Urban river regeneration as a tool for healthy city planning: the case of Shenzhen Futian river.

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Abstract: In the last decades, urban river regeneration (URR) has been increasingly adopted to solve environmental issues, especially in China. The prevalence of this trend is due in part to the fact that, besides solving water pollution problems, urban rivers are a potential new source of open public space for contemporary cities. Due to the extremely rapid urban development, available public space in these cities is shrinking and becoming more and more inadequate. In this context, URR can enhance the quality of the built environment, social life, and public health. This study aims to investigate the influence of URR on social life by analyzing people's behavior and perception of space. Due to its geographical location and its urban context, Futian River in Shenzhen has been chosen as a case study. Methods adopted include direct observation, interview, and survey research. The study is expected to explore the influence of urban river regeneration on social life, adding new knowledge for future healthy city planning in contemporary urban environments.

Keywords: urban river regeneration, open public space, human interactions, urban life

Introduction

Urban rivers as Linear Parks

After the 1950s, in China, the provision of urban green spaces started to be increased (Xiao-Jun, 2009). By 2000, China's green space ratio, green space coverage, and public green area reached 27.4%, 23% and 6.52%, respectively. However, these percentages are still relatively low. As noted by Xiao-Jun (2009), theories and methods for the planning of the urban green space system are still lacking. These issues are due to a lack of knowledge about biological processes and natural spaces in relation to urban form development. Moreover, administrative zoning limits green space development, as natural spaces and urban processes do not evolve along the same timeline (primarily due to biological principles). In their critique of the 1989 City Planning Act of the People's Republic of China, Ng and Wu (1995) explain how long-term city planning in China (20 years) is not effective in guiding urban development. In response to this critical situation, the Chinese Government over the last two decades adopted new planning strategies to increase the provision of green spaces in urban contexts (Zhao et al., 2013, Chen and Hu, 2015). Green spaces are usually public, and provided by the government (You, 2016). However, there is still an unequal distribution of green space in urban contexts due to the high-density built-up development (You, 2016). Specifically, in cities that are becoming denser, the often-adopted infilling approach produces compact urban areas, which threaten the ability to provide open green spaces accessible to the public (Haaland and Bosch, 2015). As Haaland and Bosch (2015) point out, there is growing evidence of the decrease of urban green space due to urban densification processes, especially in Asian cities. In this context, urban rivers emerge as a potential source of urban green open space, providing continuity within the green infrastructure and bringing more advantages than the sporadic green infill that is normally adopted in high-density cities.

One of the main advantages of URR is to provide the city with a new continuous greenway. In fact, the space generated by URR is typologically a linear urban open space, very similar to a linear park. While the positive role of urban green space in improving social and mental health is well-known (Grahn & Stigsdotter, 2010; Wolch et al., 2014), there is also a growing body of literature on the advantages of having urban green space

distributed along liner spaces in the form of greenways. As an example, Brown et al. (2014), indicated that urban parks of various shapes offer different opportunities for people and influence both physical activities and the distribution of social and environmental benefits. To confirm this study, Liu et al., (2016), demonstrated that in the case of Shenzhen, green and well-developed areas strongly support physical activities such as walking, jogging, and cycling. In addition to facilitating physical activities, linear parks provide many more benefits compared to other types of urban parks. In fact, linear spaces may have a greater impact on urban neighborhood environments and social interactions because of their narrow and long shape, which can provide more access to diverse neighborhoods. Accessibility is especially important for children, the elderly, and the unemployed, in other terms, vulnerable groups (Shen et al., 2017). In addition to accessibility for vulnerable groups, the linear typology can also provide access to different social groups, with a wide range of income and social status. In this regard, since linear shapes can cross continuously different districts in the city, urban rivers appear as a collector of social and urban life. Moreover, Park and Kim (2019) provided evidence that linear space has strongly influenced surrounding economies. To summarize, newly developed linear green space has frequently served social, environmental, and economic purposes.

As extremely rapid urbanization over the last few decades in contemporary cities has caused the available public space to shrink and become more and more inadequate, river regeneration has increasingly been adopted to improve ecosystems, enhance the quality of urban environments, or to gain economic benefits (Palmer et al., 2005). In fact, URR has become a worldwide tendency (Holmes, 1998; Henry et al., 2002; Ormerod, 2003). The common objectives of URR include controlling the quality of the natural environment (Gordon, 1996), improving accessibility, and improving the urban landscape along rivers. Given differences in national policies, geographical conditions, climatic conditions, and cultural backgrounds, every country has its own strategies and methods for river regeneration. The US, Canada, and Europe all have policies and legal requirements to encourage RR, such as the US Water Act (1972), the Canadian Water Act (1985), and the EU Water Framework Directive (WFD), (2000), (Morandi et al., 2014). However, in these countries, river regeneration is more oriented towards solving ecological and environmental issues and is mainly adopted in sub-urban or peripheral contexts. On the other hand, in China, several river restoration projects were undertaken from the 2000s as part of a national effort to improve mostly urban environments (Zhao et al., 2013). Compared to western countries, URR in Chinese cities is a relatively recent practice, but the pace of URR development in China is faster.

River Regeneration impact assessment

Although river regeneration projects are frequently executed around the world, there are relatively few studies to assess their success. Bernhardt et al. (2007), concluded that only 10% of RR projects in the United States over the last 30 years have had their progress monitored. In Japan, Nakamura et al. (2006) also emphasized that while these projects have been growing rapidly since the 1990s, it was rare to evaluate them at that time. In China, there are thousands of rivers that have been regenerated in recent years, but the knowledge of how to evaluate the results of URR is weak. It is crucial to assess whether any restoration project has successfully reached its objectives (England et al., 2008). Indeed, for Bradshaw (1983), the conclusion of the evaluation of restoration projects is an acid test of our understanding, and it is crucial for future studies.

According to Palmer et al. (2005), the success of URR projects can be explicitly evaluated along three axes, as shown in Table 1. Ecological success is the primary axis: URR achieves this success by enhancing the quality of the environment, mainly by solving water pollution issues and improving urban microclimates. Many studies that analyze bioremediation technologies for the natural and ecological environment have been conducted with the hope of improving the quality of remediation and control of urban rivers pollution (Qu and Fan, 2010; Wang et al., 2012). However, despite a growing body of knowledge on the ecological success axis, few researchers have investigated the social impact of URR.

Table 1. Axes of success in RR (Palmer et al., 2005).

Success	Evaluation Guidelines
Ecological Success	Guiding image exists
	Ecological improvement
	Self-sustaining
	No lasting harm dome
	Assessment completed
Stakeholders Success	Aesthetics
	Economic benefit
	Recreation
	Education
Learning Success	Scientific contribution
	Management experience
	Improve methods

Social Impact of Urban Rivers Regenerations

The regeneration of urban riverfront space, which always combines natural and social resources, provides more public open space for urban residents. It is believed that the new space generated after URR can both improve a population's relationship with the river and provide new space for different kinds of social groups. In fact, the new riverfront space is an important part of urban open and green space, which is increasingly recognized as a recreation-oriented part of an urban landscape (Kienast et al., 2012).

Achieving both ecological and social success has increasingly been acknowledged as among the most essential parts of URR (Palmer et al., 2005; Petts, 2007). Baschak and Brown (1995) demonstrate that riverfront space brings not only ecological benefits to the city but also social benefits. The assessment of social impact is not clear because, compared to ecological impact, social impact is generally of secondary importance (Eden and Tunstall, 2006). Yang et al. (2013) believed the waterfront area to be a golden zone that brought new opportunities to developers. In addition, they believed riverfront space to be a new place for improving the urban living environment. The social impact of public green space considers how people use the new riverfront space, how people experience new human interactions along the river, and whether the new space truly caters to people's daily needs. Diverse recreational facilities and well-planned landscapes within public open spaces can encourage people to visit and thus promote human interactions between people (Gehl, 2011). Much research has focused on the human dimension of urban greenways (Gobster and Westphal, 2004), classifying them in categories such as cleanliness, aesthetics, safety, appropriateness of development, naturalness, and access. Other studies have related human interactions to the connectivity concept (Kondolf and Pinto, 2017), but little research has investigated the influence of rivers regeneration on human interactions.

Human interactions, in particular Face-to-Face (FtF) interactions, are intense and pervasive along urban reaches of rivers and along with these interactions come the communication and movement of different people, cultures, and ideas (Kondolf and Pinto, 2017). As time has passed, human interactions around rivers have been changing. Kondolf and Pinto (2017) identified that rivers can, depending on their size, have different social impacts. In ancient time, interactions occurred along rivers given their importance for transportation and agricultural use. With the development of society, however, urban rivers have become multi-functional spaces that can provide ecological and social benefits to the urban environment. An important aspect of social life, FtF human interactions are fundamental to people's well-being. In fact, it has been demonstrated that human interactions have positive benefits on public health, especially mental health (M. Leyden, 2003, Bernstein et al., 2012, Francis et al., 2012). In some cases, increasing the number of human interactions can even prevent premature mortality (Holt-Lunstad, 2018). Relevant studies have demonstrated the relative importance of FtF human interactions compared to online interactions; these studies have shown the association of the symptoms of depression with time spent online (Kraut et al., 2002). Caplan (2003) confirms this theory, relating psychosocial well-being to online communication rather than to FtF. Moreover, human interactions play a fundamental role in the definition of social life and social capital (M. Leyden, 2003), both of which are features very relevant to one's well-being. Finally, human interactions between different social groups can blunt the

effects of segregation in urban contexts. For example, Cattell et al. (2008) observed that in public open spaces, people of different backgrounds could join each other in the same recreational activities and learn from one another. Rasidi et al. (2012) indicated that urban green space could enhance human interactions between different communities. The research also revealed that the vegetation density, biological diversity, landforms, and water bodies provided favorable conditions for human interactions.

The paper will focus on recreational use along the river to investigate the impact of URR on urban life, mainly focusing on human interactions as a relevant aspect of social life. The study attempts to answer the following questions. (1) Who are the frequent river users? (2) From where do they come? (3) How frequently do they visit? (4) What is their level of satisfaction with and perception of the riverfront space? (5) What is their level of human interactions and with whom are these interactions occurring?

Methodology

Case study: Futian River, Shenzhen

Due to its extremely rapid urbanization and its massive demographical development, Shenzhen is here chosen as a case study. Having evolved for only around forty years, Shenzhen is located at the border of Hong Kong, 100 km south from Guangzhou and part of The Greater Bay Area and is one of the major high-density financial centers in southern China. In 2014, with its 50 million inhabitants, Shenzhen overtook Tokyo in terms of population and territorial expansion. Shenzhen, the first SEZ (Special Economic Zone) in China, is a leading city in economic reform. Moreover, Shenzhen territory is characterized by a dense urban fabric, so there are obstacles to providing green spaces and to introducing new green elements. Due to its dynamic evolution, history, and urban morphology, Shenzhen appears as a relevant testing site to proceed with data collection and analysis for investigating the impact of URR on social life. Special emphasis will be focused on the role of urban rivers as potential sources of new green space in high-density cities.

From north to south, Futian River runs through Bijiashan Park, Central Park and finally joins Shenzhen River; the flow pattern follows a linear distribution. Futian River is a 6.8 Km long urban river, and it crosses the main urban neighborhoods in Shenzhen. In 2008, due to severe water pollution issues and the need to improve waterlogging areas in the city, the Shenzhen Government renovated the river space. The Government hoped not only to solve the pollution issues and to increase flood control and prevention but also to improve the urban landscape and the equality of the areas crossed by the river. Furthermore, the government aimed to enhance public open space. Moreover, accessibility to the rivers has been improved, promoting the connection between people and the waterfront space (Shenzhen Water Conservancy Planning and Design Institute, 2008).

Survey Research Design and Interviews

Whether or not the regenerated riverfront space is actually promoting communication and interactions among different users around the river needs to be verified. The methods typically adopted to investigate people's perceptions of space and demographics include both quantitative and qualitative approaches, such as surveys and interviews. These methods are applied here to answer the research objectives. Demographics data must be collected, as the percentages of human interactions and social activities along the river have to be calculated. Moreover, people's satisfaction will be investigated, combined with accessibility and frequency of visits to the river. Questionnaires were distributed randomly along Futian River on weekdays and weekends between 7.00 a.m. – 7.00 p.m. At the same time, in-depth interviews were conducted. People who showed interest in being interviewed on the topic of the social impacts of URR would be asked explorative questions about social interactions along the regenerated river.

Results and Discussion

Demographics

The results of the survey analysis are based on 220 questionnaires. Data were coded into IBM SPSS for the descriptive statistical analysis. The general information in Table 2 shows that the sample of the respondents is 49.1% male and 50.9% female, and that most respondents are aged between 31 – 42, which accounts 30.9% in total. The results also showed that users of Futian River are very diverse, with different ages, educational levels, and income levels.

Table 2. Descriptive Characteristics of the Questionnaire Respondents

		Frequency	Percent (%)	Valid Percent (%)
Total number	Valid	220		
	Missing	0		
Gender	Male	108	49.1	49.1
	Female	112	50.9	50.9
	Total	220	100	100
Age	Cannot tell	1	0.5	0.5
	Below 18	5	2.3	2.3
	19-30	61	27.7	27.7
	31-42	68	30.9	30.9
	43-54	34	15.5	15.5
	55-65	35	15.9	15.9
	above 66	16	7.3	7.3
	total	220	100	100
Education	High school and below	95	43.2	43.2
	Junior college or undergraduate	102	46.4	46.4
	Postgraduate or above	23	10.5	10.5
	Total	220	100	100
Occupation	Cannot tell	23	10.5	10.5
	Student	18	8.2	8.2
	Retired	61	27.7	27.7
	Unemployed	26	11.8	11.8
	Employed	92	41.8	41.8
	Total	220	100	100
Household Income	Cannot tell	3	1.4	1.4
	Below 5000	17	7.7	7.7
	5000-10000	52	23.6	23.6
	10000-15000	55	25	25
	15000-20000	54	24.5	24.5
	Above 20000	39	17.7	17.7
	Total	220	100	100

Frequency

The first part of the survey questionnaire aims to understand the frequency of visits to the Futian River. It includes three questions, which are how often, for how long, and when people visit the river waterfront. Table 3 shows descriptive statistics of these frequency related questions. As we can see from Figure 1, in the total sample, around 30% of people visit Futian River daily, making this the most common of five frequency

choices; the second most common frequency (24.5%) are those who come to the Futian River three or four times a week, and only 6.8% is the first time to visit Futian River.

Table 3. Descriptive Statistics of Frequency Questions

			First time	Less than 1 day per month	Once per week	3-4 days per week	Everyday
How often		N	15	47	38	54	66
		Percent	6.8	21.4	17.3	24.5	30
			Never	Rarely	Sometimes	Often	Always
How long stay	Less than 30 minutes	N	32	107	46	25	10
		Percent	14.5	48.6	20.9	11.4	4.5
	30minutes - 1 hour	N	28	70	85	33	4
		Percent	12.7	31.8	38.6	15	1.8
	1-1.5 hours	N	30	49	90	47	4
		Percent	13.6	22.3	40.9	21.4	1.8
	1.5-2 hours	N	41	62	59	58	0
		Percent	18.6	28.2	26.8	26.4	0
	more than 2 hours	N	61	44	47	43	25
		Percent	27.7	20	21.4	19.5	11.4
When	Before 9am	N	73	37	45	48	17
		Percent	33.2	16.8	20.5	21.8	7.7
	9am-13pm	N	66	56	46	40	12
		Percent	30	25.5	20.9	18.2	5.5
	13-17pm	N	47	47	69	48	9
		Percent	21.4	21.4	31.4	21.8	4.1
	17-21pm	N	37	31	80	63	9
		Percent	16.8	14.1	36.4	28.6	4.1
	Above 21pm	N	189	19	7	3	1
		Percent	85.9	8.6	3.2	1.4	0.5

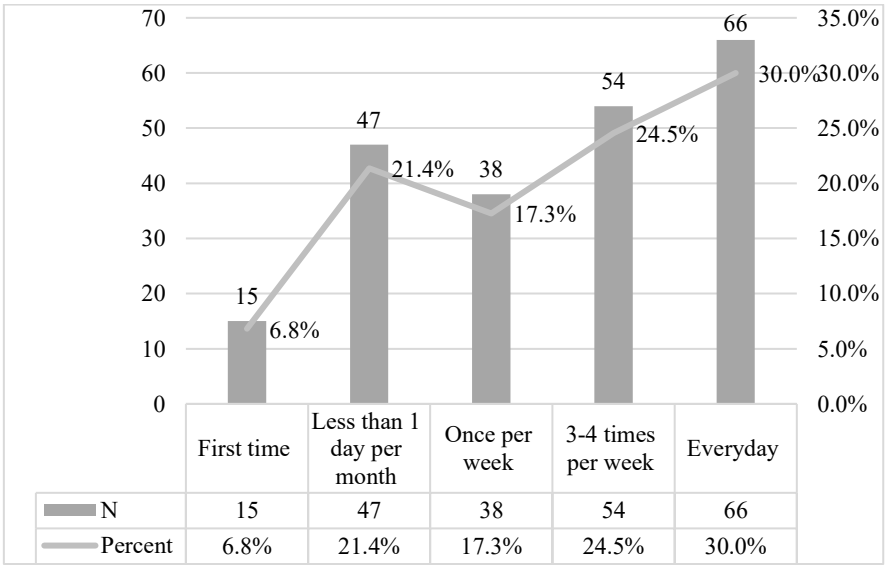


Figure 1. The Frequency of people visit Futian River

Accessibility

On the accessibility dimension, the main purpose is to find out from where people have traveled, what kind of transportation they use, and how long it takes for them to reach the Futian River. Table 4 gives an overview of accessibility-related questions. The results indicate that most people come to Futian River from their homes, with walking the most common means of transformation. As shown in Figure 2, most people (37.3%), can get to Futian River in between 10 and 20 minutes, and 33,2% travel within 10 minutes. The results show that Futian River has relatively high accessibility in terms of walking distance from the riverfront space.

Table 4. Descriptive Statistics of Accessibility Questions

			Never	Rarely	Sometimes	Often	Always
Where	Home	N	11	10	19	78	102
		Percent	5	4.5	8.6	35.5	46.4
	Work	N	123	30	43	18	6
		Percent	55.9	13.6	19.5	8.2	2.7
	School	N	191	7	9	10	3
		Percent	86.8	3.2	4.1	4.5	1.4
	Shopping	N	138	53	27	2	0
		Percent	62.7	24.1	12.3	0.9	0
	Restaurant	N	136	52	29	2	1
		Percent	61.8	23.6	13.2	0.9	0.5
Transportation	Walking	N	30	15	34	51	90
		Percent	13.6	6.8	15.5	23.2	40.9
	Bicycle	N	113	26	42	29	10
		Percent	51.4	11.8	19.1	13.2	4.5
	Bus	N	154	21	25	13	7
		Percent	70	9.5	11.4	5.9	3.2
	Driving by self	N	189	9	14	5	3
		Percent	85.9	4.1	6.4	2.3	1.4
	Metro	N	200	9	10	1	0
		Percent	90.9	4.1	4.5	0.5	0
			Within 10 minutes	10-20 minutes	20-30 minutes	30-40 minutes	More than 40 minutes
Travel time		N	73	82	33	13	19
		Percent	33.2	37.3	15	5.9	8.6

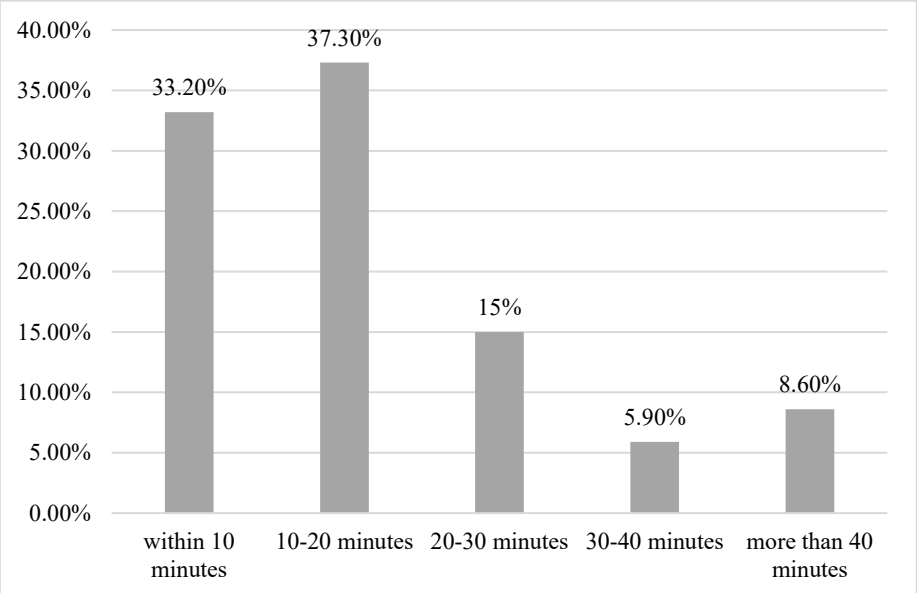
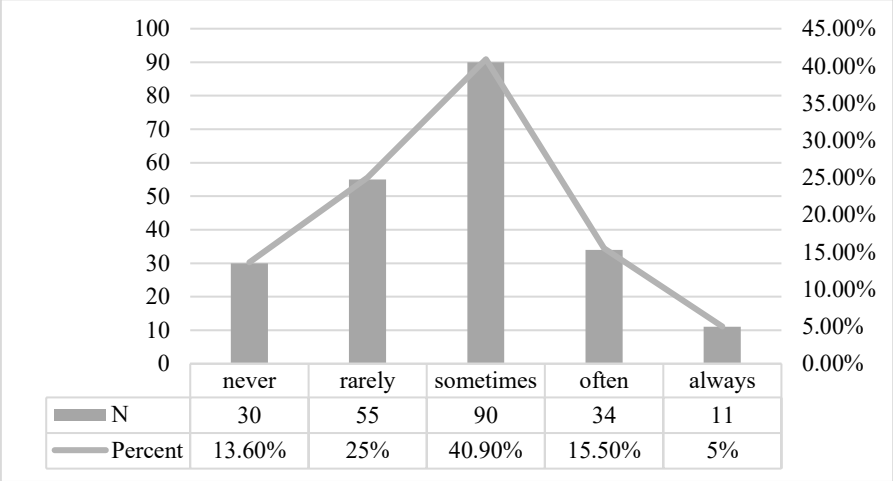


Figure 2. The Travel time to Futian River

Human Interactions

One of the most critical parts of the survey questionnaire consists of investigating whether people have human interactions in the riverfront space. The third and fourth part of the questionnaire is designed to collect information about the usage of riverfront space and people's interaction habits. The collected data in these two parts can help to find out the relationship between human interactions and the use of the space. As shown in Figure 3, around 60% of people indicated that they sometimes, often, or always having social interactions with others along Futian River. Only 13,6% of the survey replies affirmed that they never have human interactions along the riverfront, but a further 25% acknowledged that they rarely have such interactions. The majority of responses (40%) stated that human interactions occur sometimes. The percentage of people interacting compared to people not interacting is therefore relatively high.



	never	rarely	sometimes	often	always
N	30	55	90	34	11
Percent	13.60%	25%	40.90%	15.50%	5%

Figure 3. The number and percentage of people's social interactions along the Futian River

After analyzing human interactions percentages, Pearson correlation has been applied to verify if human interactions are related to some activities happening on the riverfront space. People's activity preference is based on Likert scale 1 to 5 (where one means never, and five means always do these kinds of activity along with riverfront space). In Figure 4 the mean and standard deviation of all activities observed are shown; at a higher level of mean, a higher number of people involved in the activity. Preferred activities are walking, relaxing, or resting in the riverfront space. Further correlational analysis results show that among all activities relaxing, resting, waiting or killing time, and dancing have a positive correlation with the percentage of human interactions.

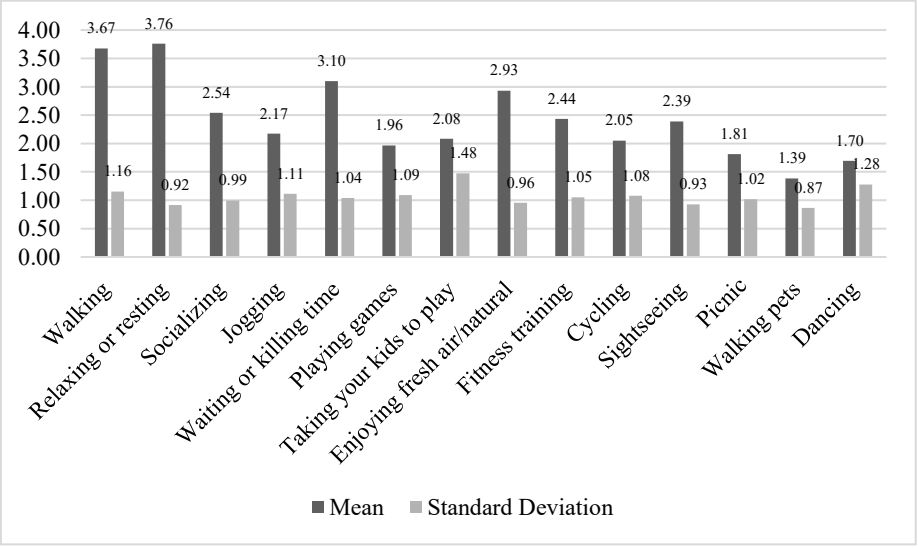


Figure 4. People's Activity Preference along Futian River

Finally, in order to understand people's perception of the riverfront space, some questions were asked to investigate and measure satisfaction and importance of the riverfront space, the variables investigated are as follow: safety (SA), activities (ACT), cleanliness (CL), facilities (FAC), public service (PS), spatial features (SF). Importance and satisfaction rates were expressed on Likert scale 1 to 5. Table 5 shows the average rates of people's perception. It appears that users of riverfront space consider relevant all variables, but with satisfaction rates are relatively lower than importance rates. The correlational analysis between people's satisfaction rate and human interactions shows that the satisfaction of the cleanliness and maintenance of public toilets, distribution of rubbish bins, and playground for children have a positive effect on human interactions. At a higher rate of satisfaction of these four factors, a higher number of human interactions is happening on the riverfront space. This type of analysis is relevant in assessing which are from users perspectives the most important variables. By associating with which factors people are not satisfied, further improvements can be arranged to increase frequency index, consequently the number of users, number of people participating in social activities and finally the percentage of human interaction.

Table 5. People's Satisfaction and Importance Rate of Futian River

	Satisfaction rate	Importance rate	Satisfaction std	Importance std
(SA) Personal safety	3.89	4.57	0.82	0.64
(ACT) Public events	3.69	4.26	0.85	0.74
(CL) Cleanliness of public toilets	3.70	4.32	0.77	0.69
(CL) Distribution of rubbish bins	3.54	4.19	0.90	0.70
(FAC) Bicycles parking	3.20	4.05	0.86	0.73
(FAC) Facilities for disabled	3.04	4.08	0.94	0.74
(FAC) Playgrounds for children	3.16	4.11	0.90	0.76
(FAC) Sport facilities	3.26	4.09	0.82	0.76
(FAC) Water disposals	2.83	3.93	0.95	0.79
(PS) Distribution of public toilets	3.26	4.20	0.97	0.75
(PS) Maintenance of public toilets	3.41	4.22	0.87	0.70
(PS) Service areas	3.45	4.10	0.80	0.70
(SF) Shadow areas	3.91	4.34	0.72	0.64
(SF) Lawns	3.85	4.40	0.78	0.70
(SF) Benches	3.84	4.41	0.79	0.71

A critical aspect of human interaction mentioned before concern the importance of facilitating interactions among different social groups, helping to heal segregation in urban environments. To investigate this aspect, besides statistical analysis, in-depth interviews have been conducted to understand people's attitude towards experiencing human interactions with strangers. The three most frequent answers reveal the fact that they generally do not care who are the people they are interacting with. Most people have interactions with other individuals with the same hobbies such as dancing, playing chess or fishing; kids are also seen as a bridge for interactions; usually, if kids are playing together, parents have communication with each other.

These were the most popular answers to the question regarding who are the people they are interacting with. In these statements, people show that they do not care about the social status of others. Another prevalent answer was related to the fact that human interactions happen on some specific occasions, such as asking others necessary information. This answer provides support to the fact that people feel safe to ask instant information to strangers, still not caring about social status or provenance.

To summarize, from the results, people on the riverfront space are in percentage inclined to experience human interactions. Moreover, most users did not care about social status, income, level of education, or provenance. Therefore, it can be assumed from this study that the riverfront space has a positive impact on people's behavior in terms of social life and human interactions, even between different social groups.

Conclusion

As an indispensable part of urban development and green space provision, rivers are getting more and more attention nowadays. In this context, URR emerges as a potential source of new green space well-distributed in the city, allowing residents of different communities to easily enjoy social resources, experiencing human interactions, and improving their social life. URR has developed rapidly in China, but few studies have assessed the social impact of URR on urban life. This paper discusses whether the regenerated river as a linear public open space in the city promotes human interactions as an aspect of social life, providing more public activity opportunities for urban population. Methods applied to evaluate the regenerated riverfront space are both quantitative (survey research design) and qualitative (direct observations and interviews).

The results show that the regeneration of Futian River promotes the advantage of its linear characteristics and provides more public open space for the surrounding residents within the linear range. Accessibility and availability of the riverfront linear space promote a well-distributed use of social resources and a high frequency of visits. Moreover, findings from survey and in-depth interviews also indicate that the improvement of the riverfront space quality increases people's satisfaction of Futian River, leading to a high frequency of visits and consequently increasing the chance to experience human interactions. People of all ages, all levels of education and income showed interest in the riverfront space, and a relatively high percentage of human interactions generally occurs in the riverfront of Futian River regardless the social status of users.

Eventually, this study has several limitations and offers room for future improvement. Firstly, data collected should be benchmarked against a sample of other case studies with different morphological characteristics in order to rise the evidence of the social impact along the regenerated riverfront. Secondly, the sample size can be enlarged in order to increase the accuracy of data results and decrease the margin of error due to calculation processes. In conclusion, this study can be considered as a preliminary research aiming to demonstrate the effectiveness of URR on the improvement of social development and provision of public green space in a Chinese high-density city such as Shenzhen. Besides, it contributes to the current knowledge on the assessment of URR success.

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