LANDSCAPE PERFORMANCE SERIES presented by the Landscape Architecture Foundation

# Suining South Riverfront Park
# Methods

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The full case study can be found at: https://landscapeperformance.org/case-study-briefs/suining-south-riverfront

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## Acknowledgements

The study of Suining South Riverfront Park was carried out during the time when China hit a two-year high of COVID-19 cases, and international travel was severely affected. In the first half of 2022, the number of international airlines flying to China dramatically decreased, and the required quarantine time for international visitors went up to 28, and in some places, 42 days. In response to the unexpected travel restrictions, we collaborated with two graduate students majoring in urban planning and landscape architecture respectively in Southwest Jiaotong University, Jiaying Li and Yao Zhang, and a professional landscape architect and landscape architecture photographer, Yu Yu, to complete all the primary data collecting for this research. The study would not be possible without their effort and contributions.

We would also like to thank our firm collaborators: Jenny Tang, our firm liaison, and Mandy, the landscape designer and liaison's assistant, for their continuous support of this research.

## Research Strategy

The evaluation of Suining South Riverfront Park is based on a combination of a cross-sectional study (comparing the performance of the park compared to other parts of the city) and a longitudinal study (comparing the performance of the park before and after the construction).

The primary data, gathered by our research assistants in China, include the following: 1) two surveys conducted in spring and summer, 2022 respectively; 2) follow-up interviews with park users; 3) thermo data; 4) noise data; 5) field surveys of plants species; 6) observation, activity mapping, and behavior mapping; and 7) photographs of current plants, activities, landscape features, etc. All primary data were collected from March to June 2022.

Secondary data were collected either through online academic articles, official government websites, or from the construction documents and reports from ECOLAND Planning and Design Corp. The data we used for the preparation of this report include: 1) CAD files of the final master plan and planting plan; 2) plant inventory and purchase list; 3) pre-construction photographs; 4) government report and public records; and 5) regional environmental characteristics and analysis.

## Environmental Benefits

**Increases the time stormwater takes to reach the Fujiang River via sheet flow from an estimated 310 seconds to 989 seconds for a 2-year, 24-hour storm in the South Plaza.**

***Background:***

The design of Suining South Riverfront Park intentionally considered the movement of stormwater and aimed to extend the water concentration time. Contrary to the existing concrete riverbank, which flushes the water directly into the river without remediation or catchment, the new design used a combination of strategies, including reducing paving slopes, adding vegetation buffers, adding terracing structures, redirecting water flows, retaining water in rain gardens, and more, to dramatically increase the sheet flow travel time.

***Method:***

The calculation of the time of concentration has several common methods, while a simplified Manning's kinematic solution can be used to compute travel time for sheet flow, which is defined as flow over plane surfaces. In the simplified kinematic equation, the flow time of concentration is impacted by the roughness of flowing surfaces (coefficients), the rainfall intensity, the sheet flow length, and the slope of the land surface. To be more specific, the equation is

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}S^{0.4}}$$

where:

$T_t$ = travel time, h
n = Manning's roughness coefficient (Table 2B-3.01)
$\ell$ = sheet flow length, ft
$P_2$ = 2 year, 24 hour rainfall, in
S = slope of land surface, ft/ft

| Surface description | $n$ [1] |
|---|---|
| Smooth surface (concrete, asphalt, gravel, or bare soil) | 0.011 |
| Fallow (no residue) | 0.05 |
| Cultivated soils: | |
| Residue cover ≤ 20% | 0.06 |
| Residue cover > 20% | 0.17 |
| Grass: | |
| Short-grass prairie | 0.15 |
| Dense grasses [2] | 0.24 |
| Bermudagrass | 0.41 |

Figure 2. The kinematic equation and the surface roughness coefficient (retrieved from USDA NRCS, 2010, 15-4)

***Calculations:***

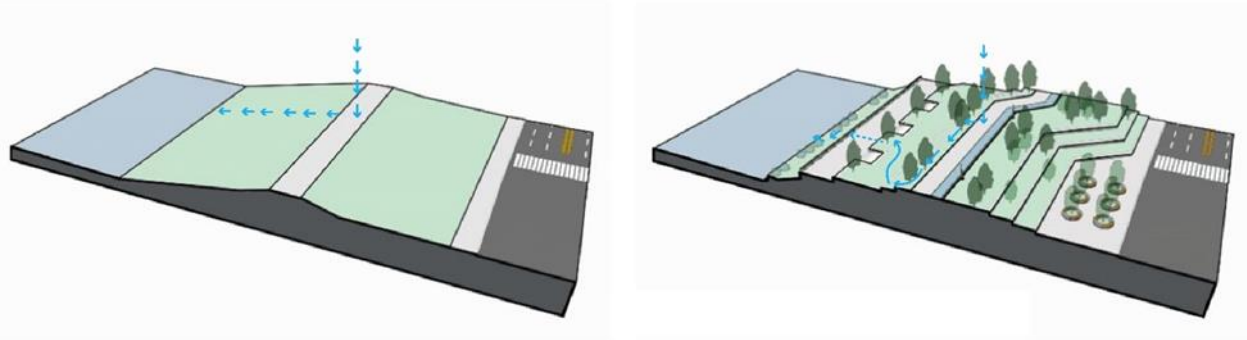


Figure 3. Stormwater retention design and water flow diagram (base image provided by Ecoland Design and Planning Corp.)

This portion of the south urban plaza was selected for analysis because its design intentionally aimed to capture water and retain it long before it flows into the river (see Figure 3). A 2-year, 24-hour storm (3.6 inches) was used per the equation requirement. Before the construction of the South Riverfront Park, the rainwater directly rushed into the Fujiang River through unmaintained short grass. The elevation change is 12 feet, and the surface used in the equation was short-grass prairie with a Manning coefficient of 0.15 (see Figure 2). The travel time of sheet flow from the top of the bank to Fujiang River in the "before" scenario is:

$$T(t) = \frac{0.007[(0.15)(112)]^{0.8}}{3.6^{0.5}0.1^{0.4}}$$

= 0.06689/0.75536=0.08855 hour =318.8 seconds

After the construction of South Riverfront Park, the water is directed from the top of the bank to the closest vegetated area with a shallow slope, and then flows into a tree planting area. When it overflows, it moves through the concrete pavement area, then into the lower vegetated area, and finally to the river. The first vegetated area is dense grasses, with a Manning coefficient of 0.24 (see Figure 2), a travel distance of 122 feet, and a 3% slope. The concrete has a coefficient of 0.011, 26-foot distance, and a 2% slope. Finally, the last vegetated area is a short-grass prairie as the existing situation, with a coefficient of 0.15, 37 feet long, and a 6% slope. To sum, the proposed travel time after the park construction then is:

$$T(t) = + \frac{0.007[(0.24)(122)]^{0.8}}{3.6^{0.5}0.03^{0.4}} + \frac{0.007[(0.011)(26)]^{0.8}}{3.6^{0.5}0.02^{0.4}} + \frac{0.007[(0.15)(37)]^{0.8}}{3.6^{0.5}0.06^{0.4}}$$

= 0.10432/0.46666 + 0.00257/0.39679 + 0.02758/0.61576 = 0.22355+0.00648+0.04479 = 0.27482 hour = 989.4 seconds

***Sources:***


- USDA NRCS. (2010). Time of Concentration. National Engineering Handbook Hydrology.

***Limitations:***

- All calculations were based on computation from one traditional method, hence deviations are not avoided.
- Because the existing condition was not recorded comprehensively, there might be mistakes associated with the elevation and slope estimation.

## Increases flood storage capacity by approximately 1.3 million gallons, equivalent to about 2 Olympic-sized swimming pools.

***Background:***

The construction of the wetland used a balanced cut and fill process to achieve increased storage capacity. The soil cut was built up and became either the fill for the small islands that support the extended boardwalk and viewing pavilion or became fill in the land area as landform features. At the same time, the cuttings increase water storage capacity and allow the river to slow down while passing through the vegetation zones growing in the wetland area.

Suining has abundant rainfall throughout the year with an average annual rainfall of around 930 mm (36.6 in). Rainfall is mainly concentrated from June to August with mostly heavy rain and thunderstorms. The wetland was designed the with flooding season in mind – when the water rises up in summer, part of the wetland can be submerged underneath the water surface.

***Method:***

Based on the dimensions of the featured stormwater treatment area, the amount of water the site can retain was calculated using the rational method. The shape and depth of the wetland was estimated by creating quadrangles in AutoCAD to conduct measurements. The average depth of each quadrangle was calculated and multiplied by its area to find incremental volume.

***Calculations:***

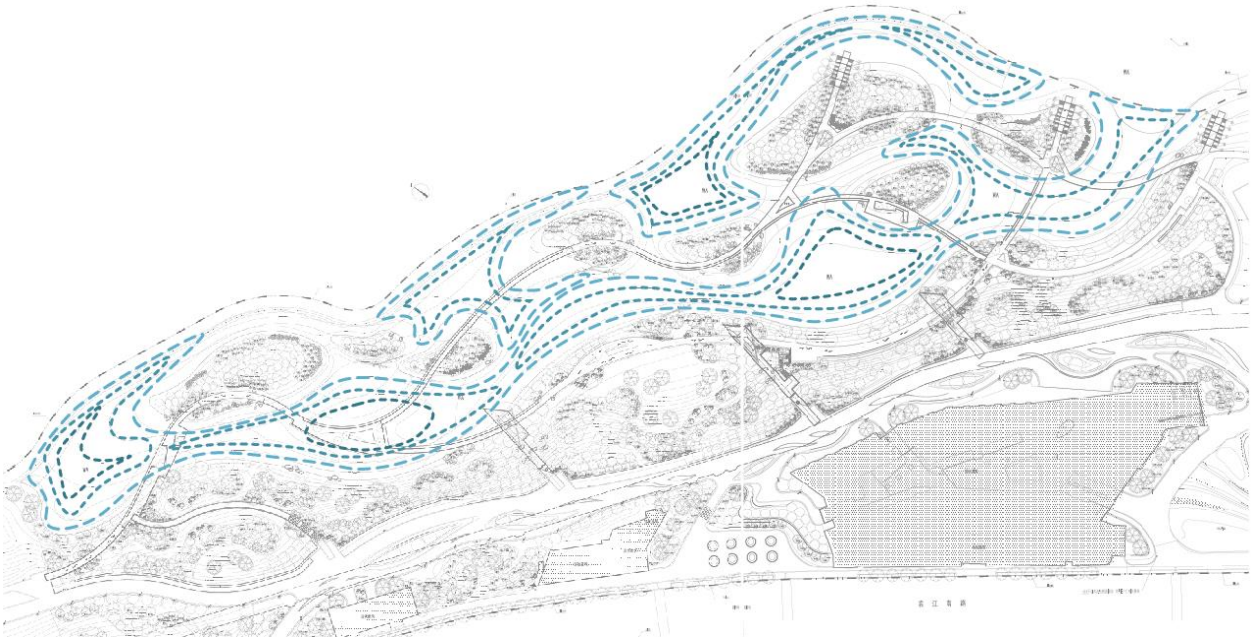


Figure 2. Wetland storage calculation diagram.

| | *Area (sq meter)* | *Area (sq feet)* | *Volume (gallon)* |
|---|---|---|---|
| *6" deep* | *20317* | *218694* | *817973* |
| *12' deep* | *10159* | *109348* | *408989* |
| *18" deep* | *2274* | *24475* | *91544* |

*Total volume = 1,318,506 gallons*

An Olympic-sized swimming pool volume = 164 ft * 82 ft * 6.6ft = 88756.8 cubic ft = 663,946.97 gallons

*1,318,506*/663,946.97 gallons = approximately 2 Olympic-sized swimming pools

***Sources:***

- Construction documents provided by the firm
- Weather China. http://en.weather.com.cn/

***Limitations:***

- The CAD file does not represent the exact final design, and the volume amount calculated might have some deviations.

**Increased ecological quality as demonstrated by a Reciprocal Simpson Index value of 6.25 on average in the wetland area, as compared to a value of 1.09 for a nearby area that resembles the site prior to construction. The more urban area of the site increased its Reciprocal Simpson Index value from 1.09 to 2.09, even with a formal planting style.**

***Background:***

Biodiversity is an indicator of ecosystem resilience, and the reciprocity Simpson's Index is a common variant of the Simpson's Diversity Index used to measure biodiversity. The Simpson's reciprocal index measures biodiversity by considering both species richness and evenness of abundance. The lowest possible value is 1, meaning the measured community only contains one species. The higher the values, the greater the biodiversity of that area. The maximum possible value is equal to the total number of species in the sample.

***Method:***

The research team went to the site in summer and measured plants and wildlife abundance on site with a randomly selected 4-meter by 4-meter quadrat (the 4 meters is put down using a consistent measurement tape) in three different areas. One is in the wetland area, one in the south urban plaza area, and one as a control area (chosen to be a nearby unmaintained grassy area that mimics the pre-construction condition). All three quadrats were chosen to be representative of that area due to their average performance (the plot contains the most frequented planting patterns in that area, and represents the average numbers of species of the most diversified and least diversified plot).

***Calculations:***

| Found species (in selected area one - wetland) | The amount of species within the 4x4 quadrat (n) | N(n-1) |
|---|---|---|
| ***Thalia dealbata*** | 20 | 380 |
| ***Ludwigia adscendens*** | 10 | 90 |
| ***Nymphaea tetragona*** | 8 | 56 |
| ***Pontederia cordata*** | 15 | 210 |
| ***Acer almatum*** | 3 | 6 |
| ***Ophiopogon bodinieri*** | 15 | 210 |

| | | |
|---|---|---|
| ***Ctenopharyngodon Idella,*** | 2 | 2 |
| ***Carassius auratus*** | 2 | 2 |
| ***Anisoptera*** | 2 | 2 |


Figure 6. Some species in the measured wetland area (the north bank).

$D = \Sigma(ni(ni - 1)) / (N(N - 1))$

*Hence, the D = 958/77x76= 958/5852=0.16*

*Simpson's reciprocal index (1 / D) is: 1 / D = 6.25*

| Species (in selected area 2 – south urban plaza area) | The amount of species within the 4x4 quadrat (n) | N(n-1) |
|---|---|---|
| ***Loropetalum chinense var. rubrum*** | 2 | 2 |
| ***Salix babylonica L.*** | 2 | 2 |
| ***Osmanthus fragrans*** | 1 | 0 |
| ***Lagerstroemia indica L.*** | 1 | 0 |
| ***Hydrangeamacrophylla(Thunb.) Ser.*** | 60 | 3540 |
| ***Euryops pectinatus*** | 108 | 11556 |
| ***Apis cerana*** | 3 | 6 |
| ***Scolopendridae*** | 1 | 0 |

$D = \Sigma(ni(ni - 1)) / (N(N - 1))$

*Hence, the D = 15106/178x177= 15106/31506=0.479*

*Simpson's reciprocal index (1 / D) is:*

*1 / D = 2.09*


Figure 7. Some species in the measured urban area (the south bank).

***Reference Group (the area with no design or intervention)***

| Species (in selected area 3 – area representing original condition) | The amount of species within the 4x4 box (n) | N(n-1) |
|---|---|---|
| *Trifolium repens* | 1400 | 1958600 |
| *Arundinella hirta* | 15 | 210 |
| *Melilotus officinalis (L.) Pall.* | 20 | 380 |

| | | |
|---|---|---|
| *Erigeron canadensis* | 30 | 870 |
| *Cnidium monnieri* | 3 | 6 |


Figure 8. Some species in the referenced area (area represents pre-design condition).

$D = \Sigma(ni(ni - 1)) / (N(N - 1))$

*Hence, the D = 1960066/1468x1467= 1960066/2153556=0.91*

*Simpson's reciprocal index (1 / D) is:*

*1 / D = 1.09*

***Limitations:***

- Some species may have been misidentified because of similarities between plants of the same cultivar or genus when they are not in bloom. As a result, some species may have been over-counted or under-counted.
- While the Simpson Index in its pure form is considered a dominance index because it weights towards the abundance of the most common species, the Reciprocal Simpson Index corrects for this bias.

- The species indicated here are the species observed/measured within that particular quadrat at that particular time. The experiment could be improved by more observations or repeated times.

***Sources:***

- http://www.countrysideinfo.co.uk/simpsons.html

**Provides habitat for wildlife and migratory bird species including black-headed gull, mallard, barn swallow, Siberian white crane, white-browed laughingthrush, and little egret, as observed on-site and described in local media reports. These species were not commonly seen in the area before park's construction.**

***Background:***

China has limited public data on bird records, and in this study, we used field observations as well as the integration of images of local posts, ecological reports, social media, and other outlets retrieved from the internet. The increased and more diversified native vegetation is believed to provide habitat and food sources for wildlife and migratory bird species according to increased wildlife sightings across multiple sources.

***Method and Result:***

The data collection was retrieved from multiple outlets identified below:

- On-site observation. Two graduate landscape architecture and urban planning students went to the site to conduct data collection including animal species. The observation was done 3 times in March, May, and July 2022 respectively. In each of the visits, they recorded the wildlife they saw. According to their informal interviews with residents, those species have increased since the construction and opening of the park, though the exact numbers are uncertain.

  The species they have witnessed at least two times are Mallard, barn swallow, white-browed laughingthrush, Plumbeous Water Redstart, turtle dove, and sparrows.

- The research team searched government official reports, local digital newspapers, local forum posts, and social media posts with geo-references dated back from 2018 to 2022. We found that at a certain time of the year, the South Riverfront Park witnessed an increased number of migrating birds, such as the Siberian white crane, and black-headed gull. The interviewed residents also indicate they see more little egrets now, which almost never appeared before.

Figure 4. Observed wildlife and migrating birds on site.

***Sources:***

- On-site observation
- https://baijiahao.baidu.com/s?id=1693223448237490946&wfr=spider&for=pc
- https://baijiahao.baidu.com/s?id=1682801539183507648&wfr=spider&for=pc
- https://www.163.com/dy/article/GLS0CSJ90514DBE9.html
- https://www.sohu.com/a/213175030_224282

***Limitations:***

- There was no professional biologist to identify all the animals observed from the site, and limited-time was spent on animal observation.

**Reduces experienced temperatures within the park by 4°F on average on sunny summer afternoons, as compared to a nearby area that resembles the site before construction. Of 60 surveyed park visitors, 78% reported satisfaction with the temperature and microclimate in the park.**

***Background:***

Located in the Sichuan Basin in Southeast China, Suining has a humid subtropical climate that keeps a temperate climate throughout the year and has four distinct seasons. The average daily highest temperature in the city in May is 80.6°F.

***Method:***

The LAF team measured the air temperature inside the park and compared it to the air temperature on a concrete road outside the park that resembles pre-construction conditions. On May 28, 2022, the temperature was measured by using an infrared thermometer DL333600B. In order to reduce measuring errors, multiple measurements in the same weather condition were performed, and the average temperature of each spot was recorded for calculation. The LAF

team chose three different environmental conditions to measure and compare: hardscape (not shaded), areas shaded by trees, and areas shaded by buildings/structures. We chose these conditions to see if the park (the newly added vegetation, pavement, green islands, and the microclimate the park creates) has contributed to a reduction in temperature on sunny afternoons compared to the surrounding environment. For each condition, on-site and off-site locations were identified and measured to compare the temperature under the same conditions. The locations where the temperature was measured were noted in the map below.

See below for information on the survey.

Figure 5. Location indications of temperature measurements

***Calculations:***

9. Temperature of Hardscape (not shaded)

| Location | Outside the Park<br>On the Road<br>**Point A** | Inside the Park<br>On the Hardscape<br>**Point B** | Inside the Park<br>On the Hardscape between the Lawn<br>**Point C** | Inside the Park<br>On the Hardscape in the Wetland Area<br>**Point D** |
|---|---|---|---|---|
| Temperature °F | 91.76 | 90.14 | 85.46 | 84.56 |
| Net Decrease °F | | 1.62 | 6.30 | 7.20 |

2. Temperature of Areas Shaded by Trees

| Location | Outside the Park<br>On the Street<br>**Point E** | Inside the Park<br>Under the trees<br>**Point F** | Inside the Park<br>Under the trees in the Wetland Area<br>**Point G** | Inside the Park<br>Under the trees in the Wetland Area<br>**Point H** |
|---|---|---|---|---|
| Temperature °F | 70.16 | 69.98 | 68.00 | 69.08 |
| Net Decrease °F | | 0.18 | 2.16 | 1.08 |

3. Temperature of Areas Shaded by Building/Structure

| Location | Outside the Park<br>Under the Building<br>**Point I** | Inside the Park<br>At the Dock<br>**Point J** | Inside the Park<br>In the Wetland Area<br>**Point K** |
|---|---|---|---|
| Temperature °F | 79.34 | 74.12 | 70.16 |
| Net Decrease °F | | 5.22 | 9.18 |

Average net decrease in temperature (°F) = the sum of the net decrease/number of locations

= (1.62+6.3+7.2+0.18+2.16+1.08+5.22+9.18)/8

= **4.12**

***Sources:***

- Measurements on and off-site
- Weather China. http://en.weather.com.cn/

***Limitations:***

- The data only represents the temperature measured on a single sunny afternoon and does not account for all the weather/time conditions
- Measuring errors could affect the final data collected
- Benefits may not be obvious as the site is small

**Sequesters an estimated 84 tons of atmospheric carbon annually in 2,521 newly-planted trees and over 8,000 newly-planted shrubs, equivalent to the annual emissions of about 17 single passenger vehicles. Trees and shrubs are projected to sequester approximately 9,670 tons of atmospheric carbon over the next 20 years.**

***Background:***

According to the construction documents provided by the designer of the park, 2521 trees were newly planted in the park, including more than 49 tree species. This change will greatly increase the carbon sequestration in Suining City due to the construction of the park.

i-tree by the USDA Forest Service (itreetools.org/, 2022) is the common method when calculating the potential benefits. It is widely used in the U.S. context. The utilization of i-Tree has been proven to be effective in other countries, including China (Qian, Zhang, and Ping, 2019; Wang et al., 2018).

***Method:***

Carbon sequestration was calculated using i-Tree My Tree. Because the calculator's default regions have not been extended to areas outside the U.S., Tennessee in the South Zone was selected for calculation because of its similar climate to Suining, Sichuan. There are no records of the exact number of trees preserved during construction, but according to our dialogue, the principal designer estimated about 200 trees were existing trees and were preserved during construction. These were included in the analysis.

The tree species were typed manually by the researcher, with the planting list and the catalog was provided by our firm liaison from Ecoland. The result shows that 41.03 tons of CO2 can be sequestered in the trees of the park, and 42.92 tons of CO2 can be sequestered in the shrubs of the park annually.

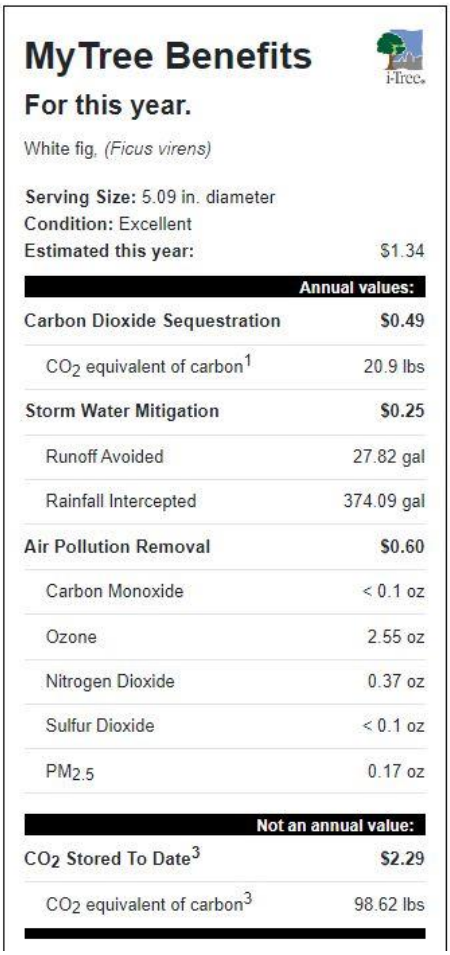
41.03+42.92=83.95 tons

According to the EPA, on average, A typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year, which equals 5.07 tons per year.
83.95 ÷ 5.07 = 17 vehicles

***Calculations:***

| Quantity | Plant Name | Replacement Tree | size(inch) | Carbon Annual(lbs) | Carbon 20 Yrs(lbs) | Annual Total | 20 Yrs Total |
|---|---|---|---|---|---|---|---|
| 127 | Ficus virens | Ficus virens | 16 | 20.9 | 964.59 | 2654.3 | 122502.93 |
| 25 | Cinnamomum camphora | - | 10 | 48.02 | 3810.95 | 1200.5 | 95273.75 |
| 115 | Pistacia chinensis | - | 9 | 15.38 | 988.99 | 1768.7 | 113733.85 |
| 24 | Sapindus saponaria | soapberry spp | 16 | 103.08 | 4942.59 | 2473.92 | 118622.16 |
| 159 | Salix babylonica | - | 11 | 59.27 | 3820.16 | 9423.93 | 607405.44 |
| 8 | Cercis Chinensis | redbud spp(Cercis) | 10 | 28.71 | 1817.78 | 229.68 | 14542.24 |
| 23 | Prunus serrulata | Prunus serrulata | 9 | 32.46 | 2358.26 | 746.58 | 54239.98 |
| 178 | Osmanthus fragrans | olive spp | 9 | 44.17 | 2729.41 | 7862.26 | 485834.98 |
| 260 | Cinnamomum camphora | - | 12 | 60.76 | 4168.63 | 15797.6 | 1083843.8 |
| 84 | Cinnamomum yabunikkei | cinnamon spp | 8.5 | 56.39 | 4151.06 | 4736.76 | 348689.04 |
| 8 | Magnolia grandiflora | magnolia spp | 7.8 | 21.36 | 1686.76 | 170.88 | 13494.08 |
| 39 | Celtis sinensis | Celtis sinensis | 12.5 | 14.84 | 532.32 | 578.76 | 20760.48 |
| 109 | Jacaranda mimosifolia | jacaranda spp | 9 | 35.41 | 2144.64 | 3859.69 | 233765.76 |
| 49 | Gleditsia sinensis | Gleditsia sinensis | 9.5 | 26.99 | 1767.51 | 1322.51 | 86607.99 |
| 54 | Acer buergerianum | Acer buergerianum | 9.5 | 38.41 | 2286.49 | 2074.14 | 123470.46 |
| 10 | Hibiscus mutabilis | Hibiscus mutabilis | 7.8 | 40.51 | 3806.77 | 405.1 | 38067.7 |
| 60 | Ginkgo biloba | Ginkgo biloba | 8.7 | 5.09 | 310.14 | 305.4 | 18608.4 |
| 278 | Metasequoia glyptostroboides | dawn redwood spp | 7.8 | 33.79 | 2339.1 | 9393.62 | 650269.8 |
| 13 | Taxodium ascendens | bald cypress spp | 7.8 | 34.21 | 2366.96 | 444.73 | 30770.48 |
| 48 | Osmanthus fragrans | cinnamon spp | 7.8 | 50.48 | 3981.79 | 2423.04 | 191125.92 |
| 27 | Eriobotrya japonica | loquat spp | 7 | 29.26 | 2633.39 | 790.02 | 71101.53 |
| 168 | Prunus serrulata | Prunus serrulata | 6 | 19.11 | 1957.95 | 3210.48 | 328935.6 |
| 101 | Chinese magnolia | Chinese magnolia | 5.5 | 12.57 | 1276.74 | 1269.57 | 128950.74 |
| 150 | Malus | Malus trilobata | 5.7 | 13.45 | 1462.75 | 2017.5 | 219412.5 |
| 89 | Prunus cerasifera | Cherry plum | 5.7 | 15.02 | 1610.93 | 1336.78 | 143372.77 |
| 48 | Acer rubrum | Red maple | 3 | 9.79 | 2150.59 | 469.92 | 103228.32 |
| 116 | N. Kimberly Crepe Myrtle | N. Kimberly Crepe My | 5.2 | 17.42 | 2388.75 | 2020.72 | 277095 |
| 151 | Prunus cerasus | Prunus cerasus | 6.3 | 20.35 | 1996.77 | 3072.85 | 301512.27 |
| | | | | | | 82059.94 | 6025237.97 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | 41.03ton | 3012.62ton |

| Quantity | Plant Name | Replacement Tree | size(inch) | Carbon Annual(lbs) | Carbon 20 Yrs(lbs) | Annual Total | 20 Yrs Total |
|---|---|---|---|---|---|---|---|
| 89 | Lagerstroemia indica cv "Bush" | Lagerstroemia | 3 | 26.93 | 1,814.13 | 2396.77 | 161457.57 |
| 35 | Chaenomeles cathayensis | Chaenomeles cathayensis | 1 | 10.59 | 1999.94 | 370.65 | 69997.9 |
| 61 | Cycas revoluta | Cycas revoluta | 5 | 55.04 | 2080.5 | 3357.44 | 126910.5 |
| 108 | Camellia japonica | Camellia japonica | 1 | 6.63 | 855.07 | 716.04 | 92347.56 |
| 89 | Chinese Redbud | Cercis canadensis v. mexic | 1 | 8.69 | 1178.78 | 773.41 | 104911.42 |
| 44 | Rhododendron simsii | Rhododendron simsii | 1 | 14.25 | 2395.25 | 627 | 105391 |
| 37 | Bougainvillea glabra | Annona glabra | 1 | 6.53 | 1187.66 | 241.61 | 43943.42 |
| 22 | Osmanthus fragrans | cinnamon spp | 1 | 16.78 | 2919.7 | 369.16 | 64233.4 |
| 133 | Pittosporum tobira | Pittosporum | 1 | 10.95 | 2018.54 | 1456.35 | 268465.82 |
| 14 | Ligustrum japonicum 'Howardii' | Ligustrum japonicum | 1 | 19.7 | 3355.65 | 275.8 | 46979.1 |
| 14 | Loropetalum chinense | Chionanthus | 1 | 13.23 | 1876.16 | 185.22 | 26266.24 |
| | | | | | | 0 | 0 |
| 861 | Serissa japonica (Thunb.) Thunb. | snowbell spp | 1 | 4.75 | 1240.5 | 4089.75 | 1068070.5 |
| 987 | Rhododendronsimsii&R.spp | Rhododendron simsii | 1 | 14.25 | 2395.25 | 14064.75 | 2364111.75 |
| 58 | Rhododendron hybridum Ker Gawl | Rhododendron mucronulat | 1 | 12.92 | 2337.61 | 749.36 | 135581.38 |
| 711 | Alocasia macrorrhiza | | | | | 0 | 0 |
| 2238 | Schefflera heptaphylla | Schefflera heptaphylla | 1 | 12.09 | 1835.67 | 27057.42 | 4108229.46 |
| 547 | Fatsia japonica | | | | | 0 | 0 |
| 359 | Rhapis excelsa | Rhapis excelsa | 1 | 6.6 | 332.92 | 2369.4 | 119518.28 |
| 1554 | Hydrangeamacrophylla | Hydrangea arguta | 1 | 11.03 | 2027.74 | 17140.62 | 3151107.96 |
| 194 | Gardenia jasminoides | gardenia spp. (Gardenia) | 1 | 8.25 | 1294.07 | 1600.5 | 251049.58 |
| 1030 | Philodenron selloum | philodendron spp | 1 | 7.77 | 974.94 | 8003.1 | 1004188.2 |
| | | | | | | 85844.35 | 13312761.04 |
| | | | | | | 42.92ton | 6656.38ton |



**MyTree Benefits**

**For this year.**

White fig, *(Ficus virens)*

**Serving Size:** 5.09 in. diameter
**Condition:** Excellent
**Estimated this year:** $1.34

| Annual values: | |
|---|---|
| **Carbon Dioxide Sequestration** | **$0.49** |
| $CO_2$ equivalent of carbon[1] | 20.9 lbs |
| **Storm Water Mitigation** | **$0.25** |
| Runoff Avoided | 27.82 gal |
| Rainfall Intercepted | 374.09 gal |
| **Air Pollution Removal** | **$0.60** |
| Carbon Monoxide | < 0.1 oz |
| Ozone | 2.55 oz |
| Nitrogen Dioxide | 0.37 oz |
| Sulfur Dioxide | < 0.1 oz |
| $PM_{2.5}$ | 0.17 oz |
| **Not an annual value:** | |
| **$CO_2$ Stored To Date[3]** | **$2.29** |
| $CO_2$ equivalent of carbon[3] | 98.62 lbs |

**MyTree Benefits**

**Over 20 years.**

White fig, *(Ficus virens)*

**Serving Size:** 5.09 in. diameter
**Condition:** Excellent
**Expected over 20 years:** $57.68

| | |
|---|---|
| **Carbon Dioxide Sequestration** | **$22.43** |
| $CO_2$ equivalent of carbon[1] | 964.59 lbs |
| **Storm Water Mitigation** | **$6.81** |
| Runoff Avoided | 762.17 gal |
| Rainfall Intercepted | 10,247.85 gal |
| **Air Pollution Removal** | **$28.44** |
| Carbon Monoxide | 2.71 oz |
| Ozone | 89.77 oz |
| Nitrogen Dioxide | 13.53 oz |
| Sulfur Dioxide | 0.69 oz |
| $PM_{2.5}$ | 8.18 oz |

Figure 1. Screenshot of I-tree result (Annual on the left, 20 years on the right) for one species

***Sources:***

- Planting table, construction document provided by firm (on-site comparison verifies the accuracy of plantings)
- I-tree official website: https://mytree.itreetools.org
- EPA Greenhouse Gas Emissions from a Typical Passenger Vehicle https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle
- Qian, W. A. N. G., Zhang, Z., & Ping, W. A. N. G. (2019). An Assessment of Ecosystem Services of Urban Green Spaces Based on i-Tree. *Journal of Landscape Research*, *11*(1).
- Wang, X., Yao, J., Yu, S., Miao, C., Chen, W., & He, X. (2018). Street trees in a Chinese forest city: Structure, benefits and costs. *Sustainability*, *10*(3), 674.

***Limitations:***

- As i-Tree is not designed to be utilized in China, deviations exist and exact numbers would vary due to the slight environmental condition differences between Tennessee and Sichuan.
- The calculator only accounts for trees and large shrubs, the atmosphere carbon sequestered by groundcovers, and perennials are not included in this analysis.
- The tree species and numbers are based on the construction documents provided by the firm and do not take into account the changes that might have happened in the construction and maintenance phase or plant mortality.

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## Social Benefits

**Overall methods for social benefits:**
We used a combination of site observation, survey, and in-person interviews targeted at park users to collect data about the social benefits the park has produced. The first phase of the survey focused on collecting data about user groups, visit times, and site evaluations. Phase 1 was conducted Mar.13-14, 2022 (Sunday & Monday), from morning to late evening, for about 12 hours per day. 49 on-site responses were retrieved during a two-day period of span. The main questions covered in this phase include travel time, age groups, visit frequency, and several questions about first impressions and evaluation of the park (see Appendix I for the full survey format).

The second phase of the survey was completed on May 28-29, 2022 (Saturday & Sunday) and focused more on environmental benefits, user experiences, and visitors' opinions toward the park. 60 on-site responses were retrieved over a weekend. The study time is about 14 hours per day for two days. The main questions in the second phase asked visitors to rate the park's contribution to the city's aesthetics, people's relation with water, experienced temperature, plant diversity, and visitors' physical and mental pleasures. During each on-site visit, a site observation was conducted to roughly count the total number of people who visited the park during the day and record their behaviors and age composition by making behavior mapping.

The last visit was made from June 29th to July 1st, 2022 (Wednesday, Thursday, Friday) to make sure the weekday park usage is consistent with that from the two observations in Phase One and Two.  No more surveys were conducted. The research team used this visit to verify the previous findings, take additional photographs, and fill in the blanks of some previously unfinished research.

In general, the overview of park users and the usage pattern is represented by Figure 1 below.

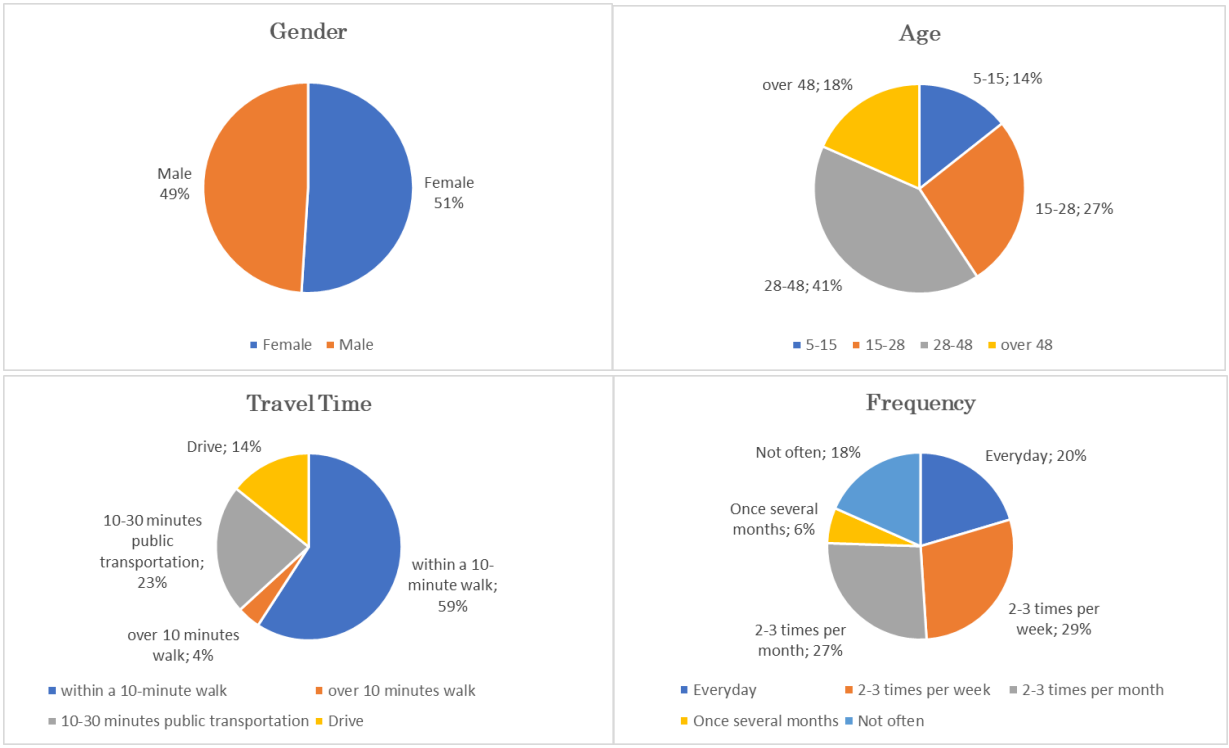


Figure 9. Survey 1 responses related to park usage.(49 surveys collected)

The detailed social benefits are below.

**Attracts over 1,200 visitors as observed on a typical Saturday in the summertime, with the most visitors during the morning and evening, and at least 800 visitors on a typical Sunday in early spring, with the most visitors in the early and late afternoon.**

***Background:***
The renovation of the riverfront aims at revitalizing the city and invigorating the riverbank. By adding entrances and exits along with wayfinding elements to lead visitors to travel through the park, the design serves to attract more visitors and encourage human interactions.

***Method:***
The number of users was counted at different locations and at different times of the day on

Mar.13, 2022 (Sunday) and May 28, 2022 (Saturday). Time periods are divided into 5 for calculation: 9-10 AM, 10:30-11:30 AM, 2-3 PM, 4-5 PM, and 7-8 PM. During each time period, two researchers walked through the site and took photos along the route. User numbers, activities, age composition, and locations were documented at different nodes on each map. A total of 809 people were observed on Mar.13, 2022, and about 1,200 visitors were observed on May 28, 2022. The actual number of visitors on a typical weekend day would be greatly over these two numbers due to the limits of the observational techniques.

***Calculations:***

Calculations were made based on the on-site observations and were visualized by behavior mapping.
Ex. Number of people observed on Mar.13,2022:
9-10AM: 104
10:30-11AM: 80
2-3PM: 252
4-5PM: 84
7-8PM: 289
Total=104+80+252+84+289=**809**
The same counting techniques were utilized for the May summer visit. The number is comparable with the July visit.

***Limitations:***

- As we only counted the number of users in several time periods, the data was not accurate enough to show the actual number of people who visited the park on Mar.12, 2022, and May 28, 2022. The actual number would be much larger than the ones we produced.
- This data is subjected to time and weather conditions. Data from a cloudy Sunday in early spring and a sunny Saturday in the summertime may not be enough to calculate the average number of people who visit the park on a typical weekend day.
- Measuring mistakes may affect the final data as the numbers of visitors were counted by humans and were subjected to measuring errors.

## Provides a setting for at least 30 types of cultural and recreational activities with 13 types of multi-generational interactions.

***Method:***
We marked 3 nodes on the map within the designed area and produced behavior mapping (Gehl Public Life Tools) to visualize and better understand human activities on the site. From Mar.13-14, 2022, two researchers conducted site observation and produced 6 behavior mappings (2 for each node) at different times of the day. In total, 30 different activities were observed, and 13 of them involved more than one generation.

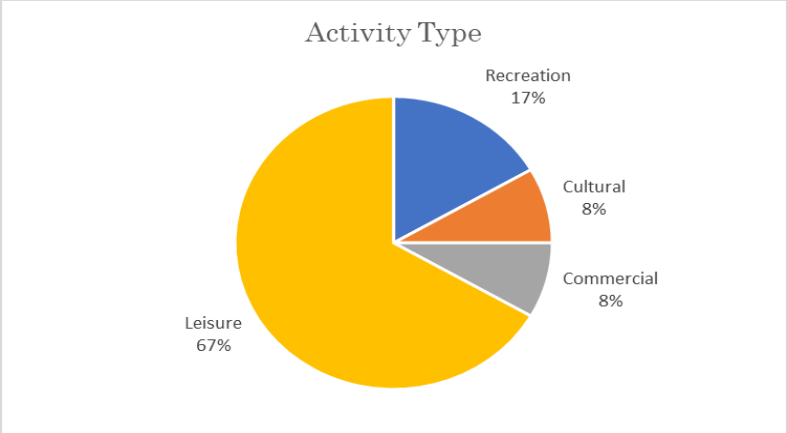
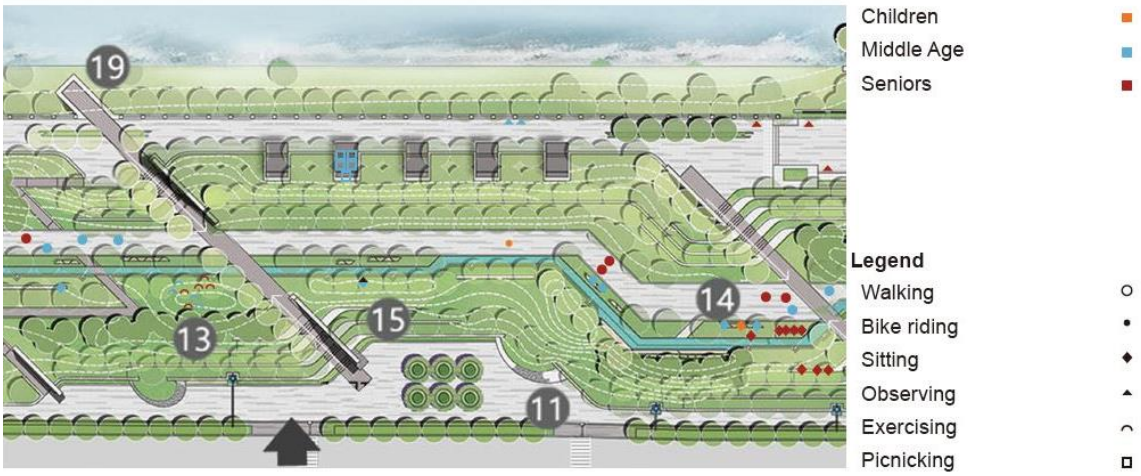



Figure 13. Activity typologies observed.

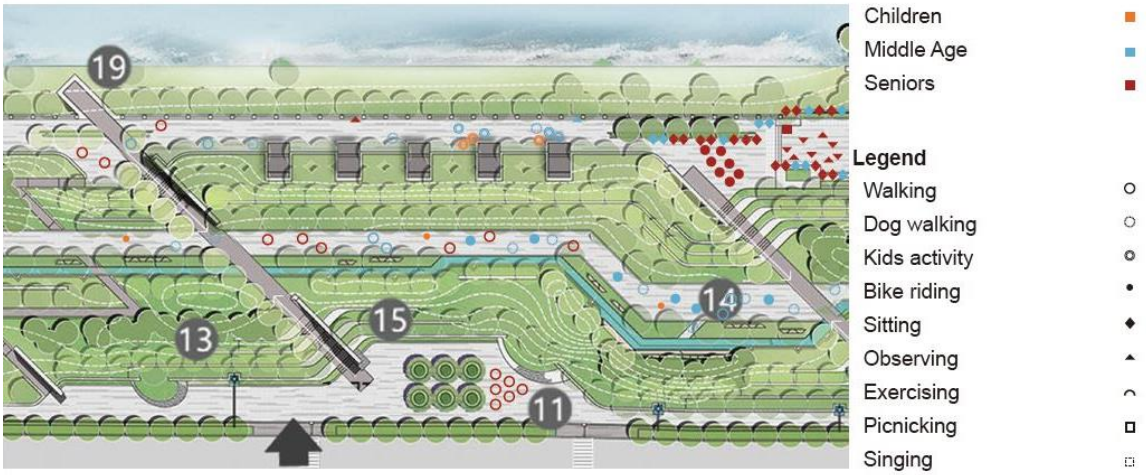
Recreational activities were calculated based on behavior mapping on 4 nodes and observation around the park. Cultural/recreation activities include: Walking, walking dogs, walking kids, bike riding, sitting, standing and observing, picnicking, singing, selling stuff, outdoor barbeque, picnic, fishing, playing spinning top, dancing, playing Taiji, club meeting, outdoor classroom, camping, and boating.

***Calculations:***

3/13 14:00



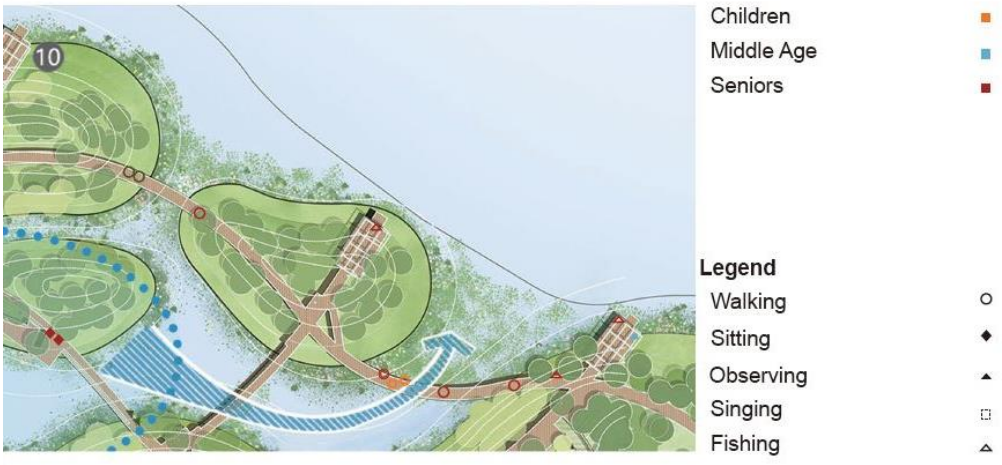
3/13 19:00




3/13 10:30


3/13 16:00

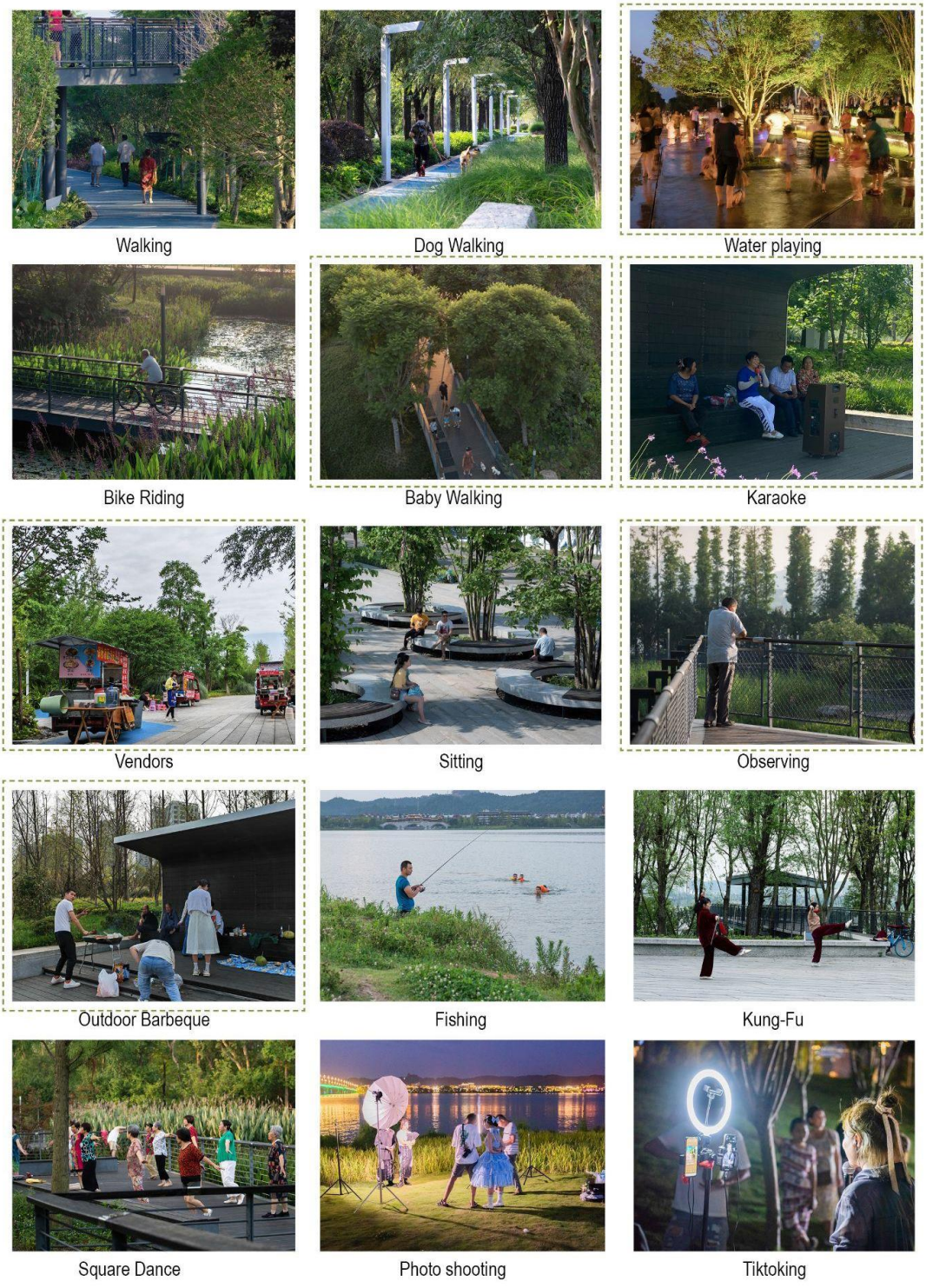
3/14 10:00




3/14 16:00


Figure 14. Behavior mapping series.

Multi-generation interaction activities are circled in green dashed lines



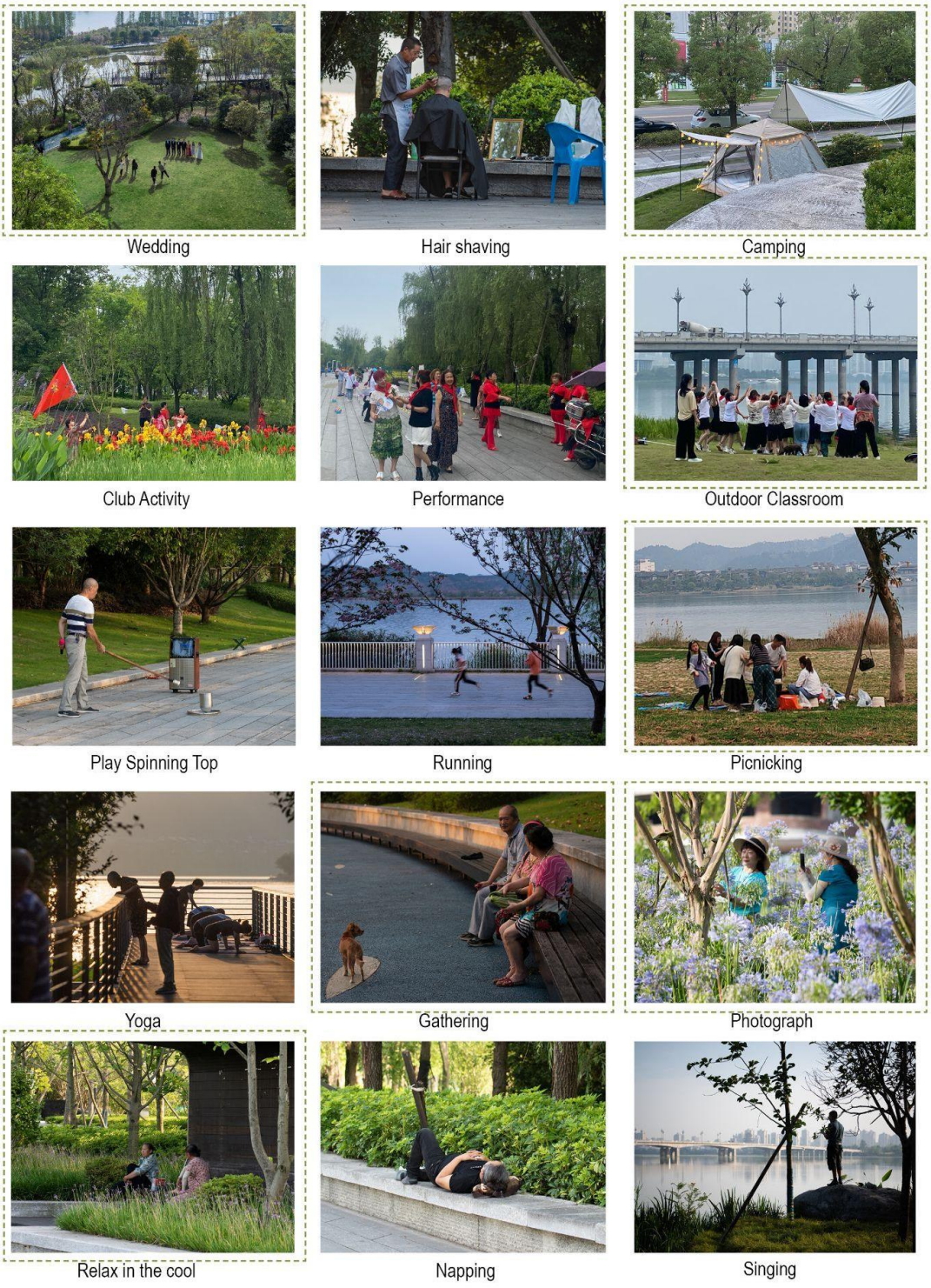



Figure 15. Photograph collage of observed activities.

***Sources:***

- Public Life Tool https://gehlpeople.com/tools/
- On-site observation on Mar.13-14, 2022.

***Limitations:***

- Activities observed on-site are subjected to weather conditions and may not represent a comprehensive analysis of human activities on site.

## Promotes spending time outdoors, with 75% of 60 surveyed visitors reporting that they spend more time outside after the park's opening. 49% of 49 surveyed visitors report visiting 2-3 times per week.

***Background:***

The site is adjacent to a residential area and is visited by a large number of people on a daily basis. Questionnaires can be used to obtain the satisfaction of visitors and the changes the park has made. The first question involved is from the first survey conducted in March, and the second and third question is from the second survey conducted in May.

***Method:***

Among a total of 49 respondents, 10 people said they come to the park almost every day, 14 people said they come to the park two or three times a week, 13 people said they come to the park two or three times a month, 3 people said they come to the park once every few months, 9 people said they come to the park only occasionally.

In a total of 60 respondents, 45 people agreed that they have spent more time outside after the park construction, 14 people think their time did not change, and 1 people think they have not spent more time outside after the park construction. Rate is calculated based on those data.

***Calculation:***

(Survey 1 Question 2): How often do you usually come to this park？

☐Almost every day(10) ☐About two or three times a week(14) ☐ Two or three times a month(13) ☐Once every few months(3) ☐Only occasionally(9)

(Survey 2 Question 1): I have spent more time outside after the park construction.

☐Agree(45) ☐Did not change(14) ☐ Disagree(1)

If you were to evaluate for yourself, how much more time did your family spend playing outside compared to before the park was built _____ hours per week?

Mostly 1-2 hours, and 6 people responded with more than 7 hours

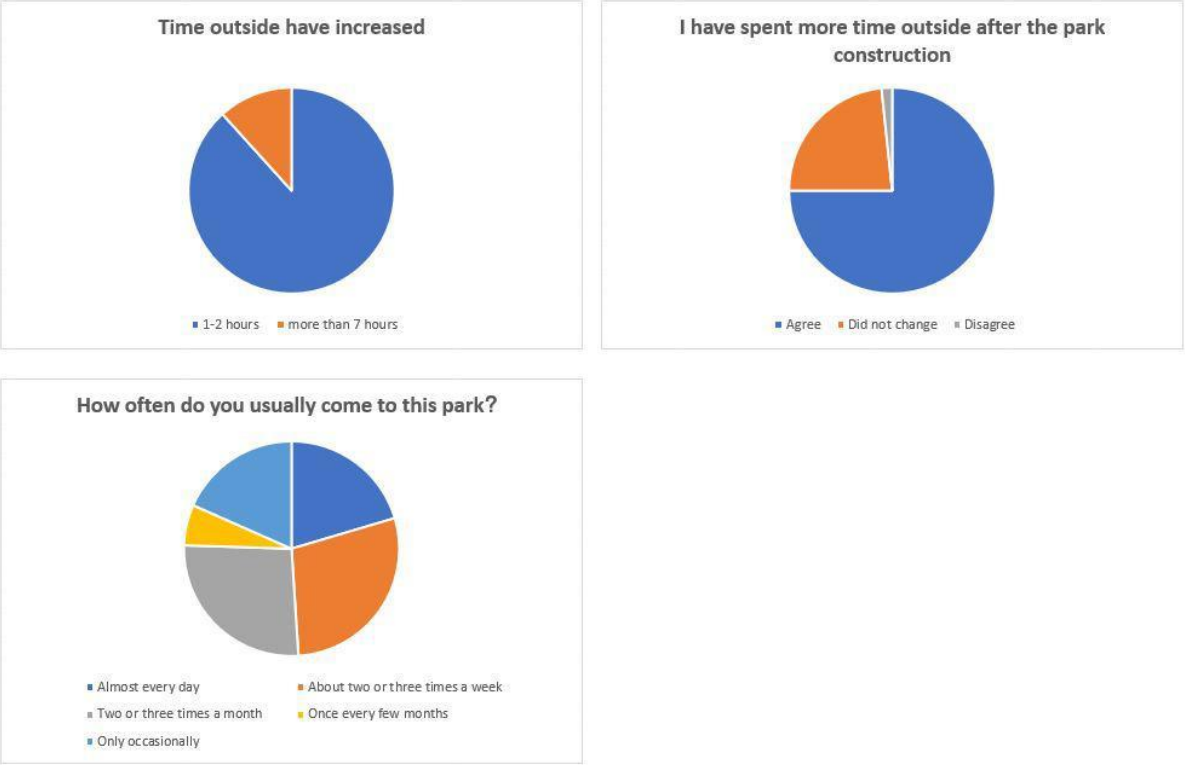



Figure 10. Selection of survey results related to outdoor usages.

***Limitations:***

- Not all people from the survey have filled out the increased time they spent outside, a small respondent base for this question could lead to a biased result.

**Facilitates a closer human-nature relationship and sense of well-being, with 100% of 49 surveyed visitors reporting that the park brings people closer to nature and 90% of 60 surveyed visitors reporting that the park provides enjoyment and relaxation.**

***Background:***

The site is adjacent to a residential area and is visited by a large number of people on a daily basis. Questionnaires were used to obtain feedback from visitors. The first question involved is from the first survey conducted in March, and the second and third question is from the second survey conducted in May.

***Method:***

In a total of 49 respondents, 18 people highly agreed that the park brings people closer to

nature, and 31 people agreed.

In a total of 60 respondents, 59 people agreed that the park gives people enjoyment and relaxation, 1 person thought the park did not change the result, and 0 people disagreed that the park gives people enjoyment and relaxation. The rate is calculated based on those data.

***Calculation:***

**(Survey 1 Question 5.6): The park brings people closer to nature**

☐Highly Agree(18) ☐ Agree(31) ☐Neutral(0) ☐Somewhat Disagree(0) ☐Disagree(0)

**(Survey 2 Question 4): The park gives people enjoyment and relaxation**

☐Agree(59) ☐ Did not change(1) ☐Disagree (0)


Figure 11. Selection of survey results related to human-nature relationships.

***Limitations:***

- Out of over a thousand visitors on a sunny day, the sample size of 49 and 60 is relatively small and may have a biased result.

## Improved perceived nighttime safety on site, with 58% of 60 surveyed visitors agreeing that the new lighting (a 27% increase in lighted area) makes them feel safe and comfortable.

***Background:***

Adequate lighting in the park at night can ensure the safety of visitors. A variety of nighttime recreation activities are happening at the park, including Karaoke, walking, vendors, and so on. During the first visit, we noticed that many visitors mentioned light coverage. Appropriate lighting is needed to ensure the safety of visitors, especially the elderly.

The total site area is 117 acres, which includes urban streetscape design. In this lighting calculation, we are focusing on the park area of the site, which is 45 acres.

***Method:***

Measure the total acre of the project area, and use google earth street view and images before construction to estimate a lighted area calculation. Calculate the newly designed lighting area by the construction document, and compare it with the previous lighting coverage.

Based on the survey conducted in the park, information about satisfaction rate, and people's impressions of different aspects of the park were gathered. In a question asking how satisfied visitors are with the lighting of the park, there were 60 responses gathered ranging from "satisfied", "Did not change", to "not satisfied".

***Calculations:***

The total area of the site is about 45 acres based on construction documents, and there was no lighting on-site before the construction of the park. There are 96 light poles, and 53 ground lighting features currently functioning on-site. 62 light poles along the boardwalk area were installed but not in use.

Based on area calculations in construction documents, the total lighting area is 12.2 acres.
12.2/45= 27.1%

| | Island Pier Section | Lawn Section | Ecological Island Section |
|---|---|---|---|
| Lighted Area (Acre) | 8.4 | 0 | 3.8 |

**(Survey 2 Question 5): The lighting in the constructed portion of this park makes me feel safe and comfortable**

☐ Agree ☐ No change ☐ Disagree

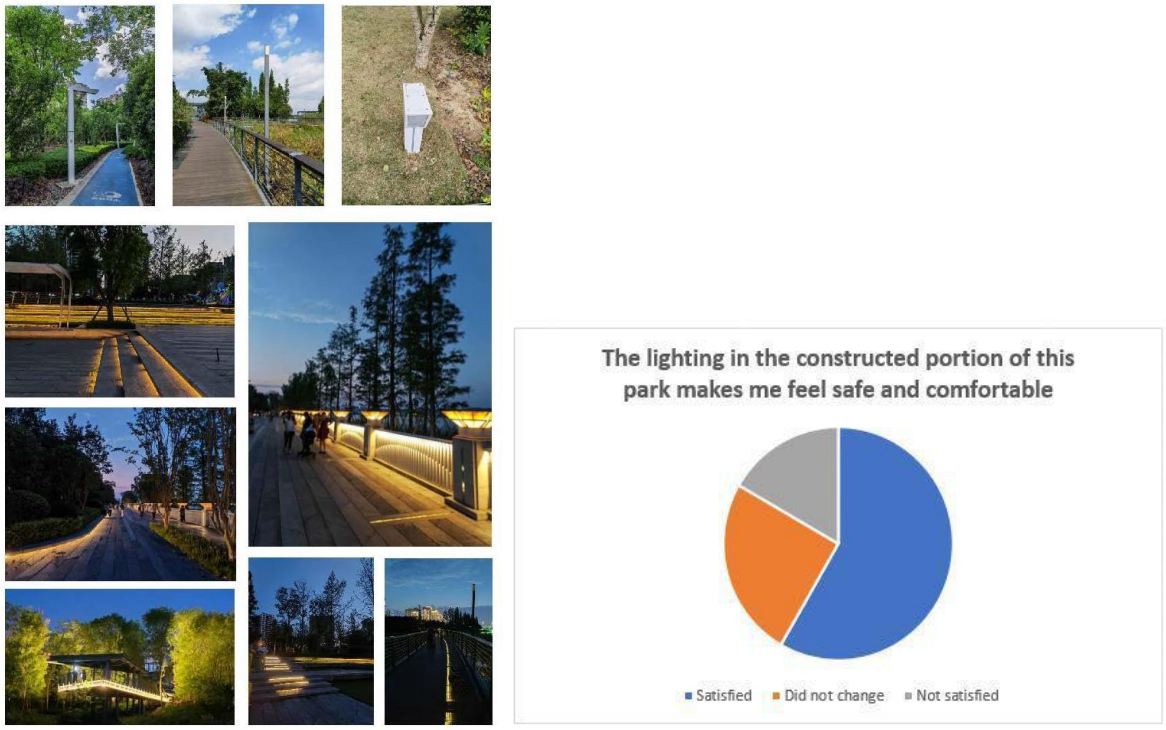



Figure 17. Lightings on site and survey results related to lighting improvement.

***Sources:***

- *Data produced by on-site observation*
- *Construction documents provided by the firm*

***Limitations:***

- Lighting coverage before park construction may not be 100% accurate due to limited sources of information and estimated illusion area.
- Large areas of ponds have no lighting due to nature preservation and decreased the lighting coverage rate.

**Increases scenic value index scores for the Suining waterfront from 4.6 to 46.8 for select views when comparing before and after the park's construction. Additionally, 98% of 60 surveyed visitors reported an improved perception of the aesthetic quality of the riverfront.**

***Background:***

The renovation of the riverfront greatly improved the aesthetics of the bank. By adding over 2,000 trees, various species of shrubs, and multiple aquatic perennial plants, the riverfront has transitioned from a concrete bulkhead without any recreational value to a vigorous river park

that promoted various activities. The scenic quality of the bank has also greatly increased.

***Method:***

The Bureau of Land Management's Visual Resources inventory evaluates scenic quality by categories such as "vegetation", "water", and "cultural modifications". In the previous case study of Chicago Riverwalk Phase 2 & 3 in the LAF *Landscape Performance Series* database, they updated and renovated the method to calculate the scenic quality index (SQI) of the park by measuring the takeoff of the categories for each photo in AutoCAD. We referenced and adopted their method to measure the scenic quality index of Suining South Riverfront Park. Due to the limitation of pre-construction photos and the features of the Suining Riverfront Park, we decided to use "vegetation" and "circulation" as two categories to calculate the SQI. Several factors were considered when choosing the pre-construction photos as cross reference: the resolution and quality of photos, the presence of reference structure in the photos, and the content richness of the photos. Four sets of pre-construction and post-construction photos taken at the same angle were sized to 10 x 8 inches and then imported to AutoCAD 2021 for calculation. Areas of each category were measured and represented in different colors. Green represents vegetation and blue represents circulation. The SQI was calculated by adding the total category areas together in each photo. The total net gain was measured by comparing the total SQI of pre-construction scenic quality and post-construction scenic quality. All data below is represented in units of square inches, and higher score means higher scenic quality.

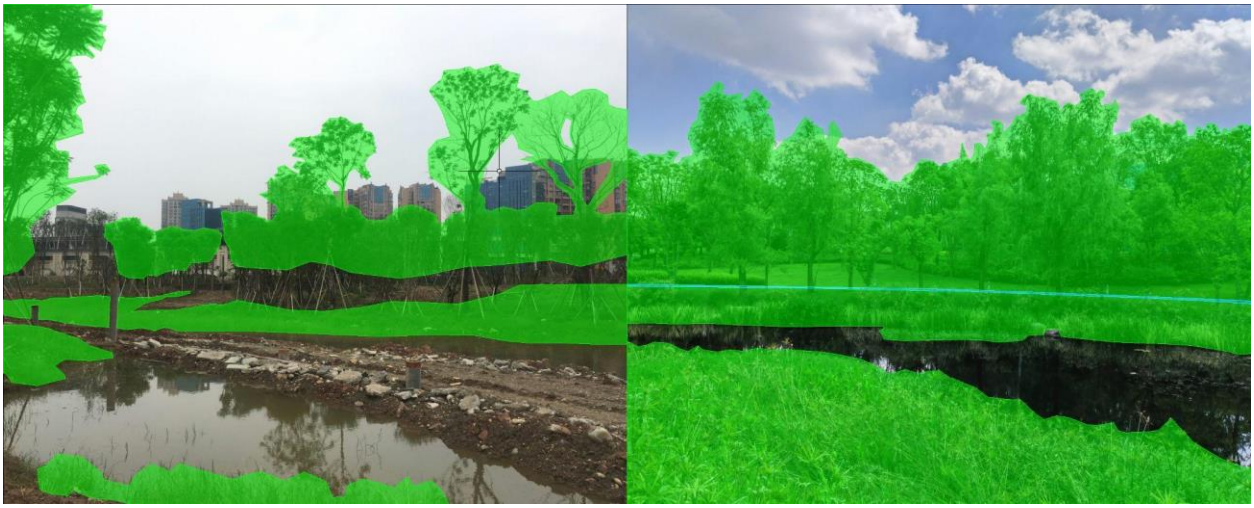
On May 28, 2022, on-site surveys were distributed to the visitors in Suining Riverfront Park. Surveyed visitors were asked if they think the completion of Suining Riverfront Park has contributed to an improvement of the aesthetics of the city. Of 60 surveyed visitors, 59 gave a positive answer and only one said there is no change.

***Calculations:***

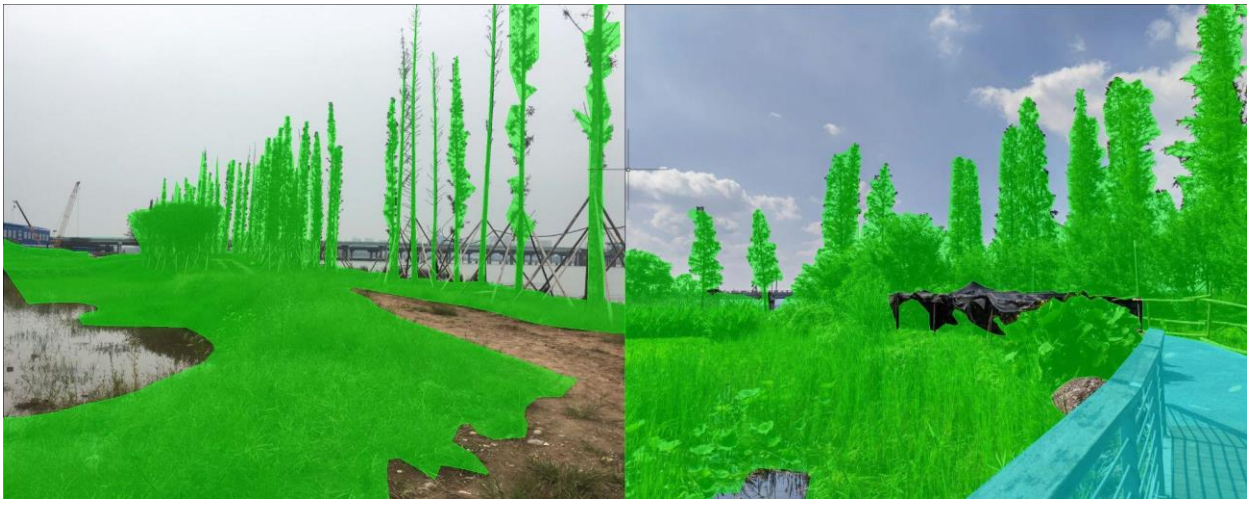
| | Before | | | After | | | SQI Net Gain |
|---|---|---|---|---|---|---|---|
| | Vegetation | Circulation | SQI | Vegetation | Circulation | SQI | |
| Aerial View | 8.03 | 2.49 | 10.52 | 53.72 | 3.62 | 57.34 | 46.82 |
| Planting Pond | 26.66 | 0 | 26.60 | 51.12 | 0.31 | 51.43 | 24.83 |
| Wetland Area | 34.19 | 0 | 34.19 | 41.03 | 7.74 | 48.77 | 14.58 |
| Lily Pond | 32.60 | 0 | 32.60 | 47.90 | 6.90 | 54.80 | 22.20 |
| Total SQI | | | 103.91 | | | 212.34 | **108.43** |

Aerial View Before and After

Planting Pond Before and After



Wetland Area Before and After



Lily Pond Before and After

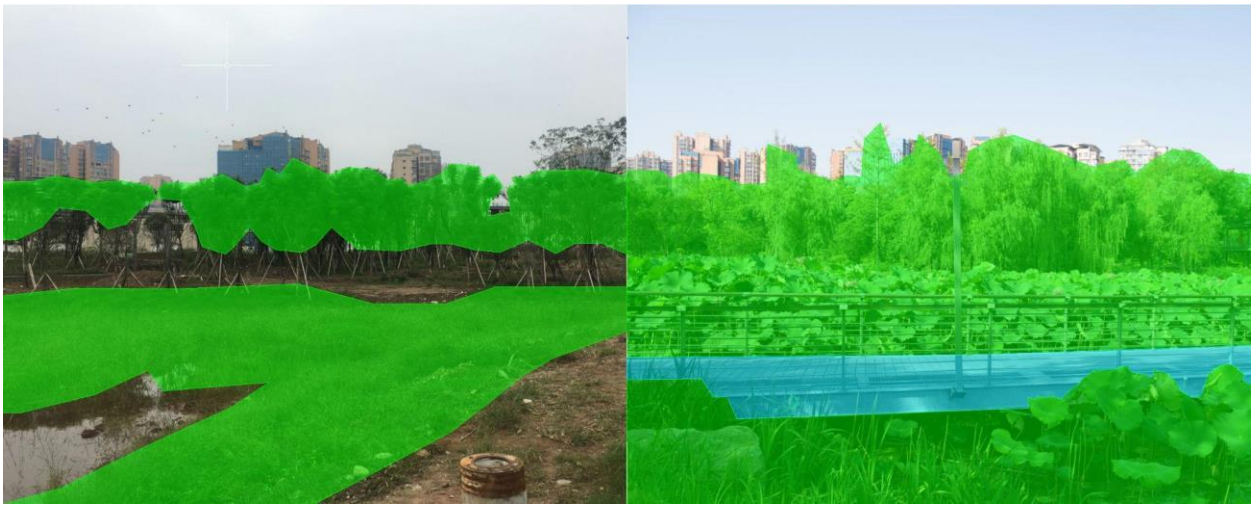


Figure 16. SQI analyzed photograph comparisons.

***Sources:***

- Pre-construction photos provided by the firm
- Post-construction photos taken on-site
- User survey
- https://www.landscapeperformance.org/sites/default/files/Chicago-Riverwalk-Phases-2-and-3-Methods_1.pdf

***Limitations:***

- Because of a lack of reference in many pre-construction photos, only a limited number of photos were used to calculate the SQI. Furthermore, the limitation of photos restricted the scenic quality category used for evaluation.
- Pre-construction and post-construction photos were not taken at the exact same angle and could lead to errors when calculating the areas in AutoCAD.
- Only limited locations were used, and the data was not comprehensive enough to represent the whole park.

## Increases green space per capita from 28 sf to 68 sf and provides recreational opportunities and green space access for estimated 50,200 potential visitors within a 0.6-mile walking distance.

***Background:***

One of the objectives of the park was to provide more green spaces for nearby residents. Before the construction of the park, very limited areas of green spaces were accessible to residents in the surrounding neighborhoods.

***Method:***

The LAF team estimated the total number of residents living nearby to gain a better

understanding of the role the park plays in providing green space access for residents within a walkable distance. We used 1km (about 0.6 mile) as a measuring boundary as an adult can walk about 1km in 10 minutes on average. We thought it is a reasonable time and walking distance for a resident to travel in order to access the closest green space from home. Our team web-searched the residences nearby and estimated the total households and population living within 1km of the park. Then, the individual's green space per capita was calculated by measuring the green space on Google Earth before and after the construction of the park and divided by the area's population. The total number of households in a neighborhood was documented from a real estate website and then multiplied by the average household size of Sichuan Province to estimate the total population.

According to the Sichuan Provincial Bureau of Statistics, the data from the 2020 China census showed that the average household size in Sichuan Province was 2.51. We used 2.5 for ease of calculation.

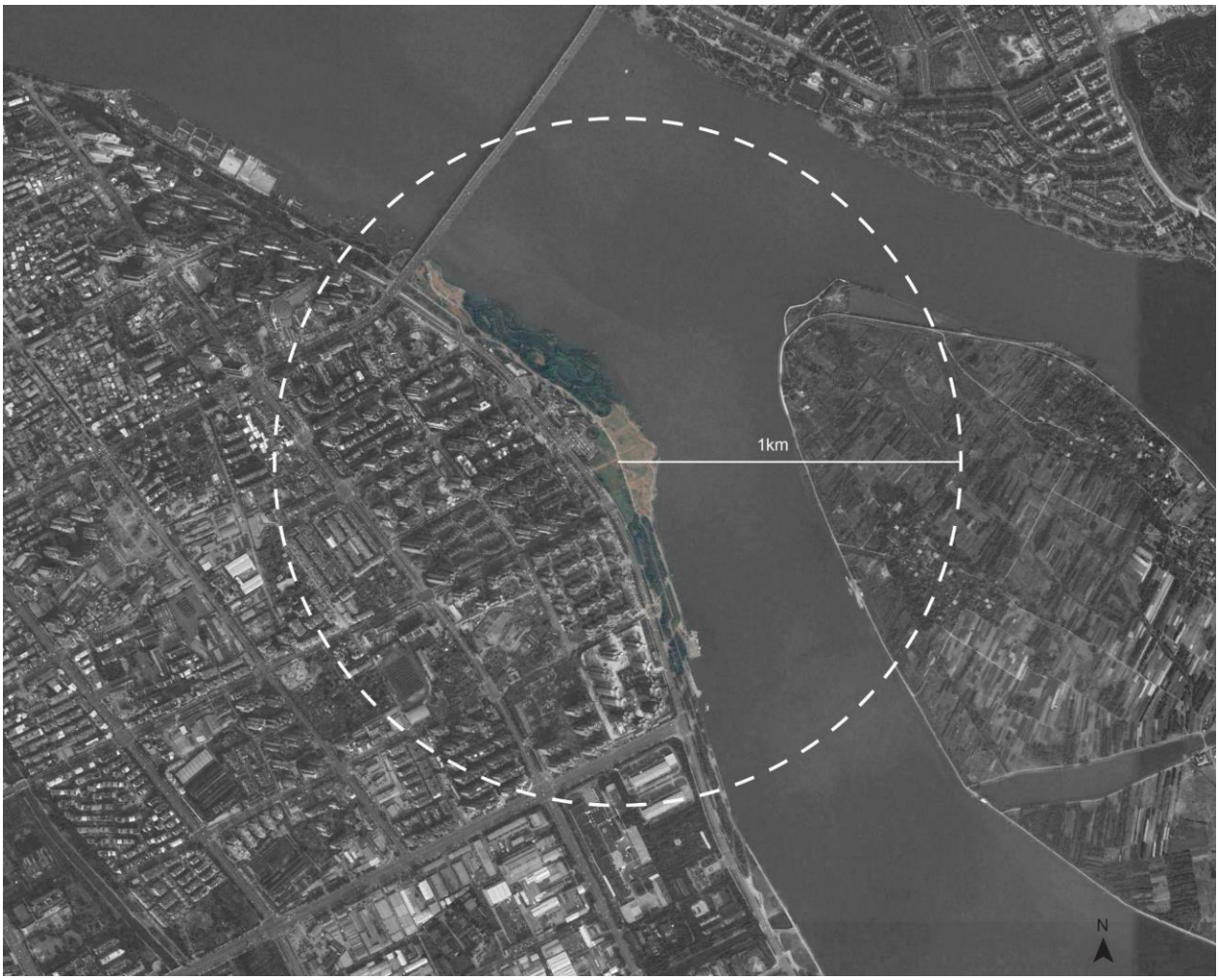


Figure 12. One kilometer coverage.

***Calculations:***

| Residence | # of Household | Estimated Population | Residence | # of Household | Estimated Population |
|---|---|---|---|---|---|
| 滨海名城 BinHaiMingCheng | 600 | 1500 | 双发浅水湾 Shallow Bay | 2184 | 5460 |
| 开源小区 KaiYuan Neighborhood | 518 | 1295 | 国滨首府 GuoBinShouFu | 4262 | 10655 |
| 荣兴时代滨江 ShiDaiBinJiang | 373 | 933 | 江南美邸 JiangNanMeiDi | 1456 | 3640 |
| 城南丽景 SouthCityLiJing | 613 | 1533 | 南城郡 SouthCity Neighborhood | 550 | 1375 |
| 鼎程锦绣兰庭 JinXiuLanTing | 1100 | 2750 | 富成小区 FuCheng Neighborhood | 960 | 2400 |
| 深南小区 ShenNan Neighborhood | 216 | 540 | 一品花苑 YiPin Garden | 512 | 1280 |
| 荣兴南苑 RongXingNanYuan | 144 | 360 | 兴文小区 XingWen Neighborhood | 448 | 1120 |
| 宜园小区 YiYuan Neighborhood | 504 | 1260 | 华泰诗意人家 ShiYiRenJia | 192 | 480 |
| 马宗岭小区 MaZongLing Neighborhood | 400 | 1000 | 港城国际 GangChengGuoJi | 288 | 720 |
| 清水港湾 Port City | 723 | 1808 | 永明南湖逸景 NanHuYiJing | 240 | 600 |
| 南湖尚城 NanHuShangCheng | 1020 | 2550 | 君宏世纪春天 ShiJi Spring | 1536 | 3840 |
| 金裕香江 JinYuXiangJiang | 1252 | 3130 | **Total** | **20,091** | **50,229** |

Existing Green Space Area: 132,803 square meter
Park Area From Google Earth: 182,826 square meter
Individual's green space per capita (**before**) = existing green space area/population = 132,803/50,229 = **2.64 sq meters (28.41672 sf)**
Individual's green space per capita (**after**) = total green space area/population = 132,803+182,826/50,229 = **6.28 sq meters (67.59736 sf)**

***Sources:***

- http://tjj.sc.gov.cn/scstjj/tjgb/2021/5/26/91f211253f0548b6975c68d233fa6e39.shtml

***Limitations:***

- Using population data is not an exact method for calculating the actual number of residents who have access to the park within a 1km walking distance.
- Even though the park provides green space access to nearby residents, it does not mean that people in this area are actually accessing and using the park as their recreational space.
- This analysis assumes that all residents within a 1km radius buffer area of the park are able to walk 1km per minute and does not take into account people with physical disabilities that might prevent them from accessing the site. Also, this analysis only accounts for a 1km linear distance from the site but does not take into account road and traffic conditions or any barriers to walking to the site,
- There might be a slight difference in the population before and after the construction of the park. The green space per capita calculated here does not take into account this difference.

**Represents an icon for the city's recreational center, as evidenced by its mention 11 times by locally notable social media content creators as of 2022. 578 social media posts have used scenes in the park for video backgrounds.**

***Background:***

With over 70% of the population using the internet in China, social media can capture urban park usage based on location, images posted, and keywords mentioned. Using social media as a way of analyzing urban parks was proven to be effective in Shenzhen, China. (Chen et al., 2018)

***Method:***

We searched the Riverfront Park on three main social platforms including Weibo, Tiktok, and Wechat, as well as the city's government official website. We counted the posts that mentioned the Riverfront park as well as how many times influential accounts of the city mention the park to promote the city. All content created before summer 2022 was included.

***Calculations:***

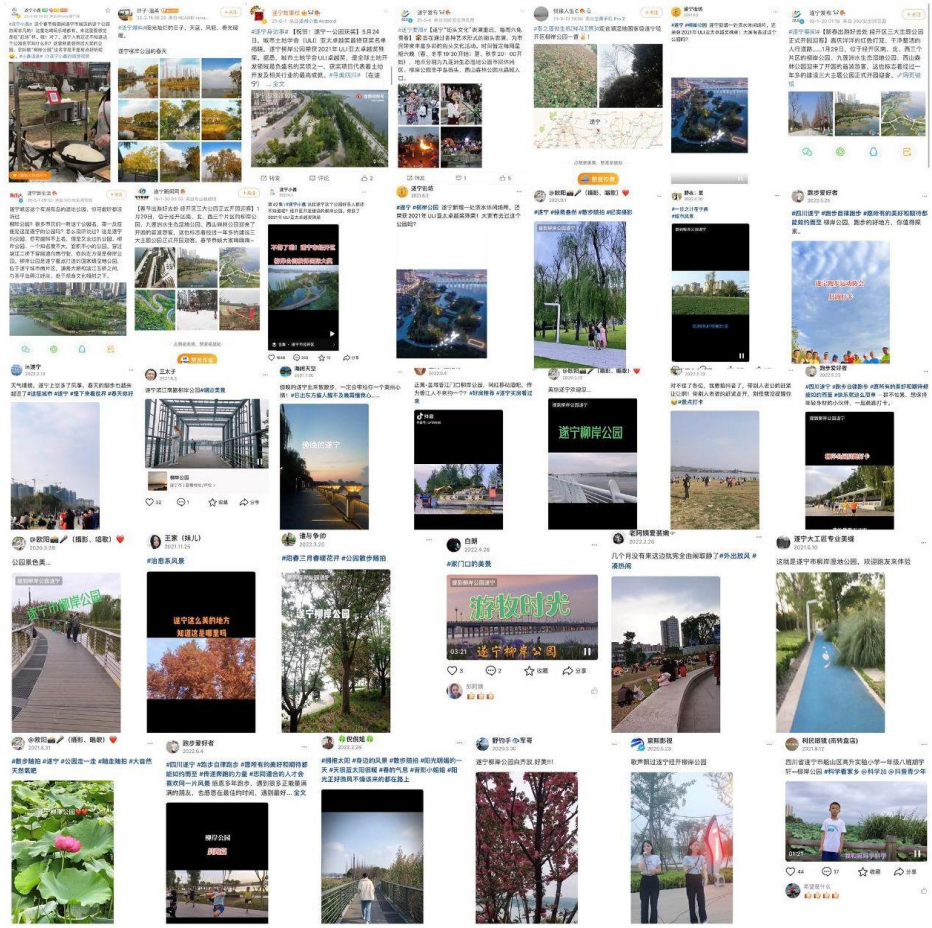



Figure 19. Screenshot of select social media accounts referencing South Riverfront Park.

Different Social Media Platforms

Weibo (微博)

- Suining Stories (遂宁故事绘)
    - Followers:155K
    - 4 posts related to the Park
- Suining Posts (遂宁发布)
    - Followers: 421K
    - 3 posts related to the Park
- Suining City Association (遂宁同城会)
    - Followers: 178K
    - 1 post related to the Park

Tiktok (抖音)

- Xin Suining (遂宁小鑫)
    - Followers: 88K

    - 3 posts related to the Park
- 578 posts created in the Riverfront Park, 481 posts with picture or video.

WeChat (微信)

- Suining News (遂宁新闻网)

***Sources:***

- Y., Liu, X., Gao, W., Wang, R. Y., Li, Y., & Tu, W. (2018). Emerging social media data on measuring urban park use. *Urban Forestry & Urban Greening*, *31*, 130–141. https://doi.org/10.1016/j.ufug.2018.02.005

***Limitations:***

- Suining is a relatively small city, as a fifth-tier city, it has even fewer official platforms and less data to mine

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## Economic Benefits

### Contributed to an average increase in housing price of 29.8% on average from 2017 to 2019 among 2 randomly selected real estate developments within a 5-minute walk of the park, compared with an average increase of 4.8% from 2017 to 2019 among 2 randomly selected comparable real estate developments elsewhere in Suining City.

***Background:***

In this analysis, 4 individual developments were selected, two were selected to represent typical properties near the site, and two were selected to represent those far from the site but with similar properties/characteristics. All of them are located in Suining City, Chuanshan Area. Shallow Bay and Port City are located within 5 minutes walk of the park. Urban Garden and Aocheng Garden are located far from our site.

Aocheng Garden and Urban Garden are selected as a comparison set because they are all located close to water, they all have a similar price range, and have an adjacent urban park within 10 minutes' walking distance.

In 2018, the housing price collapsed due to a new policy established on May 15th, it requires both household registration booklet and social security to buy housing, and limits each family to buy one house only, divorced families less than 2 years old still count as one family. That leads to a decrease in value for most properties within the city.

There are normally three housing price increases near a park, including a deterministic schedule, before construction, and construction completion.

***Method:***

The research team collected housing prices from real estate websites and official real estate data websites. According to the housing price (/m²) every month, we calculate the average housing price (/m²) of the year, then calculate the percentage difference from park construction to construction completion, and COVID-19 started.

Compare the difference of increase/ decrease rate to identify the potential impact of the park

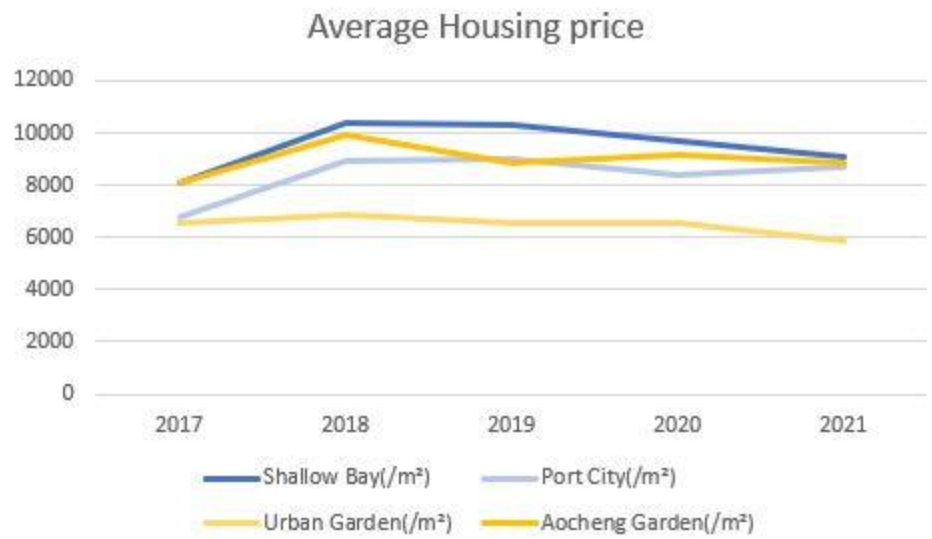
***Calculations:***

*Price calculated in CNY(China Yuan)
According to the housing price (/m²) every month to calculate the average housing price (/m²) of the year.

| | 浅水湾 Shallow Bay(/m²) | 港城清水港弯 Port City(/m²) | 城市花园 Urban Garden(/m²) | 奥城花园 Aocheng Garden(/m²) |
|---|---|---|---|---|
| 2017 *Park announced | 8113 | 6815 | 6572 | 8053 |
| 2018 | 10352 | 8943 | 6864 | 9896 |
| 2019 *Park Opened | 10303 | 9032 | 6558 | 8841 |
| 2020 | 9661 | 8430 | 6528 | 9135 |
| 2021 | 9064 | 8724 | 5885 | 8868 |

| | 浅水湾 Shallow Bay(/m²) | 港城清水港弯 Port City(/m²) | 城市花园 Urban Garden(/m²) | 奥城花园 Aocheng Garden(/m²) |
|---|---|---|---|---|
| 2017-2019 | 27.0% Increase | 32.5% Increase | 0.2% Decrease | 9.8% Increase |
| 2019-2021 | 12.0% Decrease | 3.4% Decrease | 10.3% Decrease | 0.3% Decrease |

* Price reduction due to COVID-19 started in 2019




*Blue represents properties near the Park, Yellow represents the other two properties

Figure 18. Average house prices of the four selected properties from 2017 to 2021.

***Sources:***

https://www.creprice.cn/community/0943238371.html?city=sn&sinceyear=5
https://suining.anjuke.com/

***Limitations:***

- COVID-19 has made a big impact on the property value after construction and caused major price shifts in the market between 2019-2021.
- There are multiple factors that control the shift in housing prices.
- Control group and comparison group have other differences that may impact housing prices, including being close to hospitals and high schools.

## Encourages local business establishment, with 73% of the 11 stores within a 10-minute walk of the park opening after park construction was complete.

***Backgrounds:***

Suining Riverfront Park, with over 1,200 visitors on a typical Saturday, provides business opportunities for small vendors as well as shops, restaurants, and other leisure stores. Based on site visit information from the firm (Ecoland), there were very few stores and restaurants in this location in 2016. The park opened in 2019, and stores around the park that opened after the park construction were evaluated.

***Method:***

We offset the park boundary 10- minute walking limit, and counted all the stores within this area. We searched online or called the store location to record their year of opening.

***Calculations:***

| Store Name | Year of Opening | Store Name | Year of Opening |
|---|---|---|---|
| 大自然鲜鱼馆<br>Fish restaurant | 2020 | 鱼尚鲜鱼庄<br>Fresh Fish | 2019 |
| 江南聚鑫茶楼<br>Jiangnan Tea | 2021 | 喜事汇<br>Joy Lou | 2018 |
| 十七糖水铺<br>17 Desserts | 2019 | 佳昕超市<br>Jiaxi Market | 2016 |
| 川鱼酒家<br>Spicy Fish | 2021 | 永佳馨大酒店<br>Jiaxin Hotel | 2015 |
| 张麻子鱼府<br>Zhang's Fish | 2019 | 金林自助火锅<br>JinLin Hotpot | 2019 |
| 魅力国滨KTV<br>Charming KTV | 2021 | 原原聚贤鱼蛙<br>Yuan's Fish&Frog | 2021 |

8 stores were opened after 2019, 8/11=72.7%

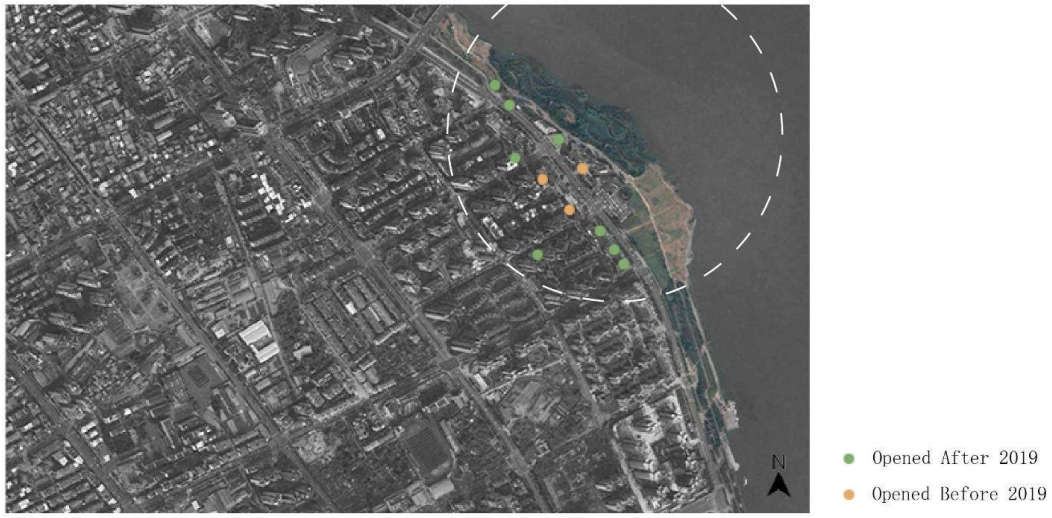



Figure 20. Opening time for stores located near the park.

***Limitations:***

- Stores that closed before the time of evaluation were not included in this analysis.
- A new school also opened nearby during this time period, which may have contributed to attracting these businesses.

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## Inconclusive Benefits

**Water quality in the park was expected to improve with the construction of the wetland. However, due to the over-generalized public data in water quality monitoring, the water quality improvement cannot be quantified.**

***Background:***

The wetland was constructed with the goal of improving water quality. In the Suining government, there is water quality data available that is released to the general public, and there is a water monitoring station right next to the site.

***Method:***

The research team retrieved all the public records for water quality monitoring, all the way back to the first available report in 2016.

***Calculations and Limitations:***


2016年遂宁市地表水水环境质量状况 - 水...
2017年1月水环境质量公告 - 水环境管理 ...
2017年2月水环境质量公告 - 水环境管理 ...
2017年3月水环境质量公告 - 水环境管理 ...
2017年4月水环境质量公告 - 水环境管理 ...
2019年6月遂宁市地表水水环境质量状况 ...
2019年8月遂宁市地表水水环境质量状况 ...
2019年9月遂宁市环境质量公告 - 水环境...
2019年10月遂宁市地表水水环境质量状...
2020年2月遂宁市地表水水环境质量状况 ...
2020年3月遂宁市地表水水环境质量状况 ...
2020年5月遂宁市地表水环境质量状况 - ...
2020年8月遂宁市地表水环境质量状况 - ...
2020年9月遂宁市地表水环境质量状况 - ...
2020年11月遂宁市地表水环境质量状况 - ...
2021年3月遂宁市地表水环境质量状况 - ...
2021年5月遂宁市地表水环境质量状况 - ...
2021年7月遂宁市地表水环境质量状况 - ...
2021年8月遂宁市地表水环境质量状况 - ...
2021年9月遂宁市地表水环境质量状况 - ...
2021年11月遂宁市地表水环境质量状况 - ...
2021年12月遂宁市地表水环境质量状况 - ...
2022年2月遂宁市地表水环境质量状况 - ...

| 断面名称 | 所在地 | 规定类别 | 上月类别 | 上年同期 | 本月类别 | 主要污染指标/超标倍数 |
|---|---|---|---|---|---|---|
| 香山 | 射洪 | III | III | III | III | / |
| 梓江大桥 | 射洪 | III | III | III | III | / |
| 鄰江口 | 大英 | III | III | III | IV | 五日生化需氧量/0.25、化学需氧量/0.15 |
| 米家桥 | 船山 | III | II | II | III | / |
| 老池 | 船山 | III | II | II | III | / |
| 跑马滩 | 安居 | III | 劣V | V | 劣V | 总磷/1.85、溶解氧 |
| 大安 | 安居 | III | IV | III | IV | 总磷/0.50 |

注：1. 地表水环境评价执行《地表水环境质量标准》（GB3838-2002）和《地表水环境质量评价办法（试行）》（环办〔2011〕22号）。

2. 21项评价指标为：pH、溶解氧、高锰酸盐指数、五日生化需氧量、氨氮、石油类、酚、汞、铅、镉、阴离子表面活性剂、铬（六价）、氟化物、总磷、氰化物、硫化物、砷、化学需氧量、铜、锌、硒。

3. 超过III类水质标准的指标为断面污染指标，取超标倍数最大的前三项为主要污染指标。

Figure 21. Screenshot of collected water quality data summary and data details.

The water quality near Suining Riverfront Park has always been either Level II or Level III in different seasons when rain water quantity is different. There is no obvious pattern observed

from the past five years of data. However, the water quality data reported is quite broad. Hence, it does not mean the water quality has not improved.

***Sources:***
Suining City Bureau of Ecology and Environment Water Environment Management. https://ssthjj.suining.gov.cn/shjgl

## Suining South Riverfront Park is part of a "sponge city" initiative. The construction of the park is expected to contribute to the city's overall air quality improvement, environmental improvement, and ability to attract external investment.

***Methods, Calculations, and Limitations:***
According to "Sichuan Economic Daily", Suining South Riverfront Park, together with other city parks in Suining City, has expanded more than 1,100,000 square meters (or 272 acres) green coverage of the entire city. The green coverage has increased to 39.7%, and the air quality, water quality, and soil quality is believed to have greatly improved (Sichuan Economic Daily, 2021). From 2016 to 2020, the city has successfully attracted more than 50 billion (approximate 7 billion US dollars) external investments.

Suining South Riverfront Park has specifically been mentioned in the news; however, no quantifiable data is available to measure the specific benefit the park brings to the city in terms of air quality improvement, or sponge city improvement. However, we do feel it should be acknowledged as the park does play an important role in all these environmental improvements, and potentially economic attractors.

***Sources:***
Sichuan Economic Daily. 2021-02-24. "Suining Economic and Technological Development Zone "Thirteenth Five-Year Plan" Development Overview." https://xmapp.snxw.com/wap/article/index/580413

## Reduced noise by 9.15 dB on average in the island pier section of the park as compared with the lawn section which has no new planting installed.

***Background:***

The site is adjacent to 5-lane traffic that produces noise pollution. According to our data, the noise level on the road is about 72.7 dB. Using a decibel meter to track noise mitigation of urban parks is proven to be effective in Hong Kong (Xing & Brimblecombe, 2020). The team used a decibel meter "Deli DL333202" around the site to collect noise data.

***Method:***

The noise was measured in 2 levels of depth in the park with hand-held noise meters. Level one is closer to the road, level two is deeper in the park with more planting coverage. An average of two levels are used to compare, see the map below for point locations.

Record time: 10:00am-11:00am May 28


Figure 22. Noise level measurement on site.

(54.4+53.9)/2 (calculated with logarithmic values) = 54.2 dB
(62.3+64.3)/2 (calculated with logarithmic values) = 63.4 dB
63.4-54.2 = 9.2 dB change

***Limitations:***

- Lacking pre-construction noise data to compare with.
- There are many singing and dancing activities going on around the wetland area that produce noise, therefore wetland area is not included when calculating noise level

***Sources:***


- Xing, Y., & Brimblecombe, P. (2020). Traffic-derived noise, air pollution and urban park design. Journal of Urban Design, 25(5), 590–606. https://doi.org/10.1080/13574809.2020.1720503
- https://www.noisemeters.com/apps/db-calculator/


**The district the park is in saw a 5.05% lower decrease in property value in 2020, and a 3.83% lower decrease in 2021 as compared to another sub-district in Suining City, given the impact of the COVID-19 pandemic lowering property values across the City**.

***Background:***

Suining City is composed of 5 districts, Chuanshan and Anju are both level 2 districts, and the other 3 districts are smaller in scale. In this comparison, we use Chuanshan to compare with Anju to see the difference of housing prices.

In 2018, the housing price collapsed due to a new policy established on May 15th, it requires both household registration booklet and social security to buy housing, and limit each family to buy one house only, divorced families less than 2 years old still count as one family.

There are normally three housing price increases near a park, including deterministic schedule, before construction, construction completion.

Method:

Collect housing prices from real estate websites. According to the housing price (/m²) every month to calculate the average housing price (/m²) of the year, then calculate the percentage difference by year and area of those districts. Apply the same principle to calculate the percentage difference of the community within a 10 minute walking distance to the Park. Compare those data and conclude.

Calculations:

*Price calculated in CNY(China Yuan)
According to the housing price (/m²) every month to calculate the average housing price (/m²) of the year.

| | Chuanshan Area(/m²) | Anju Area(/m²) | Suining City(/m²) |
|---|---|---|---|
| 2015 | 6340 | 3003 | 4583 |
| 2016 | 6351 | 3587 | 4611 |
| 2017 | 6581 | 4022 | 5376 |
| 2018 | 8390 | 7213 | 7705 |
| 2019 | 7158 | 5229 | 6739 |
| 2020 | 6693 | 4667 | 6491 |
| 2021 | 6658 | 4472 | 6506 |
| 2022(Jan-April) | 6628 | 4263 | 6564 |


Figure 23. House price trends from 2015 to 2021.

| | Chuanshan District | Anju District | Suining City |
|---|---|---|---|
| 2015-2016 | 0.17% | 16.3% | 0.61% |
| 2016-2017 | 3.49% | 10.82% | 14.23% |
| 2017-2018 | 21.56% | 44.24% | 30.23% |
| 2018-2019 | -17.2% | -37.9% | -14.3% |
| 2019-2020 | -6.95% | -12.0% | -3.82% |
| 2020-2021 | -0.53% | -4.36% | -0.23% |
| 2021-2022 | -0.45% | -4.90% | -0.88% |

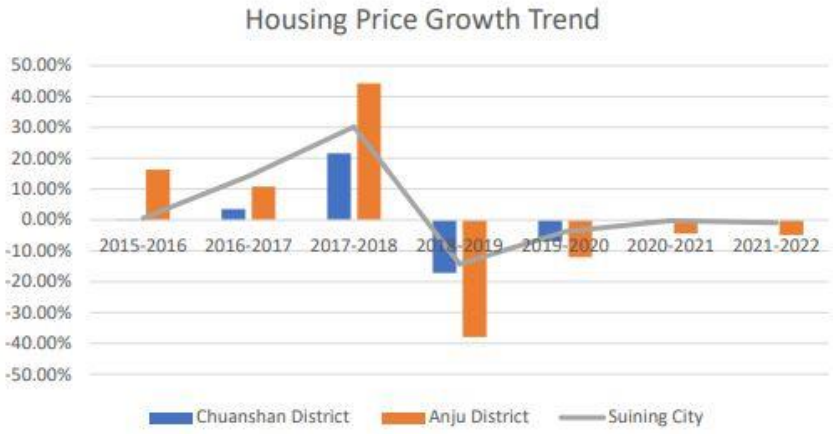



Figure 24. House price growth trends from 2015 to 2021.
Sources:

https://m.gotohui.com/fangjia/3021(Housing Price of Chuanshan District)
https://m.gotohui.com/fangjia/3022(Housing Price of Anju District)
https://suining.anjuke.com/(Housing Price of Suining City)
https://suining.anjuke.com/community/view/1126013(Guobinshoufu)
https://suining.anjuke.com/community/view/996403?from=shpt_xq(Qianshuiwan)
https://suining.anjuke.com/community/view/1126006?from=PC_COMM_Page_ZBlist(Qingshuigangwan)
https://mobile.anjuke.com/xf/fj-sn/chuanshanqu/2017/
https://www.landscapeperformance.org/sites/default/files/Buffalo-Bayou-Park-Methods_1.pdf
Limitations:

- Covid has made a big impact on the property value after construction and caused major price shifts in the market.
- There are more than one factors that control the shift in housing prices.
- Due to the different scales of the Chuanshan area and Anju area, there is controversy about whether they are comparable in tracking property value, so we moved this benefit to inconclusive

**Offers 16 types of informal marketing and small business opportunities, including street artists, vendors, facility renting and seasonal events. The park also provides spaces to gain financial support for unemployed individuals/family vendors during the COVID-19 pandemic.**

***Background:***

The park opened in 2019 when the COVID-19 pandemic started, and many nearby residents would come to gather outdoors instead of having indoor activities. The lawn area provides a platform for vendors to come and sell food or small goods.

During the May and June visit, we counted the number of types of informal marketing and small businesses, and found 16 different ones, including movable karaoke, ice cream cart, toys selling, bounce house, roller skate teaching, snack carts, to name a few. The research team interviewed a few sellers, and they indicated that although the income is not a lot, it helped the family during the COVID-19 pandemic to make a living.

***Method:***

On-site Observation

***Limitation***:

As there is no written record or official recognition, plus the markets are informal and movable, these benefits cannot be quantified as an economic benefit.

# Appendix I: On-Site Survey

**Suining South Riverside Park/Liu'an Park Questionnaire survey on the people who use the park**

Hello, residents! We, landscape architecture students, are working with the design firm of Liu'an Park to conduct a survey on the use of the park(Also known as South Riverside park) in Suining to assess the impact of the design on life and culture of local residents. Please take five minutes of your time to take a questionnaire for us. Thank you for your participation and for your love of the park!

**Are you a resident of Suining or a visitor from abroad？** ☐ Local Resident （Travel time: _____minutes，transportation：_____） ☐ Visitors（I came from_____city，staying in Suining for _____day）

**Which age range do you fall into？** ☐15-28 years ☐28-48 years ☐48years+
**You are** ☐Male ☐Female

**Which age group do you think uses this park the most？(select all that applies)**
☐Children ☐Teenagers ☐Middle age ☐Older people

1. **What is your impression/feedback of this new Liu'an Park？**

☐Very Good ☐Good ☐Fair ☐Not very Good

2. **How often do you usually come to this park？**

☐Almost every day ☐About two or three times a week ☐ Two or three times a month ☐Once every few months ☐Only occasionally

3. **How long do you stay and play in this park each visit？**

☐Very short, only a few minutes ☐20-30minutes ☐About an hour ☐2-3 hours ☐4-6 hours ☐Other_____

4. **Did you come to this park with others？**

☐I'm with my friends ☐I brought my kids ☐I'm here alone ☐Other_____

5. **Can you make a competent evaluation of the following aspects of this park？**

1) The park enhances the image of the City： ☐Highly Agree ☐ Agree ☐Neutral ☐Somewhat Disagree ☐Disagree
2) The park has increased recreational opportunities for residents：☐Highly Agree ☐Agree ☐Neutral ☐Somewhat Disagree ☐Disagree
3) The plant configuration of the park is pleasant：☐Highly Agree ☐ Agree ☐Neutral ☐Somewhat Disagree ☐Disagree
4) I would take pictures in this park：☐Highly Agree ☐ Agree ☐Neutral ☐Somewhat Disagree ☐Disagree
5) The Park's construction has increased ecological benefits：☐Highly Agree ☐Agree ☐Neutral ☐Somewhat Disagree ☐Dissagree

6) The park brings people closer with nature：☐Highly Agree ☐ Agree ☐Neutral ☐Somewhat Disagree ☐Disagree

**6. My favorite thing about this park is**：

_____

**7. Each time I visit this park is approximately** Please circle the time frame):

6am 9am 12pm 2pm 4pm 6pm 10pm

## Appendix II: On-Site Survey 2

**Suining South Riverside Park/Liu'an Park Questionnaire survey on the people who use the park**

**Version 2**

Hello, residents! We, landscape architecture students, are working with the design firm of Liu'an Park to conduct a survey on the use of the park(Also known are South Riverside park) in Suining to assess the impact of the design on life and culture of local residents. Please take five minutes of your time to take a questionnaire for us. Thank you for your participation and for your love of the park!

**Are you a resident of Suining or a visitor from abroad？** ☐ Local Resident （Travel time: _____minutes，transportation：_____） ☐ Visitors（I came from_____city，staying in Suining for _____day）

**Which age range do you fall into？** ☐15-28 years ☐28-48 years ☐48years+
**You are** ☐Male ☐Female

**Which age group do you think uses this park the most？** ☐Children ☐Teenagers ☐Middle age ☐Older people

1. **I have spent more time outside after the park construction.**

☐ Agree ☐ No change ☐ Disagree

**If you were to evaluate for yourself, how much more time did your family spend playing outside compared to before the park was built _____ hours per week?**

2. **This park has brought residents and visitors closer to the water since it was built**

☐ Agree ☐ No change ☐ Disagree
**How have you ever interacted with the water?**

_____

3. **This park has made Suining a better place to look** ☐Agree ☐No change ☐Disagree

**What do you think about this park that adds most to the beauty of the city**

_____

4. **The park gives people enjoyment and relaxation** ☐Agree ☐No change ☐Disagree

**What do you typically do at this park?**

_____

5. **The lighting in the constructed portion of this park makes me feel safe and comfortable**

☐ Agree ☐ No change ☐ Disagree

6. **I feel cooler and have a better plant atmosphere than outside when I am in the park in the summer** ☐ Agree ☐ No change ☐ Disagree

7. **This park helps with family harmony and neighborhood building** ☐Agree ☐No change ☐Disagree

**Have you met any acquaintances or neighbors at this park?** ☐Yes ☐No change ☐No

**Do adults and children play at this park?** ☐Yes ☐No change ☐No

8. **If possible, could you or your child draw a picture related to this park in the space below? Thank you so much!**