**RESEARCH ARTICLE**

# Citizens' preferences and attitudes towards urban waterfront spaces: a case study of Qiantang riverside development

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## Abstract
Many cities are facing various environmental problems, where performance-based planning and nature-based solutions have been proposed to address such problems. As a natural landscape in the city, urban waterfront space has efficient ecological benefits, high-quality landscape vision and environment, and it is an important carrier of citizens' activities. However, existing studies have mainly focused on coping with environmental problems, while social functions and strategies have been neglected. Therefore, this study aims to fill such research gaps by understanding the social performance of urban waterfront spaces. Field observation and questionnaire survey were conducted in a famous urban waterfront space, Qiantang riverside walkway, in Hangzhou, China. The results indicate that the Qiantang riverside walkway serves as a space for tourism, leisure and entertainment, as the visitors who lived more than 5 km away from here accounted for about 50% and the local people also accounted for about 50%. People's activities exhibited significantly temporal differences, where the occupation of the Qiantang riverside walkway reached a peak at night. For the people who lived far from here, they mainly depended on self-driving, which led to two critical problems relevant to transport linkage with the city and parking lot. Results also indicate that the landscape, supporting facilities and road functions could perform well among the mind of 102 respondents. However, public service and main facilities should be improved to meet more people's requirements. Moreover, importantly, the results indicate the phenomenon of stratification and agglomeration so that the similar aspects (e.g. rest seat quantity, rest seat style) could be merged into the same cluster (e.g. rest seat) for consideration in the urban waterfront space planning and design. This study also generates some implications for the renovation of urban waterfront spaces. Overall, this study provides people with basic understanding of the social performance of existing urban waterfront spaces, which can further promote urban planners and designers to comprehensively build sustainable, resilient and healthy water-based living environments.

**Keywords** Preferences and attitudes · Urban waterfront spaces · Social performance · Landscape · Public service · Supporting facilities · Main facilities · Road functions · Stratification and agglomeration · Qiantang River walkway

## Introduction

Our world is currently experiencing a rapid upward trend of urbanisation. Meanwhile, it is projected that 68% of the global population will live in urban areas by 2050, from only 54% in 2014 (United Nations 2018). However, the anthropogenic activities and rapid urban population growth have brought urban areas with great burdens and a series of urban problems (Mutatkar 1995; Mills and Song 2020; Olalekan 2014; Xu et al. 2020). Several kinds of environmental problems, such as urban temperature increase (Zhang et al. 2009; Argüeso et al. 2014; He et al. 2020; He 2019), air and water pollution (Han et al. 2014; Zinia and Kroeze 2015), urban flooding (He et al. 2019) and green and blue infrastructure reduction (Liu et al. 2015; Zhang et al. 2020), are becoming prominent. Moreover, such environmental degradation has also resulted in economic and social problems such as the increase in the investment of energy and water (Kolokotroni et al. 2012), the reduction of working productivity (Kjellstrom et al. 2009) and the occurrence of physiological, psychological and physical problems. (Weisskopf et al. 2002; Kravchenko et al. 2013).

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To cope with such environmental issues and the associated economic and social issues, it requires decision-makers to properly conduct urban planning and design (Qin et al. 2020b; Qin et al. 2020a). Both nature-based solutions and performance-based urban planning have been advocated as effective approaches to achieving so (Nesshöver et al. 2017; Grant et al. 2013). The green infrastructures and blue infrastructures are the primary focuses among such design philosophy and practices to tackle the environmental, economic and social challenges in urban areas (Depietri and McPhearson 2017). For instance, green and blue infrastructures have been evidenced as effective ways to mitigate urban environmental problems through lowering urban temperature (Žuvela-Aloise et al. 2016), alleviating urban flooding (He et al. 2019), reducing air and water pollution (Abhijith et al. 2017) and improving urban aesthetics (Baptiste et al. 2015).

Although the multiple benefits of green and blue infrastructures in both innovative urban planning and design philosophy and practices have been well acknowledged (Wholey 1999; Cohen-Shacham et al. 2016; Faivre et al. 2017), the implementation of such innovative philosophy and practices is quite challenging as they need to meet comprehensive requirements (Kabisch et al. 2016; Thorslund et al. 2017; Hoberg and Malkinson 2013). For instance, the implementation of nature-based solutions is elucidated in several aspects including the appealing aesthetics, novel green commons, trust in local government and experimentation, social innovation, collaborative governance, urban integration and long-term learning and replication (Frantzeskaki 2019). Meanwhile, the implementation of performance-based planning also requires decision-makers' acceptance and their understandings of inclusive and systematic integration of different urban components such as green and blue infrastructure, transportation and ecosystem services (Pelorosso 2020). Otherwise, the innovative urban planning and design paradigm might be misused, failing to fulfill their anticipated functions (Botequilha-Leitão and Díaz-Varela 2020).

For urban waterfront space, it is a critical component in shaping urban environment, not only due to its prominent benefits to alleviate urban flooding and mitigating urban heat island (Dong et al. 2019; Targino et al. 2019) but also because of its potential to improve urban landscape and image (O'brien 1997), promote economic development (Binns and Nel 2002) and provide people with a comfortable and healthy environment for recreation and relaxation (Kostopoulou 2013; Cheung and Tang 2015). However, most previous studies on performance-based planning have mainly concentrated on addressing environmental challenges such as climate change, air and water pollution and urban flooding (Pelorosso 2020; Eggermont et al. 2015). For instance, the SCS developed provisions and assessment framework for implementing the performance-based water planning in Australia for water conservation, urban flooding control and stormwater quality improvement (SCS 2019). In Melbourne of Australia, Rauch et al. concentrated on the optimal position for water infrastructures with the consideration of societal and biophysical properties in the city (Rauch et al. 2017). Contextualised in Ma'anshan of China, Gao et al. investigated the optimal combinations of best practices to manage water infrastructures, with the consideration of cost, water pollution reduction and urban flooding alleviation (Gao et al. 2015). Viavattene and Ellis focused on the suitable locations the flooding mitigation strategies should apply to and the best combinations of such strategies for optimal performance in the context of Birmingham in the UK (Viavattene and Ellis 2013).

Nevertheless, the consideration of techniques and strategies in existing studies can only ensure them to fulfill the environmental performance of water infrastructures, while the social functions of the waterfront spaces are difficult to guarantee. Therefore, to ensure the efficient and effective performance of urban waterfront spaces (Frew et al. 2016), it is essential to understand if they can meet the requirements of social functions. With such, urban planners and designers can have a holistic vision towards the urban waterfront space planning and design, which is a critical requirement for either nature-based solutions or performance-based planning (Frantzeskaki 2019). Through this way, urban planners and designers can potentially reduce the possibility of misunderstanding some strategies and techniques for achieving social functions (Pelorosso 2020).

Therefore, for facilitating better planning and design of urban waterfront spaces, this study aims to understand the social performance of urban waterfront spaces. The objectives of this paper are to (1) obtain the information of citizens' preference to the urban waterfront spaces for socio-economic activities, (2) to analyse citizens' attitudes towards the social outcomes and (3) to understand citizens' preference of upgrading the infrastructures of the urban waterfront spaces. This study is conducted via field observation and questionnaire survey within the context of Qiantang riverside in Hangzhou, China. Overall, this study can add urban planners' and designers' knowledge of the social performance of existing urban waterfront spaces and further provide the opportunities to comprehensively build sustainable, resilient and healthy water-based living environments with the inclusive consideration of environmental, social and economic performance. The remainder of this paper is structured as follows. The "Case study area" section presents the case study area of Qiantang riverside in Hangzhou, China. The "Research methods" section indicates the research methods of this paper; after which, the "Results and analysis" section analyses the results obtained from the questionnaire as a response to the three objectives in this paper. Afterwards, the "Discussion and implications" section discusses this paper and the "Conclusion" section concludes this paper.

## Case study area

This study is conducted in the city of Hangzhou (30° 15′ 39″ N, 120° 15′ 26″ E), Zhejiang Province, China (Fig. 1). Zhejiang Province is one of the richest provinces in China and its urbanisation has reached a high level (exceeding 68% in 2018). The socio-economic pattern, on the one hand, indicates people's basic living demands have been satisfied and people have a higher pursuit of better living quality. On the other hand, the goals of urban development in Zhejiang Province have been shifting towards creating sustainable, resilient, healthy living environments from traditionally upgrading urban infrastructures. As a result, ongoing urban planning and design should be dedicated to focusing on improving urban environmental quality and meeting socio-economic requirements of citizens.

Hangzhou, the capital city of Zhejiang Province, is a very prosperous city in the Yangtze River Delta. It is also the core of the Hangzhou metropolitan area, consisting of 10 districts, one county-level city, and two counties. Meanwhile, Hangzhou is a populous city, where the 10 districts with an area of 8292.31 km$^2$ accommodate 8.24 million people (about 990 people/km$^2$). In particular, the six urban districts witness a much higher urban population density, with 706.27 km$^2$ holding a population of 3.78 million (about 5350 people/km$^2$). The high population density has driven the replacement of urban natural land with manmade surfaces and brought significant challenges to urban environments (e.g. urban flooding, urban heat island effect) and further citizens' living quality.

Nevertheless, Hangzhou is a pioneering city embarking to reverse such situations. In particular, the local governments have released regulations and policies to promote urban greening and low-impact development. Fortunately, these urgent actions have taken into effects and natural environments have been significantly improved. For instance, the urban greening rate has been improved to 40.2%, the urban forestry coverage has been improved to 65.54% and the public green area per capita has been improved to 15.1 m$^2$. Accordingly, Hangzhou has been certificated as the 'National ecological garden city' among 300 'National garden cities'. These governmental efforts indicate the transitions of urban development and governance philosophy and practices. Such urban circumstances, therefore, enable us to further focus on the interaction between urban natural landscapes and citizens, namely the social performance of urban natural landscapes.

This study will focus on urban waterfront spaces for performing the analysis of the social performance of urban natural landscapes, as water landscape is a typical urban landscape in Zhejiang Province. In particular, the Qiantang River, alternatively known as 'Zhe River' and 'Zhe Jiang', is the origin of the name of Zhejiang Province. The most famous section of the Qiantang River relevant to the tide view is situated in Hangzhou city. Moreover, the riverside walkway is developed along the Qiantang River to provide people with a leisure, tourism and entertainment place that integrates landscape and ecology. Meanwhile, with the consideration of urban environmental problems, the riverside walkway is also aimed to create a healthy, comfortable and pleasant living environment for residents.

The riverfront walkway is built on both banks (with the depth of 500–1000 m) of the Qiantang River. The north bank starts from the no.1 Qiantang River Bridge on the west and
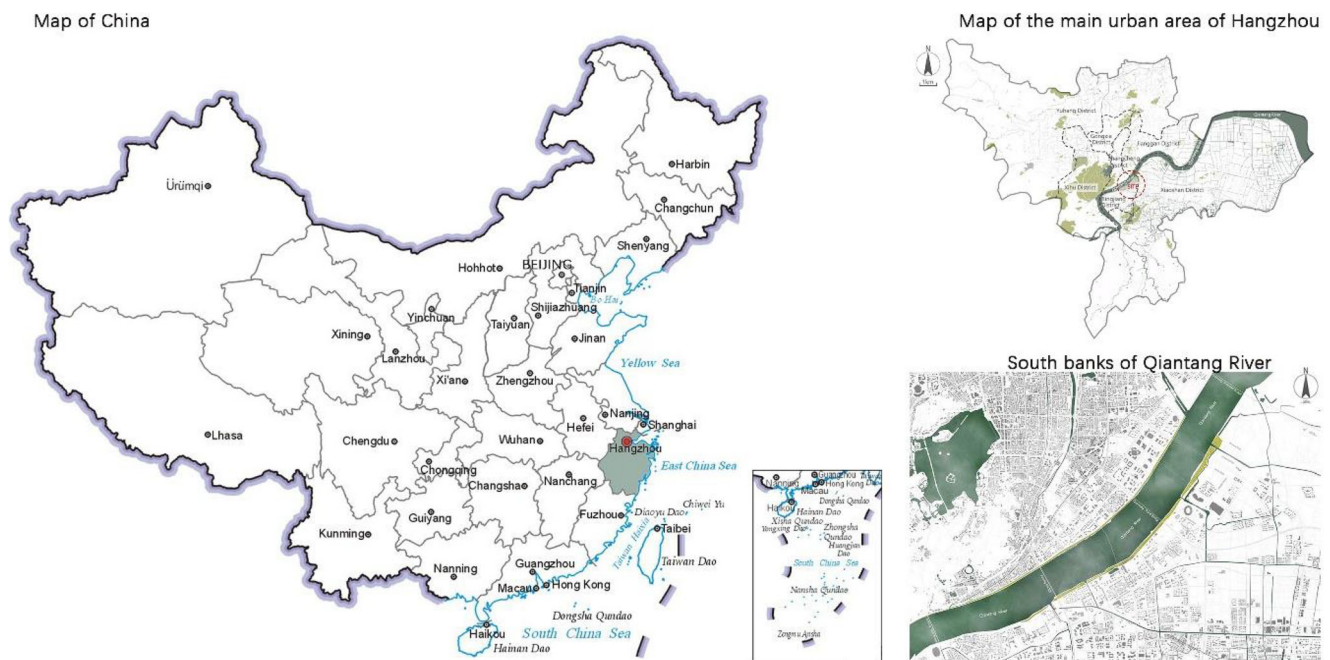


**Fig. 1** The location of Hangzhou, China, and the case study area Qiantang riverside walkway

ends at no.2 Qiantang River Bridge on the east. In comparison, the south bank is situated between no.1 Bingjiang Road (west side) and no.3 Qiantang River Bridge (east side). Overall, the Qiantang riverside landscape can be divided into three sections from the west to the east: natural landscape (on the west side of Baita), the transition from the natural landscape to urban landscape (between Baita and Fuxing Bridge) and the urban landscape (between Fuxing Bridge and no.3 Qiantang River Bridge). In particular, in the urban landscape section, there is a central business district between the no.1 and no.2 Qiantang River Bridge.

The case study area ranges between no.3 and no.4 Qiantang River Bridge in the west-east direction and ranges between the Qiantang River and Wentao Road in the north-south direction, having a length of 3800 m and an area of 42.3 ha. In such an area, there are many high-end office buildings, commercial and residential building, and commercial blocks. This area also presents a mature landscape aiming to create a tourism city complex that focuses on tourism and integrates functions of culture, living, leisure, entertainment, communication and business. It should be mentioned that the Qianjiang Long Binjiang Park, with a diameter of 60 m, is the central node of the case study area. It is a centralised place for leisure, entertainment and tide viewing through a circular enclosure. Moreover, the Qianjiang Dragon Sculpture is a landmark icon of this park.

Overall, this waterfront space makes full use of the existing terrain and has designed double-layer viewing sheds to provide citizens with ideal places for entertainment, sightseeing and relaxation. From the dawn of the morning, some fitness people are running on the green fitness track or practising aerobics in a small area. At noon, residents and people working in surrounding office buildings come to take a walk or have a rest. In the evening, the study area can be densely populated, where most people come to enjoy the evening breeze and the night view of the city.

## Research methods

Overall, this study adopts methods of field investigation and questionnaire survey to understand the social performance of urban waterfront spaces. The specific descriptions of field observation and questionnaire survey are presented as follows.

### Field investigation

Since the case study area is an area for tourism and integrates leisure, entertainment, culture and living functions, citizens' activities are complex to describe, especially with the consideration of time dependence of citizens' activities. Therefore, to have an overall understanding of the social performance of the urban waterfront space, the researchers conducted field observation to assess citizens' activities patterns. We divided the field investigation into three time periods including morning (7:50–8:50), around noon (12:00–15:00) and night (19:30–20:50). In particular, it should be noted that the field investigation was performed between April and May 2020. During such period, the outdoor activities are limited with the governmental advocacy of staying at home due to the COVID-19 virus. Nevertheless, people's activities in the case study area could reflect citizens' strong preferences to the usage of such public spaces.

### Questionnaire survey

The questionnaire was further designed to understand the social performance of urban waterfront space by understanding people's attitudes and preference. Considering the complex functions of the case study area, the questionnaire was carefully designed. There are five sections in this questionnaire. The first and second sections aim to collect the basic information of respondents and acquire their representative activity patterns in this case study area.

Moreover, the third section is designed to investigate the quality of the urban waterfront space. These components in the urban waterfront space were divided into five parts including the landscape, public service, main facilities, supporting facilities and road functions. In each part, concerns are relevant to various aspects such as the layout, quantity, safety and type. Also, each question was five-point based, where 1 represents poor, 2 fair, 3 average, 4 good and 5 excellent.

Afterwards, the fourth section concerns the overall quality of the urban waterfront space. It consists of questions such as transport connectivity with the city, linkage with city characteristics, user's quality and cultivation, space personality and the quality of green belt in isolating freeway. Likewise, each question was five-point based like above.

The fifth section solicits respondents' opinions on the renovation of the case study area. The questions are relevant to the increase in indoor leisure space, the increase in theme exhibition or shows, the increase in E-vehicle and the increase in large business services. The questions are five-point based, where 1 represents strongly disagree, 2 disagree, 3 average, 4 agree and 5 strongly agree. The option of 1—strongly disagree—indicates the respondents are satisfied with the current settings of the urban waterfront space, while the option of 5—strongly agree—indicates respondents are not satisfied with the current settings.

The survey was conducted in April and May 2020. To reduce the contact between different respondents due to the COVID-19, the questionnaire survey was conducted at the mobile phone end rather than face-to-face ways. Overall, we received responses from 179 respondents, while only 102 samples were valid as some samples were incomplete.

## Data analysis

This study mainly analysed the frequency of the responses from the citizens in order to have a detailed understanding of the social performance of the Qiantang riverside walkways. Moreover, the average score of different components was calculated for comparing respondents' satisfaction towards the performance of different aspects. During this process, the one-sample *t* test was used to make sure whether the average score of each factor was significant or not. Moreover, the comparative analysis was conducted through the independent *t* test to examine whether there were significant differences between similar aspects (e.g. rest seat quantity, rest seat style). If the results from the comparative analysis were not significant, the similar aspects could be considered as a cluster in the urban planning and design.

## Results and analysis

### Field observation of people' activity in the Qianjiang riverside walkway

Before the questionnaire survey, we conducted the field observation to examine people's activity in the Qiantang riverside walkway. A set of images were taken to illustrate the real scenarios of people activity, as given in Fig. 2.

Overall, the field observation indicates there were significantly temporal differences in people's activity. In the morning (6:00–8:00), there were a few people doing morning exercises in the square and children entertainment areas. There was a slight increase in the people who were doing morning exercises, especially in the square between 9:00 and 12:00, while other people were mainly under tree shades. Between 12:00 and 14:00, as well as between 14:00 and 17:00, the occurrence of people who were playing decreased, while there could still be found some people having rest under the dense tree shades, as well as the vehicle on the road. In the night, between 19:30 and 20:50, many people were exercising and entertaining in the children entertainment area, square and the main road.

### Basic information of respondents

A total of 102 respondents were surveyed via mobile phone end with the questionnaire of the social performance of the Qiantang riverfront walkway. Table 1 presents the basic information of all respondents. The questionnaire consists of 38 men (37.3%) and 64 women (62.7%), which may indicate women group was about 2 times the men group in presence in the riverfront walkway. Concerning the age of interviewees, three groups of 18–24, 25–34 and 35–59 accounted for 98% of all respondents. The age group of 18–24 accounted for the largest proportion (36.3%), slightly higher than the proportion (34.3%) of the people who were between 35 and 59 years old. The proportion of the people aged 25–34 was 27.5%. Such results indicate there was no obvious stratification in the age groups. For the education background, there were obvious differences among different levels, where most people (50.0%) held the undergraduate education background, followed by the people (31.4%) who had the senior high education. People who had a postgraduate or above education and people who received other forms of education (i.e. vocational education) accounted for 5.9% and 12.7%, respectively. However, no respondent fell into the group of junior or below education background.

On the living distance from the case study area, people who lived very far (> 10 km) accounted for the largest proportion (31.4%). For the remaining respondents, their living distance can be divided into four groups with similar proportion, such as 18.6% for not too far (1–2 km), 17.6% for relatively far (5–10 km), 17.6% for moderated (2–5 km) and 14.7% for very close (< 1 km), respectively. The results evidence the Qiantang riverside walkway played a mixed role in city tourism and local leisure and entertainment.

### Transportation pattern and activities of respondents

Figure 3 present respondents' behaviours in terms of the way to come and their activities in the Qiantang riverside walkway. Regarding the transportation pattern, 31.4% of people came here through self-driving. This is followed by the people (28.4%) who came here by bus, and then cycling (22.5%) and walking (12.7%). 4.9% of people came here depending on the taxi. It is found that the proportion (31.4%) of people who selected self-driving was equivalent to the proportion (31.4%) of the people who lived very far from here (Table 1). The sum of proportion (35.2%) of the people who selected cycling and walking was similar to the proportion (33.3%) of the people who lived within 2 km (Table 1). For the frequency coming here, most people (52.9%) come with a frequency of lower than average, with 35.3% for low frequency and 17.6% for extremely low (rare) frequency, respectively. People who come here with an average frequency and those who often come here accounted for 22.5% and 21.6%, respectively. Only 2.9% of people came to the study area very frequent.

According to the time that people generally come here, the proportion gradually increased from the morning to night. In particular, at night (after 18:00), the proportion (47.1%) of visitors reached the peak, about three times the proportion of the visitors in the period of 14:00–17:00 (18.6%), 12:00–14:00 (14.7%) and 9–12 am (13.7%). The presence of people obtained through the questionnaire survey was consistent with the results presented in the field observation. People who came here before 8 am only accounted for 5.9%. On the time

Fig. 2 The field observation of people's activity in the Qiantang riverside walkway



6:00-8:00 am

9:00-12:00 am

12:00-14:00 pm

14:00-17:00 pm

19:30-20:50 pm

duration, most people (66.7%) stayed here less than 60 min, where 41.2% of people stayed here for 30–60 min and 25.5% of people stayed here for 15-–30 min. Following this, 23.5% could stay here for 1–2 h, while very few people could stay here for 2 h (3.9%) or more than 3 h (5.9%).

For the setting of rest space, most people (51.0%) suggested reasonable distance should be 250–500 m, while 26.5% of the people thought it would be reasonable to set rest spaces in 250 m. The distance of 500–750 m could be reasonable for 9.8% of the respondents, 750–1000 m for 11.8% of the respondents and more than 1000 m for only 1% of the respondents. People who came here for walking and breathing fresh air accounted for 38.2%, followed by the proportion (27.5%) of the people who came for exercising and then 16.7% of the respondents came for tourism. It should be noted

that no one purely came for a bath in the sun, while 17.6% of the respondents came for other purposes. More than 90% of the respondents came here with less than three people, where 42.2% came with other two, 25.5% with only one and 23.5% came solely. Such results indicate the Qiantang riverside walkway was not for group reunion or activities.

## Satisfaction level to the settings of the Qiantang riverside walkway

This section presents respondents' preference and attitudes towards the components of the Qiantang riverside walkway in terms of landscape, public service, main facilities, supporting facilities and road functions.

**Table 1** The basic information of respondents

|  | No. | Frequency (%) |
|---|---|---|
| Gender |  |  |
| Male | 38 | 37.3 |
| Female | 64 | 62.7 |
| Age |  |  |
| 12–17 | 2 | 2.0 |
| 18–24 | 37 | 36.3 |
| 25–34 | 28 | 27.5 |
| 35–59 | 35 | 34.3 |
| > 60 | 0 | 0.0 |
| Education |  |  |
| Junior or below (below nine grades) | 0 | 0.0 |
| Senior high | 32 | 31.4 |
| Undergraduate | 51 | 50.0 |
| Postgraduate or above | 6 | 5.9 |
| Others | 13 | 12.7 |
| Living distance from here |  |  |
| Very far (> 10 km) | 32 | 31.4 |
| Relatively far (5–10 km) | 18 | 17.6 |
| Moderated (2-5 km) | 18 | 17.6 |
| Not too far (1–2 km) | 19 | 18.6 |
| Very close (< 1 km) | 15 | 14.7 |

highest among six aspects, followed by satisfaction level (4.06) of vegetation type, and then that of sculpture or landmark style (4.05), large area lawn (4.03) and tall tree cultivation (4.02). However, the score of the sculpture or landmark quantity was the lowest but still reached 3.97. This indicates the necessity to improve the sculpture or landmark style for better satisfaction level.

A further analysis was conducted to examine the frequency of different level of responses to six aspects. The 'excellent' score of the greening quantity was 39.2%, the highest proportion of the 'excellent' score among six aspects, and the 'good' score of the greening quantity was 37.3%, ranking the third-highest among the 'good' score among six aspects. In comparison, vegetation type had the highest proportion (47.1%) of 'good' score among six aspects and it received the lowest 'excellent' score (32.4%) among six aspects. The proportion of 'good' and 'excellent' score of the remaining aspects all exceeded 30%, apart from the proportion (29.4%) of 'good' score of large area lawn. In addition, the sculpture or landmark style received the highest 'fair' score (8.8%) among six aspects and the tall tree cultivation received the highest 'average' score (22.5%) among six aspects. Such results have scrutinized the reason resulting in the lowest satisfaction level of sculpture or landmark style and the second lowest satisfaction level of tall tree cultivation.

## Satisfaction level of landscape

Figure 4 illustrates respondents' sanctification level to the landscape, such as the greening quantity, vegetation type, sculpture or landmark style, sculpture or landmark quantity, large area lawn and tall tree cultivation. Respondents generally had a good satisfaction to the settings of landscapes, as the average satisfaction level of six aspects was all-around 4.00. The satisfaction level (4.09) of greening quantity was the

## Satisfaction level of public service

Table 2 presents respondents' response to the public service and whether the public service can meet respondents' requirements. The satisfaction level ranged between average and good, as the average scores of 15 aspects all ranged between 3.61 and 3.89.

1—poor, 2—fair, 3—average, 4—good, 5—excellent; sig (2-tailed) was obtained based on $t$ test



**Fig. 3** Respondents' behaviours in terms of the way to come and their activities
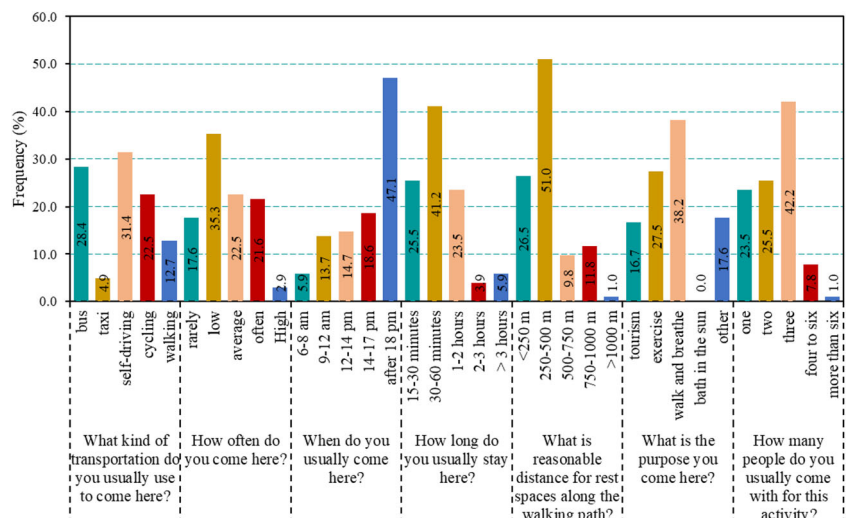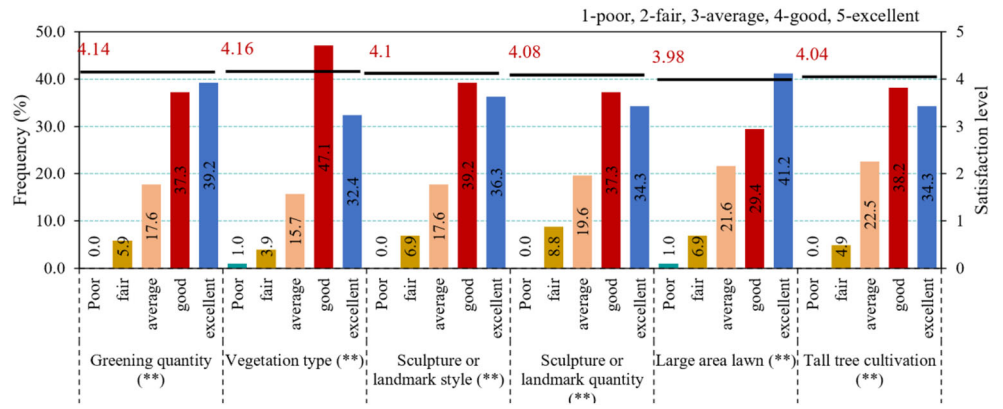
**Fig. 4** Satisfaction level of landscape among 102 respondents (double asterisks indicate the data with significant results according to one-sample $t$ test ($p < 0.01$) (2-detailed))



The overall satisfaction level indicates the necessity of improving public services, especially the quantity of public bathroom (3.61 scores). Moreover, the average score of 15 aspects indicates the stratification and agglomeration of respondents' satisfaction. For instance, information signs in terms of clarity and quantity had the highest scores of 3.89 and 3.84 among 15 aspects. Trash bin received 3.78, 3.76 and 3.75 in terms of quantity, style and location, ranking at 3rd, 4th and 5th place, respectively. The rest seat received 3.74 and 3.72 in terms of quantity and style, ranking the 6th and 8th, respectively. The setting of the public bathroom was not reasonable, with its style, location and quantity receiving 3.70, 3.64 and 3.61, ranking at 10th, 13th and 15th, respectively.

A further scrutinisation to the frequency of different responses indicated that only the proportion of 'excellent' score in information (e.g. quantity, clarity) reached 30%. The rest seat received the lowest proportion of 'excellent' score (25.5% and 22.5% in quantity and style, respectively), but it received the highest proportion of 'good' score (34.3% and 37.3% for quantity and style, respectively) which held the overall rank of rest seat in the middle place. For the items that received the lowest rank, such as the public bathroom, parking lot and

**Table 2** Satisfaction level of public service in terms of rest seat, public bathroom, service kiosk, trash bin, information signs and parking lot

| Question | Frequency of responses (%) (n=102) | | | | | Mean | SD | Rank | Sig. |
| | 1 | 2 | 3 | 4 | 5 | | | | (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| rest seat (quantity) | 1.0 | 9.8 | 29.4 | 34.3 | 25.5 | 3.74 | 0.98 | 6 | 0.000 |
| rest seat (style) | 0.0 | 9.8 | 30.4 | 37.3 | 22.5 | 3.72 | 0.94 | 8 | 0.000 |
| public bathroom (quantity) | 2.0 | 16.7 | 25.5 | 30.4 | 25.5 | 3.61 | 1.10 | 15 | 0.000 |
| public bathroom (location) | 1.0 | 14.7 | 30.4 | 27.5 | 26.5 | 3.64 | 1.06 | 13 | 0.000 |
| public bathroom (style) | 1.0 | 10.8 | 31.4 | 31.4 | 25.5 | 3.70 | 1.00 | 10 | 0.000 |
| service kiosk (quantity) | 3.9 | 7.8 | 25.5 | 34.3 | 28.4 | 3.74 | 1.07 | 6 | 0.000 |
| service kiosk (location) | 2.9 | 7.8 | 31.4 | 31.4 | 26.5 | 3.70 | 1.05 | 10 | 0.000 |
| service kiosk (style) | 2.9 | 5.9 | 36.3 | 29.4 | 25.5 | 3.69 | 1.01 | 12 | 0.000 |
| trash bin (quantity) | 2.0 | 8.8 | 27.5 | 33.3 | 28.4 | 3.78 | 1.02 | 3 | 0.000 |
| trash bin (location) | 2.0 | 7.8 | 32.4 | 29.4 | 28.4 | 3.75 | 1.02 | 5 | 0.000 |
| trash bin (style) | 3.9 | 6.9 | 27.5 | 33.3 | 28.4 | 3.76 | 1.07 | 4 | 0.000 |
| information signs (quantity) | 1.0 | 7.8 | 28.4 | 31.4 | 31.4 | 3.84 | 0.99 | 2 | 0.000 |
| information signs (clarity) | 0.0 | 6.9 | 28.4 | 33.3 | 31.4 | 3.89 | 0.93 | 1 | 0.000 |
| parking lot (bicycle) | 0.0 | 12.7 | 33.3 | 24.5 | 29.4 | 3.71 | 1.03 | 9 | 0.000 |
| parking lot (vehicle) | 2.0 | 14.7 | 32.4 | 21.6 | 29.4 | 3.62 | 1.12 | 14 | 0.000 |

Note: 1-poor, 2-fair, 3-average, 4-good, 5-excellent; sig (2-tailed) was obtained based on t-test.

service kiosk, more than 43% of the respondents thought public bathroom failed to perform well, where the 16.7% and 14.7% of the respondents thought quantity and location of the public bathroom could only perform fairly. The parking lot could only perform fairly among 12.7% (bicycle) and 14.7% (vehicle) of respondents.

## Satisfaction level of the main service

Figure 5 demonstrates respondents' satisfaction degree towards main service as well as the detailed responses to six aspects, such as children entertainment facilities (quantity, safety), elderly activity facilities (quantity, safety) and fitness facilities (quantity, type). The satisfaction degree of supporting service ranged between 3.67 and 3.78, indicating the main service could not perform well generally. There was no obvious difference among six aspects, where the fitness facility type had the highest satisfaction degree (3.78), only slightly higher than the lowest satisfaction degree of 3.67 received by the quantity of children entertainment facilities. In addition, the satisfaction level also exhibited the phenomenon of stratification and agglomeration, where the quantity (3.77) and type (3.78) of fitness facilities ranked the highest, while the children entertainment facilities ranked the lowest in both quantity (3.67) and safety (3.69).

The detailed responses to six aspects of main facilities indicate that people could have diverse responses to their performance, where the proportion of 'average', 'good' and 'excellent' groups all exceeded 25%. Nevertheless, in terms of the safety of children entertainment facilities, the number of elderly activity facilities and the safety of elderly activity facilities, people who thought the public service only reach an average level in performance accounted for the highest proportion, about 35.3%, 35.3% and 39.2% in value, respectively. Nevertheless, most people (about 55%) thought that such aspects could perform well or the best in meeting their requirements. Moreover, for the quantity of children entertainment

facilities, 17.6% of the respondents thought it was fair to meet the requirements.

## Satisfaction level of supporting service

The supporting service was considered in terms of lighting (e.g. type, intensity, aesthetics) and accessible facilities. The survey results are presented in Fig. 6. Respondents generally had 'good' satisfaction with the supporting facilities, especially for the lighting intensity (4.04) and aesthetics (4.04). Meanwhile, the scores of lighting type and accessible facilities approached to 4.0, roughly indicating people thought the lighting type and accessible facilities performed well. A further track of the detailed response indicated that most people were satisfied with supporting services as the proportion of 'good' and 'excellent' groups exceeded 72%. Nevertheless, there were 19.6% (lighting type), 14.7% (lighting intensity), 17.6% (lighting aesthetics) and 20.6% (accessible facilities) of the respondents who thought the supporting services only performed at an 'average' level. In comparison, less than 8% of the people ranked the supporting facilities at the 'poor' and 'fair' level.

## Satisfaction level of road functions

Figure 7 presents respondents' response to the road functions and whether the road functions can meet respondents' requirements. The results overall suggest that most people thought the road could well fulfill their functions, with a satisfaction level of 4.04 for pavement texture, 4.05 for pavement colour, 4.08 for pavement width and 4.10 for walkway route reasonability. Moreover, there were slight differences in the degree of satisfaction towards different aspects. Further analysis of the detailed responses to the road functions indicates most people (> 75%) ranked the road performance at 'good' and 'excellent' levels. Yet still, 17.6% (pavement texture), 19.6% (pavement colour), 18.6% (pavement width) and 16.7%



**Fig. 5** Satisfaction level of the main service among 102 respondents (double asterisks indicate the data with significant results according to one-sample $t$ test ($p < 0.01$) (2-detailed))
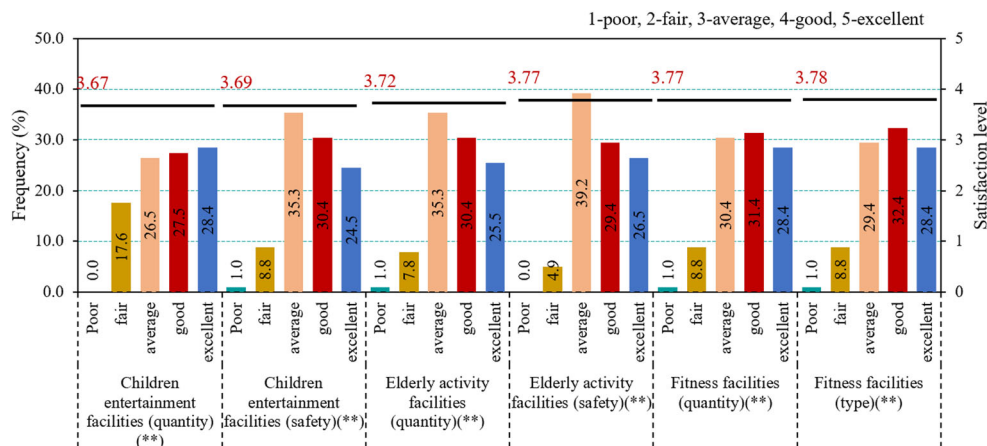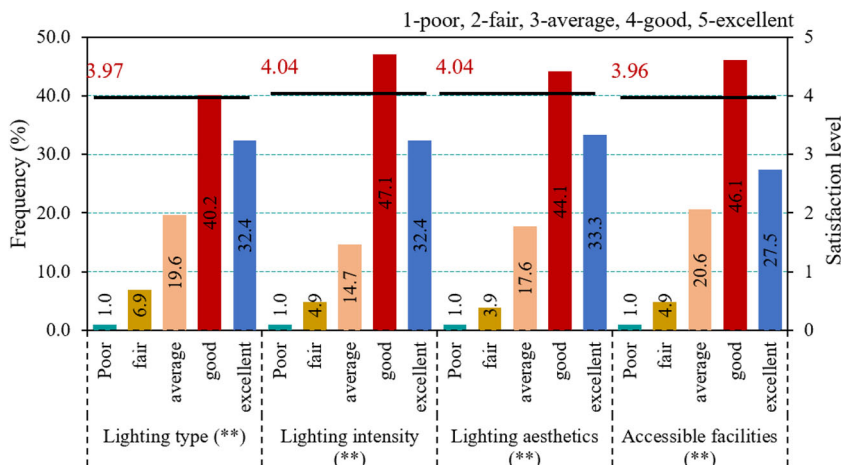
Fig. 6 Satisfaction level of supporting service among 102 respondents (double asterisks indicate the data with significant results according to one-sample $t$ test ($p < 0.01$) (2-detailed))



(walkway route reasonability) of the respondents thought the road could only obtain 'average' satisfactions. Fortunately, less than 5% of the respondents thought the road performed poorly or fairly.

## Assessment of the overall quality of the Qiantang riverside walkway

The interviewees were also invited to assess the overall quality of the Qiantang riverside walkway in terms of the transport connectivity with the city, linkage with the city characteristics, users' quality and cultivation, space personality and quality of green belt in isolating freeway. Figure 8 presents respondents' attitudes towards such aspects. The results indicate the Qiantang riverside walkways had a 'good' linkage with city characteristics, with an average score of 4.02. At the same time, the urban waterfront space studied could well exhibit its space personality, having different characteristics and forming specific atmospheres from other tourism spaces, with

an average score of 4.02. The transport overall could not perform well in connecting the city with the Qiantang riverside walkway, with an average score of 3.84. Respondents thought the setting of the green belt performed well to isolate freeways surrounding the Qiantang riverside walkway, with an average score of 4.17. Such results may indicate the quality of the Qiantang riverside walkway was affected significantly by the freeway (e.g. safety, noise, air pollution). Respondents also indicate visitors had good quality when using the Qiantang riverside walkway, with an average score of 4.02.

The detailed responses to each aspect indicated that the people who thought 'green belt' had the 'excellent' performance accounted for the largest proportion of 44.1%, followed by the 'user's quality and cultivation' (39.2%), and then 'linkage with city characteristics' (35.3%), 'space personality' (31.4%) and 'transport connectivity with the city' (28.4%). Space personality received the highest proportion of 42.2% in 'good' ranking, followed by the proportion (37.3%) of user's quality and cultivation and that (37.3%) of linkage with

Fig. 7 Satisfaction level of road functions among 102 respondents (double asterisks indicate the data with significant results according to one-sample $t$ test ($p < 0.01$) (2-detailed))
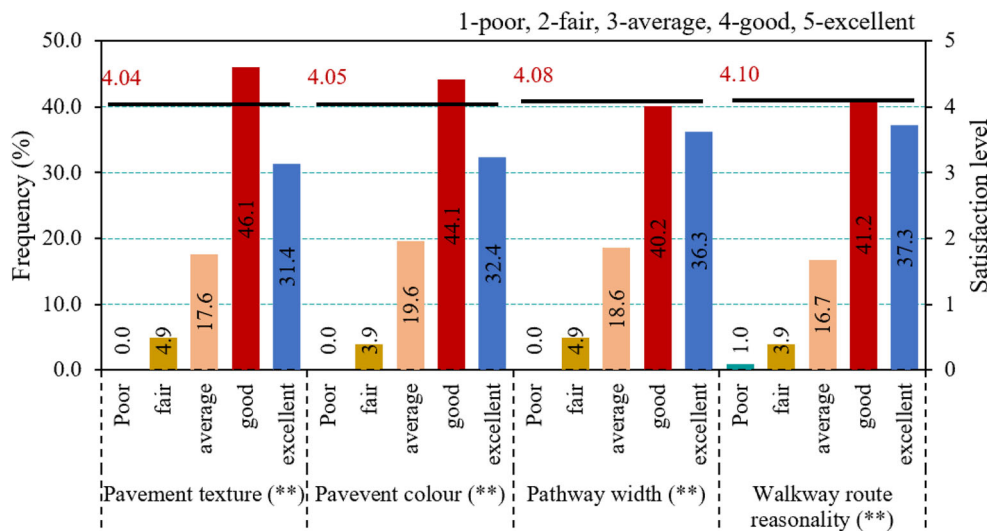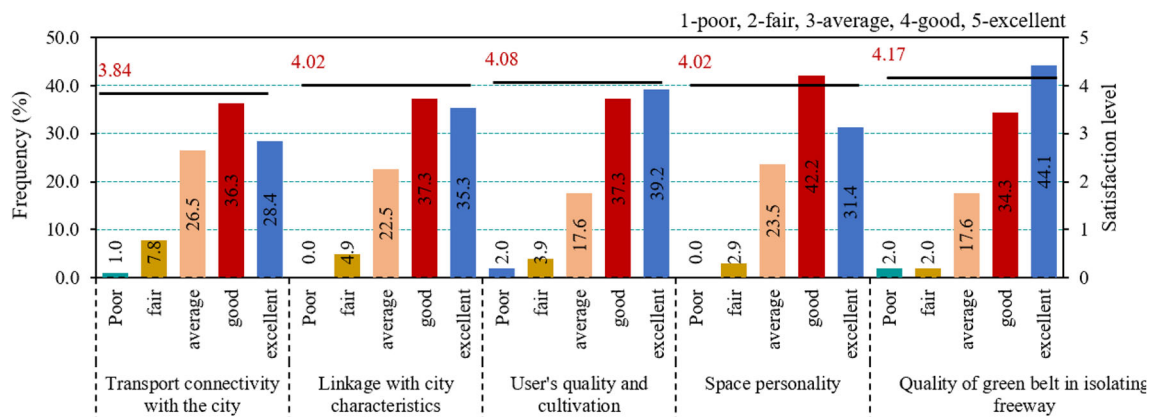
**Fig. 8** Satisfaction level of overall quality among 102 respondents

city characteristics. Regarding the transport connectivity with the city, 26.5% of the respondents thought that the transport connectivity performed averagely and 7.8% of the respondents thought the transport connectivity only performed fairly, all the highest among five aspects.

### Opinions on the renovation of the Qiantang riverside walkway

Further analysis of citizens' responses to the renovation of the Qiantang riverside walkway was conducted in terms of increases in indoor leisure space, increases in theme exhibition or shows, increases in E-vehicle and the increases in large business services, as illustrated in Fig. 9. The results indicate that people had a strong preference for the increase in indoor leisure space (4.20) and the increase in theme exhibition or shows (4.12). The people who strongly thought indoor leisure space was essential accounted for 41.2% and those who agreed accounted for 33.3%. Regarding the increase in theme exhibition or shows, 41.2% of the respondents strongly agreed and 31.4% agreed. For the increase in E-vehicle, most people (53.9%) thought it was essential. However, the people who

had an average need accounted for the highest proportion of 31.4%, while 8.8% and 5.9% of the respondents disagreed and strongly disagreed, respectively. For the business services, the score of 3.90 was also not sufficient to support the conclusion of the agreement or strong agreement, as 7.8% and 4.9% of the respondents strongly disagreed and disagreed, respectively. Meanwhile, 25.5% of the respondents had an average need.

### Discussion and implications

The social performance of the urban waterfront space was analysed through the field work and questionnaire survey in the case study area of the Qiantang riverside walkway in Hangzhou, China. This study reveals the diverse performance of components in the Qiantang riverside walkways that should meet different requirements of citizens in terms of leisure, tourism and entertainment. For instance, some categories could not well perform in meeting citizens' satisfaction; therefore, a need for improvement in such aspects is required. According to the results of the questionnaire survey, several critical issues should be discussed as follows.

**Fig. 9** Respondents' opinion on the renovation of Qiantang riverside walkway
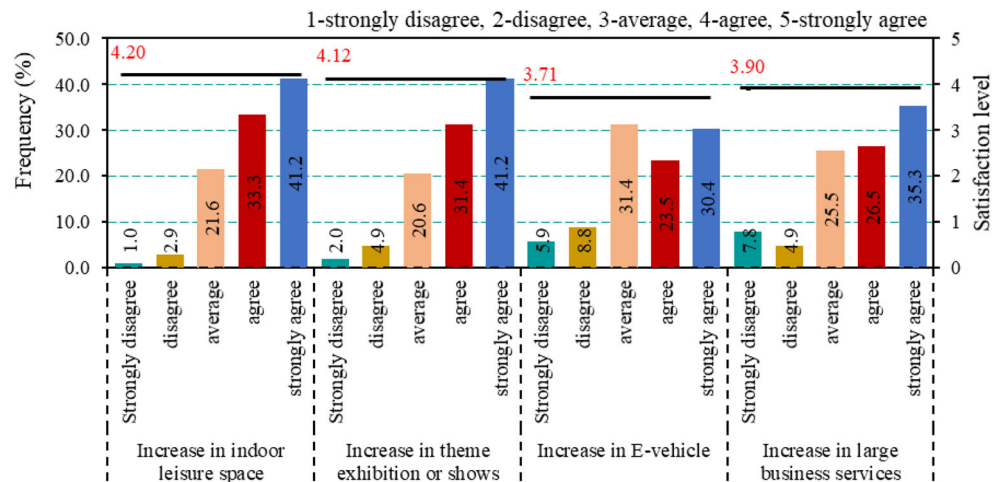
## Comparison of the satisfaction degree of different categories

The results indicate that different components in the Qiantang riverside walkways exhibit different performance. An overall comparison of different categories in terms of landscape, public service, main service, supporting service and road function is shown in Fig. 10. The landscape, supporting service (lighting) and road functions could well meet citizens' requirements. This indicates the Qiantang riverside walkway had been well designed to fulfill tourism functions. This could be attractive for the visitors who lived more than 5 km away from the case study area. However, the problem in aspect of the transport linkage with the city (3.84) was a critical problem deterring visitors' feeling for the people who depended on self-driving or cycling. The problem relevant to the transportation was also evidenced by the low satisfaction of respondents in terms of the parking lot (e.g. bicycle, vehicle).

In comparison, the public service and main service performed above average level while it could reach a good level. Such results may reflect the Qiantang riverside walkway could not work well on site, not only for visitors who come for tourism but also for local people who come for leisure and entertainment. For the tourists, for example, only the setting of information signs was good to direct them to the right location. Moreover, the tourists may have some specific requirements on the public bathroom, service kiosk, rest seat and parking lot, while such public service could not perform well. This can also be reflected by the people's strong need for the indoor leisure space. Moreover, for the local people, they may have a strong reliance on the public service, such as the children entertainment facilities, elderly activity facilities and fitness facilities, while such service could not reach the good level.

The landscape that could meet people's requirements at the 'good' level may result from the increasing efforts to improve the city greenery from the government. Meanwhile, the setting of sculpture or landmark worked well, while there was still a strong need for the theme exhibition or shows. Moreover, the planning and design of the landscape had made the Qiantang riverside walkway perform well in the linkage with city characterics and space personality. For the supporting services, people were generally satisfied with the night lighting, especially when most people come after 18:00. The road functions were also good for people's walking, breathing fresh air and exercising. The high satisfaction degree towards the road functions also lowered the requirements in the increase in E-vehicle. The function of tourism, leisure and entertainment may also defer the increase in large business service. People were satisfied with the trash bin in terms of quantity, location and style, also corresponding to the results that most people thought the user's quality and cultivation.

## Stratification and agglomeration

In the analysis, the phenomenon of stratification and agglomeration was observed that the same cluster could obtain a similar satisfaction degree. For instance, the quantity and style of rest seat had the satisfaction levels of $6^{th}$ and $8^{th}$ and the quantity, location and style of the public bathroom all performed the worst, ranking at $15^{th}$, $13^{th}$ and $10^{th}$ place. Therefore, a further examination of the phenomenon of the stratification and agglomeration was conducted through independent $t$ test. The results are shown in Table 3. The results further indicate aspects in the same cluster did not exhibit significant difference and evidence the occurrence of stratification and agglomeration. The occurrence of stratification and agglomeration could have significant implications for the planning and design of the Qiantang riverside walkways, as the complexity caused by the quantity and social requirements (e.g. aesthetic, personal feeling).

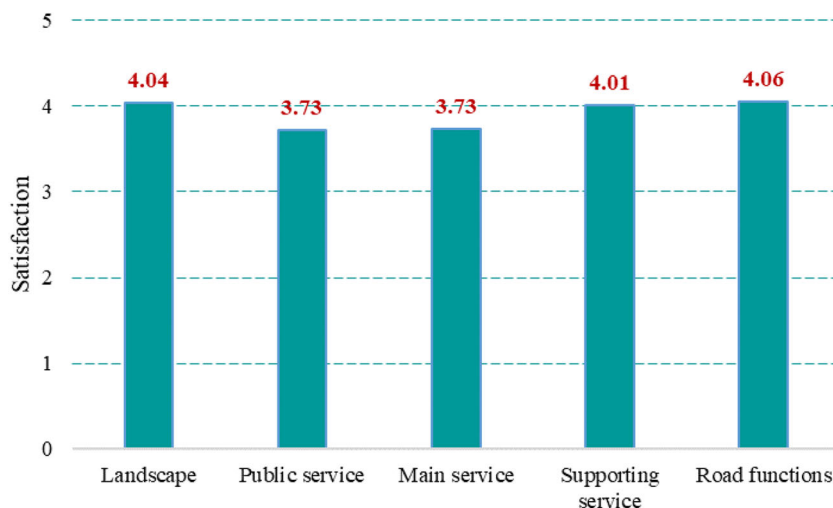**Fig. 10** Comparison of the overall satisfaction degree of five categories

**Table 3** The significance (2-tailed) among similar aspects in the independent *t* test

| Comparison | Levene's test for equality of variances (sig. (2-tailed)) | Significance (2-tailed) | Difference |
|---|---|---|---|
| Greening quantity and vegetation type | 0.220 | 0.749 | Insignificant |
| Sculpture or landmark (quantity & style) | 0.644 | 0.546 | Insignificant |
| Large area lawn and tall tree | 0.120 | 0.941 | Insignificant |
| Rest seat (quantity and style) | 0.510 | 0.942 | Insignificant |
| Public bathroom (quantity and location, location and style, quantity and style) | 0.714, 0.369, 0.217 | 0.846, 0.684, 0.550 | Insignificant |
| Service kiosk (quantity and location, location and style, quantity and style) | 0.937, 0.842, 0.788 | 0.741, 0.892, 0.640 | Insignificant |
| Trash bin (quantity and location, location and style, quantity and style) | 0.833, 0.922, 0.769 | 0.837, 0.947, 0.894 | Insignificant |
| Information signs (quantity and clarity) | 0.446 | 0.717 | Insignificant |
| Parking lot (bicycle and vehicle) | 0.308 | 0.558 | Insignificant |
| Children entertainment facilities (quantity and safety) | 0.132 | 0.892 | Insignificant |
| Elderly activity facilities (quantity and safety) | 0.483 | 0.654 | Insignificant |
| Fitness facilities (quantity and type) | 0.920 | 0.944 | Insignificant |
| Lighting (type and intensity, intensity and aesthetics, type and aesthetics) | 0.308, 0.826, 0.413 | 0.489, 1.000, 0.489 | Insignificant |
| Pavement (texture and colour) | 0.691 | 0.414 | Insignificant |
| Pathway (width and route reasonability) | 0.486 | 0.804 | Insignificant |

## Implications for the renovation of the Qiantang riverside walkway

According to the findings in this study, several categories or aspects could not work well to meet the social requirements of respondents. The renovation of the Qiantang riverside walkways was required in several aspects. First of all, it is essential to focus more on public service and the main service to meet the requirement of both tourists and local people. A consideration of public bathroom, service kiosk and parking lots should be the good starts. The increase in indoor leisure space is also required to enable visitors to have more fun here. For the local people, the improvement in the children entertainment facilities, elderly activity facilities and fitness facilities is important. Moreover, people may feel the landscape of the Qiantang riverside walkways monotonous and the increase in the theme exhibition or show may be required to improve the vitality. Second, the transport problems that may restrict tourists' feeling on the Qiantang riverside walkways should be critically addressed in terms of the transportation linkage with the city and the parking lot (e.g. bicycle, vehicle). According to the phenomenon of stratification and agglomeration, during the improvement in the Qiantang River, planners and designers may just merge the consideration of specific aspects into a cluster in order to reduce the complexity.

Nevertheless, there should be two further things to consider. The first one is the 'other' purpose people come here, especially when different aspects of urban problems (e.g. air pollution, temperature increase) may occur in the current era.

The second one is the questionnaire survey conducted around COVID-19 when many people preferred to stay at home. Therefore, their preferences and attitudes were not included in this questionnaire survey. Nevertheless, the next-step survey will be conducted after the COVID-19 restriction for comparing whether there are some deviations in the questionnaire survey results. Moreover, the Qiantang riverside walkway is a location for leisure, entertainment and tourism, while the sample for the tourism was limited in the current study. The limited samples may be insufficient in informing the tourism function. Therefore, in the next stage, more samples will be collected to verify the tourism function and further analyse the transport connectivity with the city.

## Conclusions

This study was designed to understand the social performance of the urban waterfront spaces to fill the research gaps of limited studies on the social aspects of the performance-based planning and nature-based solutions. This study responded to three objectives, such as understanding citizens' preferences to the urban waterfront spaces, analysis of citizen's satisfaction towards the components of the waterfront spaces and understanding people's opinion on the renovation of the urban waterfront spaces, through the field observation and questionnaire survey in the Qiantang riverside walkway, Hangzhou, China. Overall, the urban waterfront space performed good in providing people with the landscape, night

view and walking. However, the onsite performance of the urban waterfront space was not good, especially in aspects of public service and main facilities, which reduced the satisfaction of tourists and local people. Moreover, the transport was also a critical issue for tourists, in terms of transport linkage with the city and parking lot in the urban waterfront spaces. There was a need for further renovation of the Qiantang riverside walkway, while the occurrence of stratification and agglomeration may reduce the workload of planners and designers by merging similar aspects into a cluster. Overall, this paper adds urban planners' and designers' knowledge of the social performance of existing urban waterfront spaces and further provides the opportunities to comprehensively build sustainable, resilient and healthy water-based living environments with the inclusive consideration of environmental, social and economic performance.

# References

Abhijith K, Kumar P, Gallagher J, McNabola A, Baldauf R, Pilla F, Broderick B, Di Sabatino S, Pulvirenti B (2017) Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments–A review. Atmos Environ 162:71–86

Argüeso D, Evans JP, Fita L, Bormann KJ (2014) Temperature response to future urbanization and climate change. Clim Dyn 42:2183–2199

Baptiste AK, Foley C, Smardon R (2015) Understanding urban neighborhood differences in willingness to implement green infrastructure measures: a case study of Syracuse, NY. Landsc Urban Plan 136:1–12

Binns T, Nel E (2002) Tourism as a local development strategy in South Africa. Geogr J 168:235–247

Botequilha-Leitão A, Díaz-Varela ER (2020) Performance based planning of complex urban social-ecological systems: the quest for sustainability through the promotion of resilience. Sustain Cities Soc 56:102089. https://doi.org/10.1016/j.scs.2020.102089

Cheung D M-w, Tang B-s (2015) Social order, leisure, or tourist attraction? The changing planning missions for waterfront space in Hong Kong. Habitat Int 47:231–240

Cohen-Shacham E, Walters G, Janzen C, Maginnis S (2016) Nature-based solutions to address global societal challenges. IUCN: Gland, Switzerland, 97

Depietri Y, McPhearson T (2017) Integrating the grey, green, and blue in cities: nature-based solutions for climate change adaptation and risk reduction. Nature-based solutions to climate change Adaptation in urban areas. Springer, Cham

Dong R, Zhang X, Li H (2019) Constructing the ecological security pattern for sponge city: a case study in zhengzhou, china. Water 11:284

Eggermont H, Balian E, Azevedo JMN, Beumer V, Brodin T, Claudet J, Fady B, Grube M, Keune H, Lamarque P (2015) Nature-based solutions: new influence for environmental management and research in Europe. GAIA-Ecol Perspect Sci Soc 24:243–248

Faivre N, Fritz M, Freitas T, de Boissezon B, Vandewoestijne S (2017) Nature-based solutions in the EU: innovating with nature to address social, economic and environmental challenges. Environ Res 159:509–518

Frantzeskaki N (2019) Seven lessons for planning nature-based solutions in cities. Environ Sci Pol 93:101–111. https://doi.org/10.1016/j.envsci.2018.12.033

Frew T, Baker D, Donehue P (2016) Performance based planning in Queensland: a case of unintended plan-making outcomes. Land Use Policy 50:239–251

Gao J, Wang R, Huang J, Liu M (2015) Application of BMP to urban runoff control using SUSTAIN model: Case study in an industrial area. Ecol Model 318:177–183. https://doi.org/10.1016/j.ecolmodel.2015.06.018

Grant M, D'Ignazio J, Bond A, McKeeman A (2013) Performance-based planning and programming guidebook. United States. Federal Highway Administration

Han L, Zhou W, Li W, Li L (2014) Impact of urbanization level on urban air quality: a case of fine particles (PM2. 5) in Chinese cities. Environ Pollut 194:163–170

He B-J (2019) Towards the next generation of green building for urban heat island mitigation: Zero UHI impact building. Sustain Cities Soc 50:101647. https://doi.org/10.1016/j.scs.2019.101647

He B-J, Zhu J, Zhao D-X, Gou Z-H, Qi J-D, Wang J (2019) Co-benefits approach: opportunities for implementing sponge city and urban heat island mitigation. Land Use Policy 86:147–157

He B-J, Ding L, Prasad D (2020) Wind-sensitive urban planning and design: precinct ventilation performance and its potential for local warming mitigation in an open midrise gridiron precinct. J Build Eng 29:101145. https://doi.org/10.1016/j.jobe.2019.101145

Hoberg G, Malkinson L (2013) Challenges in the design of performance-based forestry regulations: lessons from British Columbia. Forest Policy Econ 26:54–62

Kabisch N, Frantzeskaki N, Pauleit S, Naumann S, Davis M, Artmann M, Haase D, Knapp S, Korn H, Stadler J (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecol Soc, 21

Kjellstrom T, Holmer I, Lemke B (2009) Workplace heat stress, health and productivity–an increasing challenge for low and middle-income countries during climate change. Glob Health Action 2:2047

Kolokotroni M, Ren X, Davies M, Mavrogianni A (2012) London's urban heat island: impact on current and future energy consumption in office buildings. Energ Buildings 47:302–311

Kostopoulou S (2013) On the revitalized waterfront: Creative milieu for creative tourism. Sustainability 5:4578–4593

Kravchenko J, Abernethy AP, Fawzy M, Lyerly HK (2013) Minimization of heatwave morbidity and mortality. Am J Prev Med 44:274–282

Liu Y, Wang Y, Peng J, Du Y, Liu X, Li S, Zhang D (2015) Correlations between urbanization and vegetation degradation across the world's metropolises using DMSP/OLS nighttime light data. Remote Sens 7:2067–2088

Mills ES, Song B-N (2020) Urbanization and urban problems, Brill

Mutatkar R (1995) Public health problems of urbanization. Soc Sci Med 41:977–981

Nesshöver C, Assmuth T, Irvine KN, Rusch GM, Waylen KA, Delbaere B, Haase D, Jones-Walters L, Keune H, Kovacs E (2017) The science, policy and practice of nature-based solutions: an interdisciplinary perspective. Sci Total Environ 579:1215–1227

O'brien, C. (1997). Form, function and sign: signifying the past in urban waterfront regeneration. Journal of Urban Design, 2, 163-178.

Olalekan BG (2014) Urbanization, urban poverty, slum and sustainable urban development in Nigerian cities: challenges and opportunities. Dev Country Stud 4:13–19

Pelorosso R (2020) Modeling and urban planning: A systematic review of performance-based approaches. Sustain Cities Soc 52:101867

Qin G, Zhang P, Hou X, Wu S, Wang Y (2020a) Risk assessment for oil leakage under the common threat of multiple natural hazards.

Environ Sci Pollut Res 27:16507–16520. https://doi.org/10.1007/s11356-020-08184-7

Qin G, Zhang P, Wang Y (2020b) Investigating an assessment model of system oil leakage considering failure dependence. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-020-09999-0

Rauch W, Urich C, Bach PM, Rogers BC, de Haan FJ, Brown RR, Mair M, McCarthy DT, Kleidorfer M, Sitzenfrei R, Deletic A (2017) Modelling transitions in urban water systems. Water Res 126:501–514. https://doi.org/10.1016/j.watres.2017.09.039

SCS (2019) Perspectives on performance-based planning provisions and assessment ... -Based-Planning-Provisions-for-GI-and-WSUD, Seed Consulting Services. https://www.watersensitivesa.com/wp-content/uploads/Perspectives-on-Performance-Based-Planning-Provisions-for-GI-and-WSUD-FINAL-Sept19.pdf

Targino AC, Coraiola GC, Krecl P (2019) Green or blue spaces? Assessment of the effectiveness and costs to mitigate the urban heat island in a Latin American city. Theor Appl Climatol 136:971–984

Thorslund J, Jarsjo J, Jaramillo F, Jawitz JW, Manzoni S, Basu NB, Chalov SR, Cohen MJ, Creed IF, Goldenberg R (2017) Wetlands as large-scale nature-based solutions: status and challenges for research, engineering and management. Ecol Eng 108:489–497

United Nations (2018) 2018 Revision of World Urbanization Prospects. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

Viavattene C, Ellis JB (2013) The management of urban surface water flood risks: SUDS performance in flood reduction from extreme events. Water Sci Technol 67:99–108. https://doi.org/10.2166/wst.2012.537

Weisskopf MG, Anderson HA, Foldy S, Hanrahan LP, Blair K, Török TJ, Rumm PD (2002) Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: an improved response? Am J Public Health 92:830–833

Wholey JS (1999) Performance-based management: responding to the challenges. Public Product Manag Rev, 288-307

Xu X, Zhang L, Chen L, Liu C (2020) The role of soil N2O emissions in agricultural green total factor productivity: an empirical study from China around 2006 when agricultural tax was abolished. Agriculture 10:150

Zhang DL, Shou YX, Dickerson RR (2009) Upstream urbanization exacerbates urban heat island effects. Geophys Res Lett, 36

Zhang G, He B-J, Dewancker BJ (2020) The maintenance of prefabricated green roofs for preserving cooling performance: a field measurement in the subtropical city of Hangzhou, China. Sustain Cities Soc, 102314. https://doi.org/10.1016/j.scs.2020.102314.

Zinia NJ, Kroeze C (2015) Future trends in urbanization and coastal water pollution in the Bay of Bengal: the lived experience. Environ Dev Sustain 17:531–546

Žuvela-Aloise M, Koch R, Buchholz S, Früh B (2016) Modelling the potential of green and blue infrastructure to reduce urban heat load in the city of Vienna. Clim Chang 135:425–438