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RESEARCH ON WATERSIDE URBAN OPEN SPACES IN RESIDENTIAL ENVIRONMENT OF LOWLAND CITY- A CASE STUDY OF SAGA

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ABSTRACT: In this research, waterside spaces of a lowland city were studied from the interactive aspect of physical conditions, users' consciousness/behaviors, and waterside design. Firstly, using Saga City as a case study, the overall conditions of waterside spaces in the city and their physical properties were made clear through site surveys. Then, by Semantic Differential (SD) survey and analysis, three main image components of waterside spaces in urban open spaces and residential environment of lowland cities were found: natural view, environmental arrangement, and urban density. Next, through Cluster Analysis, five image types of waterside spaces and their characteristics were obtained. Furthermore, the behavior tendency of each type of waterside was also analyzed. Finally, on the basis of above surveys and analysis, environmental designs were performed in the five types of waterside, and a SD simulation was conducted to verify the effectiveness of the design. The effective reformation methods for different types of waterside spaces were discussed in order to improve the image of waterside and to activate users' behaviors. The results of this research could be applied directly in the development and improvement of waterside spaces for practice.

Keywords: Waterside spaces, consciousness and behavior, image evaluation, environmental design, lowland city

BACKGROUND AND OBJECTIVES

Waterside space is one of the most important urban open spaces and plays a significant role in residential environment and daily life, especially for lowland cities. Lowland cities are characterized as large flat lands with abundant water networks. Although lowland cities are easily affected by flood and pollution because of their topographical characteristics, on the other hand, making full use of waterside spaces to create a beautiful urban landscape and a comfortable residential environment is noteworthy. Waterside spaces provide local citizens with a wide open feeling, a natural view and ample resources for recreation, activities and festivals, because human beings wish to be close to water instinctively.

Saga is a typical lowland city located on the largest lowland plain in Kyusyu (Fig.1). It is known as a "water city" due to the fact that the city of 103.76 km^2 has a water system of over 2000 km, which is the top level for Japanese cities. The overall area of Japan is 37,784 kha, and the overall water area of Japan is 1,330 kha, with the ratio of 3.5% (including water area in non-urban area); while the area of Saga City is 10376 ha and the water area is 510 ha, with a ratio of 4.9%. In the past this area was full of sea water. Chikugo River as well as hundreds of other small rivers was running to the sea carrying millions of tons of sand and clay year by year. Many man-made land reclamation sites were also developed gradually. Therefore, the lowland expanded at a speed of one kilometer per one hundred years resulting in the present situation. Far removed from the mountain foot, there is no clear topographic variation such as valleys and hills, however, the waterside network formed by Kasegawa River and its branches as well as other small rivers and creeks are the only land characteristics of this city. Even in the central part of Saga, there are a plenty of water and waterside spaces. When walking along the streets, you can see rivers and creeks here and there. Tabuse River and Kase River are important water systems around Saga, and Matsubara River is located in the very central part of the city. Furthermore, Saga has traditionally been an agriculture area, so that hundreds of small water troughs were built to carry water to every corner of farmers' fields. Some of them are not used for agriculture now, but they still exist and become an interesting backdrop for the city. All the rivers and streams comprise the intricate water system that makes up Saga City today. Accordingly, waterside spaces are

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Fig.1 Map of Japan and the location of Saga City

the most important feature of land use in Saga City. However, there are many disappointing aspects of waterside spaces in Saga, and watersides have not been perfectly utilized to act for the attractiveness of lowland residential environment. A pre-survey of the utilization of waterside spaces was made previous to this study. As a result, 33.3% of the respondents utilize the waterside once a month and 45.6% never go to waterside spaces in daily life. Obviously the utilization of watersides in Saga has been disappointing up until now. The pollution of waterside spaces is also serious in various locations. Therefore, it is an important task to make full use of waterside resources to create a comfortable and attractive urban landscape and residential environment in lowland cities like Saga.

Many researchers have been studying about waterside spaces for a long time and there are a plenty of achievements.

In the researches on physical characteristics of water, many theories such as water pollution, transition, fluid dynamics, chemistry properties, ecosystem, and in a larger range, geographic feathers of flowing area were built up, most of which were in engineering.

There has also been a lot of research performed on the consciousness and utilization of waterside spaces, from the viewpoint of users. This research is usually carried out through questionnaires and interviews. Many results regarding the relationship between residents' use and their image of waterside spaces have been published. In order to evaluate the perceived worth of waterfront area as one of several open spaces in our living environment, Nagakubo et al. (1994) conducted a questionnaire survey at 16 districts in Tokyo Metropolitan area, eliciting information on residents' consciousness and behaviors. The survey was designed to address the attractiveness of waterside spaces, residents' expectations and the psychological effects of water spaces. Nishina et al. (1999) conducted a research on recreational uses of inhabitants in urban riverside in order to clarify the value of a river as a recreational space for inhabitants. In their research, they made observations and interviewed users in the Seno area located east of Hiroshima city. The river region was divided every 100 meters into 75 parts. Detail physical conditions of every part were surveyed and the relation between the usage of the space and the physical conditions were analyzed. Kamiyama et al. (1994) observed how people used the water park over the course of a year, and discovered what the water park could provide, and what effects it had on the surrounding environment, especially concerning community formation. With the development of cities, the environment continues to change and people are becoming isolated from nature including waterside spaces. Ui and Kuroyanagi (2001) studied this problem in the process of urbanization.

Considering waterfront design, many new ideas and methods have lead to successful results. New York City (1992) completed a successful waterfront reforming plan in the 1980s. The Comprehensive Waterfront Plan proposed by the Department of City Planning, for the first time in the city's history, provided a framework to guide land use along the city's entire 578-mile shoreline in a way that recognizes its value as a natural resource. The plan present a long-range vision that balanced the needs of environmentally sensitive areas and the working port with opportunities for waterside public access, open space, housing and commercial activity. Another famous case of waterfront reforming is Boston's eastern barrier case (Kay, 2002). However, there also have been a lot of waterfront planning and designs which have failed, or led to public dissatisfaction.

There have been many research studies in the field of waterside space usage, presenting different viewpoints, as well as tackling various issues. These viewpoints and issues are not isolated but have strong interconnections, as well as provide a comprehensive view for waterside spaces. The physical nature of waterside spaces is for human activity, and as such can be planned and designed to meet those needs. Therefore, the aspects of waterside spaces including physical nature, image, activity, and design are interconnected and each one of them should be accounted for in the research of waterside spaces. In this paper, these interactions will be studied for practical use, in order to realize the target of making full use of waterside spaces of lowland cities to develop an attractive and comfortable urban open spaces and residential environment. This study focuses on the physical nature, consciousness and behaviors related to waterside spaces, as well as the interrelationship between these factors; and finally to put forward the effective

design methods for improving the image of waterside spaces and activating people's behaviors towards them. Although many researchers like Kamiyama (1994) have already studied the relation between the usage of watersides and the physical conditions, this study took a more comprehensive and integrated approach. Furthermore, the results of the research can be applied in practical design directly. The objectives of this research are: (1) to make clear the physical conditions of waterside spaces related to residents' image and behavior; (2) to obtain residents' image of waterside spaces and find different image types of urban watersides, as well as to find physical characteristics and people's behavior tendency in different types; (3) to find the effective reformation methods for improving waterside images and activating people's behaviors in different waterside spaces.

In this paper, a comprehensive and integrated view was taken on studying the waterside spaces, such as physical nature of the site, image and human use, and finally a practical design was given. This kind of research investigating lowland cities has been limited up until now, yet waterside spaces are of great significance in residential environment and landscape.

METHODOLOGY

The flowchart of the research is shown in Fig.2.

Research Areas

Saga City was selected as the case study because it is

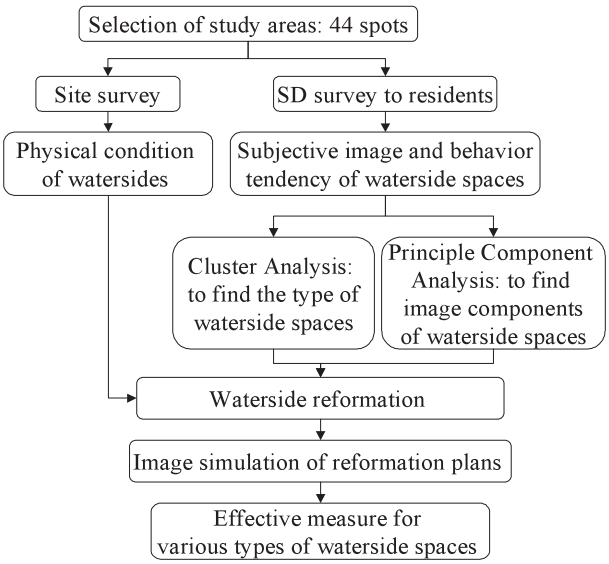

Fig. 2 Flowchart of the research

Fig. 3 Research area

a typical lowland city with plenty of urban waterside spaces. Hundreds of rivers and creeks can be found in every corner of the city. In total, 44 spots (see Fig. 3) with open spaces around them were selected for this research. These spots not only cover the main water system of the city, such as Tabuse River, Saga Castle Lake, Matsubara River and Shirayama River, but also include small waterside spaces near residential areas and other facilities. The research spots are distributed widely throughout Saga City, and vary in scale and style.

Area A (A1~A10) is along Tabuse River. It is the most important water system in Saga City. Tabuse River runs into Kase River in the west side of the city, which is the second largest river in Kyushu. Tabuse River flows across the city center and several parks are located along it, and a cycling route is nearby.

Area B (B1~B10) is around Saga Castle Lake. It is in the center of the city and many important official, cultural and historical facilities are close by, such as Saga Government Office, Saga Prefecture Library, Saga Central Post Office, and Saga Castle, and so on.

Area C (C1~C3) is along the Matsubara River. It is a small river flowing through the central part of the commercial area of the city. The river parallels the city road system.

Area D (D1~D6) is in the Shirayama River area. The width of the river is around 6-8m, flowing through the central part of the city.

Area E (E1~E3), F(F1~F4), G(G1~G2), H (H1~F2), I(I1~I2) are other most important water systems in Saga city. Some have been reformed for recreational use while

some remained as irrigation canals. Area J (J1~J2) is the city library area and a river surrounding the buildings.

Site Survey

Site surveys were performed on each of the 44 spots during two weeks in November of 2005, in order to make clear the site condition and characteristics of the research spots, especially in regards to physical conditions. The survey was conducted by checking and recording items on the check sheets by each of the researchers, who were the students of the Department of Civil Engineering, Saga University. Pictures of each spot were also taken for the purpose of image evaluation. Survey items were divided into three parts: geographic and social conditions of the spots; water characteristics; spatial characteristics, as shown in Table 1. In the geographic and social condition section, 8 items were checked, such as the distance to the station, land use, population density, parking place, access to the city street system, cycling route, public facilities nearby, event places, etc. In the water characteristics section, 9 items was checked, such as speed of water flow, depth, width, water quality, accessibility, water visibility, and so on. In the space characteristics section, 10 items were surveyed including ground features, plant density, relation with road system, sound environment, ground pavement, surrounding facilities, cultural or historical memorials, landmark, and so on.

Table 1 Contents of site survey

Survey items	Number of items
Geographic and social condition	8
Water characteristics	9
Spatial characteristics	10

SD Survey

A Semantic Differential (SD) survey was conducted in order to obtain people's subjective image evaluation of waterside spaces; to divide the image types of watersides; and to find the behavior characteristics of each waterside type. Semantic Differential Analysis (Osgood et. al, 1957) was designed to measure the connotative meaning of concepts. The respondents are asked to choose their position on Likert scale.

In this research, the SD survey was broken into two parts: the first is the evaluation on the image of waterside spaces; and the second is an evaluation as to what extent residents are willing to do a set activity in this setting. 16 pairs of adjectives are used to describe different image feelings of waterside spaces, which are used to express the image of waterside spaces. These items were selected from our pre- research as well as by a literature review. Three items are overall evaluations such as "a bad place versus a good place", "unpleasant versus pleasant", and "ugly versus beautiful". Then, nine kinds of behaviors were listed, which were decided according to observation of behavior in the site survey, ranging from single to group activities; and also from still to intense activities. The structure of the SD items is shown in Fig.4, where 16 pairs of adjectives describing the image of the waterside spaces were listed on the left and right side of the sheet, and a 7-grade scale was listed on the top of the sheet: -3 means agree strongly with the adjective on the left side, -2 means agree with the adjective on the left side, -1 means agree slightly with the adjective on the left side, 0 means neutral, +1 means agree slightly with the adjective on the right side, +2 means agree with the adjective on the right side, +3 means agree strongly with the adjective on the right side. Then, nine kinds of behavior were listed following the image items. People were requested to give an evaluation on the willingness to do such behaviors on the spot: -3 means be unwilling to do strongly, -2 means be unwilling to do, -1 means be unwilling to do slightly; 0 means neutral; while +1 means be willing to do slightly, +2 means be willing to do, +3 means be willing to do strongly.

Questionnaire surveys were performed in January of 2006. Survey subjects were residents of Saga city willing to take part in the survey. The photos of the 44 locations were shown to the subjects randomly, and they were asked to give scores for each item in Fig.4. There are 200 samples in this survey.

A cluster analysis was performed based on the results of the SD survey, dividing the 44 locations into different groups. The characteristics of each group were then analyzed. Then a typical location for each group was selected to perform the following reformation in order to improve the image of waterside spaces and to activate the users' behaviors. The effect of these reformation methods will be checked by image simulation in order to find the effective way of various groups.

Waterside Reformation and Image Simulation

Environmental reformation were performed in order to improve the image of these spots and to activate people's behaviors; then SD simulation was used to check the effect of the reformation. Photos of the spots were modified by the software Photoshop, and the reformation items were determined from the analysis of site survey and SD survey. The detail will be explained in the next session. People were asked to evaluate on how each item changed comparing with the image before modified.

The evaluation sheet was divided into two parts: image simulation, and behavior tendency simulation. All the items were the same as those of SD survey, but the evaluation scale was changed. People were requested to give their evaluation on a 5-grade Likert scale, comparing photos before and after modification. -2 means the modification strengthened the image on the left side strongly, -1 means strengthened the image on the left side slightly, 0 means do not change, +1 means strengthened the image on the right side slightly, +2 means strengthened the image on the right side strongly. As for the evaluation of behavior, -2 means weakened the willingness of the behavior strongly, -1 means weakened the willingness of the behavior slightly, 0 means do not change, +1 means strengthened the willingness of the behavior slightly, +2 means strengthened the willingness of the behavior strongly (see Fig.5).

The simulation was carried out in May and July of 2006, mainly among students of the Department of Civil Engineering, Saga University and volunteer residents willing to help. In total, 70 questionnaires were collected.

ANALYSIS AND DISCUSSIONS

Results of Site Survey

Item No.	Adjectives on Left Side	-3	-2	-1	0	1	2	3	Adjectives on Right Side
1	a bad place								a good place
2	artificial								natural
3	cold								warm
4	monotonous								various
5	disorder								united
6	narrow								wide
7	dangerous								safe
8	unpleasant								pleasant
9	traditional								morden
10	unqualified								qualified
11	public								private
12	rural								urbanized
13	depressed								encouraged
14	ugly								beautiful
15	closed								open
16	inactive								active
	unwilling to do	-3	-2	-1	0	1	2	3	willing to do
17	resting								resting
18	reading								reading
19	fishing								fishing
20	walking								walking
21	playing with pets								playing with pets
22	jogging								jogging
23	chatting								chatting
24	party								party
25	soccker and sports								soccker and sports

Fig.4 Items of SD survey

From the site survey, physical conditions of all the 44 locations were checked and recorded, including a total of 27 items of geographic and social conditions, water characteristics, and spatial characteristics. There are a plenty of waterside spaces in Saga city, and most of them are in urban areas, which are very rare in modern cities nowadays. But unfortunately, we found that the utilization of these spaces was poor. The following are some problems from site survey. (1) Lacking of parking spaces: According to the survey, 43% of the locations provide no parking, 14% provide only a few while the other 43% provide enough. (2) Inaccessibility of water: Water in most locations was inaccessible, or else very hard to access. High road embankments and the lack of water protection railings are the main reasons. Only a few locations provided intimacy between users and water. Increasing the accessibility of water may encourage various activities. (3) Water quality: The overall situation is good, but still around 1/3 of the sites have pollution damaging the overall image of the environment. (4) Noise pollution: Noise pollution is quite serious. According to the survey, 54% of the sites reported noise pollution, mostly caused by traffic. In 38% of the locations people could enjoy some natural sounds such as the the flow of water, sounds of birds, etc. Noise may destroy the image of the spot, and cause a bad mood, as well. (5) Ground pavement: The artificial level of ground pavement is quite high. 47% of the sites analyzed are paved by artificial materials such as asphalt, which might not be suitable for resting or recreation. Other kinds of material such as crushed stone, sand and grass may give the visitors a feeling of nature. Artificial materials may decrease the natural image of sites and also increase some dangerous elements, too. (6) Lack of basic facilities: Facilities such as toilets and rubbish bins are not sufficient around the waterside. These problems are not so serious in the central part of the city, but are serious in the spots away from the center. For example, along the Tabuse River and near the Kase River there are no toilets nearby, and almost no rubbish bins were found along many water systems, which are very inconvenient for users.

Results of SD Survey

Through the SD survey of waterside spaces, the image characteristics and behavior tendency of each spot were made clear.

Most spots of area A (Tabuse River) got a high overall evaluation. The image characteristics can be concluded as wide, pleasant, open and active. Images of warm, united, modern, public and rural can be found but not strong. Most spots of area D (Shirayama River) got a

low overall evaluation. The image characteristics can be concluded as artificial, cold, monotonous, narrow, dangerous, bothersome, bad quality, depressive, and inactive. Other areas and spots got medium scores. In regards to human behavior, walking is popular at several locations. Group behaviors such as having parties and playing soccer are extremely rare. In the locations with low evaluation, the visitors are not willing to stay and do anything. From the physical conditions surveys, these places have such characteristics as follows: (1) Water quality is bad, sometimes even pollution occurred. (2) Water is usually hard to be accessed. (3) Places are quite close to the city road system, with noise from the traffic. (4) No separated area was set. The space even has been a part of the road. (5) The view of landscape is disorder or unarranged. On the other hand, in the locations with high scores in overall evaluation and other items, most people are willing to have a rest and have a walking or jogging. Physical features of these spots are listed as follows: (1) Natural view is good. (2) Plants are arranged orderly. (3) Walkways and cycling routes are well planned away from the city road system. (4) Water is quite clean with small depth. (5) Accessibility to the water is good. (6) Facilities are plentiful such as benches, kiosks and so on.

Principle Component Analysis

After removing the three overall evaluation items, a Principle Component Analysis was conducted on the 13 items of the SD survey. Three components were obtained, and the scores of each component were shown in Table 2. Three components were selected with the eigen-value larger than 1.0, see Table 3. The eigen-value of the third component is 1.114 while the fourth reduces rapidly to 0.435. It shows that the three components are effective, and the cumulative percentage of variance is 89.256%, which shows a statistical satisfaction.

In Component 1, scores on the items of natural, warm, various, united, wide, safe, qualified, encouraged, open and active are high. This component can be considered the image of natural view. In Component 2, scores on artificial, monotonous, modern, public and urbanized are high. This component can be considered the image of environmental arrangement. In Component 3, scores on narrow, private, urbanized, and closed are high. This component can be considered the image of urban density.

Cluster Analysis

A Cluster Analysis was conducted on the scores of the three components of all the 44 research spots. Five

Table 2 Result of principle component analysis

Items	Component 1	Component 2	Component 3
Artificial - Natural	0.632	-0.654	-0.280
Cold - Warm	0.936	-0.221	0.017
Monotonous - Various	0.689	-0.448	0.382
Disorder - United	0.820	0.308	-0.148
Narrow - Wide	0.684	0.412	-0.507
Dangerous - Safe	0.924	0.089	-0.097
Traditional - Modern	-0.285	0.877	0.202
Unqualified - Qualified	0.923	0.201	0.124
Public - Private	0.171	-0.758	0.392
Rural - Urbanized	-0.100	0.848	0.459
Depressed - Encouraged	0.945	0.053	0.246
Closed - Open	0.846	0.406	-0.231
Inactive - Active	0.924	0.229	0.191

Table 3 Explanation of principle component analysis

Component	Eigen-values	% of Variance	Cumulative % of Variance
1	8.109	57.922	57.922
2	3.273	23.378	81.300
3	1.114	7.956	89.256

image clusters were obtained. The number of spots in each cluster and the average scores of three principal components are shown in Table 4, as well as the average of the overall evaluation of the cluster.

(1) Cluster 1 (12 spots: A1, A5, B4, D3, E1, E2, E3, F2, F3, H1, H2 and I1), Cluster center: F3

Cluster 1 represents the spots with low score on environmental arrangement component and relatively high score on urban density component. The score on natural view of Cluster 1 is also the highest among all clusters. They are places in the semi-central part of the city, with original natural conditions, not blended well with facilities. The urban density of this cluster is quite high accompanying the progress of urbanization, and the waterside remains original but tidy.

Table 4 Average scores on three components and overall evaluation of each cluster

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Number of spot	12	10	4	5	13
1st Natural View	0.485	-1.538	-2.153	0.404	0.415
2nd Environmental Arrangement	-0.962	0.457	-1.109	-0.205	1.047
3rd Urban Density	0.824	0.054	0.4006	-1.041	0.469
Overall evaluation	0.169	0.511	-1.525	0.876	0.138

(2) Cluster 2 (10 spots: A4, A6, A7, A8, B1, B2, B10, F1, F4 and I2), Cluster center: I2

Cluster 2 represents the spots with low score on natural view component while normal scores on the other two components. They are the watersides which are well arranged in the central part of the city. Places in this cluster do not provide a natural view, but water is usually accessible, with kiosks and playgrounds around and important public offices nearby. They feature a modern view, and over 90% of the grounds are paved with asphalt.

(3) Cluster 3 (4 spots: D2, D4, D5, and D6) Cluster center: D2

Cluster 3 represents the spots with extremely low score on natural view, and environmental arrangement. These places are in central part of the city, with pollution. There is neither a beautiful view nor well arranged facilities.

(4) Cluster 4 (5 spots: A2, A3, A9, A10, and B3), Cluster center: A10

Cluster 4 includes the spots with a low score on the urban density component, with normal scores on natural view and environmental layout components. They are large recreational areas such as parks or open spaces in suburban parts of the city. Places in this cluster are mostly located in residential zones or agricultural zones with low density, good natural views and plenty of parking spaces.

(5) Cluster 5 (13 spots: B5, B6, B7, B8, B9, C1, C2, C3, D1, G1, G2, J1, J2), Cluster center: C1

They are watersides in suburban areas with good arrangements. The natural view has a relatively good balance with urbanized view. Places in this group have well arranged facilities and views, and plants are in good order. They are away from the city's road system but still maintain a good public feeling.

In general, the scores on behavior willingness are not high in all clusters, but some characteristics were found as follows. Group activities such as party and soccer got low scores in each cluster. Each activity tendency got low score in Cluster 3, where neither natural view nor environment arrangement is good, and the urban density is quite high. Walking and jogging tend to happen in Cluster 1, 2, 4 and 5, where one of the components of natural view and environmental arrangement is good.

Waterside Reformation and Simulation

Five clusters were determined representing the five image types of waterside spaces in Saga. In each cluster, there is a cluster center, which can be considered as typical of the cluster. They are F3, I2, D2, A10 and C1, standing for Cluster 1 - Cluster 5 respectively. Therefore, it is reasonable to take them as the samples of environmental reformation.

The reformation was performed by reforming some items of the photo by Photoshop. There are 27 check list items of physical condition in the site survey, but some are impossible to be changed by environmental design, such as speed of water flow, residential density, land use, and so on. Some other large scale design should be determined according to the city plan, and need to be discussed from many aspects such as economics. Therefore, in this study, the five most economically possible reformations were selected for environmental design and simulation (Reformation Method I~V). They are shown in Fig. 5(a) ~ (e), and place C1 is taken as the sample for explanation.

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Reformation Method I (increasing the water area): the water area and its visibility from the environment were increased by enlarging the width of the rivers.

Reformation Method II (increasing the accessibility): steps were added to water by which users can access the water safely.

Reformation Method III (changing the amount of plants): trees or bushes were added in the waterside spaces where the vegetations are few; or trees were removed if the place already had a large mount of plants. After reducing plants, the evaluation scores will be rescored to see the adverse effect.

Reformation Method IV (adding recreation or resting facilities): facilities such as benches, kiosks, playground, drinking automat, cycling road and so on were added in the waterside spaces.

Reformation Method V (adjusting structures over water): the structures such as bridge, sculpture and so on were added over the water.

The photos of the five spots were modified by Photoshop through the above five different reformation methods. The original image and the modified one were

given together in the questionnaire sheet. In order not to give a hint or guide, no descriptions about the modification were informed in the simulation.

The simulation results are shown in Fig.6 (a)~(e). The value of Y axis stands for the change of image or behavior through environmental design; and the number of the X axis stands for the SD evaluation items in Fig.4, where 1-16 are the image items and 17-25 are the behavior items.

The effects of "increasing water area" on image improvement are stronger in Cluster 5 (C1), Cluster 2 (I2) and Cluster 4 (A10) than the other two clusters. The individual activities also increased in these clusters, and group activities increased in Cluster 2 obviously.

"Adding accessibility to water" is more effective on image improvement in Cluster 5 (C1) and Cluster 2 (I2) than other clusters, and so is the effect on increasing individual activities. Furthermore, it seems to encourage group activities in Cluster 2 obviously.

"Planting" has big effect on image improvement in Cluster 5 (C1), Cluster 2 (I2) and Cluster 1 (F3). It increased the individual activities in Cluster 4, but reduced the group activities of this group. It increased the group activities in Cluster 5 strongly.

"Adding recreation or resting facilities" is effective slightly on image improvement in all the clusters except Cluster 3. It seems to increase the individual activities in Cluster 4 and has opposite effect on group activities in all the clusters.

"Adjusting structures on water" improved the image only in Cluster 5, but it reduced the activities in this group. It increased the individual activities slightly in Cluster 4 and Cluster 3, and increased the group activities in Cluster 2.

Fig.5 (a) Image modification by reformation method I: increasing the water area

Fig.5 (b) Image modification by reformation method II: increasing the accessibility

Fig.5(c) Image modification by reformation method III: changing the amount of plants

Fig.5(d) Image modification by reformation method IV: adding recreation or resting facilities

Fig 5(e) Image modification by reformation method V: adjusting structures on water

The effective reformation methods for each cluster are shown in Table 5.The effects of the five reformations on images and behaviors to each cluster are shown in Table 6.

For Cluster-1: It is effective for Cluster-1 to improve the image of the waterside spaces by increasing the water; however, all of the methods can not activate peoples' behaviors.

For Cluster-2:It is effective for Cluster-2 to improve the image of the waterside spaces by adding plants, recreation/ resting facilities, and accessibility to water. Water and its easy accessibility can not only activate the

individual behaviors, but also group behaviors. Adjusting structures on water can activate the group activities.

For Cluster-3: None of the methods can improve the image or activate peoples' activity of the waterside spaces of Cluster-3.

For Cluster-4: It is effective for Cluster-4 to improve the image of the waterside spaces by increasing water, and adding recreation/ resting facilities. Adding plants can activate the individual activities.

For Cluster-5: It is effective for Cluster-5 to improve the image of the waterside spaces by adjusting structures on the water. Increasing water and its accessibility can activate the individual activities, while adding plants can activate the group activities.

It can be found that almost all of the reformation methods have effect on Cluster 2 and Cluster 5. Cluster 2 and Cluster 5 are spots with good environmental arrangement. Therefore, the basic environmental arrangement is the foundation of the improvement of waterside image. On the contrary, it also can be seen that none of the methods is effective in Cluster 3, where neither natural view nor arrangement is good, and the overall image are very bad. One single reformation can not improve the image of these spots. Thorough and comprehensive reformations are needed. The results can be used as guidelines for environmental design in everyday practice. However, there is a limitation that only five reformation variables were used in this simulation. The five variables discussed here are feasible to be changed by environmental design and possible from an economic standpoint. These methods could be used as the basic ones to improve the image of waterside spaces and activate people's behaviors. The possibility of other complicated methods should be studied furthermore in the future.

Table 5 Effective reformation of each cluster

Cluster No.	For improving image	For activating Individual behavior	For activating group behavior
Cluster-1	Method III, IV	-	-
Cluster-2	Method I,(II),III,IV	Method I, II	Method I,II,V
Cluster-3	-	Method (V)	-
Cluster-4	Method I, IV	Method III,IV,(V)	-
Cluster-5	Method V	Method I, II	Method III

Table 6 Effect of reformation methods on each cluster

Reformation Method	Effect on Image improvement	Effect on Individual behavior	Effect on Group behavior
I: Increasing water	Cluster5,2,4	Cluster 2, 5	Cluster 2
II: Increasing accessibility	Cluster 5, (2)	Cluster 2, 5	Cluster 2
III: Changing plants	Cluster 1,2,5	Cluster 4	Cluster 5
IV: Adding recreation or resting facilities	Cluster 1,2,4,5	Cluster 4	-
V: Adjusting structures on water	Cluster 5	Cluster (4),(3)	Cluster 2

Note: ( ) means the effect are not strong.

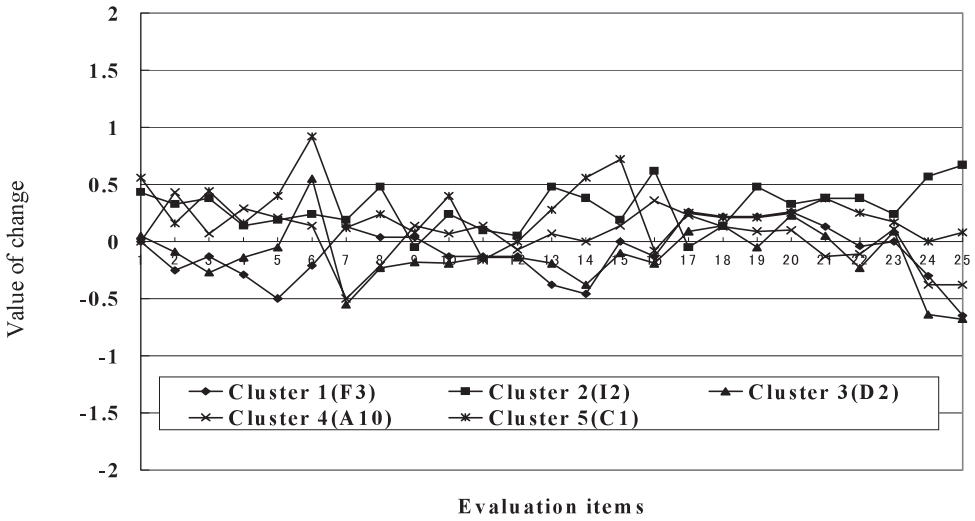

Fig .6 (a) Simulation result of reformation "Increasing water area"

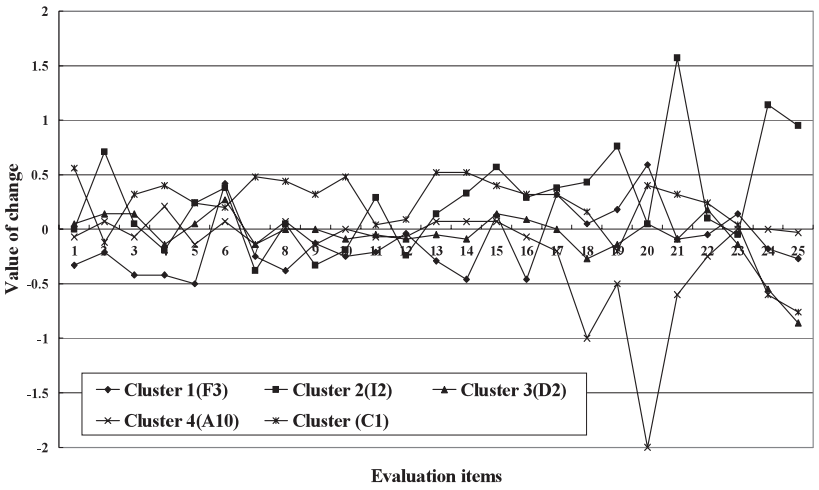

Fig.6 (b) Simulation result of reformation "Adding accessibility to water"

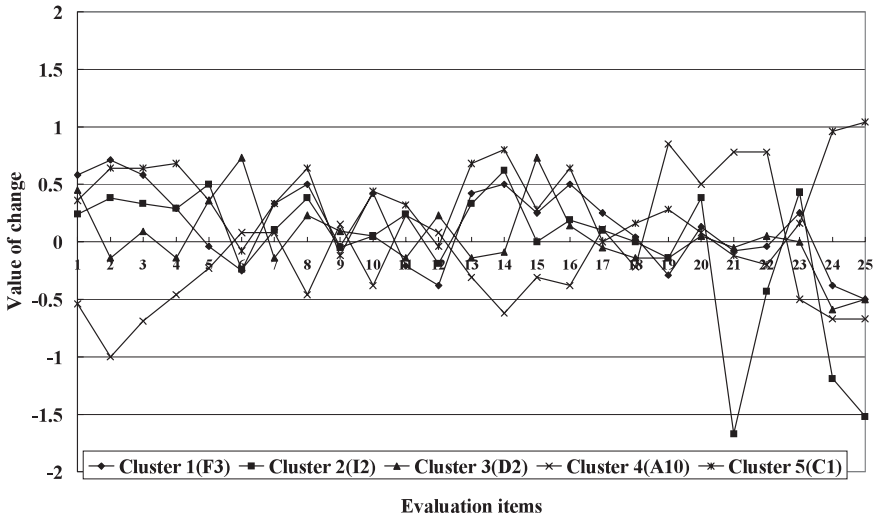

Fig.6 (c) Simulation result of reformation "Changing plants"

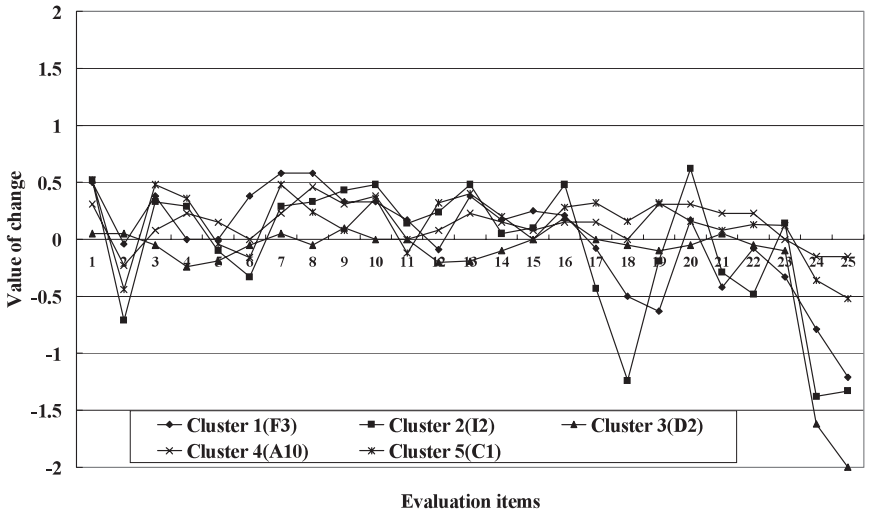

Fig.6 (d) Simulation result of reformation "Adding facilities"

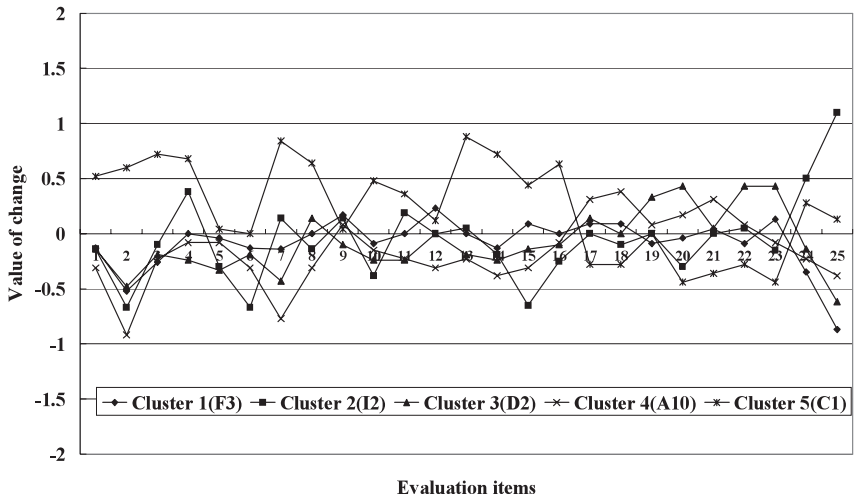

Fig.6 (e) Simulation result of reformation "Adding structures over water"

CONCLUSIONS

In this research, through studying a typical lowland city in Kyushu, Japan, waterside spaces were investigated by means of integrating physical conditions, users' consciousness/behaviors, and waterside design. From site survey, the overall conditions of waterside spaces in Saga and their physical properties were determined. Through Semantic Differential (SD) survey and analysis, three main image components of waterside spaces became evident: natural view, environmental arrangement, and urban density. Furthermore, by Cluster Analysis, five image types of waterside spaces and their characteristics were found. The behavior tendency of each type was also analyzed. Finally, on the basis of the above surveys and analysis, environmental designs were performed, and a SD simulation was conducted to verify the effectiveness of the design. The different effects of different reformation methods for each cluster group were discussed in order to improve the image of watersides and to activate the users' behaviors. It was found that different methods are effective for different types of waterside spaces. The detailed guidelines for the improvement of waterside spaces are shown in Tables 5 and 6. It is effective for Cluster-1 to improve the image of the waterside spaces by increasing the water; however, all of the methods can not activate peoples' behaviors. It is effective for Cluster-2 to improve the image of the waterside spaces by adding plants, recreation/ resting facilities, and accessibility to water. Water and its easy accessibility can activate not only individual behaviors, but also group behaviors. Adjusting structure on water can activate the group activities. None of the methods can improve the image or activate peoples' activity of the waterside spaces of Cluster-3. It is effective for Cluster-4 to improve the image of the waterside spaces by increasing water, and adding recreation/ resting facilities. Adding plants can activate the individual activities. It is effective for Cluster-5 to improve the image of the waterside spaces by adjusting structure on water. Increasing water and its accessibility can activate the individual activities; while adding plants can activate the group activities.

Waterside spaces are valuable resources in urban areas, especially for lowland cities. Waterside spaces should be fully utilized to develop an attractive and comfortable urban open space and residential environment. This paper took a comprehensive view on waterside spaces, showing the interdependency of physical condition, users' consciousness and behaviors, and design of waterside spaces. The results of this research could be expected to be useful in the development and improvement of waterside spaces in practice.

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