Benefits of resilient design approaches in urban waterfront spaces affected by flooding events

A case study of Xiangjiang River, Xiangtan, China

School of Architecture Urban Planning Construction Engineering
Landscape architecture. landscape heritage

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Background

The background of Xiangjiang River

How serious is the flood in Xiangtan?

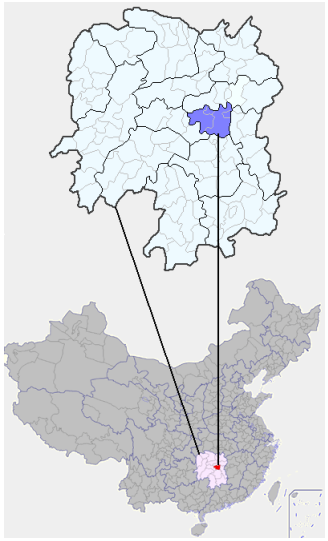
Background

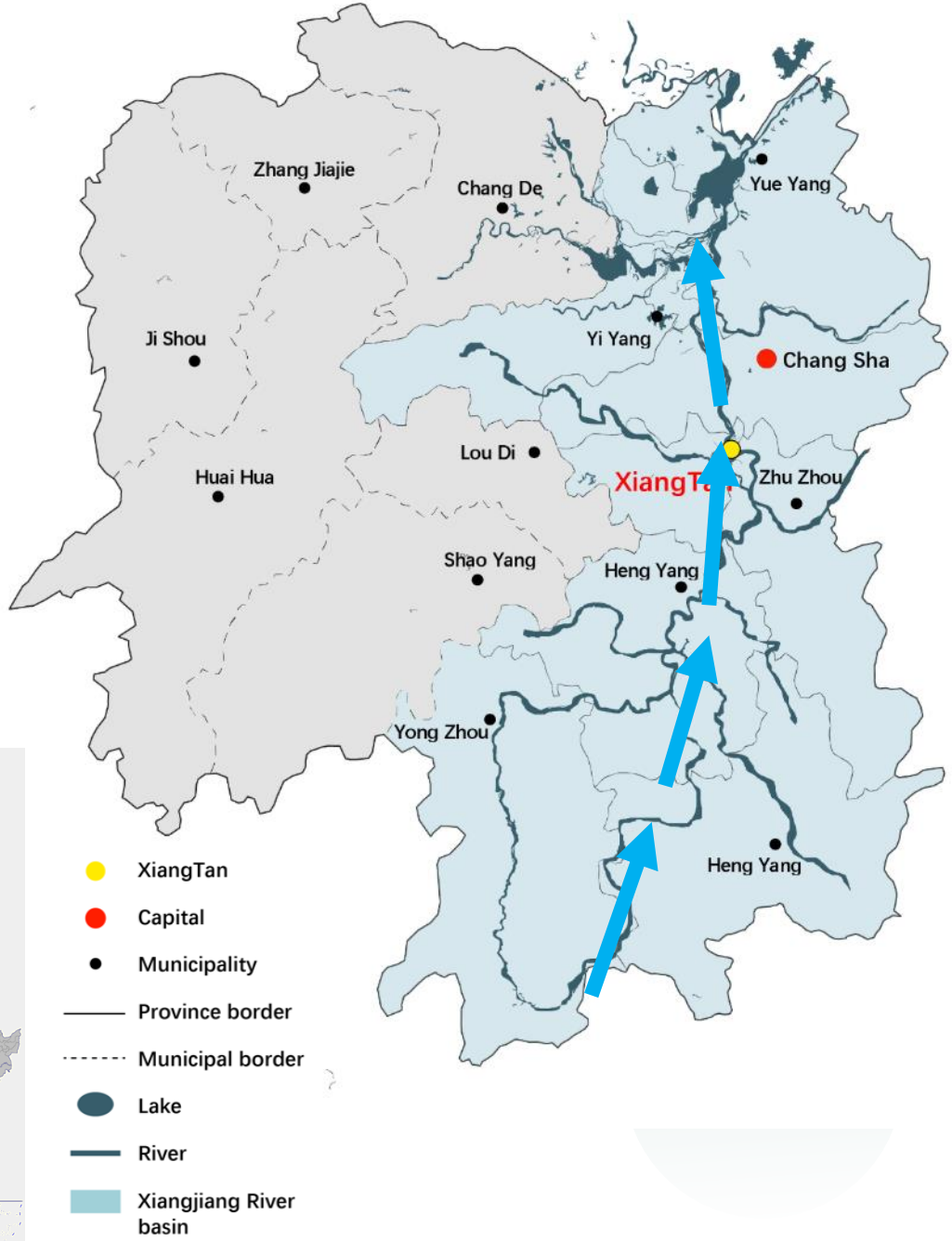
The background of the topic

Xiangjiang River

The Xiangjiang River is located in the Hunan Province, China. It is one of the main tributaries of the Yangtze River. The Xiangjiang River is 844 kilometers long, It flows through 9 regions from south to north with a basin population of 37.74 million and an area of 94,721 km^2, of which 37,888 km^2 is the flooding area

The project site is located in Xiangtan , the middle reaches of Xiangjiang River, which is one of the important industrial and economic cities in Hunan





Xiangjiang River basin

Downstream

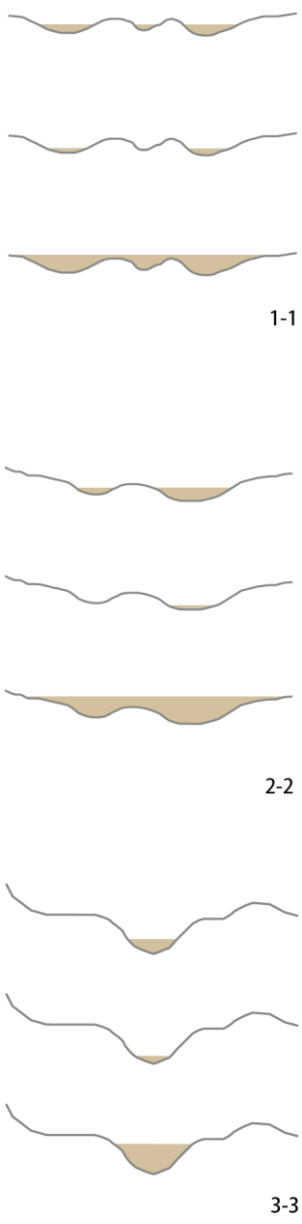
Sediment is accumulating in **Dong Ting Lake** and the water level is **rising**, which in turn **threatens the middle stream**

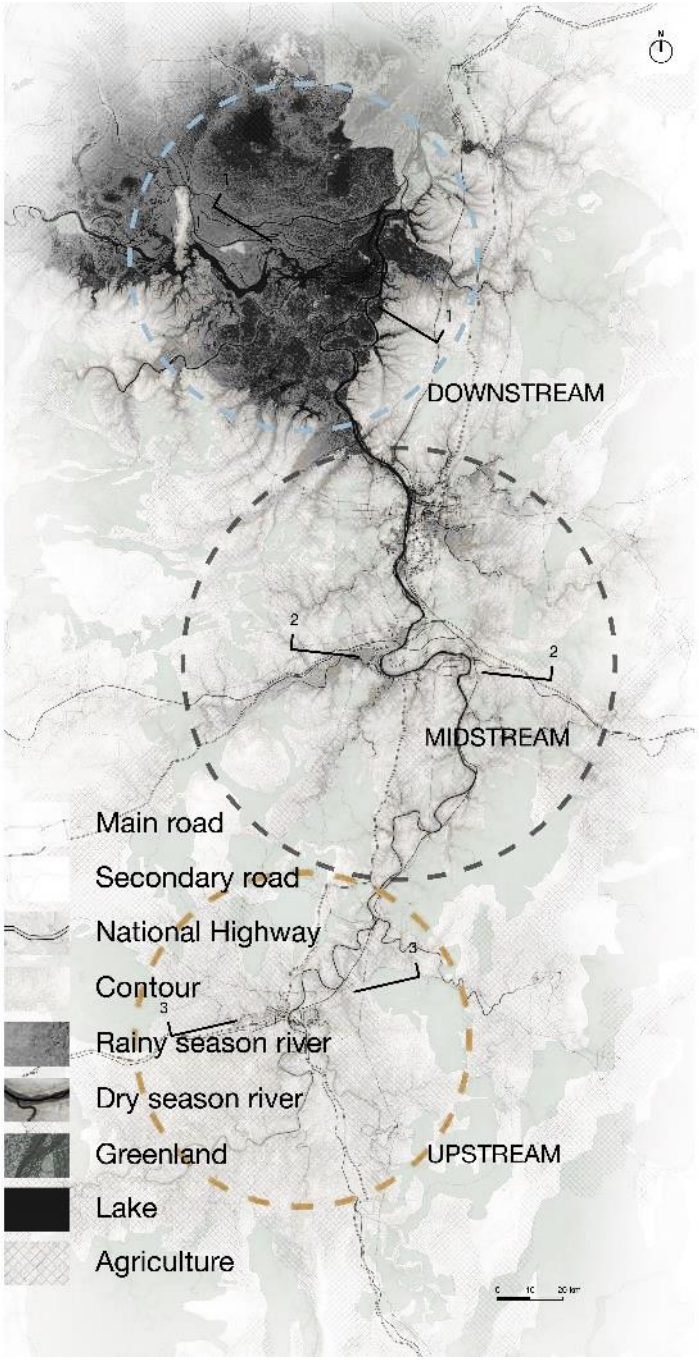
Middle stream

The midstream is the **focus area** for intervention. When the rainy season comes, it faces **floods and sediment** from upstream, as well as backfilling from the Dong Ting lake

Upstream

There are many mountainous areas with high terrain and steep slopes, accompanied by **severe soil erosion, Flash floods** are very common here during the rainy season





Background

The background of the topic

Xiangtan section of Xiangjiang River

Flood prone areas

Due to the double problems of upstream and downstream, Xiangtan section has become a flood-prone area

Although the government continues to strengthen the flood protection infrastructure, such as building embankment and walls to hold back the water, the flooding seems to be getting worse. Between 2010 and 2020, there have been 4 major floods here

On June 24, 2010, **Xiangtan** section of the Xiangjiang River. water level rose to **38.46m**, the highest level of this century

On April 4, 2013, water level in **Xiangtan** rose to **38.64m**, which caused 7,874,500 people were affected by the flood

On July 3, 2017, the water level at **Xiangtan** Station reached **39.49** meters. The Xiangjiang River burst its banks and flooded hundreds of towns

On July 16, 2019, the worst flood in more than 50 years occurred from Hengshan to **Xiangtan**, and **Xiangtan** section was the worst floods in 200 years

Site analysis

Situation in Xiangtan

Analysis of river channel, flood zone...

The current conditions of the riverbank

Old community

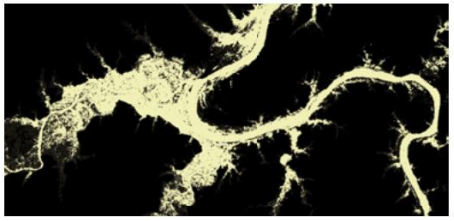
Abandoned building

Flooding water levels

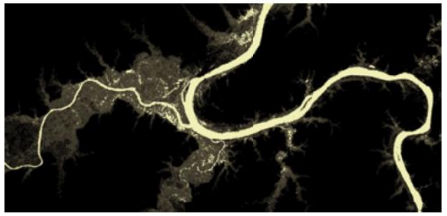
Pristine riverbank

Sections of water level in different seasons

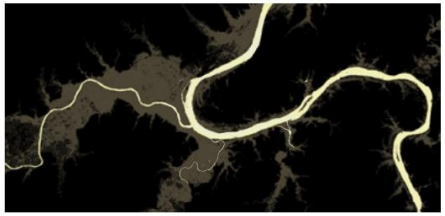
Rainy



Normal



Dry



Process

Discover of the problems

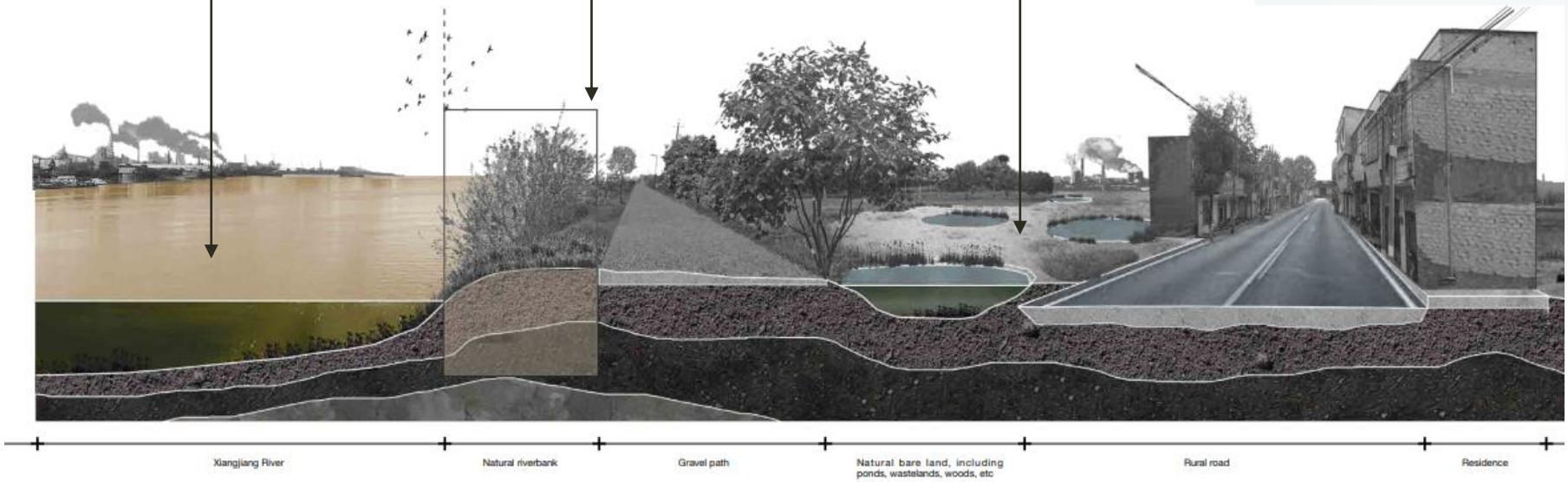
What we need to deal with?

The Xiangjiang waterfront space mainly faces 3 problems

2. Trees in poor conditions, the fragile ecology of the riverbank and the broken borders make it difficult to ensure safety

1. Variable and unmanageable water levels have caused great damage to the ecology of the riverbanks

3. The unruly site lacks effective flood warning facilities and shelters



Solutions

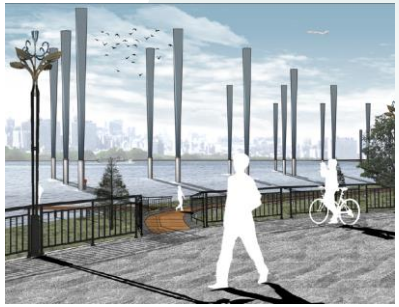
Intervention plan

Multi-dimensional resilient landscape design

The resilient solutions

Strong measures

Water conservancy projects like dams and artificial wetland, they can reduce the impact of variable water levels



Neutral measures

Add **Landscape plaza** and **warning device** along the riverbank, which can provide **emergency refuge** for the local people and **remind them to keep safe**

Soft measures

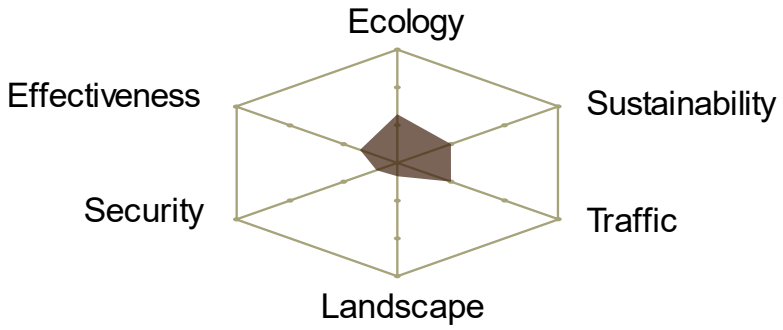
Highly resistant green corridor and associated artificial equipment help reduce the impact of unstable water levels on the site's ecology

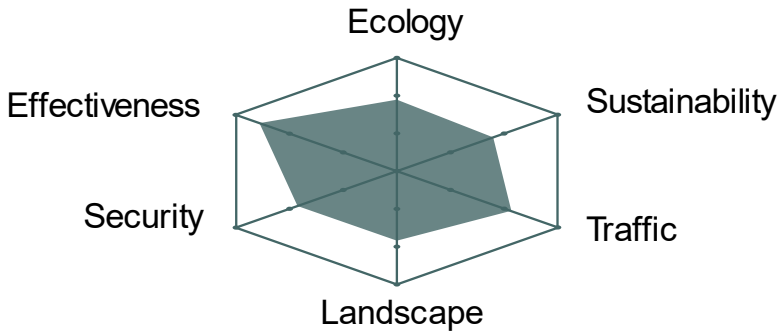
Three walking paths of different heights provide new space for viewing, activities and they can improve traffic conditions along the riverbank

The benefits comparison of normal and resilient measures

Normal flood control measures			
Actions	Benefits	Drawbacks	Score (10‘)
Grass riverbank	Simple, low cost	Single, low resistance,	4
Concrete wall	Simple, low cost	Destroy ecology, Temporary effect	3
One road on the dam top	Simple, low cost	Bad traffic, unsafe, Far from water	3
No more landscape actions	/	Boring places	1
No safe zone	/	dangerous	1
No Water storage system	/	High flood pressure	1

Resilient flood control measures			
Actions	Benefits	Drawbacks	Score (10’)
Mixed plants bank	Highly resistant, ecological, beautiful	High cost, complex maintenance	6
Hydraulic dam	Permanent effect, power generation, jobs offer	High cost	6
3 ways in different heights	Safe, fun, scenic, good traffic, waterfront	High cost	7
Landscape treatment	Fun, attractive, scenic	High cost	6
Set up safety zone	Safe, Protective effect, more space	High cost	6
Water storage system	Low flood pressure, balanced water level	/	8





Project

Intervention and actions

Consolidation, Dredging, Early warning system

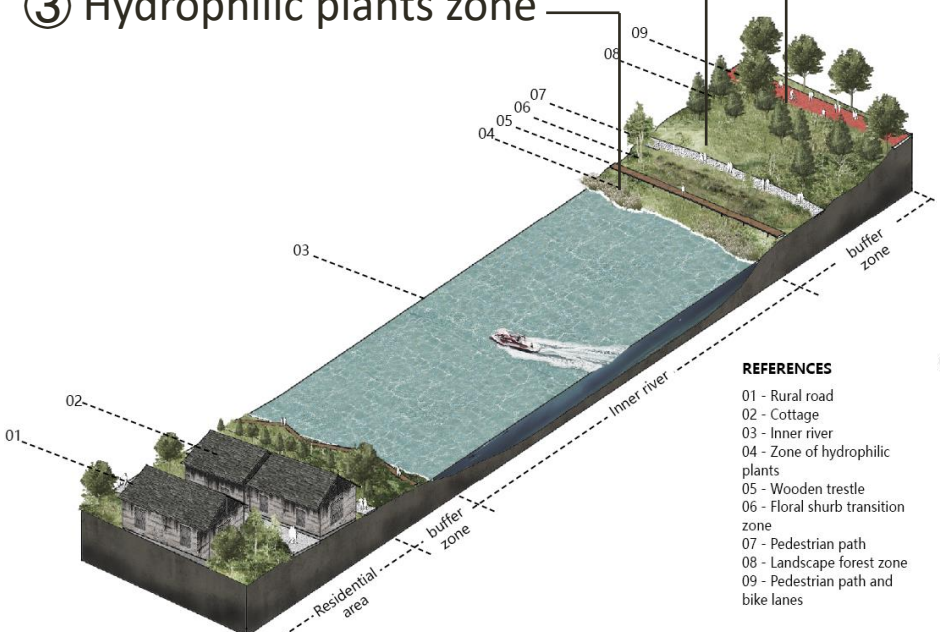
Ecological corridor and road design

1. The plant corridor is divided into **three layers**

① landscape forest zone

② Floral shrub transition zone

③ Hydrophilic plants zone



REFERENCES

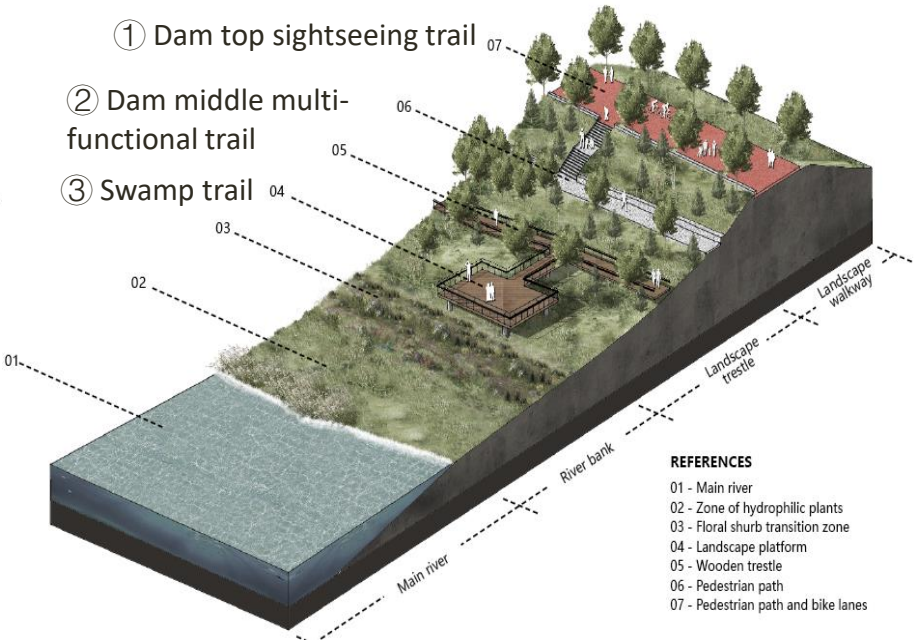
01 - Rural road
02 - Cottage
03 - Inner river
04 - Zone of hydrophilic plants
05 - Wooden trestle
06 - Floral shurb transition zone
07 - Pedestrian path
08 - Landscape forest zone
09 - Pedestrian path and bike lanes

2. **Three footpaths** with different **elevations** have been built to meet the activities and viewing needs of citizens at different water levels

① Dam top sightseeing trail

② Dam middle multi-functional trail

③ Swamp trail

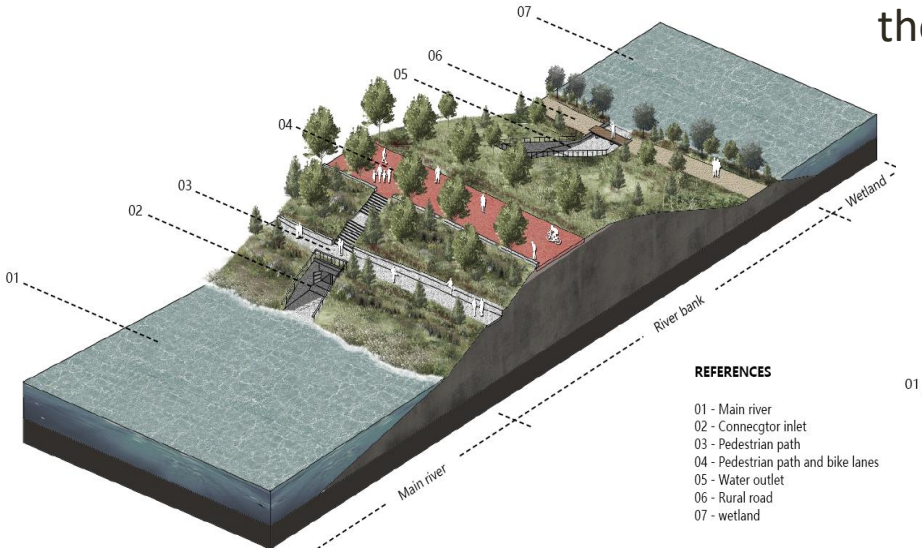


REFERENCES

01 - Main river
02 - Zone of hydrophilic plants
03 - Floral shurb transition zone
04 - Landscape platform
05 - Wooden trestle
06 - Pedestrian path
07 - Pedestrian path and bike lanes

Constructed wetland and inner river dam design

3. The constructed wetland is connected to the Xiangjiang River and **stores water** during the rainy season to reduce flood pressure



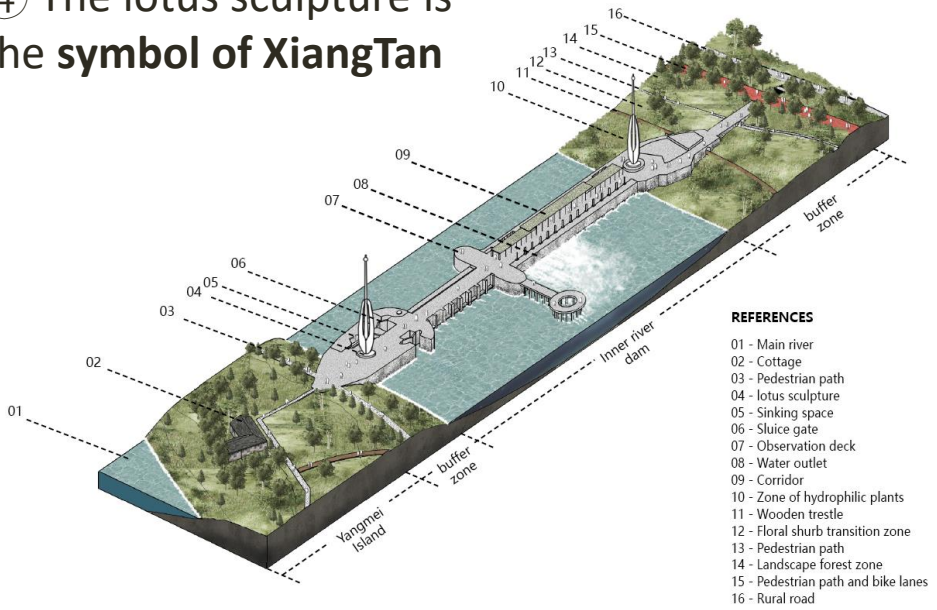
4. The dam's functions

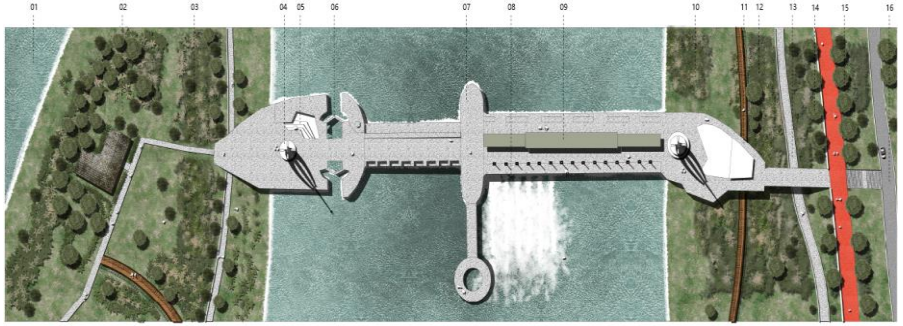
① **Regulate water levels**

② **Generate electricity**

③ **Connecting both sides**

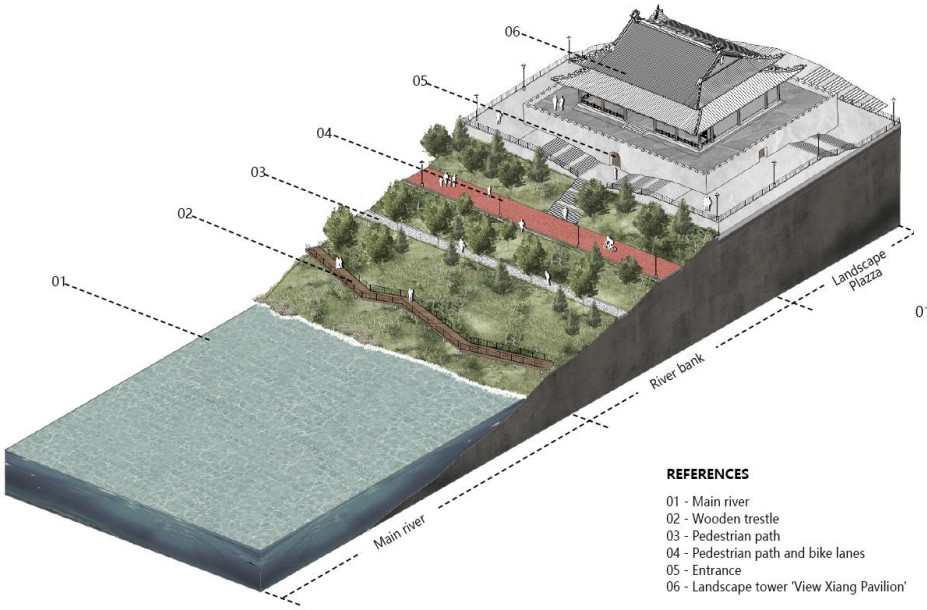
④ The lotus sculpture is the **symbol of XiangTan**





Landscape plazas and warning device design

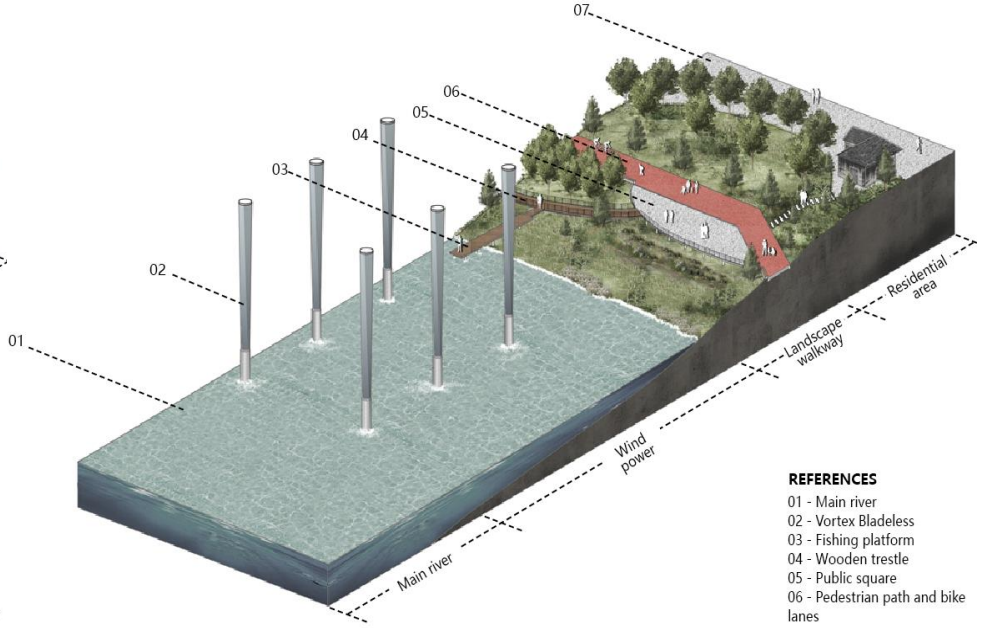
5. **Landscape plazas** provide residents with recreation and **emergency shelter**. Revitalize old buildings at the same time



REFERENCES

01 - Main river
02 - Wooden trestle
03 - Pedestrian path
04 - Pedestrian path and bike lanes
05 - Entrance
06 - Landscape tower 'View Xiang Pavilion'

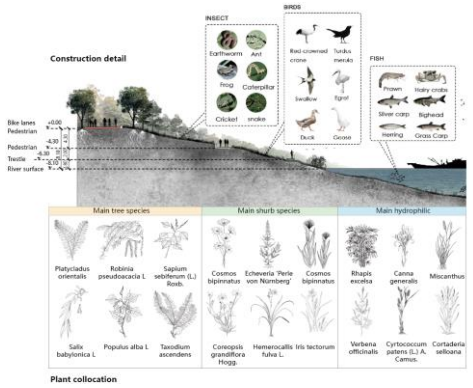
6. **Bladeless turbines** provide **clean energy** and **new landscape**. Water level **warning lights** remind people to pay attention to their **safety**



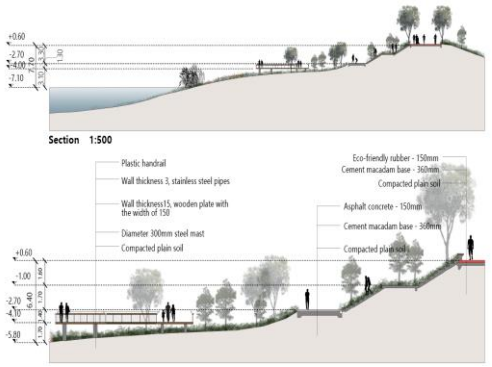
REFERENCES

01 - Main river
02 - Vortex Bladeless
03 - Fishing platform
04 - Wooden trestle
05 - Public square
06 - Pedestrian path and bike lanes

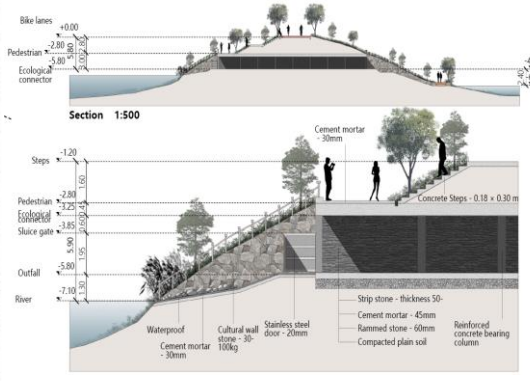
Masterplan and constructive details designs



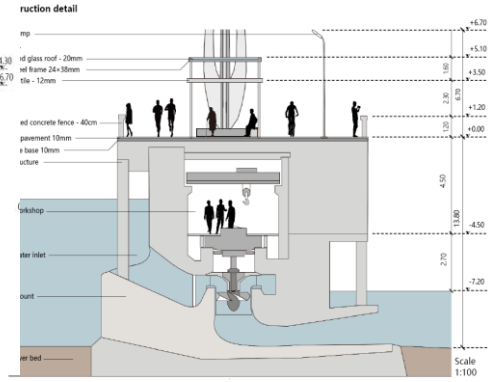
Ecological corridor



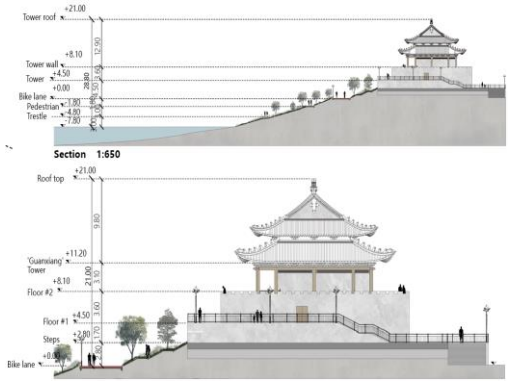
The road design



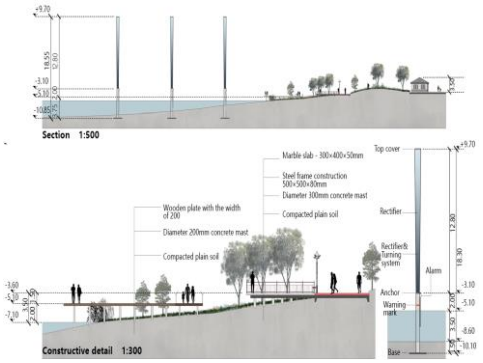
Constructed wetland



Inner river dam



Landscape plazas



Warning device

Section of after intervention

Aerial View

Summary

Evaluation and Review

Cost-benefit balancing and conclusion

Estimate of direct cost

Number	Sub-projects	Category	Goals	Unit price of construction	Total price (million €)
1	Trail on the top of dam	Traffic	30km×8.0m	16€/m^2	3.84
2	Walking trial at the middle of the dam	Traffic	30km×4.0m	3€/m^2	0.36
3	Promenade along the marshland	Traffic	15km×2.0m	30€/m^2	0.90
4	Hydropower station	Energy	2	7,500,000€	15.00
5	Landscape vegetation	Green	2.24km^2	15€/m^2	336.30
6	Landscape architecture	Landscape	2	50,000€	0.10
7	Landscape square	Landscape	0.45km^2	115€/m^2	51.75
8	Landscape bridge	Traffic, Landscape	110m×5.5m 20m×4.5m	720€/m^2	0.50
9	Constructed wetland	Landscape, Water balance	1.34km^2	18€/m^2	24.12
10	Wetland Park	Landscape, Water balance	0.32km^2	25€/m^2	8.00
11	Beach	Entertainment	8146m^2	20€/m^2	0.16
12	Fishing platform	Entertainment	19	5400€	0.10
13	Wind farm	Energy	2	562,500€	1.13
14	City furniture	Infrastructure	60km	2800€/km	0.17
Total					442.43

Estimate of indirect cost

Number	Sub-projects	Category	Goals	Unit price of construction	Total price (million €)
1	Construction waste removal	Clean	440200 m^3	0.5€/m^3	0.22
2	Destruction of natural vegetation	Ecology	0.36km^2	4.3€/m^2	1.55
3	Water pollution	Pollution	1.80 km^2	0.2€/m^3	0.90
4	Demolition of old buildings	Demolition	87900 m^2	500€/m^2	43.95
5	Lake expropriation	Government subsidies	1.34km^2	8.6€/m^2	11.52
6	Farmland expropriation	Government subsidies	0.483km^2	6.5€/m	3.14
7	Expropriation of bare land	Government subsidies	0.45km^2	4.3€/m^2	51.75
Total					113.03

The above table roughly estimates the direct and indirect costs of the project. The direct costs total €442.43 million and the indirect costs total €113.03 million

For the record, the 2 tables are not a complete cost-benefit analysis, but merely a proposed costs of preliminary consideration

Forecasting Cost and Benefit Outcomes in 5 Years

Estimated benefits from this proposal total €444.25 million in 5 years.
Although the total profit cannot exceed the total investment within five years, it has always been positive, so the feasibility of this proposal is very high, and the benefits are expected to exceed the costs within 7-8 years.

serial number	Project proposals	Benefit B (million€)	Cost C (million€)	Profit B-C (million€)	Earnings ratio B/C	Net profit ratio (B-C)/C	Ranking
1	Trail on the top of dam	3.24	3.84	-0.60	0.844	-0.156	13
2	Walking trial at the middle of the dam	0.34	0.36	-0.02	0.944	-0.056	9
3	Promenade along the marshland	0.62	0.90	-0.28	0.689	-0.311	14
4	Hydropower station	32.40	15.00	17.40	2.16	1.160	5
5	Landscape vegetation	723.24	336.30	386.94	2.151	1.151	6
6	Landscape architecture	0.23	0.10	0.13	2.300	1.300	3
7	Landscape square	105.45	51.75	53.70	2.038	1.038	7
8	Landscape bridge	0.45	0.50	-0.05	0.900	-0.100	10
9	Constructed wetland	53.47	24.12	29.35	2.217	1.217	4
10	Wetland Park	18.54	8.00	10.54	2.316	1.318	2
11	Beach	0.16	0.16	0	1	0	8
12	Fishing platform	0.09	0.10	-0.01	0.900	-0.100	11
13	Wind farm	7.00	1.13	5.87	6.195	5.195	1
14	City furniture	0.15	0.17	-0.02	0.882	-0.118	12

+444.25

Conclusion

From the perspective of dealing with floods, this project uses landscape ecology and ecological principles to take the Xiangtan section of the Xiangjiang River as the site for this design. It proposes how to improve the **resilient design** of Xiangjiang Riverside from macro to micro scale and to create spaces with **high resistance, high utilization, multi-species and identity**, while helping to reduce the **potential impact of flooding** in these areas, which will not be used for other purposes in the future (such as illegal settlements and high-risk agricultural uses). In addition, since this design is only at the theoretical stage and the subjects involved are very complex, it is inevitable that the plan will be imperfect and needs further research. It is hoped that this proposal can provide some reference and guidance for the future construction of urban waterfront space.

Before

After

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Thanks for listening

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