Analysis of Behaviors along the Waterside in a Chinese Residential Quarter

Zao Li*, Junzo Munemoto and Tetsu Yoshida

1 Professor, School of Architecture and Art, Hefei University of Technology, China
2 Professor, Department of Architecture, Okayama University of Science, Japan
3 Associate Professor, Graduate School of Engineering, Kyoto University, Japan

Abstract

The aim of this study is to investigate the behaviors of residents along the waterside in a Chinese residential quarter. Based on Hayashi's Quantification Theory Type III and Cluster Analysis and information collected through this study, the waterfront spaces are classified into nine types, each of which have unique statistical characteristics concerning behaviors. The results show that the residents tend to wait for companions of their respective defined groups frequently while they are walking along the brook. They rarely play with water in the pond if they are uncertain about the water depth, and also stay longer chatting with friends if they can find vacant benches on the deck along the pond. The residents typically hang around more frequently in waterfront spaces to either play in shallow water, if the weather permits, or enjoy the view of the brook although they may stop for a shorter time on stepping-stones. Scientifically identified human behaviors have shown that they are influenced by these different types of waterfront spaces that are described in detail in this paper.

Keywords: behavior; waterscape; residential quarter; Hayashi's Quantification Theory Type III; cluster

1. Introduction

1.1 "Waterscape Housing" in China

In China's Yangtze River valley, of essential importance to people's daily life are the natural waterways and rivers that also support economic activities such as transportation, fishery, and agriculture. In ancient times, there were many poets who left famous manuscripts expressing their deep appreciation or "feelings of fondness" for waterscapes. In fact, "water culture" can be traced back as early as it started affecting the lives of Chinese people. Unsurprisingly, the Chinese have been in favor of gardens with waterscapes due to this cultural tie with the scenery.

It has been three decades since the reform and opening up of China. During this period, sustained economic growth in China has fueled vast housing construction projects nationwide at an enormous pace. The residential housing market continues to boom or may be somewhat over-heated as some economists believe. Quality standard, definition and other factors of residential living environments have emerged as hot topics in China. It has been a trend that water facilities are becoming a national fashion. More and more architects adopt this concept in the design of residential quarters, by means of contemplating pleasant waterscape environments within their project design at the very early stages. Established waterscapes have proven to be an important element of amenities.

Generally speaking, residential quarters with waterscapes are gaining much more popularity than ever before. According to a statistical report, the addition of a waterscape to a residential building can normally increase the market price by 10% (Li R., 2002). It is quite normal that waterscape units sold out faster and with higher market prices. It has been widely accepted that waterscapes have added value to potential buyers. The "waterscape style" has been gained obvious popularity nationwide since 2000. Some Chinese architects have responded to such a market trend by including waterscapes, such as a pond, brook, or waterway, even in their design proposal.

Unfortunately, there is not sufficient research to support the establishment of a nation-wide code that can regulate and guide better planning and design of water facilities. In current practice, the concept of "waterscape housing" usually lays too much emphasis on the intuitive ideas or experiences of these design specialists. The drawback is whether such kinds of project can be successful or not as they are greatly dependent on the experience and imagination of a small group of specialized people. The shapes of
natural ponds are imitated, while artificial rectangular ponds or waterways may also be constructed. The "Western style" or "Chinese style" water facilities that were adopted largely depended on the purpose of selling and/or the designer's individual preferences or tastes, rather than by the future residents themselves.

In the authors' previous study (Li, et al. 2008), they tested the walking behavior of 47 pedestrians carrying a GPS in a Chinese residential quarter. The results showed that walking speeds were slower when visitors were going though places that crossed a water surface or passed a deck surrounded by water; and their footsteps moved faster when they were walking away from the waterside or near blocks of buildings. Behaviors could be further divided into distinctive patterns according to the walking distance, such as walking around, and taking shortcuts. Thereafter, places were classified into nine distinctive types according to walking speed, such as, an area near a building, a narrow footpath on a slight slope, and so on. And it clearly showed that visitors' walking behavior was influenced by the features of the space. However, the pedestrians investigated in this study were visitors to the site rather than residents.

The authors continue to concentrate on the research of residents' behaviors based on video observation (Li, et al. 2008). Residents' behaviors were recorded as well as their route along the waterside in the same residential quarter with community consent. Residents' age group, gender, route and moving and staying activities were thereafter analyzed. It was found that most residents stood within one meter of the waterline while viewing the scenery; playing or taking pictures, and some of them moved away from the main route in order to gain a preferred view, or to play with the water. Most residents would like to take pictures along the waterline to capture the depth of the brook. This paper concentrates mainly on residents' behaviors corresponding to their routes along the waterside. On the other hand, as an important part of the waterscape plan of residential quarters, greater emphasis should be placed on the relationship between the characteristics of residents' behaviors and corresponding spatial types of waterscapes. This is the main reason why this study was initiated and became a focused topic.

Unlike the previous paper, this one concentrates on how residents' behaviors are influenced by waterfront spaces. This continuous study aims to contribute to the establishment of a practical guide for waterscape planning and design. This is to be achieved through quantitative analysis of the observations and data, which result in a scientifically justifiable correlation between characteristics of residents' behaviors and corresponding types of waterfront spaces.

1.2 Purpose

This research attempts to map out the relationship between residents' behaviors in response to their corresponding waterscapes. More specifically, it aims to reveal within a spatial type of waterscape its residents' behaviors and/or stay duration along watersides in residential quarters.

1.3 Previous Studies

In the past, researchers used questionnaires to analyze utilization behavior and to evaluate water facilities. The conclusions were normally drawn by comparing information obtained from different areas. It was found that 60% of people believed that the water facilities around their buildings were good and also made the environment better for their children. But some research (Ishikawa et al. 1992, 1994) raised concerns about the quality of water. Ishikawa and Ohsaki compared behavioral features and conducted an evaluation by using the questionnaire survey method. However, the authors did not analyze the residents’ behaviors in response to their corresponding actual environment. Instead, their studies through questionnaires were mainly focused on the water facilities, and paid little attention to the surrounding environment and its interaction with people.

Kose & Kiya (1996, 1998) studied human behaviors beside water facilities with image processing in a residential quarter, and analyzed the density and duration of stay using video cameras. The authors classified the behavior into 10 categories, such as contact with water using object or contact with water without object, and so on. They then analyzed the characteristics of behavior with respect to human contact with water, human attributes, and average duration of stay. People's activities were recorded at a particular place using video cameras. However, it was difficult to record the whole period of activities while residents were moving along a large waterfront within a residential area, limited by fixed-point observations.

In this study, unlike those of the past, the researchers analyzed residents' behaviors related to types of waterfront spaces, and as a result we have a better understanding of their behavior in such spaces.

2. Materials And Methods

2.1 Object of Investigation

The size of the residential quarter investigated is about 30 hectares, and is located in Anhui Province, in the valley of the Yangtze River in east China. It was named "Chinese International Garden" by the United Nations Environment Program in 2004 (Fig. 1.). A pond is treated as the central landscape of the first block, while the main route extends along a brook in the second block. The investigation was conducted from Mar. 11th to Mar. 20th, 2007 with community consent.

2.2 Outline of Investigation

The authors recorded the behaviors of residents who are within the boundary of the investigated areas. Area A and Area B are defined by those places around the pond in the first block, while Area C and Area D are
along the brook in the second block (Fig.1). Residents' activities were recorded by using multiple video cameras at different areas based on follow-up observations (Table 1.).

If a resident just passed through the monitored areas without stopping or he/she was out of our scope, that data was ignored, or treated as invalid if it was found on the video. In the end the authors had 1,069 persons whose video clip data was satisfactory, which were used in this study (Table 2.).

2.3 Data Processing

A group of residents walking together was treated as one behavioral unit. And the maps of 489 behavioral units have been drawn in CAD. In this paper, "behavior" is defined as the specific action of residents when they stay at a place. These behaviors were marked on the map; A-D areas are divided into thirty sections according to the features of the space (Fig.2.). Therefore, Area A is divided into five sections (A1-A5), Area B into four sections (B1-B4), and Area C into three sections (C1-C3). Furthermore, the stepping-stones or bridges on the brook in Area D are treated as five sections (Da-De), while the ends of stepping-stones or bridges are divided into five sections (Daa-Dee) accordingly. The remaining part of the footpath along the brook at area D is divided into eight sections (D1-D8). In addition, the typical cross-sections are shown in Fig.3. The data such as stay duration, and points where residents stopped (Fig.4.) were recorded and entered into the authors' database.

3. Analysis on Behavior along the Waterside

3.1 Characters of Residents' Behaviors

The residents' behaviors are classified into four categories, including [1. Resting and Communication], [2. Viewing the scenery], [3. Playing], and [4. Others] (Table 3.). The Table shows the occurrence frequency [Viewing the scenery] (recorded 1,322 times) is of the highest frequency, and is identified as the dominant...
Fig. 3. Typical Cross-sections

Fig. 4. Residents' Behaviors in Each Area
behavior along the waterside. The occurrence of [3. Playing] (recorded 1,245 times) is the second highest.

In the subdivision of [3. Playing], it shows that [Play without touching water] (recorded 707 times) has the highest occurrence.

Because these sample data were taken randomly, they are of unequal sample size at each of the authors' four areas under study, with the result that direct comparisons cannot be made among the groups. Instead, the authors decided to take the approach of comparing the occurrence frequency of behaviors between different sections of certain areas.

The section with the highest occurrence frequency of behaviors in each area is described as follows: a wide deck with benches (A1: recorded 517 times), a deck with benches surrounded by water (B1: recorded 313 times), a footpath along the waterside where the brook widened (C2: recorded 313 times), and a footpath where the brook curved and widened (D6: recorded 301 times), (Table 3., Fig.4.).

3.2 Behavior Analysis According to Classification of Waterfront spaces

In this paragraph, the authors intend to further analyze behaviors by using Hayashi's Quantification Theory Type III and Cluster Analysis to study the distribution of these behaviors with the classified spaces of the waterfront.

1) Classification of Waterfront spaces

Data related to the elements of a space, such as water facilities, water depth, and distance to water surface were collected and tabulated. These elements are classified according to their existence or non-existence in each section (Fig.5.).

The data in Fig.5. have been analyzed using Hayashi's Quantification Theory Type III. The result shows that the cumulative contribution rate is over 60% as shown in the 1st to 3rd columns of Table 4.

It was noticed that the negative eigenvalue of the 1st axis indicated features [Against the housing] and [Depth of water >1m] along the pond, while the positive eigenvalue indicated features [Side to the housing] and [bottom be visible] along the brook. Therefore, the 1st column compares the space along the pond and the brook.

The negative eigenvalue of the 2nd axis indicates constituting elements of intimacy to water by [Bridge or stepping-stones], [Waterfall or fountain be touched] and [Waterside degree of section >0.2m] (see note of Fig.5.), while the positive eigenvalue indicates aloofness from water [Against the housing] along the pond and [Height to water surface >0.3m] (see note of Fig.5.). Therefore, the 2nd column indicates the difficulty of touching water.

The negative eigenvalue of the 3rd axis indicates features [Against the housing] while its positive eigenvalue indicates features [Facing the housing].

Table 3. Occurrence Frequency of Behaviors

| Area | Counting Unit: Observed occurrence frequency |
|------|---------------------------------------------|
| A1   | 71 80 49 80 32 3 25 28                     |
| A2   | 3 7 19 13 0 0 22 9                        |
| A3   | 0 9 2 26 45 0 6 19                        |
| A4   | 0 5 5 47 0 0 11 2                        |
| A5   | 0 6 14 41 15 0 8 41                      |
| B1   | 84 38 7 28 8 7 10 17                     |
| B2   | 4 38 34 58 10 20 24 8                     |
| B3   | 42 30 3 18 2 1 14 4                      |
| B4   | 0 0 1 0 0 0 0 0                         |
| C1   | 28 41 6 41 12 0 3 2                      |
| C2   | 5 63 16 55 66 6 2 1                      |
| C3   | 3 4 2 3 17 0 1 0                       |
| D1   | 0 0 4 3 0 0 1 0                      |
| D2   | 3 1 3 9 1 0 0 0                    |
| D3   | 0 1 7 8 5 0 0 0                  |
| D4   | 2 2 13 15 5 0 2 0             |
| D5   | 3 5 6 11 2 0 3 0              |
| D6   | 0 0 2 0 2 0 0 0          |
| D7   | 0 4 8 11 3 0 1 1         |
| D8   | 2 2 33 10 0 0 0 0     |
| C2   | 5 63 16 55 66 6 2 1         |
| C3   | 3 4 2 3 17 0 1 0               |
| D1   | 0 0 4 3 0 0 1 0                   |
| D2   | 3 1 3 9 1 0 0 0                  |
| D3   | 0 1 7 8 5 0 0 0                  |
| D4   | 2 2 13 15 5 0 2 0             |
| D5   | 3 5 6 11 2 0 3 0              |
| D6   | 0 0 2 0 2 0 0 0          |
| D7   | 0 4 8 11 3 0 1 1         |
| D8   | 2 2 33 10 0 0 0 0     |

Source: Table 4. Counting Unit: Observed occurrence frequency

Fig.5. Elements of Waterfront Spaces

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Therefore, the 3rd axis indicates the relationship between the waterfront space and the housing around it.

The authors used the quantification scores of 30 sections to form the basis of their cluster analysis. It shows that 30 sections can be classified into nine types (Fig.6.). Fig.7. shows the result of cluster analysis based on this scoring method.

2) Distribution of Behaviors based on Types of Waterfront spaces

The residents’ behavior is classified into 11 types, so the average frequency of each behavior type is normally reasoned as somewhere near 10% ([4. Others] was treated as one type for its lower frequency). While the frequency of a certain behavior was found to be over 10% in more than half of the sections, when the authors focus on one type of waterfront space, the behavior in this type will be defined as "frequent". By this rule of thumb, while the frequency of a certain behavior was under 10% in all the sections, when the authors focus on one type of waterfront space, the behavior in this type will be defined as "infrequent". 

[Viewing] and [playing] were observed as "frequent" in most of the waterfront spaces’ types, and the authors classified them as common characteristics along the waterside. Similarly, the distributions of other behavior types are also mapped out according to the types of waterfront spaces (Fig.8).

[Waiting]: Residents tended to wait for companions from their groups while they were walking along the brook. Typical types of waterfront space are shown as follows: footpath along a brook facing housing (Type 1), footpath and deck along a brook (Type 2), stepping-stones (Type 5) and the end of stepping-stones along a brook (Type 6).

[Chatting] & [Sitting]: Residents stopped on the wooden decks with benches along the pond (Type 3) to sit or chat frequently. It was also found that they seldom played with the water in the pond, perhaps thinking it was unsafe to do so. They also seldom looked through the pond, since the water was hard to see through, or the bottom of the pond could not be seen, or the depth of water was uncertain to the naked eye. [Looking through water]: Residents frequently tended to look through water on bridges (Type 4), stepping-stones (Type 5) while crossing a shallow brook or standing beside a waterfall.

[Playing with water]: Stepping-stones (Type 5) was the only type where residents played with the water frequently. Compared with the bridges (Type 4), it is easier to touch the water here. As the investigation was conducted in early spring, [Playing with water] was less than [Playing without touching water].

[Taking care of a child]: On a footpath along a brook facing housing (Type 1) or on bridges (Type 4), the behavior of [taking care of a child] has higher frequency than observed in all other places. Adults allow small children to play more freely than on the stepping-stones as these bridges have balustrades on both sides.

3) Distribution of stay duration

To understand the characters of residents’ behaviors according to different types of waterfront spaces, the distribution of stay duration (in units of seconds) at each type of waterfront space was compiled and charted as shown in Fig.9.

The stay duration that has a cumulative ratio of behaviors equaling 80% is defined as the norm standard in the authors’ analysis. Eighty percent of the behaviors occurred with a stay duration of less than 63 seconds on the wooden decks with benches along the pond (Type 3), longer than in other space types. Eighty percent of the behaviors occurred with a stay duration of less than 26 seconds on the footpath and
Resident’s activities and behaviors at the brook, lake, and pond included resting and communicating (Type 1), viewing the scenery (Type 2), playing with water (Type 5), and sitting or looking through water (Type 5). Fifty percent of the behaviors occurred with a stay duration of less than 24 seconds on the stepping-stones (Type 5), while eighty percent of the behaviors occurred with a stay duration of less than 32 seconds on the bridge (Type 1).

Fig.8. Distribution of Behaviors

Fig.9. Distribution of Stay Duration
4), longer than in the case of the stepping-stones (Type 5, less than 24 seconds), although both situations involved crossing a water setting.

Eighty percent of the behaviors occurred with a stay duration of less than 32 seconds at the end of stepping-stones (Type 6), longer than on the stepping-stones (Type 5). The residents' typical behaviors here were different at these two kinds of space as shown in Fig.9.

4. Conclusions

The following conclusions are drawn:

1) [Viewing the scenery] has the highest occurrence frequency, as residents stopped at all the areas, and this is classified as the dominant behavior along the waterside.

2) According to Hayashi's Quantification Theory Type III and Cluster Analysis, the waterfront spaces were classified into nine types with common special features. Therefore, the distribution of behaviors and stay duration are characterized as follows:

a) Distribution of specified behavior:

Residents tend to wait for a companion of their group, while they are walking along the brook (Type 1, Type 2 & Type 3), and they seldom look through the water or play with the water around the deep pond (Type 3, Type 5 & Type 9).

Residents prefer to sit on the decks with benches around the pond (Type 3), where they can chat with friends.

Residents play with water on the stepping-stones (Type 5), and have the similar behavioral feature of [looking through water] both on bridges (Type 4) and stepping-stones (Type 5). Adults allow small children to play on the bridges more frequently than on the stepping-stones.

b) Cumulative occurrence frequency of stay duration:

Most behaviors are of a stay duration of less than 63 seconds on the wood deck with benches along the pond (Type 3), with talking or sitting being the main activities.

Most behaviors are of a stay duration of less than 24 seconds on the stepping-stones (Type 2), where people play with or look through water.

In this paper, the characteristics of residents' behaviors and stay duration are understood in relation to their waterside surroundings in a systematic way. In future studies, the authors will investigate residents' behaviors along the waterside in other countries such as Japan and Korea to compare the characteristics of the behaviors between people from different countries. The relationship between the behavior and the corresponding waterside will also be explored in more detail.

Acknowledgements

This research was supported by Grant-in Aid for Scientific Research (A) of the Japan Society for the Promotion of Science (Overseas Academic Research, 20254004), and the Research (09YJCZ030) of "Humanities and Social Sciences Research Foundation of the Chinese Ministry of Education", to whom the authors would like to express their sincere gratitude.

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