenced by the accessibility of the sports places, the abundance of green area and open area, the number of instruments, and the parking of cars.

Safety is influenced by the ratio of open area, the cover rate of fire engine, and the natural surveillance (reduction of blind area).

Community is influenced by the accessibility of small plots for residents' activities and the abundance of semi-open places and plazas, and the shops are important for the attractiveness.

Total Satisfaction is influenced by the accessibility of parks and sports, the abundance of water area, car parking and the number of benches and instruments.

Table 8.2.1. (b) Correlation of Spatial factors and Satisfaction of Common Case

Spatial Index	***Satisfaction Index***					
	Applicability	**Amenity**	**Health**	***Safety***	***Community***	***Total***
1.1. Park Accessibility	.947(**)	.755	.592	.669	-.024	.970(**)
1.2. Small Plot Accessibility	-.084	.241	-.376	-.796	.892(*)	.082
1.3. Sports Accessibility	.804	.823(*)	.845(*)	.614	-.195	.925(*)
1.4. Green	.865(*)	.636	.782	.889(*)	-.419	.840
1.5. Water	.909(*)	.925(**)	.668	.467	.086	.975(**)
1.6. Road	-.209	-.566	.120	.582	-.808	-.375
1.7. Openness	.798	.504	.762	.957(*)	-.556	.724
1.8. Car parking	.834(*)	.896(*)	.895(*)	.558	-.241	.890(*)
1.9. Bike parking	.703	.753	.962(**)	.655	-.456	.769
1.10. Fire Engine	.722	.377	.682	.985(**)	-.592	.642
2.1. Bench	.930(**)	.904(*)	.509	.340	.254	.979(**)
2.2. Light	.405	.845(*)	.593	-.129	.147	.528
2.3. Instrument	.981(**)	.757	.702	.764	-.181	.944(*)
2.4. Display	.336	.813(*)	.472	-.319	-.284	.387
2.5. Shop	-.124	.000	-.600	-.793	.973(**)	-.030
2.6. Semi-open	-.342	.095	-.425	-.923(*)	.925(*)	-.183
2.7. Plaza	-.452	.045	-.389	-.949(*)	.913(*)	-.290
2.8. Blind	-.608	-.346	-.756	-.943(*)	.696	-.498

* Correlation is significant at the 0.05 level (2-tailed).

With a Principal Component Analysis as Table 8.2.1.(c) & (d), the above 18 spatial factors were classified into three principal factors. According to the influence on people's activity, the first and second factors may be defined as the *Landscape + Usage Factor* and the *Communication Factor.*

The first factor mainly comprises the spatial ratio of green, water and openness, the distance to the neighborhood park and the sports area, the facility and parking. All of them are related to the landscape and personal usage of the open space. The second factor mainly comprises the spatial ratio of plaza and semi-open space, the distance to the small plot, and the ratio of main bi-way road and blind area. They are related to the neighborhood communication.

Table 8.2.1.(c) Rotated Component Matrix

	Component		
	1	2	3
Principal Factor 1: Landscape and Usage			
1.1. Park Accessibility	.998	-.014	.059
2.3. Instrument	.973	-.176	.147
2.1. Bench	.913	.323	.226
1.5. Water	.905	.136	.399
1.4. Green	.895	-.421	.149
1.3. Sports Accessibility	.858	-.130	.497
1.7. Openness	.814	-.576	.070
1.8. Car parking	.790	-.141	.593
1.10. Fire Engine	.769	-.636	-.061
1.9. Bike parking	.689	-.368	.624
Principal Factor 2: Communication			
2.5. Shop	-.138	.983	-.039
2.7. Plaza	-.027	.979	.197
1.2.Small Plot Accessibility	-.097	.970	.221
2.6. Semi-open	-.246	.969	.033
1.6. Road	-.185	-.918	-.349
2.8. Blind	-.591	.754	-.190
Principal Factor 3:			
2.2. Light	.282	.299	.911
2.4. Display	.215	.455	.863

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 8.2.1.(d) Total Variance Explained

Principal Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1. **Landscape and Usage**	8.082	44.899	44.899
2. **Communication**	6.754	37.520	82.419
3. **Information**	3.077	17.096	99.515

Extraction Method: Principal Component Analysis.

With a regression analysis of *Spatial Indices* and *Satisfaction Indices* within the six groups (Table 8.2.1.(e)), the corresponding equations were built up for the further examination concerning the spatial influence on people's satisfaction.

Applicability is influenced by the Principal Factor 1 (Landscape + Usage Spatial Factor).

Amenity is also influenced by the Principal Factor 1.

Community is influenced by the Principal Factor 2 (Communication Spatial Factor).

Total Satisfaction is influenced by the Principal Factor 1.

Table 8.2.1.(e) Relative Equation between Satisfaction Index and Spatial Index (Common Case)

Satisfaction Index	***Spatial Index***			
	Spatial Index Name	**Regression Equation**	**R^2**	**Sig. (T-Test)**
Applicability	Principal Factor 1	$Y=0.279X_1+0.521$	0.975	0.000 0.000
Amenity	Principal Factor 1	$Y=0.216X_1+0.443$	0.733	0.030 0.002
Health	None of Principal Factors is influential.			
Safety	None of Principal Factors is influential.			
Community	Principal Factor 2	$Y=0.227X_2+0.593$	0.661	0.049 0.001
Total	Principal Factor 1	$Y=0.188X_1+0.488$	0.757	0.024 0.001

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8.2.2. Spatial Influence on Satisfaction of Campus Case

With a comparison of *Spatial Indices* and *Satisfaction Indices* within the four campuses (Table 8.2.2. (a)), a conclusion could be drawn that the satisfaction is significantly correlated to the spatial properties of campus open space. In other words, the relatively new built campuses are generally evaluated higher than the old ones.

For example, Zi-Jin-Gang Campus has the relatively high ratio of green, water and openness, and the more facilities of benches, lights and instruments, so that the satisfaction is consequently higher than other campuses. In contrast, Yu-Quan Campus has the relatively low ratio of green, water and openness, and the more facilities, so that the satisfaction is consequently the lowest among the four campuses.

Table 8.2.2. (a) Comparison of Spatial factors and satisfaction of Campus Case

		Name of Campus			
		ZJU-YQ	**ZJU-XX**	**ZJGSU**	***ZJU-ZJG***
Spatial Index	**1.1. Park Accessibility**	1.61	2.15	1.27	1.08
	1.2. Small Plot Accessibility	0.01	0.02	0.05	0.06
	1.3. Sports Accessibility	3.09	5.23	0.96	2.51
	1.4. Green	0.32	0.27	0.42	0.55
	1.5. Water	0.02	0.01	0.03	0.08
	1.6. Road	0.12	0.06	0.10	0.09
	1.7. Openness	0.78	0.75	0.84	0.89
	1.8. Car parking	0.06	0.03	0.12	0.10
	1.9. Bike parking	0.03	0.03	0.05	0.06
	1.10. Fire Engine	0.93	0.95	0.96	0.98
	2.1. Bench	0.04	0.04	0.06	0.07
	2.2. Light	0.30	0.35	0.42	0.45
	2.3. Instrument	0.02	0.02	0.03	0.03
	2.4. Display	0.03	0.03	0.06	0.05
	2.5. Shop	0.04	0.06	0.01	0.02
	2.6. Semi-open	0.01	0.02	0.03	0.06
	2.7. Plaza	0.03	0.02	0.04	0.04
	2.8. Blind	0.08	0.05	0.05	0.14
atisfaction Index	***Applicability***	0.28	0.37	0.53	0.72
	Amenity	0.19	0.22	0.74	0.92
	Health	0.34	0.58	0.76	0.83
	Safety	0.35	0.41	0.49	0.62

With a correlation analysis of *Spatial Indices* and *Satisfaction Indices* within the six groups (Table 8.2.2.(b)), it shows that the satisfaction is significantly correlated to the spatial properties of campus open space.

Applicability is influenced by the accessibility of small plots, the ratio of green area, water area and semi-open space, the number of benches and lights, and bike parking.

Amenity is influenced by the accessibility of small plots for residents' activities, the ratio of openness, the number of benches and lights, and the parking of bikes.

Health is influenced by the accessibility of the sports places, the abundance of green area and open area, the number of instruments, and the parking of bikes.

Safety is influenced by the accessibility of small plots, the ratio of green area, water area and semi-open space, the number of benches and lights, and bike parking.

Community is influenced by the accessibility of small plots for residents' activities and the abundance of semi-open places and plazas.

Total Satisfaction is influenced by the accessibility of small plots for residents' activities, the abundance of semi-open space, the number of benches, lights and bike parking.

Table 8.2.2. (b) Correlation of Spatial factors and Satisfaction of Campus Case

Spatial Index	***Satisfaction Index***					
	Applicability	**Amenity**	**Health**	***Safety***	***Community***	***Total***
1.1. Park Accessibility	-.754	-.867	-.578	-.727	-.467	-.801
1.2. Small Plot Accessibility	.971(*)	.990(**)	.957(*)	.954(*)	.986(*)	.999(**)
1.3. Sports Accessibility	-.472	-.688	-.432	-.419	-.209	-.619
1.4. Green	.936	.950	.963(*)	.929	.742	.921
1.5. Water	.904	.854	.684	.914	.731	.832
1.6. Road	-.148	.048	-.358	-.180	-.499	-.070
1.7. Openness	.922	.964(*)	.772	.908	.716	.931
1.8. Car parking	.695	.861	.661	.650	.473	.813
1.9. Bike parking	.971(*)	.997(**)	.887	.957(*)	.831	.986(*)
1.10. Fire Engine	.977(*)	.906	.767	.981(*)	.893	.944
2.1. Bench	.971(*)	.997(**)	.887	.957(*)	.831	.986(*)
2.2. Light	.969(*)	.963(*)	.987(*)	.956(*)	.941	.988(*)
2.3. Instrument	.980(*)	.902	.810	.876	.709	.949
2.4. Display	.753	.888	.815	.709	.635	.876
2.5. Shop	-.673	-.844	-.617	-.628	-.430	-.788
2.6. Semi-open	.982(*)	.905	.868	.991(**)	.966(*)	.969(*)
2.7. Plaza	.729	.872	.609	.693	.460	.810
2.8. Blind	.658	.563	.345	.687	.467	.527

8.3. SPATIAL INFLUENCE ON BEHAVIOR

This section is to analyze the relation between spatial characteristics and people's behavior. Zi-Gin-Gang Campus and Xi-Xi Campus are selected as the sample. The former is of a fashionable style, located in the suburban area of Hangzhou City, and the latter is ordinary, in the urban area. In addition, their age and the historical background are different.

8.3.1. Comparison of Spatial Characteristics and BEI

With a comparison of *Spatial Indices* and *Satisfaction Indices* within the campus sections (Table 8.3.1. (a) & (b)), a conclusion could be drawn that the behavior is significantly correlated to the spatial properties of campus open space.

Table 8.3.1. (a) Comparison of Spatial factors and Behavioral Indices of Zi-Jin-Gang Campus

Spatial Index	***Name of Section***							
	A2	**A4**	**B1**	***B2***	***B3***	***C1***	***C2***	***C3***
1.1. Park Accessibility	1.20	1.33	2.59	3.05	7.62	8.01	42.34	20.67
1.2. Small Plot Accessibility	0.04	0.06	0.00	0.03	0.00	0.03	0.08	0.08
1.3. Sports Accessibility	5.11	2.58	100	3.26	1.68	1.21	1.69	1.12
1.4. Green	0.31	0.32	0.44	0.59	0.82	0.75	0.56	0.42
1.5. Water	0.02	0.07	0.02	0.12	0.01	0.03	0.24	0.15
1.6. Road	0.05	0.13	0.09	0.11	0.05	0.07	0.12	0.08
1.7. Openness	0.75	0.81	0.97	0.89	0.91	0.88	0.90	0.86
1.8. Car parking	0.01	0.05	0.00	0.02	0.02	0.01	0.04	0.03
1.9. Bike parking	0.08	0.11	0.01	0.01	0.01	0.02	0.15	0.12
1.10. Fire Engine	1.00	1.00	1.00	0.85	0.30	0.82	0.91	0.80
2.1. Bench	0.03	0.03	0.02	0.01	0.00	0.01	0.05	0.04
2.2. Light	0.40	0.45	0.27	0.43	0.05	0.57	0.78	0.35
2.3. Instrument	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
2.4. Display	0.05	0.07	0.05	0.02	0.00	0.01	0.09	0.08
2.5. Shop	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2.6. Semi-open	0.01	0.02	0.01	0.01	0.00	0.03	0.06	0.04
2.7. Plaza	0.01	0.02	0.00	0.01	0.00	0.00	0.05	0.05
2.8. Blind	0.01	0.00	0.00	0.12	0.38	0.25	0.00	0.16
Behavior Index								
Temporal BEI	0.873	0.873	0.657	0.568	0.000	0.792	0.840	0.806

For example, the C2 section of Zi-Jin-Gang Campus is covered by the enriched water area, equipped with more benches, lights and parking places. As a result, the temporal BEI, categorical BEI and the population ratio are all higher than the other sections. In contrast, the behavior in the B3 section is exiguous due to the lack of activity places and facilities.

Generally speaking, the BEIs of the B sections (sports fields) are much lower than the others. On the one hand, the behavior in sports fields is uneven on the temporal dimension, as the morning time before 8:00 and the evening time at about 17:00 are the most favorable timing for people going there, while there are no many people during the other periods. On the other hand, the behavior in sports fields is also uneven on the categorial dimension, as the activity of sports and assembly are the most favorable categories for people going there, while the other activities, e.g. reading, rambling, viewing and talking, do not happen frequently there.

In addition, the behavior in the C sections (teaching areas) is the most complex on the categorial dimension because of the more categories of activity happening there. The behavior in the A sections (dorm areas) is the most complex on the temporal dimension because of the more periods of activity lasting there.

Table 8.3.1. (b) Comparison of Spatial Factors and Behavioral Indices of Xi-Xi Campus

Spatial Index	***Name of Section***												
	A1	**A2**	**A3**	**A4**	**B1**	***B2***	***B3***	***C1***	***C2***	***C3***	***C4***	***C5***	***C6***
1.1. Park Access	1.65	3.23	3.26	3.07	1.69	3.08	4.11	5.29	6.94	4.96	18.34	100	18.25
1.2. Plot Access	0.00	0.03	0.04	0.05	0.00	0.01	0.01	0.05	0.05	0.10	0.07	0.10	0.10
1.3. Sports Access	2.56	6.17	6.10	3.41	3.36	4.98	5.05	5.18	10.21	6.82	3.36	4.19	5.01
1.4. Green	0.19	0.29	0.24	0.21	0.53	0.59	0.31	0.33	0.28	0.39	0.55	0.85	0.45
1.5. Water	0.01	0.00	0.00	0.00	0.00	0.12	0.00	0.04	0.00	0.00	0.00	0.01	0.01
1.6. Road	0.01	0.08	0.12	0.05	0.00	0.00	0.05	0.06	0.15	0.12	0.05	0.12	0.20
1.7. Openness	0.61	0.65	0.71	0.75	1.00	1.00	0.85	0.78	0.82	0.76	0.79	1.00	0.77
1.8. Car parking	0.01	0.00	0.00	0.02	0.00	0.00	0.06	0.04	0.04	0.04	0.04	0.00	0.05
1.9. Bike parking	0.01	0.03	0.02	0.02	0.00	0.01	0.01	0.04	0.04	0.04	0.05	0.00	0.03
1.10. Fire Engine	0.86	1.00	1.00	0.94	1.00	1.00	0.81	0.93	1.00	1.00	1.00	1.00	1.00
2.1. Bench	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.02	0.04	0.03	0.02	0.01
2.2. Light	0.32	0.35	0.35	0.35	0.18	0.20	0.25	0.42	0.40	0.45	0.42	0.20	0.45
2.3. Instrument	0.00	0.00	0.01	0.01	0.05	0.07	0.03	0.00	0.01	0.00	0.00	0.00	0.00
2.4. Display	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.02	0.02	0.04	0.04	0.01	0.03
2.5. Shop	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.6. Semi-open	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.02	0.04	0.03	0.00	0.03
2.7. Plaza	0.00	0.00	0.02	0.03	0.00	0.00	0.01	0.03	0.05	0.08	0.06	0.02	0.03
2.8. Blind	0.09	0.00	0.00	0.80	0.00	0.07	0.07	0.12	0.00	0.00	0.11	0.00	0.00
Behavior Index													
Temporal BEI	0.845	0.861	0.861	0.860	0.578	0.665	0.466	0.797	0.766	0.794	0.796	0.795	0.803

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8.3.2. Correlation of Spatial Characteristics and BEI

With a correlation analysis of *Spatial Indices* and *Satisfaction Indices* within the six groups (Table 8.3.2.(a)), it shows that the satisfaction is significantly correlated to the spatial properties of campus open space.

Temporal BEI is influenced by the accessibility of small plots for students' activities, the ratio of semi-open space and plaza, and the number of facilities. On the contrary, in the open spaces without building cover, the excessive openness and greenness seems to break the balance of people stay there, although the number of people increases. For example, the sports fields are much uncovered than other districts so that many people take part in public sports activity, but the timing people choose is very few, only in the morning exercising or evening sports.

The categorial BEI is influenced by the accessibility of small plots, the ratio of semi-open spaces and plazas, and the number of benches and lights.

Population ratio is influenced by the ratio of water area and the number of facilities.

Table 8.3.2. (a) Correlation of Spatial Factors and Behavioral Indices of Campus Case

Spatial Index	***Behavioral Index***		
	Temporal BEI	***Categorial BEI***	***Population Ratio***
1.1. Park Access	.124	.307	.195
1.2. Plot Access	.505(*)	.759(**)	.105
1.3. Sports Access	-.060	-.396	.409
1.4. Green	-.488(*)	-.241	.155
1.5. Water	.089	.184	.598(**)
1.6. Road	.266	.477(*)	.012
1.7. Openness	-.449(*)	-.442(*)	.421
1.8. Car parking	-.004	.253	-.023
1.9. Bike parking	.384	.475(*)	.397
1.10. Fire Engine	.307	.296	.281
2.1. Bench	.359	.460(*)	.541(*)
2.2. Light	.601(**)	.707(**)	.314
2.3. Instrument	-.241	-.653(**)	.448(*)
2.4. Display	.303	.332	.486(*)
2.5. Shop	.402	.163	-.218
2.6. Semi-open	.397	.599(**)	.335
2.7. Plaza	.346	.606(**)	.128
2.8. Blind	-.208	-.135	-.125

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8.3.3. Regression of Spatial Characteristics and BEI

With Table 8.3.3., the corresponding equations were built up for the further examination concerning the spatial influence on people's behavior on campus.

Table 8.3.3. Relative Equation between BEI and Spatial Indices (Campus Case)

Subjective aspect	*Spatial aspect*			
	Spatial Index Name	**Regression Equation**	**R^2**	**Sig. (T-Test)**
Y: Temporal BEI	X_1: Plot Access Index	$Y=2.114X_1-0.473X_2+0.464X_3+0.678$	0.615	0.046
(TBEI)	X_2: Green Index			0.009
	X_3: Light Index			0.036
				0.000
Y: Categorial BEI	X_1: Plot Access Index	$Y=3.940X_1-0.631X_2+0.580X_3+0.736$	0.796	0.000
(CBEI)	X_2: Openness Index			0.023
	X_3: Light Index			0.014
				0.007
Y: Population Ratio	X_1: Water Index	$Y=0.592X_1+3.022X_2+2.660X_3-0.009$	0.674	0.042
(PR)	X_2: Bench Index			0.026
	X_3: Instrument Index			0.002

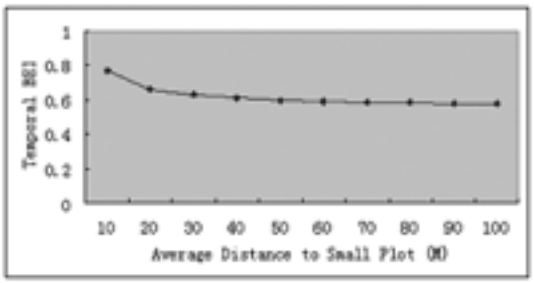

Fig. 8.3.3.(a) Plot Accessibility -TBEI relationship
(Simulation: green ratio 50%, light distance 20 m)

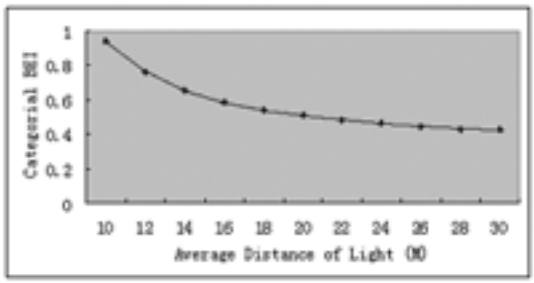

Fig. 8.3.3.(b) Light Distance -CBEI relationship
(Simulation: plot access 0.03, open ratio 80%)

Based on the regression equations, some estimations of BEIs are available with the simulation of certain conditions. For example, with the simulation of green ratio 50% and light distance 20 m, the temporal BEI will be decline from 0.769 to 0.579 as the accessibility of small plots decreases from 0.1 to 0.01 (Fig. 8.3.3(a), distance to small plots from 10 to 100 meters).

Similarly, with the simulation of open ratio 80% and the small plot distance 30 meters, the categorial BEI will be decline from 0.942 to 0.426 as the distance of lights increases from 10 to 30 meters (Fig. 8.3.3(b)).

From the regression equations in Table 8.3.3., the green and open ratios are negative to the temporal behavior index and the categorial behavior index respectively. For the campus case, the open or green ratio is very high, usually from 0.5 to 0.9. It means that the excessive greenness or openness reduces some options of activity so that behavior diversity will decline. If it increases toward 1, behavior diversity will decline (Fig. 8.3.3.(c)).

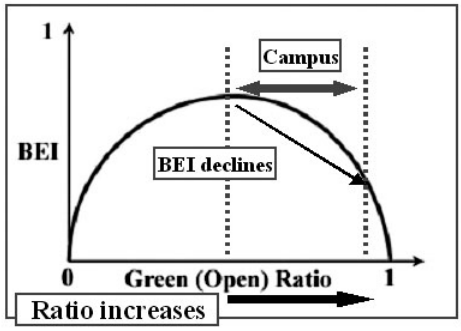

Fig. 8.3.3.(c) Green (Open) Ratio- BEI relationship

8.4. SUPPORTING INFORMATION FOR DESIGN AND PLANNING

Through the previous discussion from Section 8.1 to 8.3, it is confirmed that there are significant relations between spatial features and people's satisfaction and behavior. The 18 items of spatial index system (mentioned in Table 8.1.1.(a) & (b)) are mainly under the consideration of open space planning, and are also indirectly useful to designers. During a process of open space planning or design, it is an effective approach to improve the satisfaction degree and control users' behavior by changing the spatial characteristics that are influential. The following information can be regarded as an application in the common residential open space case.

8.4.1. Information for Planning

(i) Neighborhood Park Accessibility

The accessibility of the neighborhood park influences on the total satisfaction and applicability (Table 8.2.1. (b)). This result means that the average distance of the neighborhood parks to residences should be shortened by adjusting the spatial layout of community. In other words, a park that is located near the community center is better than the other that is located in the corner or along the sideline of the community.

Another important approach is concerned with the entrance placement. Planners may set up a few entrances that are evenly distributed at each orientation (direction) rather than only one entrance. This method can decrease the distance from residences to the park.

(ii) Small Playing Plot Accessibility

The accessibility of the neighborhood park influences on neighborhood communication (Table 8.2.1. (b)). This result means that the average distance of small plots to residences should be shortened by adjusting the spatial layout inside each building group. In other words, for each group, some small plots should be located along the main path that residents pass every day. When they meet with friends and neighbors on the way, these small plots can be used as stopping places for people's talking. If the small plots are not sufficient or located at inconvenient or inaccessible corners, the usage will be decreased so that the neighborhood communication becomes fewer.

(iii) Sports Field Accessibility

The accessibility of the sports fields influences on health and total satisfaction (Table 8.2.1. (b)). This result means that the average distance of the sports fields to residences should be shortened by adjusting the spatial layout inside each building group, and for the whole community. In other words, a main field that is located near the community center is needed, and some small fields or instruments should be set inside each building group. For example, a table-tennis field or a set of physical exercise instruments is suitable to be placed into the space between buildings.

(iv) Green Area Ratio

The ratio of green area to the total open space area influences on applicability and safety (Table 8.2.1. (b)). This result means that the green area ratio should increase by adjusting the spatial layout inside each building group, and for the whole community. In other words, abundant plantation is needed, such as roadside trees, lawn, and shrub. Even at paved plots, planting a few tall arbors is a good means to add more green space. Moreover, liana is also a useful choice to decorate building facades and roofs. This can enforce the impression of green image in open space.

(iv) Water Area Ratio

The ratio of water area to the total open space area influences on applicability, amenity and total satisfaction (Table 8.2.1. (b)). This result means that the water area ratio should increase by adjusting the spatial layout inside each building group, and for the whole community. In other words, some waterscapes or resources are needed, such as ponds, creeks, and spring fountains. Designers should make the best use of natural water systems, especially if there is a river passing the community. Moreover, a water network is better than an isolated water spot even though both areas are equal to each other, since the longer route of the water streamline can bring about more water-intimate spaces. This can sever more residents around the community.

(vi) Road Area Ratio (Bi-way motor vehicle)

Although the bi-way road area ratio does not significantly influence on satisfaction, it seems moderately influential on community in a way (Table 8.2.1. (b)). This result means that the road area ratio should increase by adjusting the spatial layout of the whole community. In other words, bi-way motor traffics should be excluded from the sub-community scale. Planners should organize the major roads at the outer area as much as possible. If it is necessary to permit cars into the central area, one-way road system is more suitable. Excessive motor traffics inside building groups will disturb pedestrian movements of residents who want to visit other sections for neighborhood communication.

(vii) Openness Area Ratio

The ratio of open area to the total area influences on safety (Table 8.2.1. (b)). This result means that the open area ratio should increase by adjusting the spatial layout inside each building group, and for the whole community. In other words, the density of buildings should decrease to a relatively lower degree so that sufficient open spaces are available. Excessively dense buildings increase uneasiness and tension of residents in open spaces.

(viii) Car Parking Area Ratio

The ratio of car parking area to the total area influences on applicability, amenity, health and total satisfaction (Table 8.2.1. (b)). This result means that the car parking area ratio should increase by adjusting the spatial layout inside each building group, and for the whole community. In other words, the car parking area should increase to a relatively high degree so that sufficient parking spaces are available. If there are no enough parking spaces for cars, drivers will possibly occupy roadside spaces and other open spaces that are provided for relaxation purpose.

(ix) Bike Parking Area Ratio

The ratio of bike parking area to the total area influences on health (Table 8.2.1. (b)). This result means that the bike parking area ratio should increase by adjusting the spatial layout inside each building group. In other words, the bike parking area should increase to a relatively high degree so that sufficient parking spaces are available. If there are no enough parking spaces for bikes, owners will possibly occupy roadside spaces and other open spaces that are provided for relaxation purpose.

(x) Fire Engine Cover Rate

The ratio of fire engine cover to the total open area influences on safety (Table 8.2.1. (b)). This result means that the fire engine cover rate should increase by adjusting the spatial layout inside each building group. In other words, planners should organize proper accesses and a road system so that fire engines can reach anywhere when a fire accident happens. If there is some space where fire engines are exclude from, residents will feel dangerous.

8.4.2. Information for Design

(i) Bench Number and Other consideration

The ratio of the number of benches to the total open area influences on applicability, amenity and total satisfaction (Table 8.2.1. (b)). This result means that the number of benches should increase by adjusting the spatial design for resting people. In other words, designers should provide more benches everywhere people possibly want to stop a while for viewing, talking or waiting. Of course, the material of benches is also worthy of consideration. For example, wooden benches are favorable for residents although they need more maintenance. In addition, the orientation and the cluster of benches are important. The benches facing landscape or pedestrians are usually favorable. The benches of face to face or in cycle can be used by a group of people who want to discuss together.

(ii) Light Number and Other consideration

The ratio of the number of lights to the total open area influences on amenity (Table 8.2.1. (b)). This result means that the number of lights should increase by adjusting the spatial design for people. In other words, designers should provide more lights everywhere people possibly pass or

stop a while for viewing, talking or waiting. Of course, the style of lights is also worthy of consideration. For example, tall lights are erected along the roadside, while low lights are placed near a bench, a bulletin board or a set of instruments. Some decoration lights are suitable to placed on a tree or embedded in the earth.

(iii) Instrument Number and Other consideration

The ratio of the number of instruments to the total open area influences on applicability and total satisfaction (Table 8.2.1. (b)). This result means that the number of instruments should increase by adjusting the spatial design for people. In other words, designers should provide more instruments not only at sports fields but also at other convenient places. Of course, the category of instruments is also worthy of consideration. Especially at small plots, more playing instruments are placed for children, such as a sand ground and a scrambling barrier.

(iv) Display Number and Other consideration

The ratio of the number of displays to the total open area influences on amenity (Table 8.2.1. (b)). This result means that the number of displays should increase by adjusting the spatial design for people. In other words, designers should provide more displays everywhere people possibly pass or stop a while for assembly. For example, a bulletin board is erected along the roadside or beside a plaza or a square, where residents can get information from the community management office or a hobby club. Moreover, some artistic expositions are placed as a visual focus around the open space.

(v) Shop Number and Other consideration

The ratio of the number of shops to the total open area influences on community (Table 8.2.1. (b)). This result means that the number of shops should increase by adjusting the spatial design for people. In other words, designers should provide more shops (or a vending booth) everywhere people possibly pass or stop a while for assembly. For example, a food booth and a paper booth is placed along the roadside or beside a plaza or a square, where residents can buy some food and drink and then enjoy them on a bench or lawn. Moreover, these small shops will provide more chances for neighbors' unplanned meeting so that the communication can be enriched.

(vi) Semi-open Area Ratio and Other consideration

The ratio of the area of semi-open space to the total open area influences on safety (negative) and community (positive) (Table 8.2.1. (b)). This result means that the area of semi-open space

should be considered properly and carefully by adjusting the spatial design for people. In other words, designers should provide some semi-open space closely connected to open space. For example, a porch of a building and a summerhouse can provide places for people even on a hot day or a rainy day. However, some semi-open spaces far from human sight possibly bring about uneasiness or unsafety.

(vii) Plaza Area Ratio and Other Consideration

The ratio of the area of plazas to the total open area influences on safety (negative) and community (positive) (Table 8.2.1. (b)). This result means that the area of semi-open space should be considered properly and carefully by adjusting the spatial design for people. In other words, designers should provide some plazas for assembly or public exercises. On the other hand, the plaza's influence on safety needs further examination. Sometimes these plazas are occupied by young ruffians' fight.

(viii) Blind Area Ratio and Other Consideration

The ratio of the area of blind area to the total open area influences on safety (negative) (Table 8.2.1. (b)). This result means that the area of dead angle should be decrease by adjusting the spatial design for people. In other words, designers should decrease the area out of sight. For example, a simple periphery of open space is better than a circuitous boundary. Excessive shrubs will obstruct natural surveillance. And a district enclosed by building facade without direct windows will also be regarded as a dangerous area.

The above explanation may be extended to the campus case based on Table 8.2.2.(b). However, the current samples of data are not enough to obtain integrated information concerning most of spatial indices. This work will be conducted in the future.

8.4.3. Further Work on Quantification of Spatial Influence

Although some quantifications of spatial influence on satisfaction and behavior have been conducted in Section 8.2 and 8.3, the degree of conviction is still needed to reinforce in further work. One point is to augment the number of the samples (respondents and survey spots). The other is to introduce more spatial indices that are possibly influential on people's evaluation and behavior.

In this case study, only several hundred respondents were invited and only ten areas were surveyed that are located in the same city. It is expected to contain more cities and more people

into the model, in order to examine the reliability and the precision of the model. Longer temporal span of residential zones is also expected to touch the changes of spatial features and people's consciousness.

In this case study, only eighteen spatial indices were considered. It is expected to contain more indices into the model, in order to discover more potential factors. For example, more architectural factors are possibly influential on open space, and they are also desired by designers. In addition, external environments have also some influence on people's choice and behavior, such as accessibility of a city park or public facilities, distance to the city center and natural conditions.

In sum, much effort should be performed to make the model more generalized and reliable.

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CHAPTER 9:

CONCLUSION AND RECOMMENDATION

9.1. CONCLUSIONS

As a basis for the methodological approach, the present study carried out an empirical study residential open spaces in Hangzhou city, China. This approach related subjective perception (evaluation and preference) and daily activity (behavior) to residential open space by using a qualitative and quantitative approach through the survey. The use of questionnaires for gathering information on the consumption of public space is to stimulate the residents' emotions. Based on this approach, the major concerns are *comparisons between different people in different spaces,* including users' satisfaction, preference, behavior, and attitude on their daily utilization. To stimulate public awareness of potential amenity benefit, the open space users as the main stakeholder to consume the service were asked for their opinion as an input for the establishment of a method to quantify the recreational benefit of open space users' evaluation and behavior through several determinants with a very high statistically significant results (*Satisfaction Index & Regression Coefficient, Preference Weight, and Behavioral Entropy Index).*

Generally speaking, this research has achieved the expected goal and objectives that were mentioned in Chapter 1, page 4.

This quantification framework can classify the diversity of residents' evaluation and behavior in residential open space.

This quantification framework can develop an evaluation system to quantify the performance of residential open space.

This quantification framework can identify the relationship between daily users' evaluation, behavior and preference to open space.

This quantification framework can provide the supporting information for environmental improvement.

With regard to the contribution of methodology, the research has set up a structure of

combination of evaluation, behavior and spatial features; and performed an application of Entropy Theory into open space behavior.

In detail, the investigation on different factors' effect on residents' preference and behavior could be concluded into three categories of analysis as follows.

9.1.1. Conclusions on Residents' Evaluation

With regard to open space users' evaluation: *Satisfaction Index and Preference Weight*, this study established the conventional methods to verify the consistency of residents' subjective perception to physical environments.

The results of satisfaction and preference evaluation revealed the following information:

(iv) the comprehensive satisfaction is significantly related to open space properties: *accessibility of park and sports, water area and facilities*.

(v) the comprehensive satisfaction is effectively influenced by *applicability, amenity, community* sequentially with both cases of the common residences and the campuses. Moreover, the applicability is evaluated as the more important aspect to influencing the satisfaction.

(vi) The *functional attribute* was evaluated as *the most powerful weight* within the three attributes that represent residents' preference of both the common case and the campus case.

9.1.2. Conclusions on Residents' behavior

With regard to open space users' behavior: *Behavioral Entropy Index*, this study established the unconventional methods to examine the complexity of residents' reaction to physical environments.

The results of behavior assessment revealed the following information:

(v) It is *insufficient* to examine the behavioral characteristics *only by simply population count*. The index of complexity constitutes to clarify the *relationship between the temporal, spatial and categorical dynamics*.

(vi) The *balance of the temporal, spatial and categorical probability* is significant to increase the efficiency of open space utilization; and *more options and opportunity* for outdoor life are important to increase the complexity of outdoor behavior.

(vii) The *weather conditions* hold the balance of outdoor behavior, which provides important information for designers that it is sound to *set up more semi-open spaces connected directly with open spaces*.

(viii) The *school schedule* also influences the balance of outdoor behavior, which provides important information for students' leaders and university organizers that it is considerable to *set up more activities not only during off days but also working days*.

9.1.3. Conclusions on Comparisons of Residents' evaluation and behavior

With regard to open space users' lifestyles: *Lifestyle Classification Model*, this study established the unconventional methods to extract the diversity (or variations) of residents' lifestyles in residential open space.

The results of lifestyle classification revealed the following information:

(iv) *There are existing differences* of preference, satisfaction, behavior and socio-demographic characteristics among the sample of respondents.

(v) Three principal components represent the main impact factors of residents' preference, labeled *(1) Ecology - Group activity, (2) Landscape, and (3) Individual - Public activity.* Four principal components represent the main impact factors of students' preference, labeled *(1) Landscape + Microclimate, (2) Ecology - Group activity, (3) Non-visual landscape, and (4) Individual activity.*

(vi) Eight types of lifestyles for the common case are described as *(1) Aged exercisers, (2) Chatterers, (3) Private nursers, (4) Chess-card fans, (5) hydro-intimates, (6) Youths and (7) Lovers and (7) Mid-aged strollers*. Six types of lifestyles for the campus case are described as *(1) Sportsmen, (2) Talkers, (3) Landscapists, (4) Scholars, (5) hydro-intimates, and (6) Lovers.*

9.1.4. Spatial Influence on Satisfaction and Behavior

Some information for environmental improvement is also acquired based on the correlation analysis of spatial influence on satisfaction and behavior.

(i) According to the influence on people's activity, the first and second factors of spatial featuers may be defined as the Landscape + Usage Factor and the Communication Factor.

(ii) Applicability is influenced by the Principal Factor 1 (Landscape + Usage Spatial Factor). Amenity is also influenced by the Principal Factor 1. Community is influenced

by the Principal Factor 2 (Communication Spatial Factor). Total Satisfaction is also influenced by the Principal Factor 1.

(iii) Temporal BEI is influenced by the accessibility of small plots for students' activities, the ratio of semi-open space and plaza, and the number of facilities. On the contrary, the excessive openness and greenness seems to break the balance of people stay there, although the number of people increases. The categorial BEI is influenced by the accessibility of small plots, the ratio of semi-open spaces and plazas, and the number of benches and lights. Population ratio is influenced by the ratio of water area and the number of facilities.

9.2. RECOMMENDATIONS

Due to the potential of several determinants development, not only behavior and preference of open space users can be examined but also the interaction of open space users' behavior and preference can lead to the very useful information in order to monitor the change effect to the dependent side. The specific recommendations from the useful findings are as follows:

(vi) The result of satisfaction evaluation shows that it is a suitable way to improve Applicability and Amenity of open space, in order to increase residents' satisfaction;

(vii) Correlation between satisfaction evaluation and physical factors shows that it is a suitable way to provide green space, attractive facility and good maintenance inside open spaces;

(viii) Spatial-Temporal BEI result shows that it is a suitable way to activate unused spaces and vacant land as more as possible, in order to improve the spatial balance for residents' utilization;

(ix) Spatial-Temporal BEI result also shows that it is a suitable way to provide more semi-open spaces connected directly with open spaces;

(x) Categorial-Temporal BEI result shows that it is a suitable way to organize special events during working days.

9.3. LIMITATION AND FURTHER STUDY

However, several extensions of the current study should be further explored alternative approaches to *quantify the interaction between the evaluation, behavior and physical factors*.

The research area was limited due to the incomprehensive samples of the behavioral survey that only touched two campuses. *There is still a need to reinforce the reliability and extension for the overall city*. The comparison between different residences and campus, even other specific open spaces should be taken into the model, in order to find more powerful information for planners and designers, as well as residents themselves.

The samples also need to be extended with a complement of more residential areas, not only Hangzhou City but also other local cities in China, since the country is so large that the natural conditions and social conditions are diverse in terms of the location. The fact brings out more diversity of residential open space lifestyles.

Until now, only eighteen spatial indices were considered. It is expected to contain more indices into the model, in order to discover more potential factors. For example, more architectural factors are possibly influential on open space, and they are also desired by designers. In addition, external environments have also some influence on people's choice and behavior, such as accessibility of a city park or public facilities, distance to the city center and natural conditions.

The current process is performed manually with some conventional software such as ACAD, Excel, SPSS and so on, so that the procedure is still laborious and time-consuming. The result presentation is also expressed as ordinary forms, which seems to obstruct the understanding of unprofessional readers and to disturb designers to accept some valuable information. As a result, *it is recommendable to apply the GIS technology into the model*, in order to automatically save time and to present the results with lively figures and 2-D or 3-D pictures.

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LIST OF PUBLICATIONS

(As the corresponding author)

Note: the papers labeled [1]-[5] are journal papers; the paper labeled [6] is a conference paper.

Reference Thesis (Journal Paper):

[1] **Authors:** SHI Jianren, GE Jian, HOKAO Kazunori (2005).
(Published already)

TITLE: **CAMPUS LIFESTYLE AND ITS RELATIONSHIP WITH RESIDENTIAL ENVIRONMENT EVALUATION - A CASE STUDY OF HANGZHOU CITY, CHINA.**

Journal Information: *Journal of Asian Architecture and Building Engineering*, Nov. 2005, Vol. 4, No. 2, pp.323-330.
(INTERNATIONAL JOURNAL, EDITORIAL OFFICE LOCATION: TOKYO, JAPAN)

[2] **Authors:** SHI Jianren, ZHAO Xiumin, WANG Zhu, HOKAO Kazunori (2006).
(Published already)

Title: Research on the Architectural Renewal of Historic Blocks in Chinese Modern Cities of Tourism, a Case Study of Hangzhou City, China.

Journal Information: *ASEAN Journal on Hospitality & Tourism*, Jan. 2006, Vol. 5, No. 1, pp.17-32.
(International Journal, Editorial Office Location: Bandung, Indonesia)

[3] **Authors:** SHI Jianren, ZHAO Xiumin, WANG Zhu, HOKAO Kazunori (2006).
(Published already)

Title: Research on the Impact Factors on Public Image of Urban Open Space.

Journal Information: *New Architecture*, Apr. 2006, Vol. 16, No. 2, pp.71-74.
(CHINESE JOURNAL, EDITORIAL OFFICE LOCATION: WUHAN, CHINA)

[4] **Authors:** SHI Jianren, ZHAO Xiumin, GE Jian, HOKAO Kazunori, WANG Zhu (2006). (Accepted)

Title: Identifying public preferences for the value of daily used open spaces using the analytic hierarchy process - A Case Study of Hangzhou City, China.

Journal Information: *Lowland Technology International*,
Dec. 2006, Vol. 8, No. 2, pp.***-***.
(INTERNATIONAL JOURNAL, EDITORIAL OFFICE LOCATION: SAGA, JAPAN)

[5] **Authors:** SHI Jianren, ZHAO Xiumin, GE Jian, HOKAO Kazunori, WANG Zhu (2006). (Published already)

Title: Interaction of public preferences and behavior in residential outdoor spaces using the analytic hierarchy process and the principal component analysis - a case study of Hangzhou City, China.

Journal Information: *Journal of Zhejiang University Science*,
Aug. 2006, Vol. 7, No. 8, pp.1372-1385.
(INTERNATIONAL JOURNAL, EDITORIAL OFFICE LOCATION: HANGZHOU, CHINA)

Other Reference Thesis (Proceeding Paper):

[6] **Authors:** SHI Jianren, ZHAO Xiumin, GE Jian, HOKAO Kazunori, WANG Zhu (2006). (Accepted)

Title: Built Environment Evaluation on a Neighborhood Park and its Residents' Behavior Mode: A Lowland Study of Hangzhou City, China.

Symposium Information: *International Symposium on Lowland Technology, 2006*
(International Proceeding, Editorial Office Location: Saga, Japan)

(End)

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APPENDEX A: A PRELIMINARY SURVEY AND RESULTS

(COMPARISON LEISURE CHOICE BETWEEN PRESENT AND FUTURE)

THIS PRE-SURVEY IS CONDUCTED TO CLARIFY RESIDENTS' DESIRE CONCERNING THE LEISURE PLACE CHOICE. IT HAS BEEN MENTION IN THE STATEMENT OF PROBLEM (CHAPTER 1.2., PAGE 2). MORE INFORMATION IS AS FOLLOWS.

Valid response No. is 255; Date: Feb. 18-26, May 10-Jul. 9, 2005; On site free interview with open-ended questionnaire; Distributed structured questionnaire; Respondent: Citizens of Hangzhou City, China.

Residents' current choice of leisure place

At home (103 persons, 40.4%)

Neighborhood open space (86 persons, 33.7%)

Open space outside the neighborhood (35 persons, 13.7%)

Public interior space (31 persons, 12.2%)

Residents' future preference of leisure place

At home (45 persons, 17.6%)

Neighborhood open space(104 persons, 40.8 %)

Open space outside the neighborhood (98 persons, 38.4 %)

Public interior space(8 persons, 3.1%)

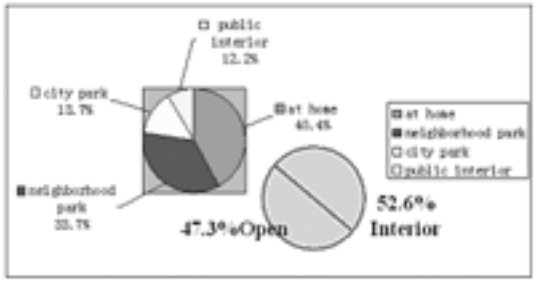

Fig. A.(a) Current Choice of Leisure Place

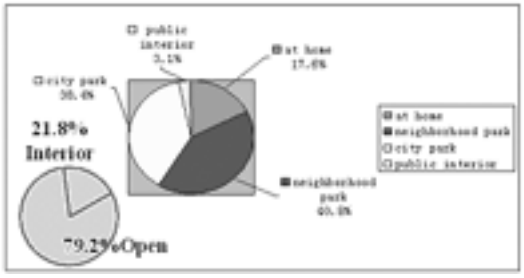

Fig. A.(b) Future Choice of Leisure Place

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***Changes of* Leisure Place if Open space is improved to be satisfactory**

The result (Fig. 3.3.(c)) shows that people will change the leisure place from interior spaces to open space.

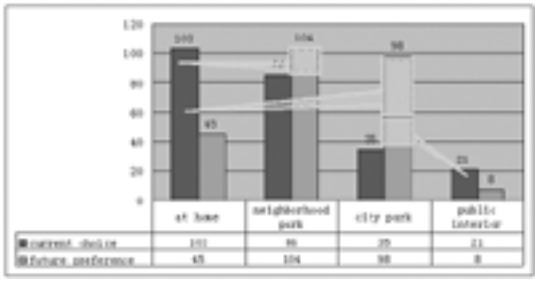

Fig. A.(c) Changes of Leisure Place if Open space is Satisfactory

Comparison of Residents' Satisfaction between neighborhood open spaces and city parks.

The result (Fig. 3.3.(d)) shows that neighborhood parks are more satisfactory than city parks at the first 3 aspects, while it is necessary to improve the amenity, health, applicability and openness.

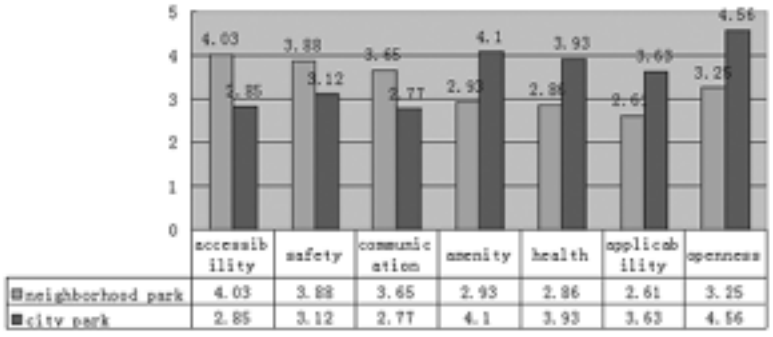

Fig. A.(d) Changes of Leisure Place if Open space is Satisfactory

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