Water Safety - Fragile Urban Riverfront

Applying more resilience to the urban river corridor of Chongqing

P5 presentation

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Content

Runoff, Qingshui creek, Chongqing shoot by Gou, Y. edited by author

01 | Problems

What is the topic? & Why has the topic been chosen?

Problem | 2020 China floods

Flooded area in Ciqikou of Shapingba District, Chongqing, shoot by Xinhua/Liu Chan

China has experienced 21 numbered floods (floods of a certain large scale) so far in 2020, **1.6 times more than that of previous years**, hitting a historical record since 1998.

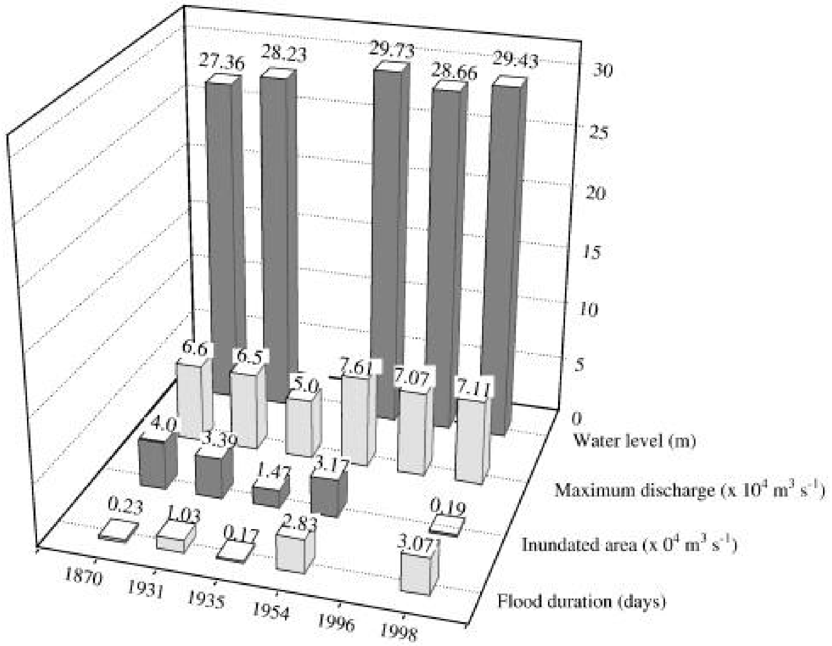
- *Global Times*, 23/9/2020

Problem | 2020 China floods

"At a briefing in Beijing last week, Zhou Xuewen, the secretary general of China's flood control headquarters, said that at least **63 million people** had been affected and **54,000 homes** destroyed. At least **78 people** have died or disappeared, he said."

-*The New York times*, 24/8/2020

Problem | Yangtze River floods history



Measurements of the six large floods since the late 19th century at Hankou hydrological gauging station, Yu and et al.

In the Yangzte River basin, there is an **increasing trend** that is notable in the average maximum water level and the frequency of the peak water level.

-Yu and et al.
Analysis of historical floods on the Yangtze River, China: Characteristics and explanations,
2009

Problem | Causes of flood

Natural causes

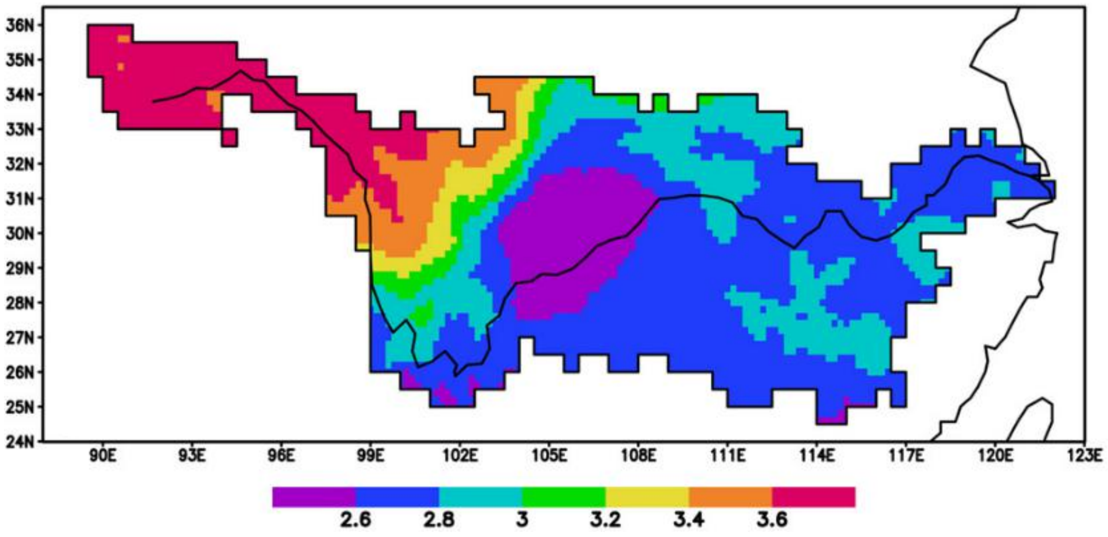
- Climate change
- Monsoon

Artificial causes

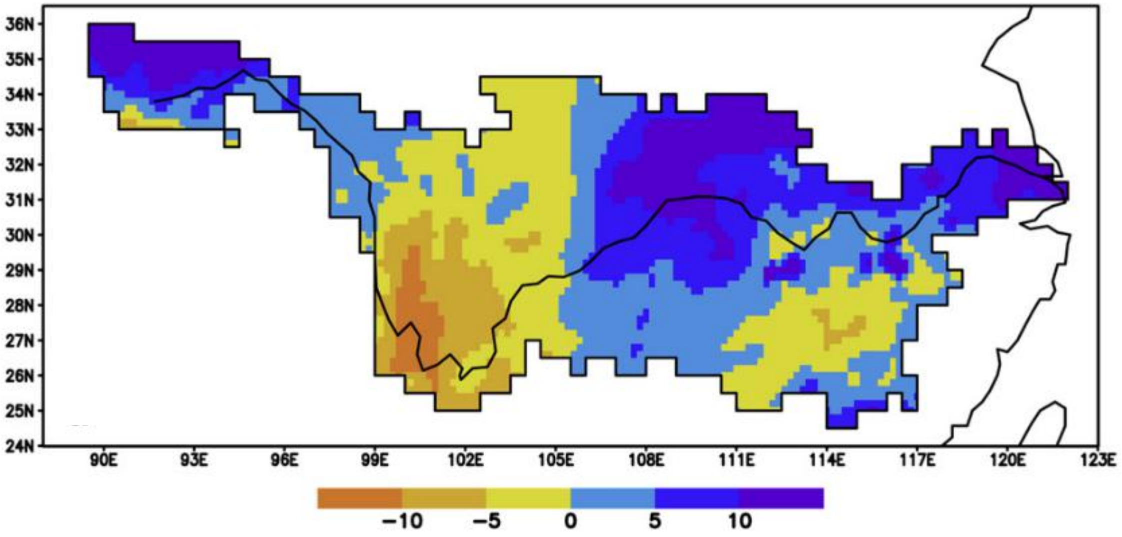
- Inefficient capacity
- Increasing runoff coefficient

Problem field | Natural causes

Climate change - The increasing of flood hazard



Effects of climate change on annual mean temperature in the Yangtze River basin (Unit: ℃)

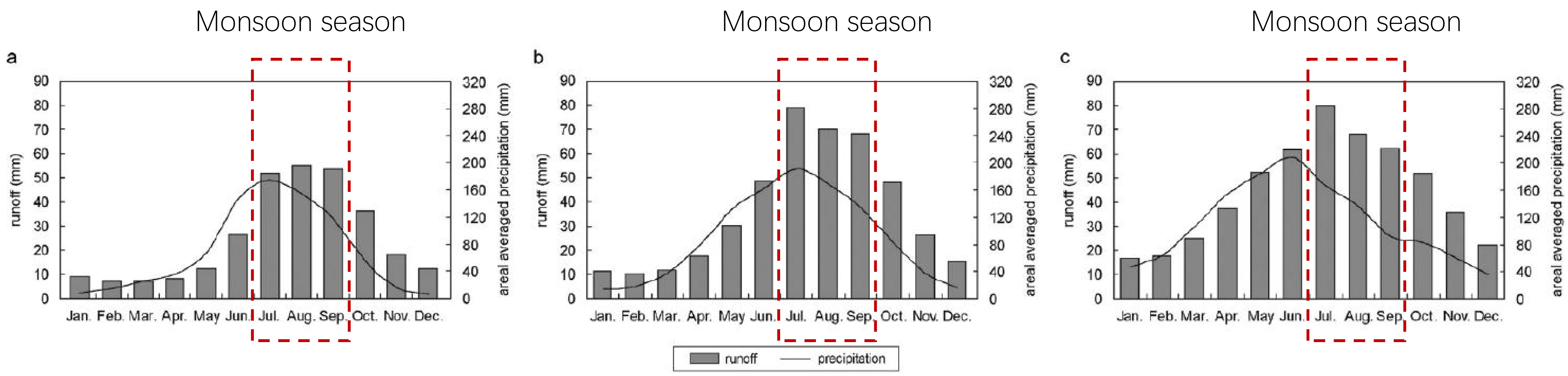


Effects of climate change on annual mean precipitation in the Yangtze River basin (Unit: %).

Data source : Cao, L., Zhang, Y. and Shi, Y., 2011. Climate change effect on hydrological processes over the Yangtze River basin. Quaternary International, 244(2), pp.202-210.

Problem field | Natural causes

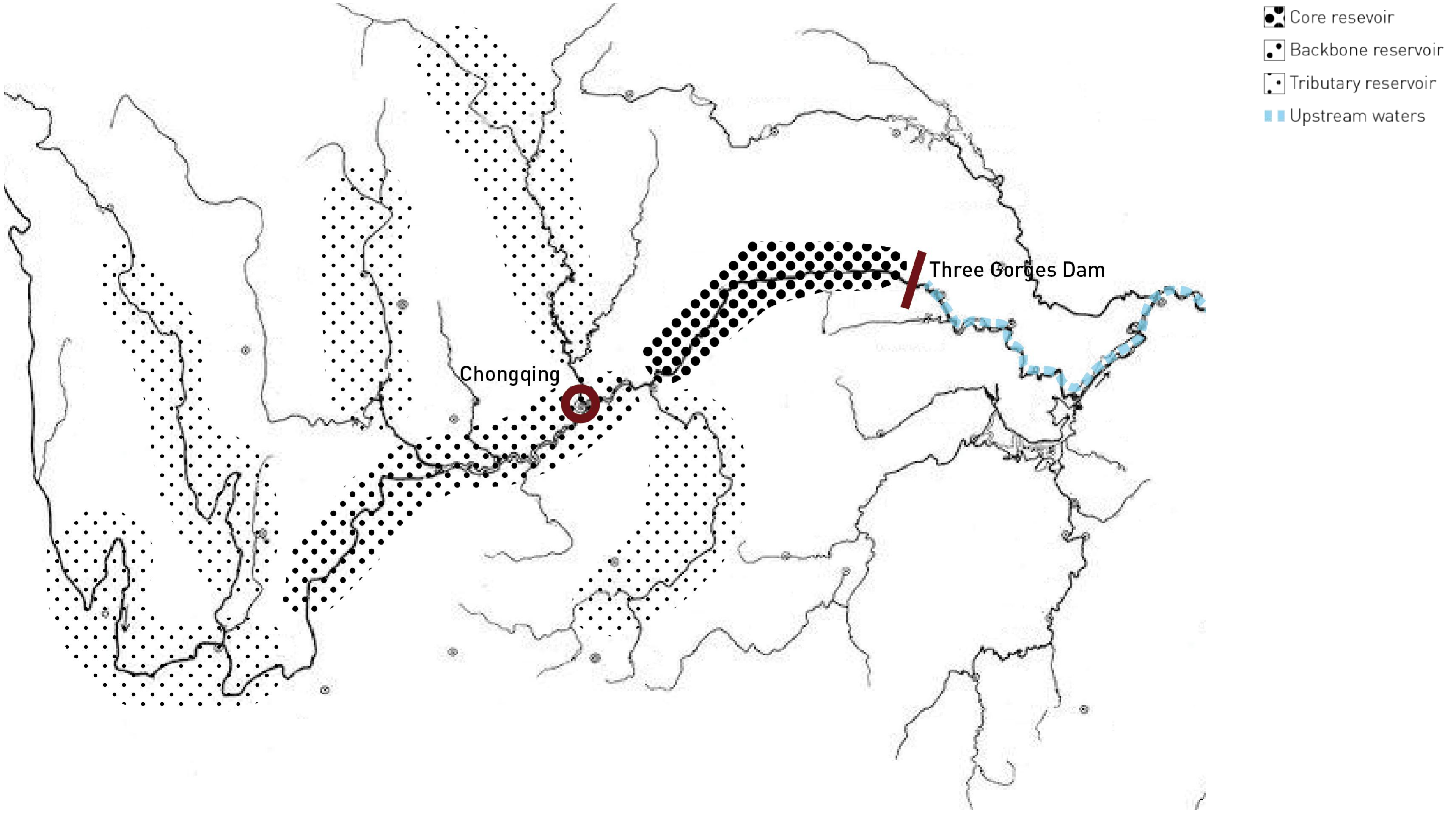
Monsoon – Brings more seasonal floods



Monthly area-averaged precipitation and corresponding discharge of the River Yangtze at (a) Pingshan, (b)Yichang, and (c) Datong (1960–2004)

Problem field | Artificial causes

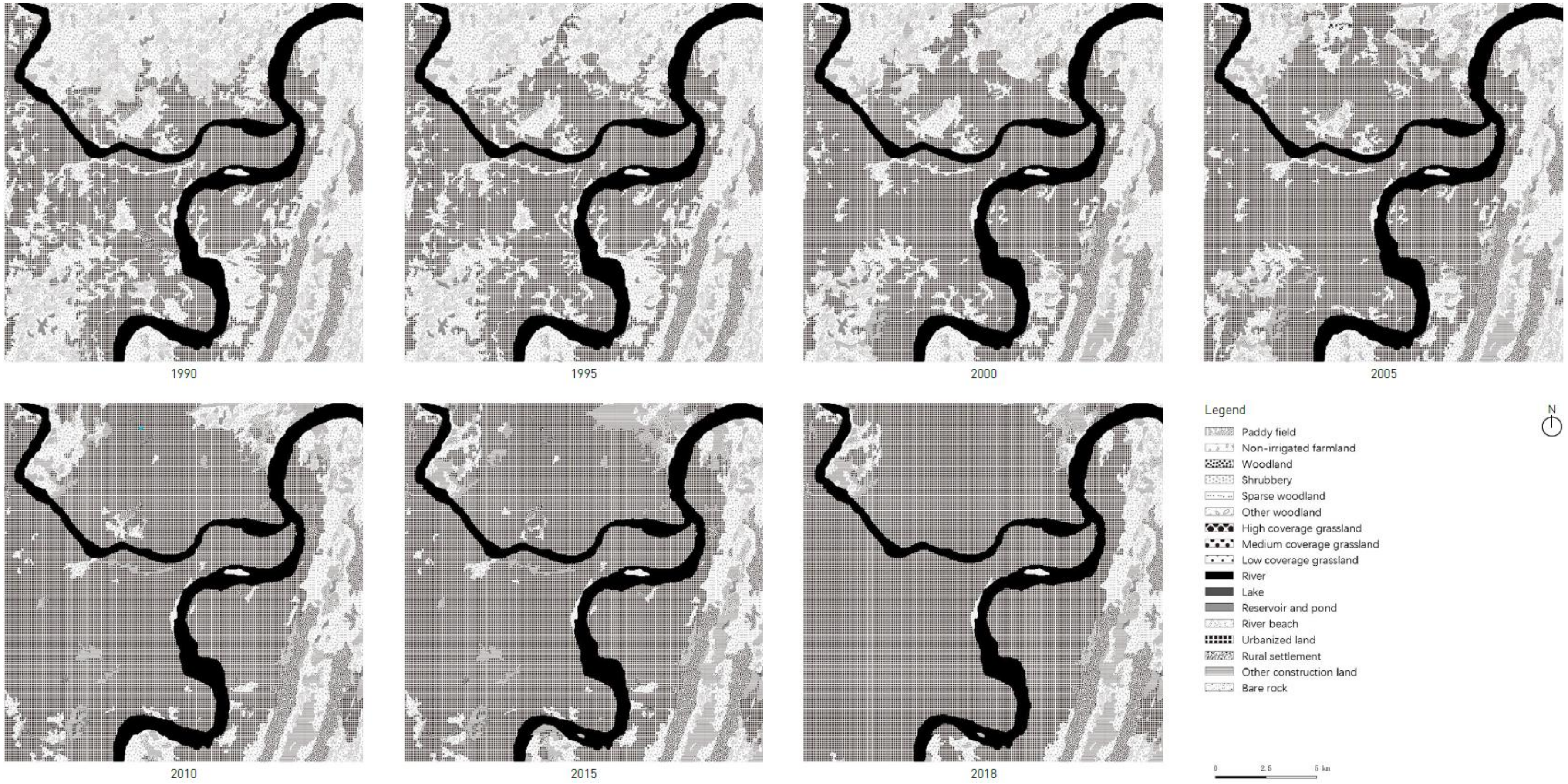
Inefficient capacity – Underutilized reservoir system



Reservoir systems in upstream Yangtze river basin

Problem field | Artificial causes

Urban development - Increasing runoff coefficient



Chongqing main town landscape change (1990-2018)

Problem field | Artificial causes

Urban development - Increasing runoff coefficient

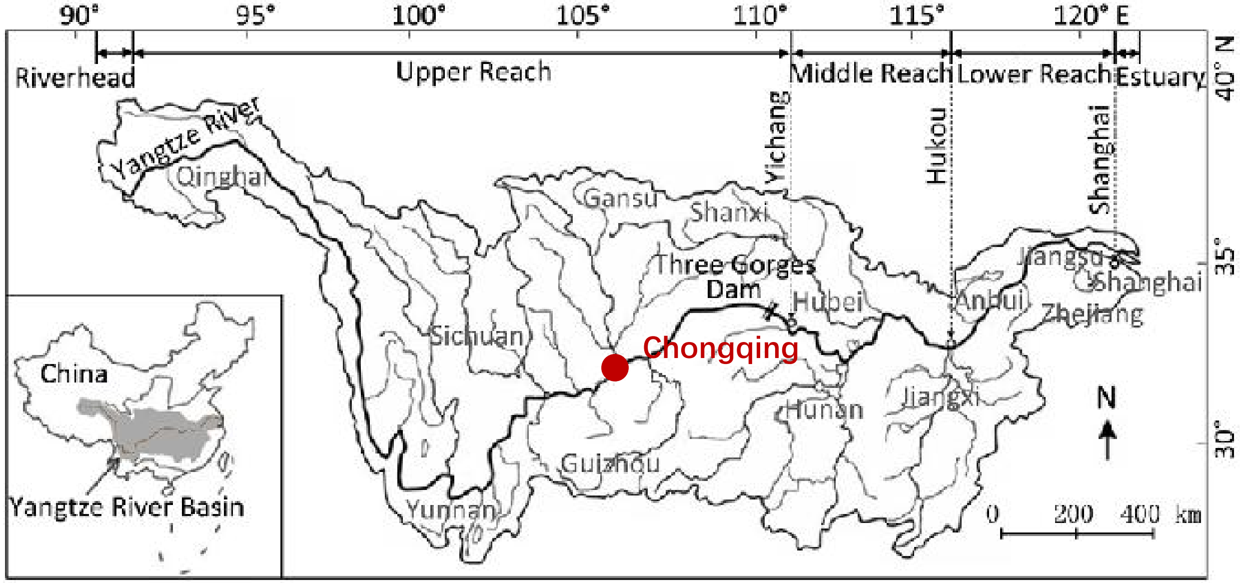
Chongqing riverside ecology current situation

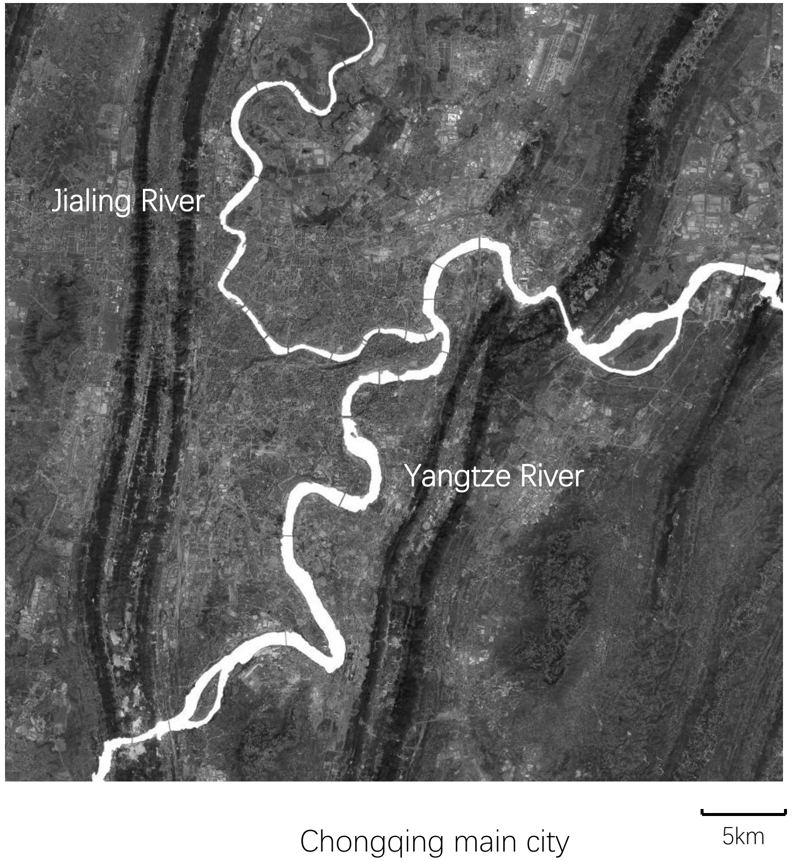
02 | Scope

What are the current responses? What are the proposed approaches in the thesis?

Research scope | Chongqing, China

Location & topography





Chongqing main city

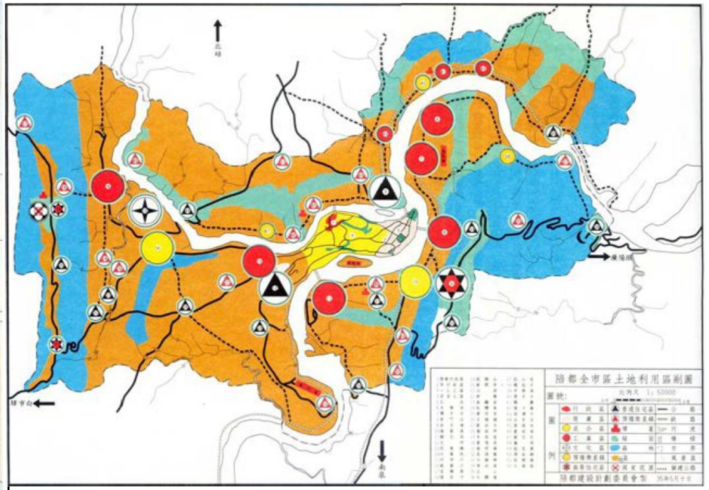
Research scope | Chongqing, China

Fight between urbanized and natural

Chongqing Fuzhi Map, 1886-1890

The main city of Chongqing at this time relies on the Yuzhong Peninsula and echoes the Jiangbei city on the north side

Chongqing Concession Commercial Port Map, 1907

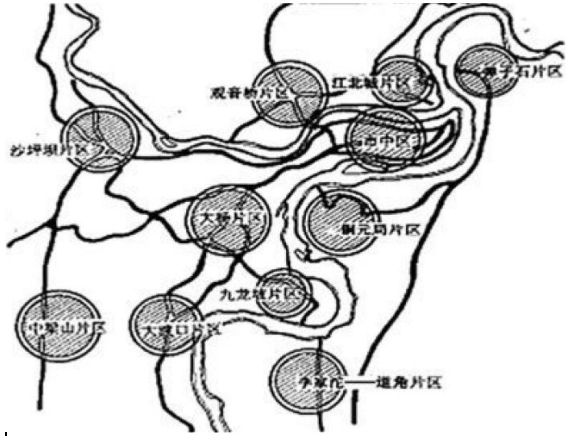


“The draft of the ten-year development plan for the temporary capital”, 1946

Reduction of population density, and development of satellite towns

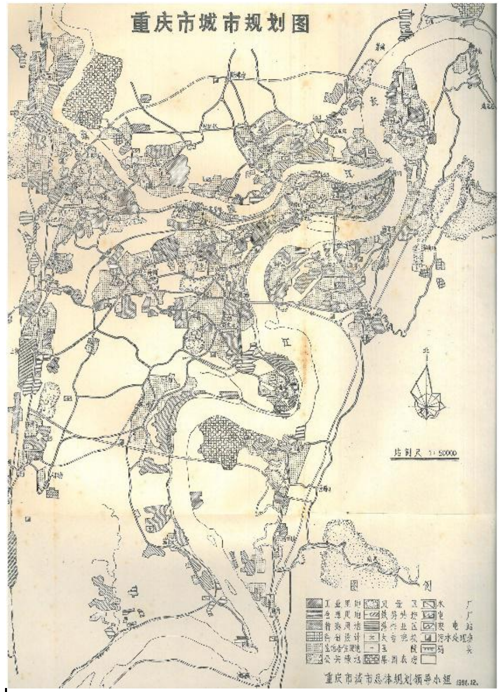
Research scope | Chongqing, China

Fight between urbanized and natural



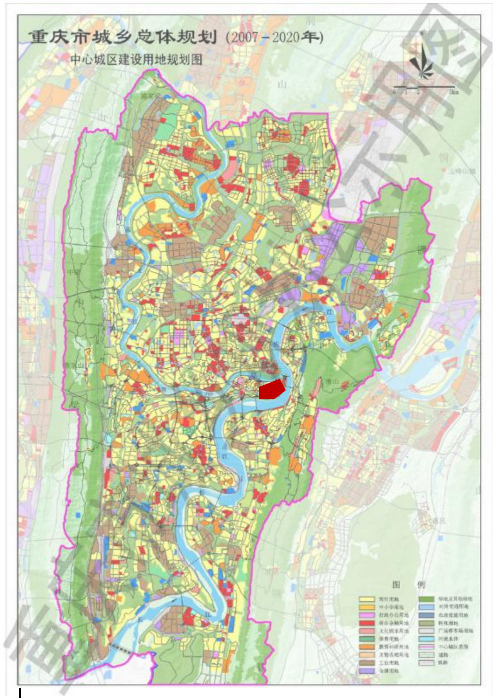
Preliminary Urban Planning of Chongqing, 1960

Cluster-like urban structure



Chongqing City Master Plan (1981-2000), 1981

“Multi-center, cluster-like” urban spatial structure from the planning, and strictly controlled the city’s scale.



Chongqing City Master Plan (2007-2020), Revised in 2011

The green belt between the clusters was gradually eroded, and the clusters in the central city gradually merged together.

Research scope | Chongqing, China

Strengthen embankments, Chongqing shoot by Gou, Y.
edited by author

Research scope | Current responses

After the emergency measures, Chongqing shoot by Gou, Y. edited by author

Emergency measures:

- Flood alert: Emergency evacuation
- Temporary facilities: Sandbag dams

Scope | Problem statement

1# Chongqing is threatened a lot by flood hazards caused by natural and artificial reasons.

2# The current emergency measurement does not help to solve the core of is issue.

3# The solution should protect the safety of inhabitants’ life and property and help the riverfront area generate maximum potential values.

Flood defense slogan “The flood is ruthless, people are compassionate, and one side is in trouble and all parties support“, Ciqikou, Chongqing shoot by Gou, Y. edited by author

Scope | Research question

How to shift the **fragile urban riverfront,** which caused by changes (climate change, monsoon, increasing infrastructure) and actual quality (spatial, infrastructural, nature), into a flood resilient area by the synergy of **nature system** and **constructed environment** in Chongqing?

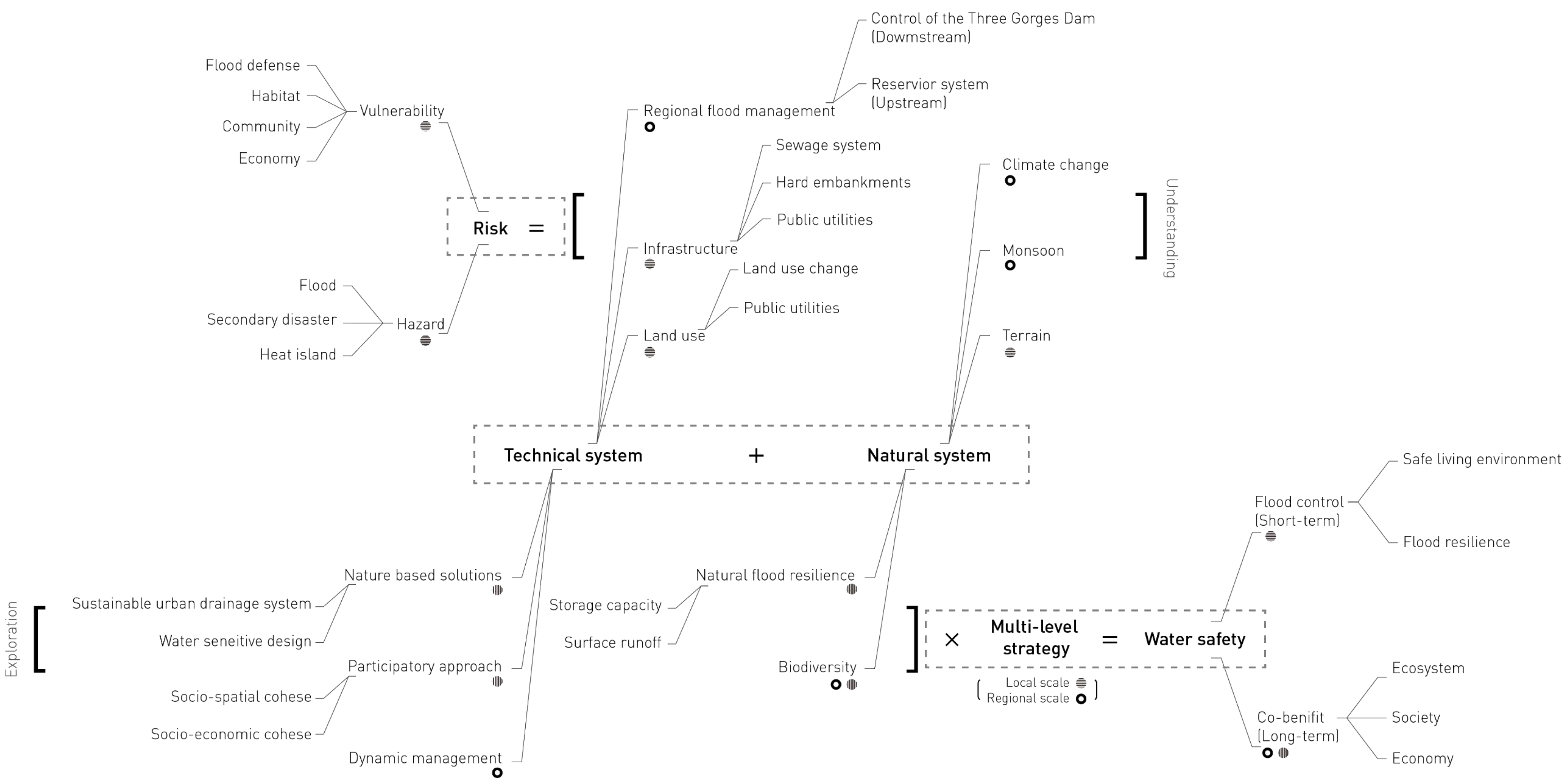
Scope | Sub questions：

1. “What are the artificial and natural **reasons** which caused the flood in the Yangtze River basin seasonal flood in Chongqing?”

2. “How does the seasonal Yangtze river flood **influence** basic urban flows (energy, water, traffic) and related (potentials for) spatial quality of Chongqing, and what measures are used to defense/mitigate flood?”
.
3. “How can **solutions** to address urbanization (development of buildings and infrastructure) and natural processes (water runoff, infiltration, biodiversity, and eco-systems services) be synergetic to increase urban flood resilience?”

4. “What **co-benefits** could flood resilient urban riverfront brings to society and economy?”

Scope | Conceptual framework

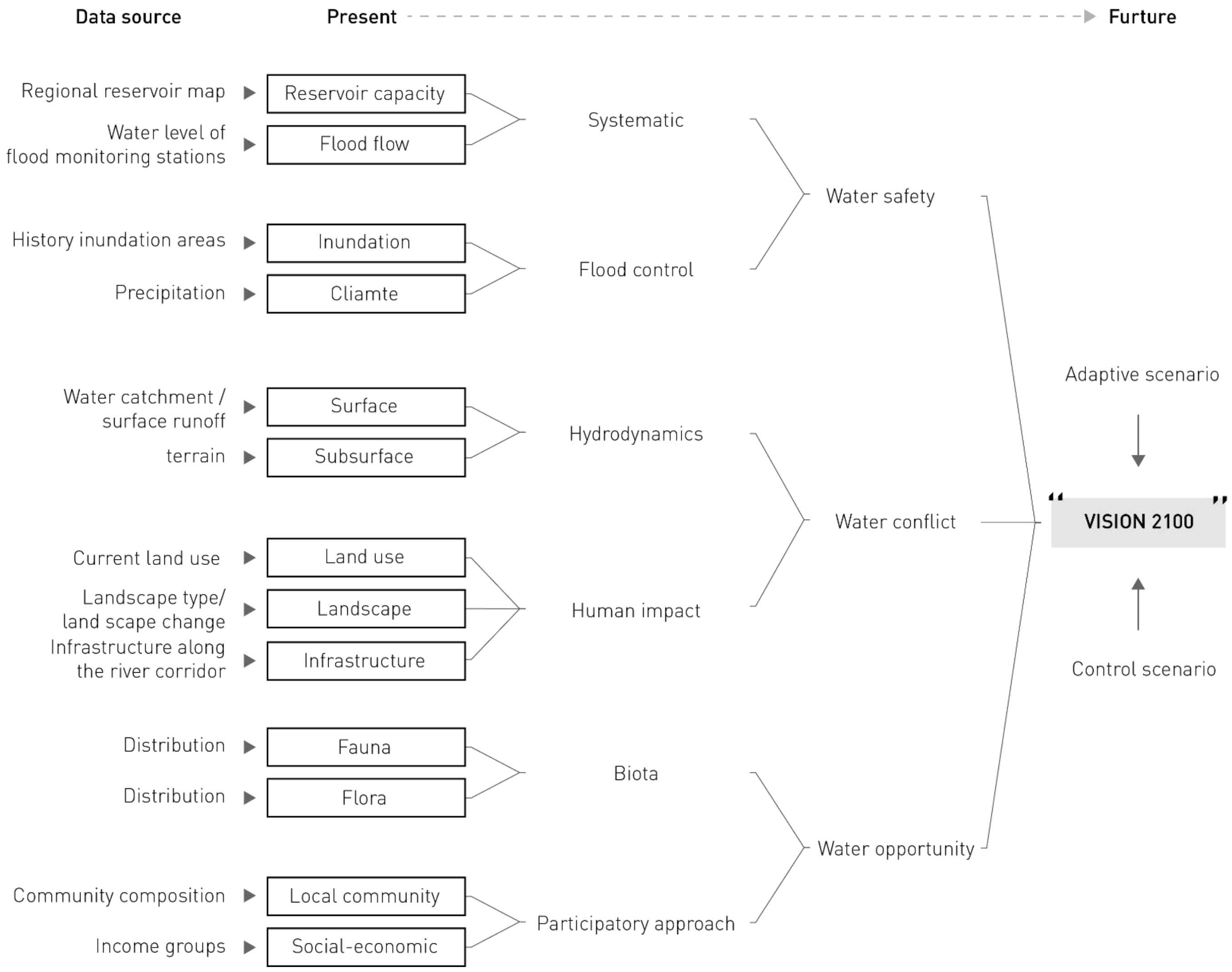


03 | Analysis

What are the factors that cause the seasonal flood? & How the floods influence the living environment?

Sub-Q1&2 CAUSATION

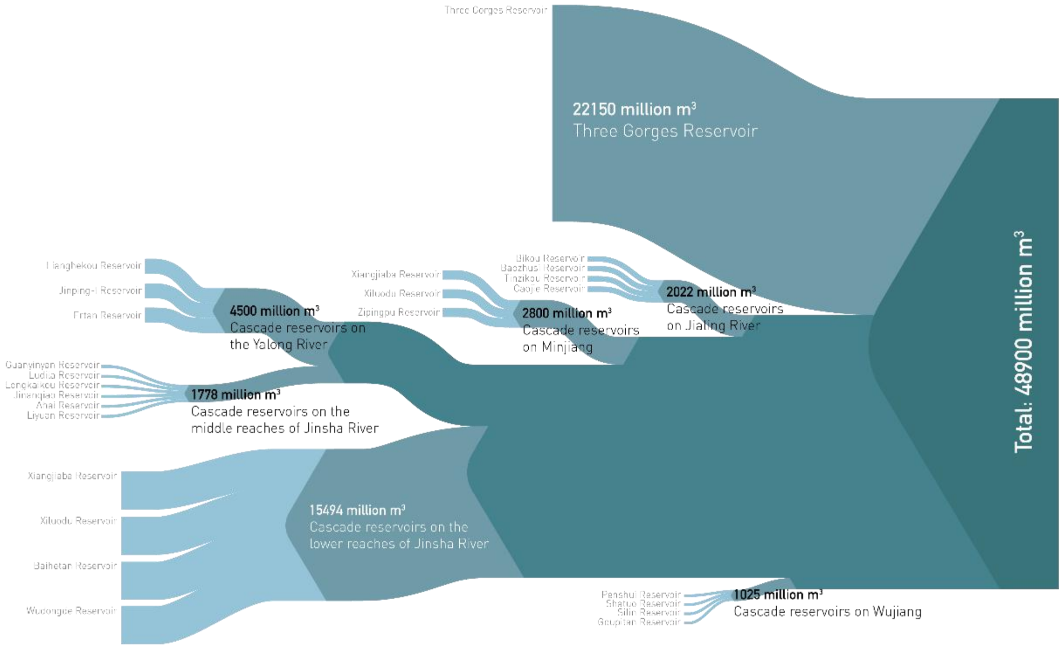
Analysis | Analytical framework



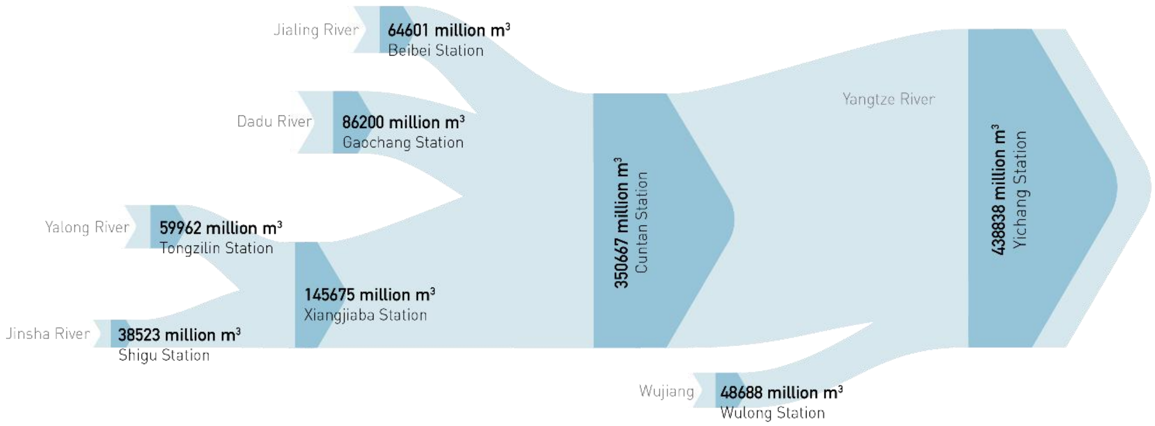
Analysis | Water safety

Reservoir capacity and flood flow

The current storage capacity has improved the flood control capacity of the upper reaches of the Yangtze River to a certain extent, but it is still difficult to cope with more sustained catastrophic floods.



Reservoir capacity of the upper Yangtze River

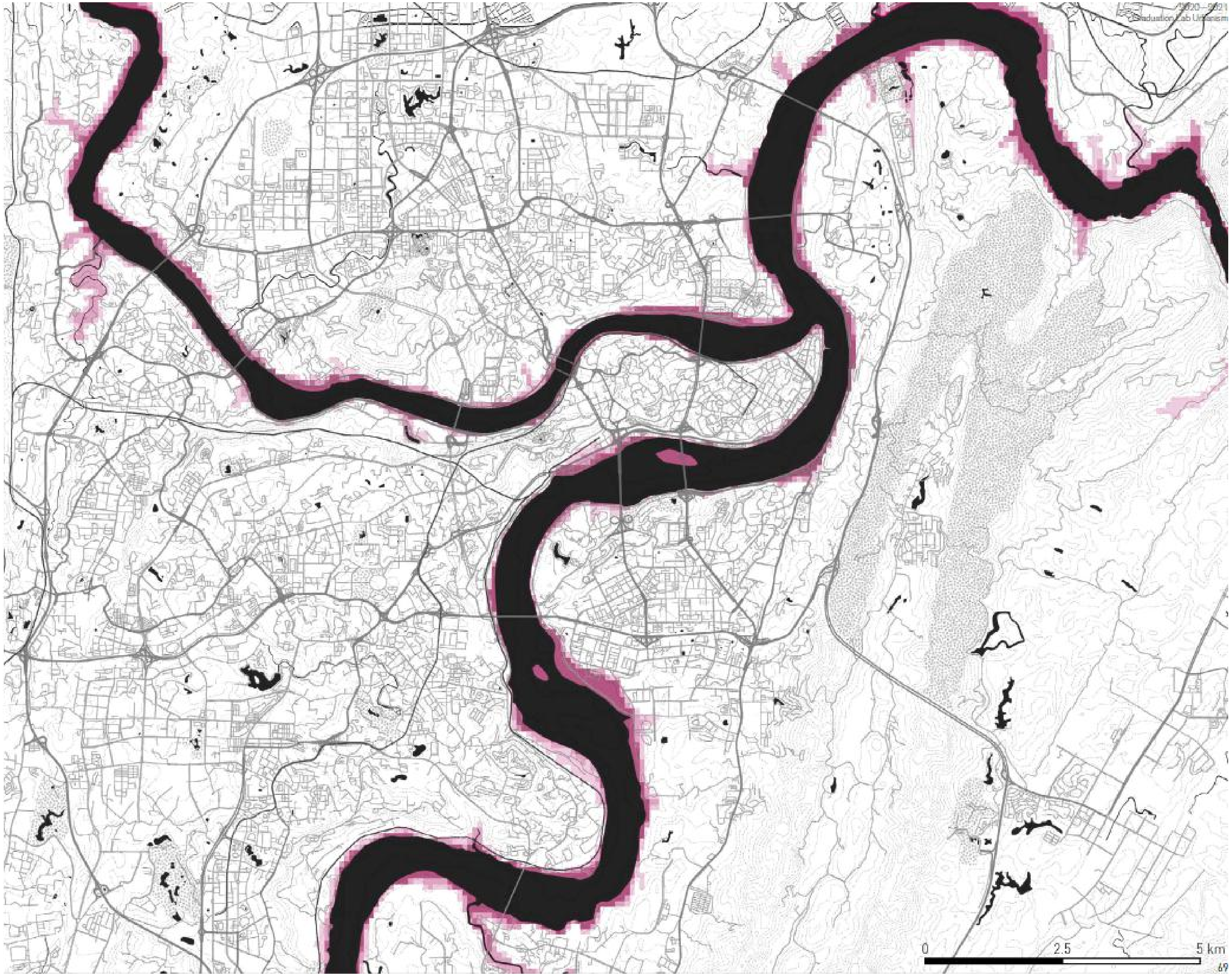


Annual runoff quantity of the upper reaches of the Yangtze River

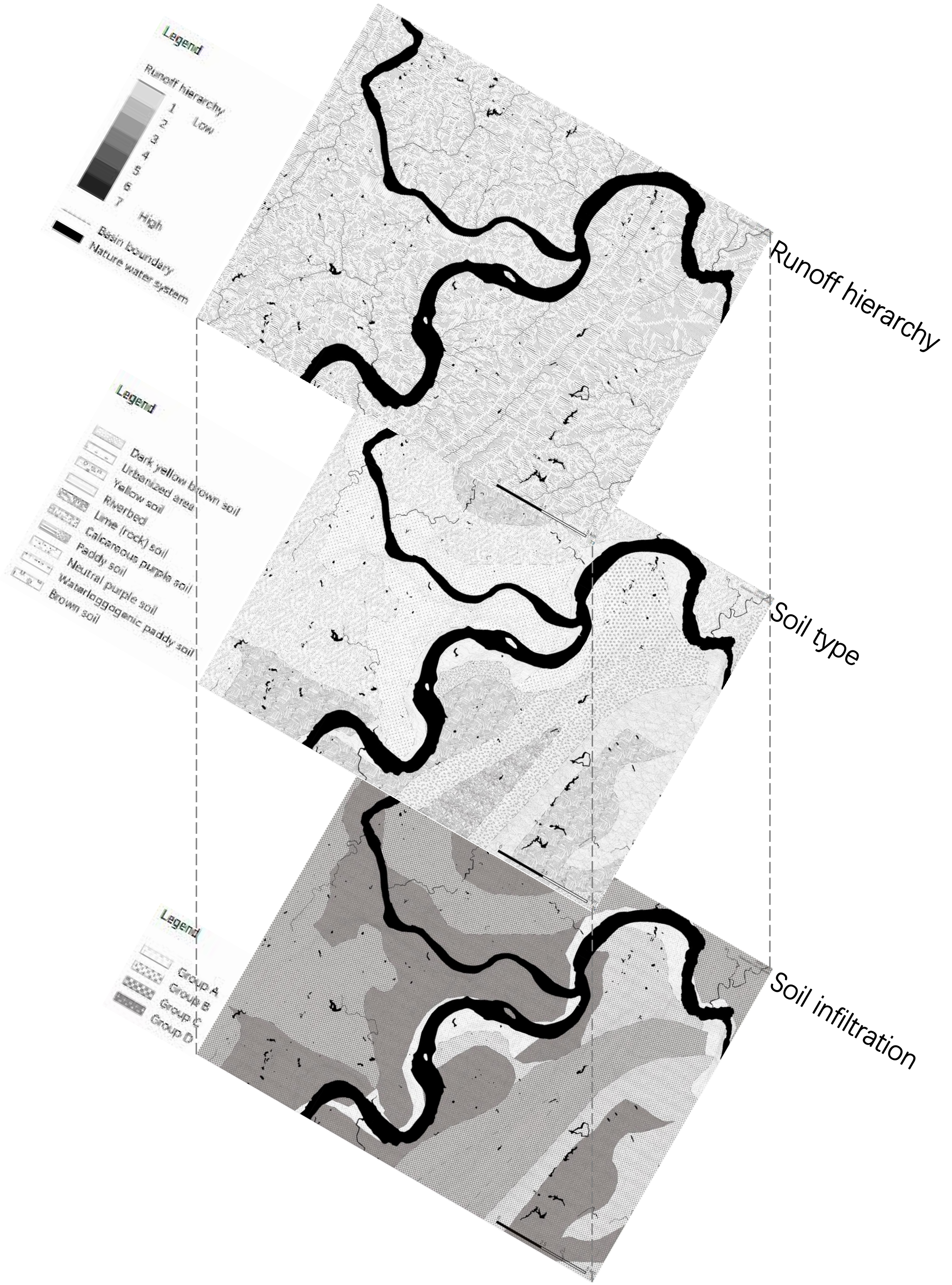
Analysis | Water safety

Safety map

The safety map is based on the data of the highest flood level from 2010 to 2020, reflecting the intensity of flooding inundation in the Chongqing main town.



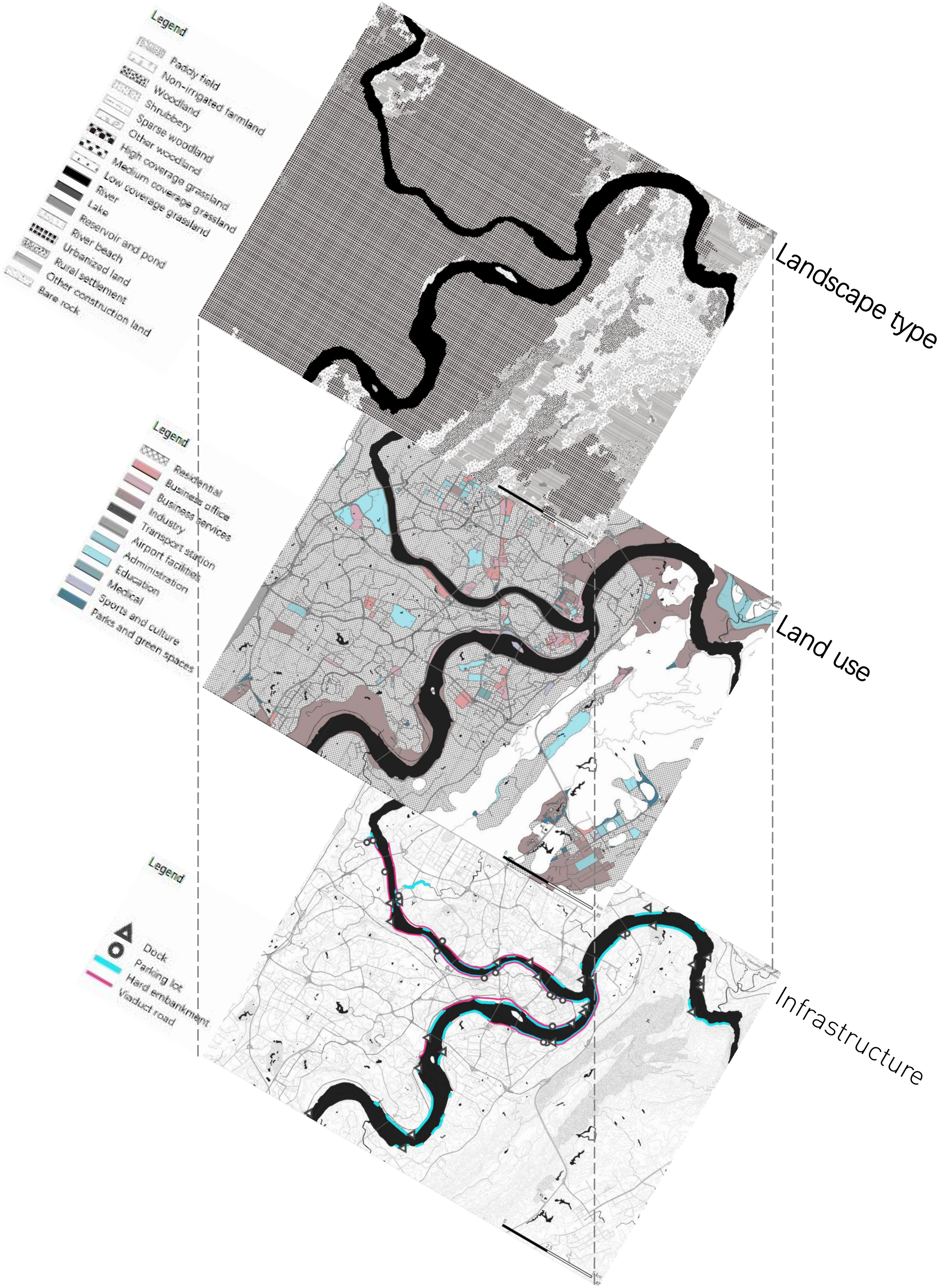
Analysis | Water conflict



Hydrodynamics

Understanding natural hydrodynamics. Overlay the runoff hierarchy and soil infiltration, to analysis the runoff intensity in Chongqing main town.

Analysis | Water conflict



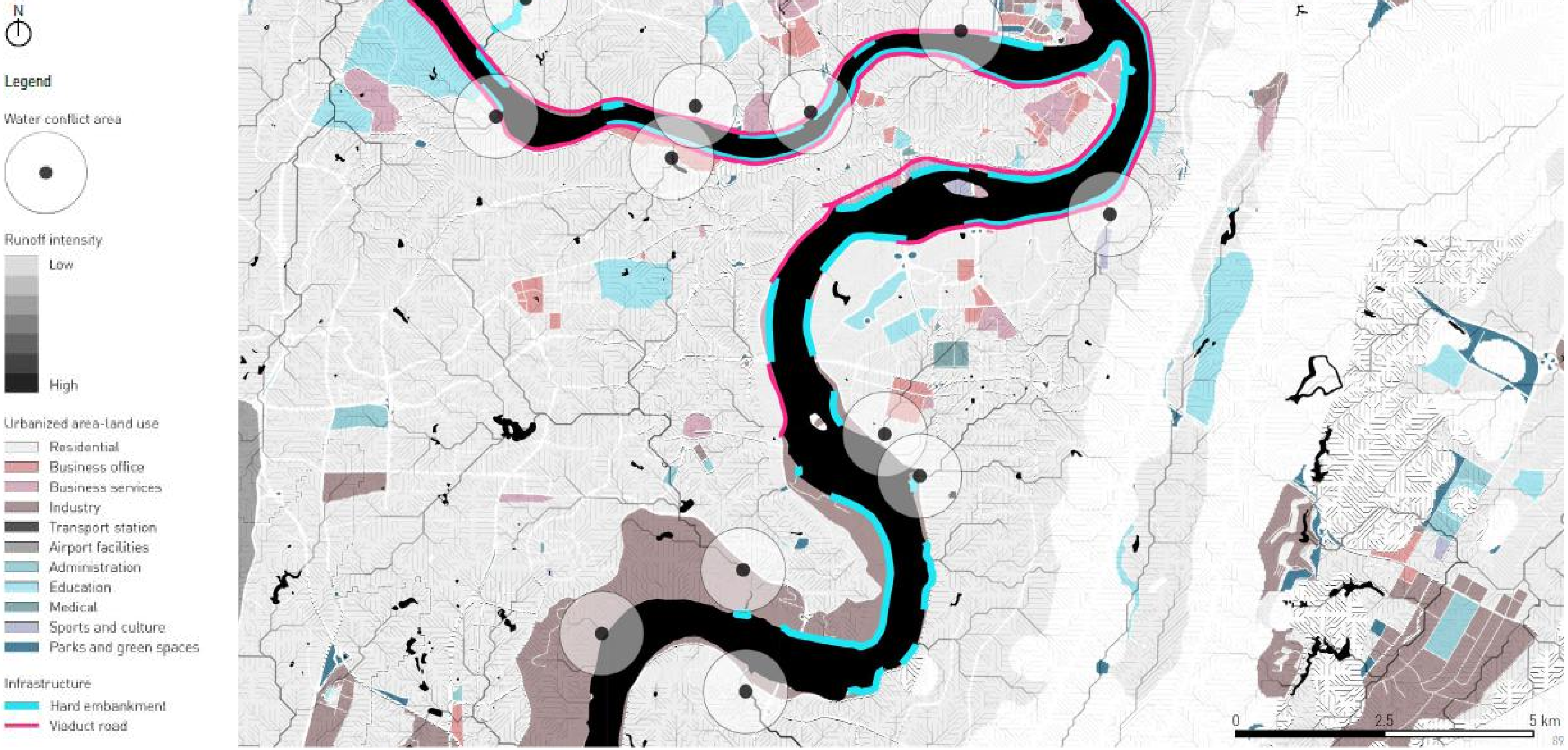
Human impact

How human activities influence surface of this area in landscape.
The current land use, and infrastructure distribution.

Analysis | Water conflict

Conflict map

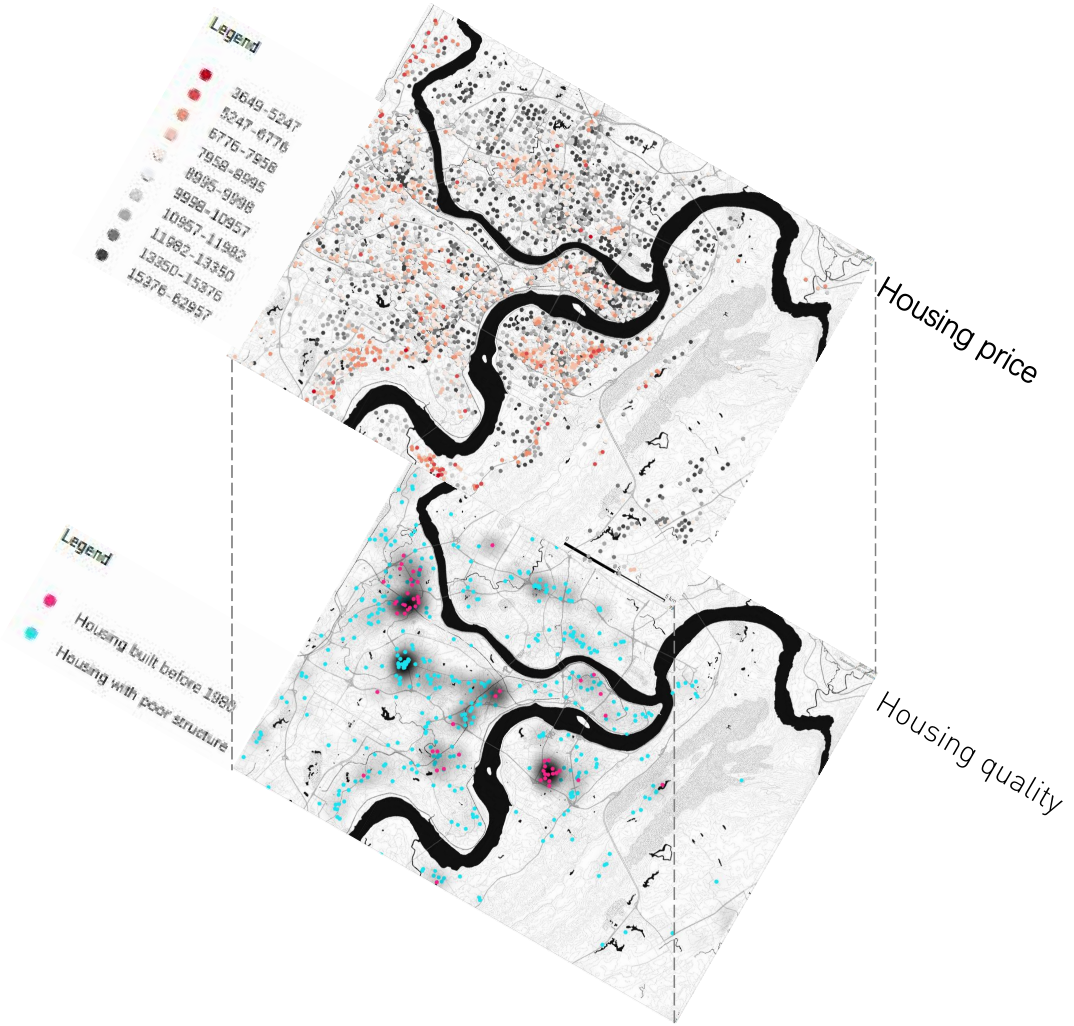
Through the overlay of the **natural water system** and the **built environment**, the potential water conflict area along the river corridor of Chongqing is obtained.



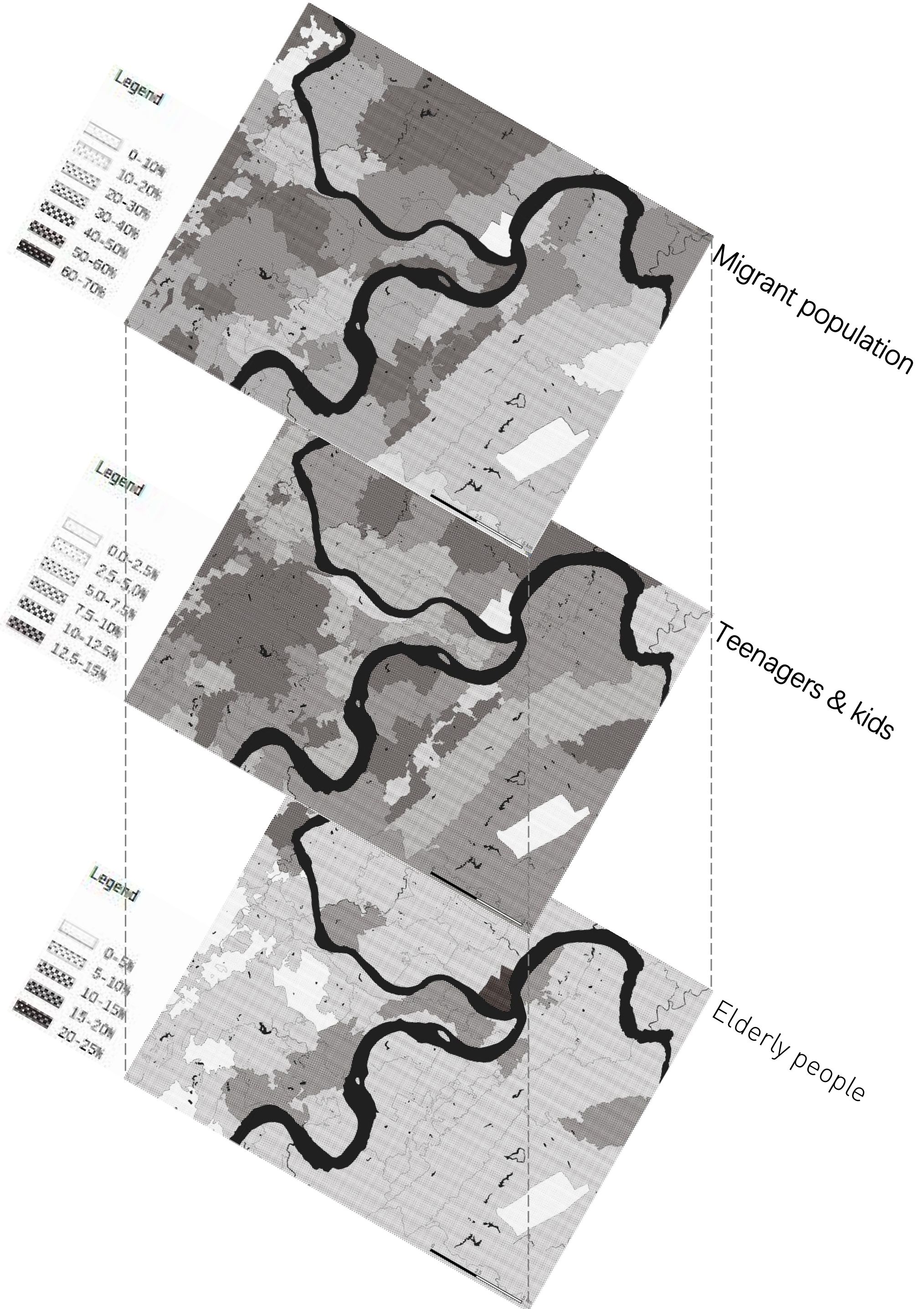
Analysis | Water opportunity

Society

Social-economy

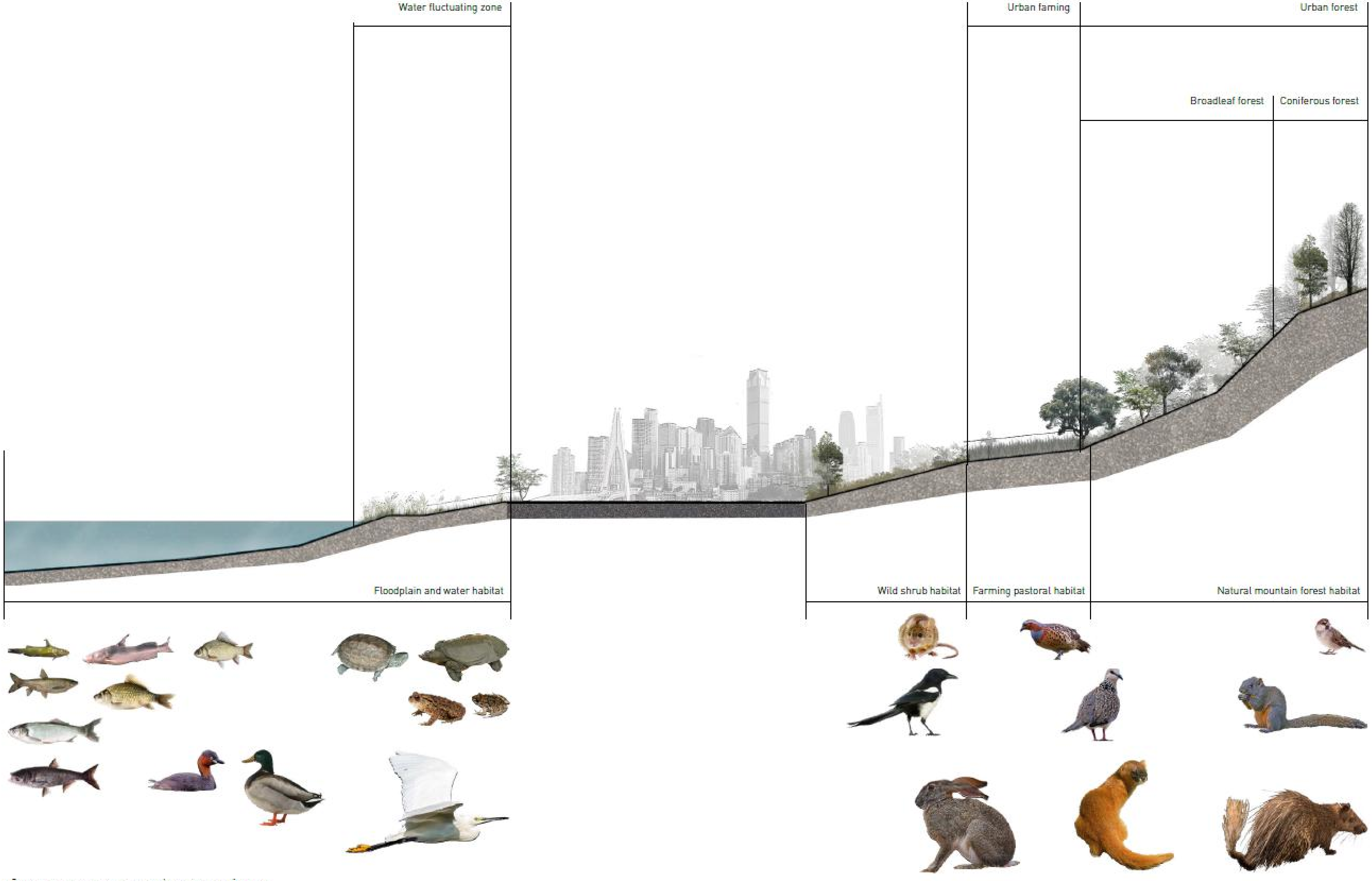


Community composition



Analysis | Water opportunity

Ecology



04 | Assessment

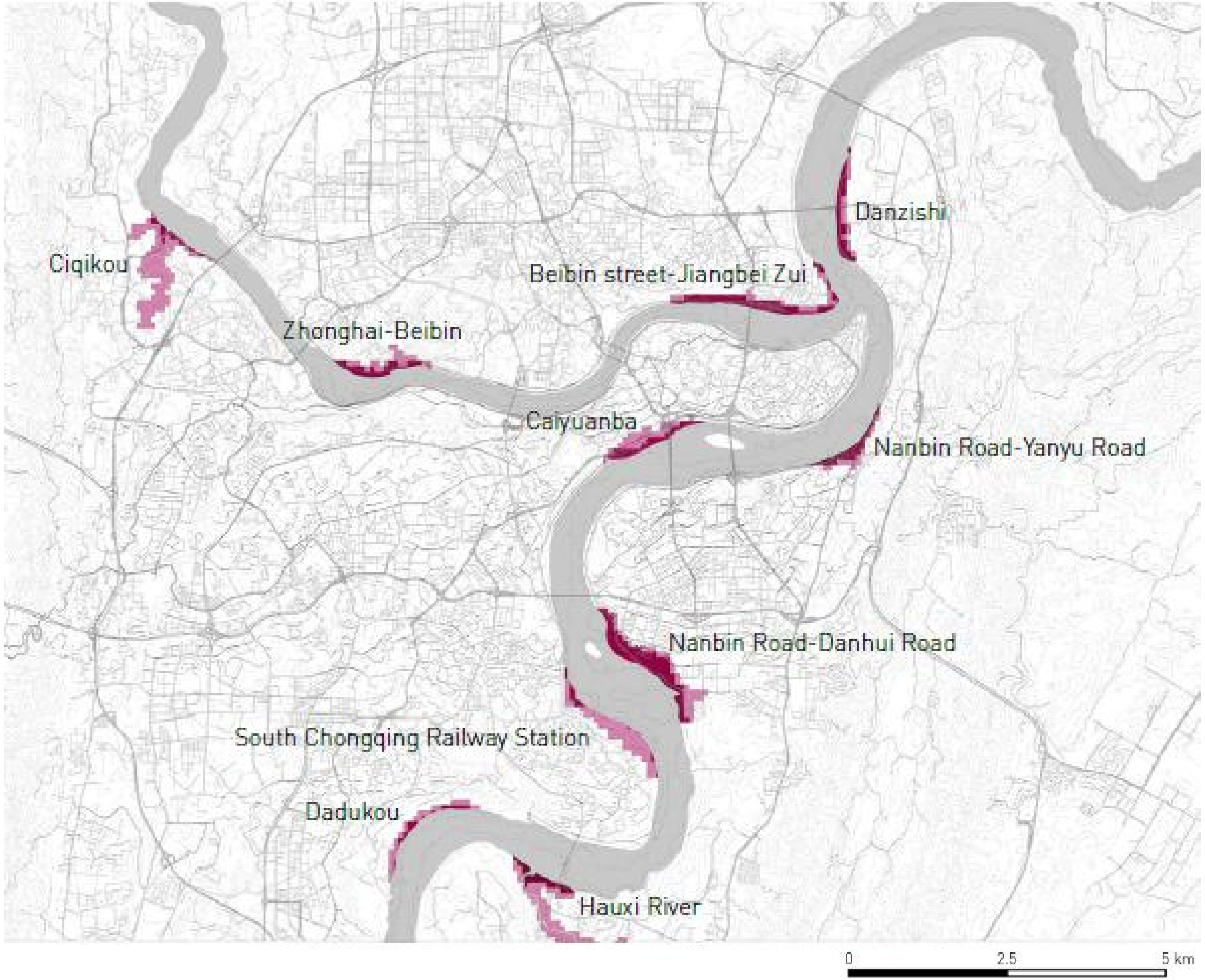
How to quantify the impact of floods on urban environments?

Sub-Q2 CAUSATION

Assessment | Site selection

Rough selection

Base on the result of the analysis of water safety and water conflict, the river corridor sections which are **under risk of seasonal flood** and have the **most serious conflict between nature and human activities** are selected as the potential location.

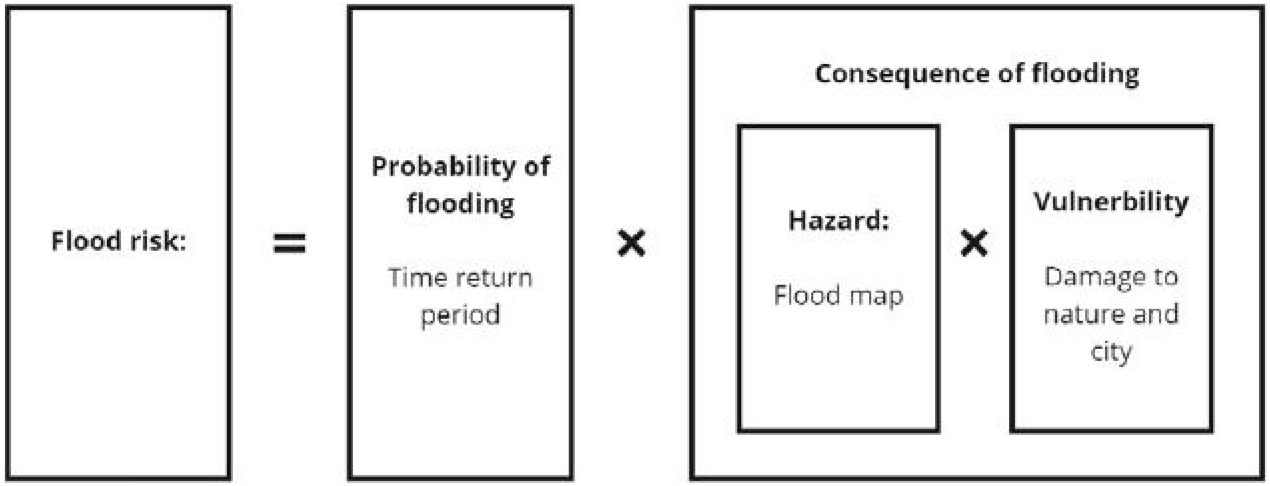


Assessment | Site selection

Scoring the locations:

The flood risk can be simply represented as "probability times damage", to describes the expected damage that can occur or will be exceeded with a certain probability in a certain period.

As for the calculation of the flood damage, a common way is using the potential damage index (vulnerable index) times the area of the area affected by the flood hazard.



$$\text{Flood risk} = \text{Flood time return period} \times \text{Inundation area} \times \text{Vulnerable index} \quad (1)$$

$$\text{Flood risk}_{10} = \text{Flooding probability}_{10} \times \text{Inundation area}_{10} \times (\text{Index}_1 + \text{Index}_2 + \ldots \text{Index}_n) \quad (2)$$

$$\text{Flood risk}_{100} = \text{Flooding probability}_{100} \times \text{Inundation area}_{100} \times (\text{Index}_1 + \text{Index}_2 + \ldots \text{Index}_n) \quad (3)$$

$$\text{Flood risk}_{total} = \text{Flood risk}_{10} + \text{Flood risk}_{100} \quad (4)$$

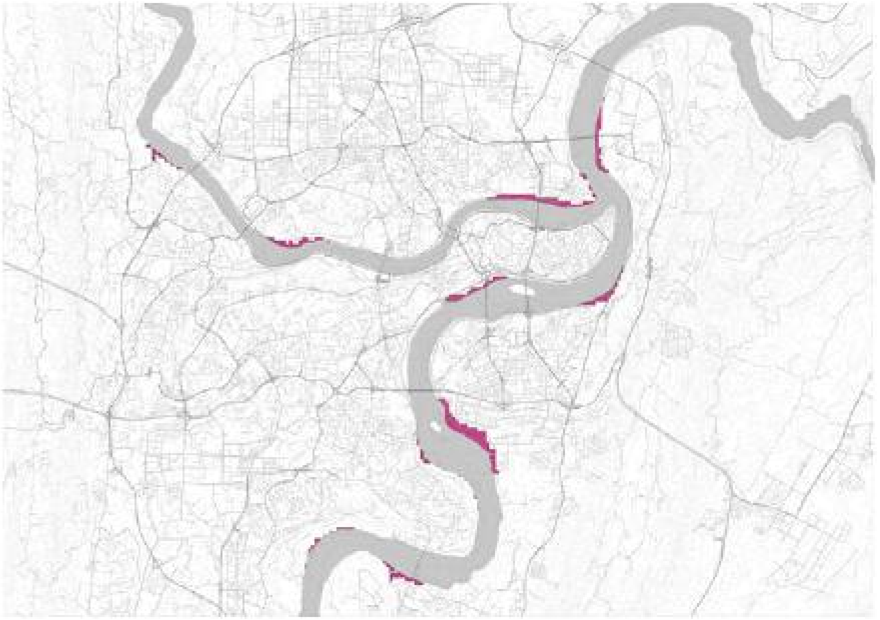
Assessment | Site selection

Scoring the locations:

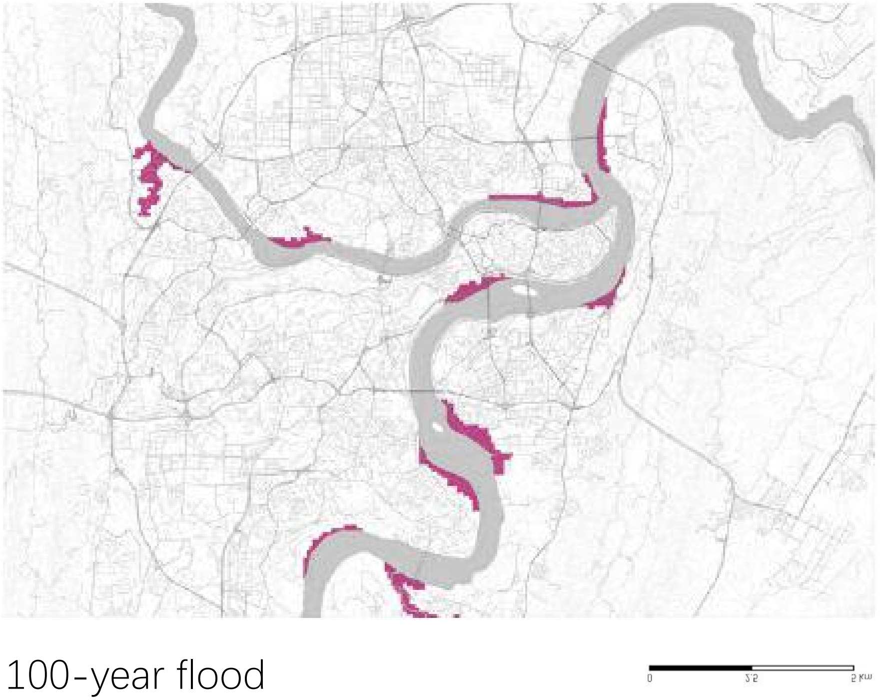
1. Flooding probability:

10-year flood ≈ 0.85
100-year flood ≈ 0.10

2. Inundation area:



10-year flood



100-year flood

Assessment | Site selection

Scoring the locations:

3. Vulnerable index:

(1) Runoff intensity

Runoff intensity					
Classification	Class I	Class II	Class III	Class IV	Class V
Runoff intensity	Extremely low	Low	Mediun	High	Extremely high
Quantitative assignment	1	2	3	4	5

(2) Vegetation coverage

Vegetation coverage rate					
Classification	Class I	Class II	Class III	Class IV	Class V
Vegetation coverage	Extremely low 0 < (V. C.) ≤ 20%	Low 20 < (V. C.) ≤ 40%	Mediun 40 < (V. C.) ≤ 60%	High 60 < (V. C.) ≤ 80%	Extremely high 80 < (V. C.) ≤ 100%
Quantitative assignment	5	4	3	2	1

(3) Infrastructure coverage

Riverside infrastructure coverage rate					
Classification	Class I	Class II	Class III	Class IV	Class V
Vegetation coverage	Extremely low 0 < (I. C.) ≤ 40%	Low 40 < (I. C.) ≤ 80%	Mediun 80 < (I. C.) ≤ 120%	High 120 < (I. C.) ≤ 160%	Extremely high 160 < (I. C.) ≤ 200%
Quantitative assignment	5	4	3	2	1

(4) Tertiary industry

Tertiary industry rate					
Classification	Class I	Class II	Class III	Class IV	Class V
Tertiary industry	0 ≥ (T. I.) > 40%	0 ≥ (T. I.) > 40%	0 ≥ (T. I.) > 40%	0 ≥ (T. I.) > 40%	0 ≥ (T. I.) > 40%
Quantitative assignment	1	2	3	4	5

(5) Vulnerable population

Vulnerable population rate					
Classification	Class I	Class II	Class III	Class IV	Class V
Vulnerable population	(V. P.) > 40%	40 ≥ (V. P.) > 30%	30 ≥ (V. P.) > 20%	20 ≥ (V. P.) > 10%	10 ≥ (V. P.) > 0%
Quantitative assignment	5	4	3	2	1

Assessment | Site selection

Scoring the locations:

Flood vulnerability score

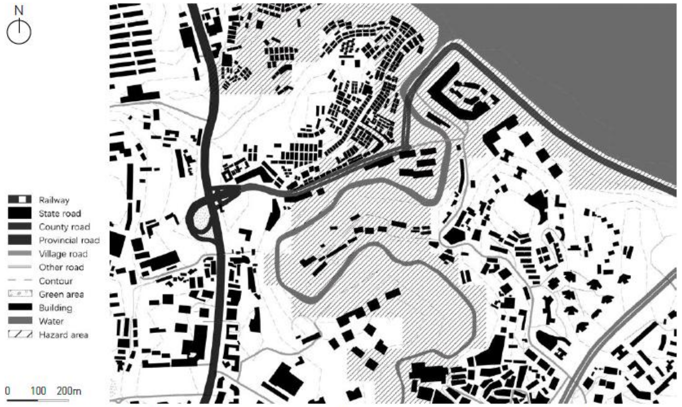
	100-year flood	10-year flood	Overall
Ciqikou	**160.4504**	133.5931	294.0436
Zhonghai-Beibin	57.1021	243.6489	300.7510
Beibin street-Jiangbei Zui	89.3021	571.1310	660.4331
Danzishi	55.0886	299.4944	354.5830
Caiyuanba	76.5226	290.5150	367.0376
Nanbin road-Yanyu road	53.3180	292.4998	345.8177
Nanbin road-Danhui road	133.1120	**765.2390**	**898.3510**
South Chongqing railway station	72.5540	76.5989	149.1530
Huaxi River	84.8134	171.6408	256.4542
Dadukou	34.7771	91.3971	126.1742

Assessment | Result

Nanbin road-Danhui road:

Runoff intensity: High
Infrastructure coverage: 0.317
Vegetation coverage: 0.145
Tertiary industry: 0.61
Vulnerable population: 0.199

Ciqikou:



Runoff intensity: Extremely high
Infrastructure coverage: 0.334
Vegetation coverage: 0.181
Tertiary industry: 0.917
Vulnerable population: 0.207

05 | Projections & intervention

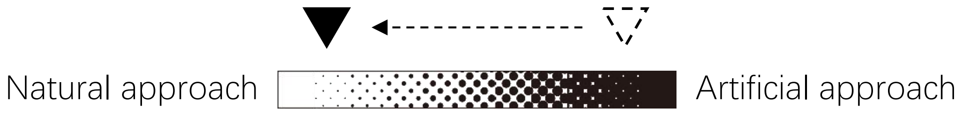
What is the potential of flood control tools? & How to implement flood resilience in urban perspective?

Sub-Q3&4 CAUSATION

Projections | Priorities' conflict

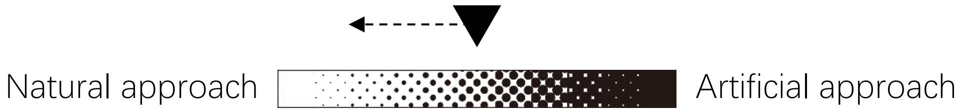
Macro-regional scale

The state government regards ecology as the top priority for the future development of the Yangtze River.



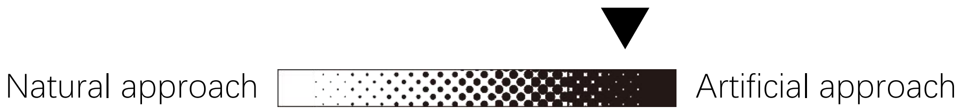
City scale

Economy, development, and safety are still the main priorities considered by the municipal government, but ecology will become an important and indispensable factor in the development of the future city.

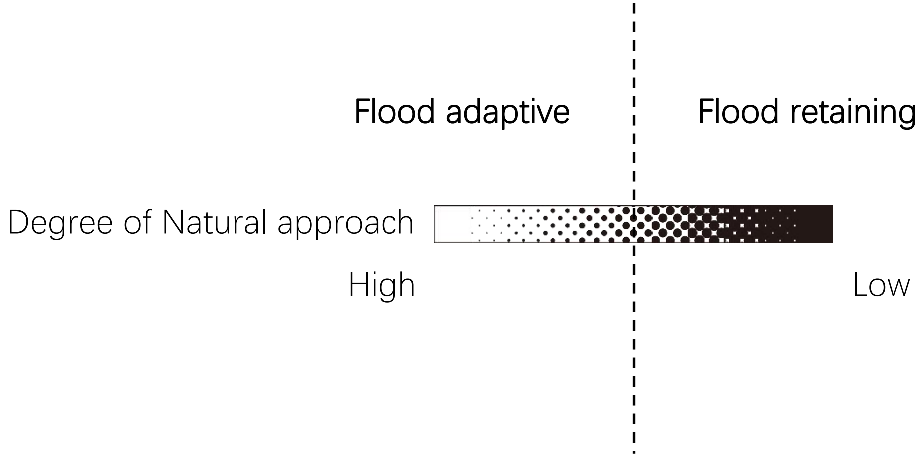


District and community scale

A more effective hard infrastructure approach or faster emergency escape approach is more likely to be favored by managers at this level.

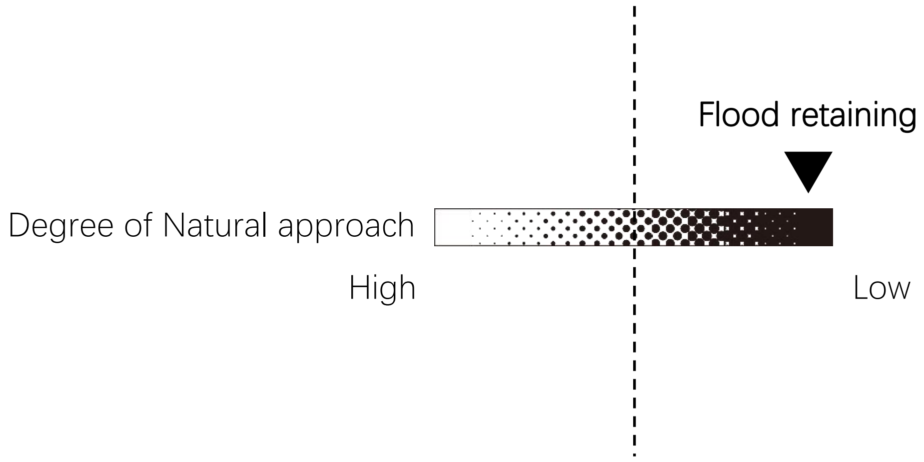


Projections | Scenario generation



Projections | Scenario generation

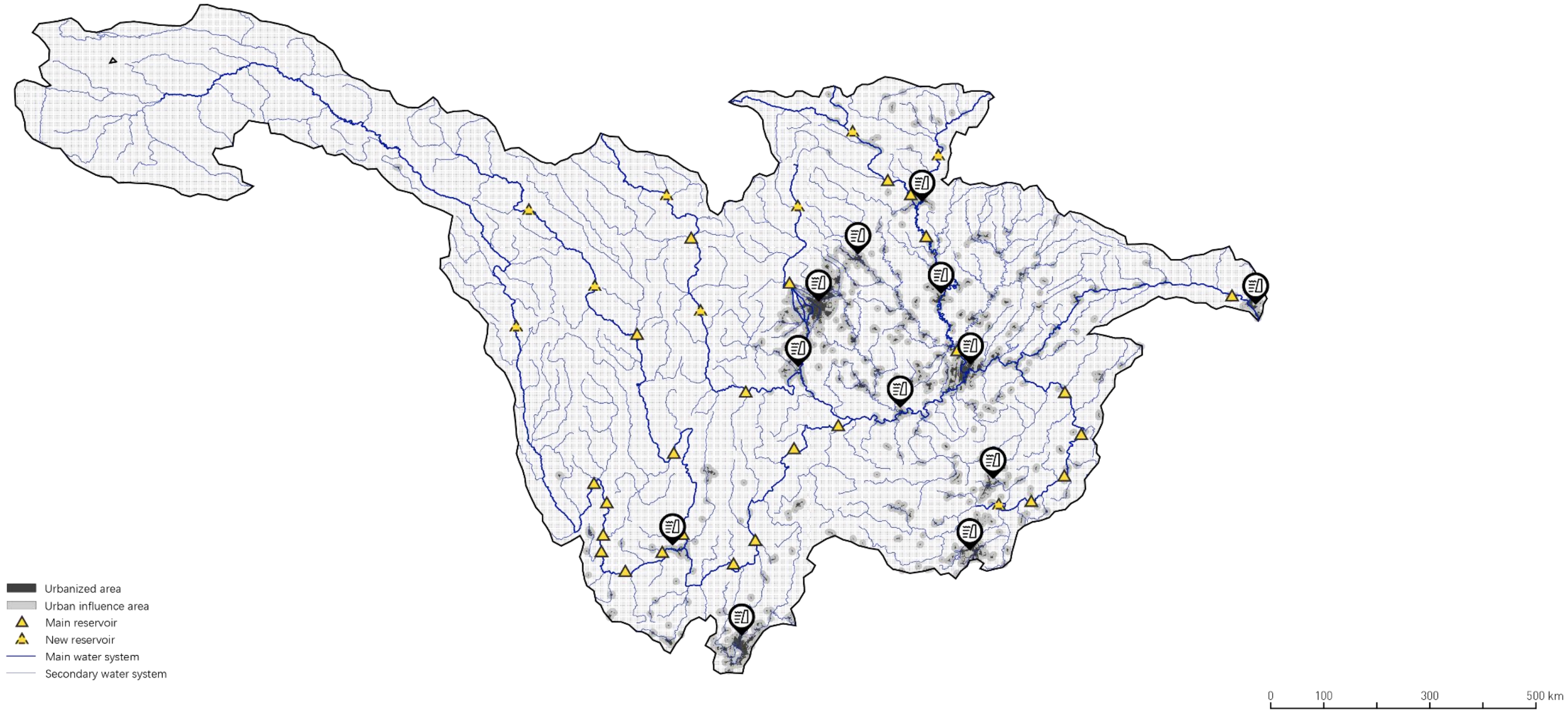
Flood retaining



Projections | Scenario generation

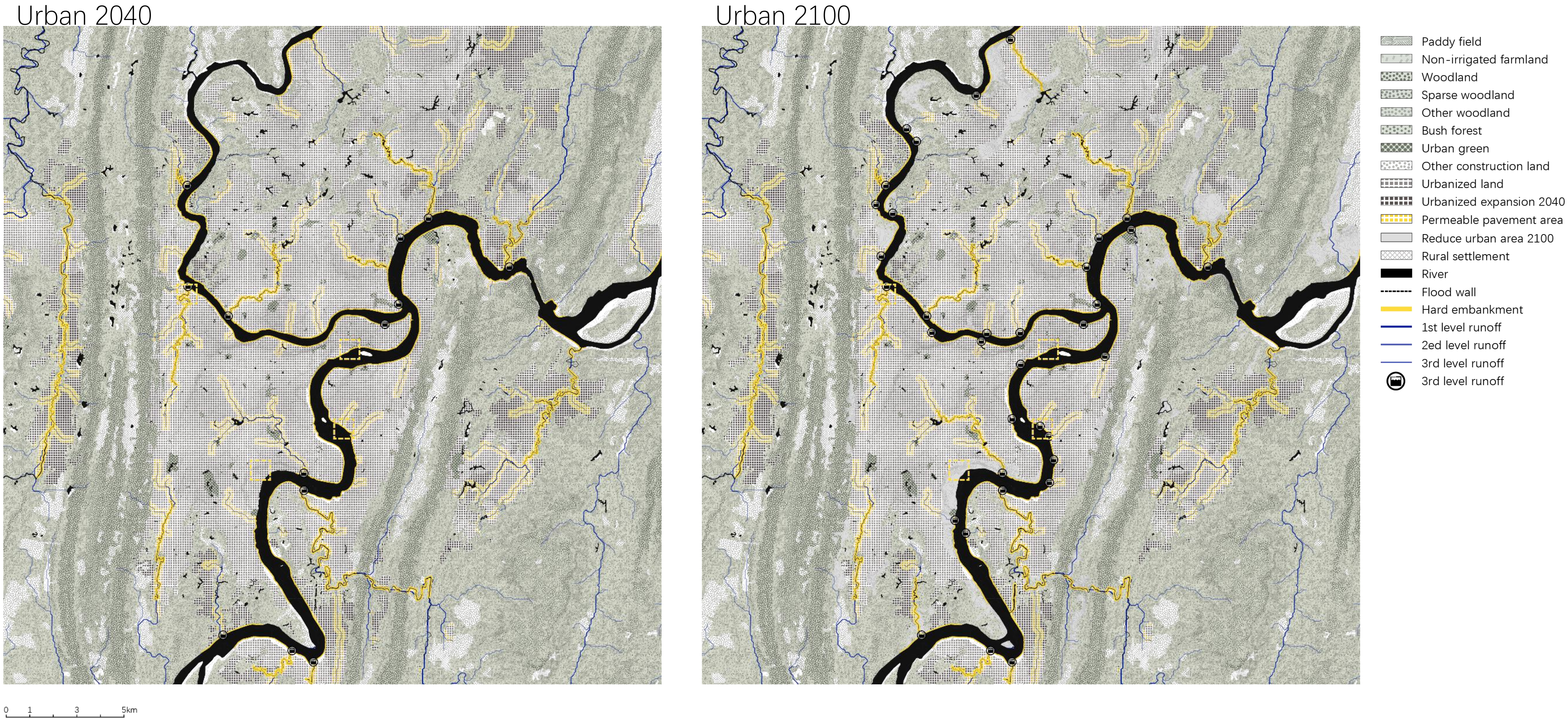
Flood retaining

Regional 2100



Projections | Scenario generation

Flood retaining



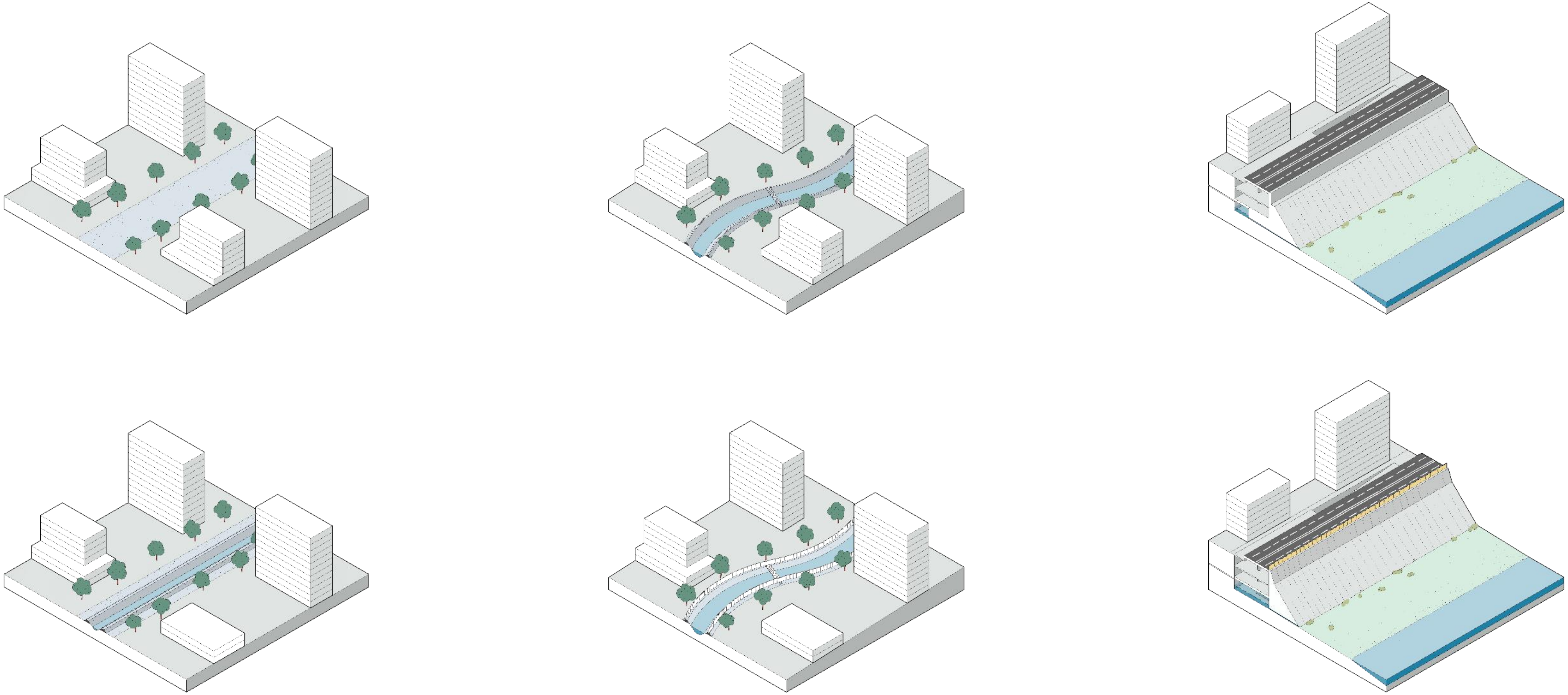
Projections | Scenario generation

Flood retaining

Runoff | Creek | River

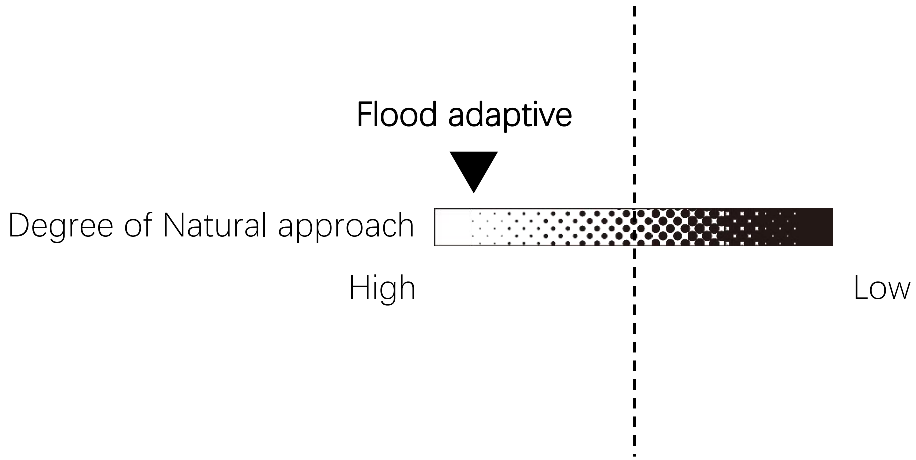
2040

2100



Projections | Scenario generation

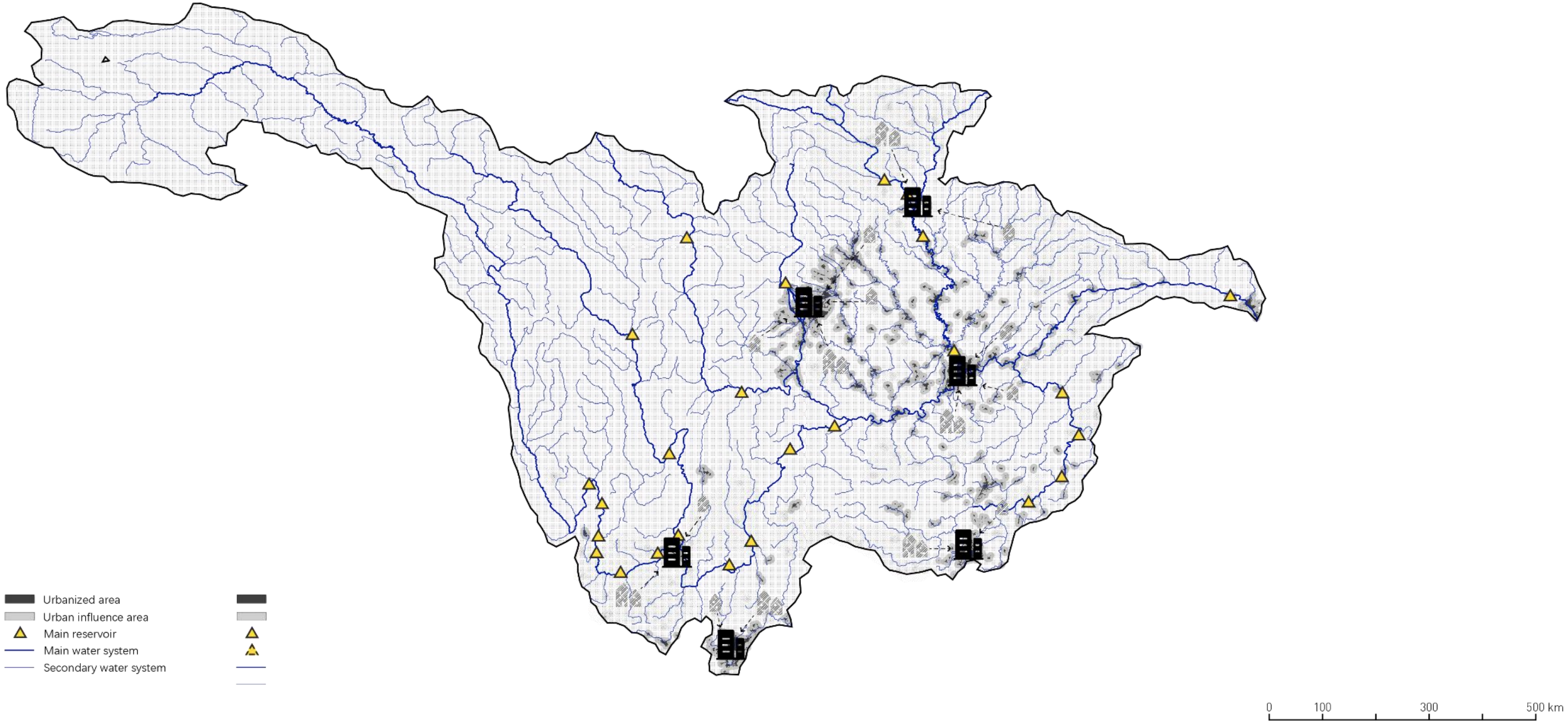
Flood adaptive



Projections | Scenario generation

Flood adaptive

Regional 2100

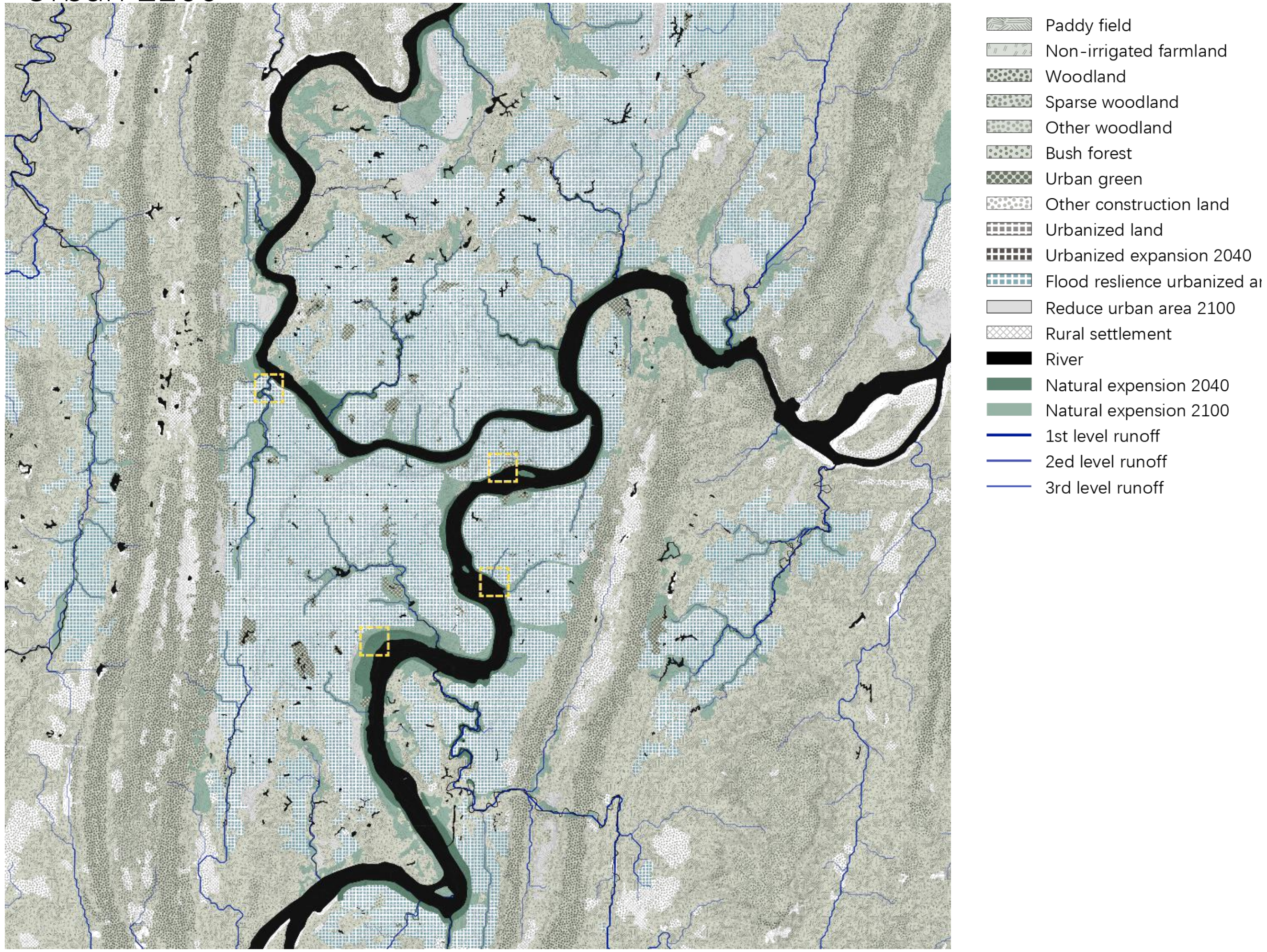


Projections | Scenario generation

Flood adaptive

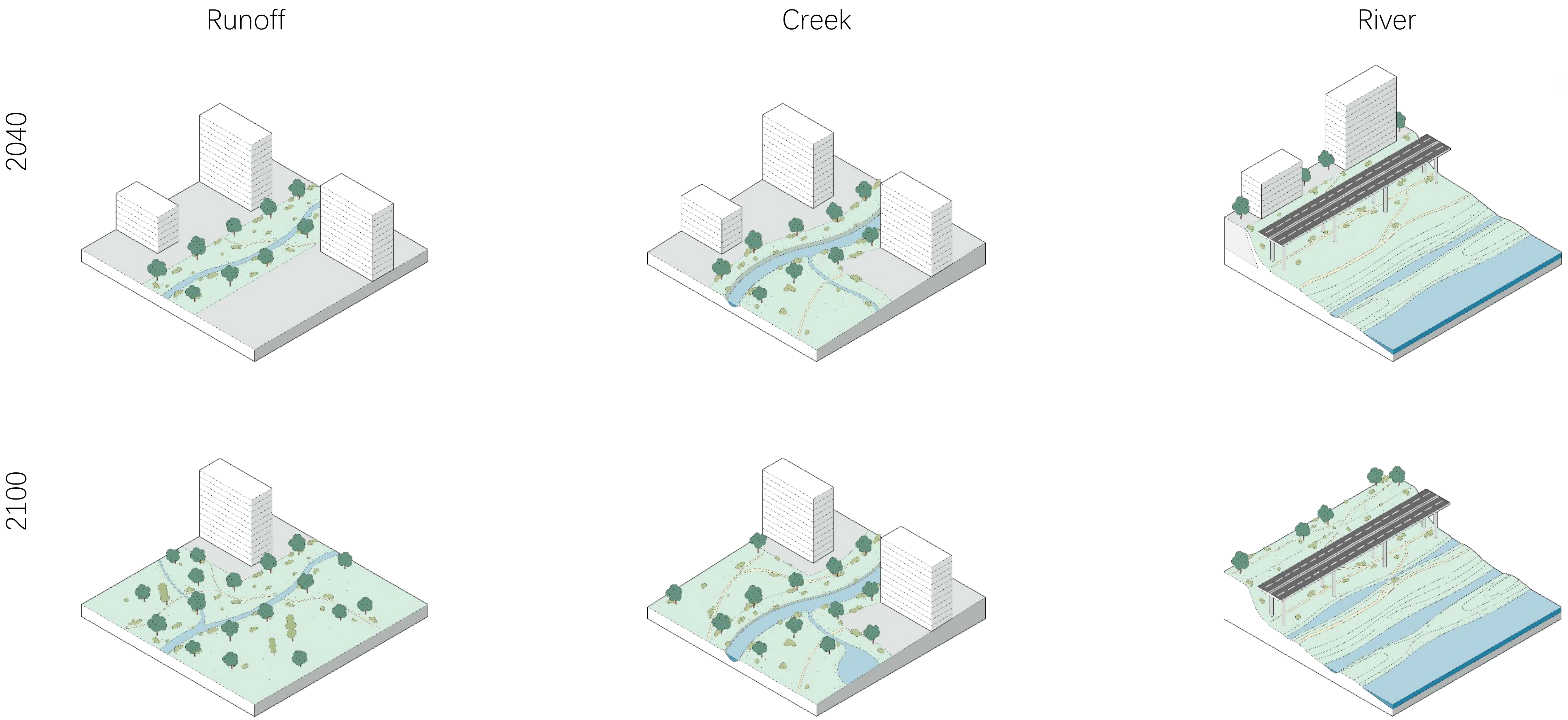
Urban 2040

Urban 2100



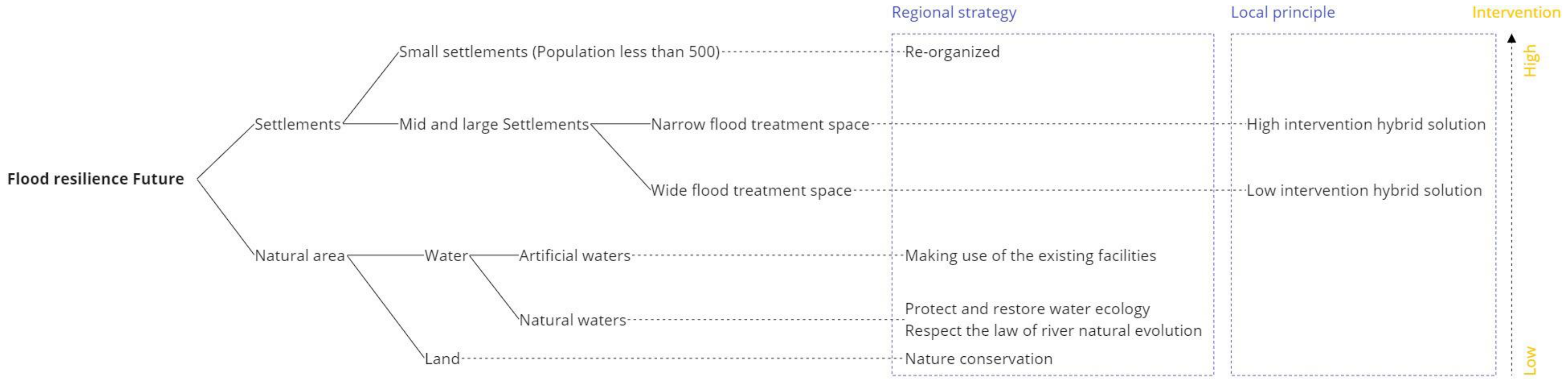
Projections | Scenario generation

Flood adaptive



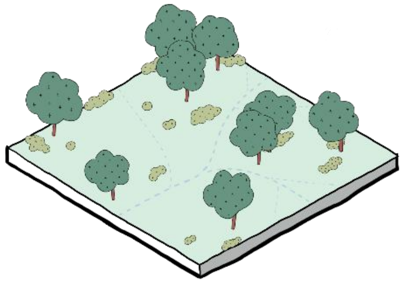
Intervention

Intervention principles



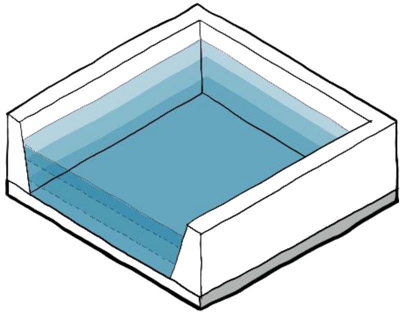
Projections | Regional strategy

Natural land



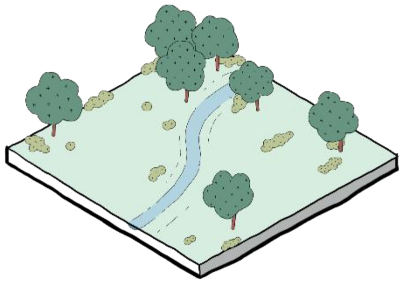
Nature conservation

Artificial waters



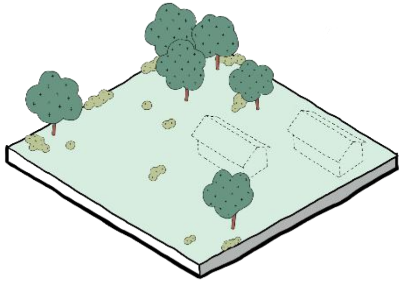
Making use of the existing facilities

Natural waters



Protect and restore natural water system

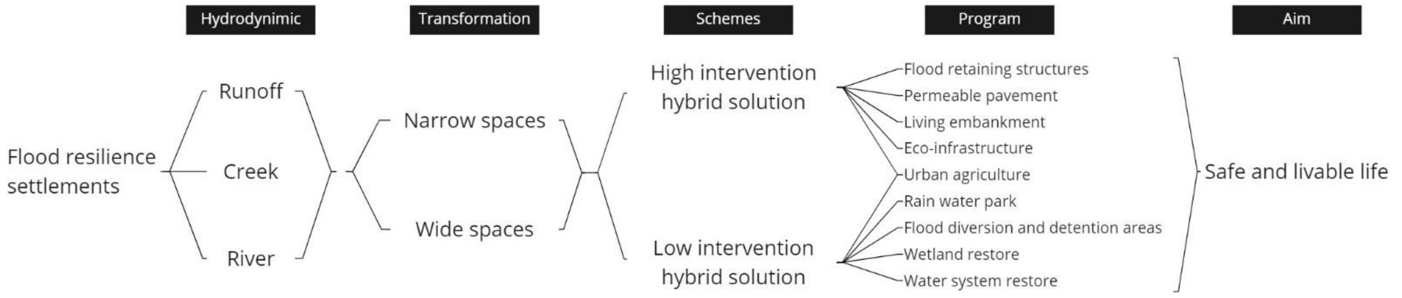
Small settlements

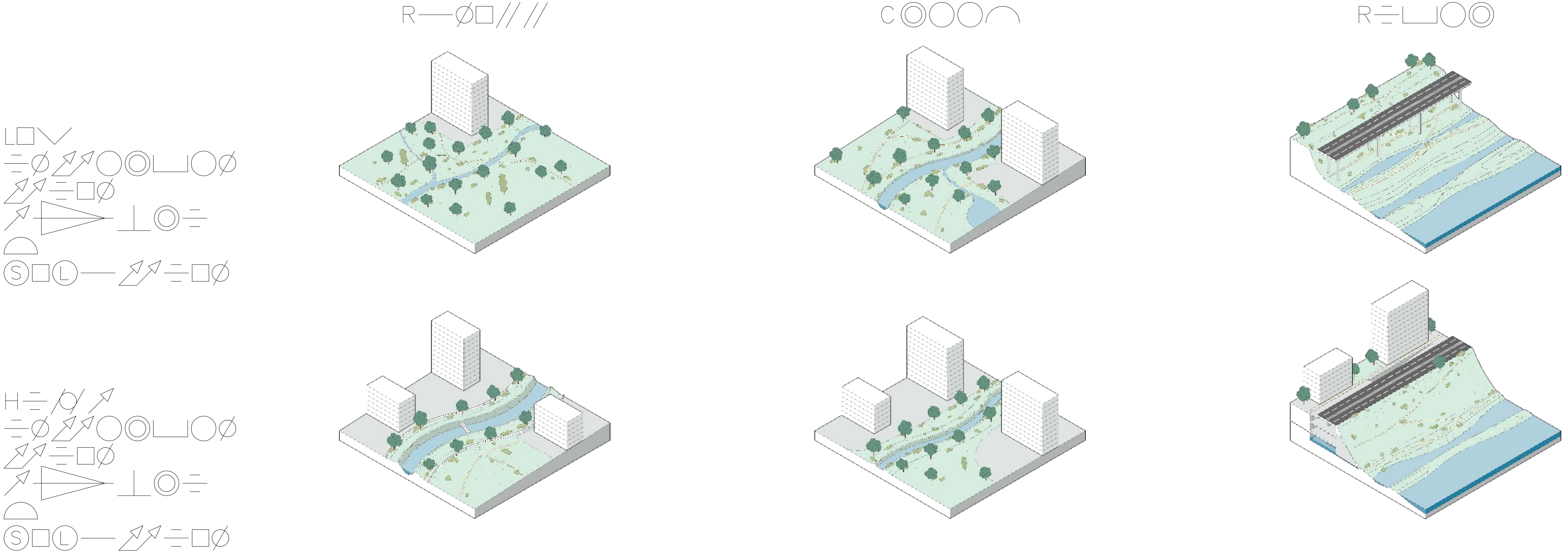


Re-design

Projections | Local principle

Local principal roadmap





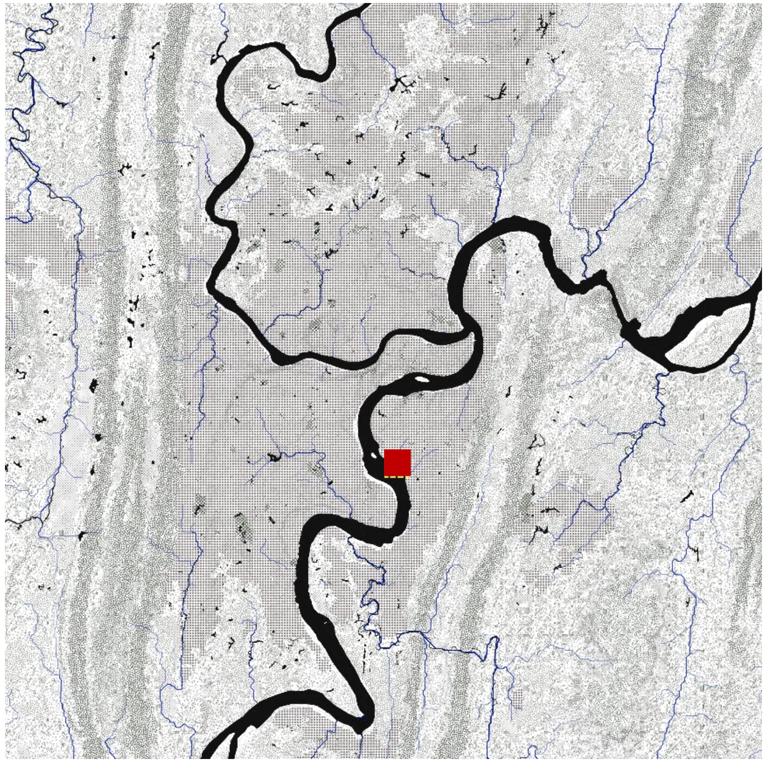
06 | Design experiment

What are the factors that cause the seasonal flood? & How the floods influence the living environment?

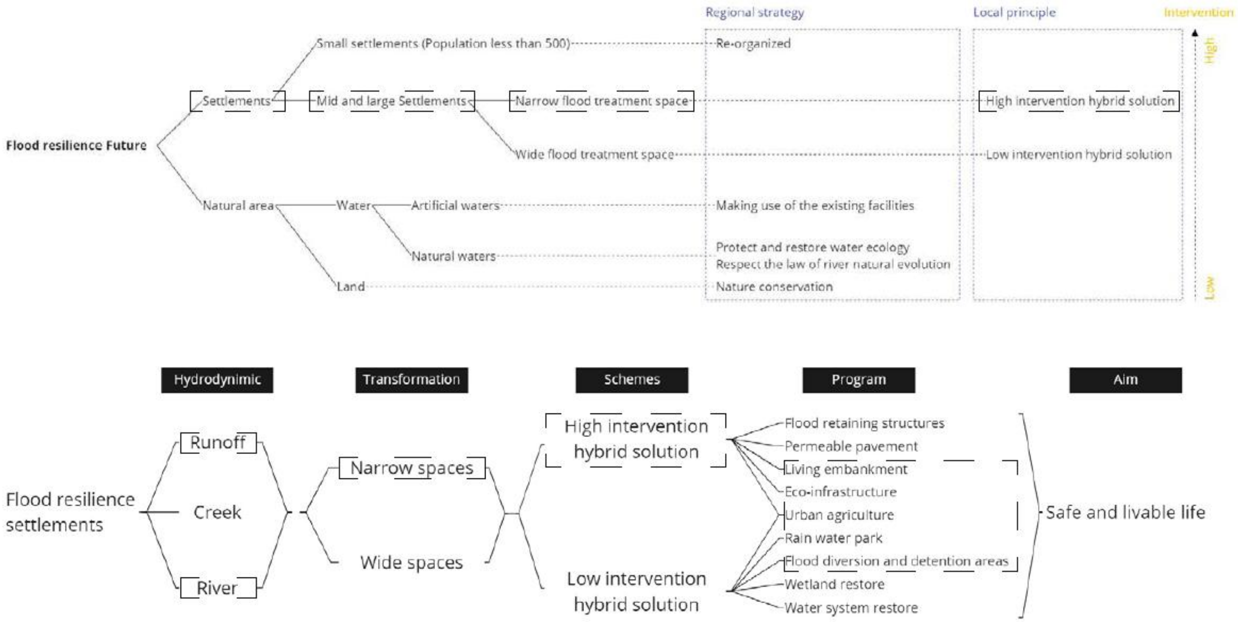
Sub-Q3&4 CAUSATION

Design experiment | Case 1.

Nanbin road-Danhui road area



Guideline



Design experiment | Case 1.

Plan

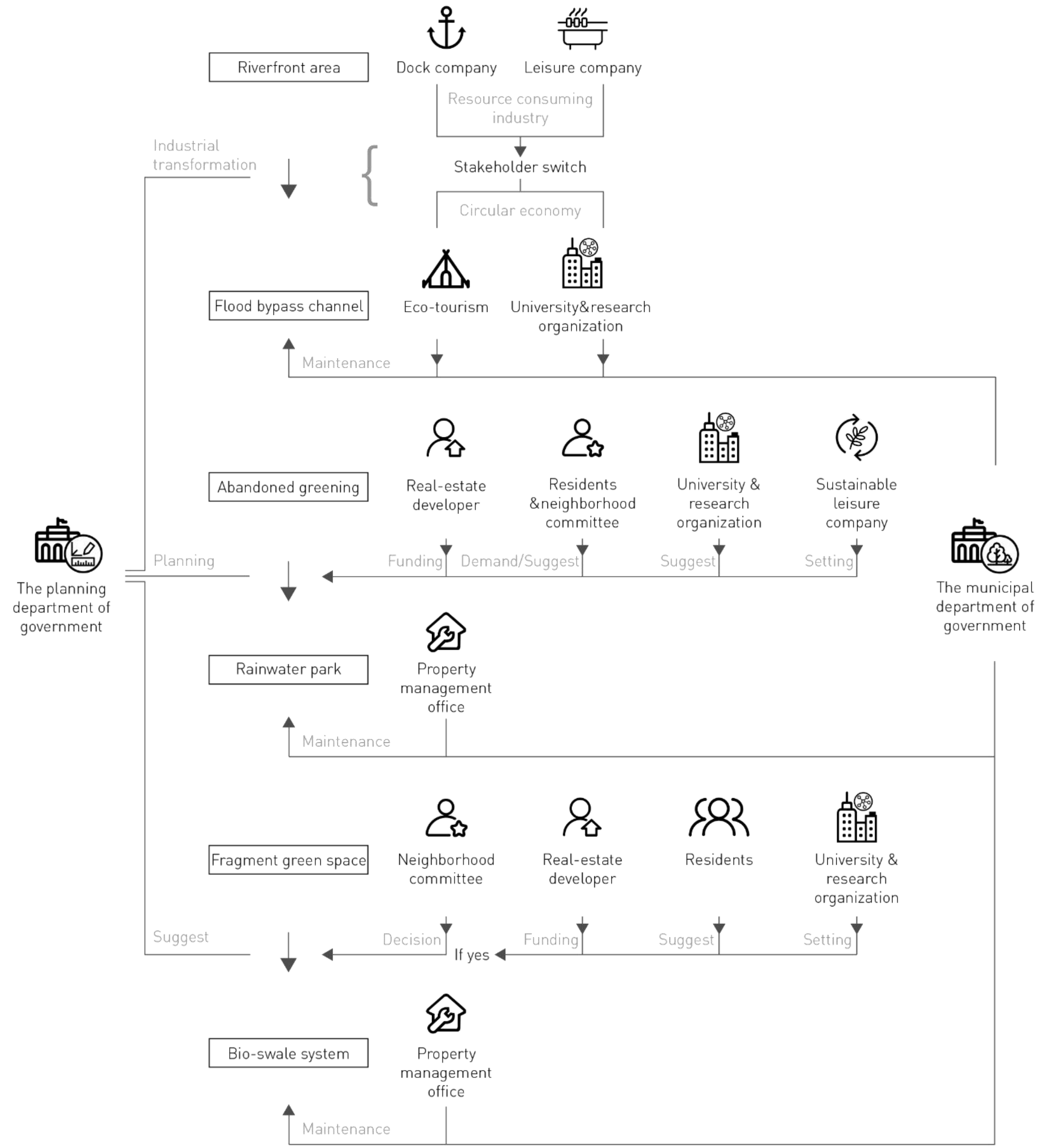
Rock revetment
Sandy embankment
Low grass zone
High grass zone
Ecodyke&bridge
Urban farming
Rainwater park
Bioswale
Rainwater pond
Court
Pathway

0 100 200m

Design experiment | Case 1.

Land ownership change & stakeholders

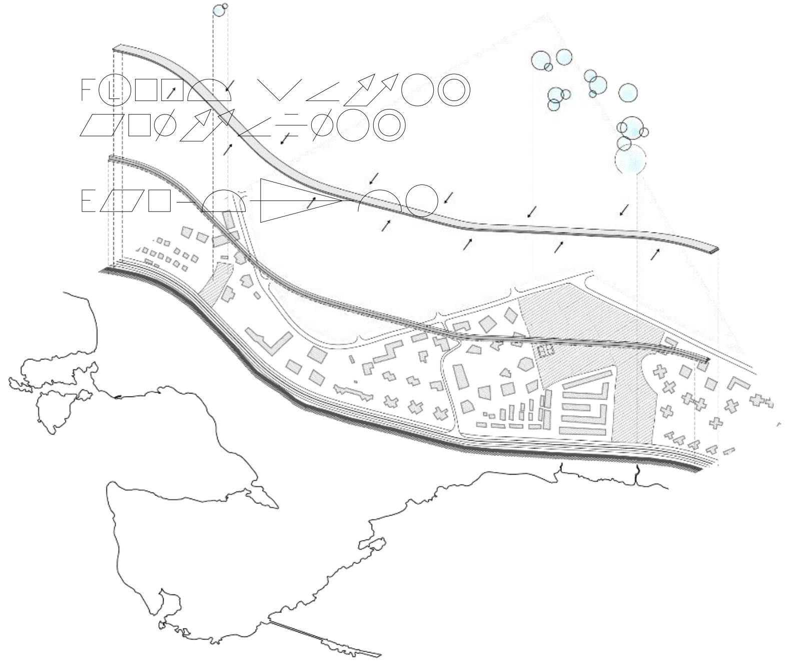
Tramsformation	Land-ownership
Riverfront area	Owned by states, rented by Yabadong dock company, and partly sublet to leisure company.
↓ Flood bypass channel	Owned by states, rented by eco-tourism company
Abandoned greening	Owned by states.
↓ Rainwater park	Owned by states, rented by sustainable leisure company and real-estate developer.
Fragment green space	The green space outside the residential community owned by states, and inside owned by local residence.
↓ Bio-swale system	The green space outside the residential community owned by states, and inside owned by local residence.

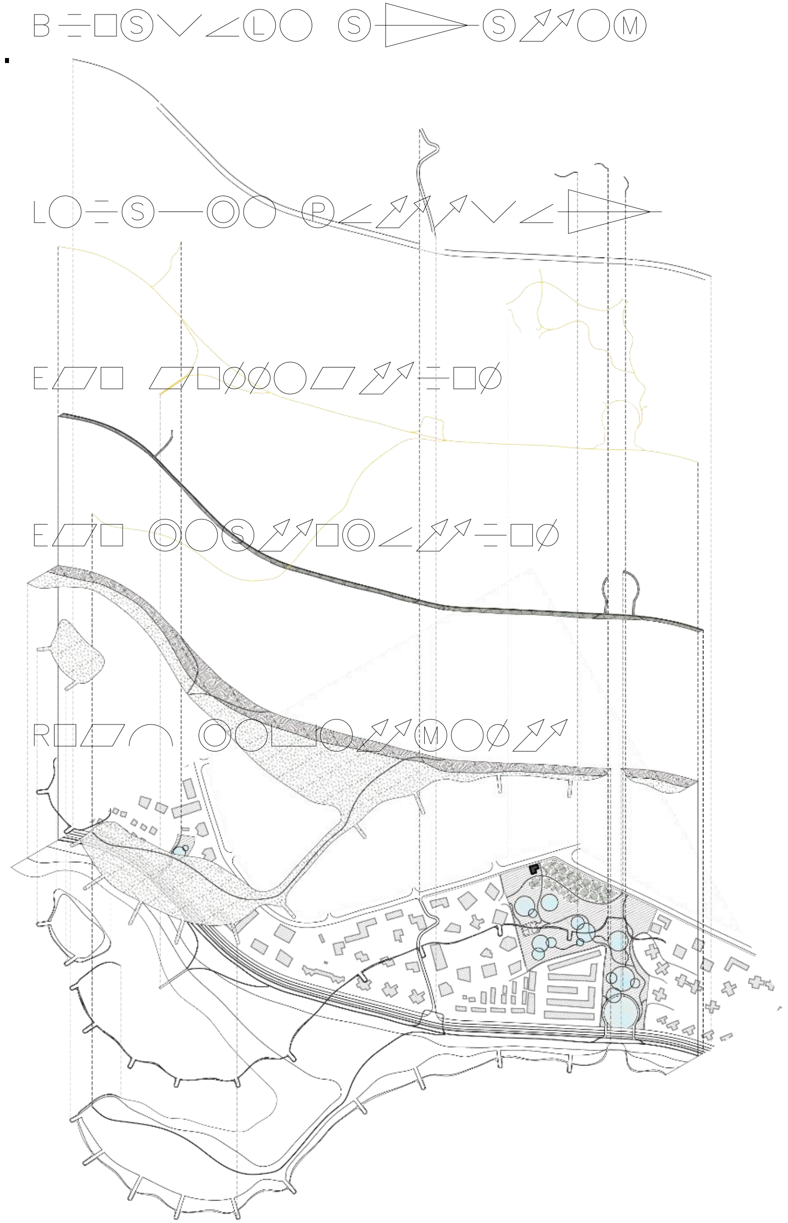


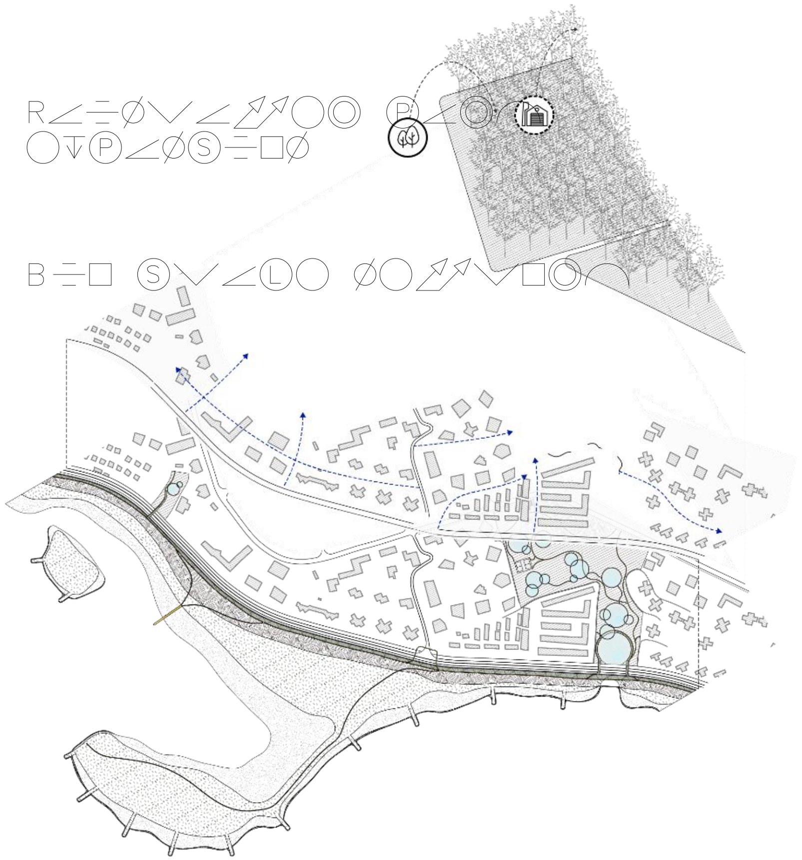
Design experiment | Case 1.

Progressive development

Rainwater park

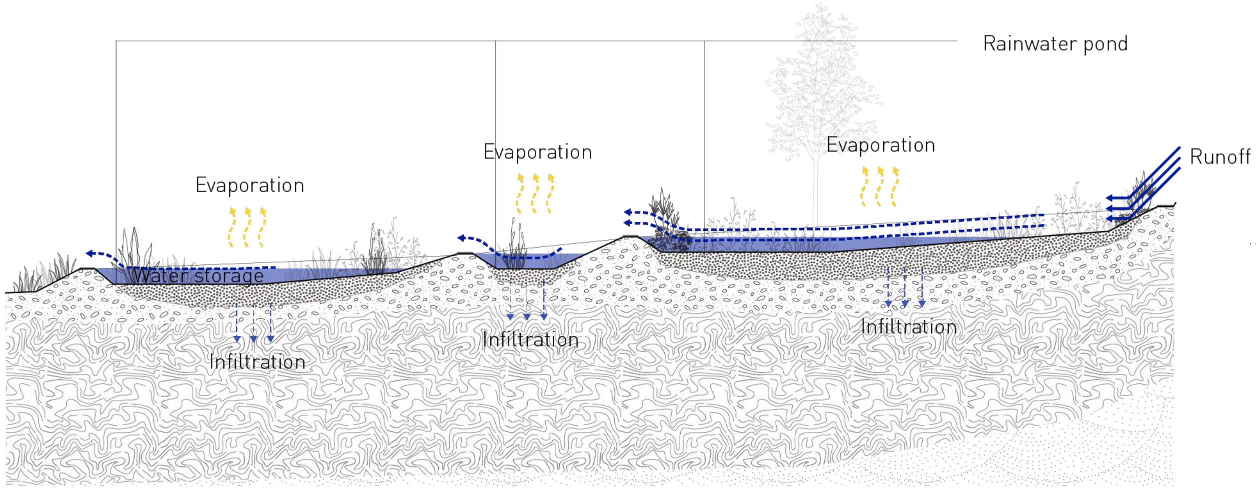


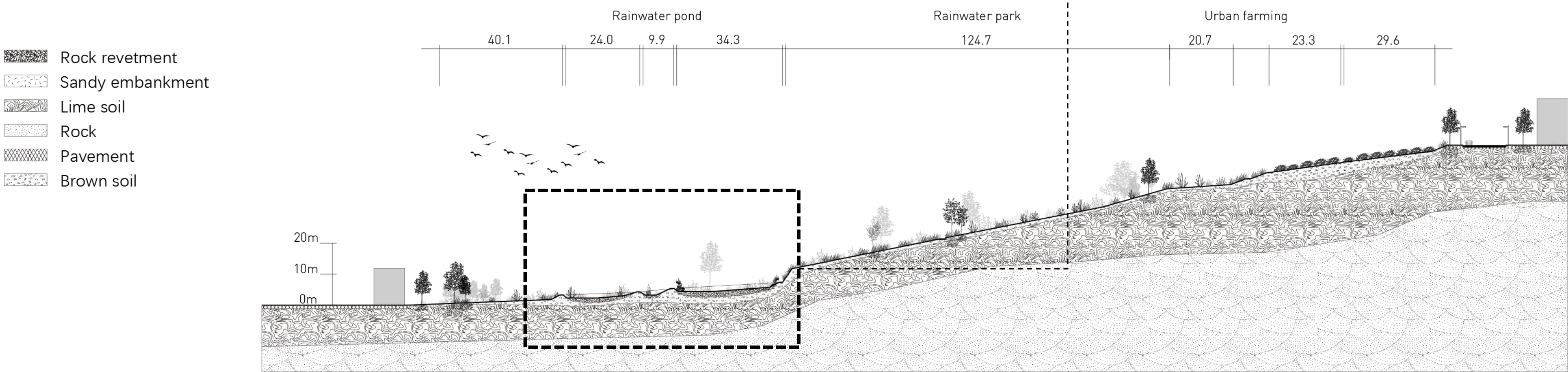




Design experiment | Case 1.

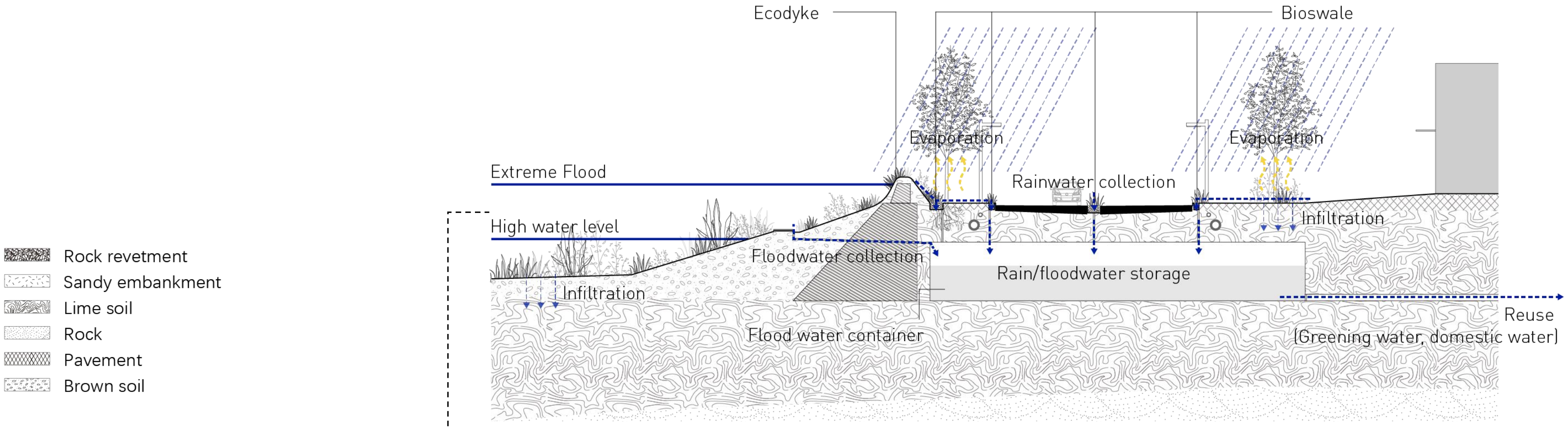
Section 1-1

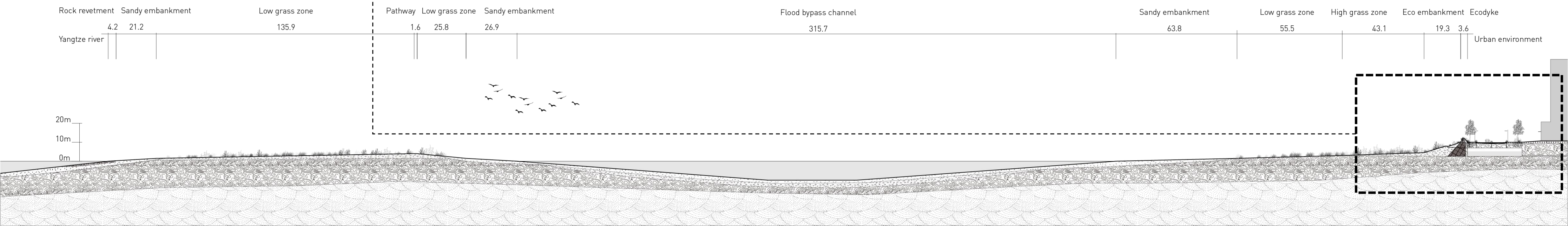




Design experiment | Case 1.

Section 2-2





Design experiment | Case 1.

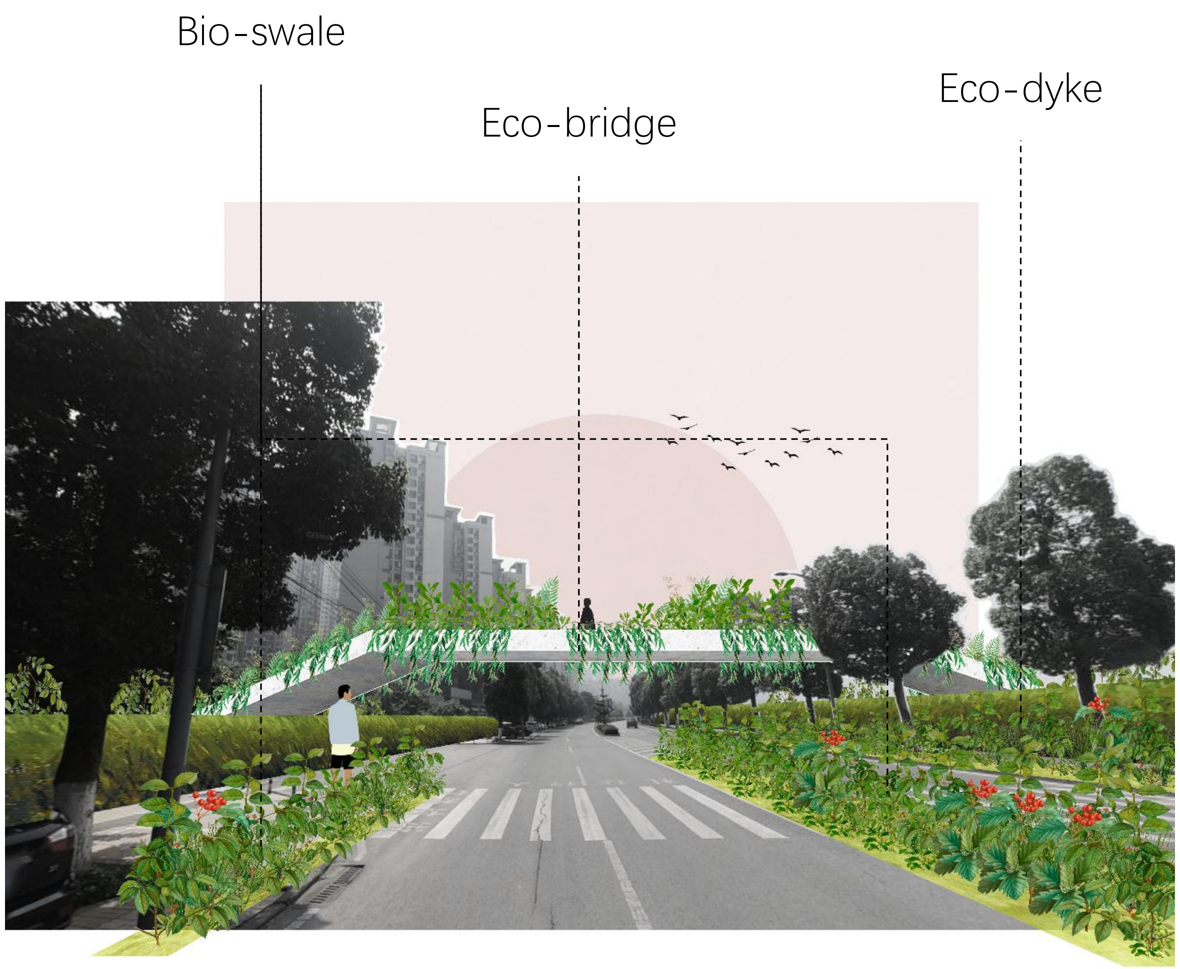
Flood occurrence situation

Low water level
(170m above sea level)

Medium water level
(175m above sea level)

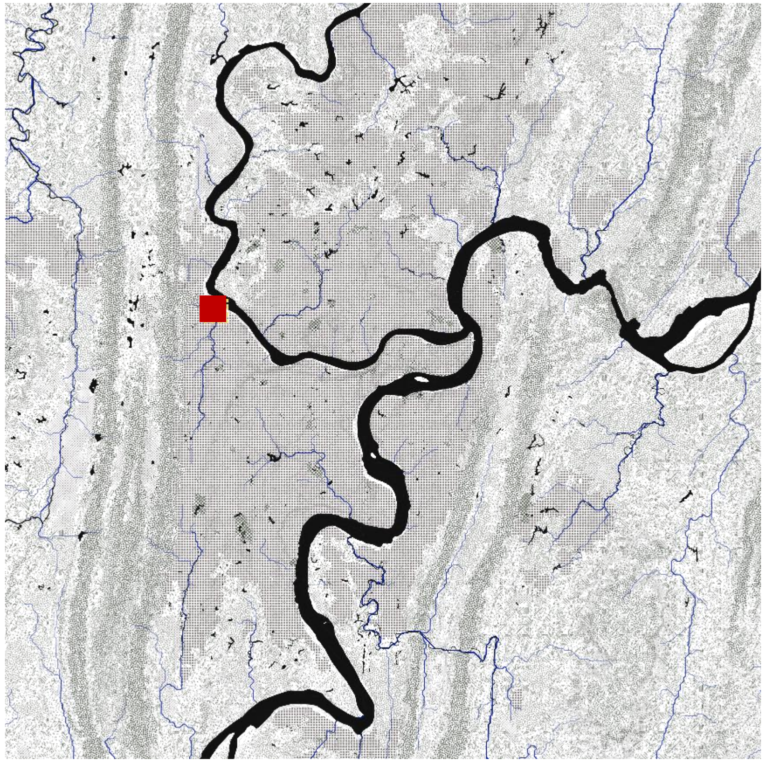
Extreme flood
(195m above sea level)

Design experiment | Case 1.

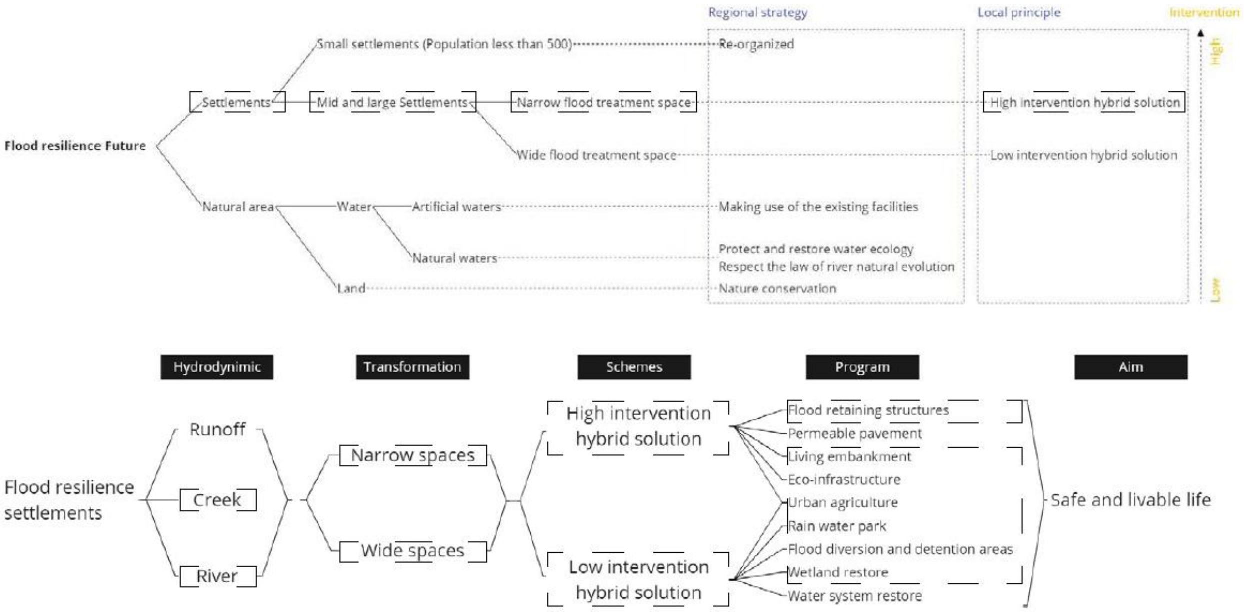


Design experiment | Case 2.

Ciqikou area

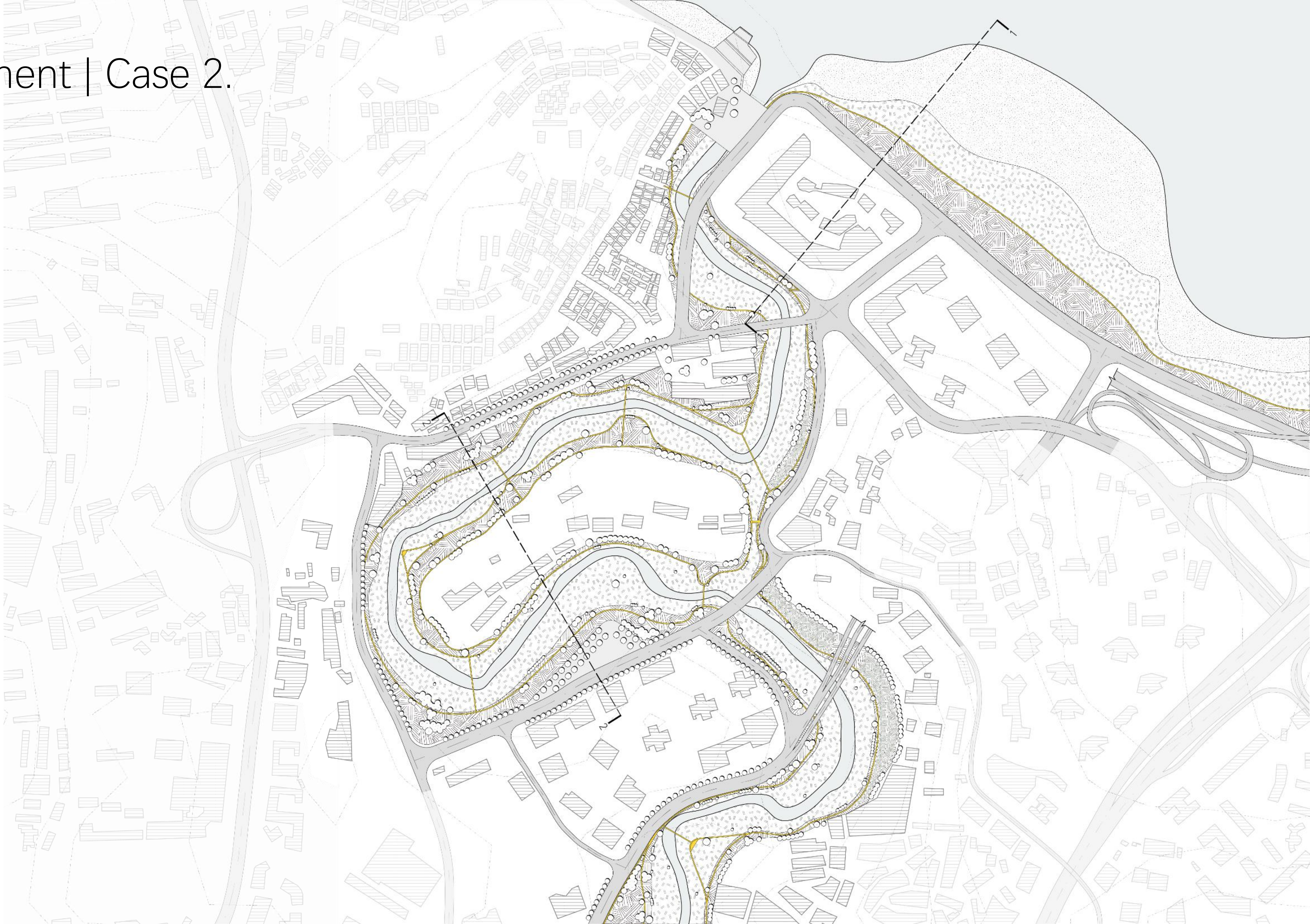


Guideline



Design experiment | Case 2.

Plan



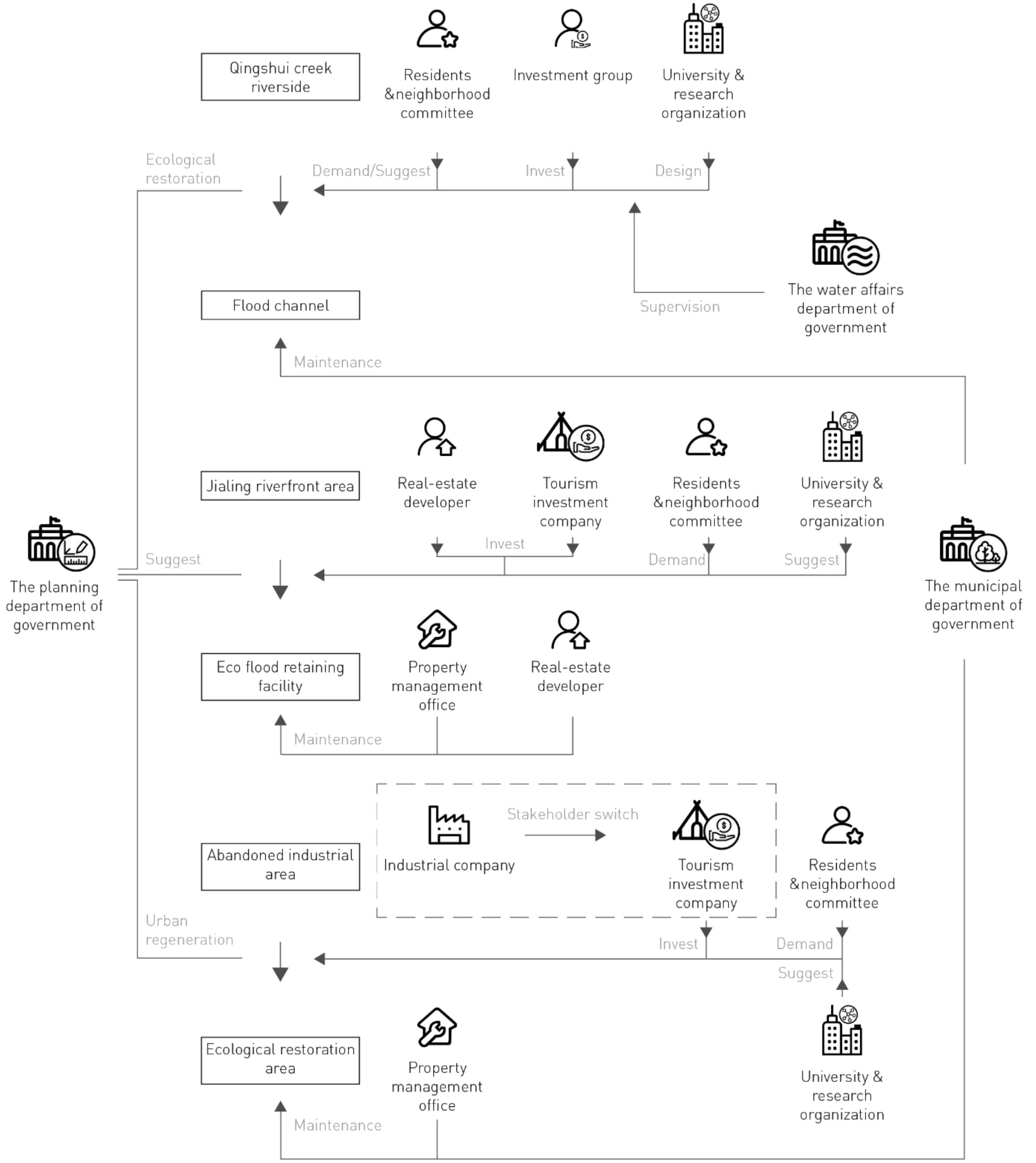
Sandy embankment
Low grass zone
High grass zone
Ecodyke&bridge
Urban farming
Rainwater park
Bioswale
Urban palaza
Pathway

0 100 200m

Design experiment | Case 2.

Land ownership change & stakeholders

Tramsformation	Land-ownership
Qingshui creek riverside	Owned by states.
↓	
Flood channel	Owned by states, rented by eco-tourism company and investment group.
Jialing riverfront area	Owned by states, rented by real estate company and tourism investment company.
↓	
Eco flood retaining facility	Owned by states, rented by real estate company and tourism investment company.
Abandoned industrial area	Owned by states, rented by the industrial company.
↓	
Ecological restoration area	Owned by states, rented by the tourism investment company.

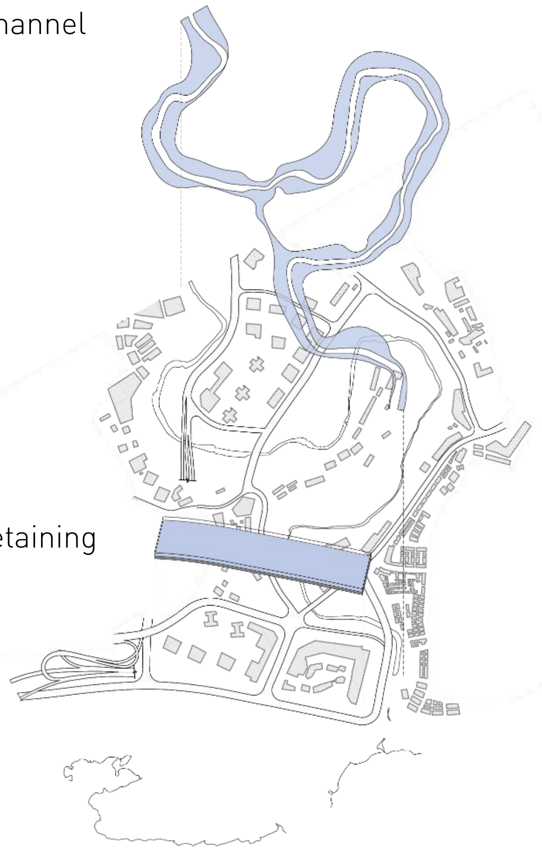


Design experiment | Case 2.

Flood occurrence situation

Flood channel

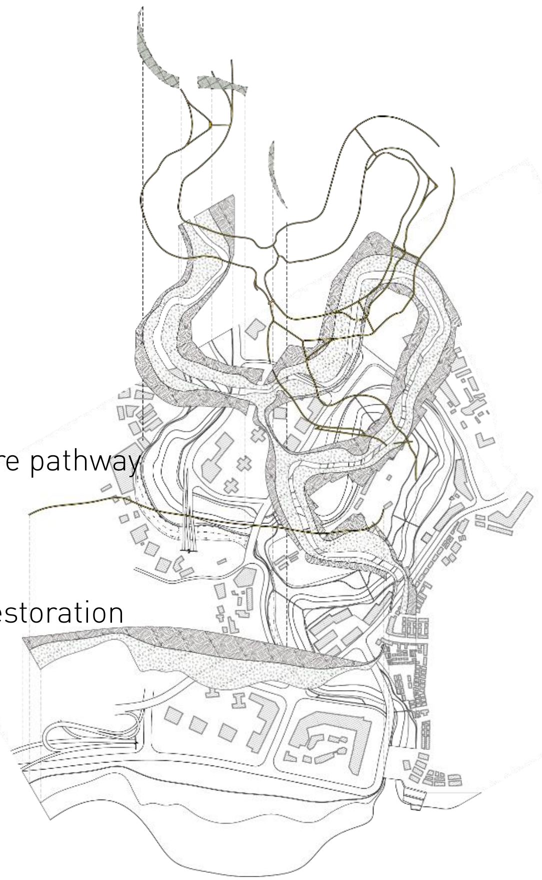
Flood retaining facility



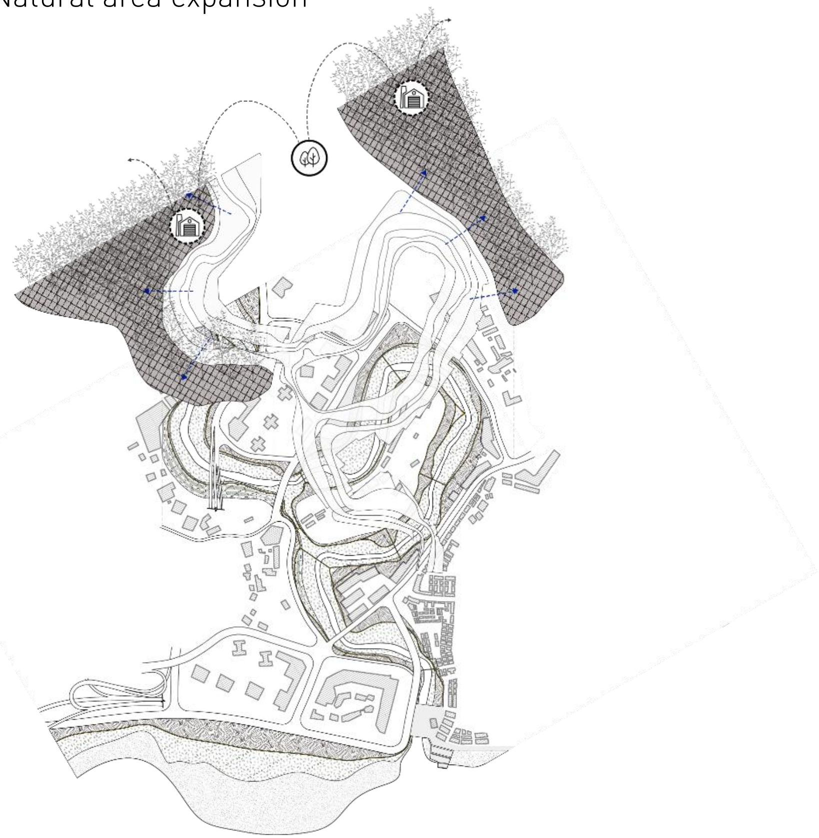
Urban agriculture

Leisure pathway

Eco restoration

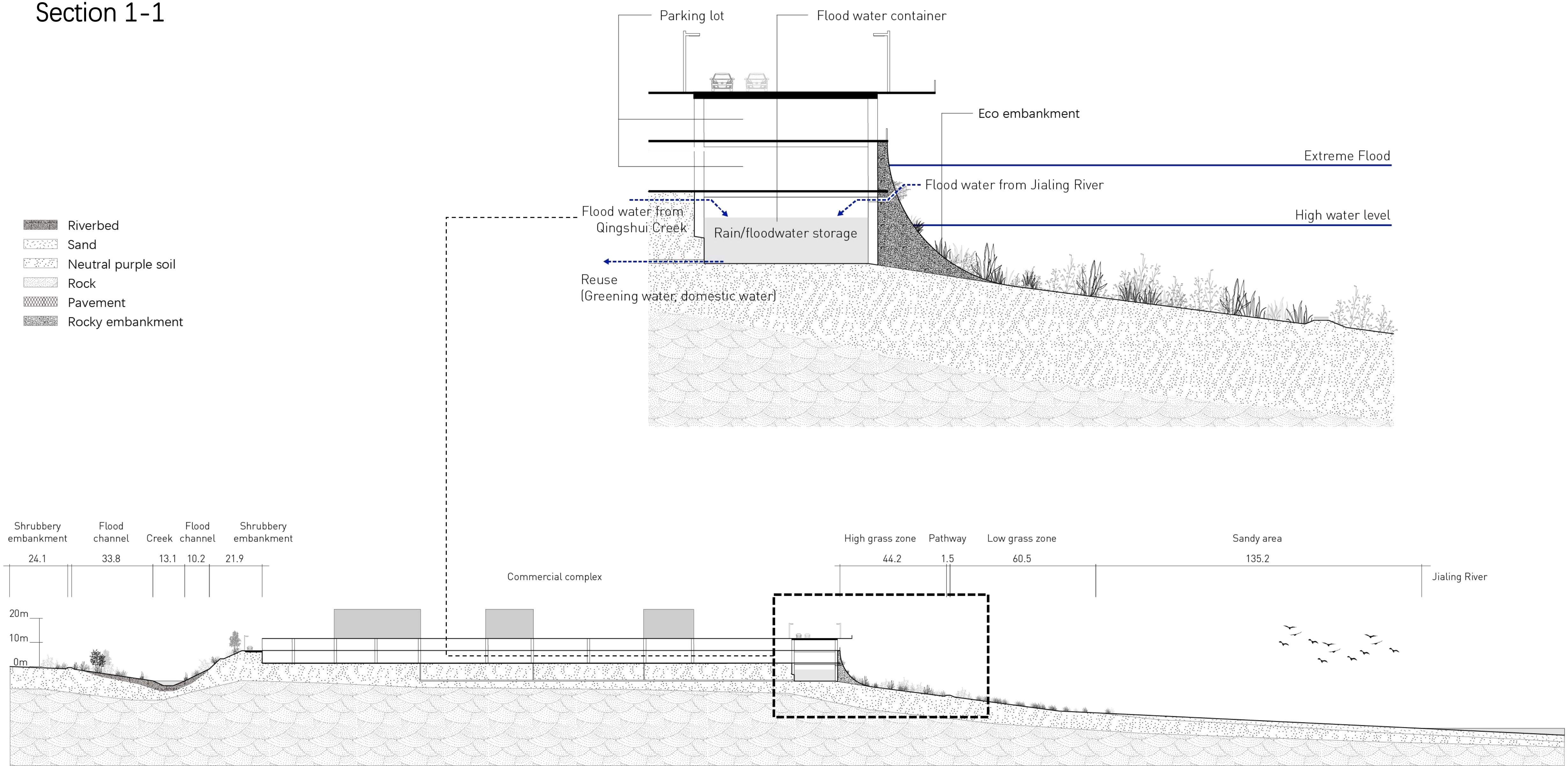


Natural area expansion



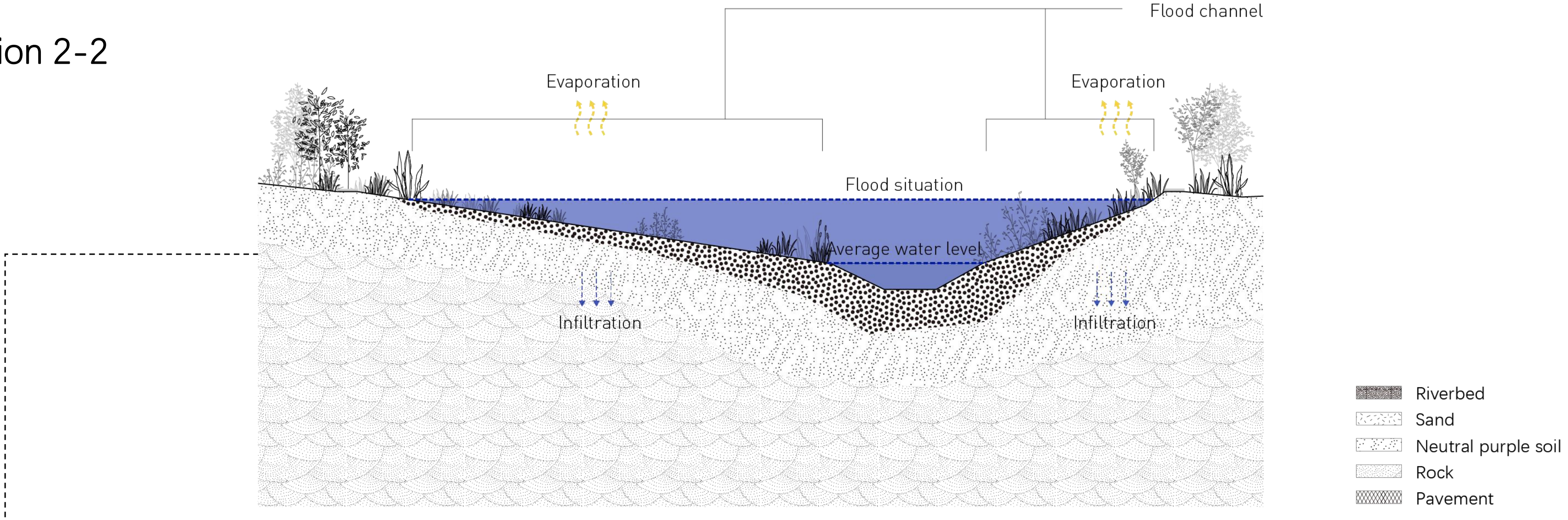
Design experiment | Case 2.

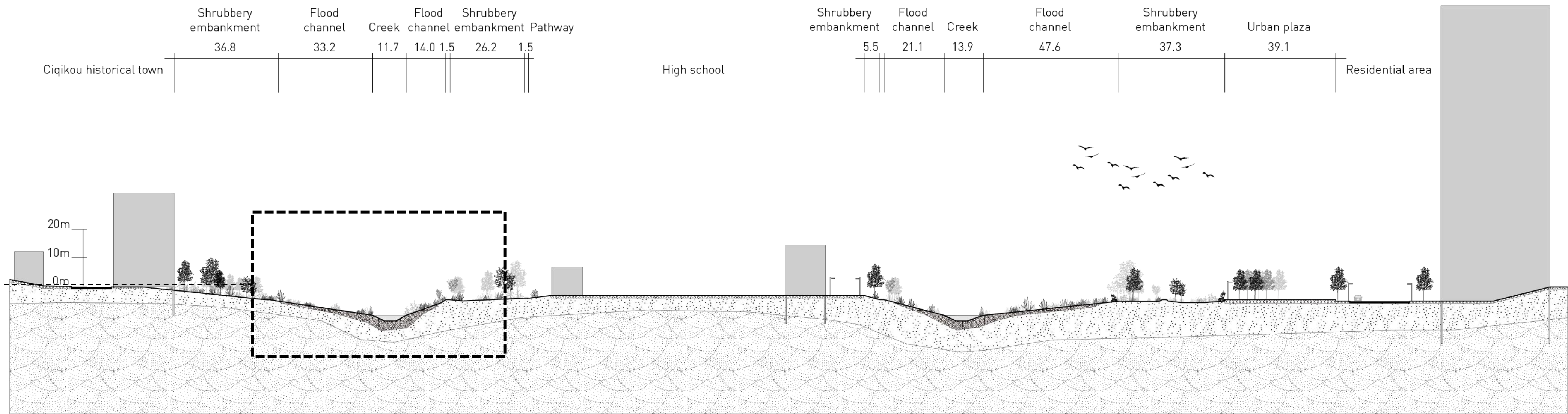
Section 1-1



Design experiment | Case 2.

Section 2-2





Design experiment | Case 2.

Flood occurrence situation

Low water level
(170m above sea level)

Medium water level
(175m above sea level)

Extreme flood
(195m above sea level)

Design experiment | Case 2.

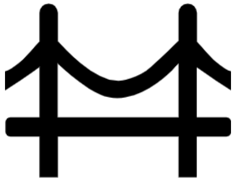
07 | Conclusion

How to shift the fragile urban riverfront, which caused by changes and actual quality into a flood resilient area by the synergy of nature system and constructed environment in Chongqing?

Main Question

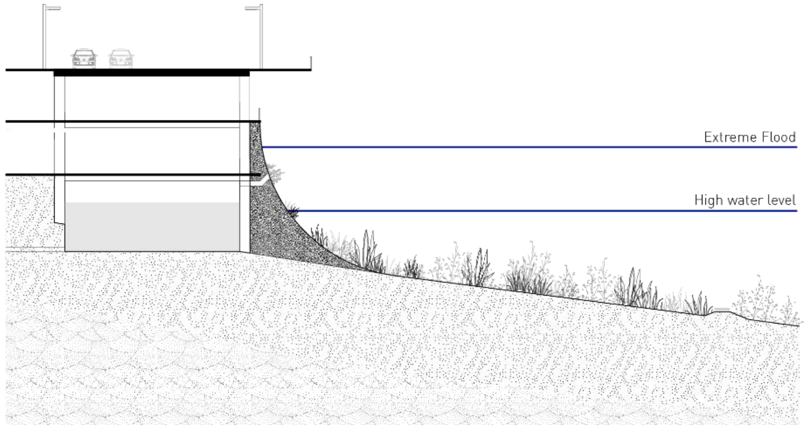
Conclusion |

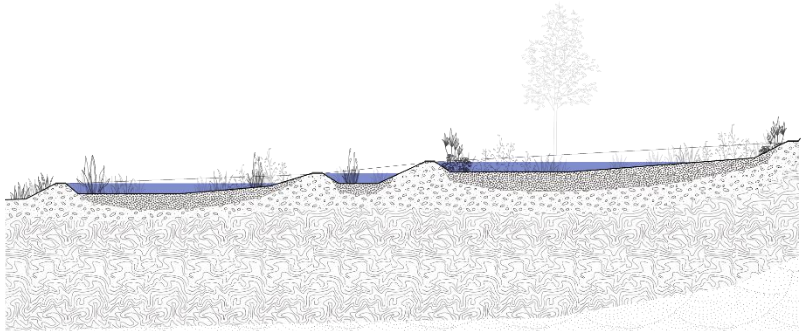
Design experiment



Opportunities of infrastructure

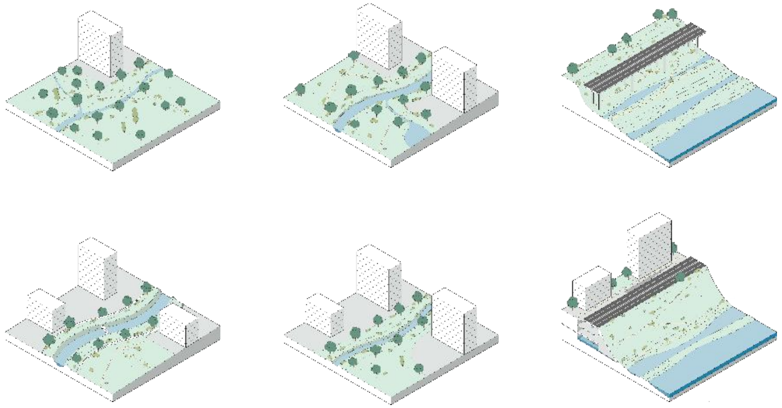
Opportunities of topography

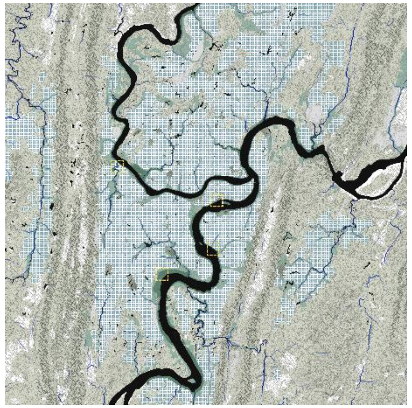


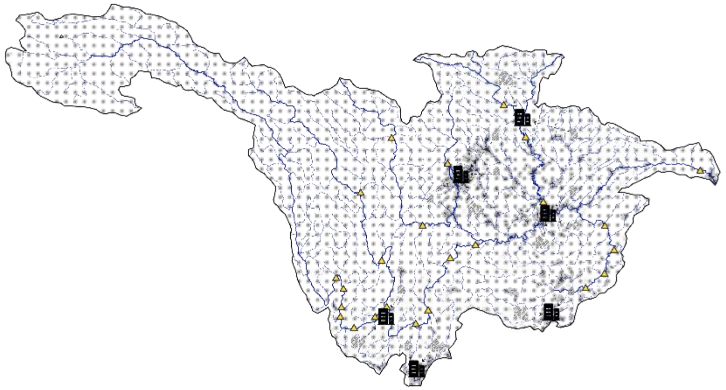


Conclusion |

Intervention principles







Short term

Long term

The most vulnerable areas	Major cities	Settlements
▼	▼	▼
All river corridor areas	All cities and towns	Whole region

Thank you :)