EcoCharge

towards a resilient design framework for water scarcity issue in Pearl River Delta

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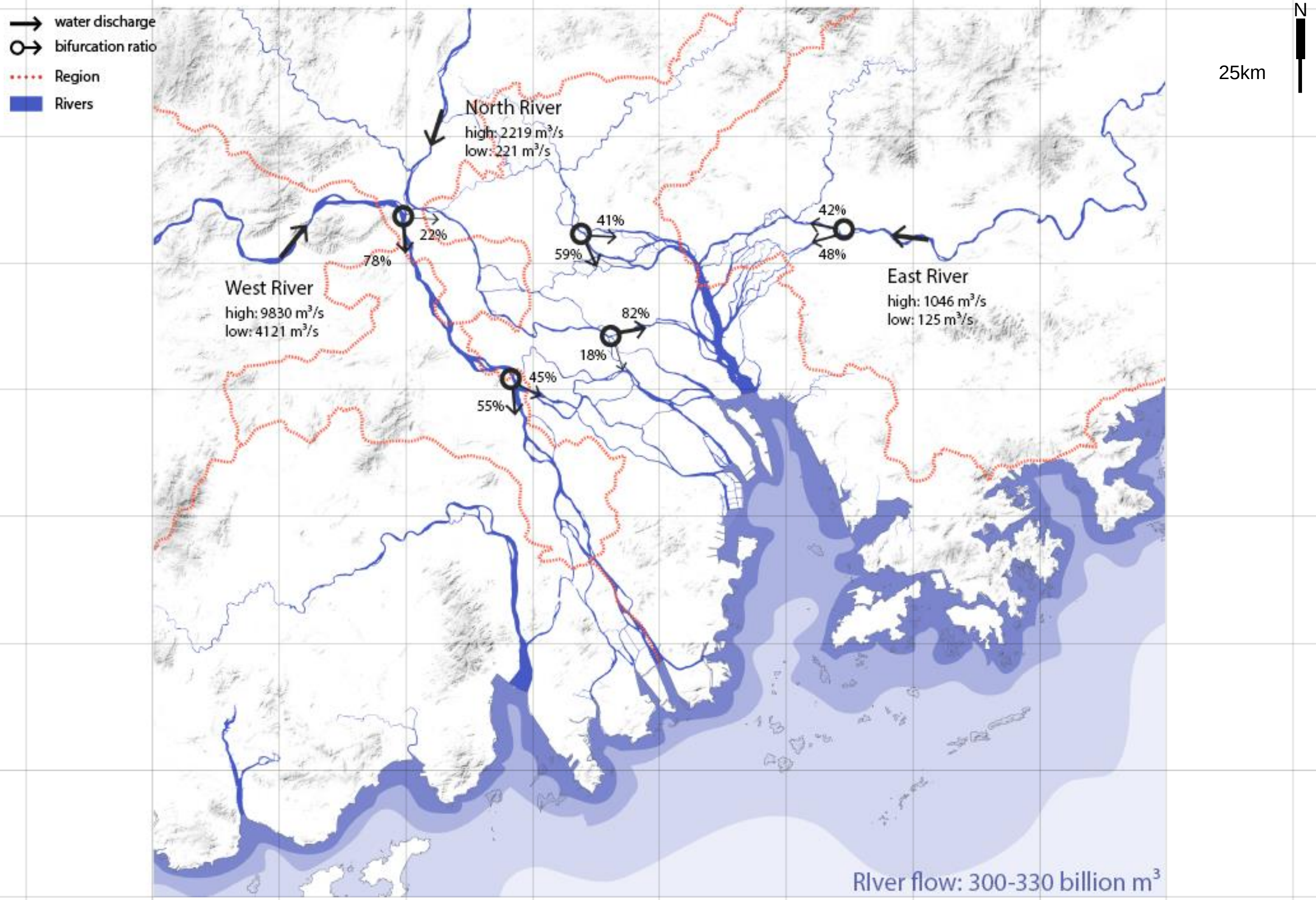
Lab: Resilient Coastal Landscape M.Sc. Landscape Architecture P4 Presentation

1.1 The Pearl River Delta Context

Precipitation: 2000mm

River flow: 300 billion m3

Hydrology Context of PRD



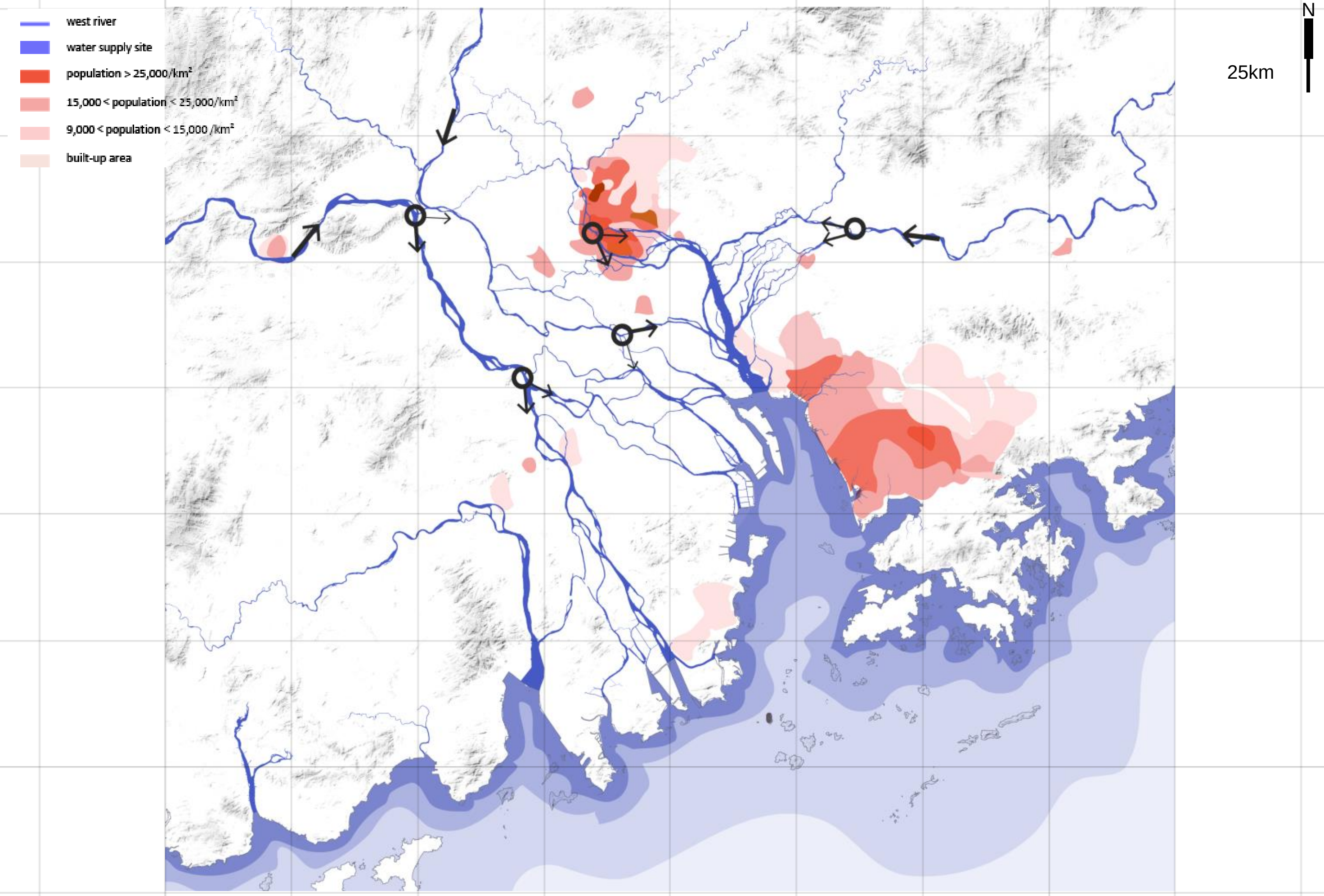
drawing: by author
source: Dai, W. (2021). Spatial Planning and Design for Resilience: The Case of Pearl River Delta.
Hydroshed.org

1.2 Freshwater resources

126.84 million people(2020)

Freshwater resource per capita

Urbanization Context of PRD



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source: Dai, W. (2021). Spatial Planning and Design for Resilience: The Case of Pearl River Delta.
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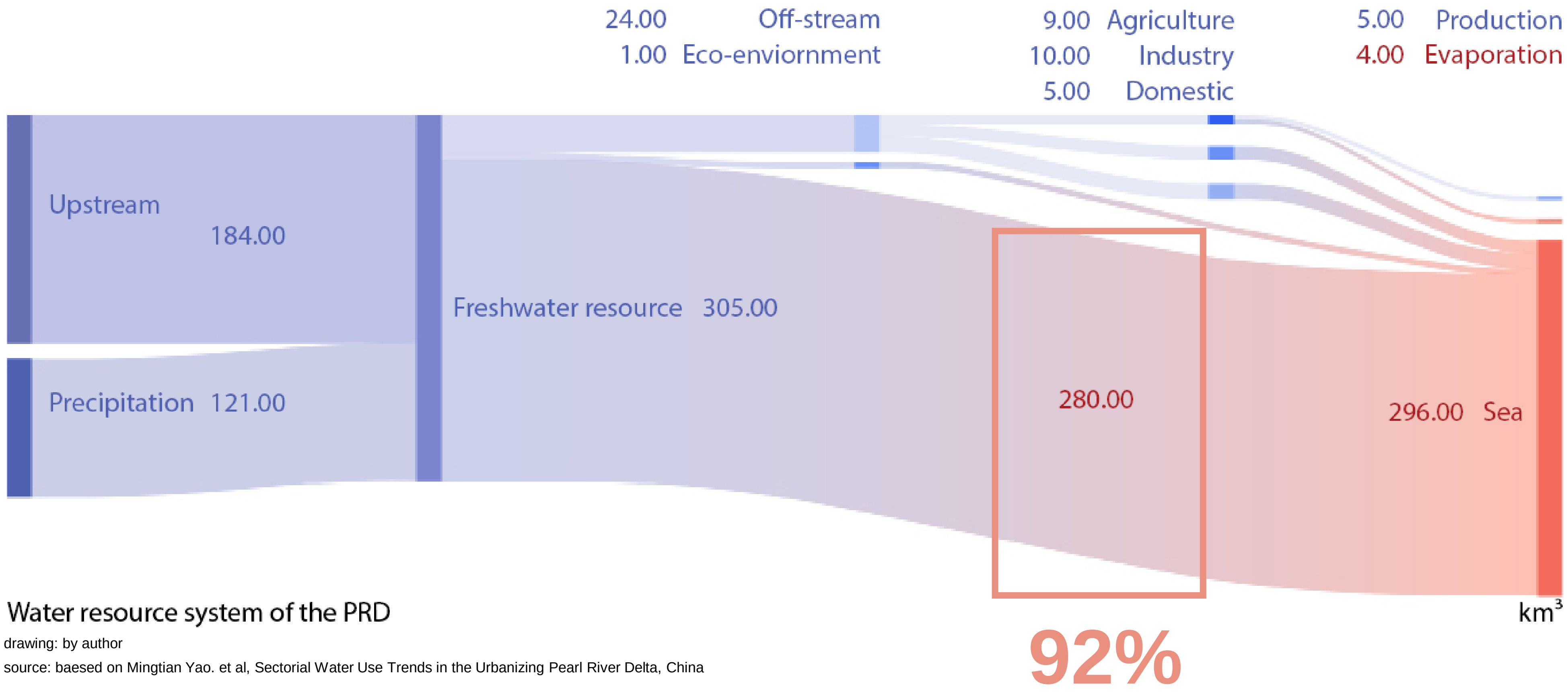
1.2 Freshwater resources

" Defense rather than optimization"



Water resource system of the PRD

drawing: by author

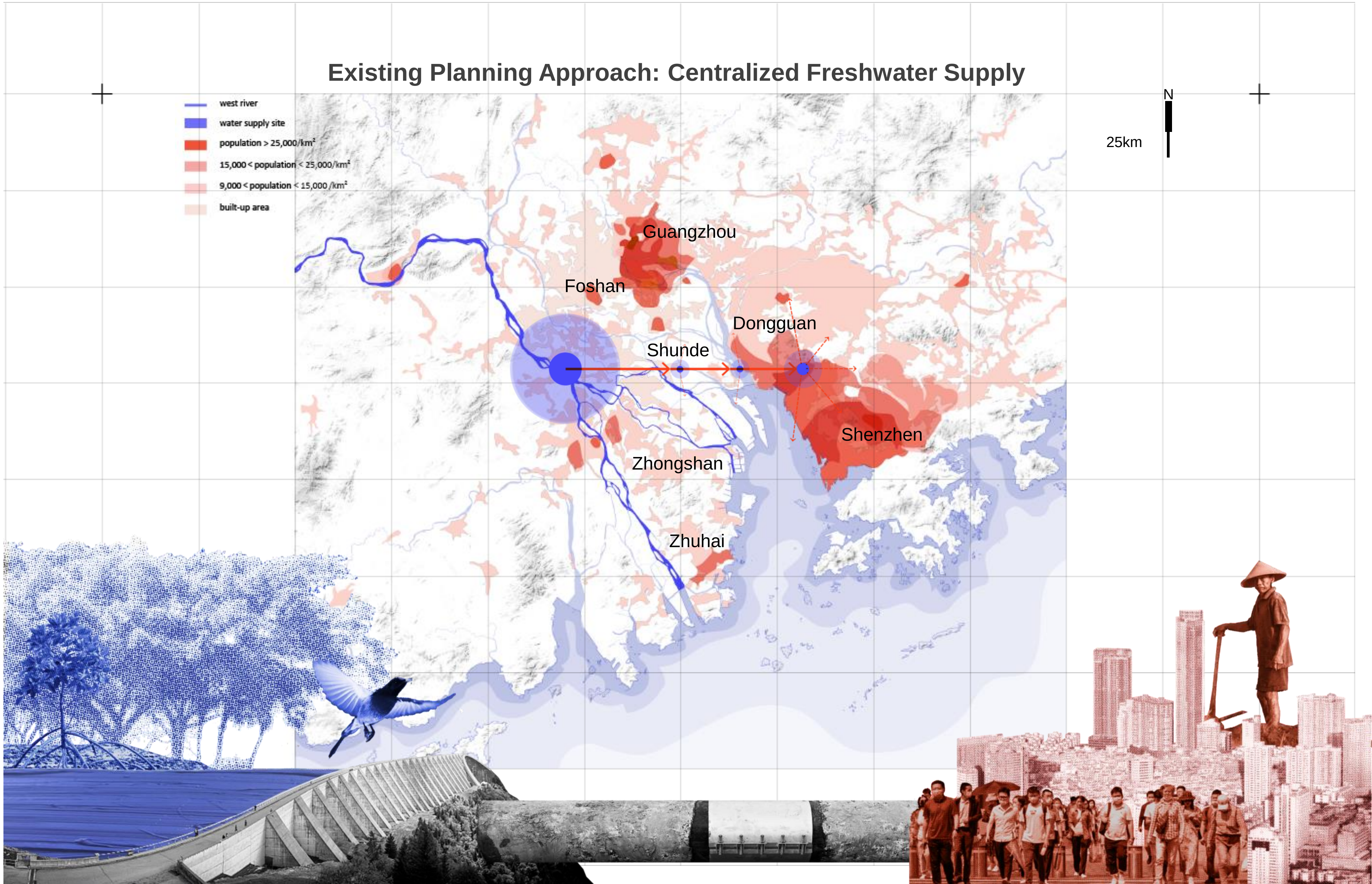
source: baesed on Mingtian Yao. et al, Sectorial Water Use Trends in the Urbanizing Pearl River Delta, China

1.3 Fascination

The water supply accounts for only
2% of the total rainfall

But result permanent acquisition of
1733.33 ha of land

supply magnitude comparison



1.3 Fascination

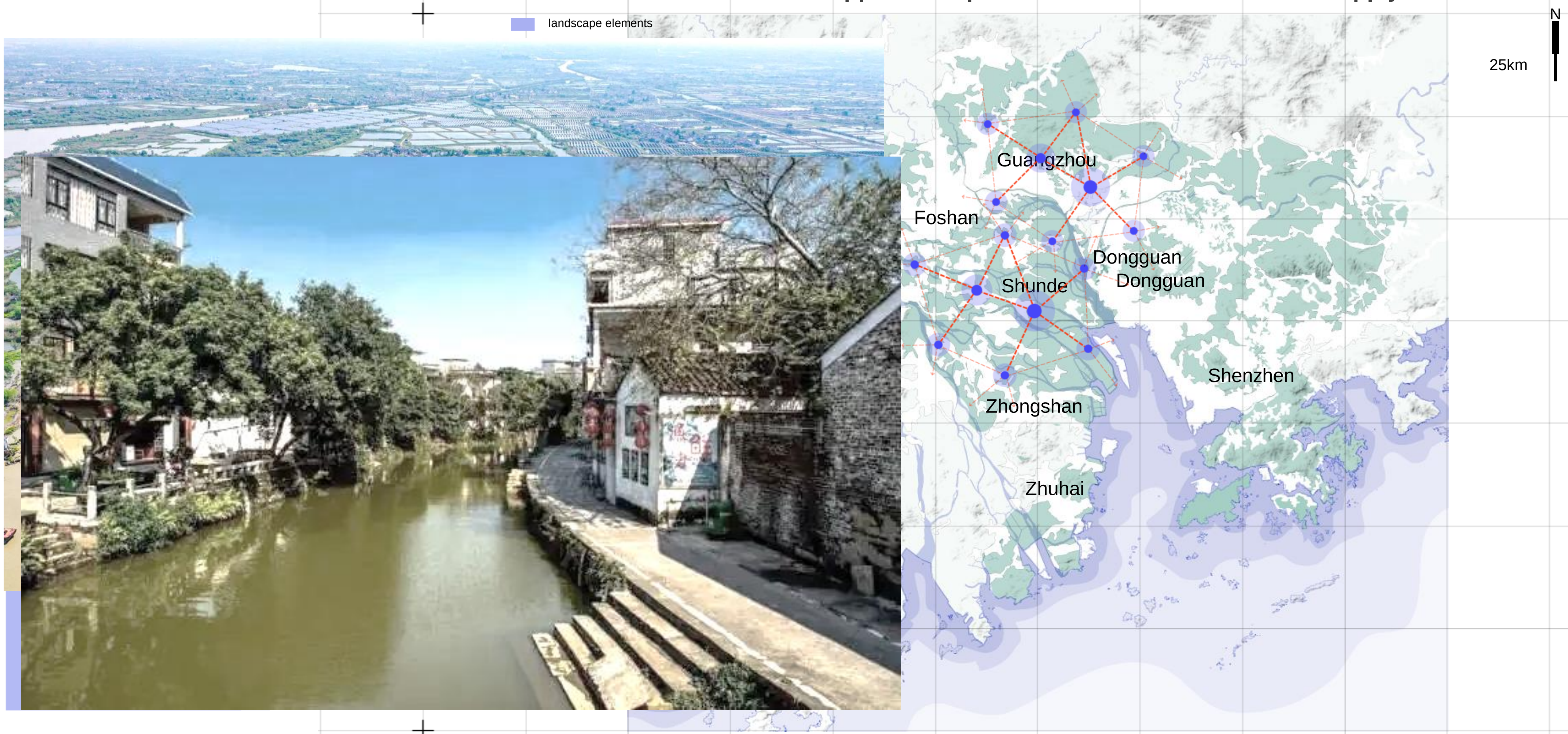
How much of the landscape's potential can be developed to utilize rainfall?

An Alternative Approach: Spatial Decentralized Freshwater Supply

drawing: by author

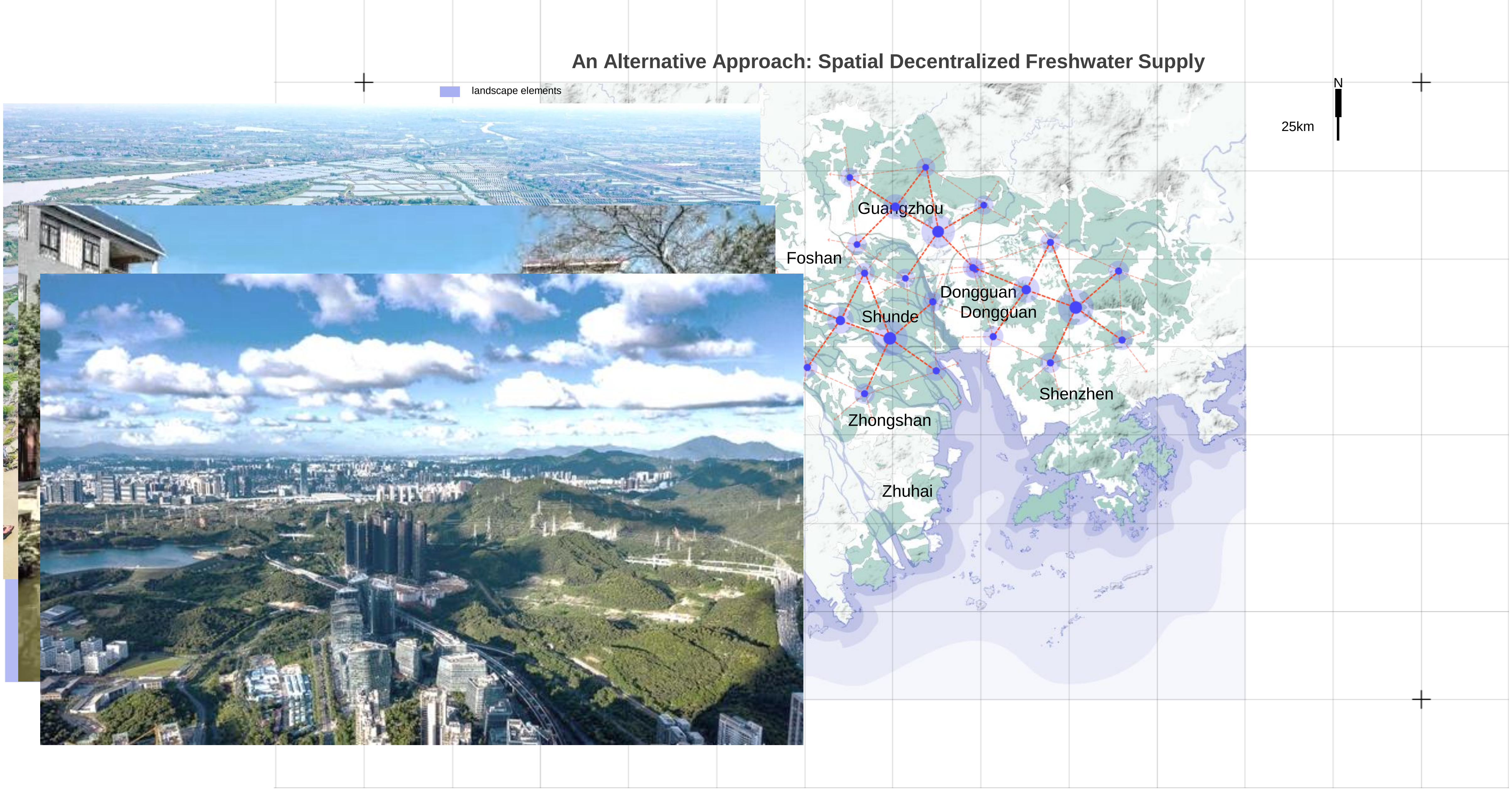
1.3 Fascination

An Alternative Approach: Spatial Decentralized Freshwater Supply

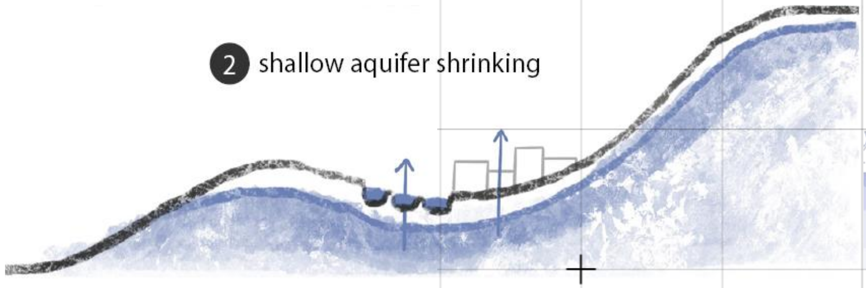


drawing: by author

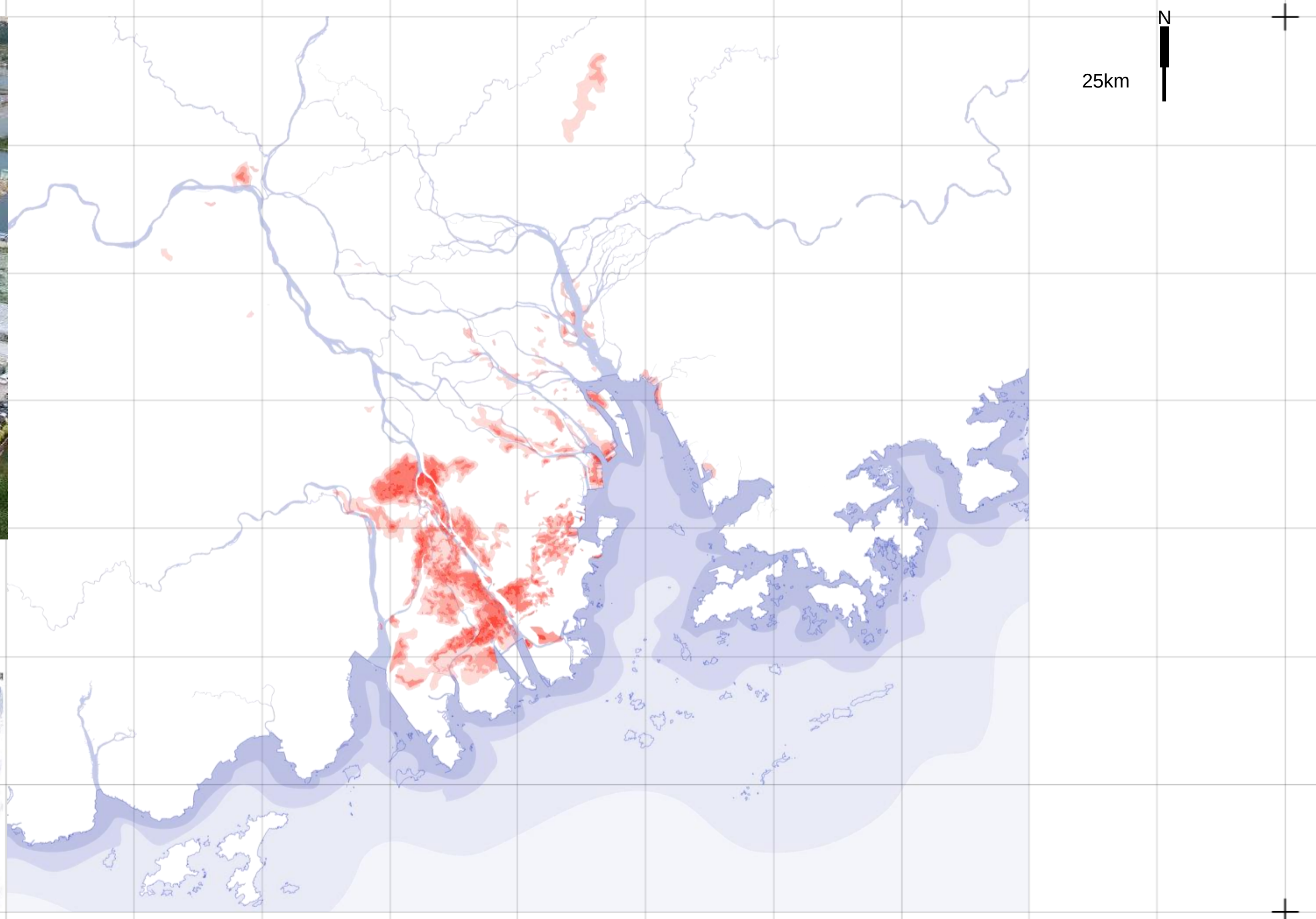
1.3 Fascination



2.1 Urban expansion as an accelerator of change in 21C



Risk Assessment: soil subsidence risk area



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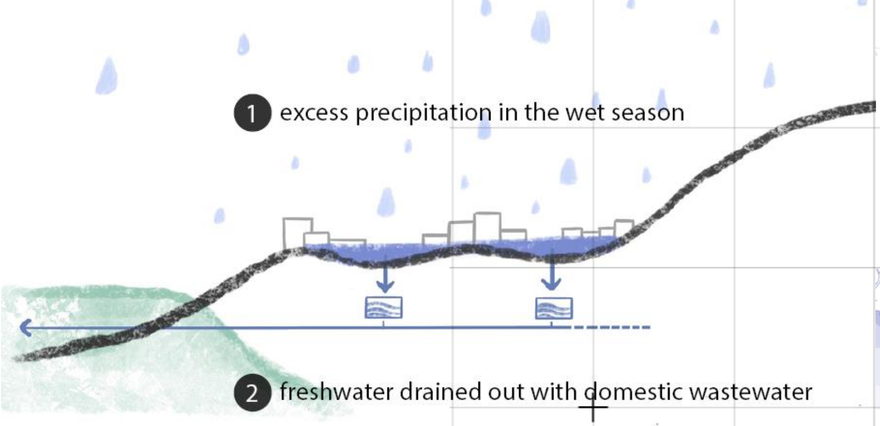
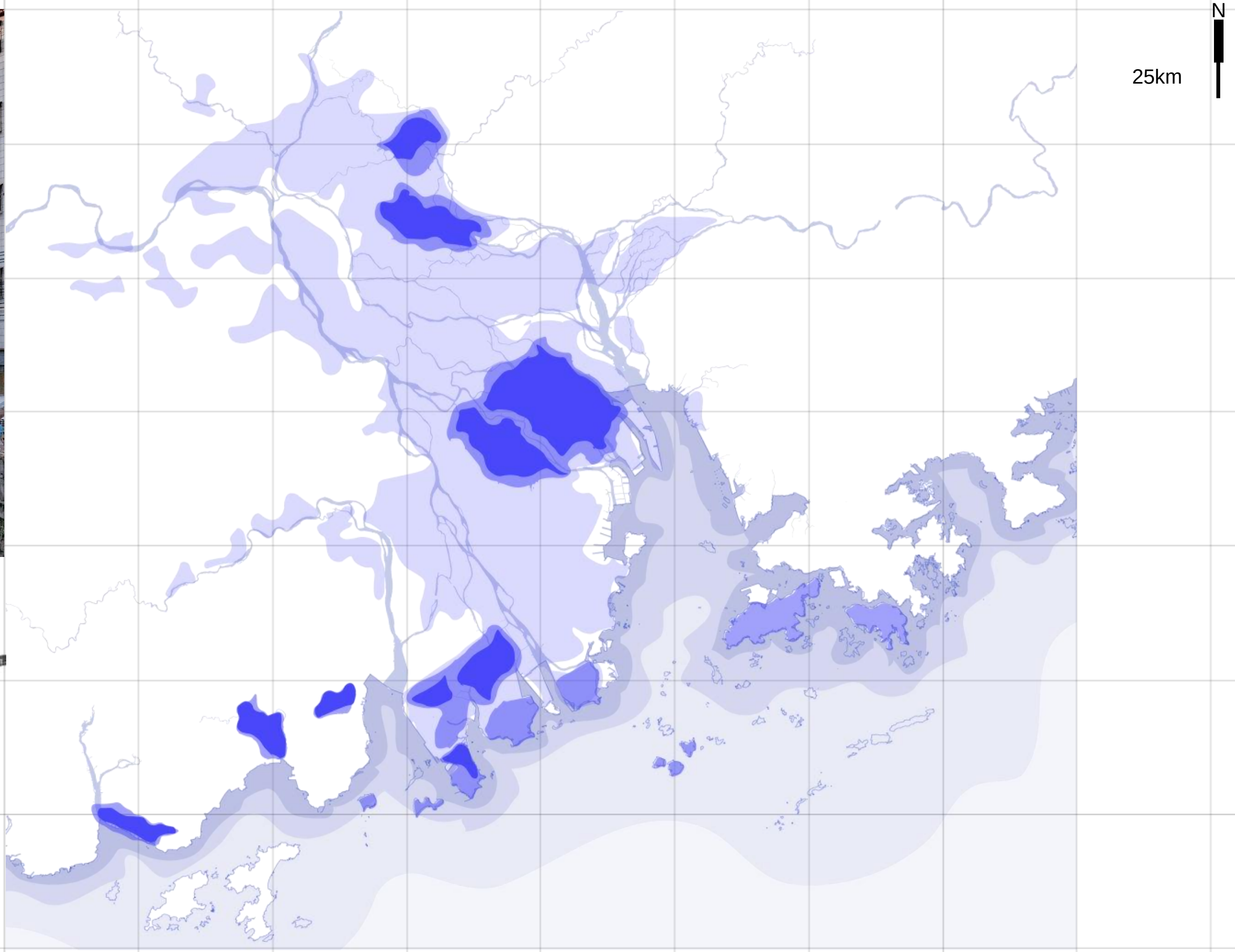
Hydroshed.org

2.2 Climate change as an accelerator of change in 21C



Risk Assessment: Flooding risk area



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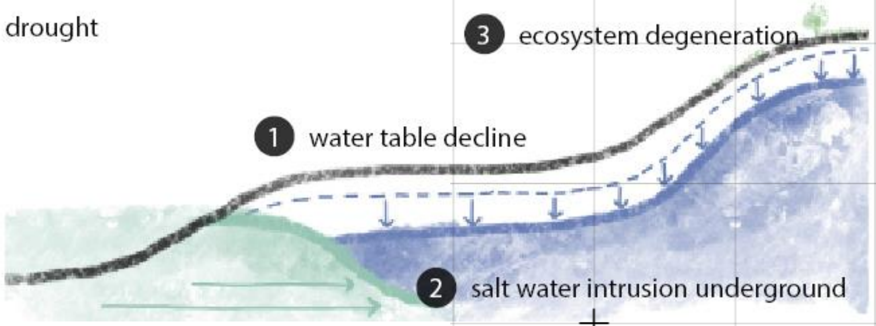
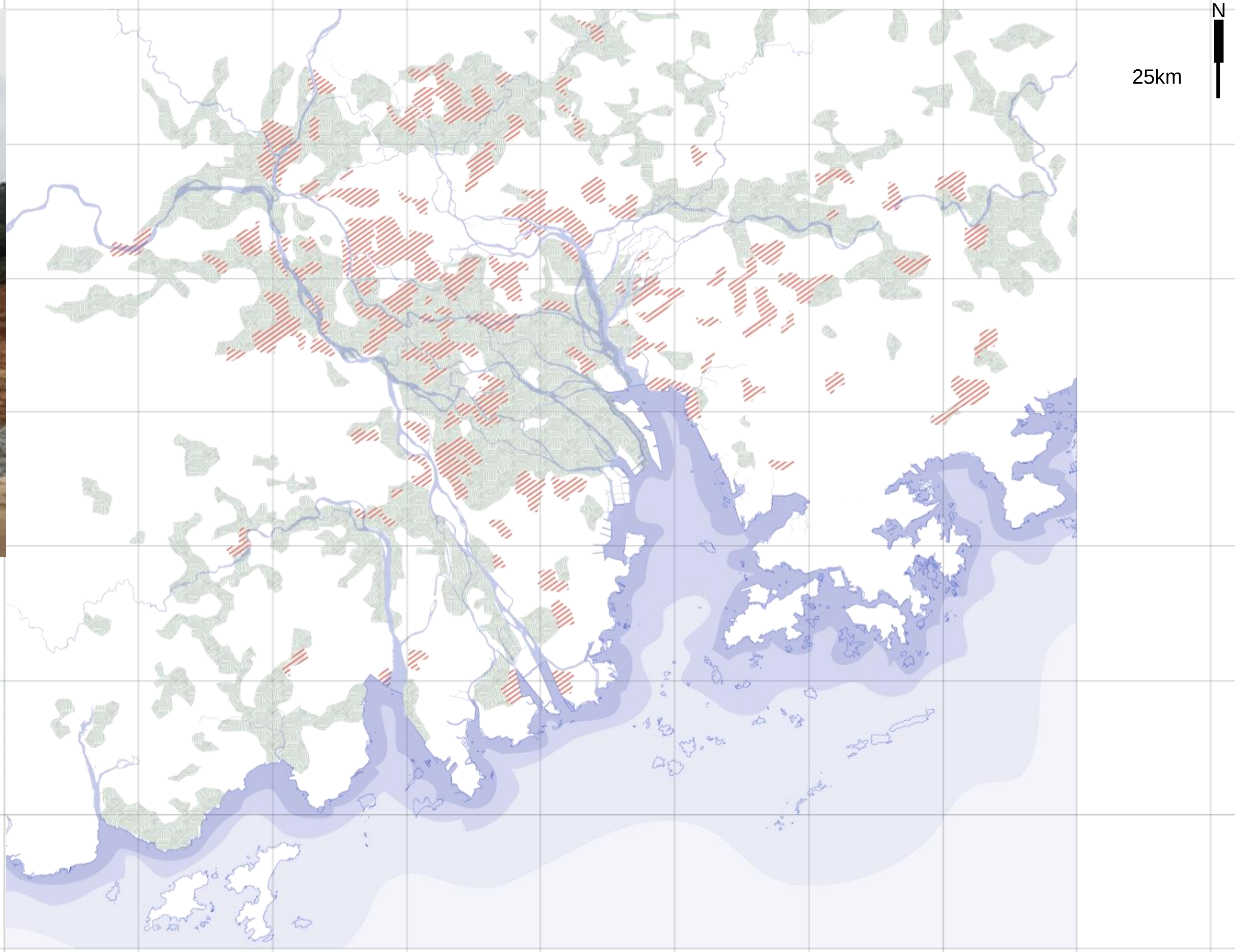


Risk Assessment: Ecology degradation



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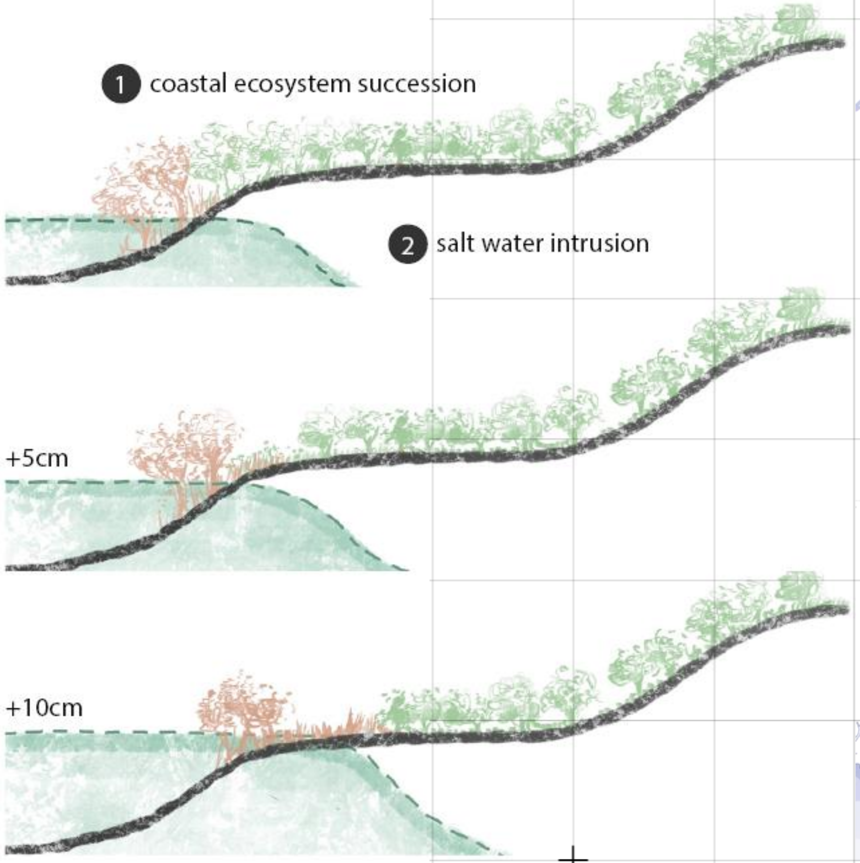
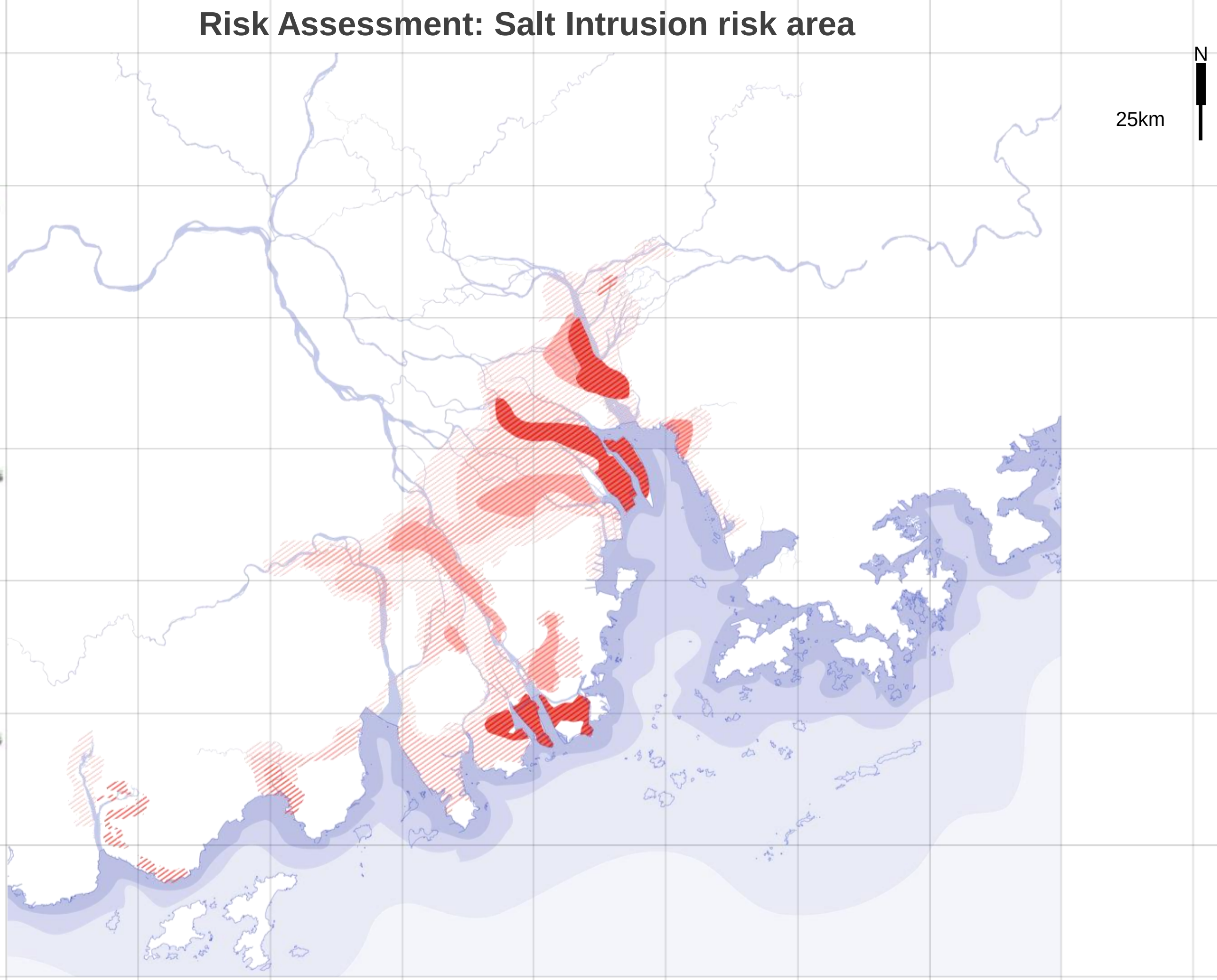


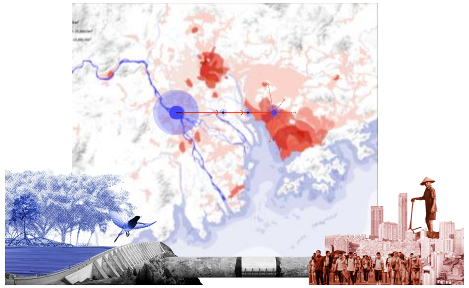


drawing: by author
source: Dai, W. (2021). Spatial Planning and Design for Resilience: The Case of Pearl River Delta.
Hydroshed.org

2.3 Problem Statement

-The infrastructures function in single-goal-oriented way

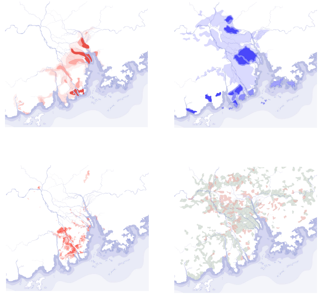
The government's proposed centralized freshwater supply system may not be sustainable for managing freshwater in the region, as it fails to tap into the potential of the local hydrological system. The landscape of the Pearl River Delta holds enormous potential for freshwater infiltration, retention, storage, and recharge. Natural systems such as mountain forests, traditional water systems, and the coastal mangrove ecosystem can be harnessed to create sustainable solutions for freshwater management. Utilizing these systems can help avoid damaging the water source area's ecosystem and promote a more efficient and effective approach to managing freshwater in the region.



Resilient thinking

-The potential of the landscape is ignored

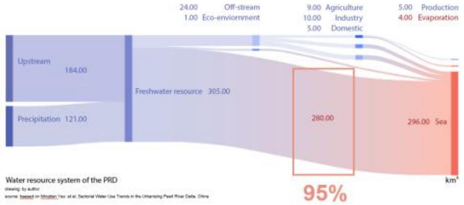
The Pearl River Delta, located in Southern China with a subtropical climate, is currently facing a severe water scarcity issue due to the combined effects of climate change and urbanization. As the hydrological cycle is being impacted by climate change, it has led to uneven distribution and limited availability of freshwater. The rise in temperatures has caused extended drought periods, and the extraction of groundwater has resulted in its depletion. Additionally, during the wet season, an increase in storm events exacerbates the uneven distribution of freshwater, leading to a loss of precipitation resources.



Landscape as a system

-The existing water flow does not operate in the holistic system

A lack of understanding about the holistic hydrological system has led to insufficient implementation of landscape-based design principles for freshwater conservation and recharge. Freshwater conservation and recharge processes are dynamic and relate to various physical spaces, ranging from the atmosphere and ground surface land types to soil types and the hydro-geological aquifer layer. By reassessing landscape types based on the hydrological cycle, the freshwater supply landscape infrastructure can be an integral design approach, where objectives and means converge to promote a more sustainable and efficient approach to freshwater management.



2.4 Research Objective

"

to identify and explore landscape-based design principles and resilient design framework for water scarcity issues in the Pearl River Delta

"

Understanding

How to understand the landscape contexts in the PRD from the perspective of landscape as a system and what lessons could be learned to respond to the upcoming challenges related to the freshwater conservation and recharge issue?

- Context analysis
- Problem identity
- The role of the landscape

Potentials

What are the potentials of the landscape as a system to develop a resilient landscape framework and What does resilience mean for freshwater conservation and recharge issues in the PRD?

- Geo-hydrology
- Topsoil
- Landscape Type

Application

What landscape-based principles be applied in different landscape contexts (including mountains, and flood plains) to optimize the potential for freshwater conservation and recharge, and How to generate principles in different landscape scales of the 3 contexts?

- Design strategies
- Regional strategy
- Spatial Principles

Lessons learned

What lessons could be learned in this project to foster a resilient landscape system on different scales?

- Conclusion
- Reflection

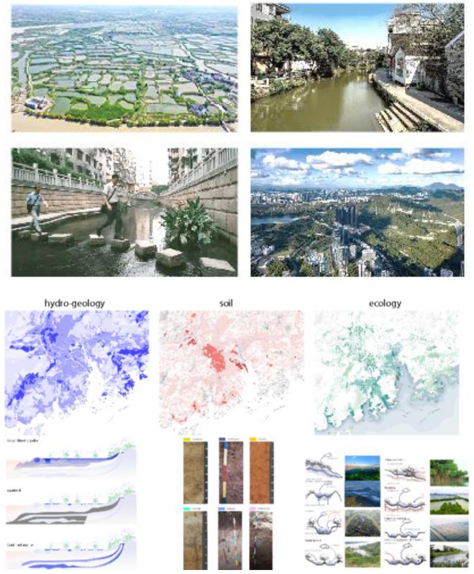
Theory & Methodology

How to understand the landscape context from the perspective of landscape as a system?

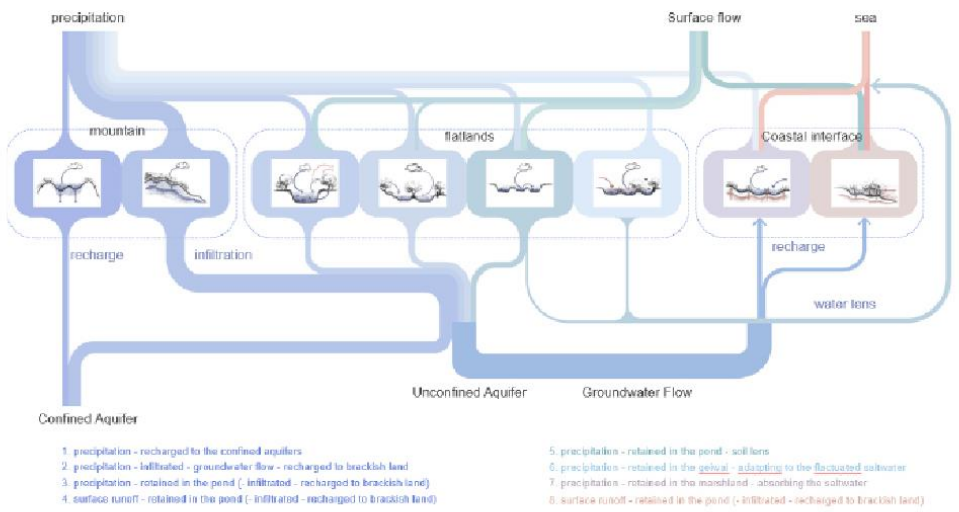
Landscape as a System

Systematic thinking

Layering analysis

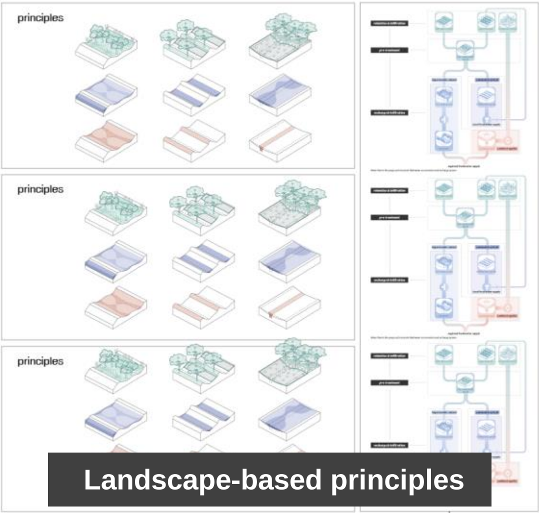


The potential of landscape



Resilient Design Framework for Freshwater Conservation and Recharge

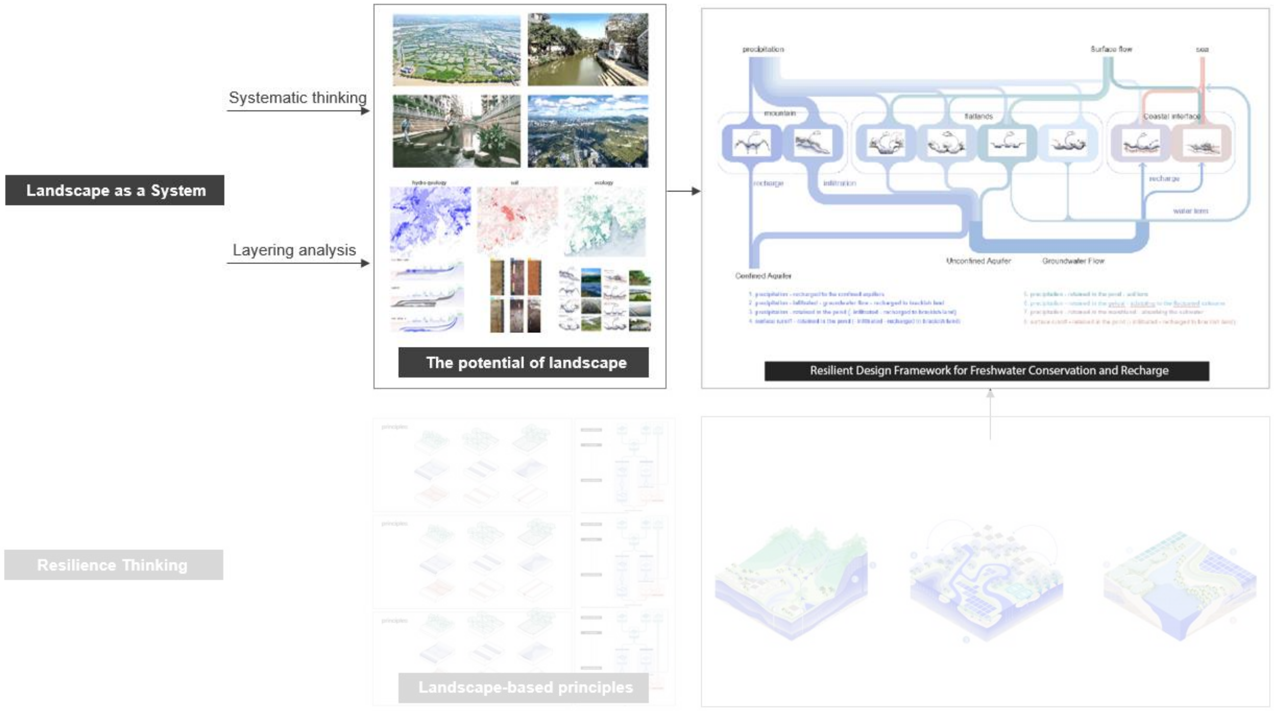
Resilience Thinking



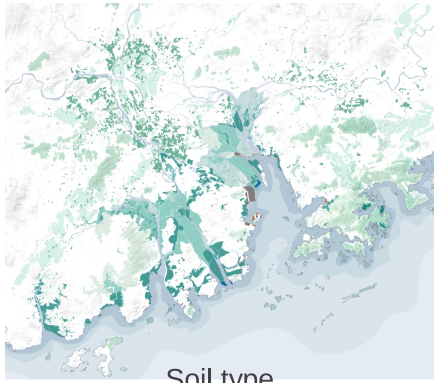
Landscape-based principles

Analysis & Understanding

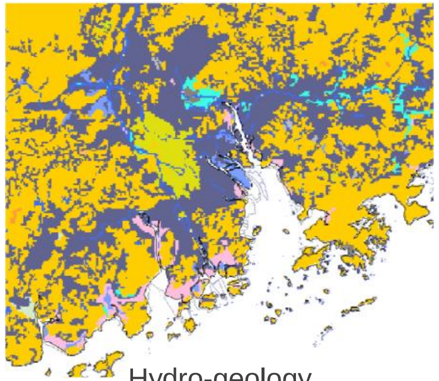
What are the **potentials** of the landscape as a system to develop a resilient landscape framework?



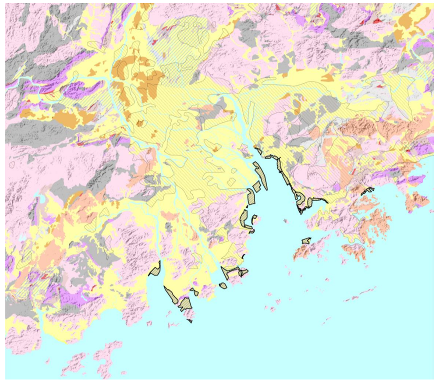
Landscape type

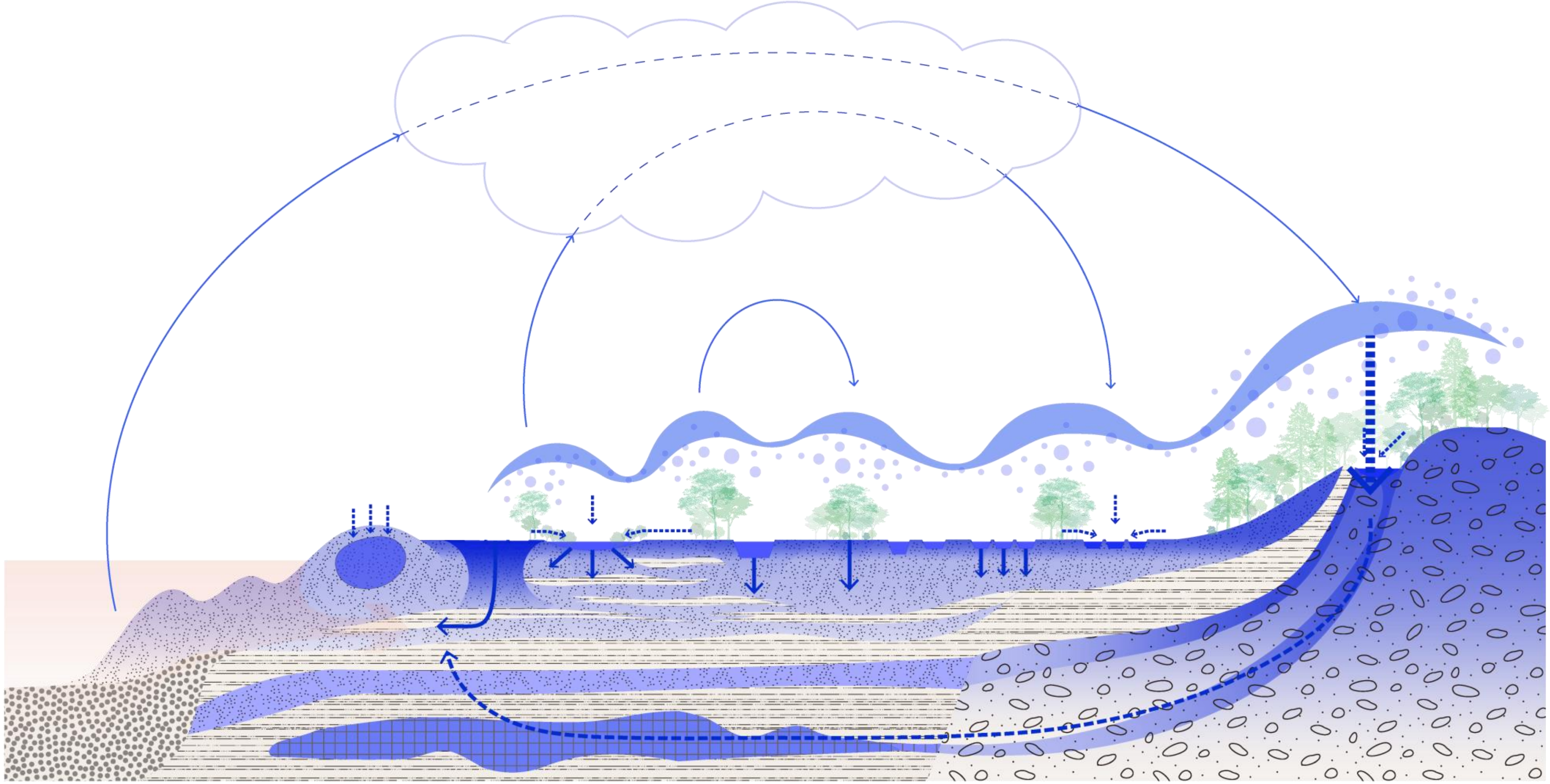


Soil type



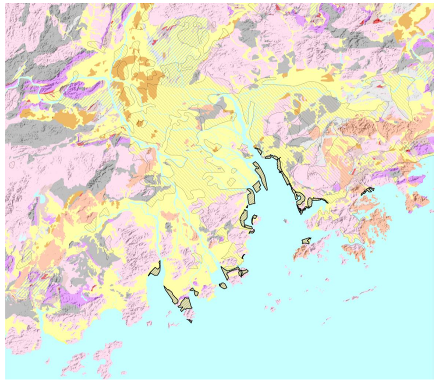
Hydro-geology

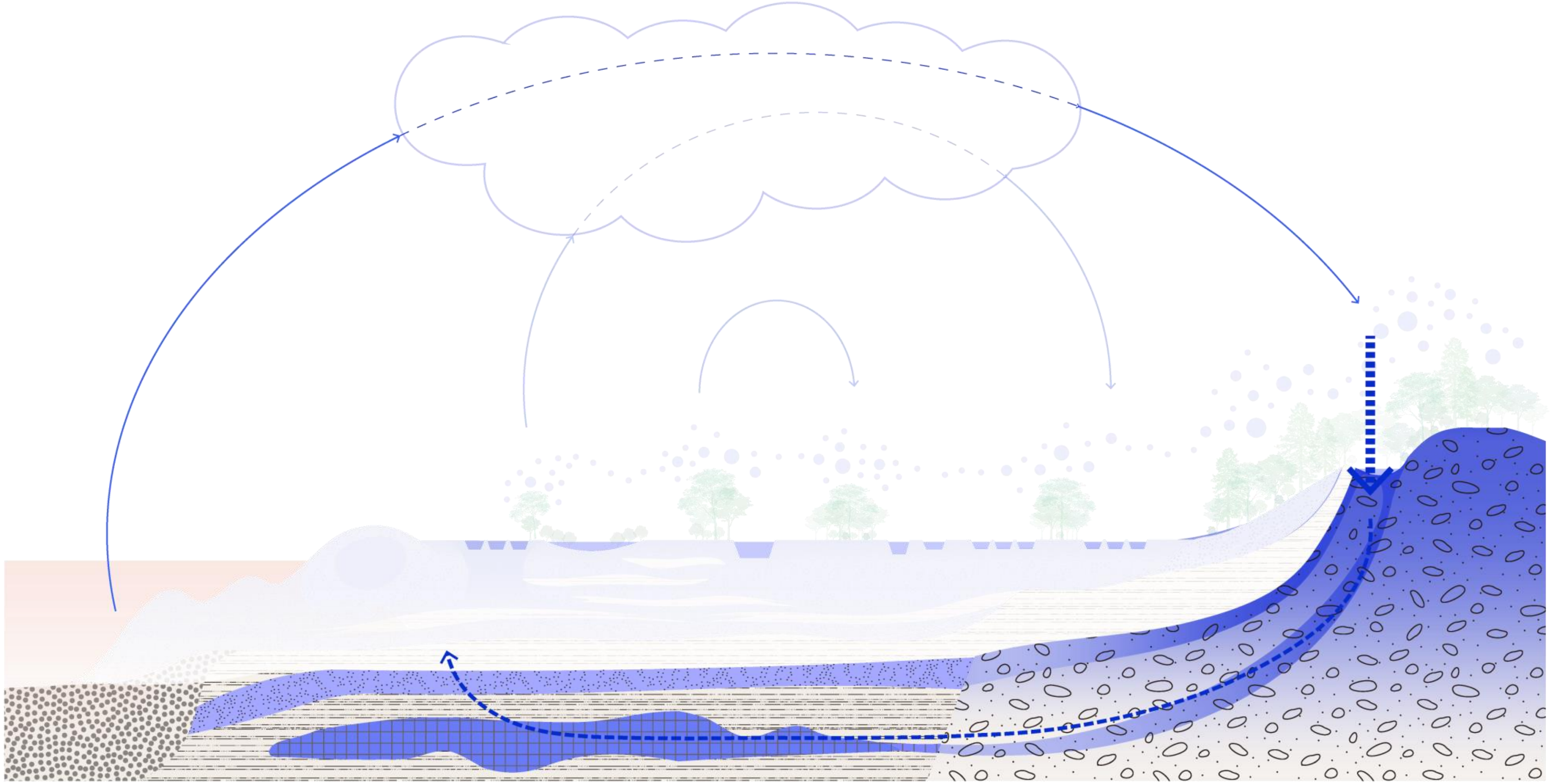




“Aquifers as Long-term Water Stocks for Sustainable Freshwater Supply”

Hydro-geology

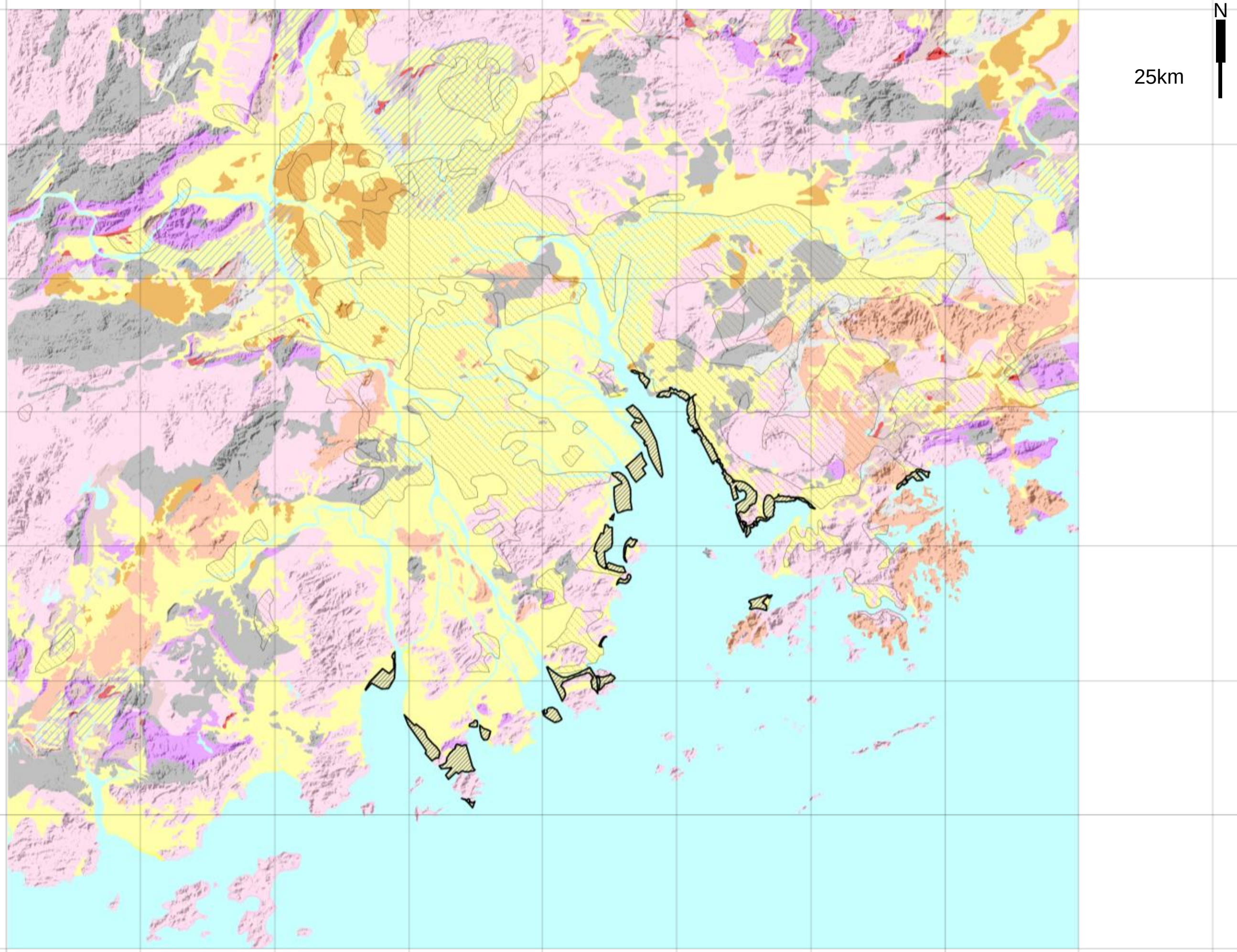




4.1 Hydro-geology

Hydrogeological Unit	Hydraulic conductivity [m/s] (10^{-9} 10^{-7} 10^{-5} 10^{-3})	Type	Class
Quaternary clastic unit	1	Porous	Regional Aquifer
Mesozoic to Tertiary reworked tuff alluvial unit	2	Porous Fractured	Regional Aquifer
Upper Mesozoic volcanic unit	3	Fractured	Regional Aquifer
Upper Mesozoic intrusion unit	4	Fractured	Local Aquifer
Mesozoic terrigenous unit	5	Fractured	Aquitard
Paleozoic terrigenous unit	6	Fractured	Aquitard
Paleozoic carbonate unit	7	Fractured Karst	Regional Aquifer
Paleozoic terrigenous clastic unit	8	Fractured	Aquitard
Basement unit	9	Fractured	Aquitard

Hydrogeology map of PRD



source: Taylor & Francis. et al, Hydrogeology of the Pearl River Delta, southern China.

4.1 Geo-hydrology

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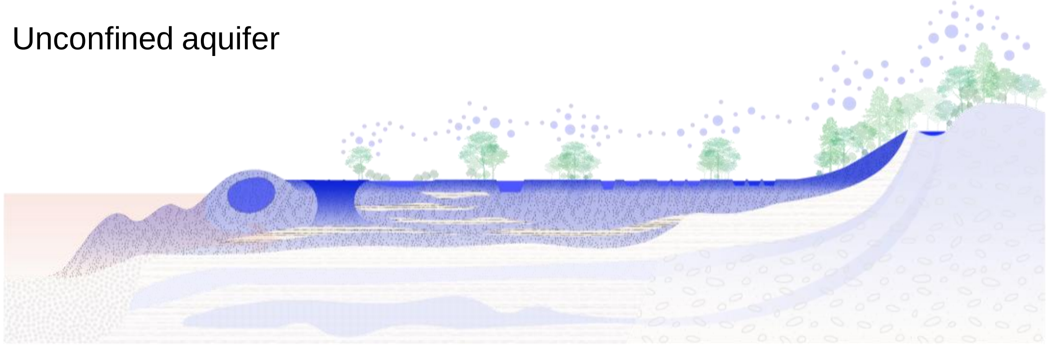
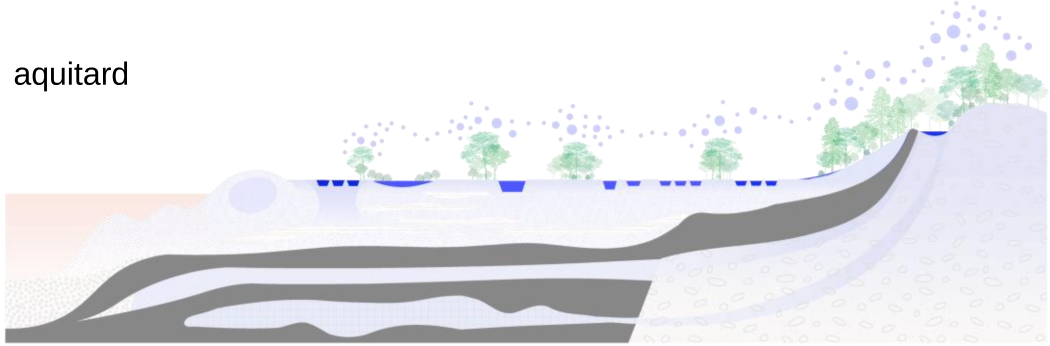
Paleozoic carbonate unit	7	Fractured Karst	Regional Aquifer
Paleozoic terrigenous clastic unit	8	Fractured	Aquitard
Basement unit	9	Fractured	Aquitard

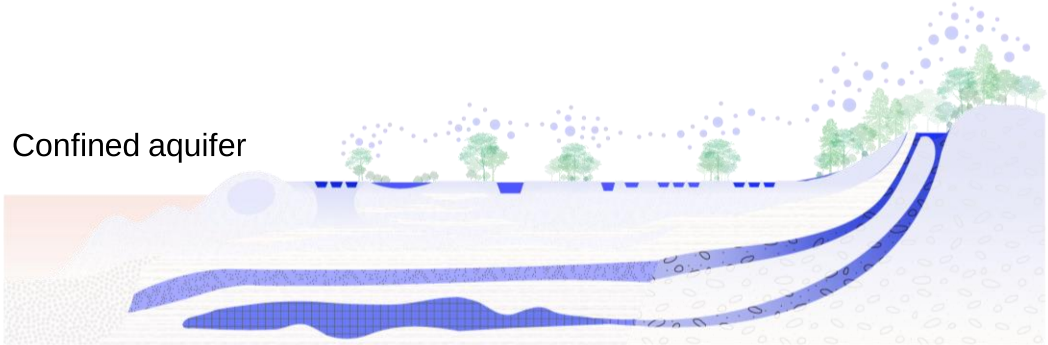
Unconfined aquifer



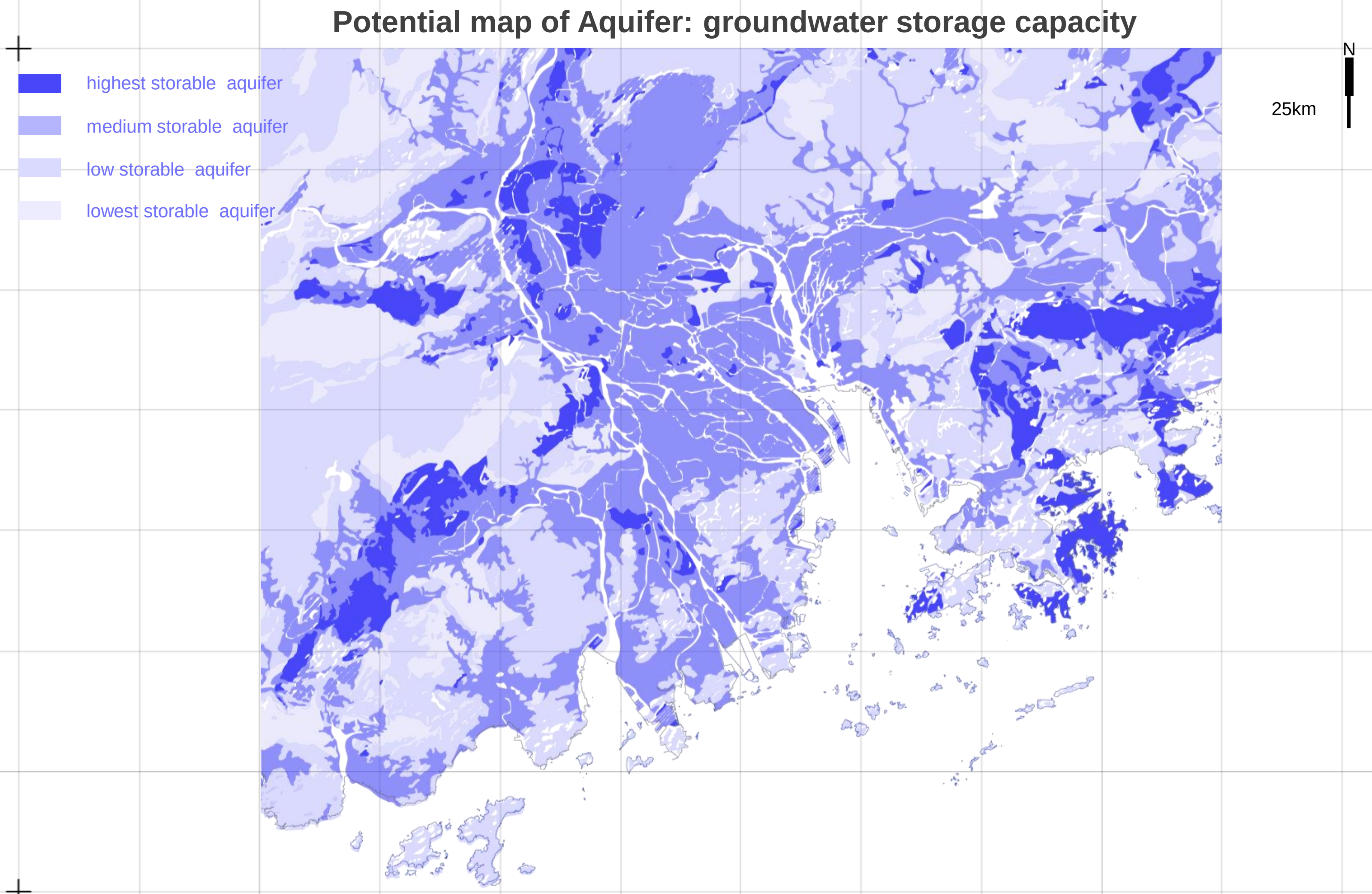
aquitard



Confined aquifer



4.1 Geo-hydrology

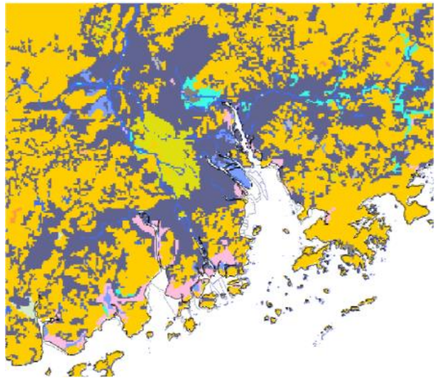


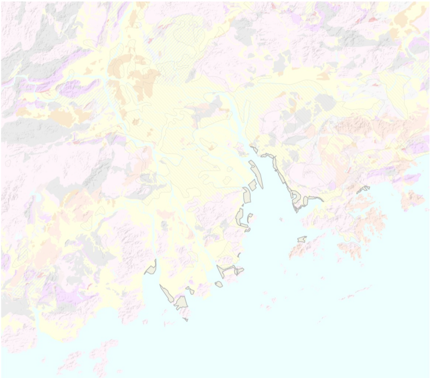
drawing: by author

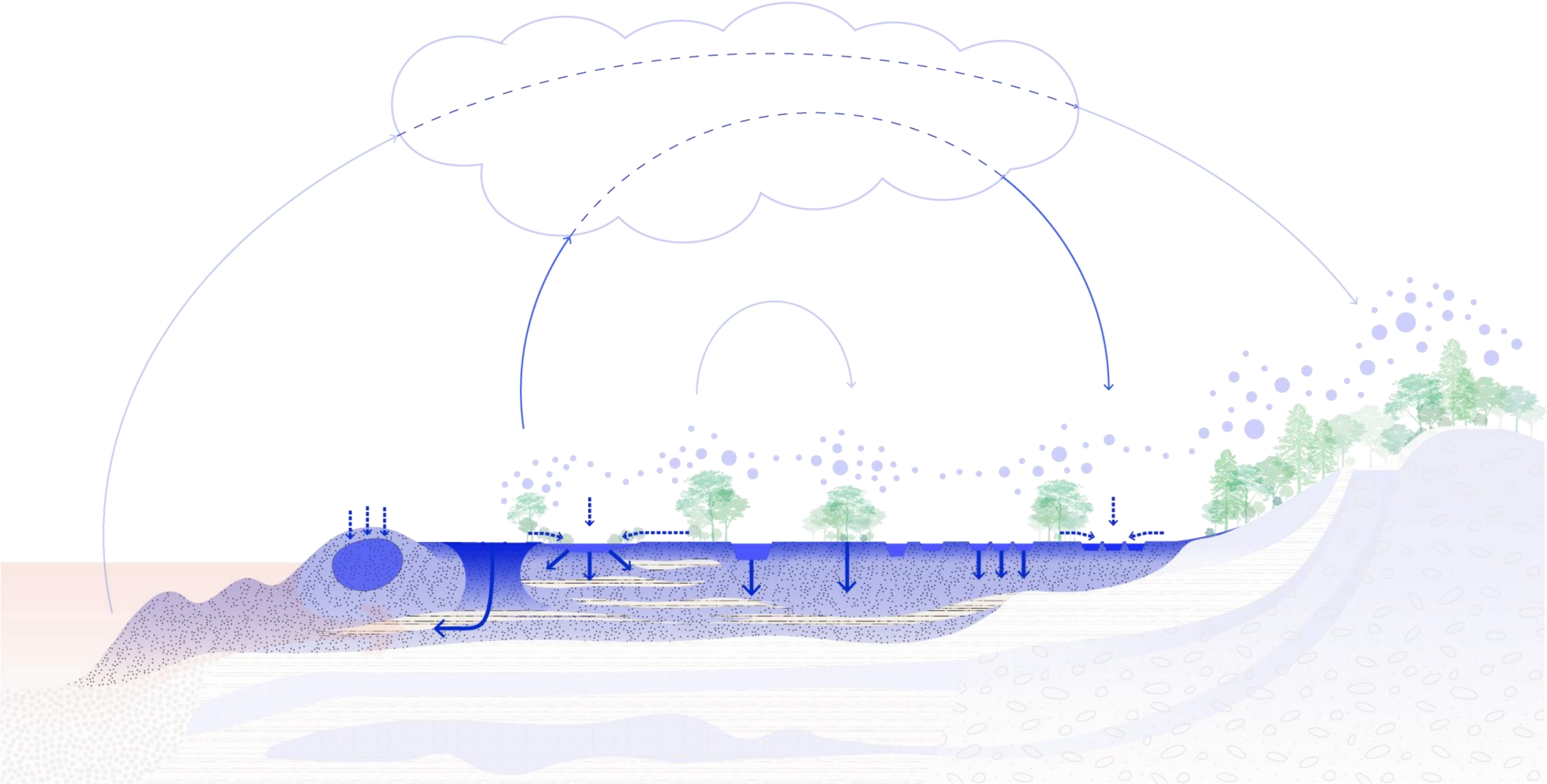
source: Taylor & Francis. et al, Hydrogeology of the Pearl River Delta, southern China.

“Soil Permeability as Key Condition for Freshwater Conservation implementation”

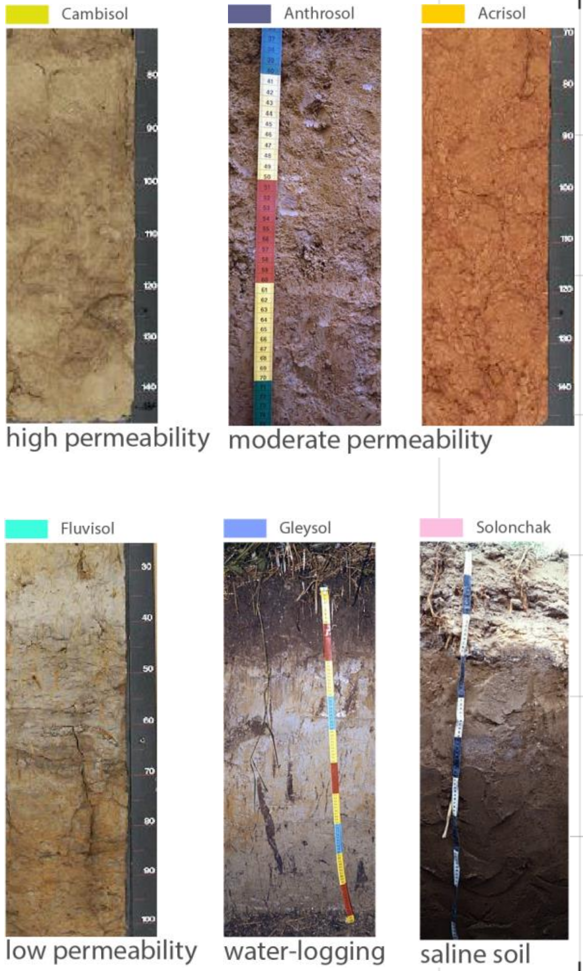
Soil type



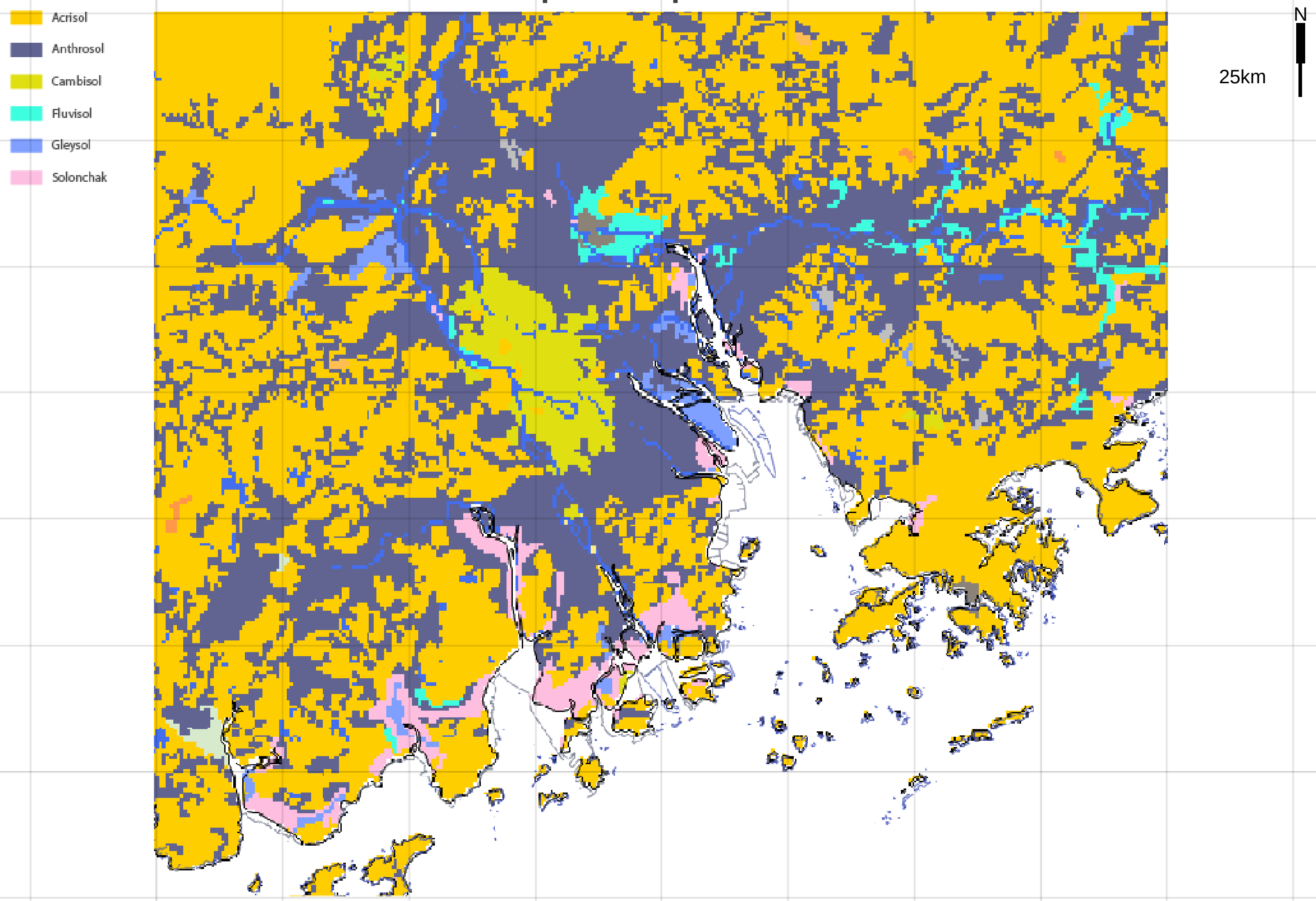




4.2 Topsoil



Topsoil map of PRD



drawing: by author
source: Food and Agriculture Organization of the United Nations, Harmonized World Soil Database v 1.2
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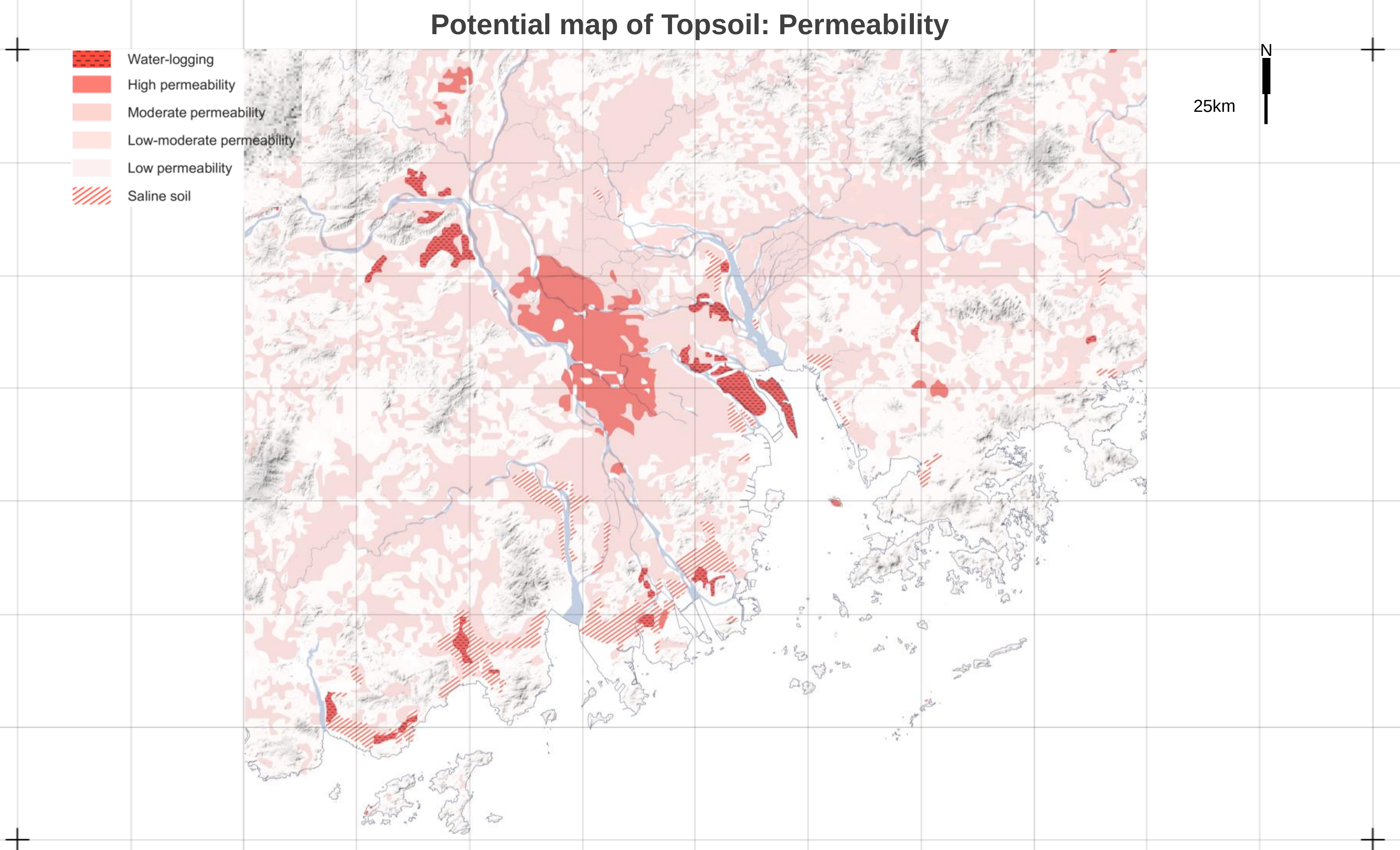
4.2 Topsoil

retain

infiltration

storage



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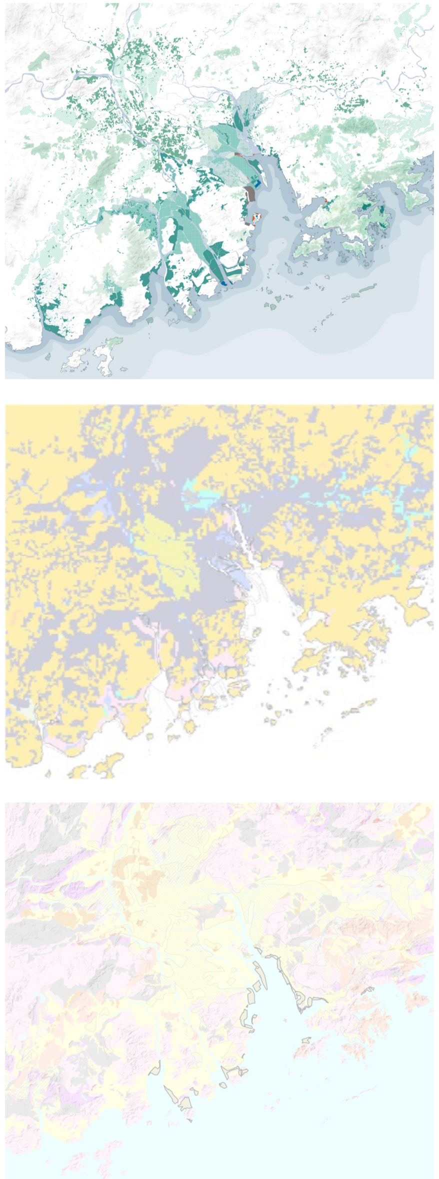
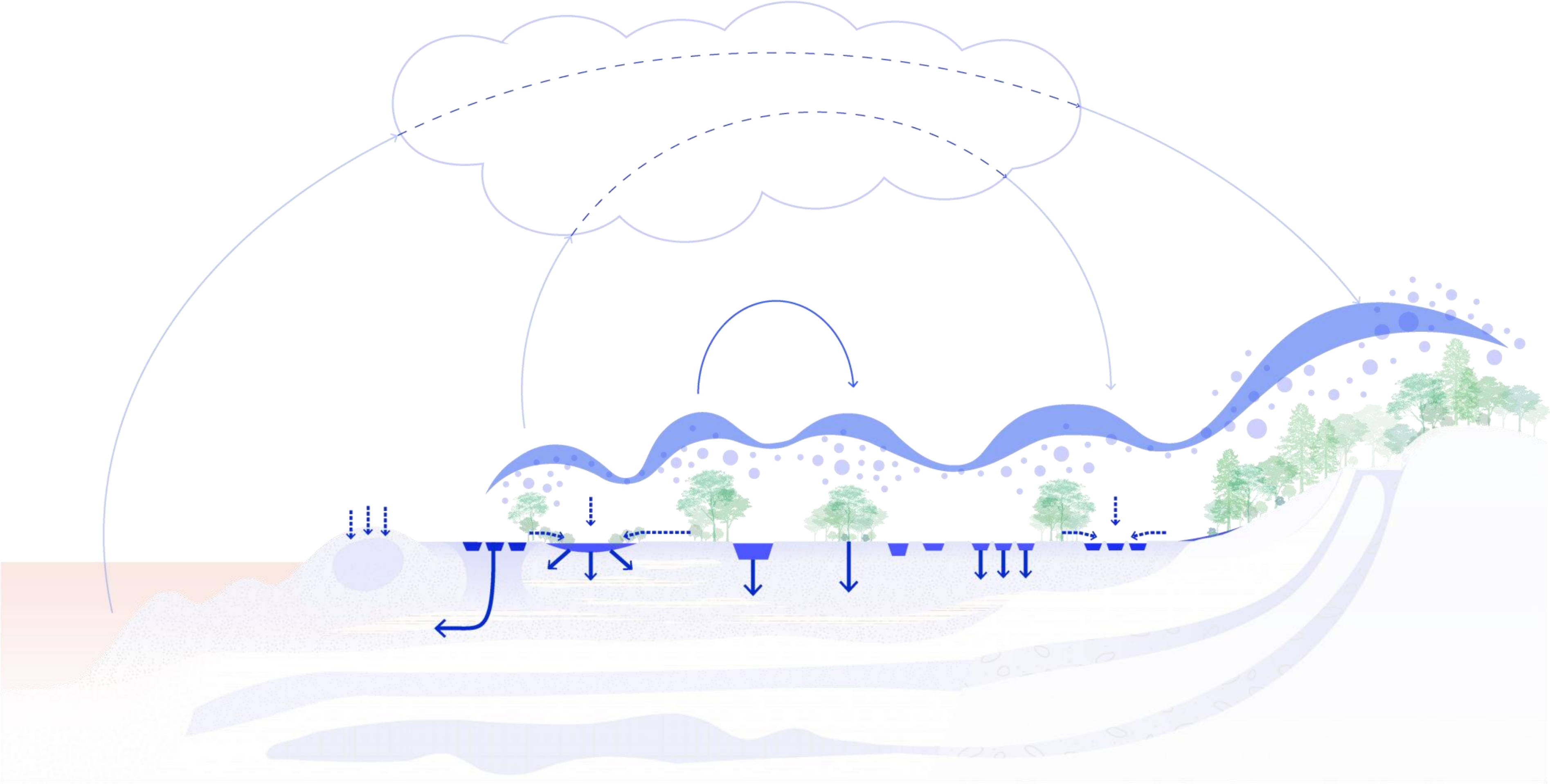
Landscape type

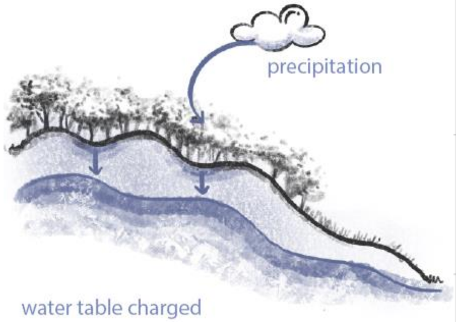


"Landscape Type as an Operative Field for the Sustainable Freshwater Supply"

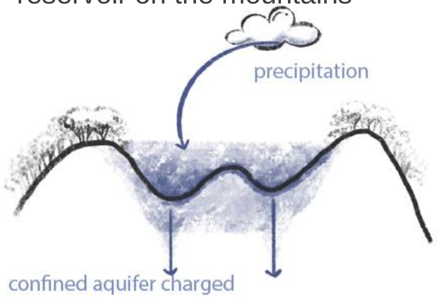


4.3 Landscape Type

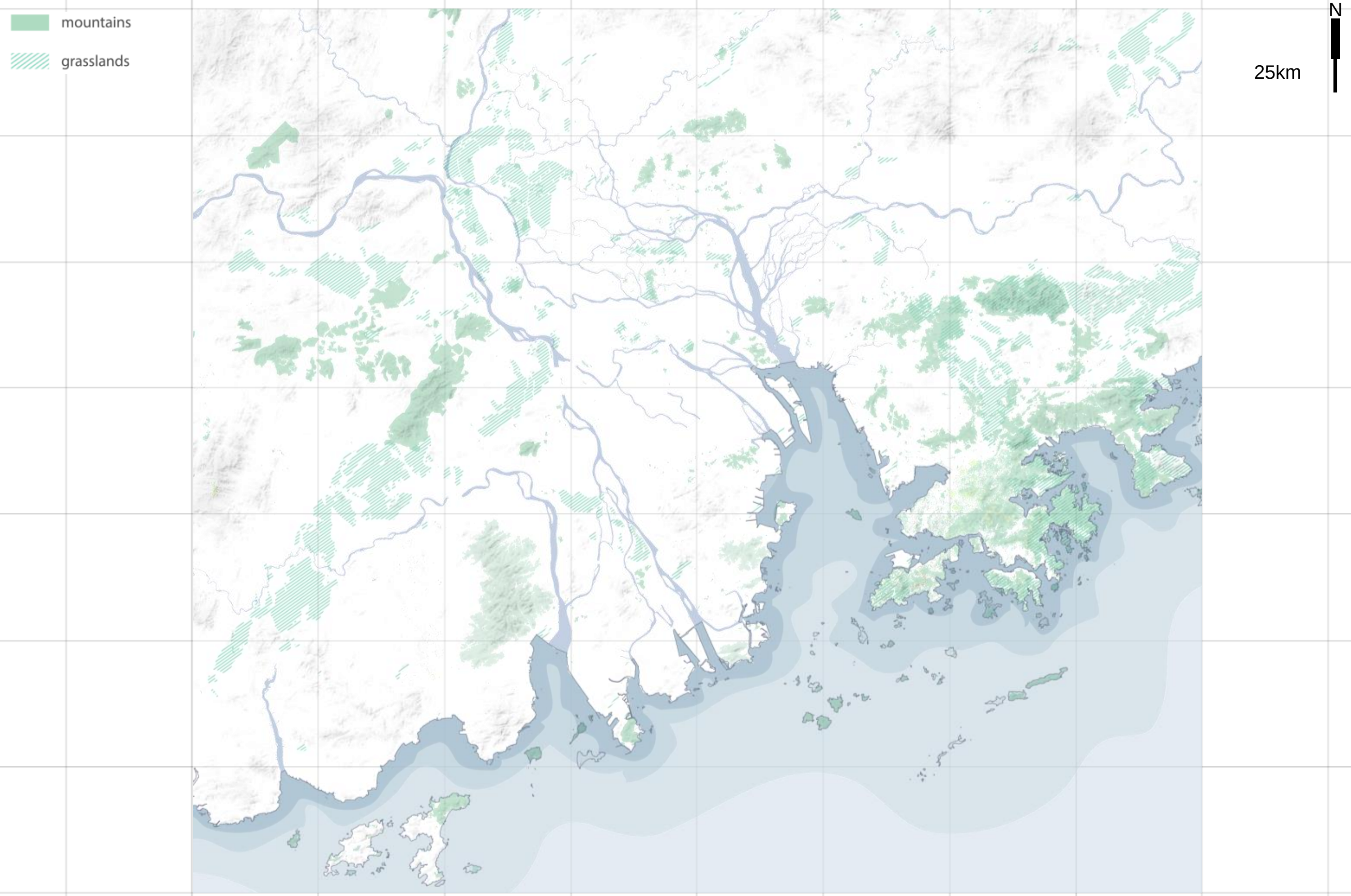
Forest on the mountains



reservoir on the mountains



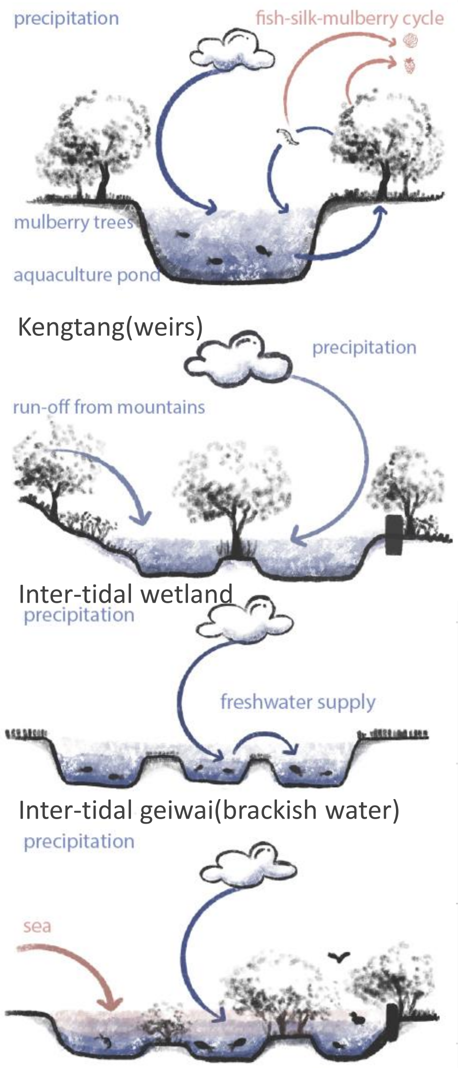
Potential Landscape Type: Mountain Areas



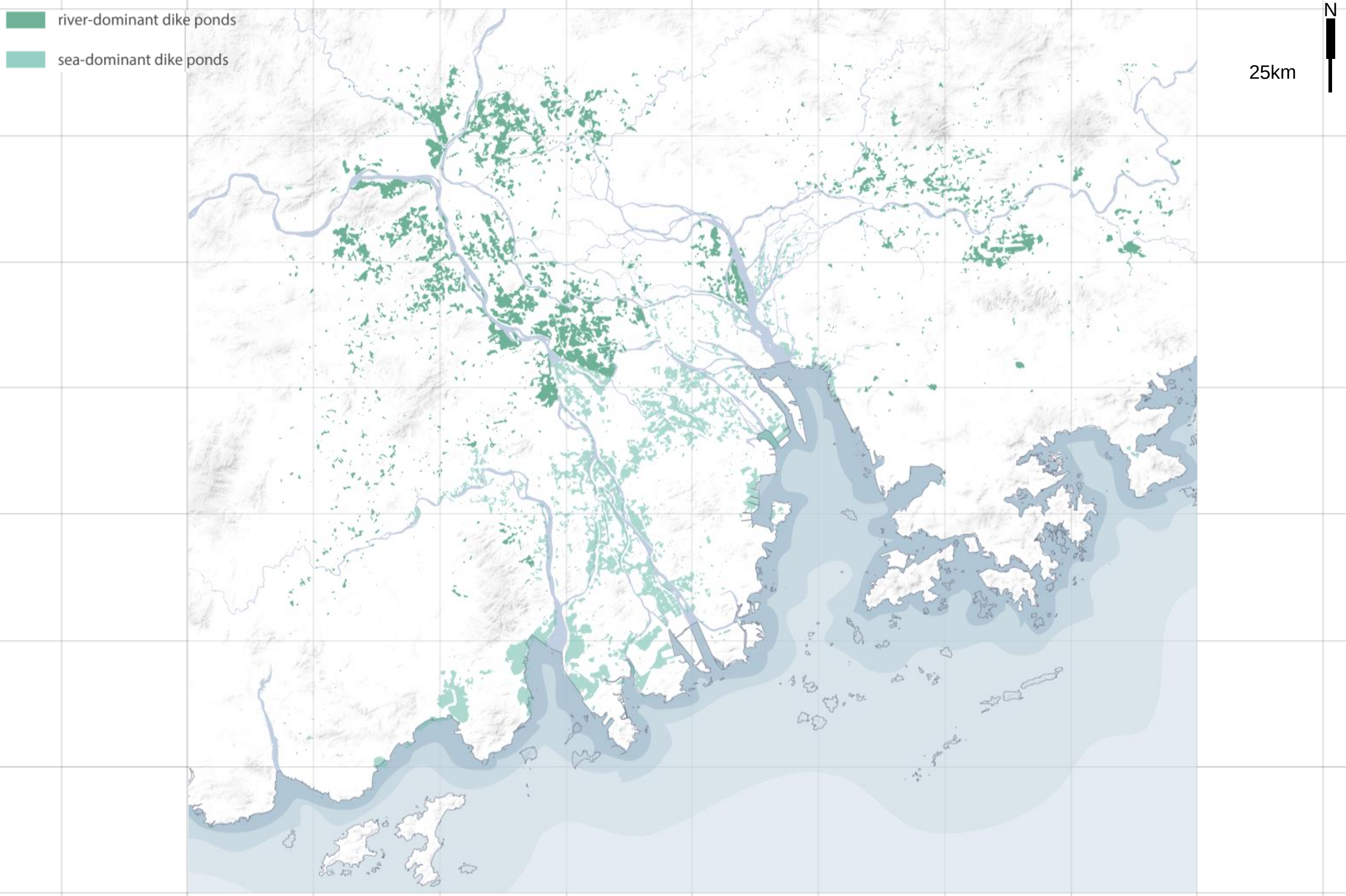
drawing: by author

4.3 Landscape Type

Dike pond system



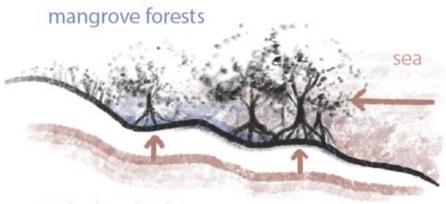
Potential Landscape Type: Water Body——Dike Pond, Kengtang



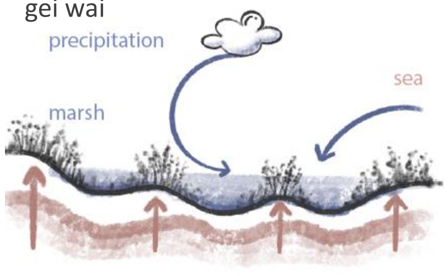
drawing: by author

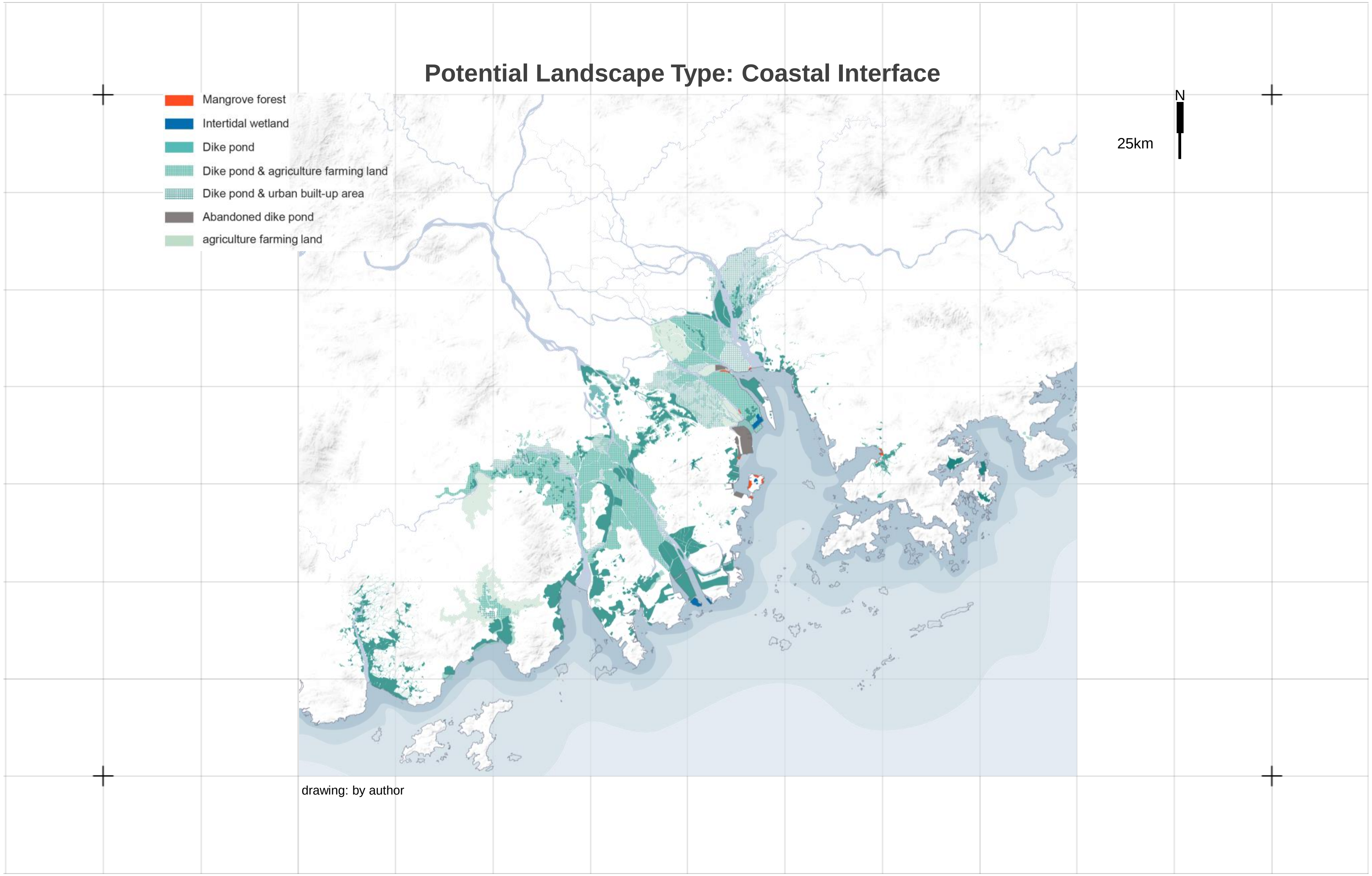
4.3 Landscape Type

Mangrove forest



gei wai





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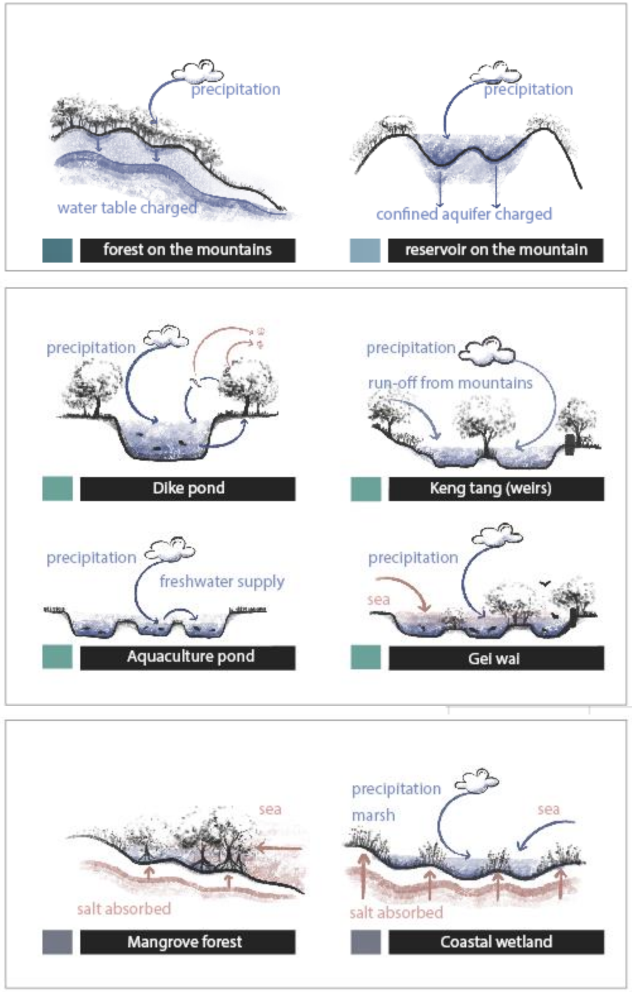
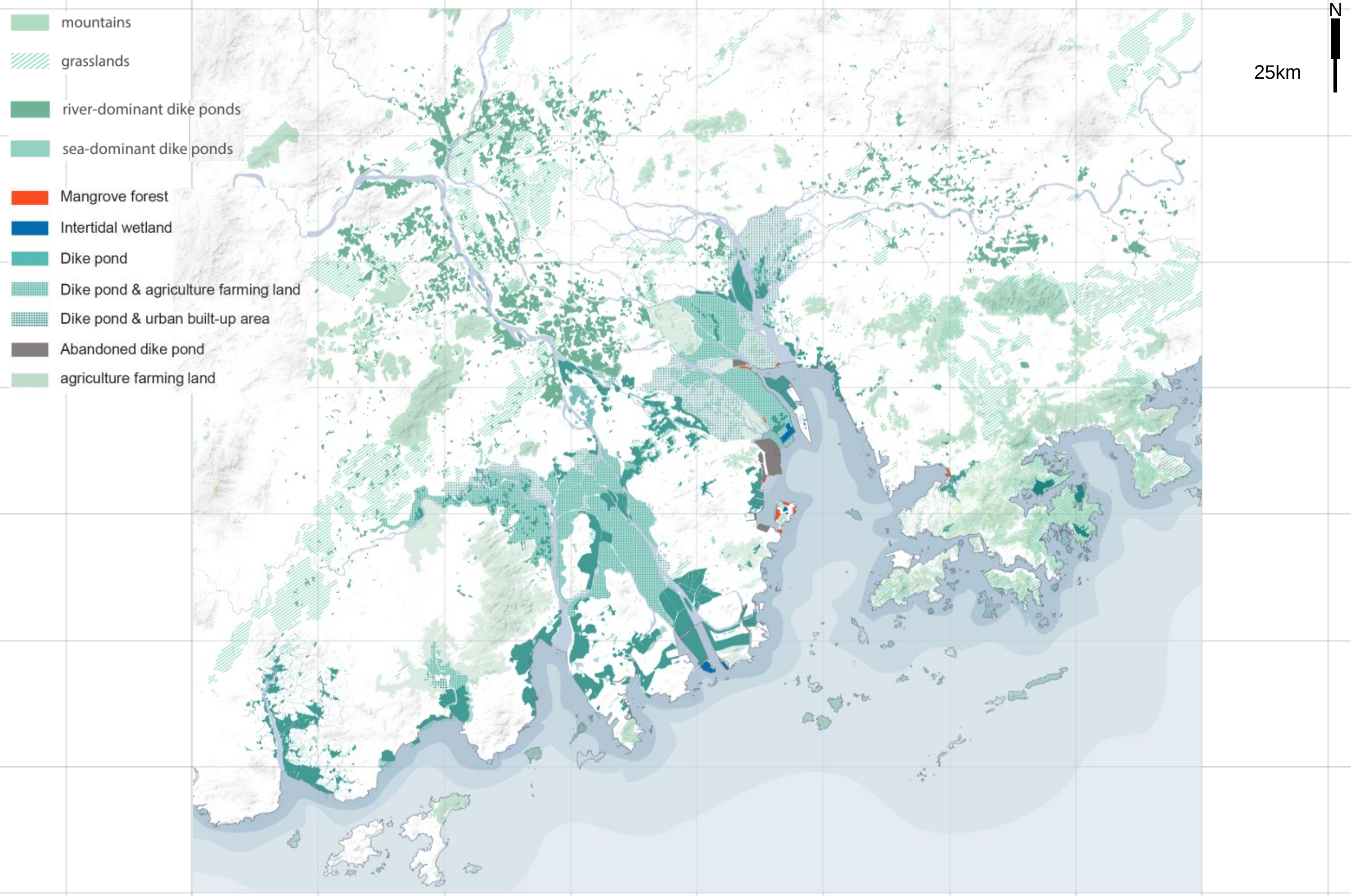
4.3 Landscape Type

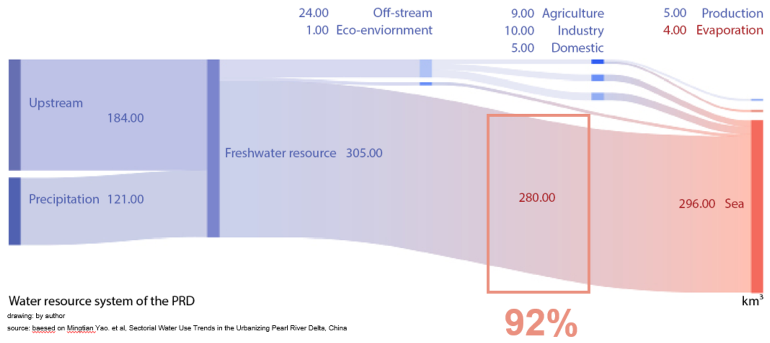


Potential Landscape Type: Coastal Interface



drawing: by author

4.4 Water Flow System

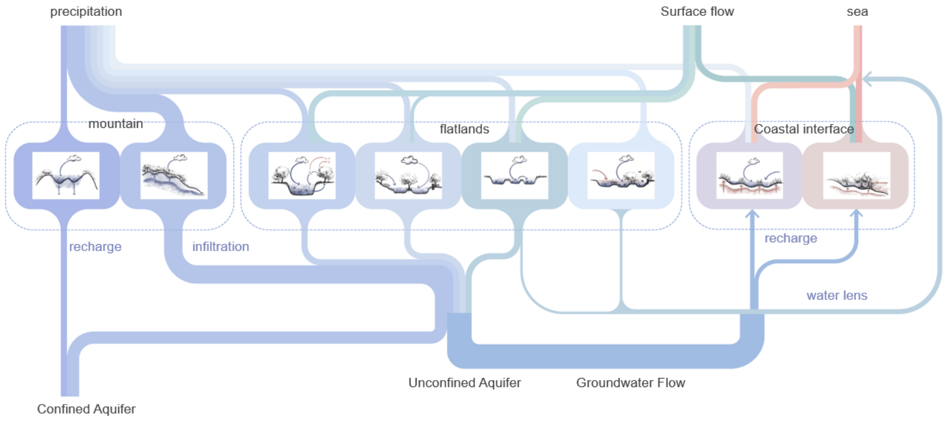


Water resource system of the PRD
drawing: by author
source: baesed on Mingtian Yao. et al, Sectorial Water Use Trends in the Urbanizing Pearl River Delta, China

Systematic thinking

Landscape as a System

Layering analysis



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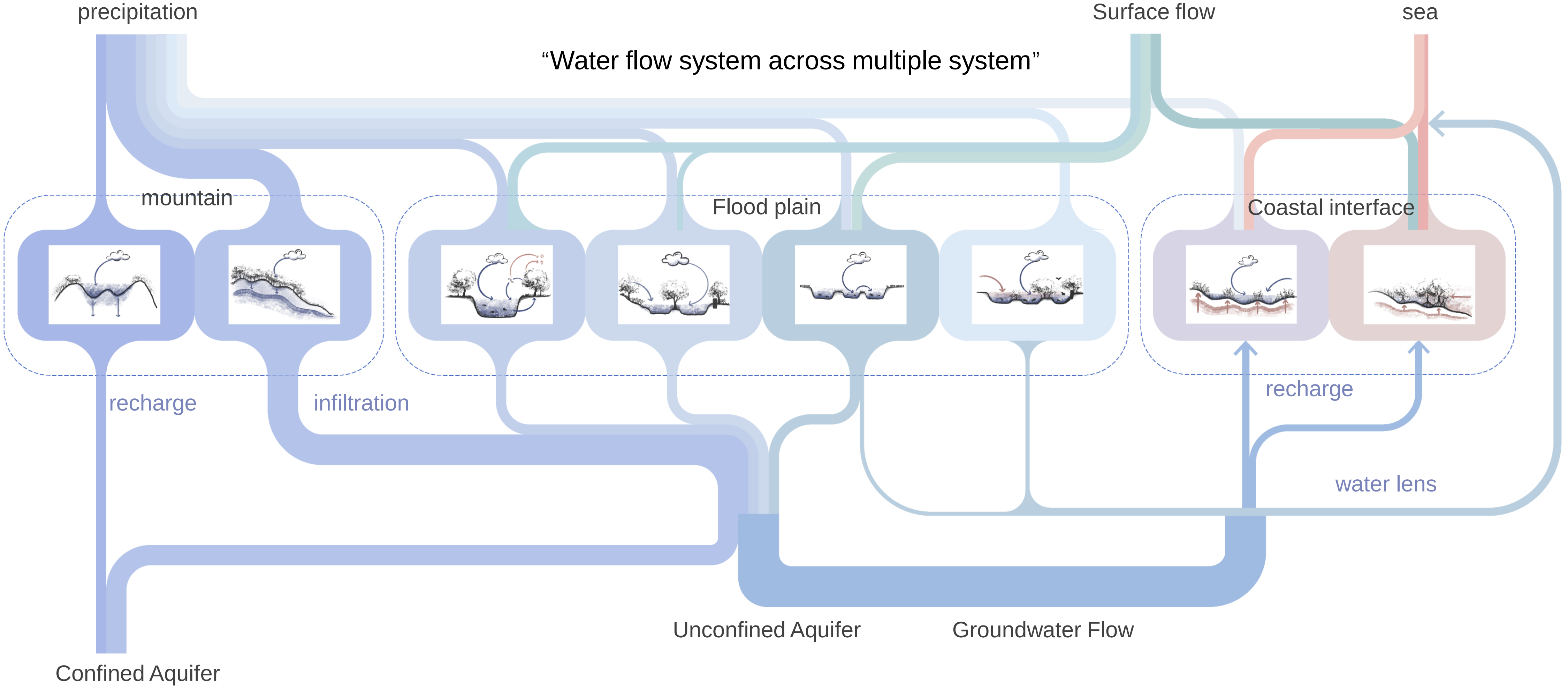
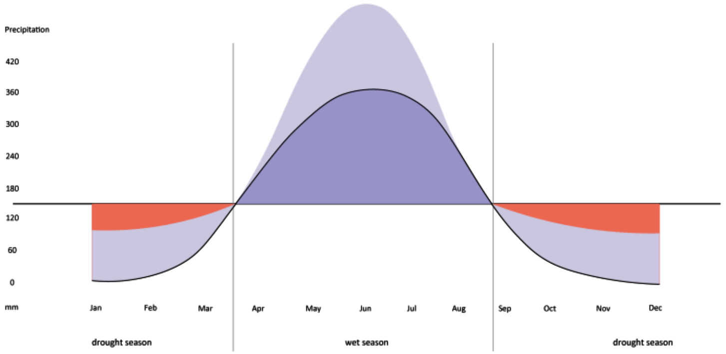


1. precipitation - recharged to the confined aquifers
2. precipitation - infiltrated - groundwater flow - recharged to brackish land
3. precipitation - retained in the pond (- infiltrated - recharged to brackish land)
4. surface runoff - retained in the pond (- infiltrated - recharged to brackish land)
5. precipitation - retained in the pond - soil lens
6. precipitation - retained in the geiwai - adatpting to the flactuated saltwater
7. precipitation - retained in the marshland - absorbing the saltwater
8. surface runoff - retained in the pond (- infiltrated - recharged to brackish land)

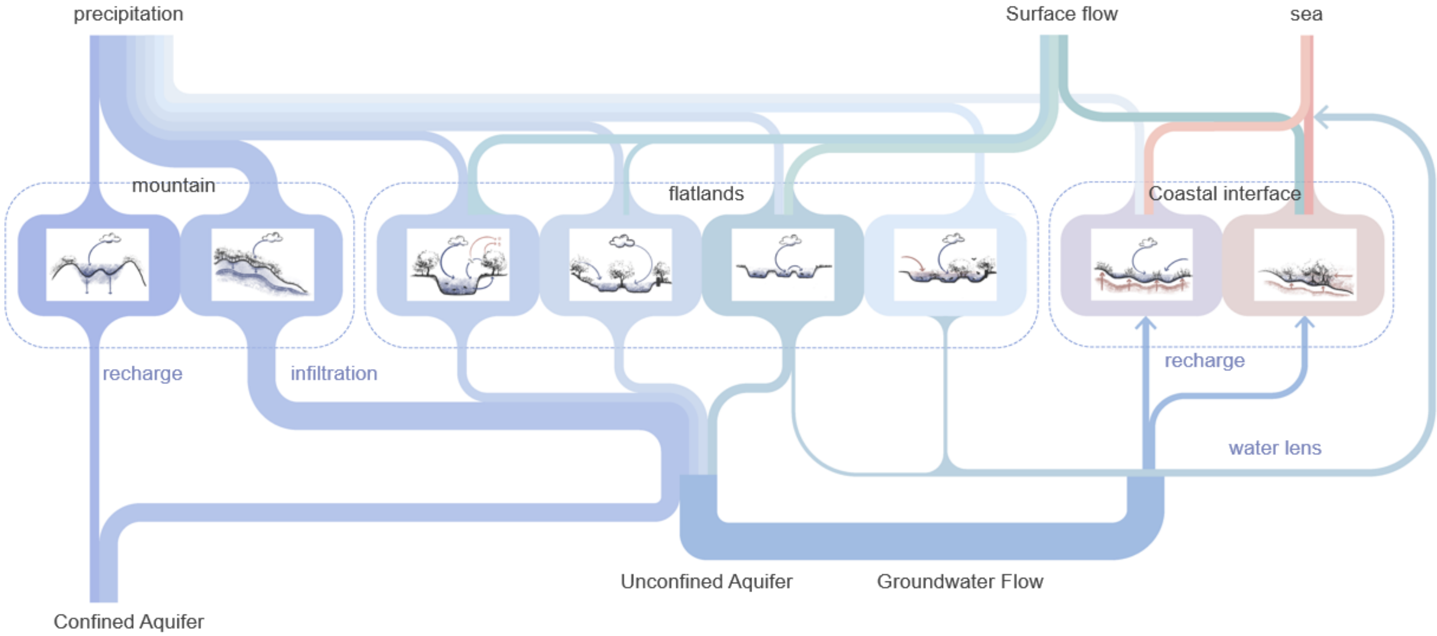
4.4 Water Flow System

“Water flow system across time”



Annual

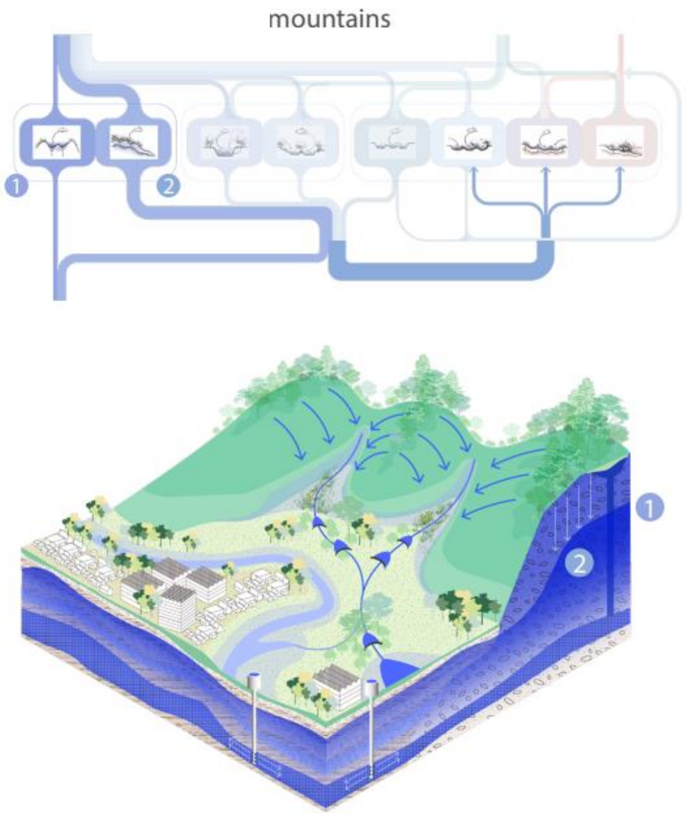
Long term



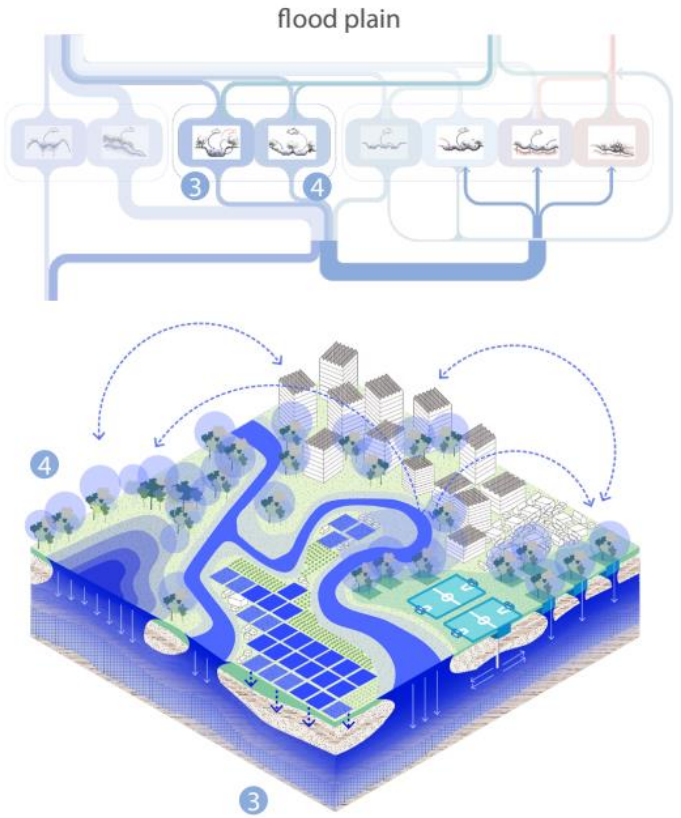
1. precipitation - recharged to the confined aquifers
2. precipitation - infiltrated - groundwater flow - recharged to brackish land
3. precipitation - retained in the pond (- infiltrated - recharged to brackish land)
4. surface runoff - retained in the pond (- infiltrated - recharged to brackish land)
5. precipitation - retained in the pond - soil lens
6. precipitation - retained in the geiwai - adatpting to the flactuated saltwater
7. precipitation - retained in the marshland - absorbing the saltwater
8. surface runoff - retained in the pond (- infiltrated - recharged to brackish land)

4.4 Water Flow System

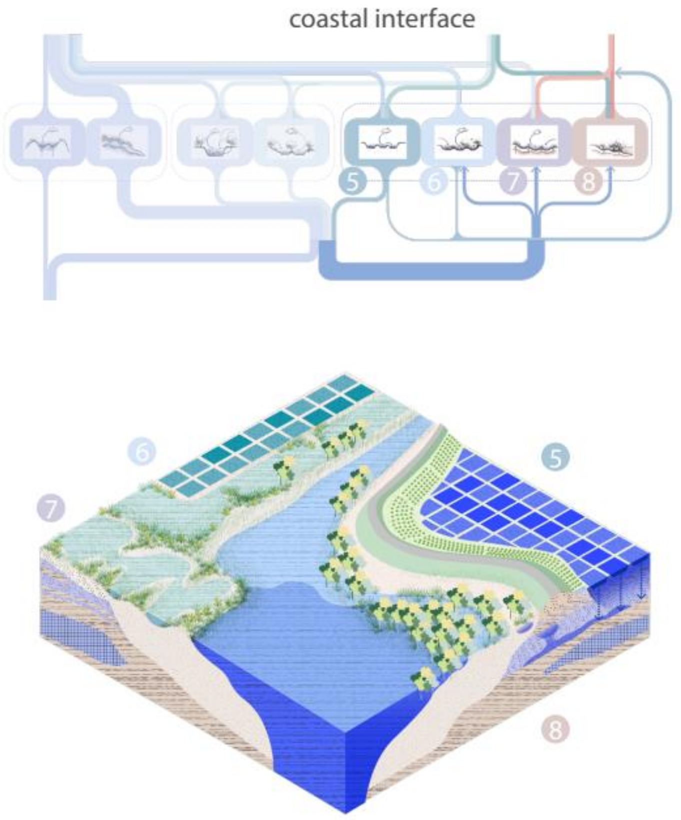
“Water flow system across geographical areas”



Mountains as the water tower



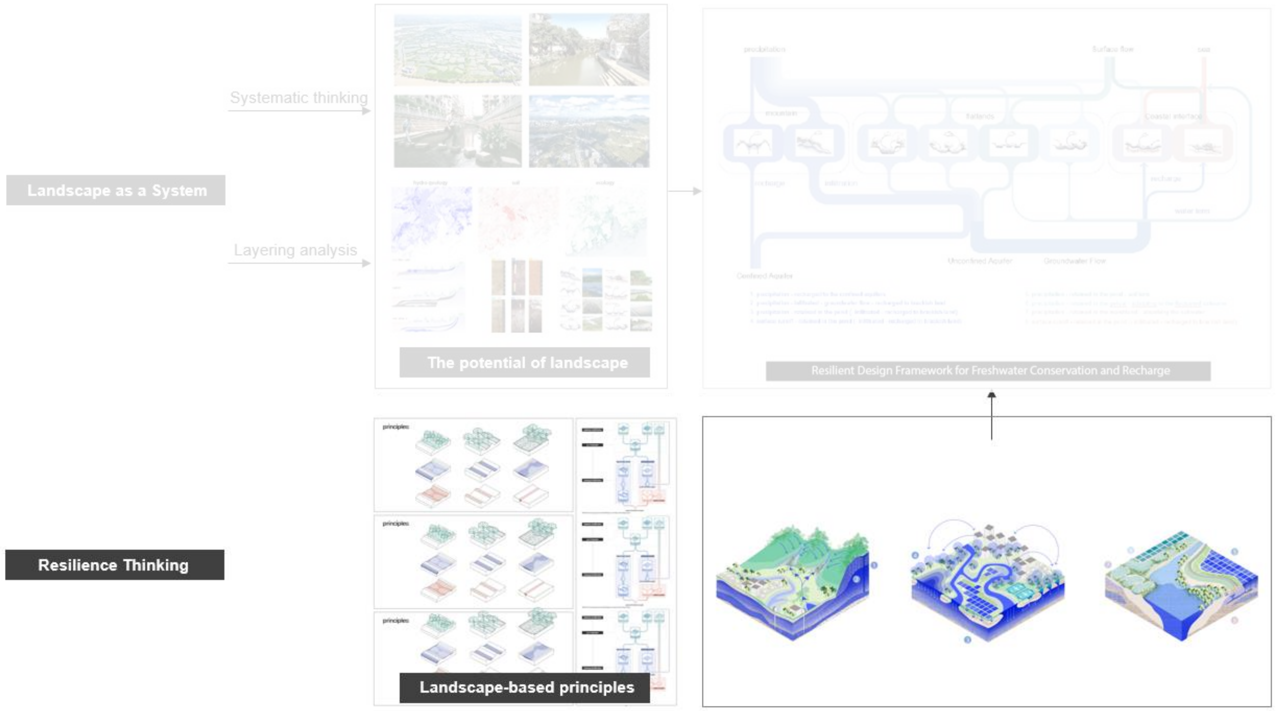
Floodplains as water-absorbing sponges

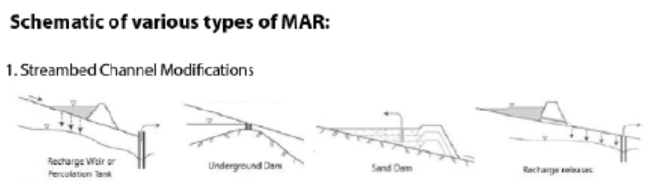


Estuaries as adaptive interfaces

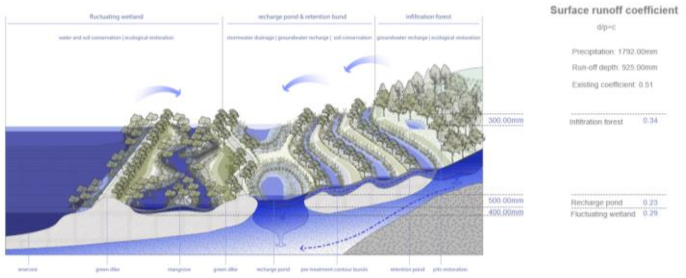
Design Exploration

What landscape-based principles could be applied in different landscape contexts to optimize the potential for freshwater conservation and recharge?





case study



ASSESSMENT

layering analysis

1. Ecosystem challenges
2. Hydrological challenges
3. Geological challenges

DESIGN

3 layers strategies

1. Ecology
2. Hydrology
3. Geology

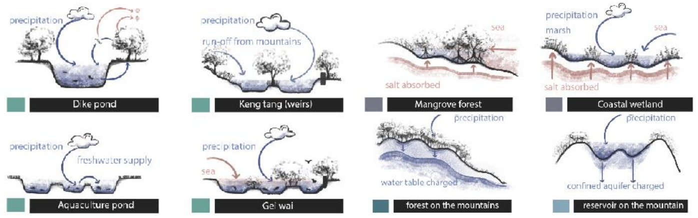
spatial principles

1. Ecological succession
2. Water management
3. Landforming

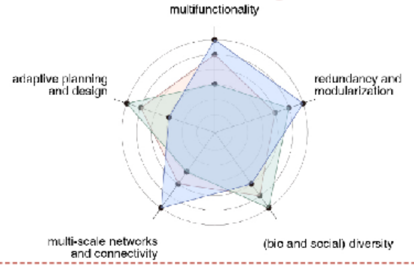
ASSESSMENT

1. capacity on freshwater conservation and recharge
2. landscape benefits

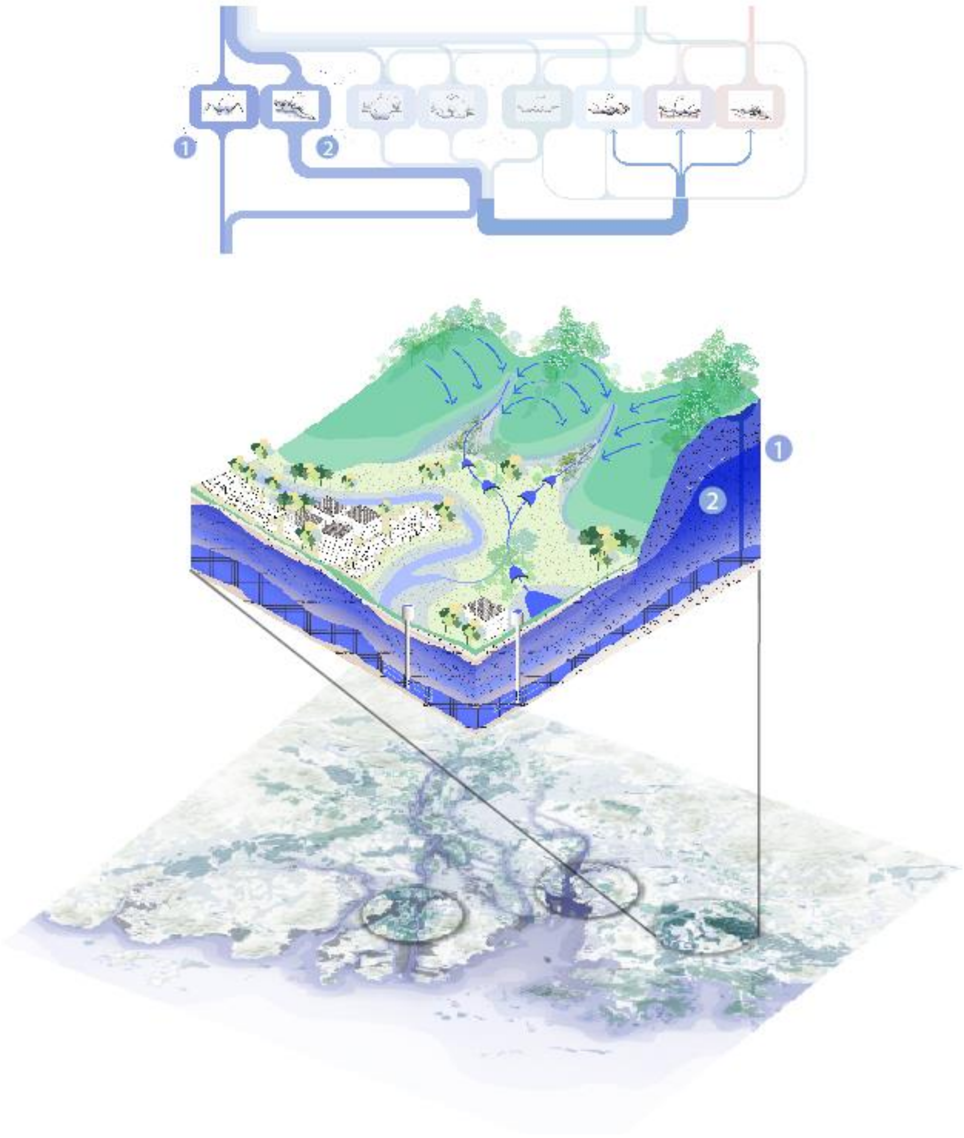
learning from history



5 resilient strategies

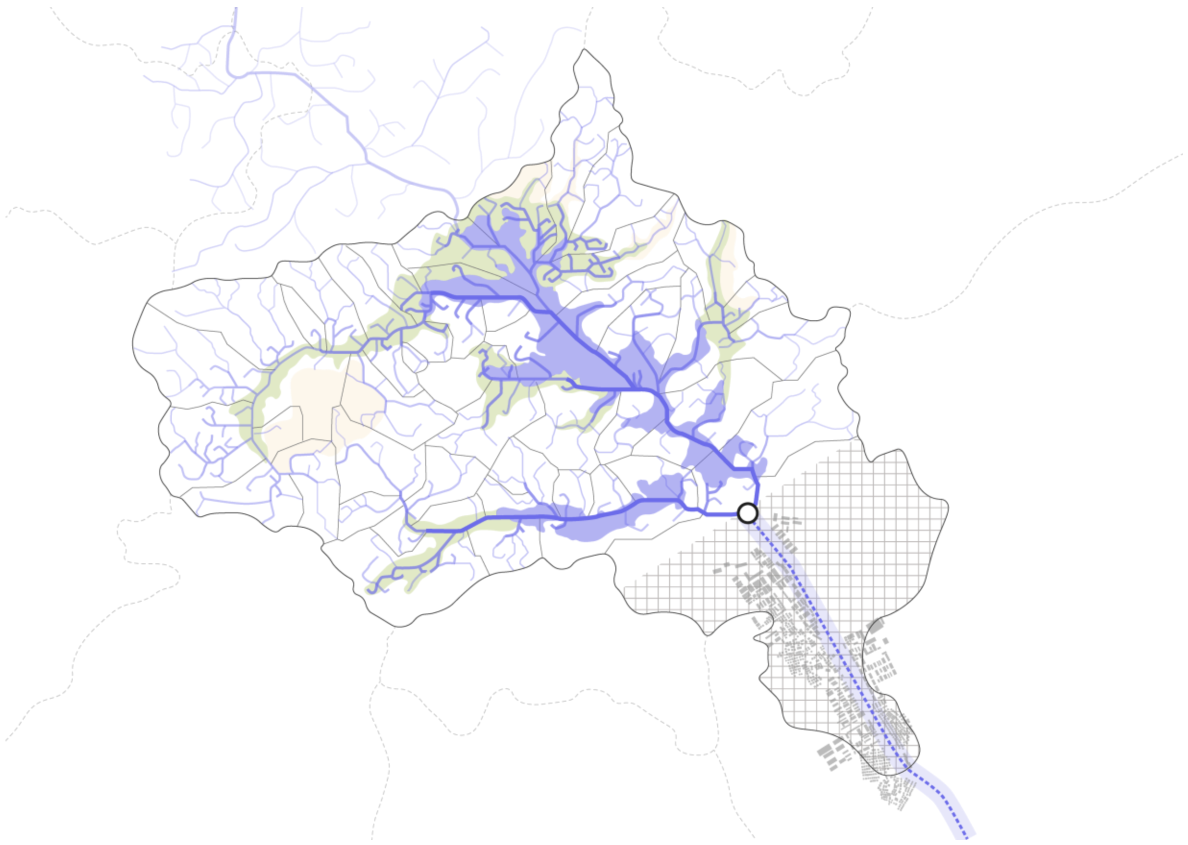


MOUNTAINS

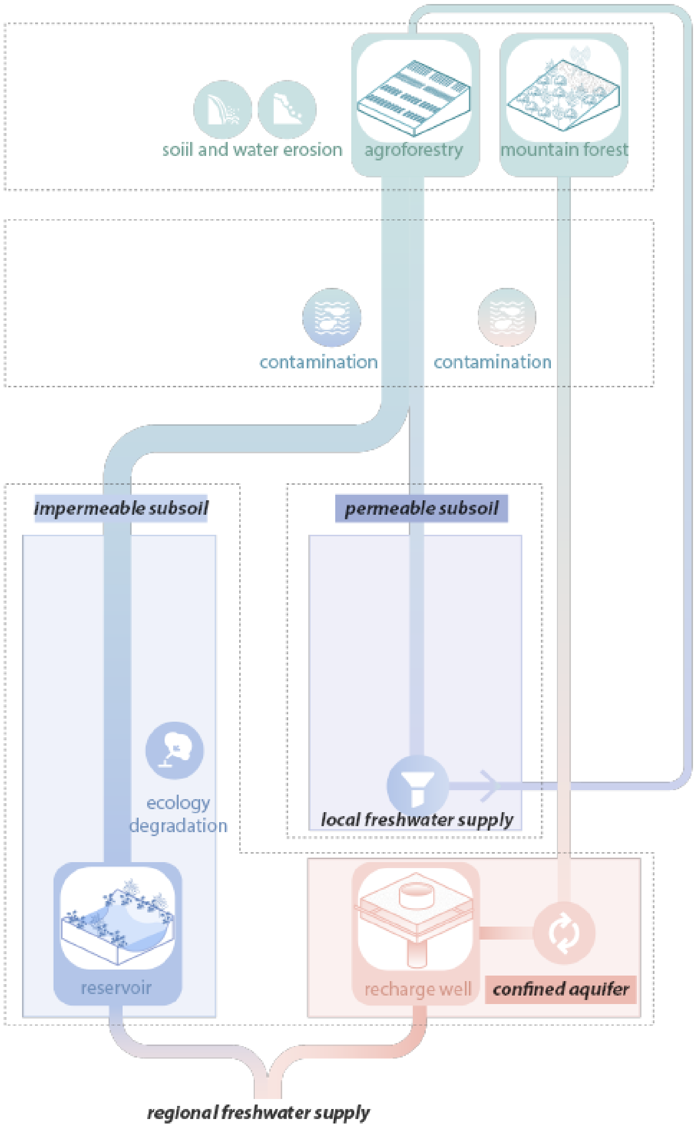


5.1 Mountain as the water tower of the PRD

watershed

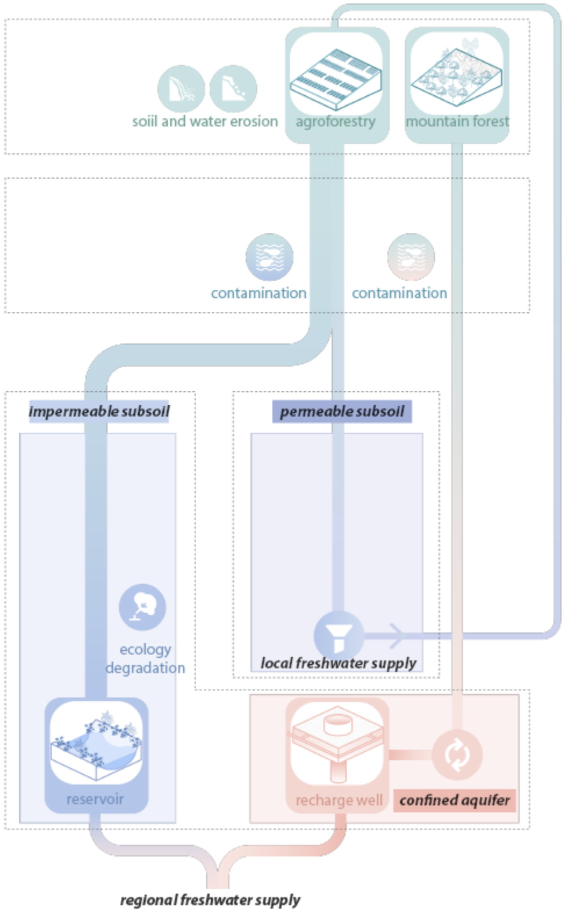


Existing water flow system of the mountain



5.1 Mountain as the water tower of the PRD

Existing run-off coefficients: 0.54

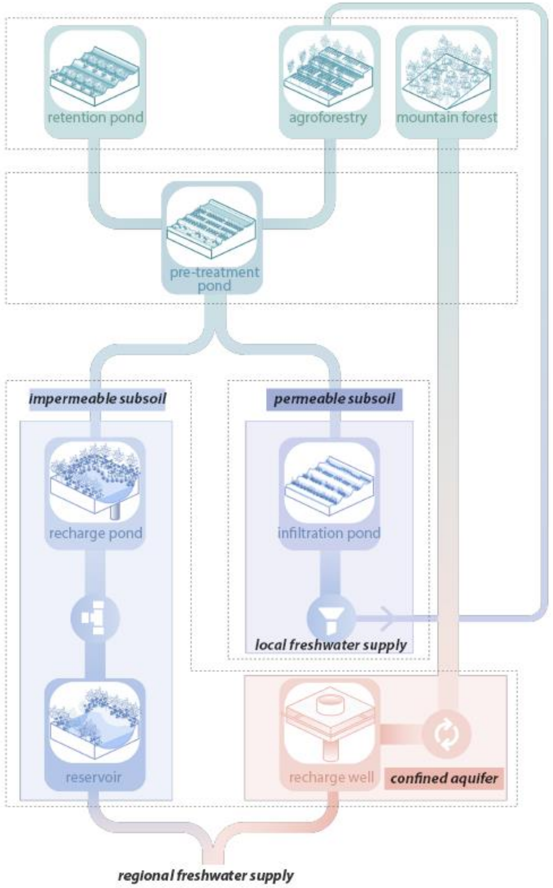


Existing water flow system of the mountain

Landscape-based principles

?

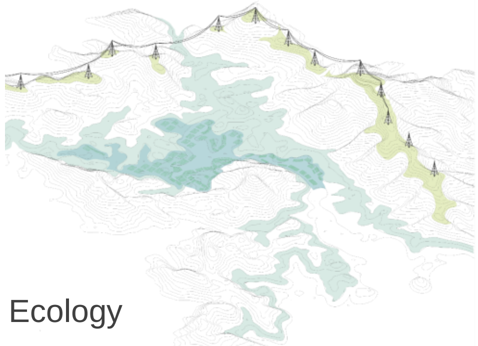
Proposed run-off coefficients: 0.25-0.35



proposed water flow system of the mountain

5.1 Mountain as the water tower of the PRD

Challenges



Ecology

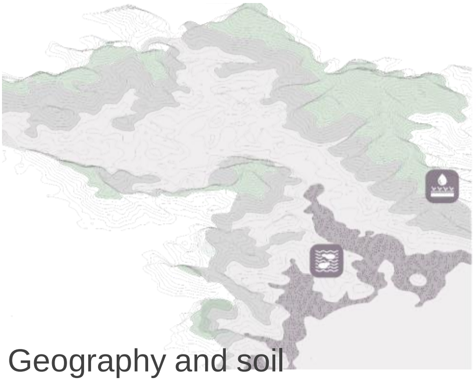
70%
Eucalyptus

-20%
Moisture content

Hydrology

Precipitation: 1792mm

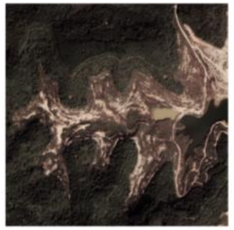
Run-off depth: 925.1mm



Geography and soil

soil erosion
18000t/a

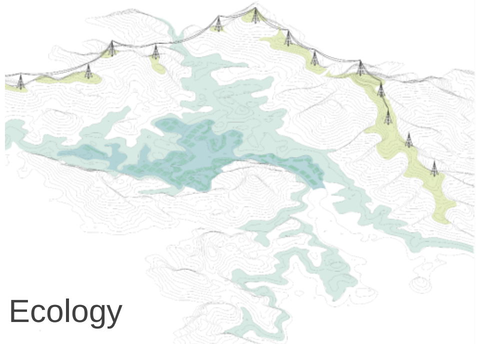
fluctuating interface



clay slope

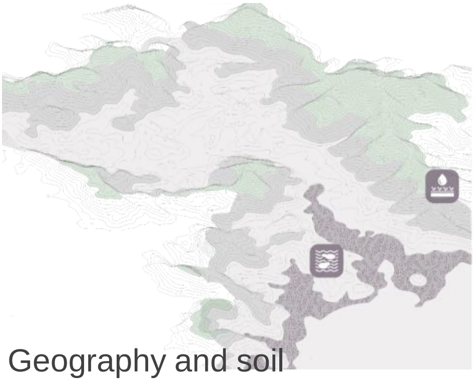
sand slope

5.1 Mountain as the water tower of the PRD



Ecology

Hydrology



Geography and soil

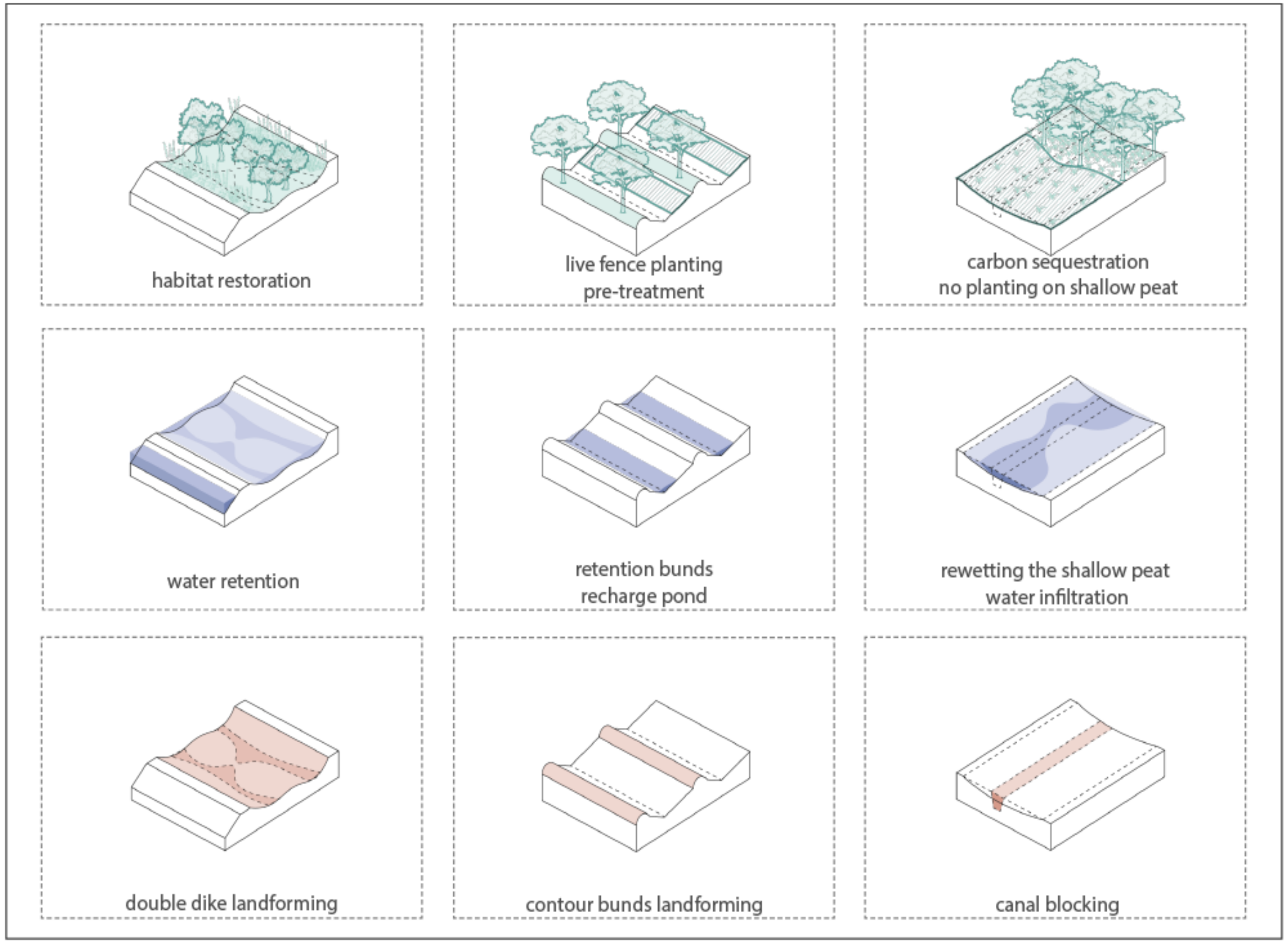
Strategies

Ecological succession by natural process →

Catch the water (infiltration, retention, recharge) →

Stabilize the soil structure
Peat restoration →

Spatial principles

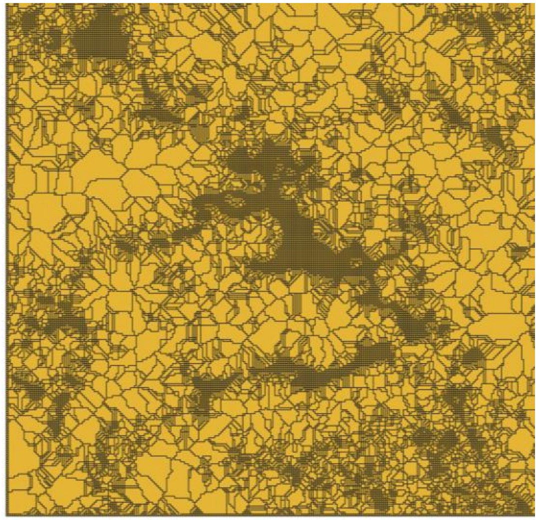


fluctuating interface
50: mangrove habitats succession

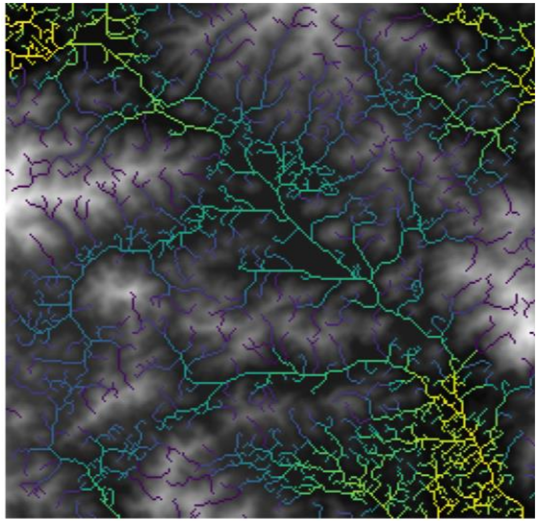
clay slope
50: peatland forest

sand slope
50: tree stories diversify forest

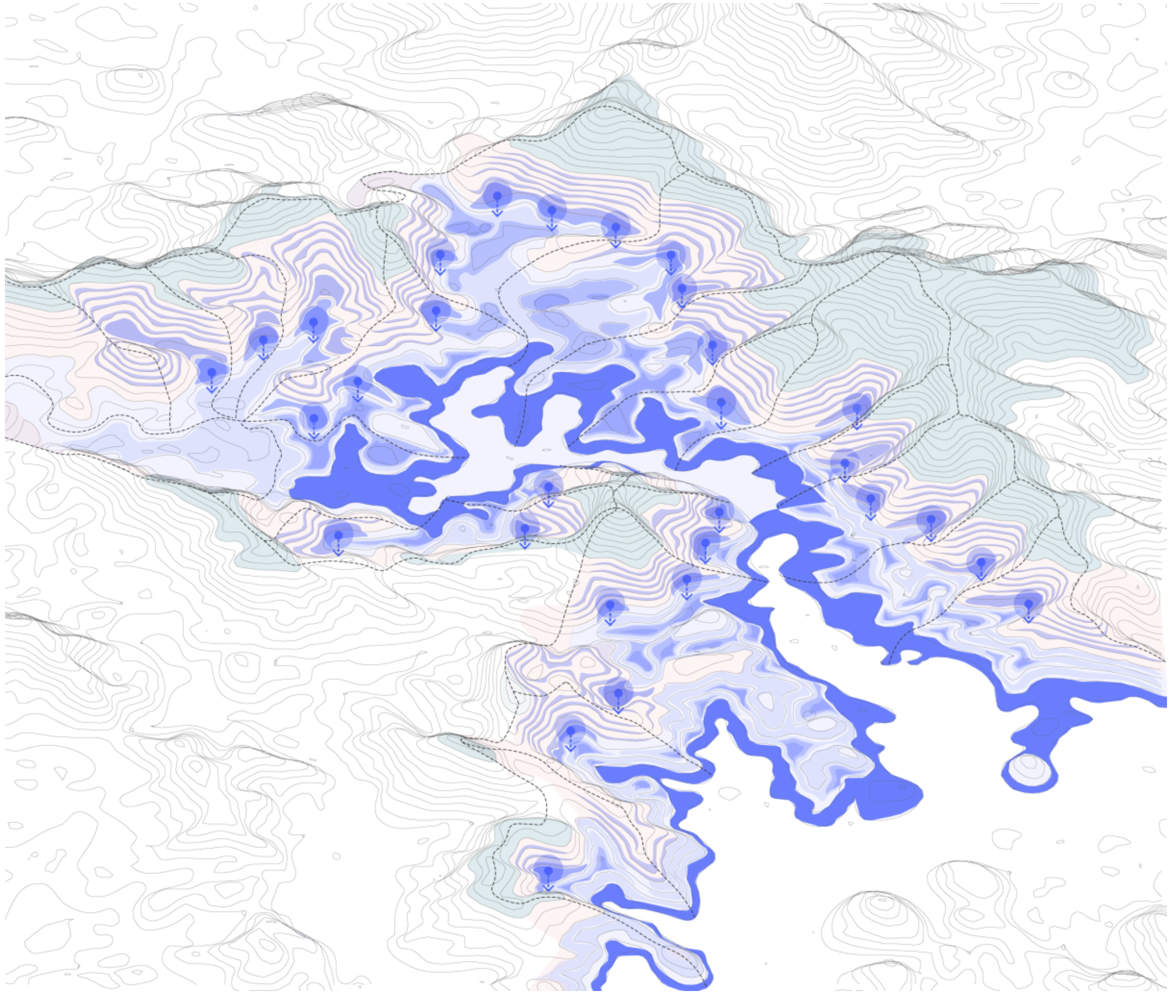
5.1 Mountain as the water tower of the PRD

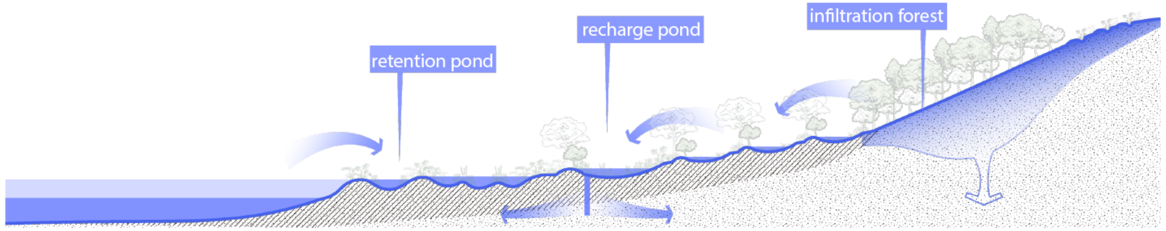


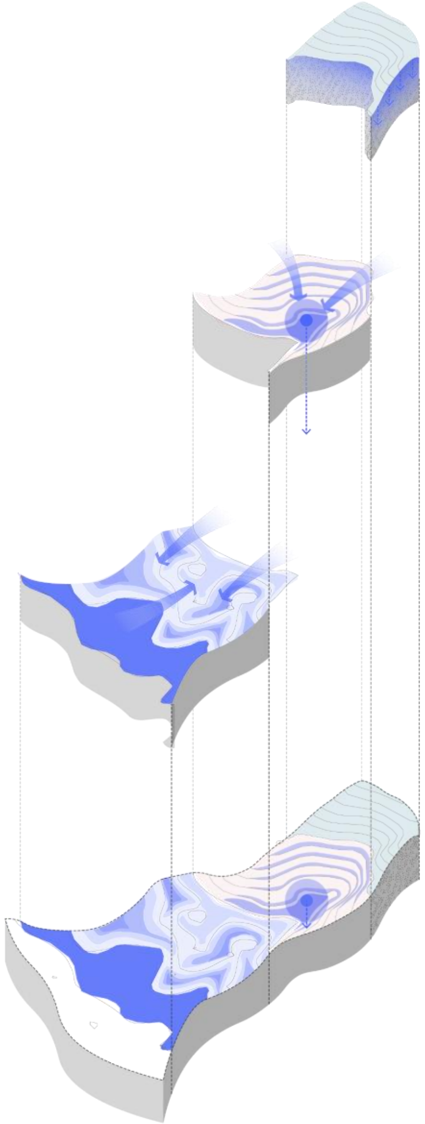
Drainage basin



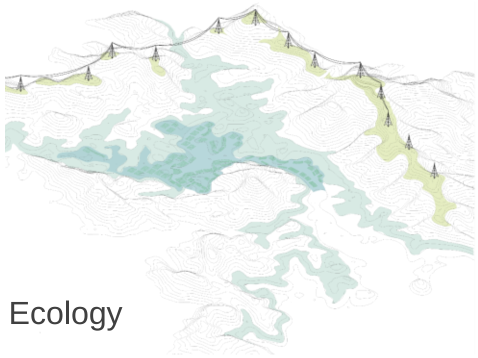
Stream network



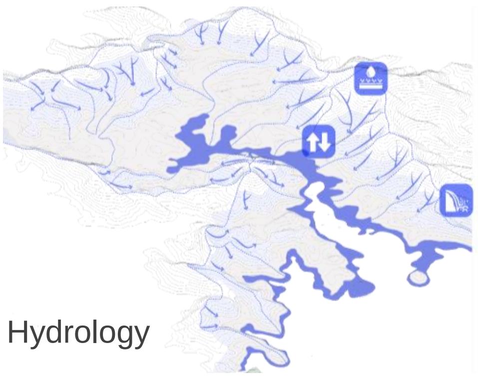




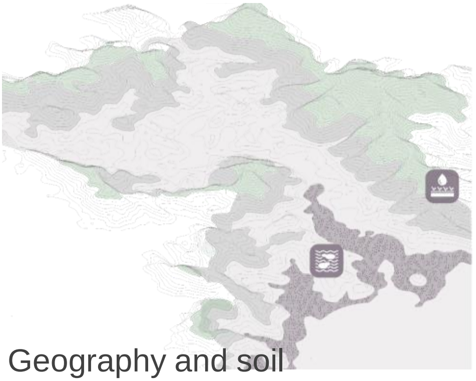
5.1 Mountain as the water tower of the PRD



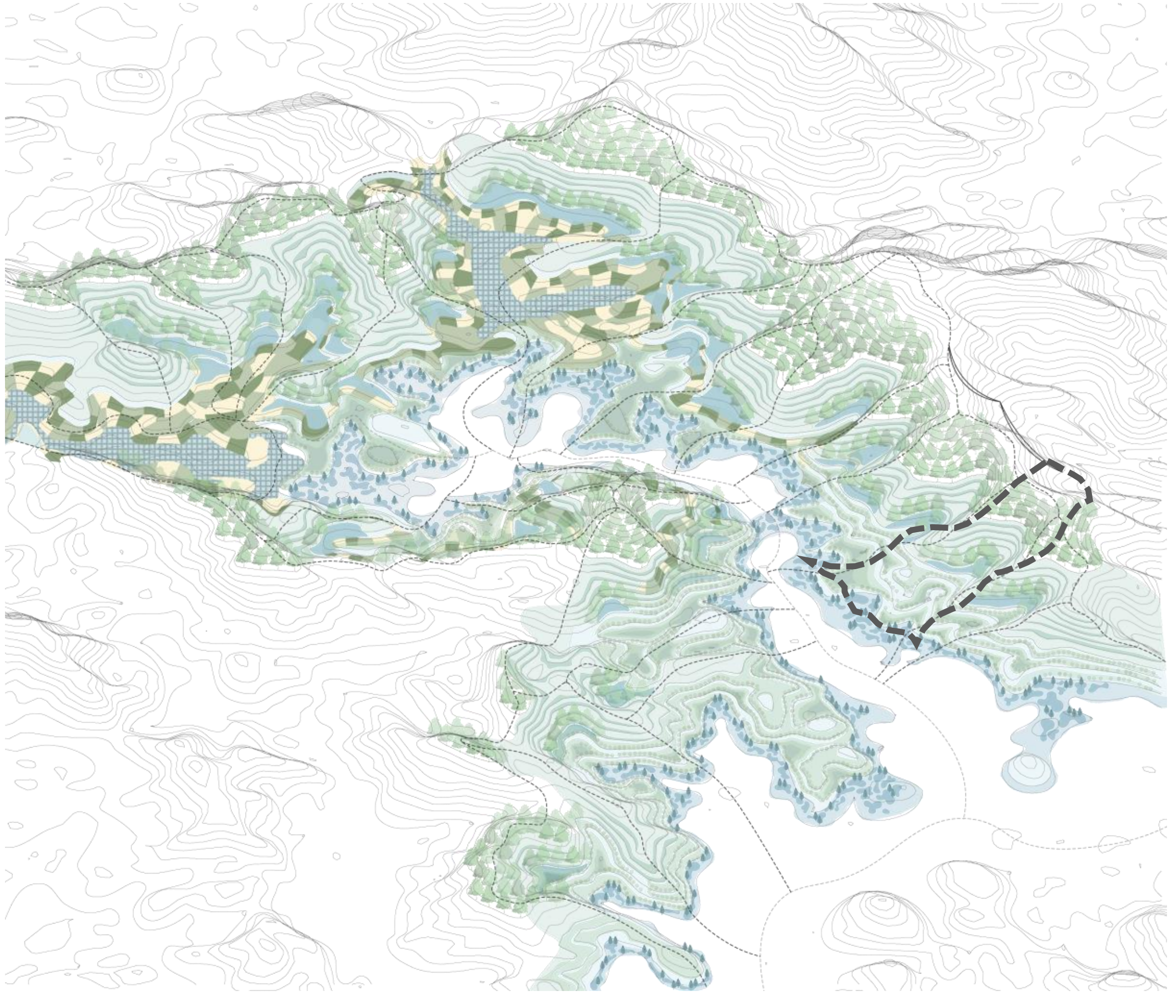
Ecology

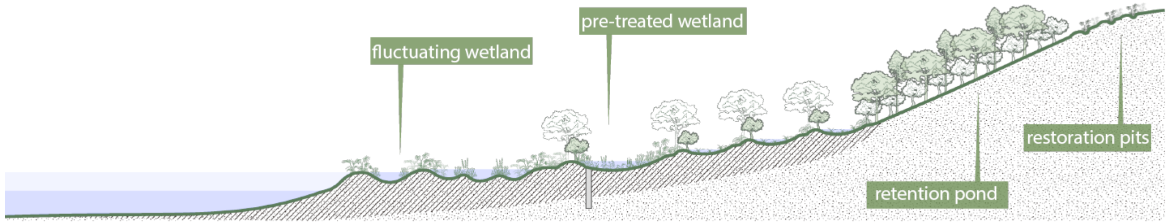


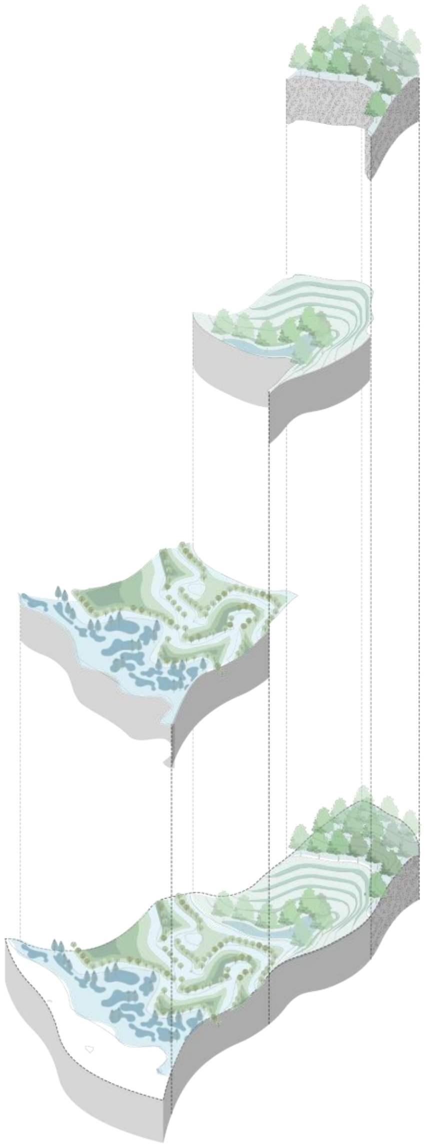
Hydrology



Geography and soil

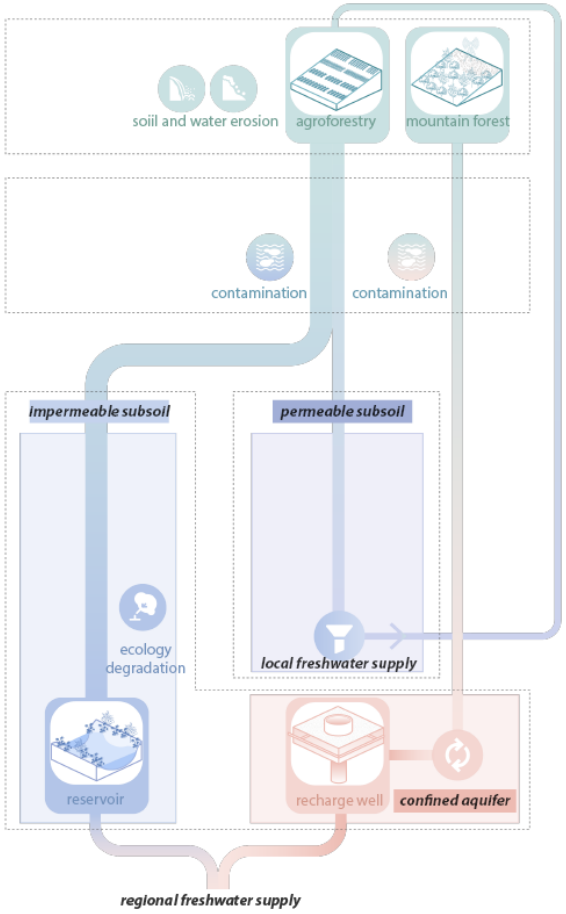


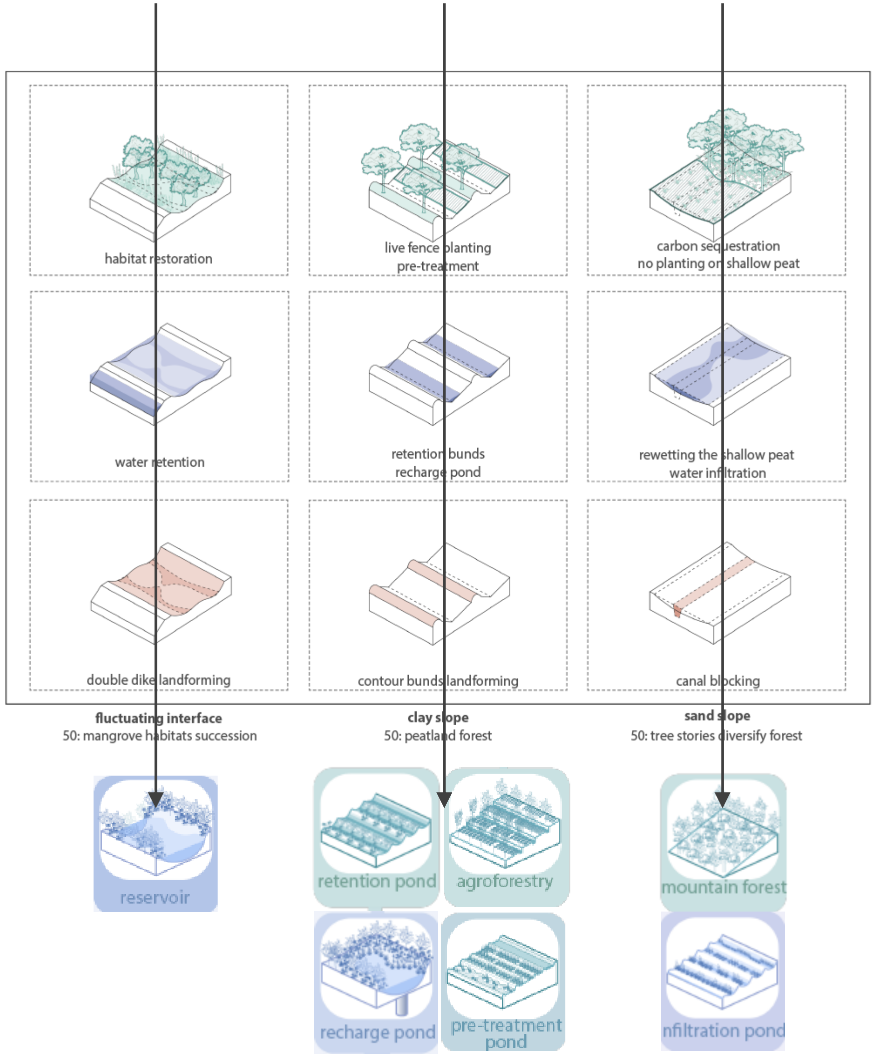




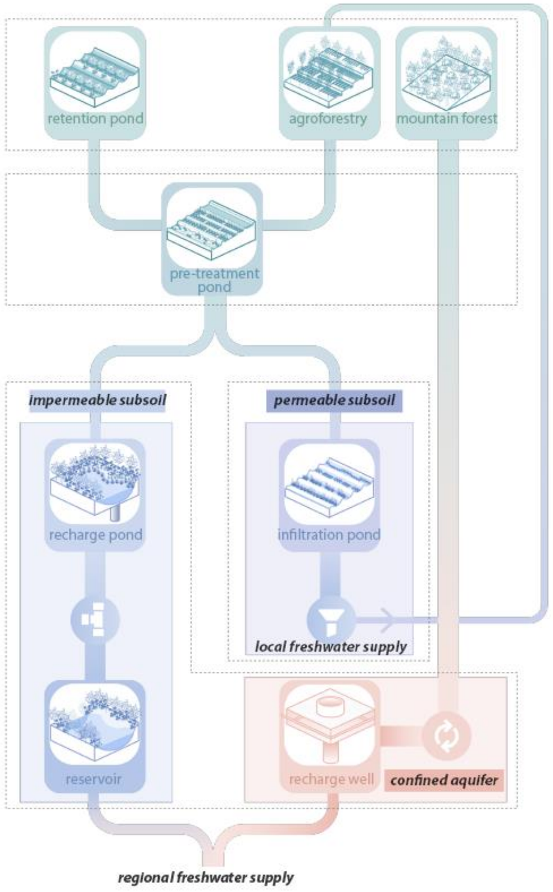
5.1 Mountain as the water tower of the PRD

Existing water flow system of the mountain





proposed water flow system of the mountain



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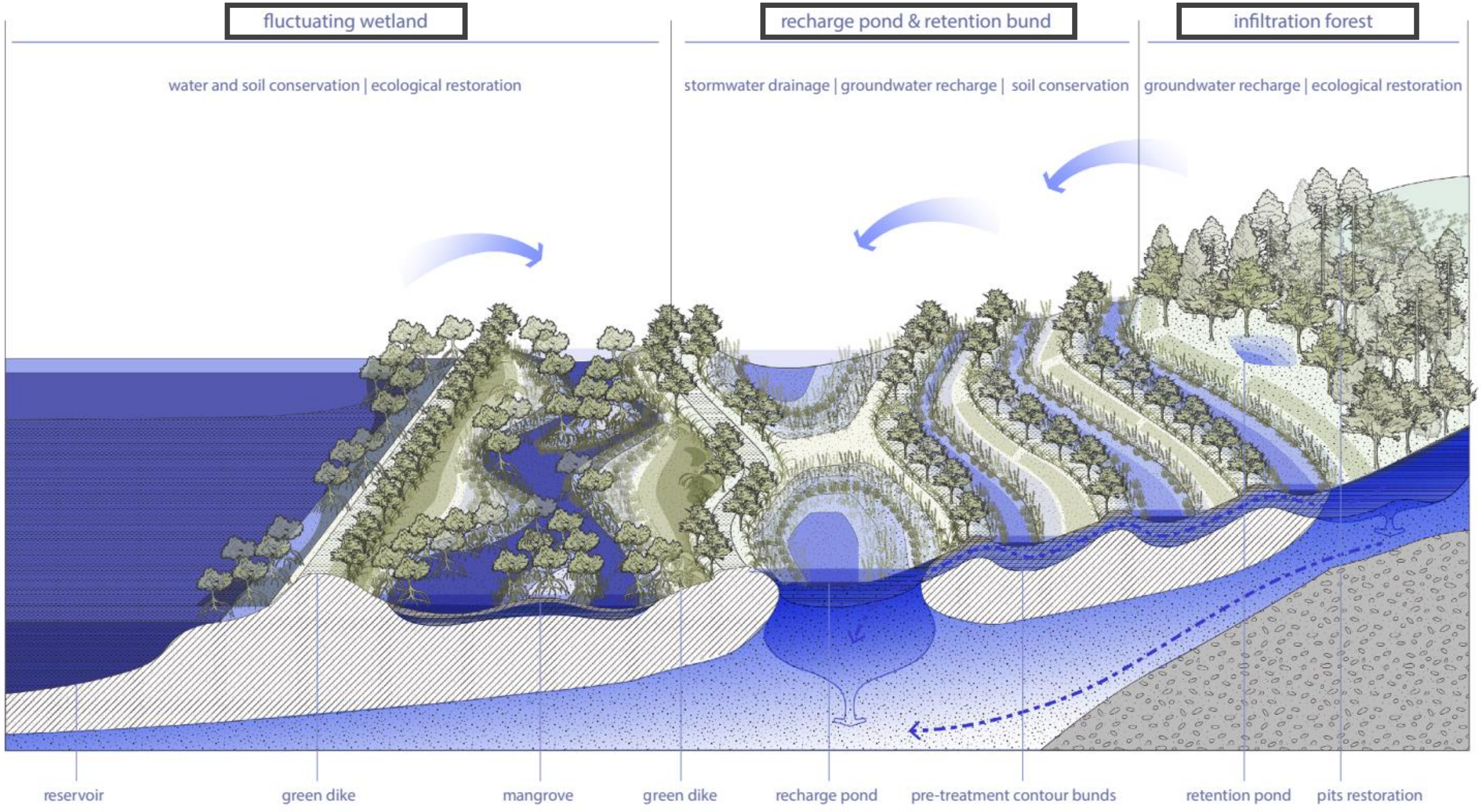
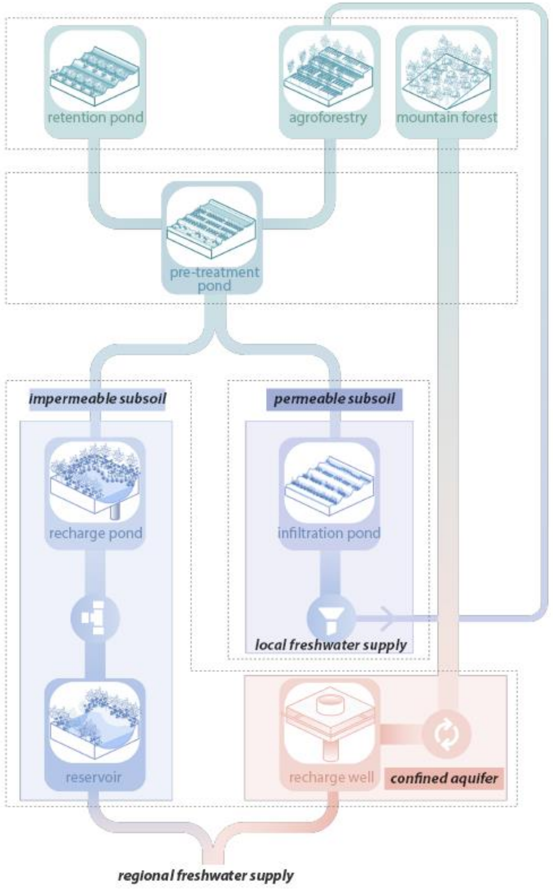


proposed water flow system of the mountain



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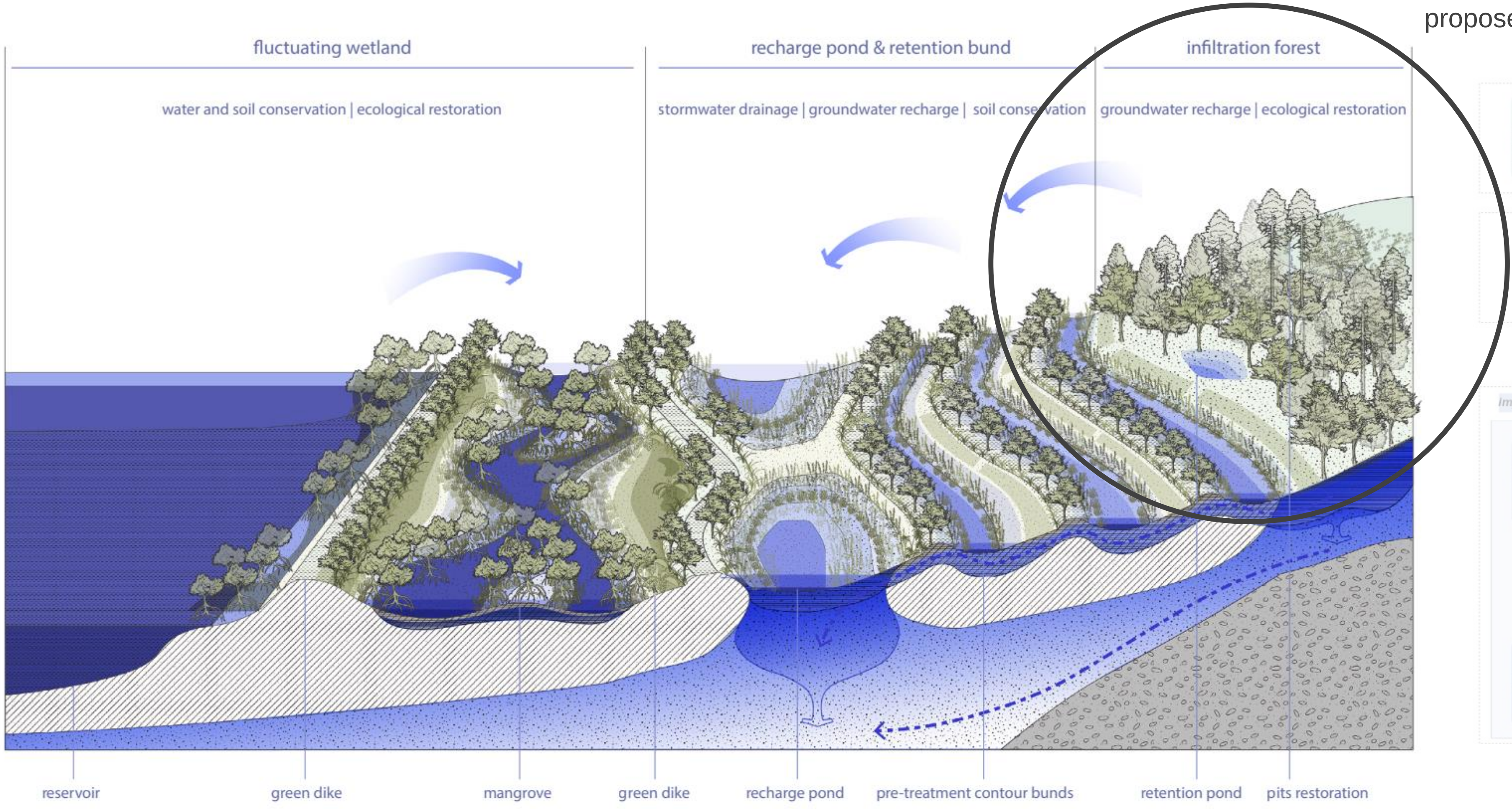
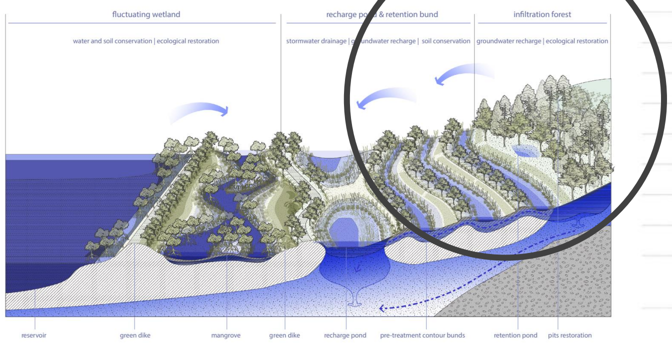


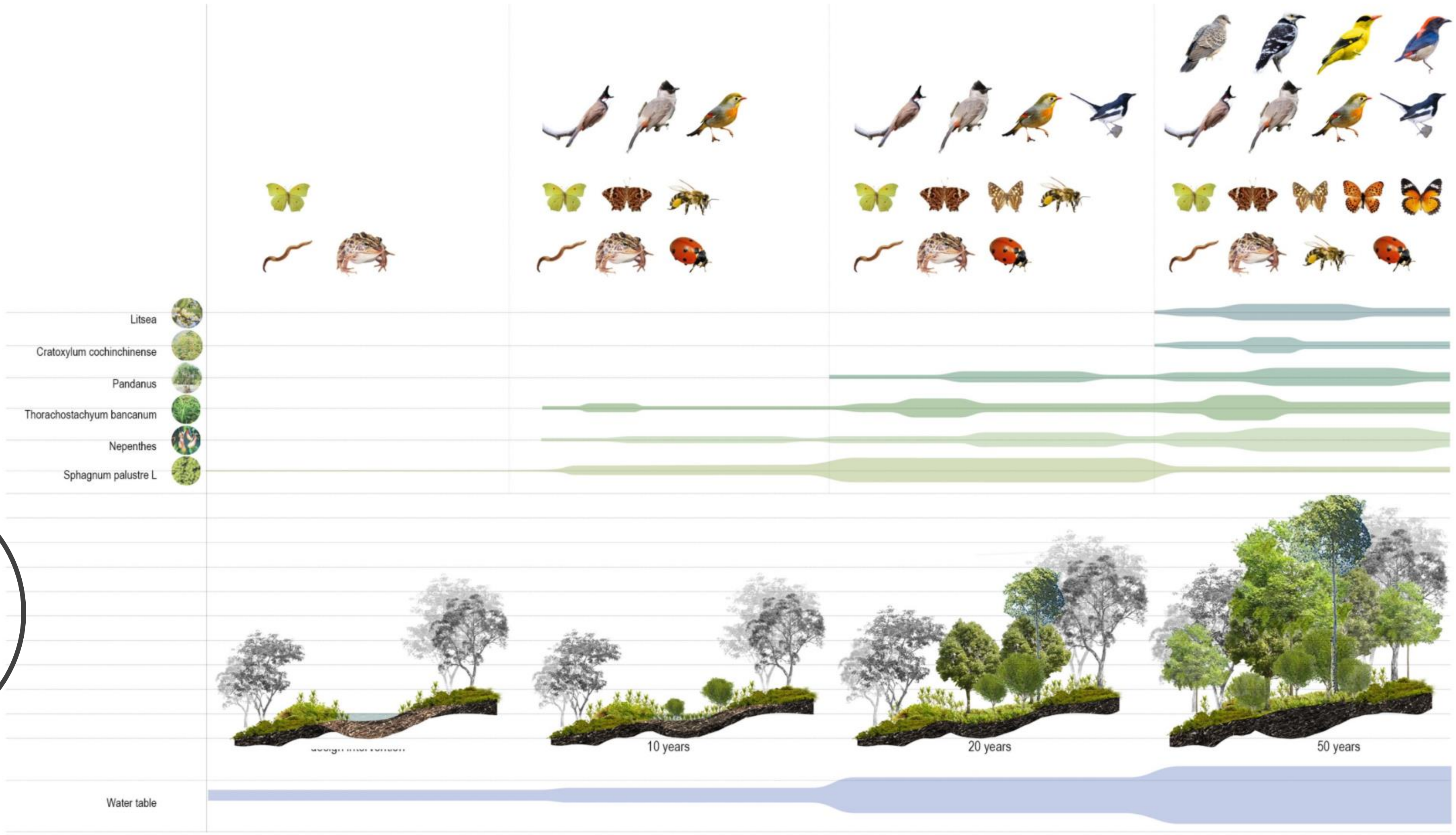
proposed water flow system of the mountain

5.1 Mountain as the water tower of the PRD

Slope degree: >10°   peat   broken topsoil with shallow/no peat   Sandy loam

5.1 Mountain as the water tower of the PRD





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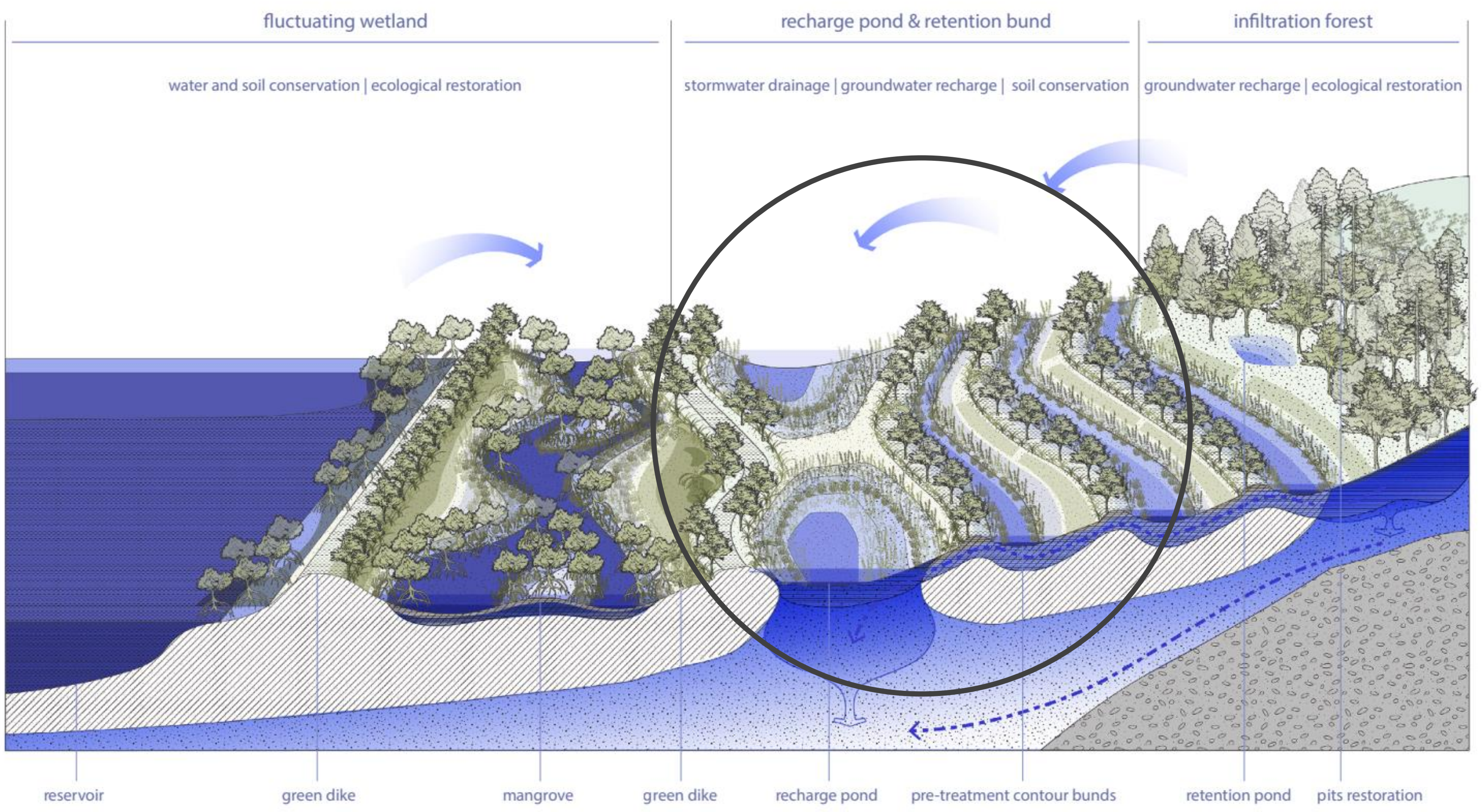
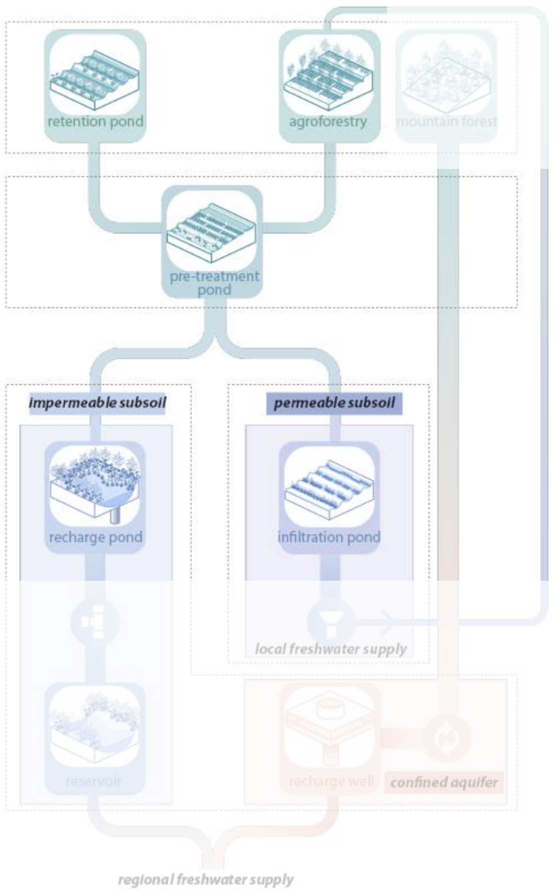


proposed water flow system of the mountain



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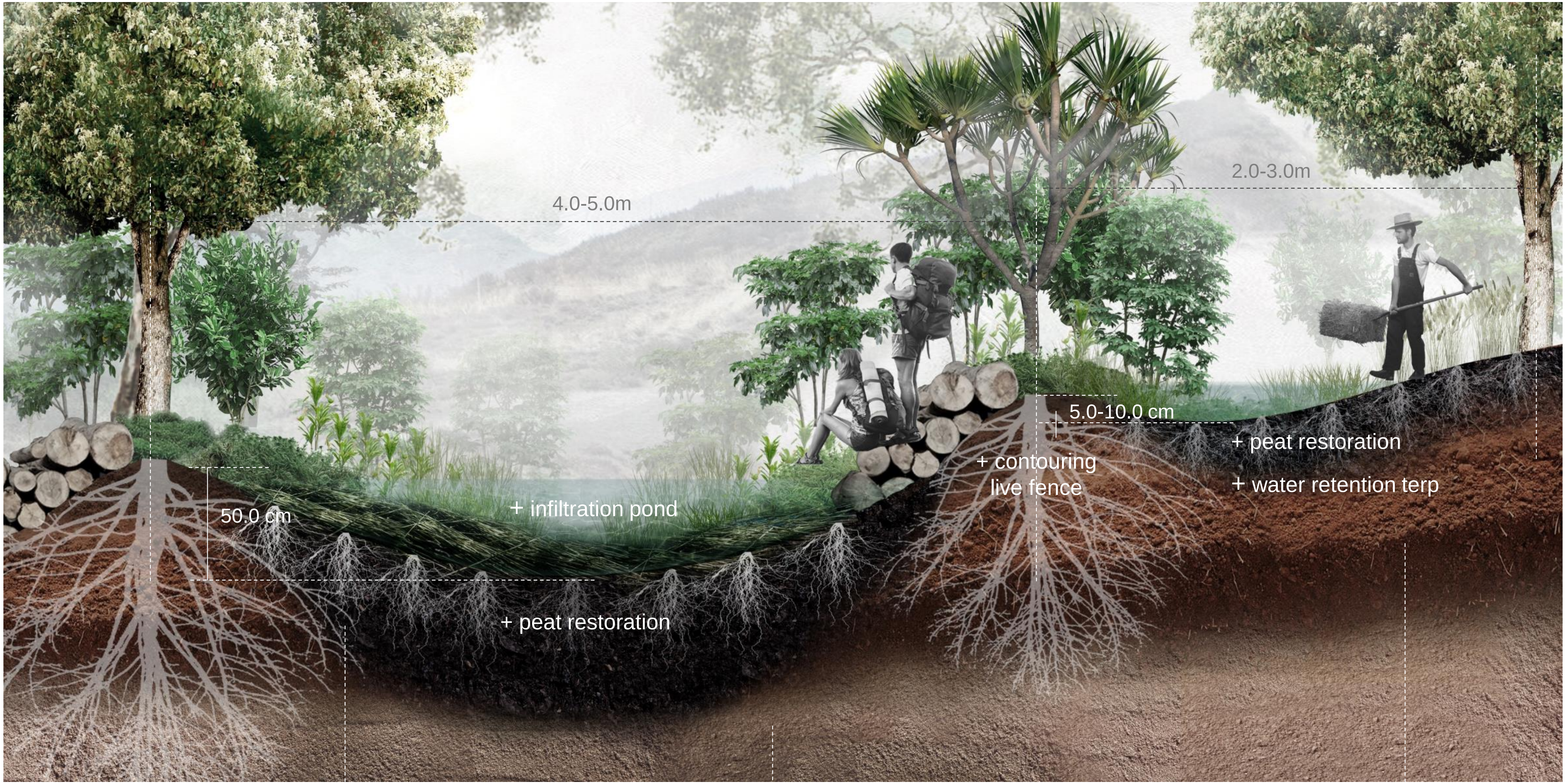


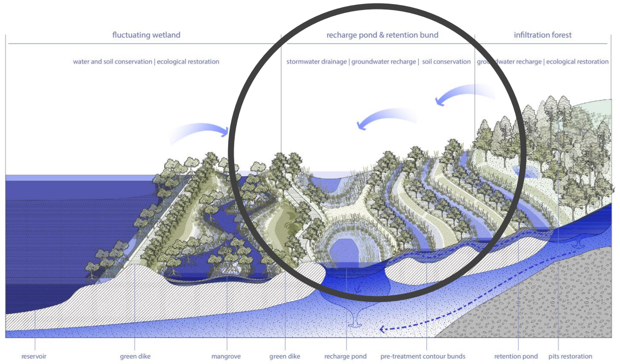
Slope degree: 5-7°

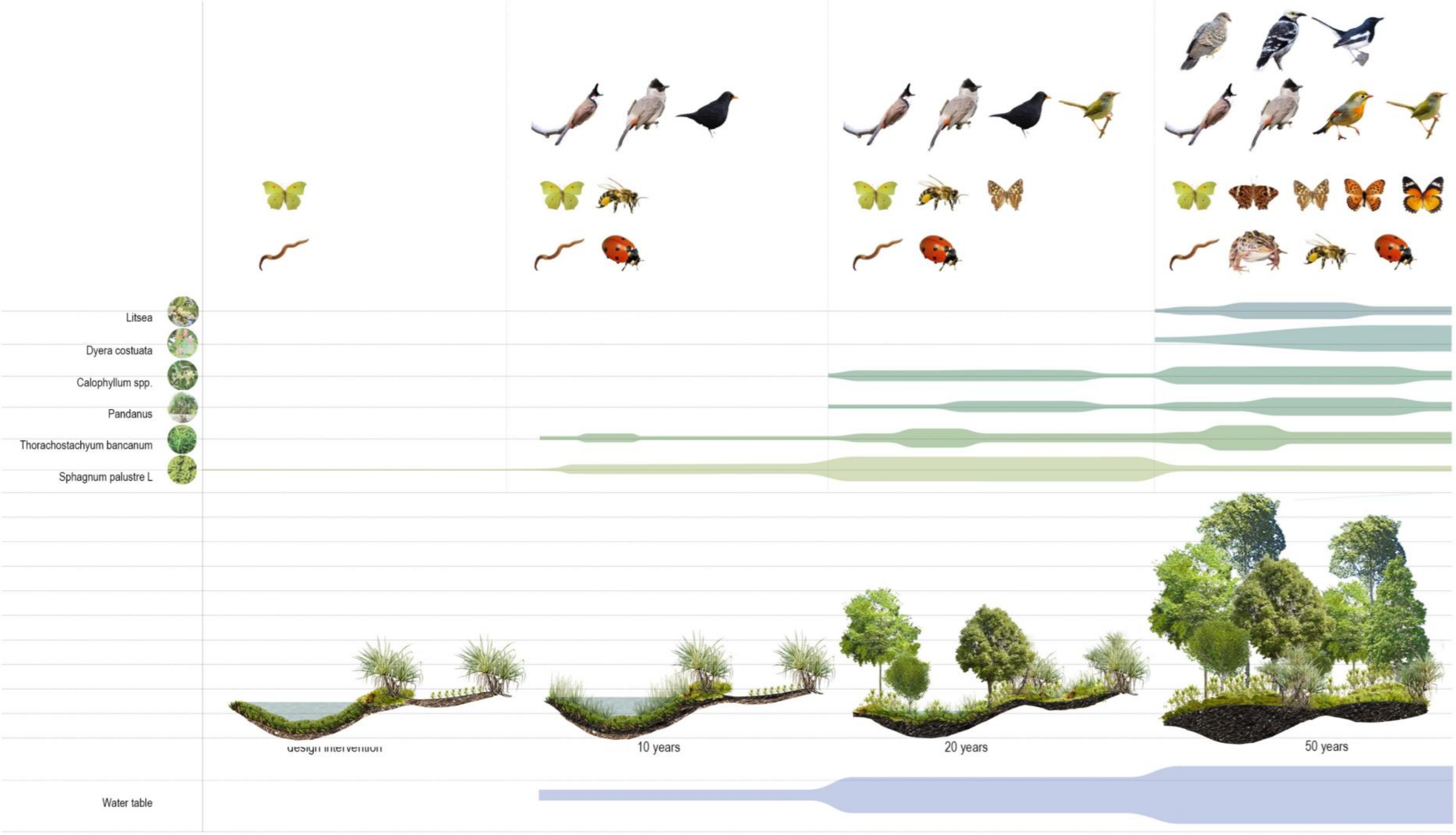
peat

Sand loam

clay

5.1 Mountain as the water tower of the PRD





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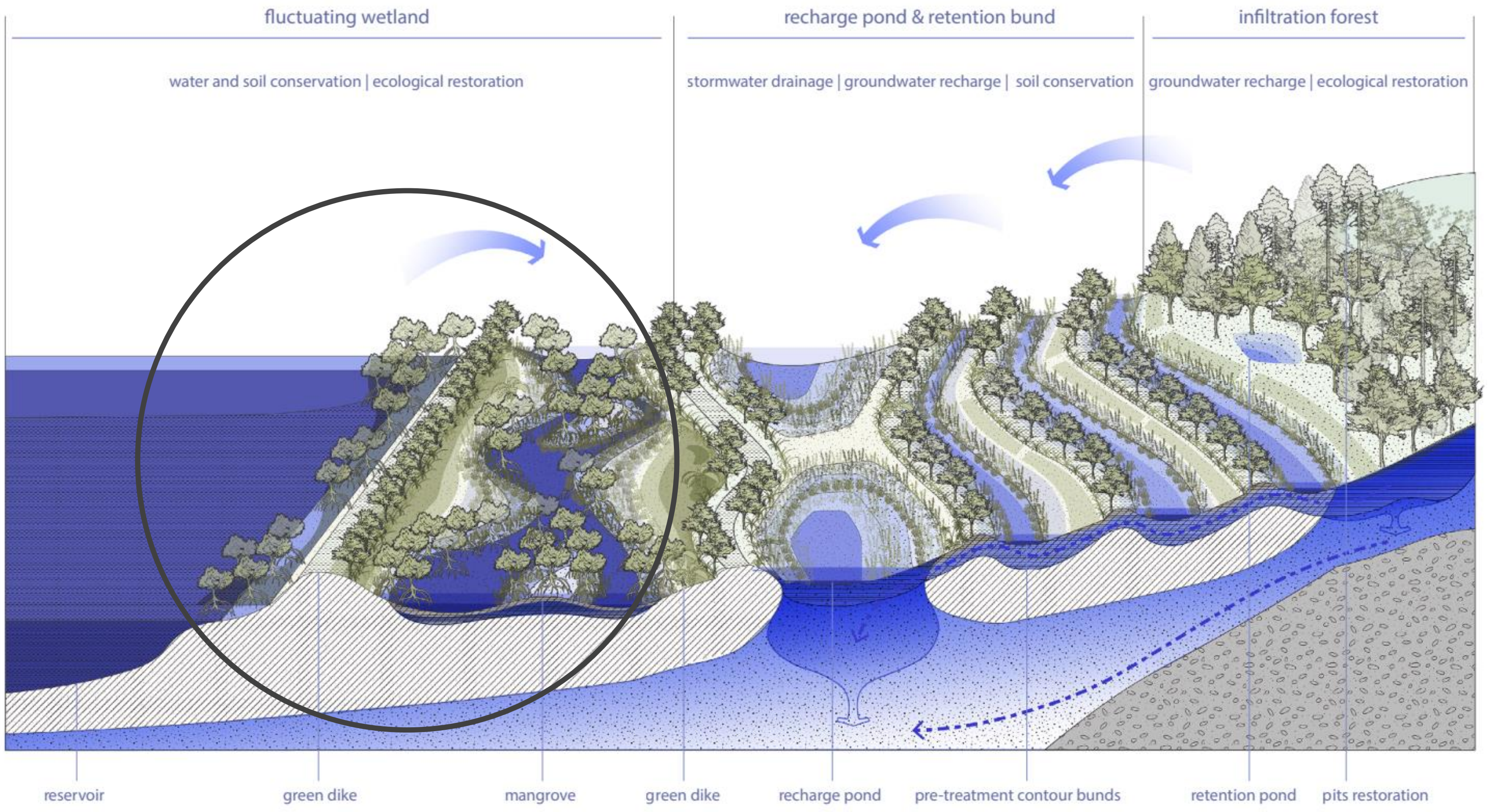
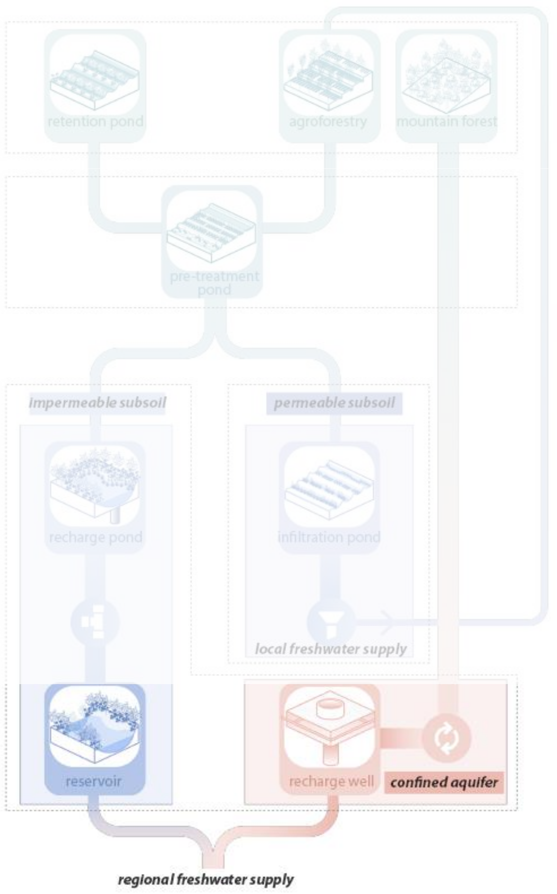
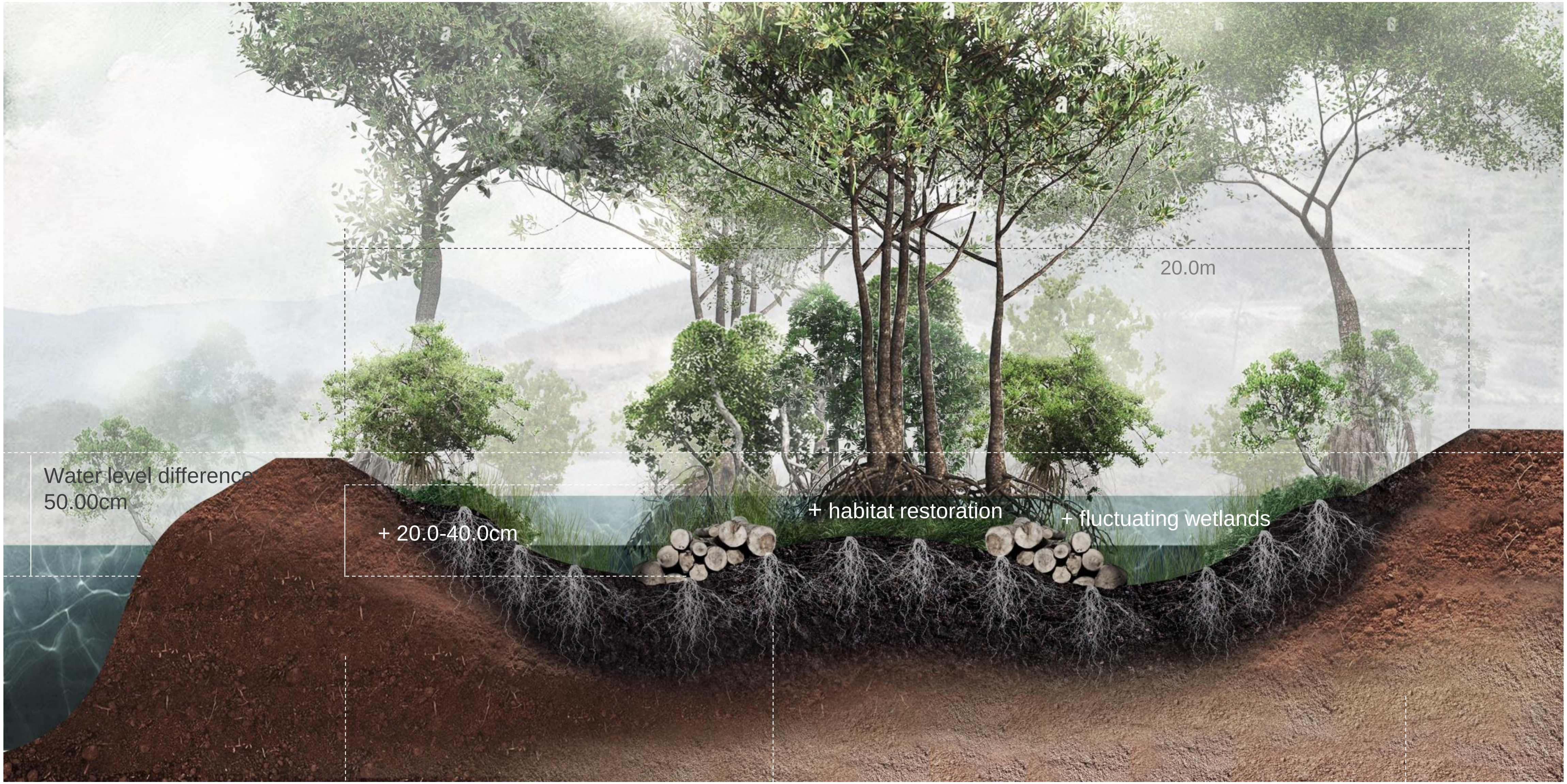


proposed water flow system of the mountain

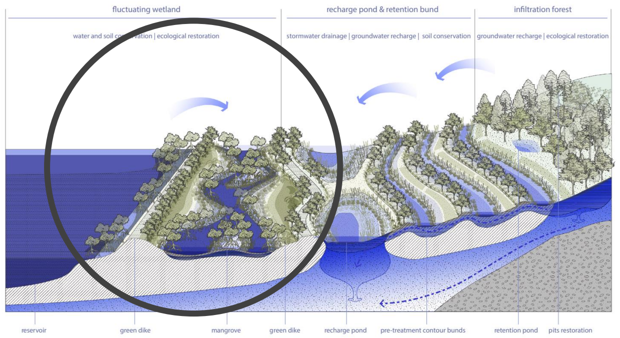


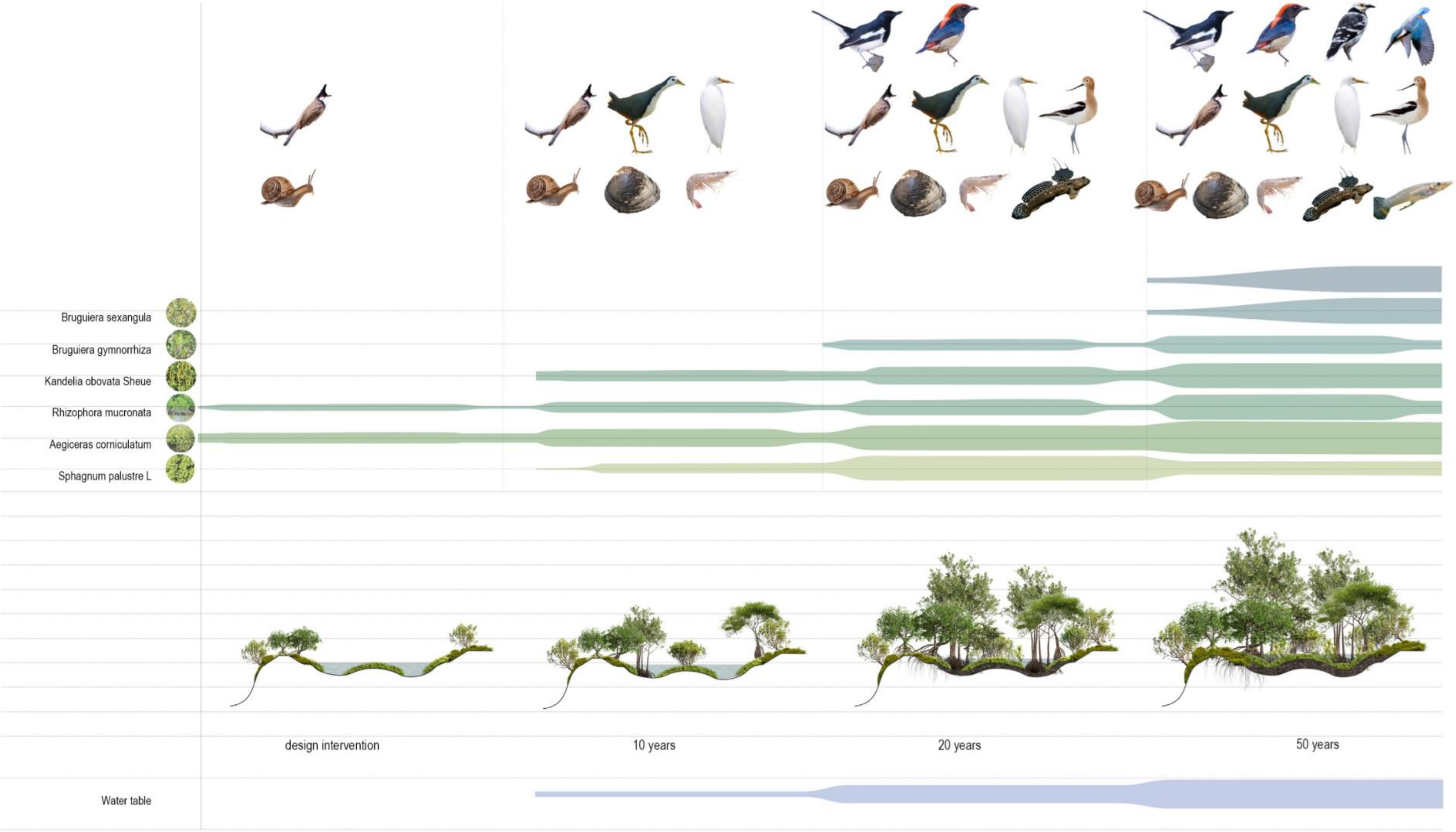
5.1 Mountain as the water tower of the PRD



Slope degree: 0-5° clay peat Sand loam

5.1 Mountain as the water tower of the PRD





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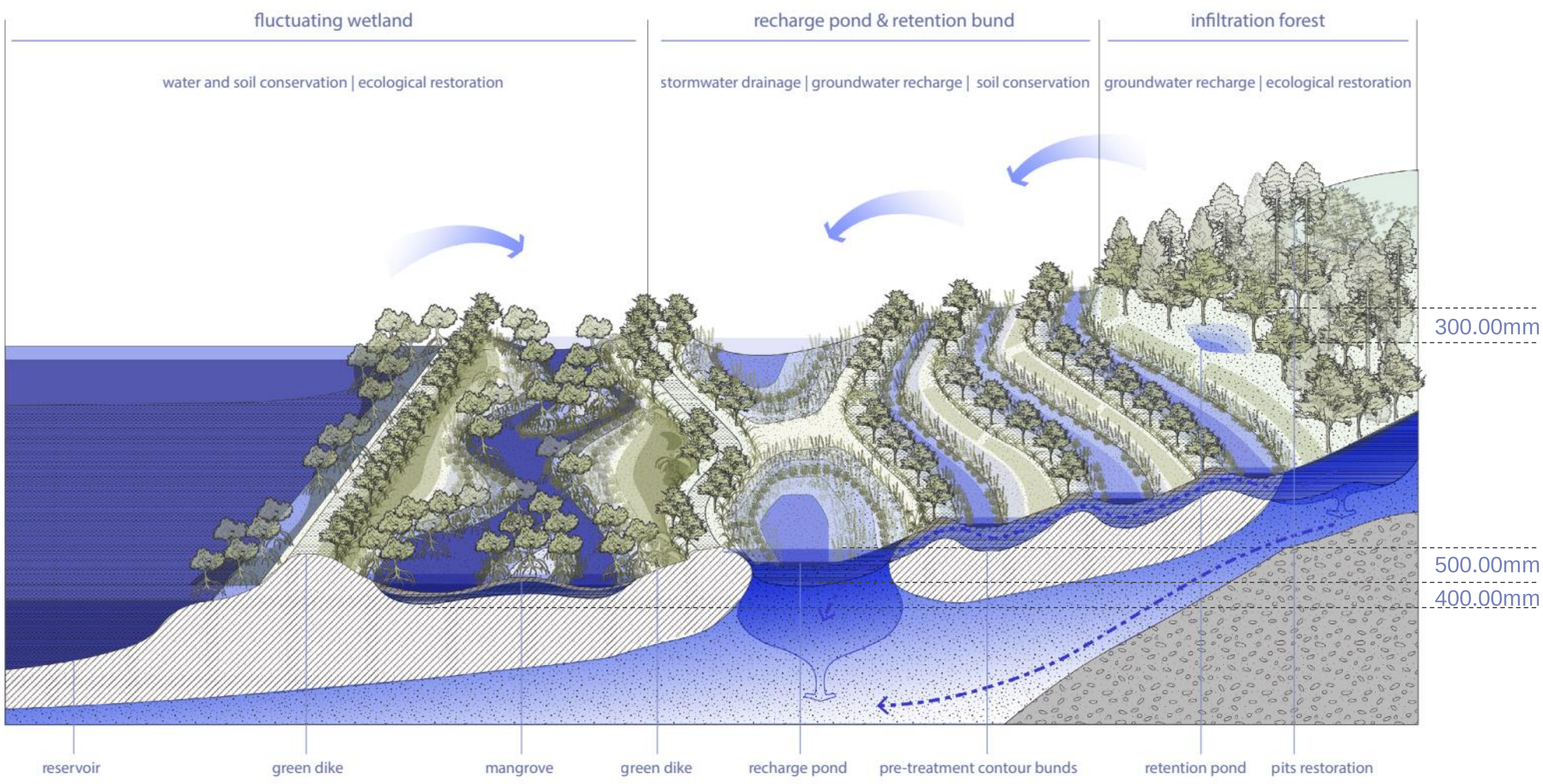


Surface runoff coefficient

d/p=c

Precipitation: 1792.00mm

Run-off depth: 925.00mm

Existing coefficient: 0.51

Infiltration forest 0.34

Recharge pond 0.23

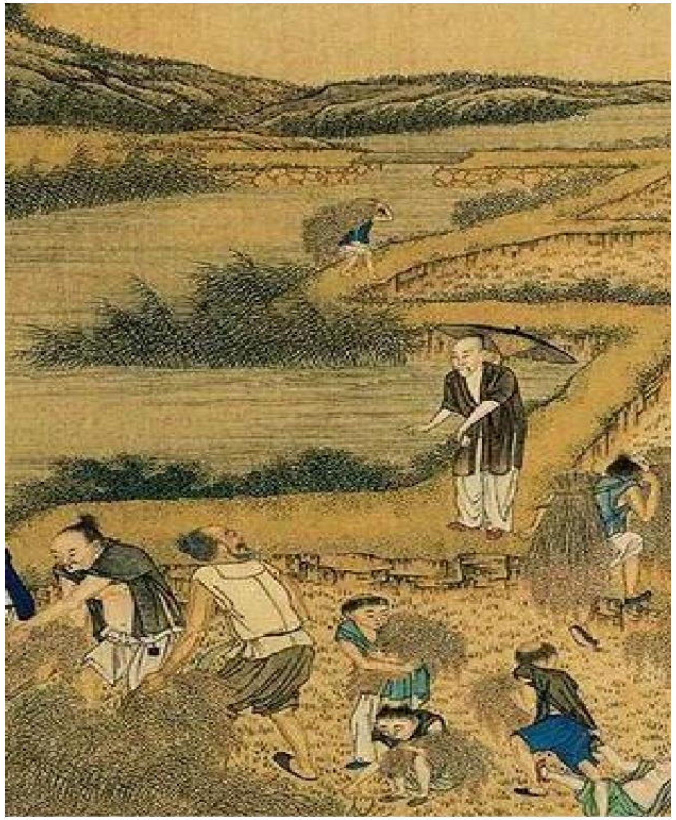
Fluctuating wetland 0.29

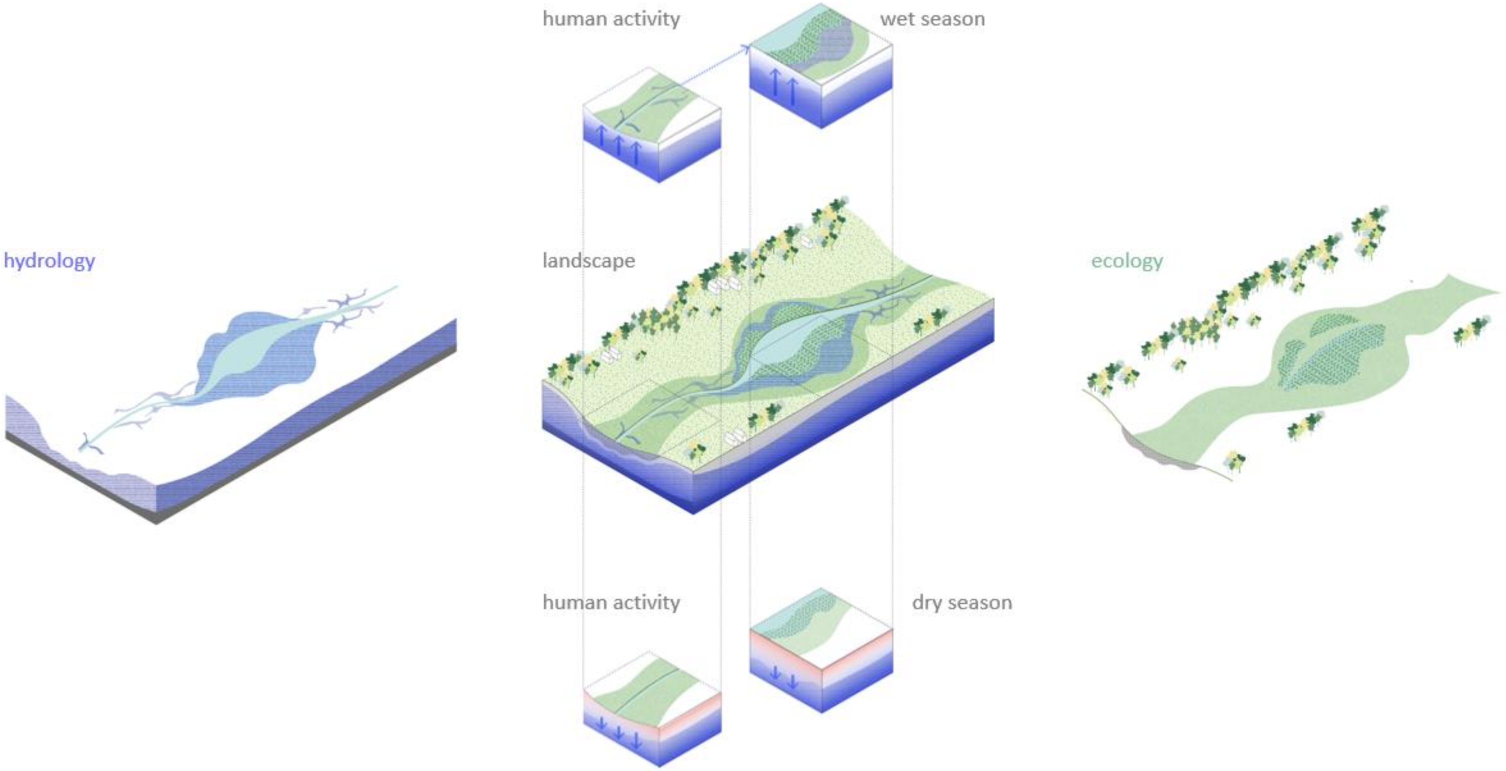
FLOOD PLAIN

5.2 Flood plain as the sponge of the PRD

2.2 Urban expansion as an accelerator of change in 21C

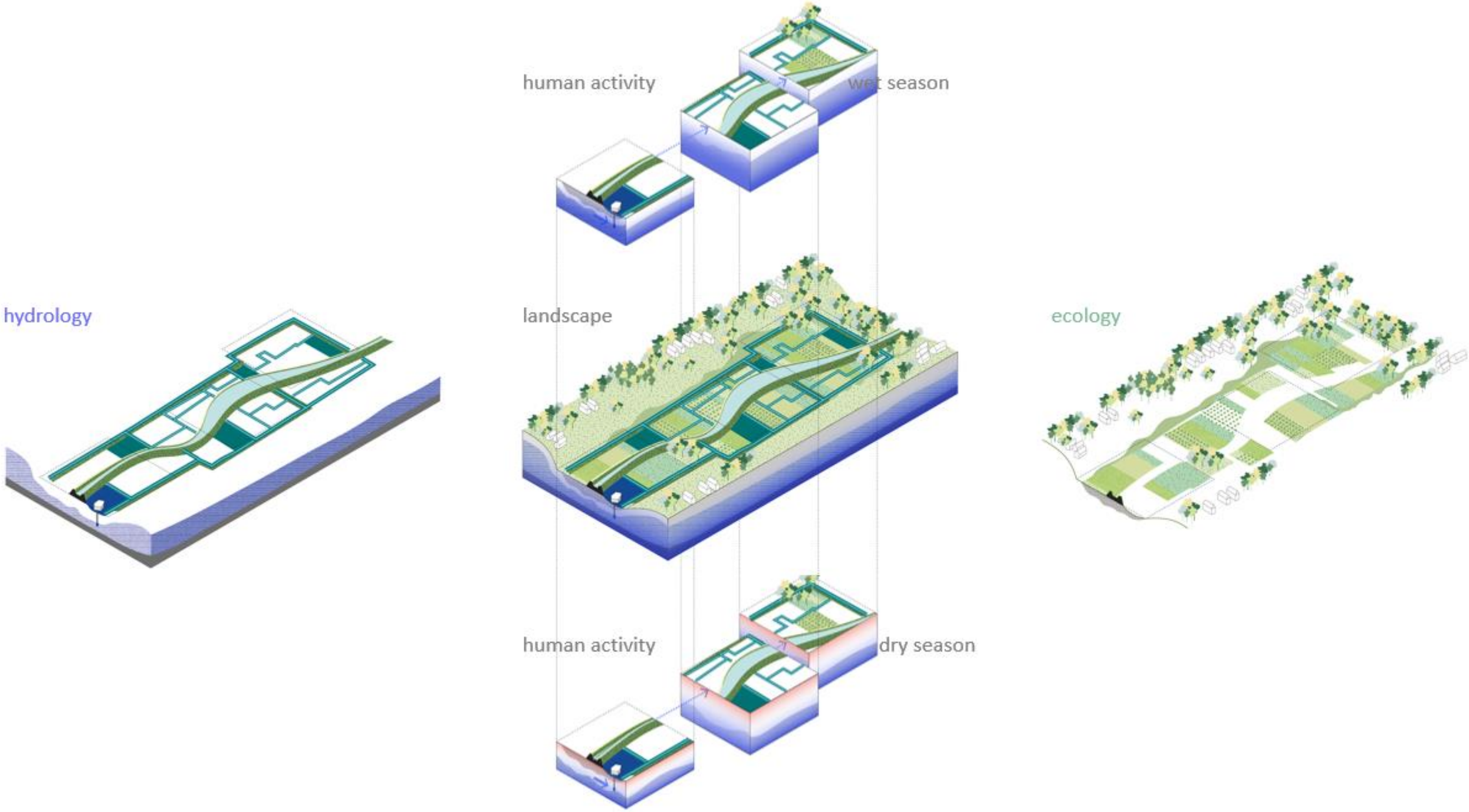
Biography study on the human-water relationship: phase1 (bc-1600s)
natural forces were dominant——rely on the groundwater spring and topsoil water





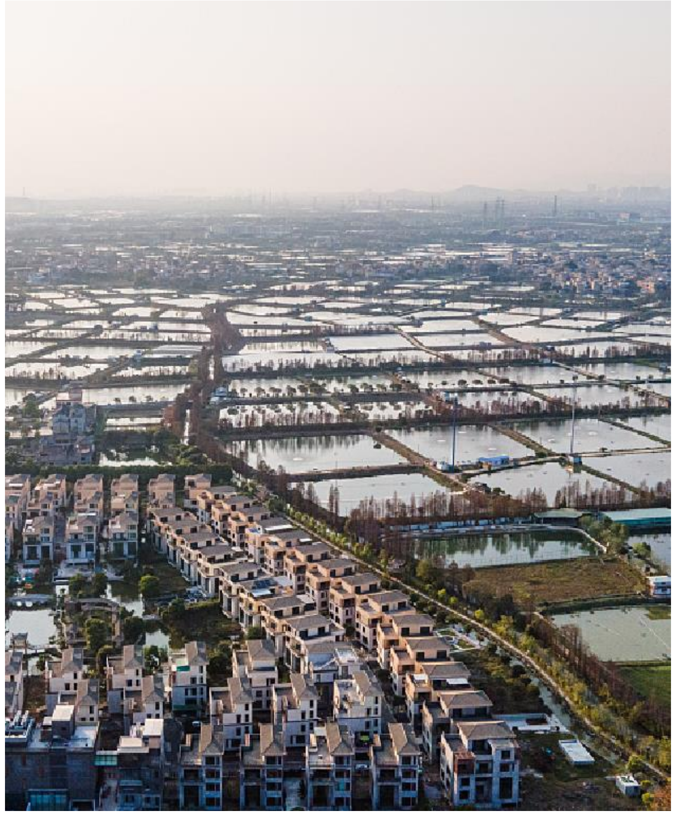
2.2 Urban expansion as an accelerator of change in 21C

Biography study on the human-water relationship: phase2 (1600s-1950s)
against the nature——rely on the water infrastructure networks

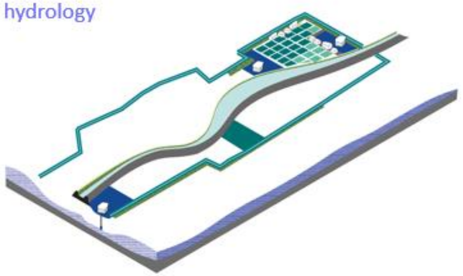


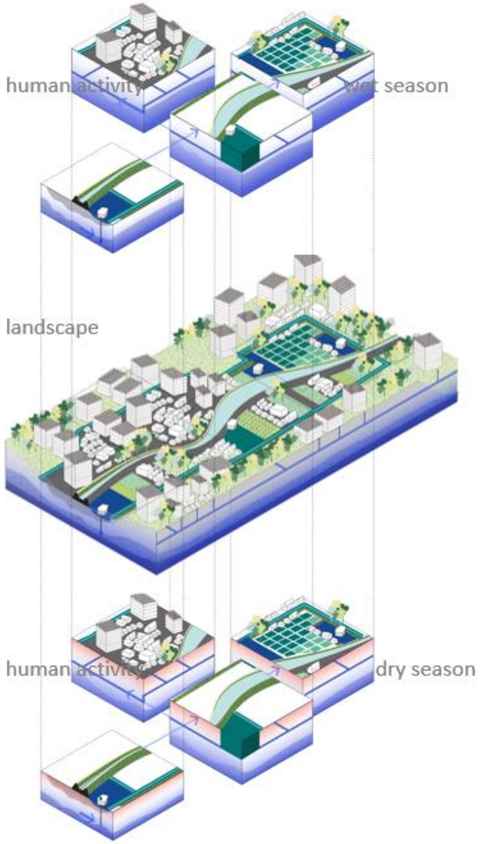
2.2 Urban expansion as an accelerator of change in 21C

Biography study on the human-water relationship: phase3 (1950s-present)
rely on the large-scale dike system: increasing groundwater extraction

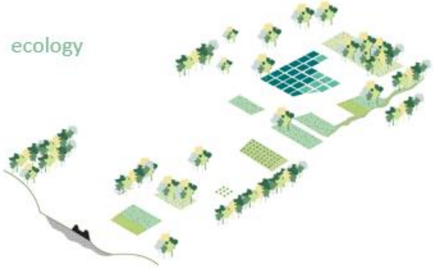


hydrology

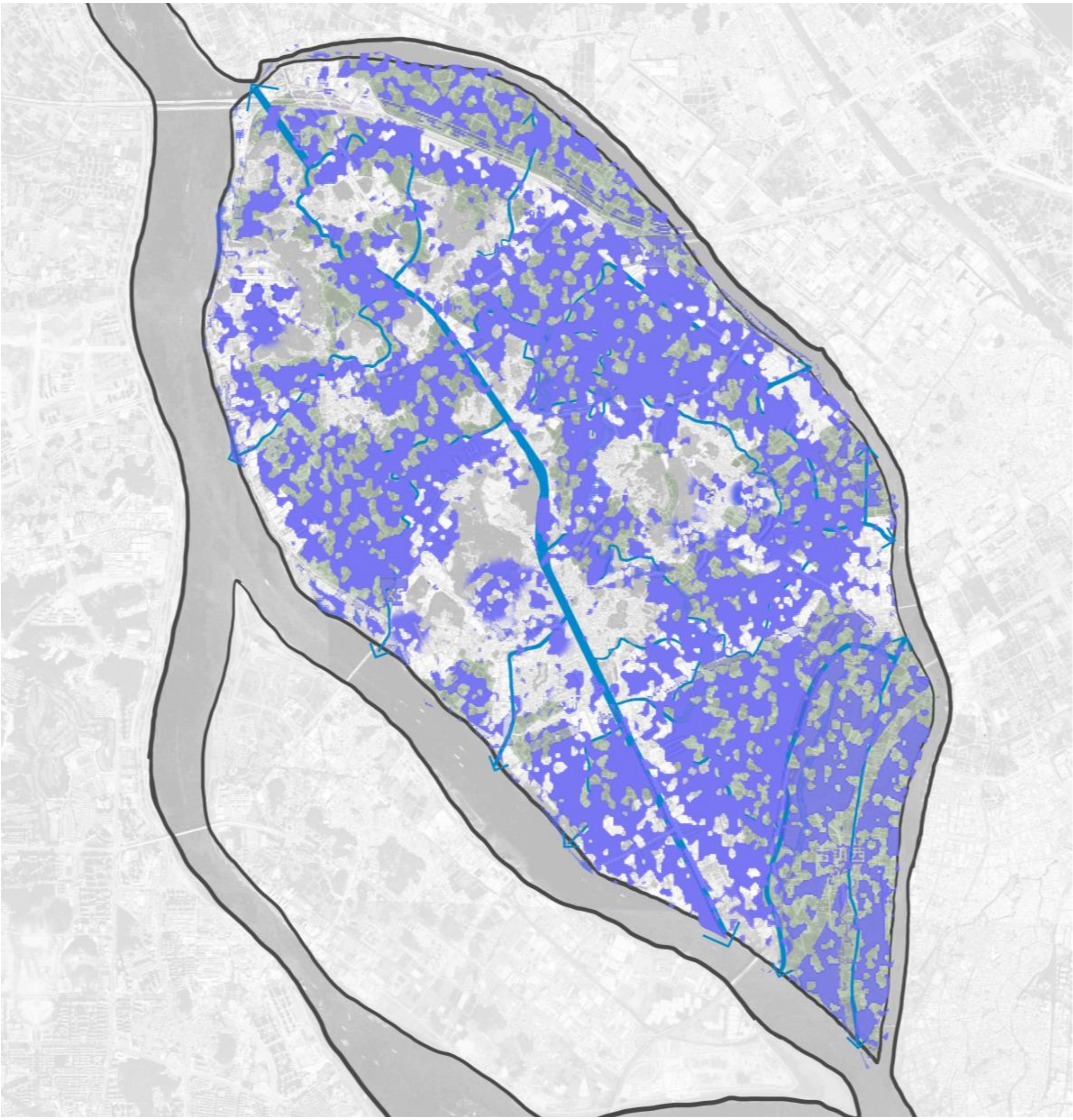




ecology



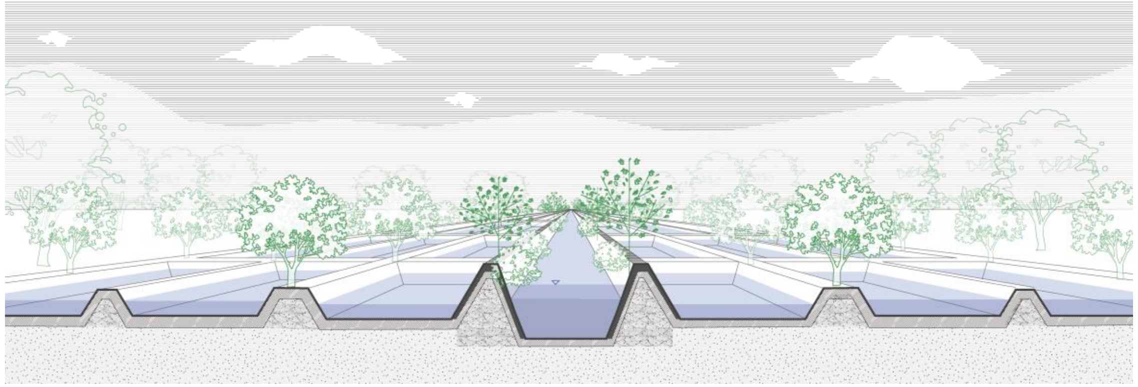
5.2 Flood plain as the sponge of the PRD



5.2 Flood plain as the sponge of the PRD

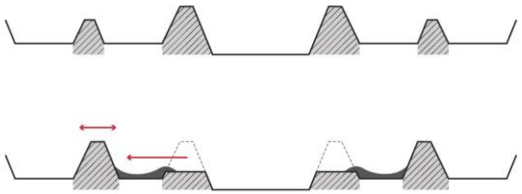
before

after

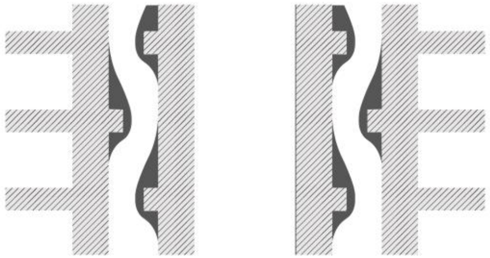


5.2 Flood plain as the sponge of the PRD

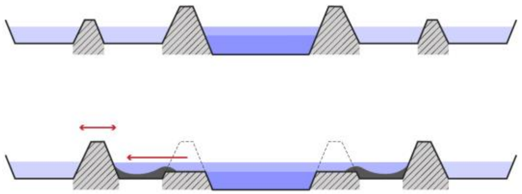
topography



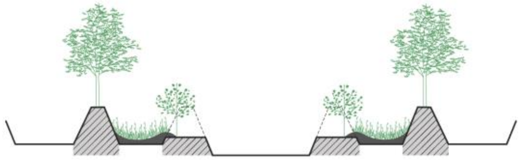
soil



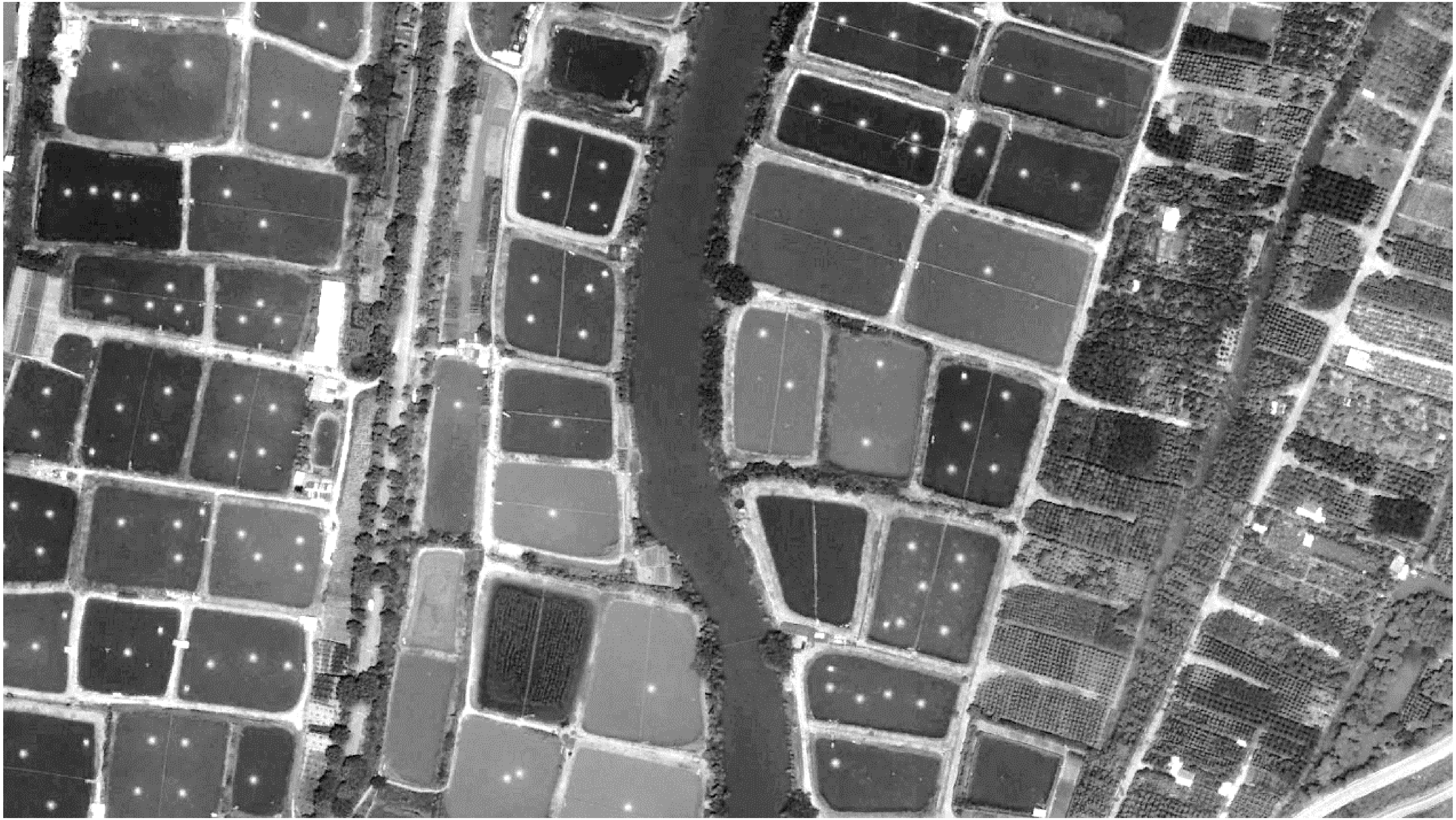
hydrology



ecology



5.2 Flood plain as the sponge of the PRD



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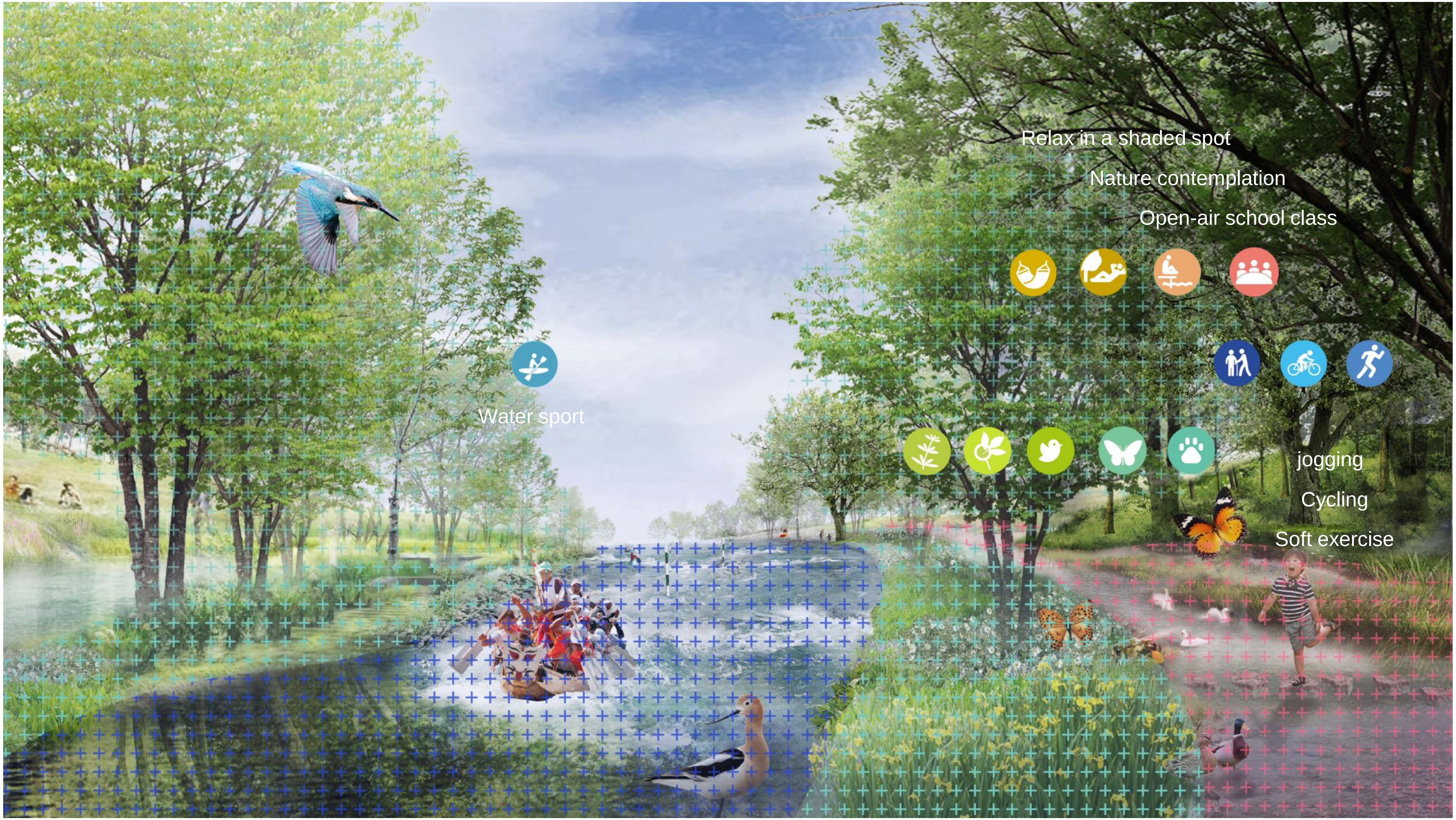
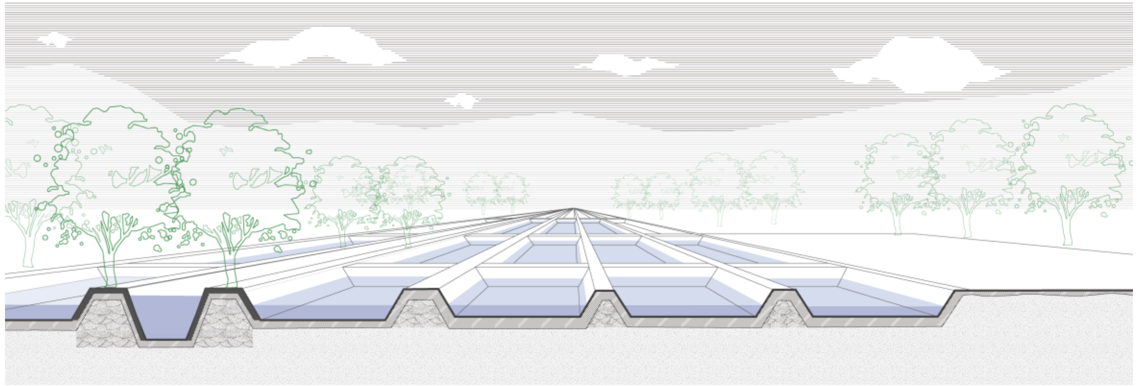
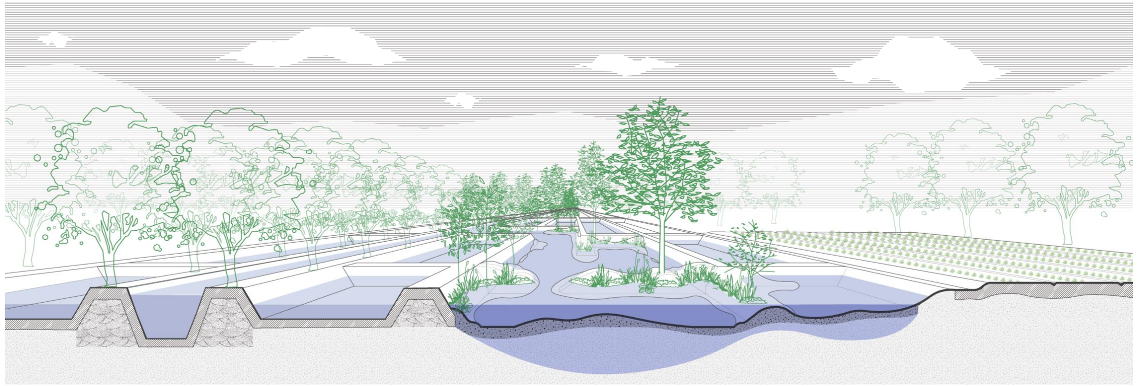


5.2 Flood plain as the sponge of the PRD

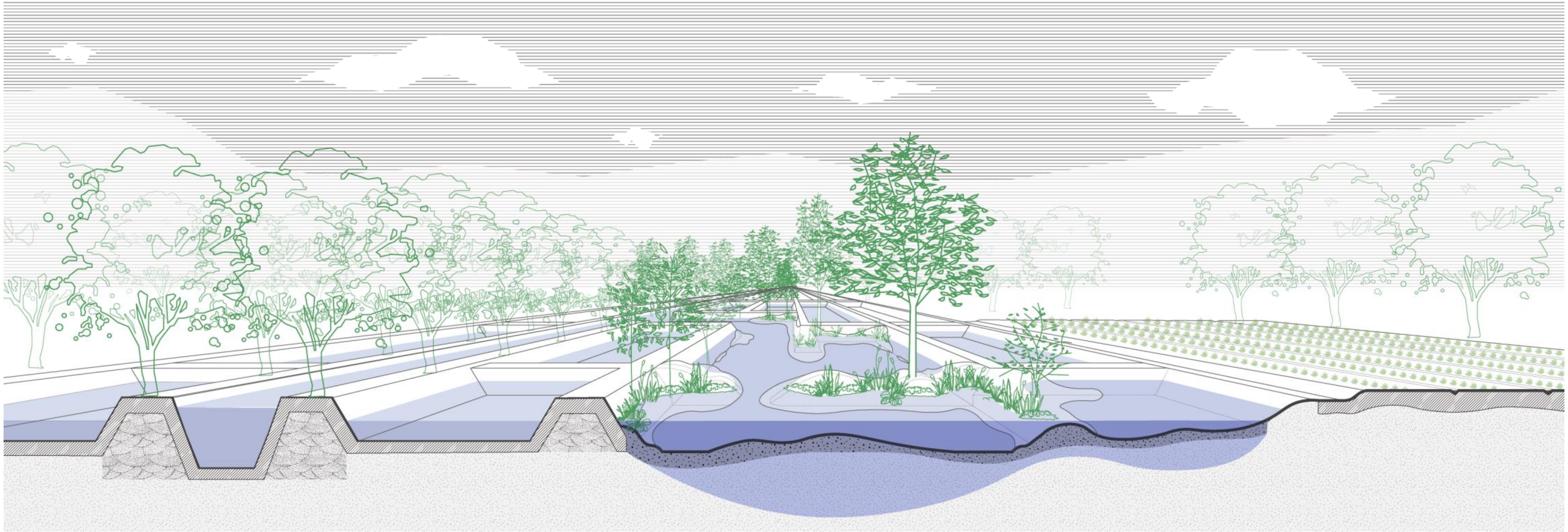
before

after

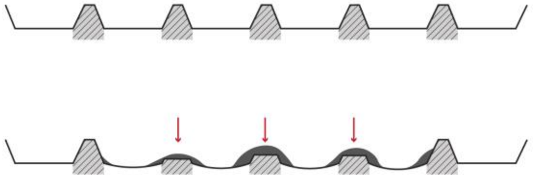




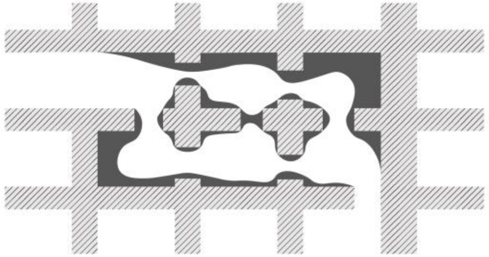
5.2 Flood plain as the sponge of the PRD



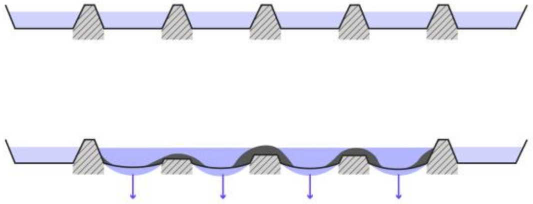
topography



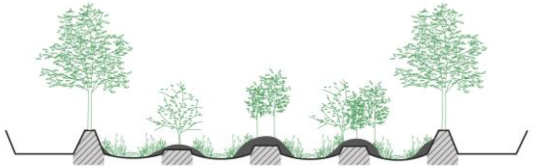
soil



hydrology



ecology



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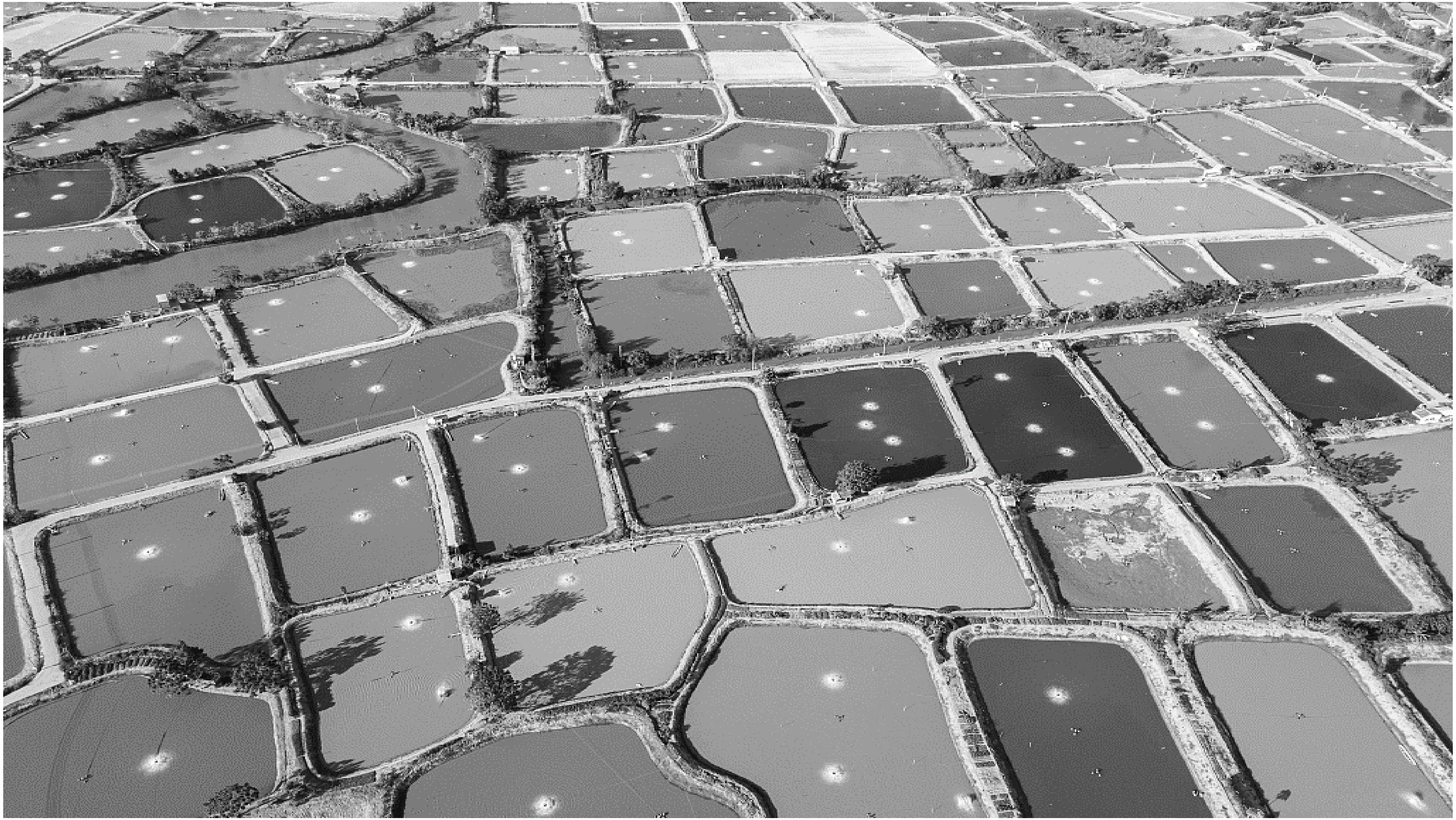

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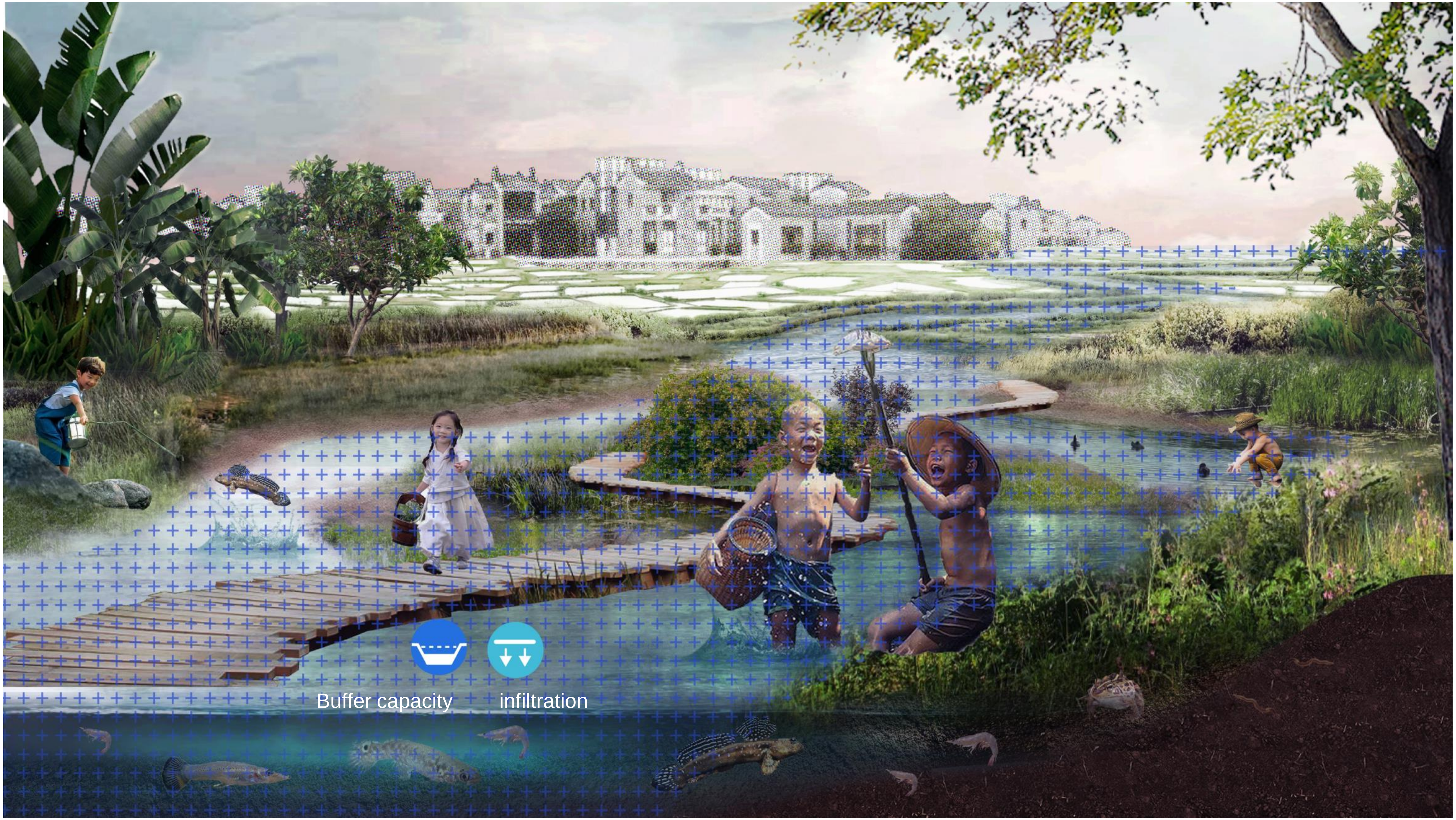

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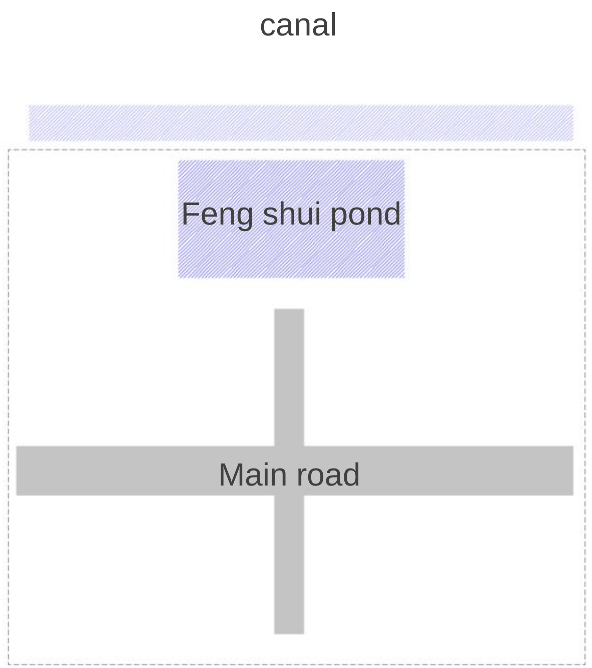

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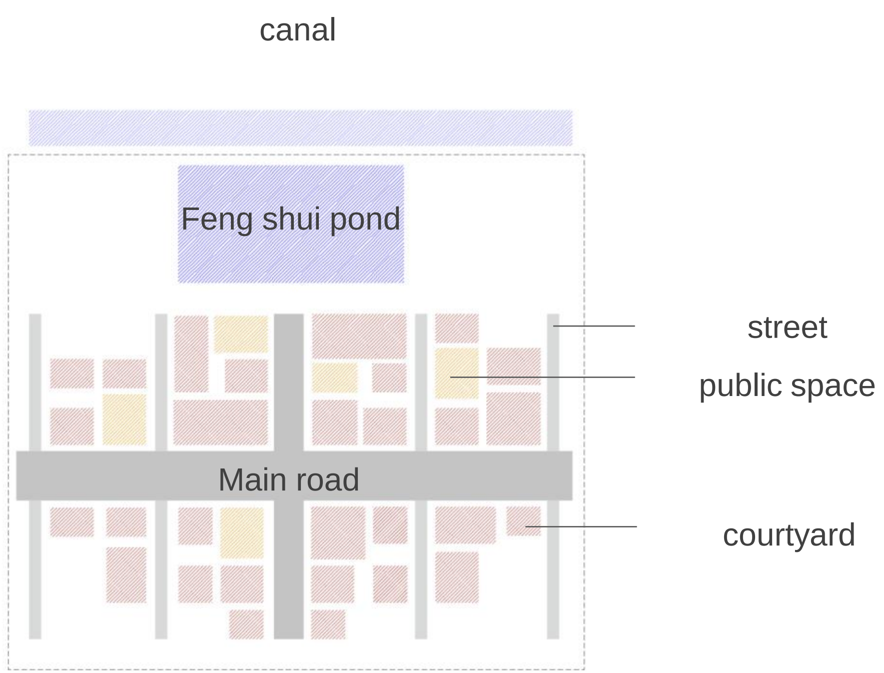

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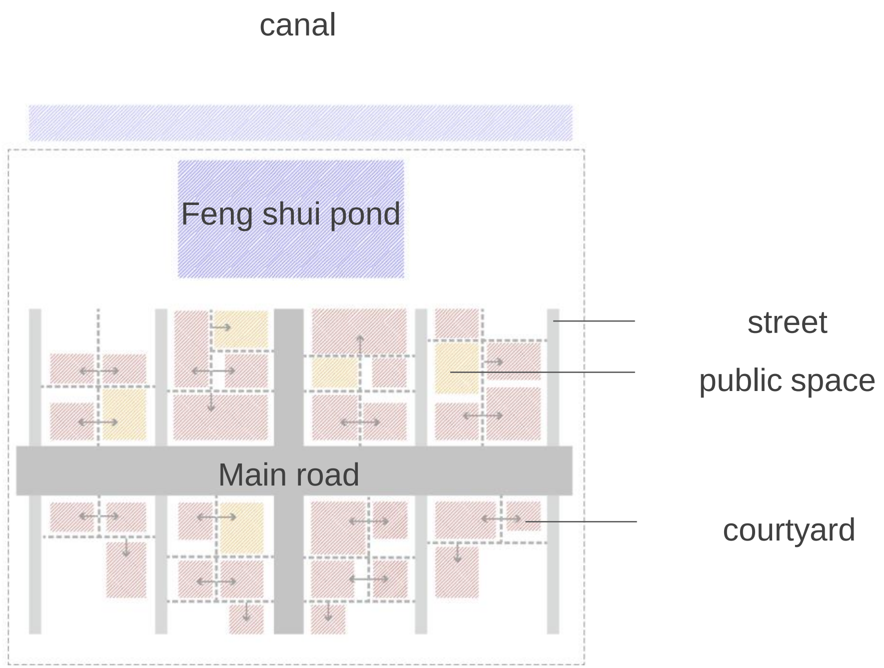

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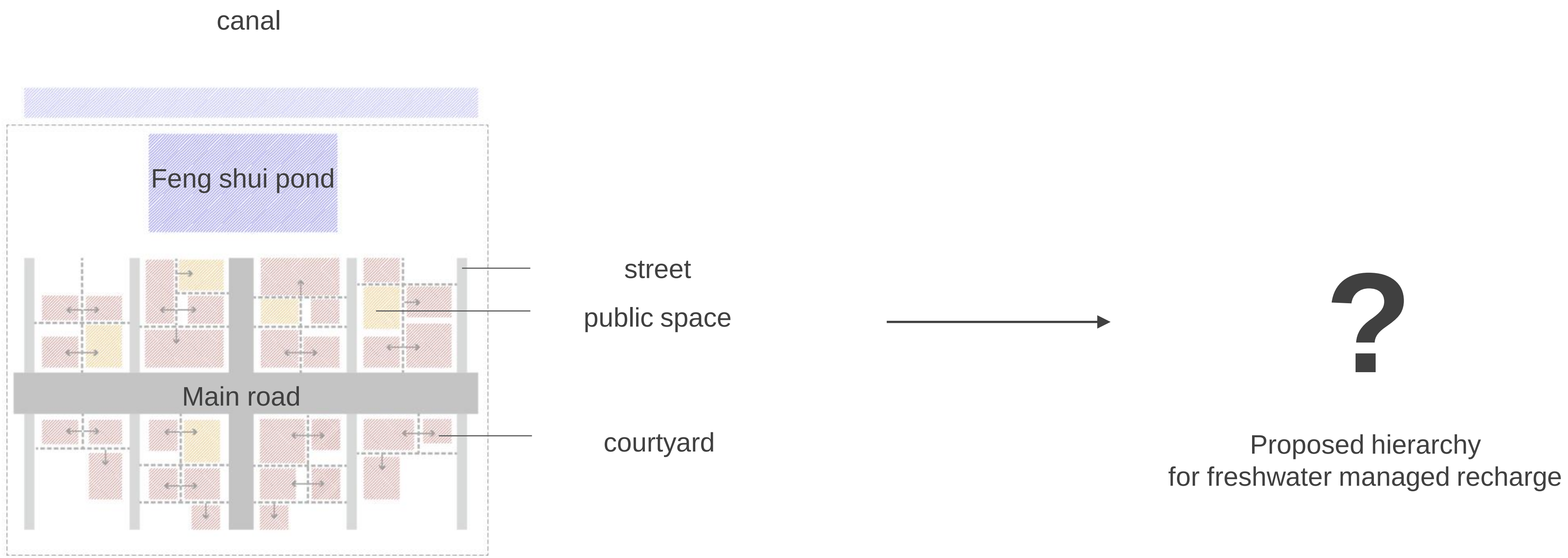

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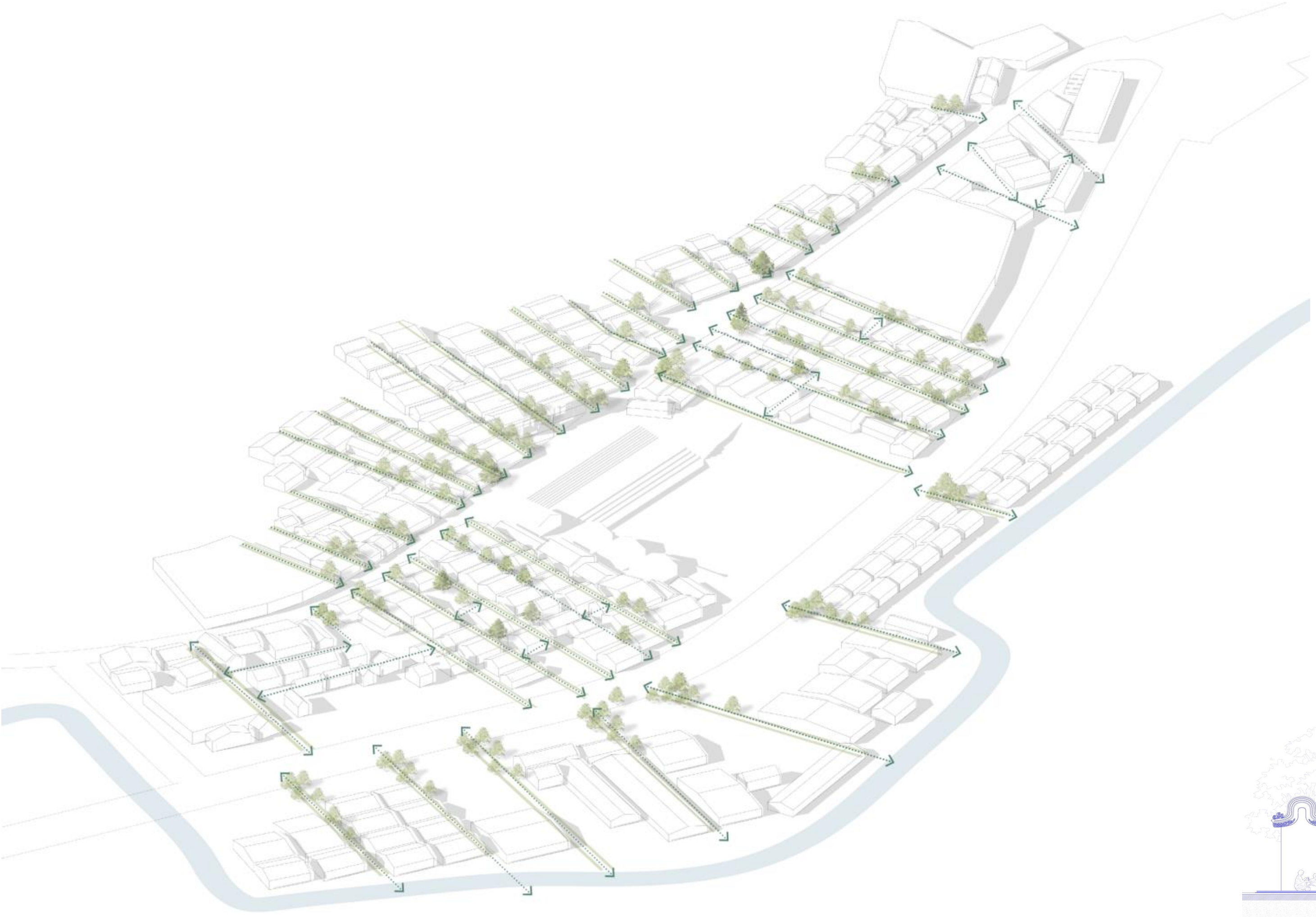

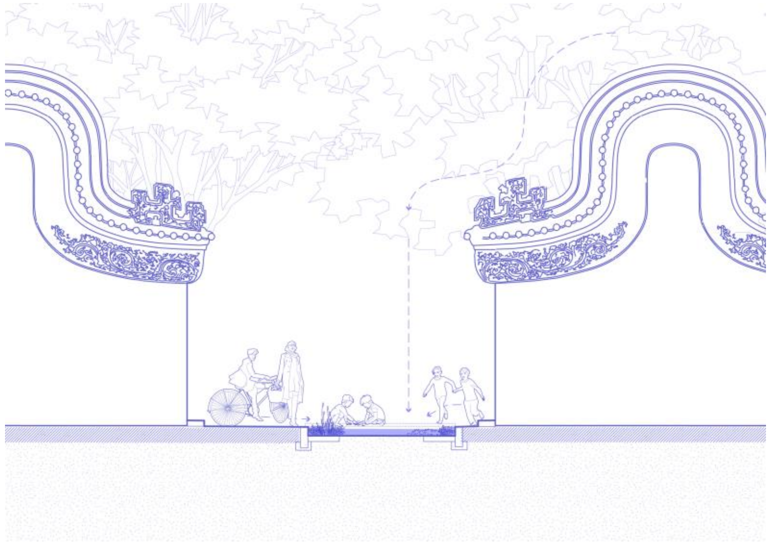

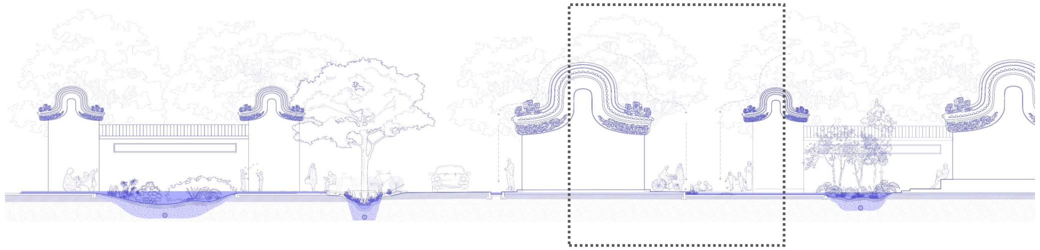

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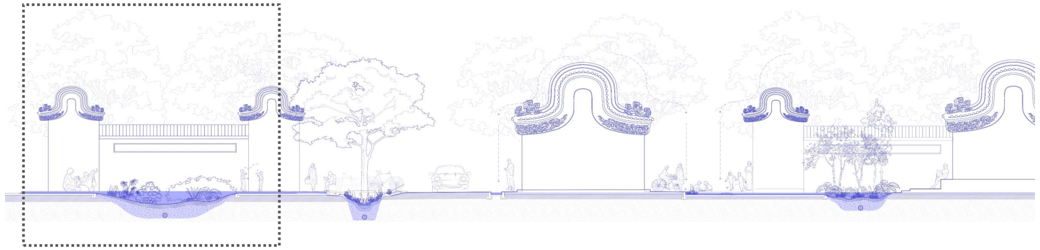

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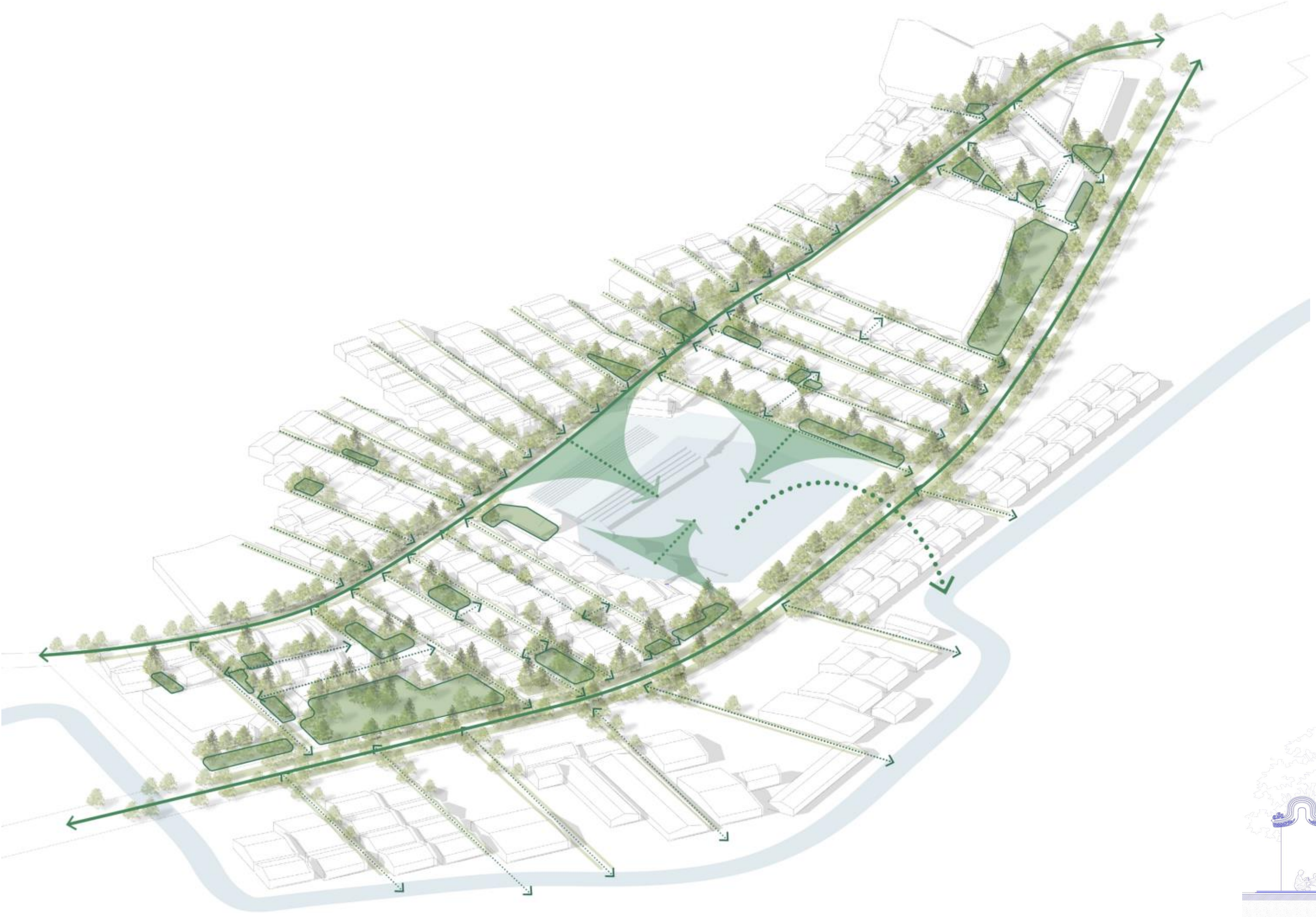

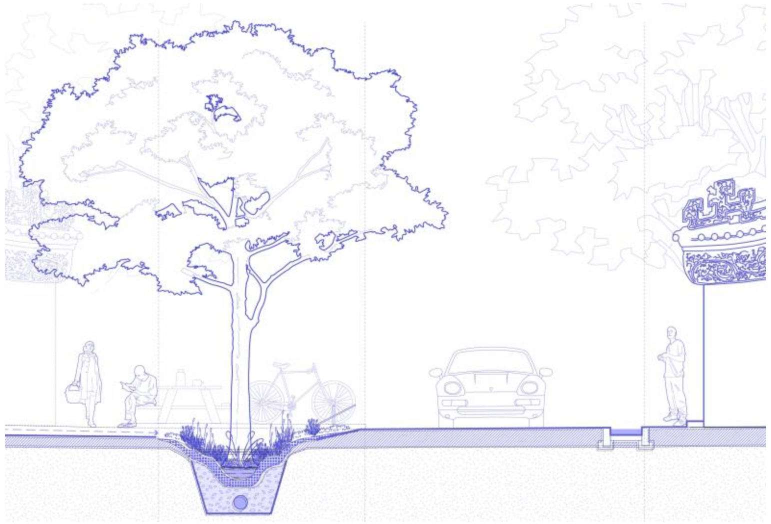

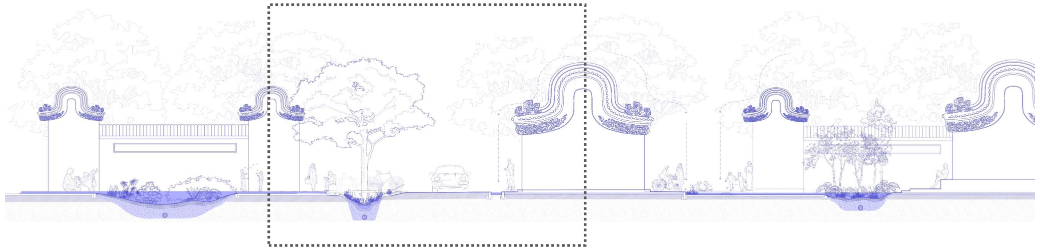

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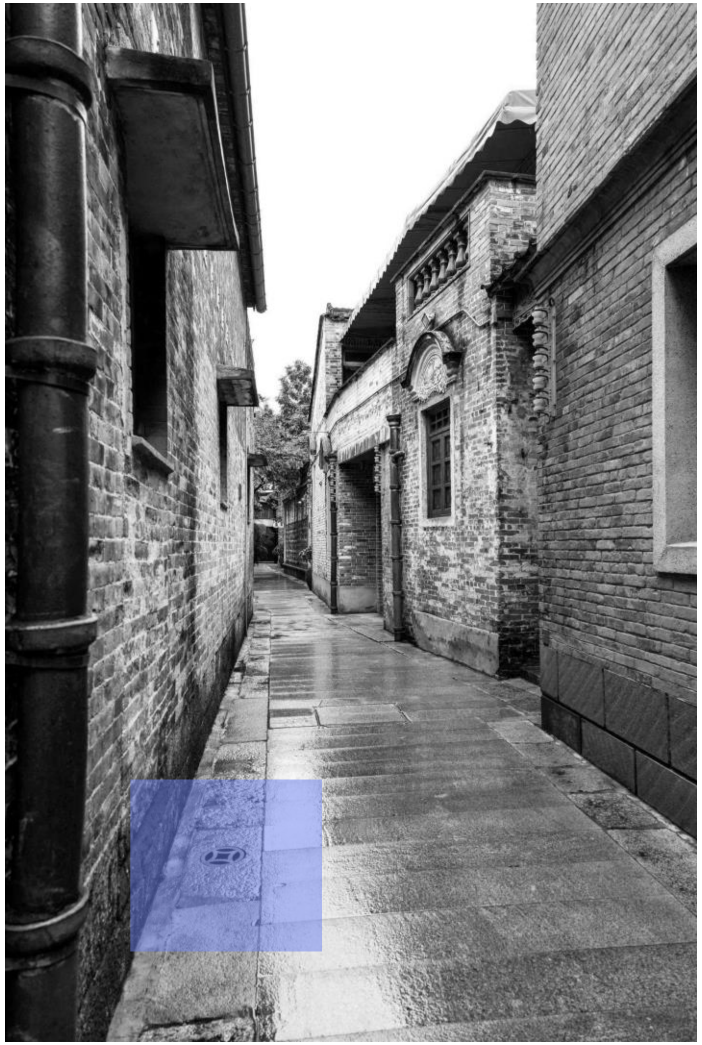


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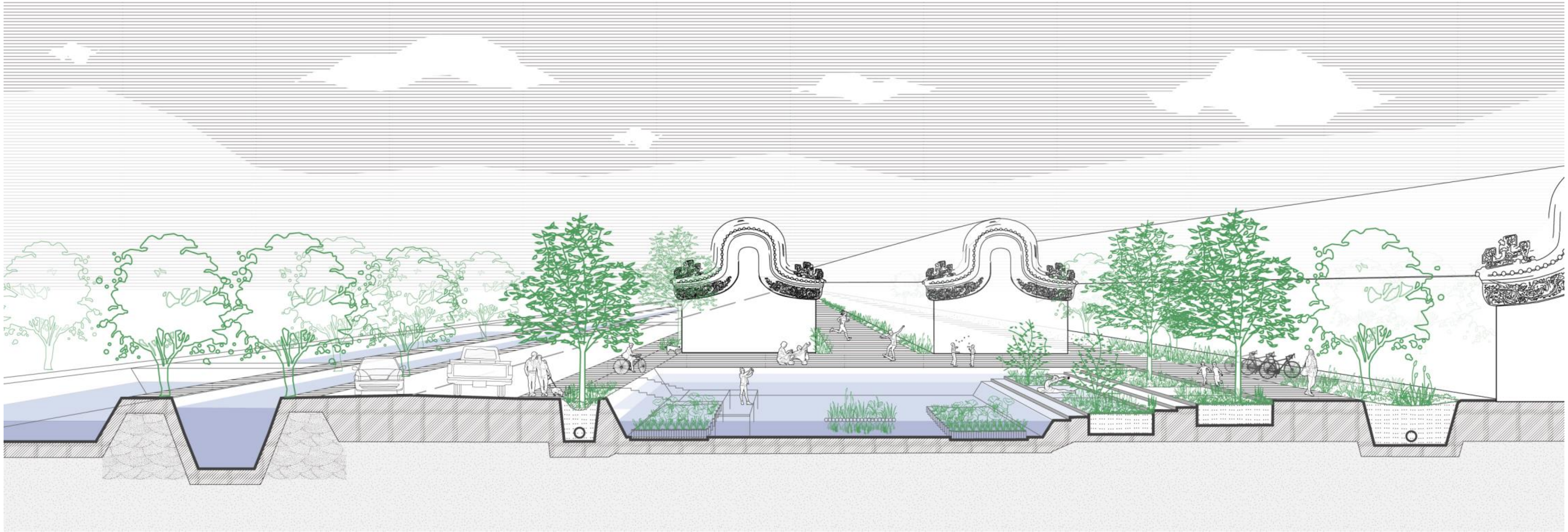

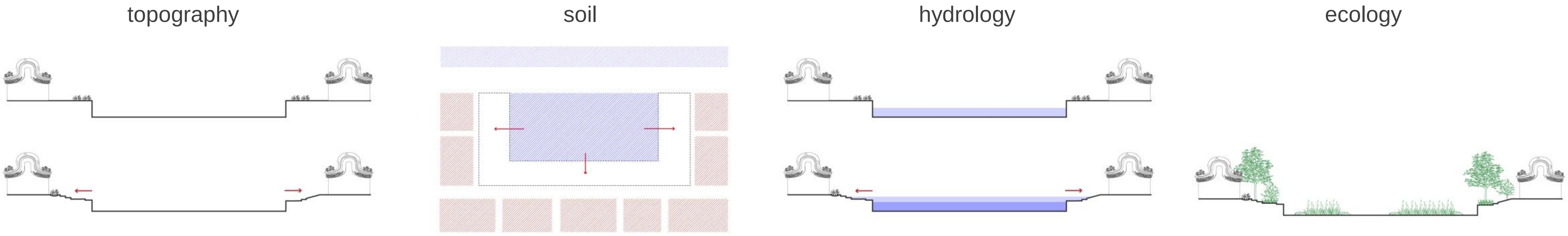

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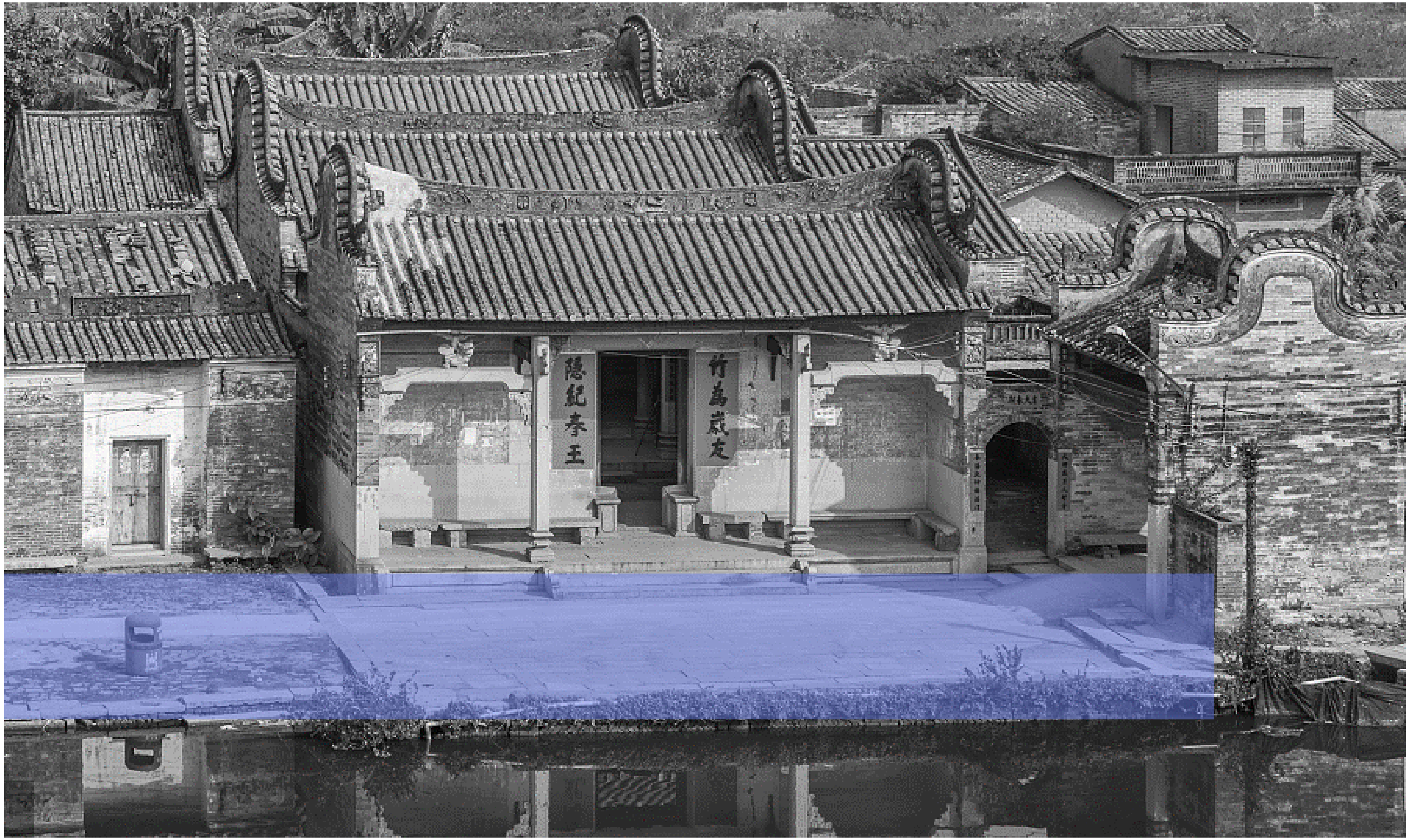

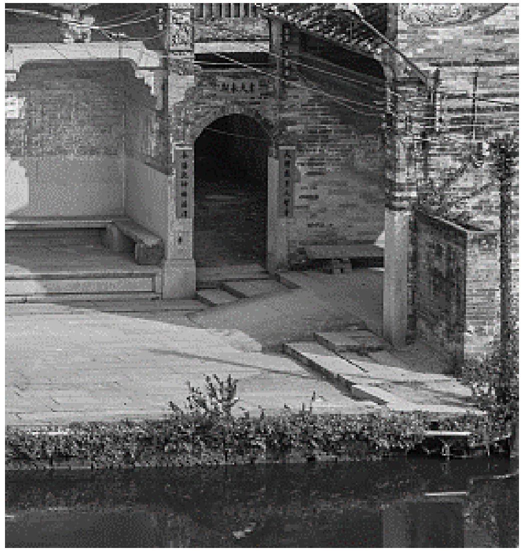

5.2 Flood plain as the sponge of the PRD

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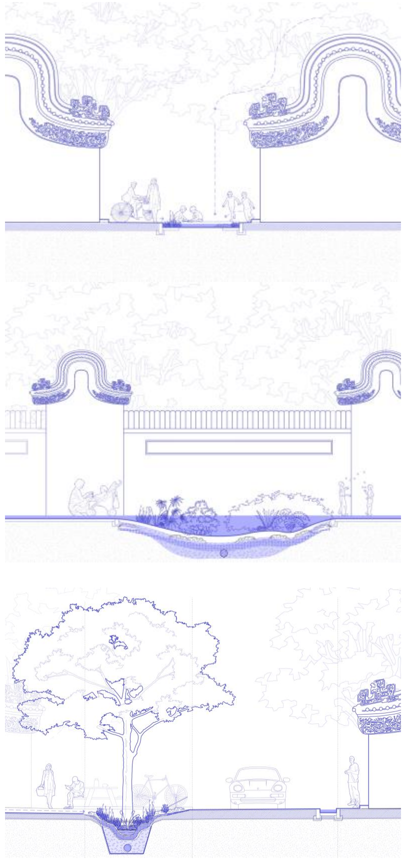
Hierarchy into the infiltration buffer

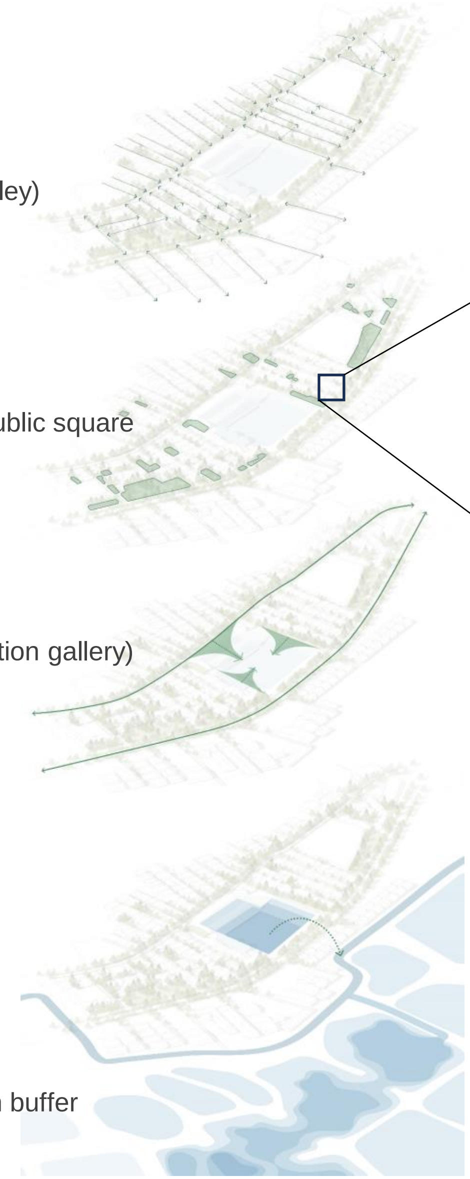


Xiang(alley)

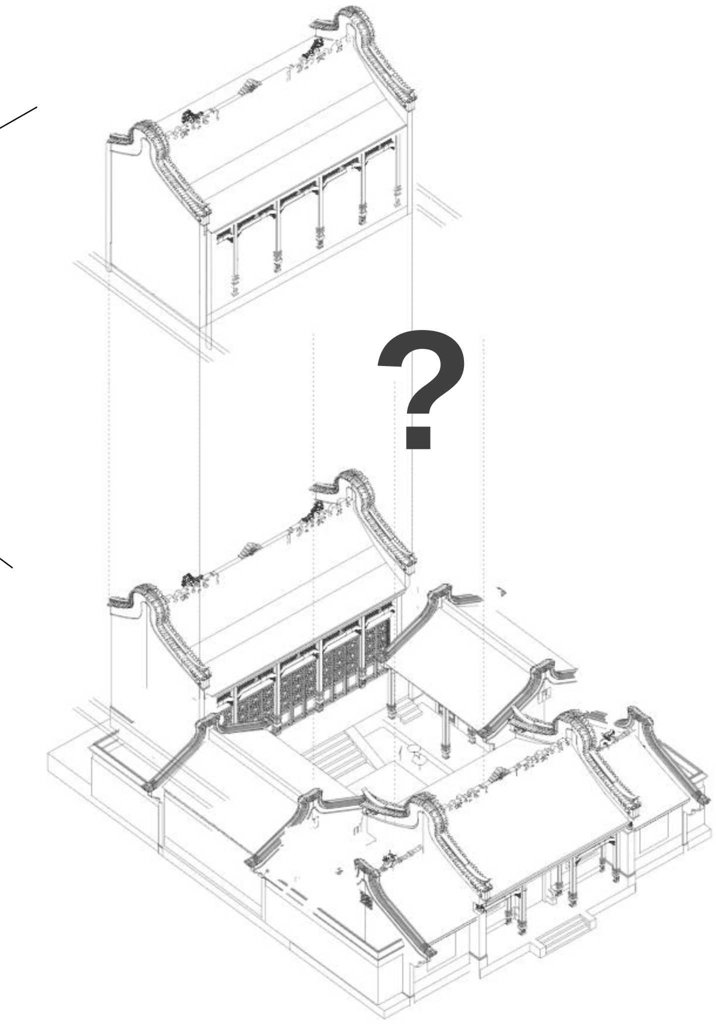
pocket park/public square

Swales(infiltration gallery)

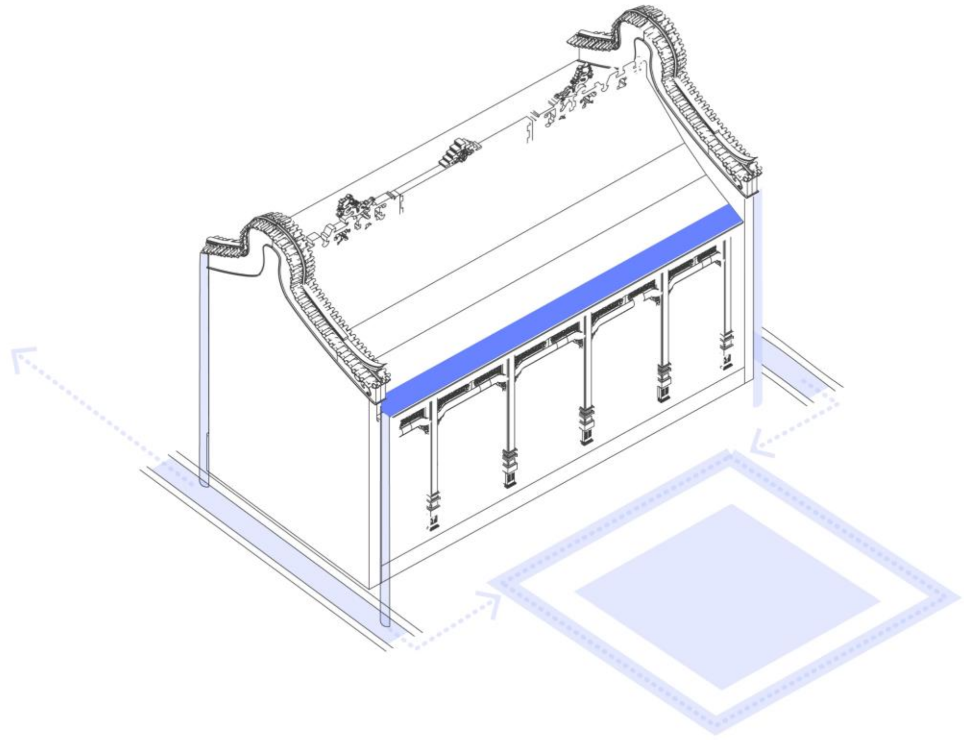
Infiltration buffer



Hierarchy into the courtyard



5.2 Flood plain as the sponge of the PRD



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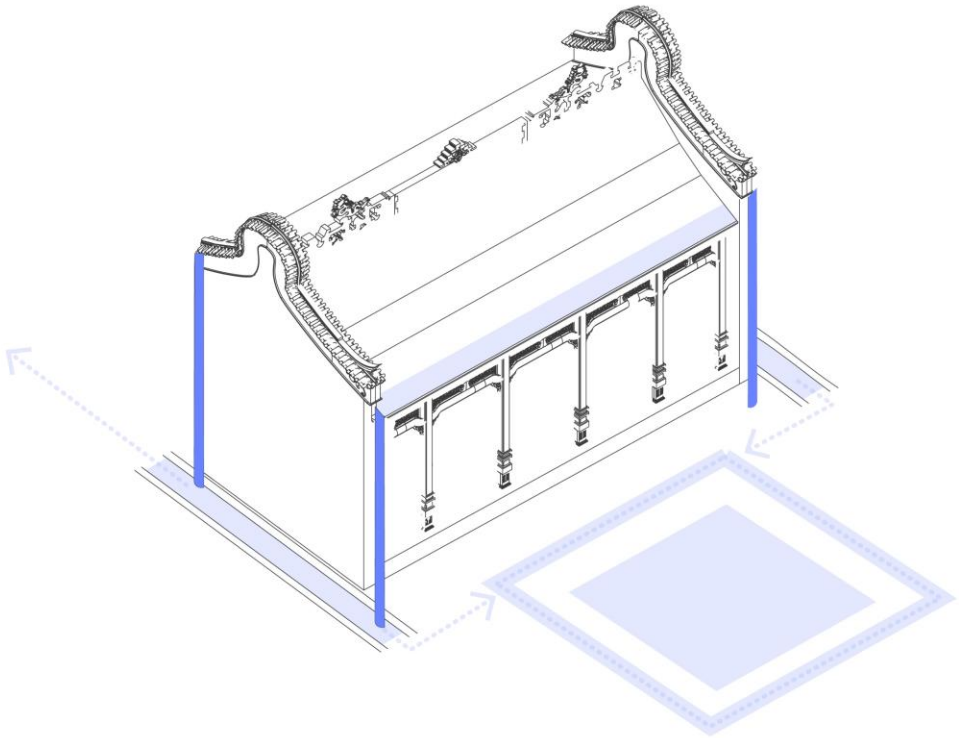

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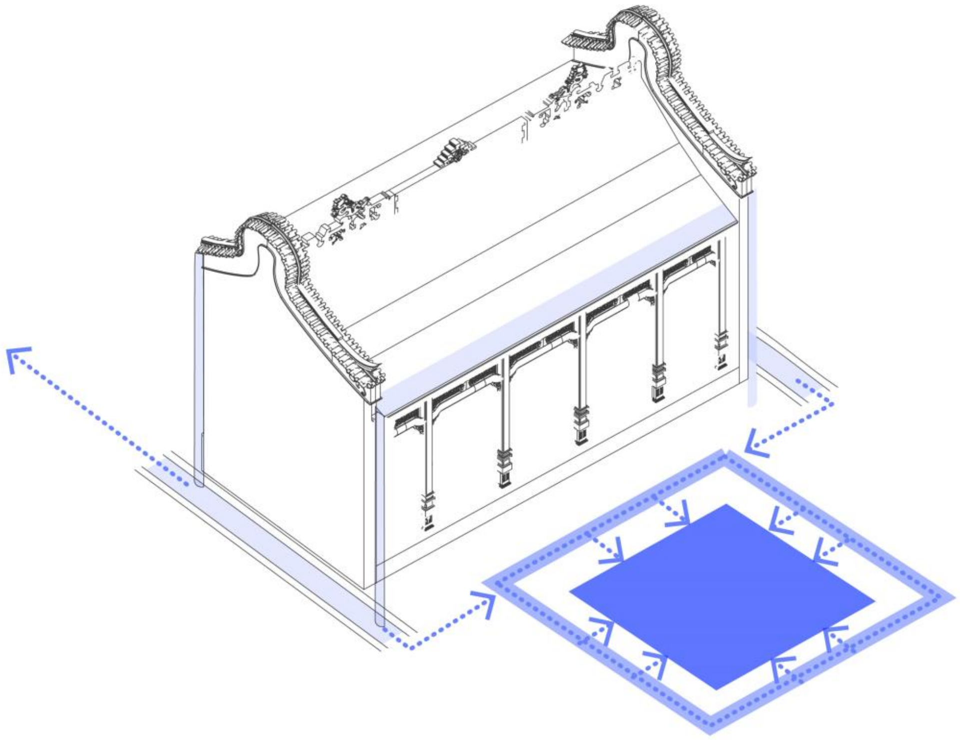

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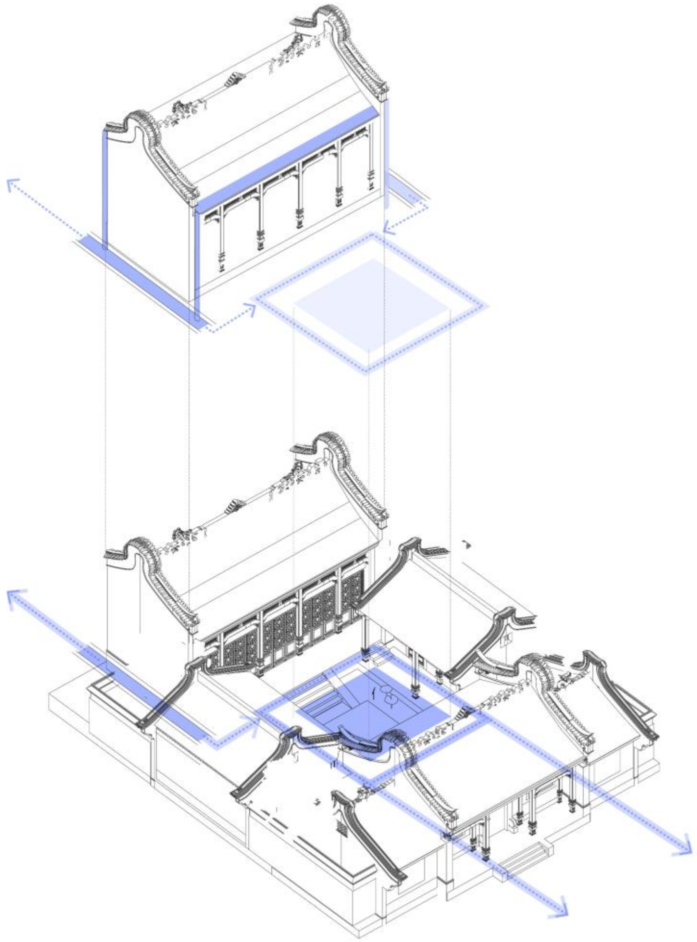

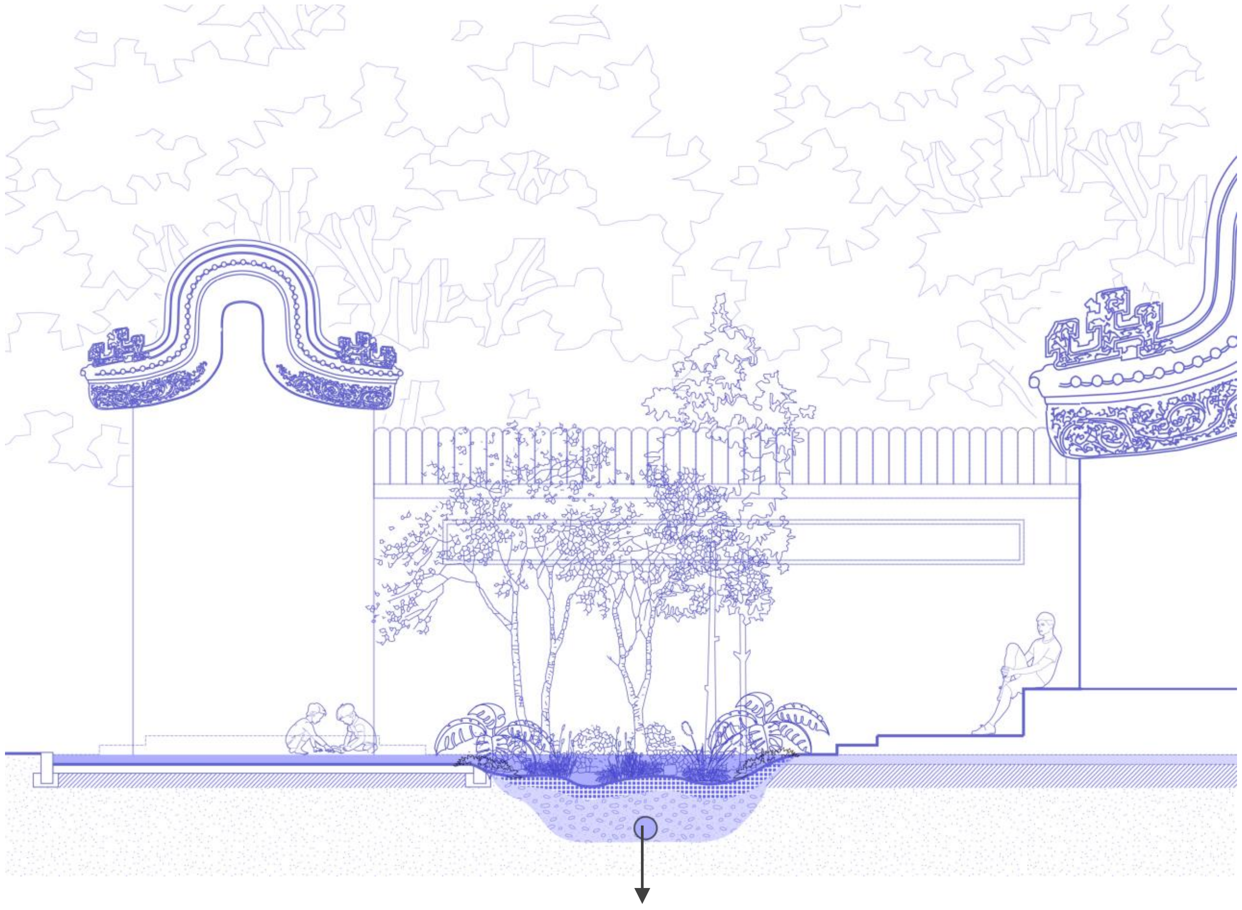

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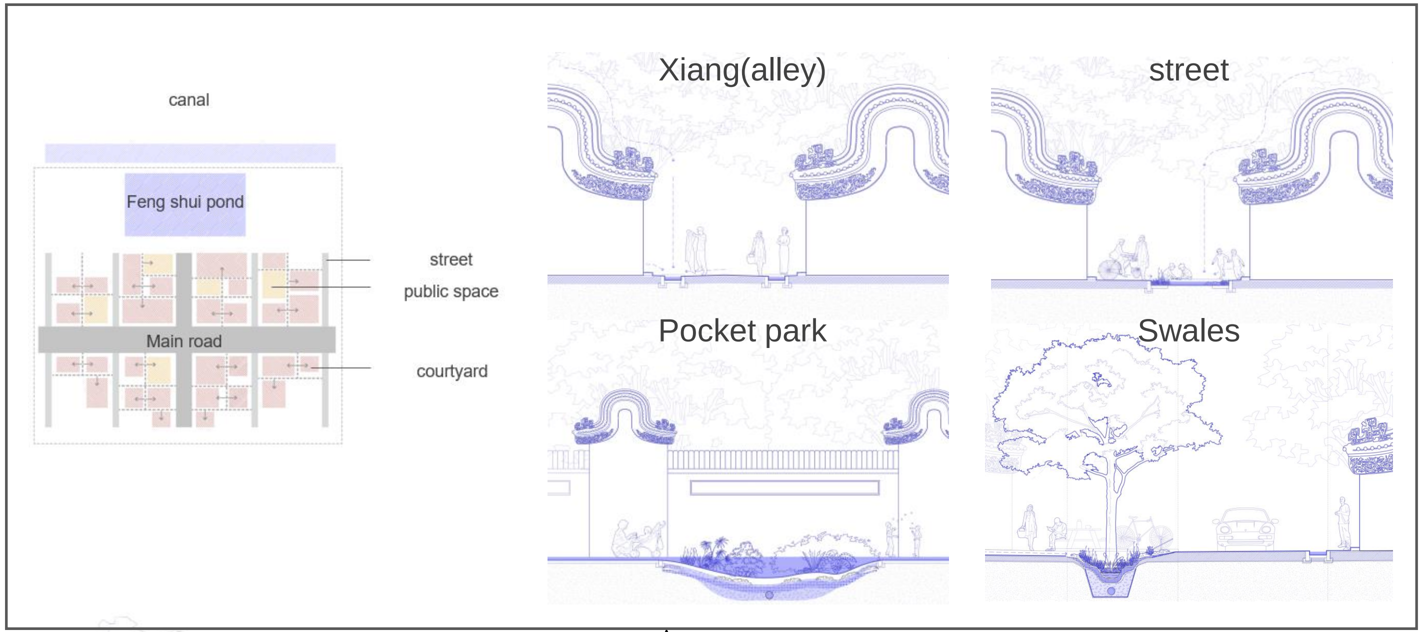
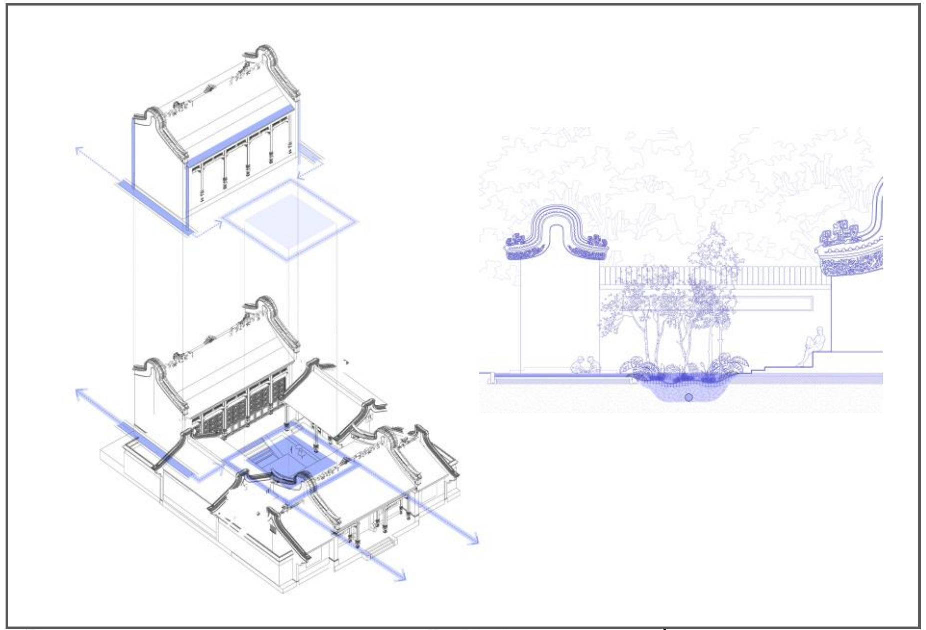
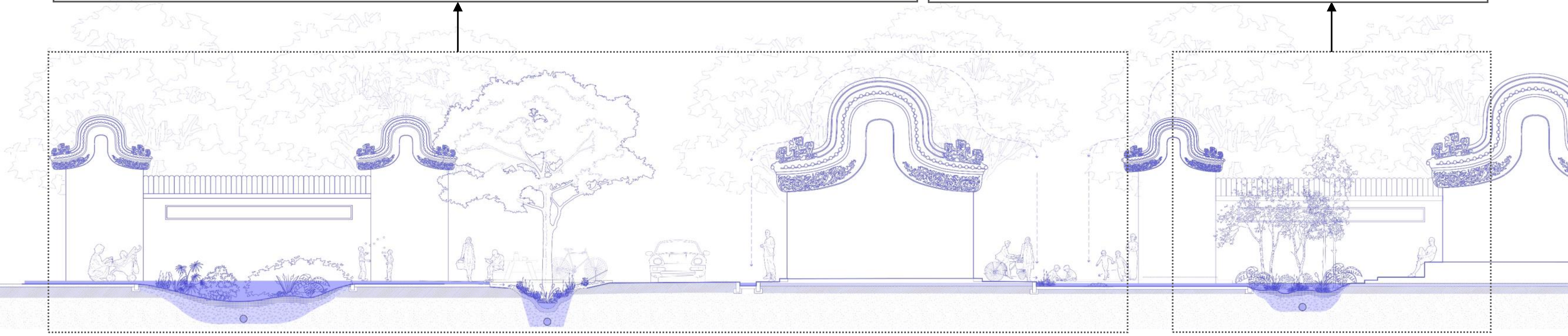
public space



courtyard





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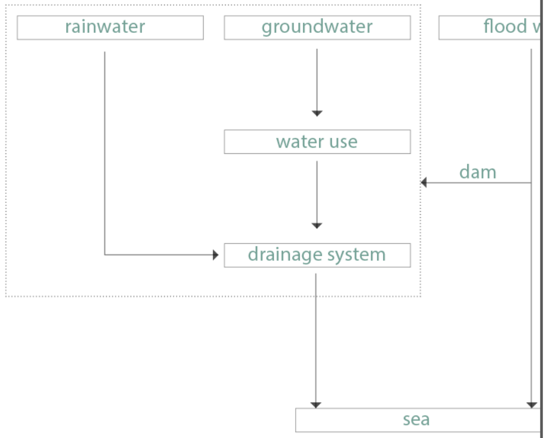
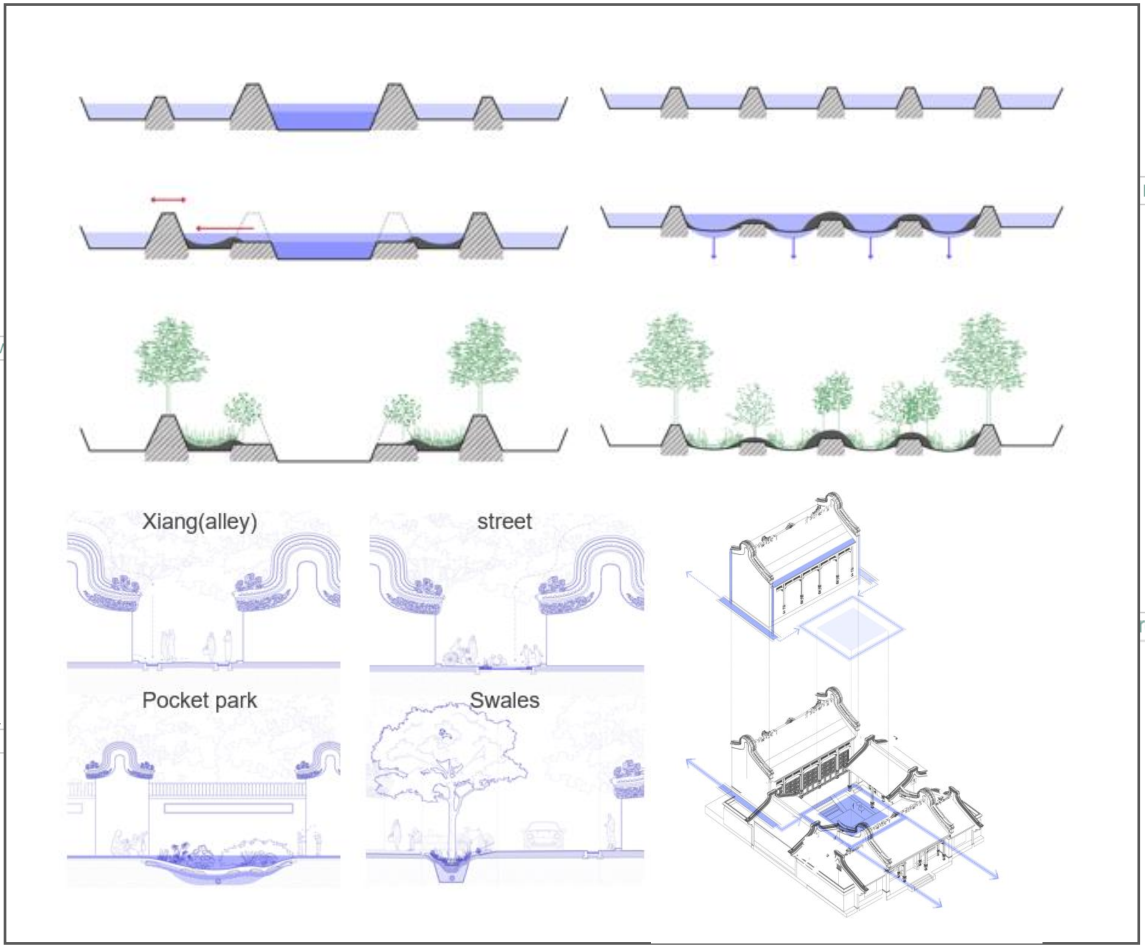
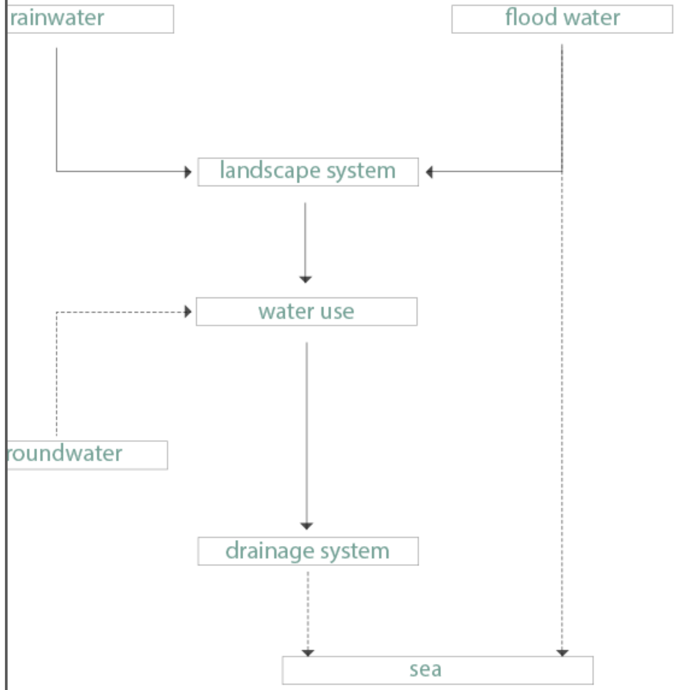


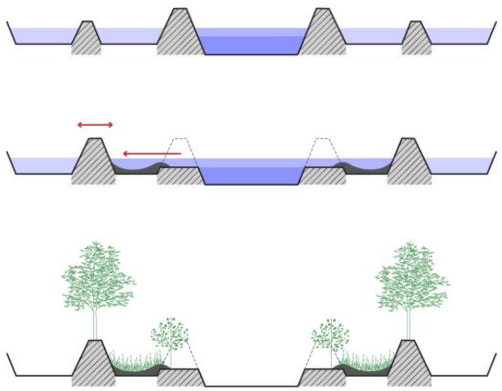


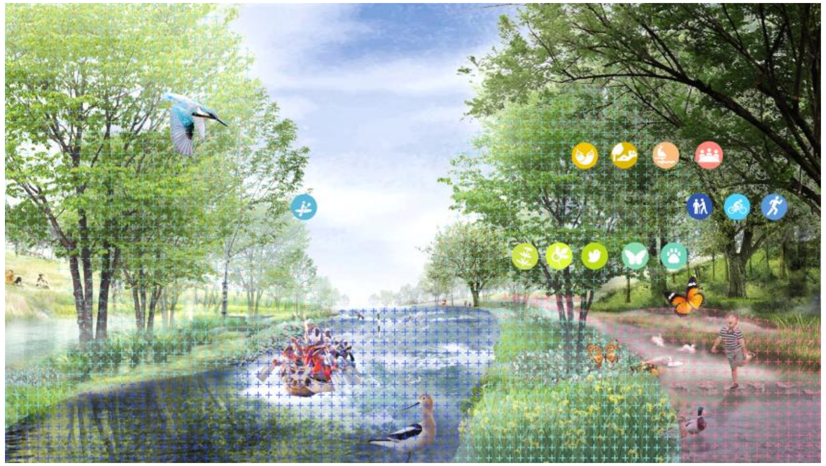


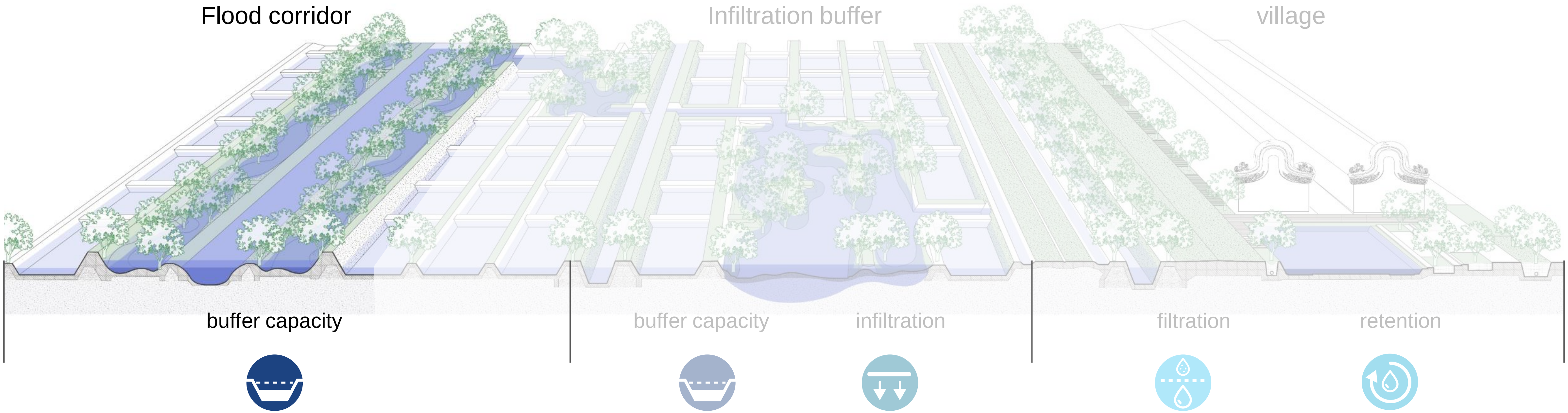
Existing water flow system of the flood plain

proposed water flow system of the flood plain

5.2 Flood plain as the sponge of the PRD







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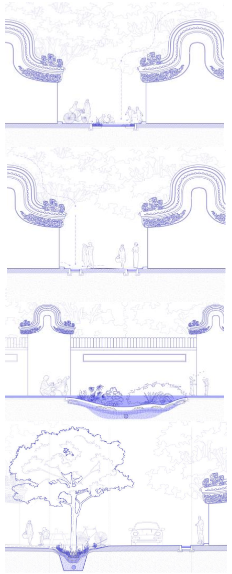

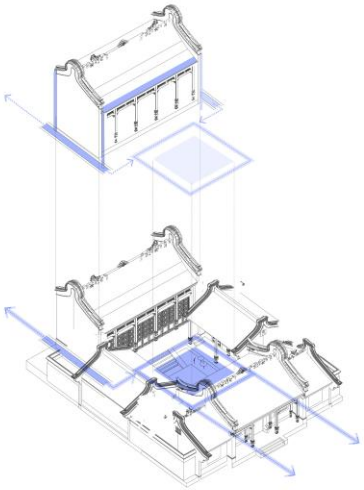

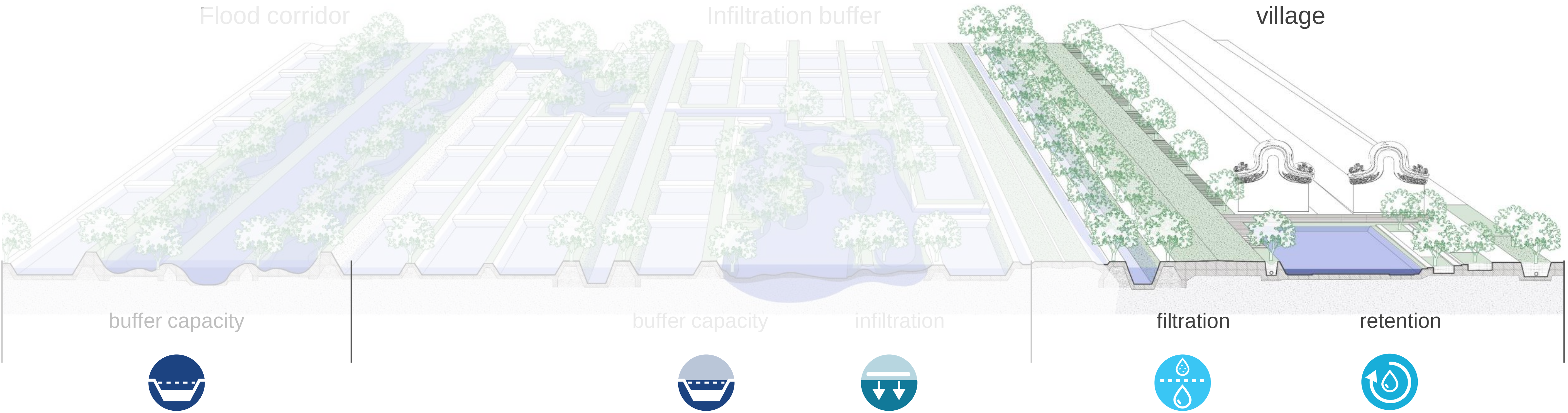

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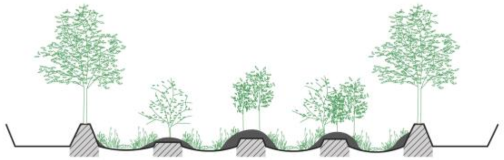
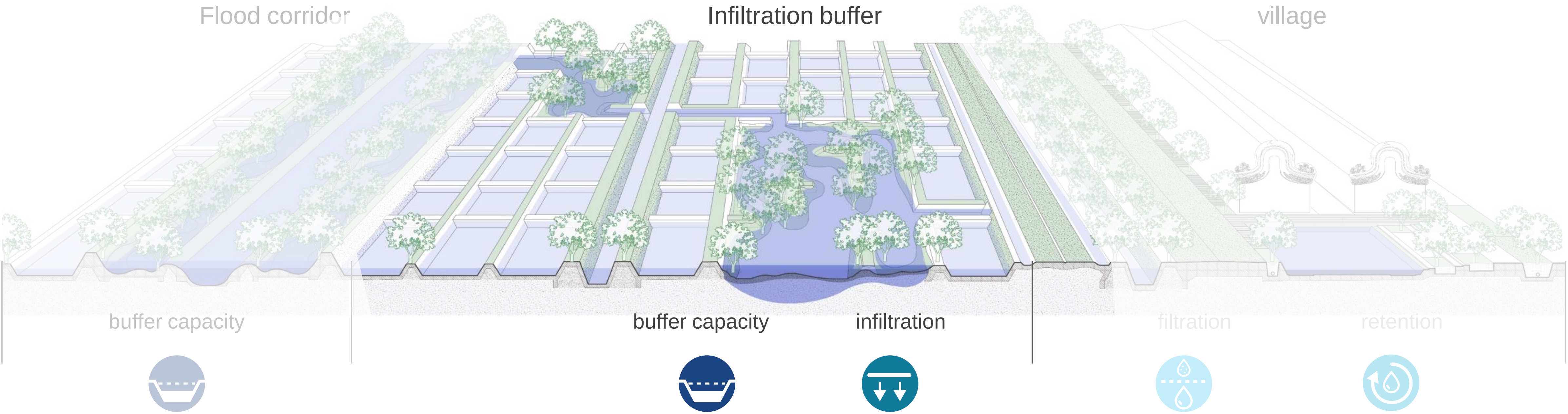




Reflection

RQ1: How to understand the landscape contexts in the PRD from the perspective of landscape as a system?

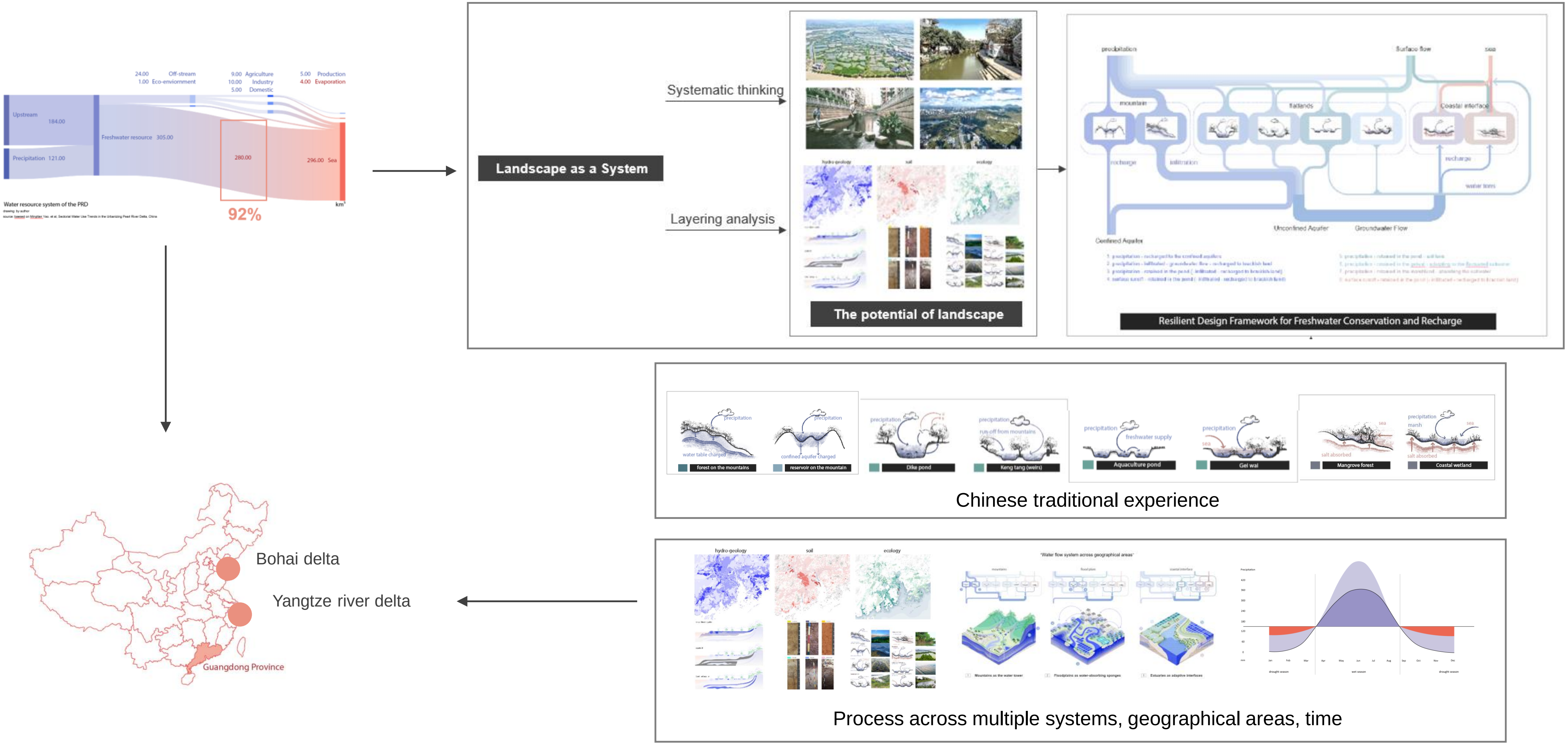
RQ2: What are the potentials of the landscape as a system to develop a resilient landscape framework?

RQ3: What landscape-based principles be applied in different landscape contexts (including mountains, and floodplains) to optimize the potential for freshwater conservation and recharge?

RQ4: What lessons could be learned in this project to foster a resilient landscape system on different scales?

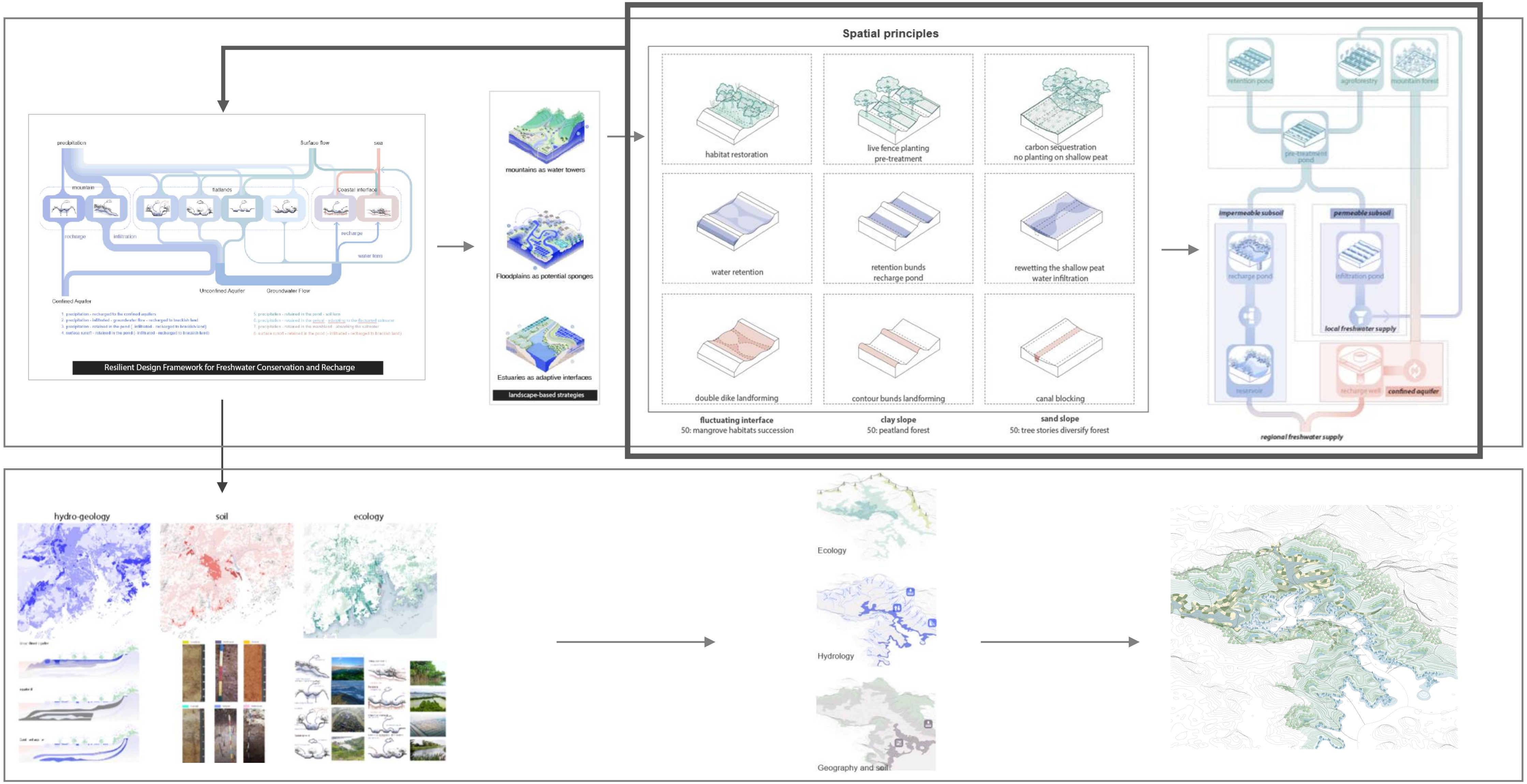
6.1 Reflection on the Research Question

RQ1&2: How to understand the landscape contexts in the PRD from the perspective of landscape as a system? And What are the potentials of the landscape as a system to develop a resilient landscape framework?



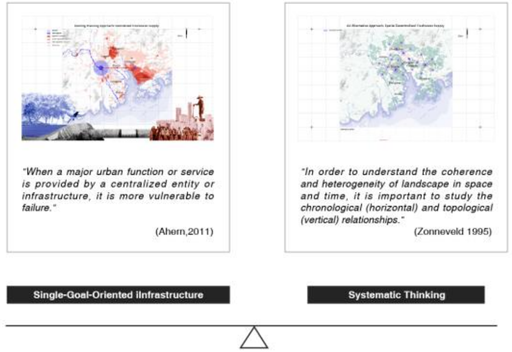
6.1 Reflection on the Research Question

RQ3: What landscape-based principles be applied in different landscape contexts (including mountains, and floodplains) to optimize the potential for freshwater conservation and recharge?



6.1 Reflection on the Research Question

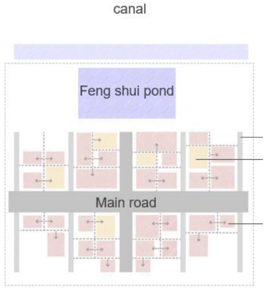
RQ4: What lessons could be learned in this project to foster a resilient landscape system on different scales?

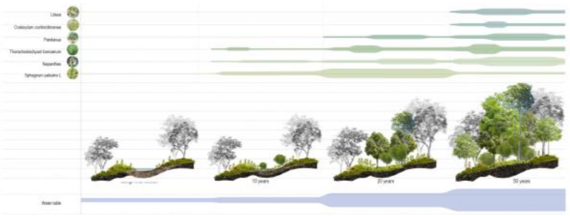


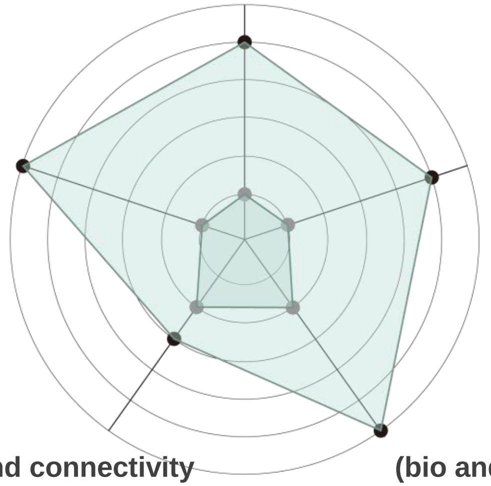
multifunctionality

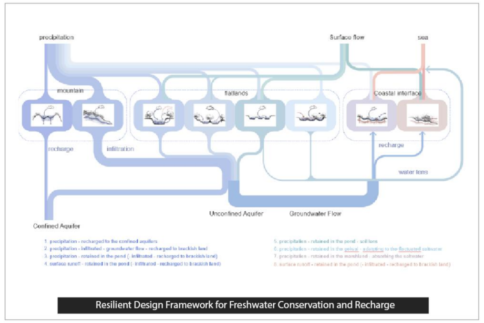
adaptive planning and design

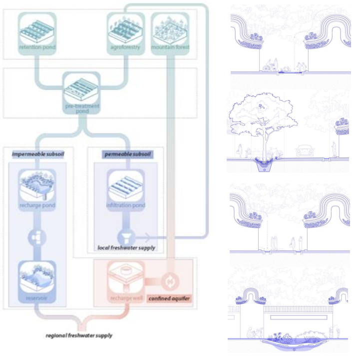
redundancy and modularization





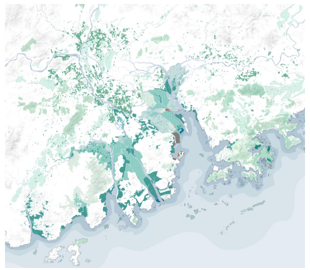






multi-scale networks and connectivity

(bio and social) diversity



6.1 Reflection on the Research Question

What is more?