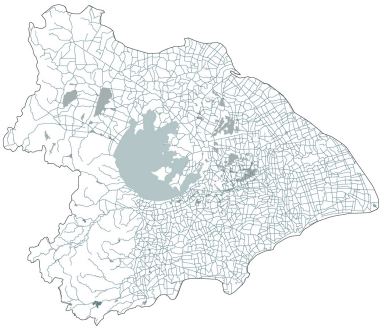

SPONGE POLDER

The revival of traditional polder wisdom in the Taihu Lake Basin

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MSc Landscape Architecture
Flowscape 2023 TU Delft

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Graduation Project Report

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This thesis is a reflection of my understanding of landscape architecture. My mentors, family, and friends give me lots of support over the past two years. Despite the challenges encountered throughout the entirety of the project, I am happy to announce that I finally made it after continuous progress.

Firstly, I would like to thank my mentors Steffen Nijhuis and Gregory Bracken. Without their help and guidance, I couldn't finish this project. Their patience and profound knowledge helped me solve my problems smoothly. Throughout the whole year of research and design, I witnessed significant growth in my professional capabilities. I am really happy to be part of the Resilient Coastal Landscape lab in the past year and I got lots of inspiration from my colleagues in the weekly group meeting.

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ABSTRACT

Key words: Cultural landscape; Polder landscape; Resilience capacity; Taihu lake basin

Polders in the Taihu basin have a history of over two thousand years. The low-lying topography and dense water network create convenient geographical conditions for the reclamation of polders. Later, with the rapid population growth, mulberry-dike-fish-pond was constructed in order to make full use of the limited land resources, which is a sustainable and ecological agricultural model, supporting biodiversity and water resilience as well as providing a basis for settlement in this region. The historical polder landscape closely linked the water system, agriculture system, and settlement system, and then derived water culture, rice culture, fish culture, and silk culture. (Miao, 1982)

However, since1950s, the Taihu basin has been under drastic urbanization, which caused a threat to water safety and cultural heritage. The city invasion of the rural area and road construction leads to the siltation of the watercourse. As a result, the polder landscape was fragmented and lost its water resilience gradually. Water crises including eutrophication, flooding, and drought become more frequent, influencing the cultivation of crops and the traditional settlement's safety. Additionally, the region has lost its unique cultural identity as a result of the standardization of agriculture.

In conclusion, the polder landscape in Taihu basin is facing three main problems: city invasion, water safety issues, and loss of cultural heritage. Compared to the civil engineering method to solve these challenges, landscape intervention costs much less, builds up a more adaptive and resilient system, and brings aesthetic experience as well. Therefore, how to learn from historical practice to protect precious cultural heritage while restoring the water resiliency in the Taihu basin through landscape approaches is the key challenge. The landscape approaches start from the base layer like soil and water, helping to create a sustainable social-ecological system as well as being flexible enough to adapt to future challenges.

CONTENT

01 Introduction

1.1 Fascination
1.2 Location
1.3 Problem statement
1.4 Research objective and questions
1.5 Scope&Relevance
1.6 Methodology
1.7 Summary of the report structure

02 Methodology

2.1 Theoretical background
2.2 Methods
2.3 Methodology framework

03 Polder landscape of Taihu lake basin

3.1 Taihu lake basin water structure
3.2 Taihu formation
3.3 Historical development
3.4 Challenges in Taihu lake basin
3.5 Polder development
3.6 Polder typology
3.7 Conclusion

04 Analysis of Lougang polder

4.1 Glimpse of Lougang polder
4.2 Structure of Lougang polder landscape
4.3 Historical development of Lougang polder
4.4 Understanding Lougang polder
4.5 Historical experience
4.6 Challenges in polder landscape
4.7 Conclusion

05 Regional Strategy&Principle

5.1 Case study
5.2 Design principles for resilient polder landscape
5.3 Design Strategy
5.4 Design assignment
5.5 Conclusion

06 Design exploration

6.1 Vision map--Resilient polder landscape
6.2 Local scale design exploration
6.3 Sponge lakeshore line
6.4 Sponge agri/aquaculture
6.5 Sponge peri-urban
6.6 Design exploration conclusion
6.7 Strategic phasing

07 Conclusion&Reflection

7.1 Conclusion
7.2 Reflection

Bibliography

Figure1.1 Polder landscape in Taihu lake basin
Source: https://ishare.ifeng.com/c/s/7qTtlRdCKnH

01 Introduction

1.1 Fascination
1.2 Location
1.3 Problem statement
- *1.3.1 Water as resource*
- *1.3.2 Water as threat*
- *1.3.3 Urban expansion*

1.4 Research objective and questions
1.5 Scope&Relevance
1.6 Methodology
1.7 Summary of the report structure

1.1 Fascination

"land of fish and rice" "home of the silk"
"Harvest in Su (zhou) and Hu (zhou) provides a year of prosperity"

Water town in the Taihu lake basin

Figure 1.2 Traditional dwellings in Taihu lake basin
Source: https://www.intrepidtravel.com/adventures/wp-content/uploads/2015/03/resized-xingtan-credit-Xianyi-Shen.jpg

Figure 1.3 Nanxun town in Huzhou
Source: https://zggjrwdl.xml-journal.net/bookPart/id/9743

1.2 Location

The photos(Figure1.2,1.3) show the water town in the Yangtze river delta, which represents the unique water landscape in this region. For thousands of years, this region has reputation as the land of rice and fish and home of silk. In the meantime, there is an old saying in China, that harvest in Su(zhou) and Hu(zhou) provides a year of prosperity.

Since China is an agricultural country, polders play an important role in agriculture production in this region. Polders formed a vital part of the culture, and identity of this region, and also shaped the landscape here.

Taihu lake basin is located in the Yangtze River Delta, China. The region, named after Taihu Lake, is the third-largest freshwater lake in China and covers an area of approximately 2,400 square kilometers. The Grand Canal, which is a man-made waterway in China that runs from Beijing in the north to Hangzhou in the south, passes through the whole region. It was used as a major transportation route for goods and troops in history. Today, it is still an important transportation and recreation route in the Taihu Lake basin.

According to data, there are about 2539 polders in the Taihu Lake basin, which accounts for 28.8% of the total basin area. By providing more arable space for crop cultivation, livestock grazing, and aquaculture, these polders play a crucial part in the Taihu Lake Basin's agricultural industry. In addition, the polders work as buffer zones between the lake and the nearby villages to mitigate the risk of floods.

2539 polders
28.8% of the total basin area

Figure 1.4 Location of Taihu lake basin

1.3 Problem statement

1.3.1 Water as resource

Agriculture heritage

Figure1.5 Mulberry dike fish pond
Source: https://www.flickr.com/photos/giahs/50192215677

Water heritage and architecture heritage

Figure1.6 Water town
Source: http://livechina.ipanda.com/2016/09/13/ARTIFchgSd09tVQ8rya5W4TT160913.shtml

Water is an important resource for the agriculture and people who live here. Polders have existed on this land for over 2000 years, which has left a significant cultural heritage in traditional buildings, man-made watercourses, and agricultural systems such as the mulberry-dike-fish-pond, and also influence the water culture here. These traditional agricultural practices and the associated architecture and water management systems are a valuable part of China's cultural heritage, showing its unique history and identity. The preservation of the heritage is crucial to understand the vernacular landscape and people's relationship with water and agriculture.

The cultural landscape in the Taihu Lake basin has been significantly influenced by its relationship with the water. Large-sized water bodies and watercourses, including the Yangtze River, the Grand Canal, and Taihu lake, have played a crucial role in shaping the geography and culture of this region, which is evident in historical maps(Wang, Nolf,2020). Water in the Taihu lake basin has been used both for functional and aesthetic purposes. The complex water network of canals, bridges, and sluices was constructed for transportation and commercial needs, while also promising the cultivation of crops like rice. Apart from its practical function, water is an important element in ancient literature like poems and articles, nourishing the water culture in the Jiangnan region. In 2016, Lougang of Taihu Lake in Huzhou has been successfully selected for the Third Batch of the World Irrigation Heritage List, which not only affirms the value of Lougang water conservancy from ancient times till now but also provides a new opportunity for Huzhou to further protect and utilize the Lougang Water Conservancy heritage.

In conclusion, water has had a significant impact on the landscape in the Taihu Lake basin. Its practical applications in irrigation, agriculture, and transportation have boosted the economy in this region. At the same time, generations of artists, poets, and writers were inspired by the unique water landscape, thus creating rich and enduring cultural works.

Resilient water system in history

Figure1.7 General map showing the district around and the approaches to Shanghai
Source: https://www.virtualshanghai.net/Asset/Preview/vcMap_ID-233_No-1.jpeg

1.3.2 Water as threat

Figure 1.8 Floods in the Taihu Lake basin

Figure 1.9 Workers clear the algae in the lake

Figure 1.10 Dry soil during dought

However, water also brings a lot of problems that threaten the life of local people and the safety of heritage including eutrophication, flooding, and drought. The rapid economic growth and urbanization of the region have led to increased pollution, eutrophication, and ecological degradation. These environmental issues have had a significant impact on the health of the lake and the surrounding ecosystem.

1) Flood: Because of the low-lying topography in the Taihu Lake basin and the low capacity for discharging water, floods become a continuous problem, especially in summer. The flooding in the area resulted in significant economic losses, and damage to infrastructure, and sometimes threaten the safety of the public. Although the Chinese government has taken a variety of measures to control floods, like the construction of dams, floodgates, and water level detection and warning system, this area has experienced extreme weather events more frequently.

2) Eutrophication: Industry sewage and agricultural water are dumped into Taihu Lake, which increases the nutrient content, such as nitrogen and phosphorus, causing cyanobacterial blooms. This can lead to a range of problems, including reduced water quality, and loss of biodiversity. Eutrophication is a significant problem in Taihu Lake, which is the primary source of drinking water for millions of people in the region.

3) Drought: The high temperature and little rain in summer pose a serious threat to autumn grain production.

Figure 1.8 Floods in the Taihu Lake basin
Source: https://news.ltn.com.tw/news/world/breakingnews/3231247
Figure 1.9 Workers clear the algae in the lake
Source: http://discovery.cctv.com/20080125/102623.shtml
Figure 1.10 Dry soil during dought
Source: https://img.sinchew.com.my/2019-11/07/31e76c36-7a1f-4dd3-a2ae-8cef0cff75d4.jpg

1.3.3 Urban expansion

Meanwhile, rapid urban expansion threatens the safety and continuity of polders, not only demolishing the historical pattern but also destroying the resilience of this region. Although urbanization boosts economic growth, it has also posed a threat to the polder landscape. The land used for agriculture or aquaculture production is encroached upon by industry and residential buildings. The city invasion of the rural area and road construction leads to the siltation of the watercourse, which decreases the resilience of the region. Moreover, the deconstruction of habitats due to excessive construction causes loss of biodiversity and degradation in ecosystems.

In the past 70 years since 1950, the Taihu basin has been under drastic urbanization, which caused a threat to water safety and cultural heritage. As a result, the polder landscape was fragmented and lost its water resilience gradually. Water crises including eutrophication, flooding, and drought become more frequent, influencing the cultivation of crops and the traditional settlement's safety. Additionally, the region has lost its unique cultural identity as a result of the rapid urbanization.

In summary, to mitigate the water crisis and solve the urbanization challenges, innovative solutions and collaboration among government, industry, and the local community are required. There is a strong need for water resilient polder landscape in the Taihu Lake basin to ensure the long-term sustainability of the region, and a more balanced approach to ecological and economic development, while preserving the cultural heritage in this region.


Figure 1.11 Urban expansion in traditional dwellings
Source: https://www.sohu.com/a/442180811_120055762

Figure1. 12 Strong need for water-resilient polder landscape

1.4 Research objective and questions

Research objective

To identify design strategies and principles for **water-resilient polder landscapes** in the Taihu Lake basin while protecting **cultural heritage** through learning from history.

Research questions

Understanding
1. What is the traditional polder system and how is the polder system connected to the Taihu lake?

Principles
2. What are the design principles of resilient polder landscape systems from the perspective of water, ecology, settlement, and agriculture systems?

Application
3. How to apply the design principles in Lougang polder in the Taihu lake basin?

Reflection
4. To what degree do the strategies and principles increase resilience in polder landscapes?

1.5 Scope&Relevance

With the rapid growth of population and fewer land resources available, the conflict between city expansion and polder heritage protection becomes more severe in most areas in China. Furthermore, the water crises continuously threaten the region because of the low-lying topography in the Taihu basin. From historical practice, polders showed high potential both in solving water crises and arable land utilization. As a result, how to design the polder landscape to improve water resilience and protect its cultural identity is a crucial assignment in the contemporary context.

This project explores the potential of polder landscapes, not only in cultural value but also in ecological value in improving water resilience and providing habitats, as well as social-economic value, like transforming agriculture into a more sustainable and ecological form, improving the quality of life in rural areas. The project provides views of the landscape approach to designing an adaptive polder landscape.

Generally speaking, my project aims to illustrate the future possibilities of polder landscapes, which will provide a reference for further water-resilient polder landscape design in other polder areas in China. It will provide views on how to construct a water resilient framework and propose a sustainable development of the cultural landscape.

1.6 Methodology

Research Through design

Research involves gathering different aspects of information, which forms the foundation for design. Through the research about the development and the mechanism of water systems of the polder, challenges and potentials will be found, thus deriving the design assignment.

Design, as the creative and problem-solving method, utilize the information gained from research and develop solutions to address the challenges, transforming the challenges into opportunities. Research and design interact and influence each other. Research through design offers a method of bridging the knowledge gap between theory and practice, encouraging creativity, and advancing both the design and research fields.

1.7 Summary of the report structure

The first chapter introduces the basic background of the Taihu Lake basin, which is famous for the fish, rice, and silk that profited from the resilient water system in history. Polder plays an important role in water resilience and economic development in the region. However, polders are threatened by the water crisis and city expansion nowadays. As a result, the conclusion is that there is a strong need for a water-resilient polder landscape. Furthermore, the research objective and questions are proposed helping to mitigate challenges and bring more possibilities.

The second chapter demonstrates the theories and methods that will guide my research and design. The cultural landscape teaches me to analyze the polder landscape from three layers, while resilient capacity guides me to think about the strategies for designing a resilient polder landscape. These two theories help me to explore the answers to four research questions through different methods.

In order to figure out what is the traditional polder system and how the polder system is connected to Taihu Lake, the third chapter starts with the formation and basic characteristics of the Taihu Lake basin, demonstrating why polders appear in this region, the development of polders, and the challenges polders are facing in recent times and the future. Based on the water conservancy construction, polders are divided into five types, among which the Lougang polder is the oldest and most well-protected, providing lots of precious traditional polder wisdom.

Choosing the Lougang polder as the research and design location, the fourth chapter explains four aspects of the Lougang polder: 1. The landscape transformation of the Lougang polder; 2. The mechanism of water, agriculture, and settlement systems and their relationship; 3. Challenges and problems that the Lougang polder has encountered; 4. Diagnosis and design assignment.

The design principles of resilient polder landscape systems from the perspective of water, ecology, agriculture, and settlement systems are demonstrated in chapter five. Based on those principles, seven strategies will be applied to the regional design which could further give instructions on detailed design.

In chapter six, three micro-scale locations are chosen to delineate the application of the design principles in the zoom-in scale from three different topic perspectives. The three sites are also selected to solve or alleviate three challenges: flooding, agriculture water pollution, and city expansion from three aspects: sponge lake shoreline, sponge agri/aquaculture, and sponge peri-urban.

The last chapter illustrates the outcome of the whole project and answers the four research questions, reflecting on to what degree do the strategies and principles increase resilience in polder landscapes, giving an outlook on the development and changes of polder in the future.

Figure2.1 Typical bridge in the Taihu Lake basin
Source: https://www.sohu.com/a/441827612_434584

02 Theoretical framework

2.1 Theoretical background
2.2 Methods
2.3 Methodology framework

2.1 Theoretical background

2.1.1 Theory to understand polder landscape and cultural heritage

Cultural landscape

Combined works of nature and by humans, and they express a long and intimate relationship between people and their natural environment. (UNESCO)

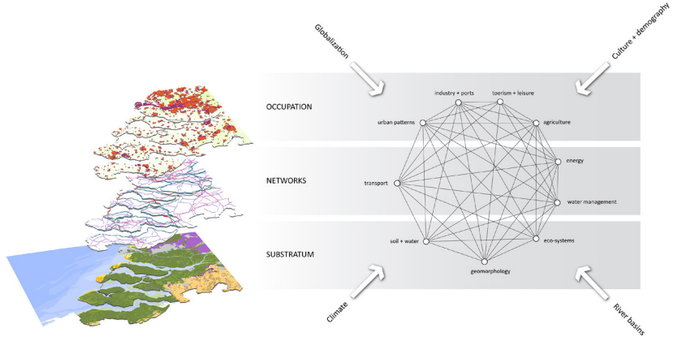

Figure2.2 Layer approach
Source: Understanding the urban landscape as a layered and complex system (image: Steffen Nijhuis).

By mapping landscape systems, designers could better understand the spatial conditions that inform adaptive planning strategies and design principles. Decomposing the urban landscape into layers according to the dynamic of change is a proven method to help a more holistic understanding of the urban landscape system and how the system functions (Meyer & Nijhuis, 2014).

The environmental factors, regarded as the most influential conditions for land use, are known as the first layer. Infrastructural networks for transportation, water management, and energy supply form the second layer. The first and second layers together influence the development of agricultural land use and urban settlements, resulting in the layer with the highest change and transformation dynamics (Meyer & Nijhuis, 2014).

According to Guo (2015), the cultural landscape can be decomposed into a muti-layer complex system, including natural system shaped by geology and hydrology, agricultural systems derived from natural forms, and settlement systems characterized by irrigation and reclamation. It can be viewed as a process of accumulation of natural and cultural layers over a long period of time. As a result, for the study of the cultural landscape, it is crucial to consider both the temporal dimension and the relationship between the superimposed layers.

(1) Natural system—Soil and water
Land and water are the foundation of agricultural production and the basic elements of the cultural landscape. The research on natural systems first includes various soil compositions and their evolution process. The water network is usually shaped by topography. At the same time, the study of the natural system should go beyond the specific spatial form and explore the connection with a social culture like shanshui.

(2) Agricultural system—Farmland and water conservancy
Although the agricultural landscape varies because of the climate condition, the goal of agricultural production is the same: the optimal usage of agricultural land. Agricultural system research encompasses three key aspects. Firstly, the size and shape of farmland units. Secondly, the arrangement of canals and paths and the formation of farmland group structures. Lastly, the connection of farmland as a whole with the surrounding environment.

(3) Settlement system
The form and organization are usually related to the reclamation, farmland, and water conservancy. from the perspectives of agricultural land layout, agricultural and industrial reclamation mode, water conservancy infrastructure, and so on. The relationship between town and farmland block, the form and distribution of settlement, etc., may have more practical significance in the current situation.

Water conservation systems, including dikes, ditches, sluices, storage and drainage systems, pumping systems, etc., play an essential role in connecting the three subsystems of nature, agriculture, and settlement. The swamps and woodlands in the natural subsystem were gradually transformed into fertile fields crisscrossed by paths, and rural settlements formed along the river. As a result, the vast natural landscape was transformed into a farming and living unit on a humanistic scale by effectively controlling and regulating rivers through the water conservancy system.

The theory of cultural landscape provides a helpful framework for understanding the polder landscape through the lens of three layers: the water layer, the agriculture layer, and the settlement layer. By analyzing each layer and considering their interrelationships, we can gain a more comprehensive understanding of the unique features and complexities of the polder landscape.

Resilience capacity

Resilience is defined as the capacity of system to respond to change or disturbance without changing its basic state (Walker and Salt, 2006).

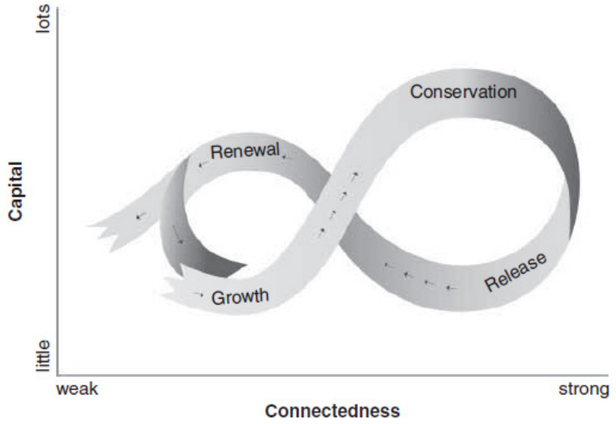

Figure2.3 A stylized representation of the four ecosystem functions (r, K, Qf, a) and the flow of events among them.
Source: Gunderson and Holling 2001 with permission of Island Press.

'Resilience' is first defined by Holling and Goldberg, referring to the ability of a system to absorb change and persist after disturbance (Holling & Goldberg, 1971). They gave multiple instances to illustrate the risks involved in concentrating too intently on a single element of a system problem. Overall, they emphasized the need for a more holistic approach to planning that considers the ability of ecosystems or urban systems to adapt to change. Later, resilience refers to the capacity of the system to respond to change or disturbance without changing its basic state (Walker and Salt, 2006).

As the resilience theory developed in the past decades, the focus expand from ecosystems to social-ecological systems, taking the importance of engaging stakeholders into account and considering social and economic factors.

Considering the landscape perspective, landscape resilience is defined as the capacity of a landscape to maintain important landscape processes, strong native biodiversity, and ecological services throughout time despite numerous stressors and uncertainties in changing environment (Beller, Robinson, Grossinger & Grenier, 2015).

Ahern (2011) put forward five strategies for building urban resilience, including multifunctionality, redundancy and modularization, (bio and social) diversity, multi-scale networks and connectivity, and adaptive planning and design.

(1) Multifunctionality
As cities become more compact over time, planners and designers should figure out a sustainable way to provide ecosystem services. Multifunctionality can be accomplished to overcome this difficulty by combining and entwining functions as well as stacking or timing them. This approach is efficient in terms of space and economics while gaining support from social constituents and stakeholders due to the multiple functions provided (Ahern,2011).

(2) Redundancy and modulization
Redundancy and modulization are strategies to disperse the stress and avoid putting "all your eggs in one basket", achieved when multiple elements or components provide the same, similar, or back-up functions. Instead of relying too heavily on a single system or a centralized entity, it prepares for potential failures (Ahern,2011).

(3) (Bio and social) diversity
Biodiversity and diversity in social, physical, and economic systems support urban resilience. Response diversity in biological systems refers to the diversity of species within functional groups which allow for a greater capacity to recover from disturbance and stress. Permeable surfaces, bioswales, and urban tree canopies are all good examples to demonstrate response diversity. Cities with higher levels of economic and social diversity are attractive places to adapt to change and socio-economic disturbance (Ahern,2011).

(4) Multi-scale networks and connectivity
Networks are systems that support functions through connectivity. Multi-scale connectivity is essential for planning and a lack of connectivity can cause fragmentation and isolation. Moreover, complex networks increase resilience by maintaining functional connectivity even after network disturbance(s) through redundant circuitry (Ahern,2011).

(5) Adaptive planning and design
Adaptive planning and design is an approach that conceives problems as an opportunity to learn by doing (Holling, 1978). Urban plans and designs will be viewed as hypotheses while designers will gain new knowledge through monitoring and analysis. The application of this method to urban planning and design is rare although adaptive management has been practiced success (Ahern,2011).

2.2 Methods

01 Layer approach

Using layer approach to identify the relationship between water, agriculture, and settlement. Based on the analysis of the development of water, agriculture, and settlement systems and their relationships, I will summarize the sustainable and feasible strategies from historical practice.

02 GIS mapping

Figure out the spatial structure of the region and try to find out the characteristics and challenges the site is facing. The geographical data of my project could be found at the Lake-Watershed Science SubCenter, National Earth System Science Data Sharing Infrastructure, National Science & Technology Infrastructure of China (http://lake.geodata.cn)

03 Literature review

To better understand the history and existing condition of the site and learn from the relative theories including cultural landscape and resilience capacity.

04 Case study

1) Learning how to design a resilient region through the design cases of sponge city including water retention, water purification, and water infiltration.
2) Design cases of circular and sustainable agriculture
3) Design cases of cultural heritage protection.

05 Research through design

Research through design is a powerful research strategy in which complex spatial problems are approached in a creative and integrated manner (Nijhuis & de Vries, 2020). This method will help me to explore the possibilities for spatial design, generating generally applicable principles.

06 Section/Making model

Drawing sections helps to understand the change in topography and the relationship between different elements like soil, water, and topography. Making model will help me to explore the spatial identity of this area.

2.3 Methodology framework

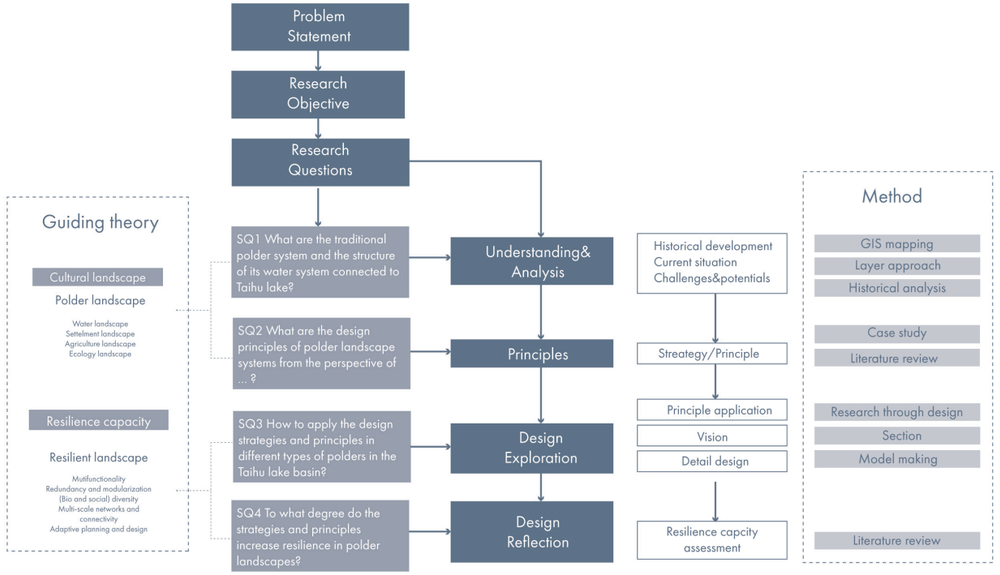

Figure2.4 Methodology framework

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Figure3. 1 Luogang Polder landscape
Source: http://zj.people.com.cn/n2/2022/0602/c186327-35298367.html

03 Polder landscape of Taihu lake basin

3.1 Taihu lake basin water structure
3.2 Taihu formation
3.3 Historical development
3.4 Challenges in Taihu lake basin
3.5 Polder development
3.6 Polder typology

3.1 Taihu lake basin water structure

Figure3.2 Structure map of Taihu lake basin

3.2 Taihu formation

The mountainous region is situated in the west, while the low-lying plain is situated in the east. This geographical feature has a significant impact on the direction of water flow, as water from the mountain flows towards Taihu Lake, which then empties into the Yangtze River via the Wusong and Taipu Rivers. Additionally, the Grand Canal, which connects the northern and southern regions of China, runs through this area. The southeast region of the area is mainly characterized by polders.

In order to figure out why polders appear in this region, I start with the formation of Taihu lake. At first, Taihu Lake Plain is a large bay connected with the sea. The Yangtze River's south bank and the Qiantang River's north bank extend to the east, surrounding the Taihu Lake area. The original bay gradually evolved into a lagoon, and finally into a lake completely isolated from the sea. As a result, the land surrounding Taihu Lake is at a lower elevation than the surrounding land, which makes it susceptible to flooding during the rainy season.

Polders, as often used in areas with a high water table, have been created to reclaim land from the lake. In the following part, I will introduce how polder has developed in this region.

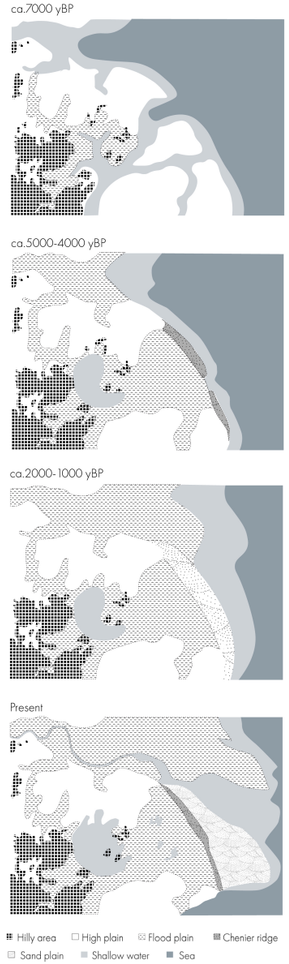


Figure3.3 The formation of Taihu lake
Source:Draw based on Umitsu, M. (1990).[Landform evolution of the southern Chang Jian River Delta]. The Journal of the Faculty of Letters, Nagoya University. History(107), 231-245.

3.3 Historical development

Swamp&Water

Figure3.4 Da Qing fen sheng yu tu. [Between 1754 and 1760] [Map]
Source: Retrieved from the Library of Congress, https://www.loc.gov/item/2002626726/.

Reclaimed land& Dense water network

Figure3.5 Military Map of Jiangnan Corps in Jiangsu Province [Map]
Source: Retrieved from website: https://digitalatlas.asdc.sinica.edu.tw/digitalatlasen/map.jsp?id=A104000049.

City development

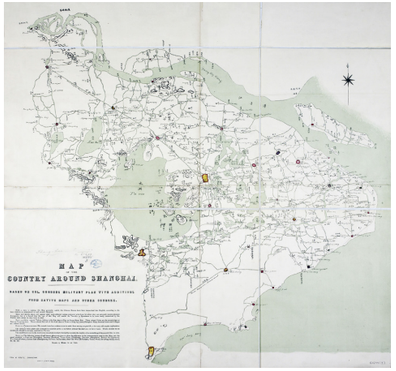


Figure3.6 Map of the country around Shanghai(1864)
Source: Retrieved from the open source collection of Virtual Shanghai.

The area used to be characterized by a lot of swampland and canals, which posed big problems for population and commercial growth. However, local people launched a massive land reclamation, converting the swamp into productive farmland and thriving cities.

Agriculture was able to flourish because of the development of a comprehensive network of rivers and irrigation systems, which also laid the groundwork for the growth of various settlements along the Grand Canal. Over time, these towns evolved into big cities, nourishing various cultures. Nowadays, these cities are still important in the economic development of the region.

Figure3.7 Benefits of polder

Historical drawings provide us with abundant evidence of the deep connection between local communities and the polders in the region. These artworks offer a window into the daily lives of people in the polder landscape, showcasing a range of activities that were essential to their livelihoods, including picking mulberry leaves, planting rice, social life, getting daily water, building houses, harvesting, draining for irrigation, and weaving.

Figure3.8 Gengzhi tu
Source: Retrieved from website:https://www.shuge.org/ebook/geng-zhi-tu/

3.4 Challenges in Taihu lake basin

Salination&Cyanobacterial bloom

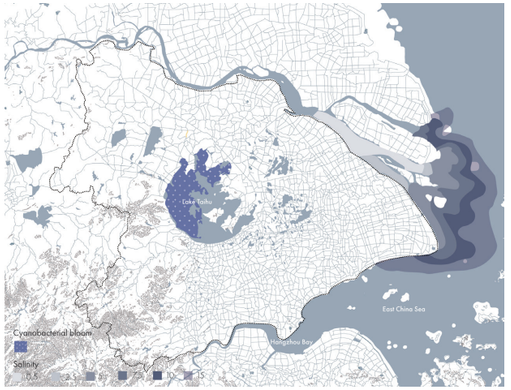


Figure3.9 Salination&Cyanobacterial bloom
Source: https://scenariojournal.com/article/yangtze-river-delta-project/

Water quality

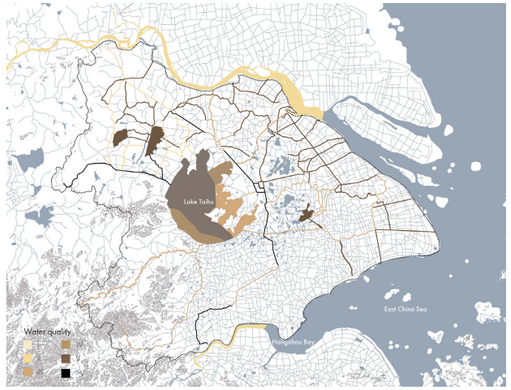


Figure3.10 Water quality
Source: Water resources report of Taihu Lake

City expansion&Water town

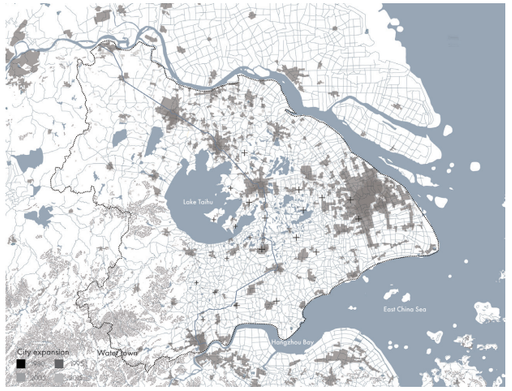


Figure3.11 City expansion&Water town
Source: Draw based on the data from Lake-Watershed Science SubCenter, National Earth System Science Data Sharing Infrastructure, National Science & Technology Infrastructure of China (http://lake.geodata.cn)

Waterlogging&Flood

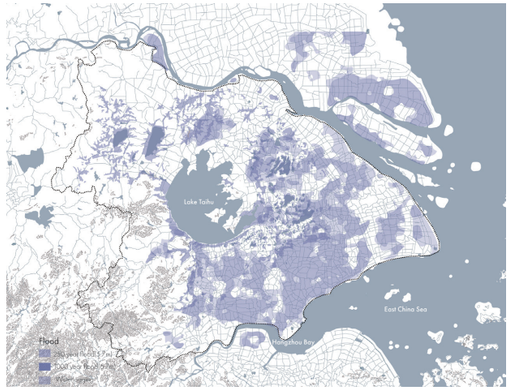


Figure3.12 Waterlogging&Flood
Source: Draw based on the Wang, Pendlebury, & Nolf, 2022

Water exchange in key areas of Taihu Basin in 2021

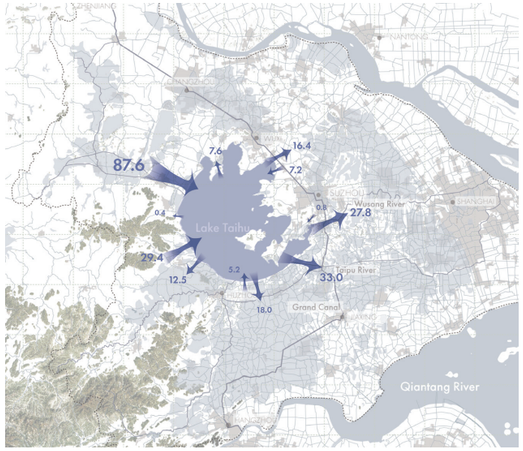


Figure3.13 Water exchange in key areas of Taihu Basin in 2021
Source:2021 Water resources report of Taihu Lake

Polders have high potential to act as sponges

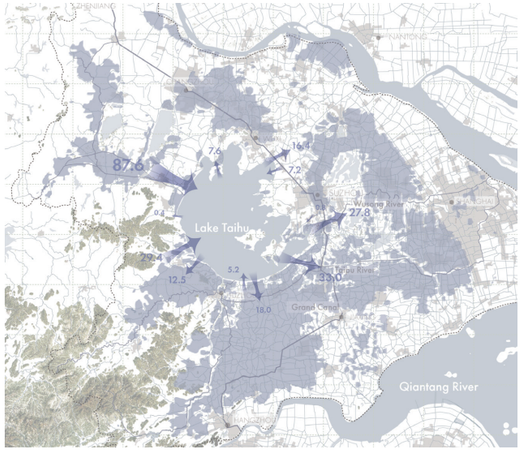


Figure3.14 Polder as sponge
Source: 2021 Water resources report of Taihu Lake

Nowadays, because of excessive human interventions, the Taihu Lake basin is facing a lot of challenges including cyanobacterial bloom, city expansion, low water quality, and waterlogging. Sewage from industry and agriculture contain the abundant nutrient, which brings the cyanobacterial bloom issue. Additionally, the summertime storms and rising water levels are to blame for the flooding issue. Meanwhile, rapid urbanization not only worsens flooding but also destroys traditional water towns in this region, which demolished the unique characteristic of the Yangtze River delta.

Among these challenges, the most urgent one is the flood problem. According to data from the 2021 Water resources report of Taihu Lake, the water volume of the river around Taihu Lake carry13.02 billion cubic meters into Taihu Lake, while the outflow of Taihu Lake is 11.57 billion cubic meters.

This has resulted in a situation where the water level in Taihu Lake is known to be 'easy to rise but difficult to fall'. In the summer months, the region experiences heavy rainfall, and due to the downstream water level being nearly the same as the upstream water level, it becomes challenging to discharge water into the Yangtze River. As a result, local authorities have been actively seeking solutions to address the flood problem, such as strengthening the infrastructure of water management and improving flood forecasting and warning systems.

Landscape, as the base layer of these constructions, has a high potential to alleviate these challenges. Polders, which make up a significant portion of the area, have the ability to act as sponges, retaining, infiltrating, and storing water. In the following section, I will delve deeper into how polders function as sponges to mitigate flooding problems.

3.5 Polder development

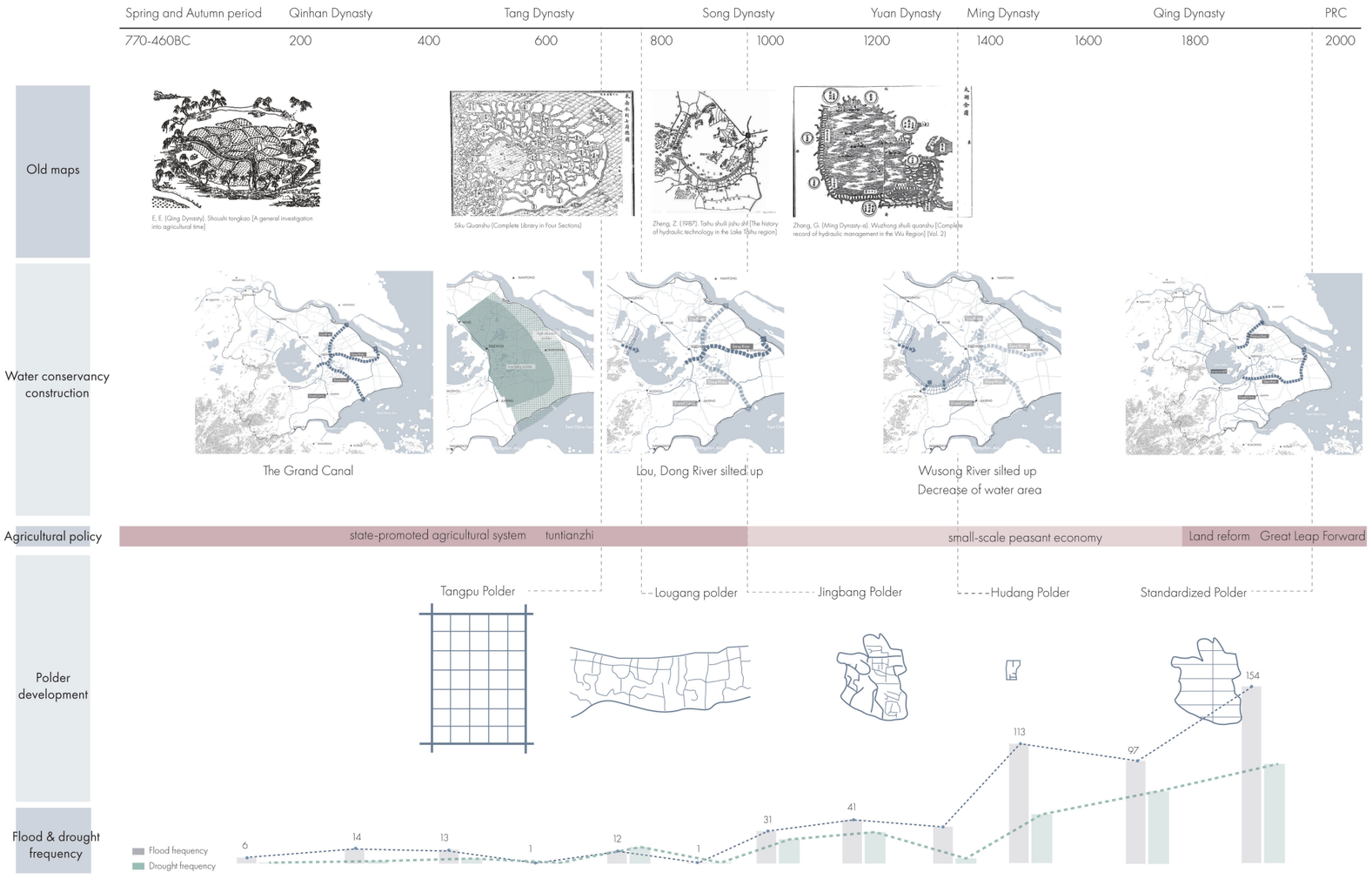


Figure3.15 Polder development
Source: Miao, Q. (1982). Taihu diqu tangpu weitian de xingcheng he fazhan [The Formation and development of Tangpu Polders in the Taihu region]. Agricultural History of China.

Scholars have different opinions on the classification of polders in the Taihu Lake basin. Historian Yongqiang He classified from the geographical location perspective while Qiyu Miao categorized from the view of polder development. In this project, I refer to the classification of Qiyu Miao's research, which was based on the succession dynasties, demonstrating the water conservancy and agricultural intervention in the polder development, and shaping the characteristics and local identities of the Taihu Lake basin.

Development of water conservancy construction

The timeline chart shows the development of polders in the past 2000 years. When the Wu State was at war with its southern state Yue, it started to regulate grain production and construct canals to ensure military supply and transport. This is when the earliest centralized construction of polders in China began (Wang, Pendlebury & Nolf,2022). During this period, there were three rivers connecting Taihu Lake and the Yangtze River, called the Lou River, Song River, and Dong River. Then, these government-led polders spread to the Yangtze's lower-reach basin. Later, the Lou River and Dong River silted up, and the high volume of water could only be discharged through the Song River, which made floods more frequent due to the decrease in the outlet. Nowadays, the Wangyu River and Taipu River are the main watercourses between Taihu Lake and the Yangtze River, carrying enormous water into the Yangtze River in the summer season.

Development of polders

Under the background of water conservancy construction, the size and shape of the polders varied in different phases. Because of the large-scale state-led agricultural system policy from the spring and autumn period to the Tang dynasty (c. the eighth century), the scale of polders is large, which made it easy to be managed by the army and country. Tang pu polder (dyked-canal polders) and Lougang polder (small-canal polders) emerged during this time. Later, the small-scale economy was introduced in the Song and Yuan dynasties (tenth–fourteenth century), and the scale of polders turned to small, called Jingbang polder (creek polders). During the Ming and Qing dynasty (fourteenth–twentieth century), the low-lying lake plain of east Lake Taihu (the modern south Suzhou, Huzhou, and Jiaxing region) has been continuously reclaimed, creating a new type of polder known as Hudang polder (lake and marsh polders), which is also one type of small polder systems.

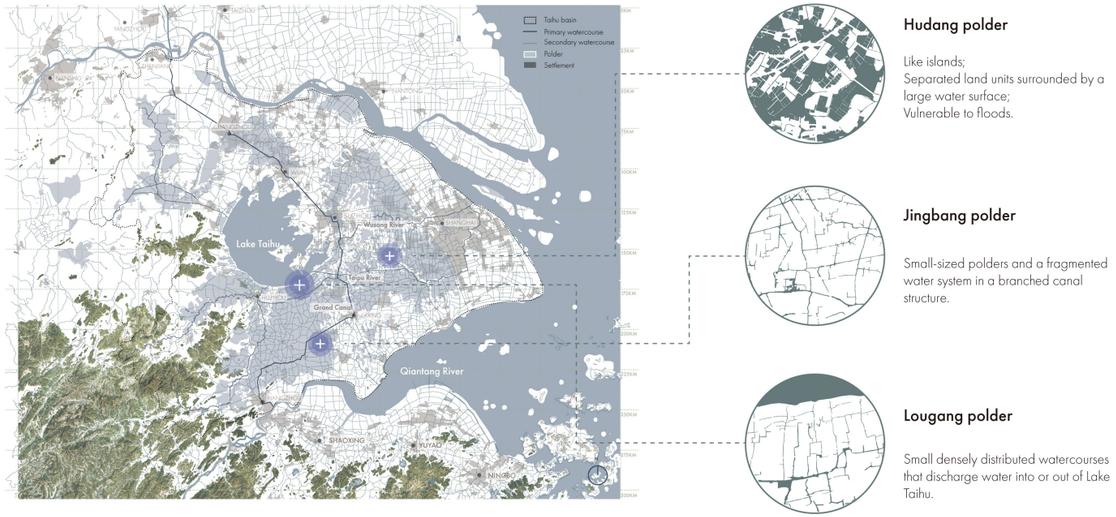
In conclusion, based on the development of the polders and their geological conditions, polders are divided into five types: (1) Tangpu polder (2) Lougang polder,(3) Jingbang polder, (4) Hudang polder (5)modernized polder.

3.6 Polder typology

Among these five types of polders, the Lougang polder, Jingbang polder, and Hudang polder are still widely distributed in this region nowadays.

1) Hudang polder: like islands, separated land units surrounded by a large water surface;
2) Jingbang polder: small-sized polders and a fragmented water system in a branched canal structure;
3) Lougang polder: small densely distributed watercourses that dischrage water into or out of Taihu lake ;

Since the Lougang polder is the oldest and most well-protected polder in this region, I choose it as my design location.



Hudang polder

Like islands;
Separated land units surrounded by a large water surface;
Vulnerable to floods.

Jingbang polder

Small-sized polders and a fragmented water system in a branched canal structure.

Lougang polder

Small densely distributed watercourses that discharge water into or out of Lake Taihu.

Figure3. 16 Polder typology

3.7 Conclusion

Figuring out the formation and basic characteristics of the Taihu Lake basin, the importance of polders is self-evident in this region. Water issues and urban expansion are the challenges polders are encountered from the past to now and still have to face in the future. Based on the water conservancy construction, polders are divided into five types, among which the Lougang polder is the oldest and most well-protected, providing lots of precious traditional polder wisdom.

Figure4.1 lougang polder
Source: https://znews.zjol.com.cn/202006/t20200604_12026720.shtml

04 Analysis of Lougang Polder

4.1 Glimpse of Lougang polder
4.2 Structure of Lougang polder landscape
4.3 Historical development of Lougang polder
4.4 Understanding Lougang polder
4.5 Historical experience
4.6 Challenges in polder landscape
4.7 Conclusion

4.1 Glimpse of Lougang polder

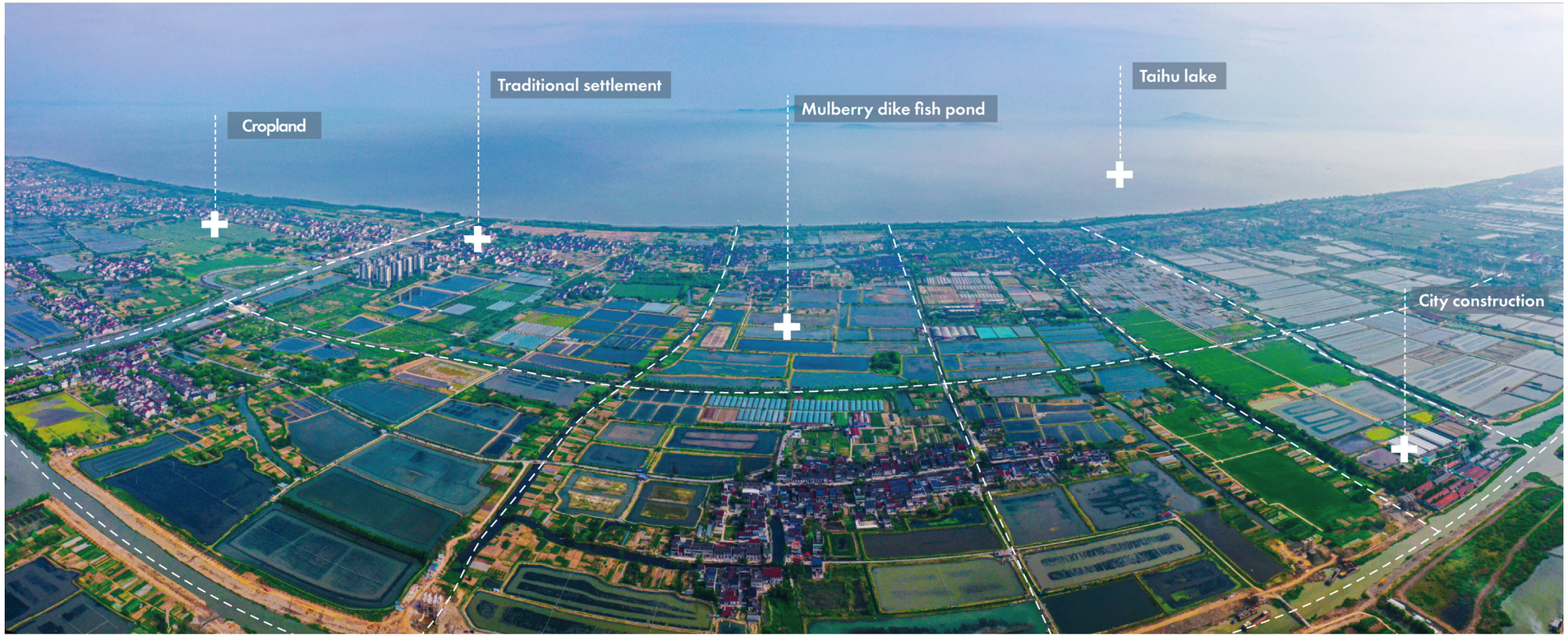


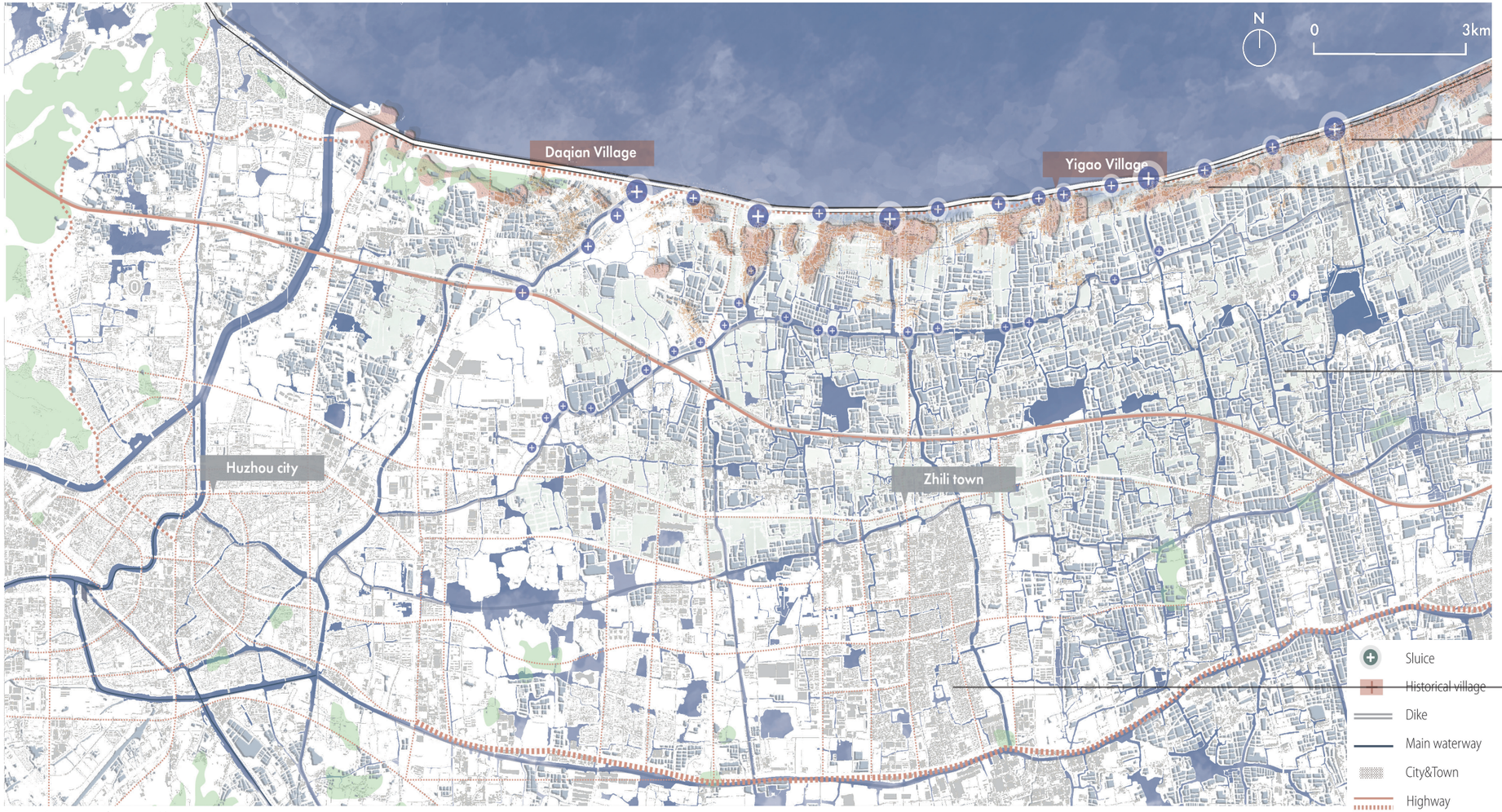
Figure4.2 Birdview of Lougang polder
Source: http://zj.people.com.cn/n2/2022/0602/c186327-35298367.html

The term "Lougang" refers to small longitudinal watercourses that connect Lake Taihu with the Tangs, which are wider watercourses used for irrigation and water transportation in newly reclaimed areas. These Lougangs were built at regular intervals and were mainly located along the west, south, and east shores of Taihu Lake. The Lougang polders are composed of various elements, including polders, irrigation and drainage systems, embankments, sluices, crisscrossed ponds and lakes, mulberry fields, and fish ponds. (Xie,2017)

The Lougang--densely watercourses continue to serve as the backbone of regional irrigation, flood control, and drainage projects. However, in recent years, rapid urbanization and large-scale real estate development have resulted in the siltation of these watercourses. The number of Lougangs connected to Taihu Lake decreased from 73 in the 1990s to 47 in 2000 and further reduced to only 39 in 2015 (Deng, Tan, Li, Wan, Liu & Zhou, 2016). As a result, the irrigation and drainage functions of the Lougangs have been affected, and the historical landscape has been damaged. In order to remind people of the precious water ecological and cultural value of the Lougang polder, the "Lougang Irrigation and Drainage System" in Huzhou was recognized as a Heritage Irrigation Structure by the International Commission on Irrigation and Drainage in 2016.

Gathering the wisdom of our ancestors, the Lougang polder solved the flood problems of Taihu Lake, which had puzzled us for thousands of years. Lougang polder plays a crucial role in the regional agricultural economy and water management. The Mulberry dike fish Pond, derived from Lougang, has given birth to the famous title of the land of fish and rice and the home of Silk in the Jiangnan region.

4.2 Structure of Lougang polder landscape




Ring dike

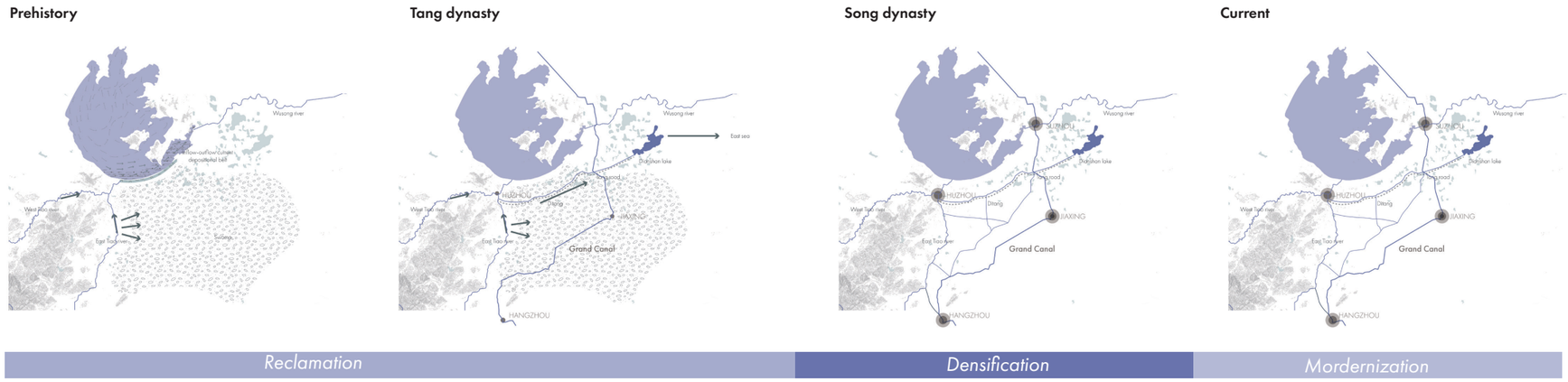

Traditional settlement


Mulbberty dike pond


Zhili Town

Figure4.3 Structure map of Lougang polder
Source: Draw based on Google map

4.3 Historical development of Lougang polder



To gain a deeper understanding of the Lougang polder, I began by exploring the historical evolution of the water system in the Taihu basin. This involved studying the region's water management practices from prehistoric times to the Tang and Song dynasties, and up to the present situation. Initially, the area south of Taihu lake was largely comprised of swampland. However, as people began to settle in the region, they found themselves frequently threatened by flooding from the mountains to the south. To address this, they constructed the first water channel, called 'Tang', which diverted water from the mountains to Dianshan lake in the east. This channel also served as an important transportation route, linking Huzhou city to other cities along the Grand Canal.

Based on the construction of the water system in the south of Taihu lake, the development process of Lougang polder is divided into three phases: reclamation, densification and mordernization.

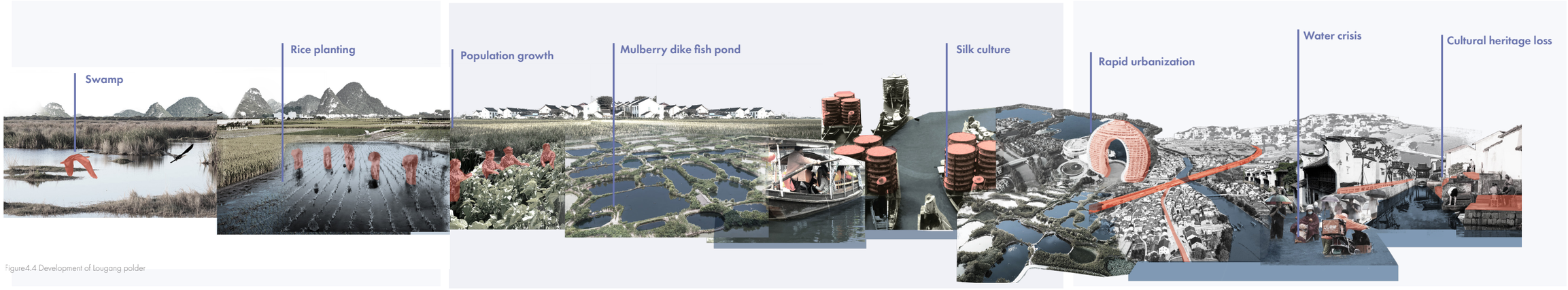


Figure4.4 Development of Lougang polder

4.3 Historical development of Lougang polder

4.3.1 Tang dynasty--From mud to fertile soil

The first phase is reclamation, the ancient people settled here and started to plant rice.

I try to find clues from poetries and ancient records. Most of them mentioned rice and small lakes, so I speculate and draw this picture to show what the landscape might have looked like during that time. Since rice can be planted in water, it became the best choice considering the frequent flooding in this area. Basically, the picture portrays a landscape dominated by rice paddies.

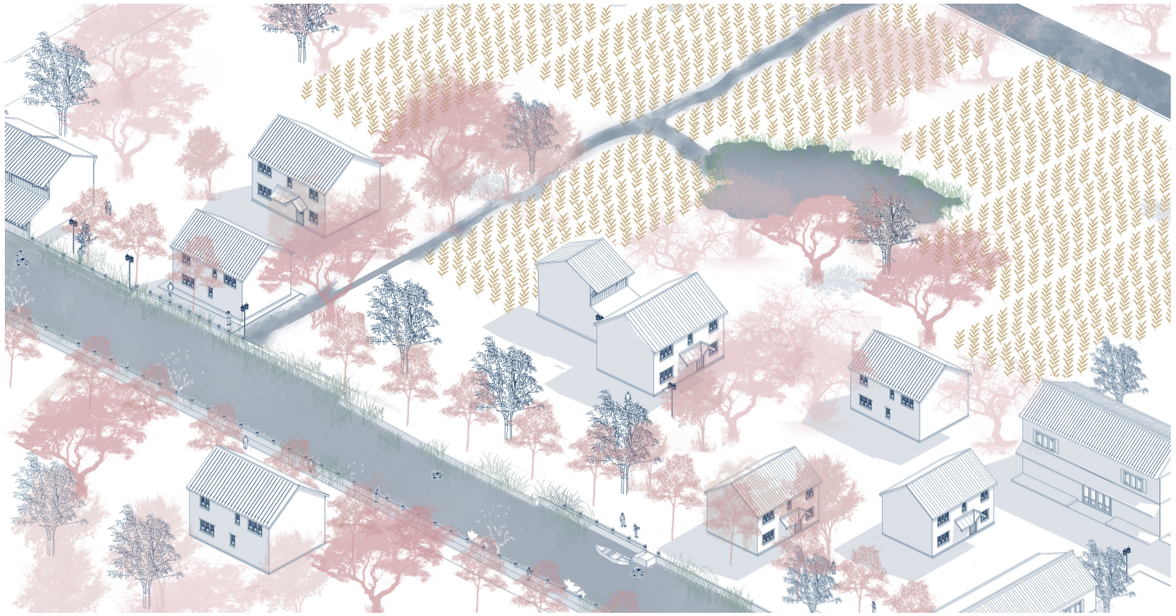
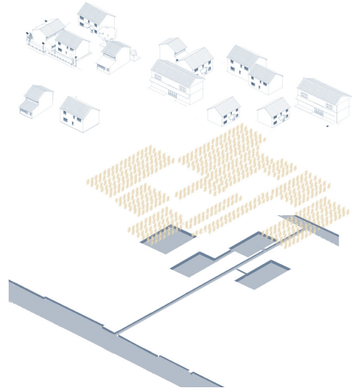


Figure4.5 Rice agricultural landscape in Tang dynasty

4.3.2 Song dynasty

During the second phase, the focus shifted towards densification due to the increasing population, leading to a greater demand for food. To address this, the mulberry dike fish pond system was introduced, leading to the flourishing of silk culture. This agricultural shift also had an impact on the landscape, resulting in a combination of rice paddies and fish ponds. Therefore, during this period, the landscape remained predominantly agricultural but with noticeable changes.



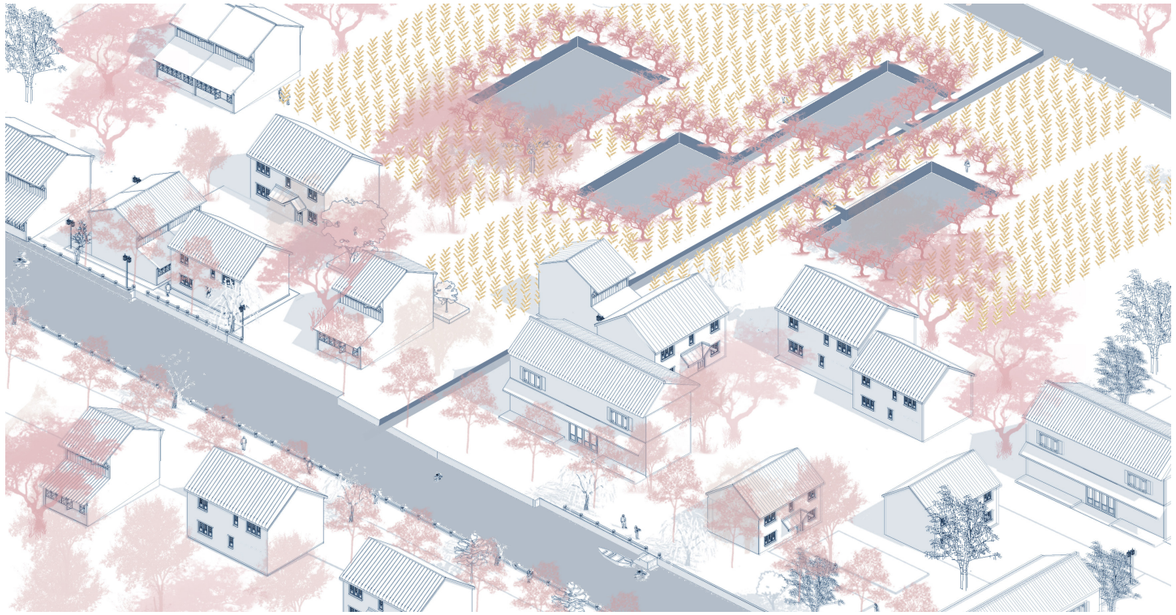


Figure4.6 Dike pond agricultural landscape in Song dynasty

4.3.3 Current--Modernization

The third phase symbolizes modernization, which brings new challenges such as water scarcity and urban expansion that pose a threat to the safety and continuity of the polder system.
The accompanying image illustrates how road development has resulted in the separation of villages. Meanwhile, farmers prioritize expanding fish ponds over maintaining dikes, as they yield higher profits. As a result, the fish ponds have grown in size, while the dikes have become narrower.

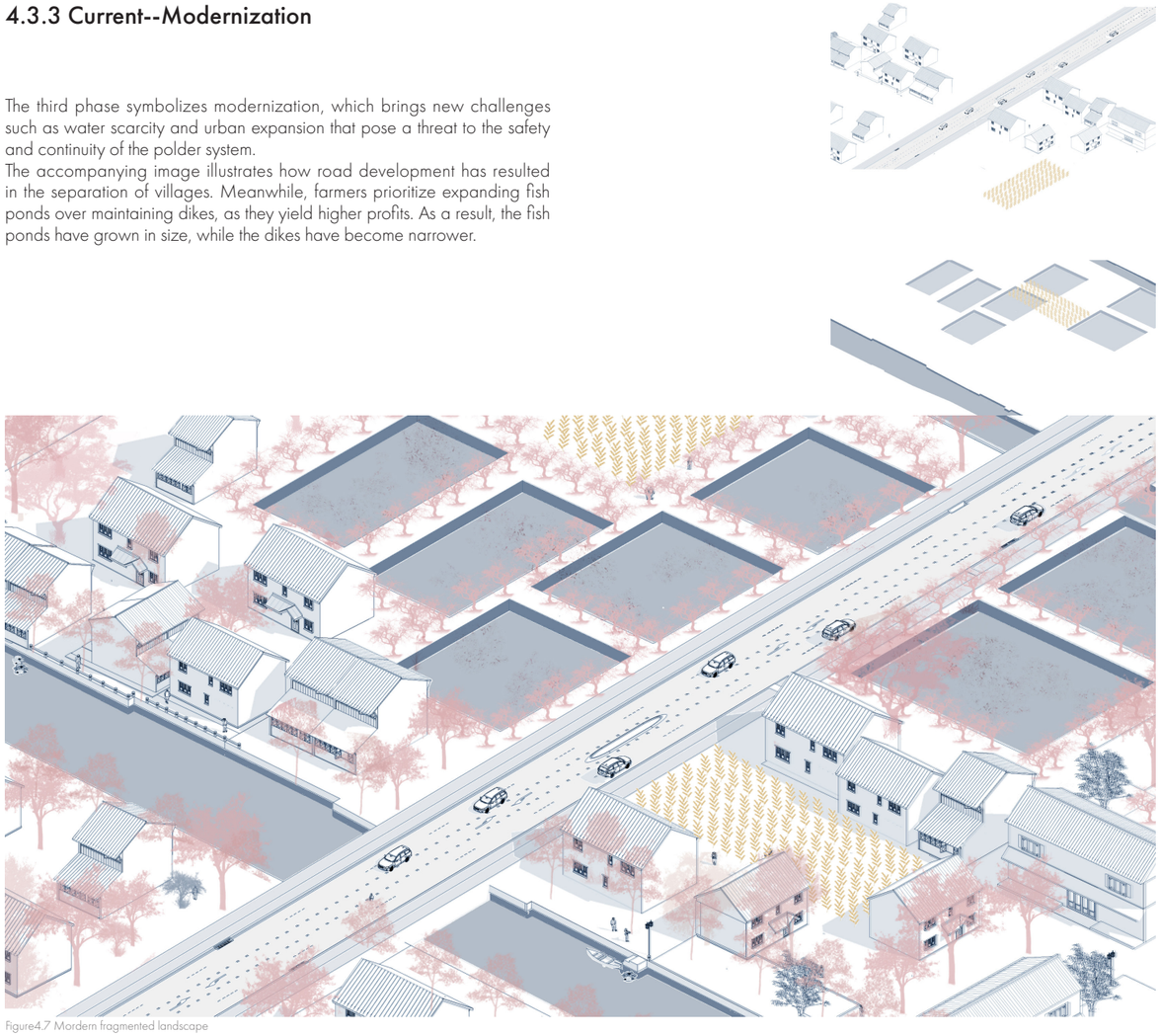


Figure4.7 Mordern fragmented landscape

4.4 Understanding Lougang polder

The interdependence of the water system, agriculture system, and settlement system is evident in the historical development of the Lougang polder landscape. These three layers combined to create a robust and stable polder landscape system. In the following part, I will explain the mechanism of each system and their interrelationships.

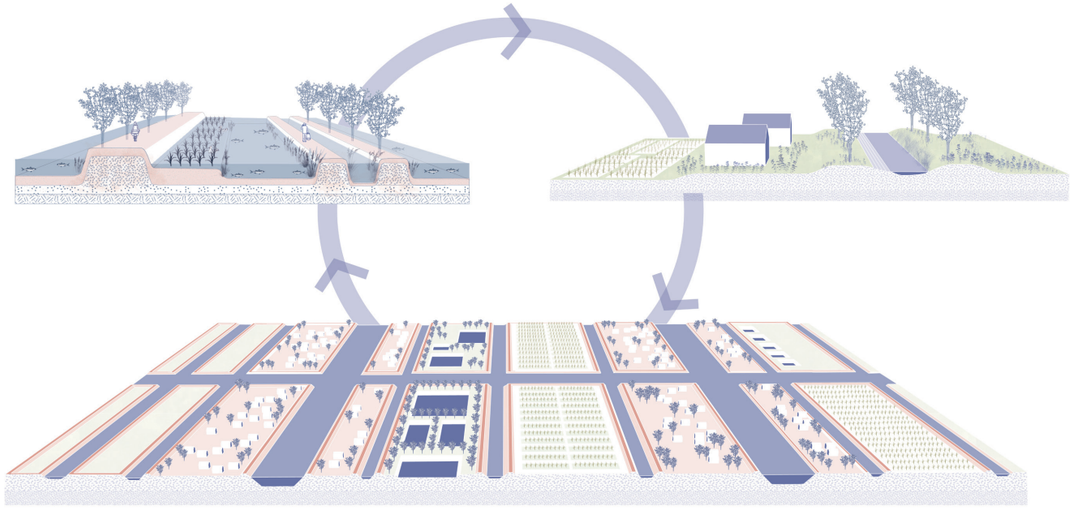


Figure4.8 Relationship among the water system, agriculture system, and settlement system

4.4 Understanding Lougang polder

4.4.1 Water system

During the Song dynasty, a dense water network was created to address drainage issues during the rainy season. Small dikes were built on both sides of the water channel, and several sluices were constructed along the lakeshore line. These sluices remain closed most of the time as the water level in Taihu Lake is higher than that of the surrounding land. However, during the rainy season, when there is an inability to drain away rainwater in a timely manner, the sluices are opened.

The water system in the Lougang polder has been designed to serve multiple purposes. It is used for the irrigation of crops, as well as for aquaculture and transportation. The canals and ponds are also important habitats for a variety of aquatic plants and animals.

Figure4.9 Water system of Lougang polder

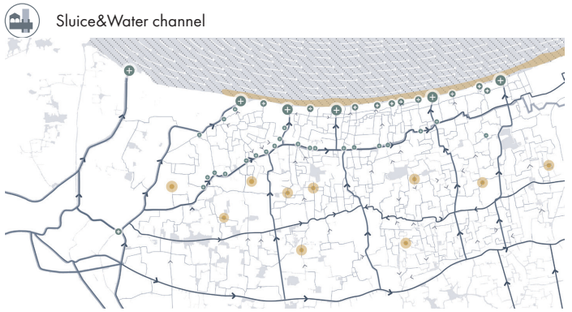


Figure4.10 Sluice and water channel distribution of Lougang polder

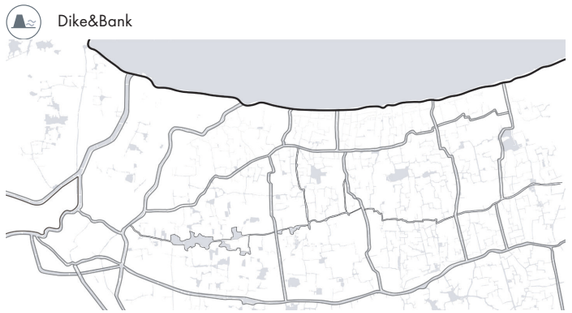


Figure4.11 Dike and bank distribution of Lougang polder

4.4.1 Water system

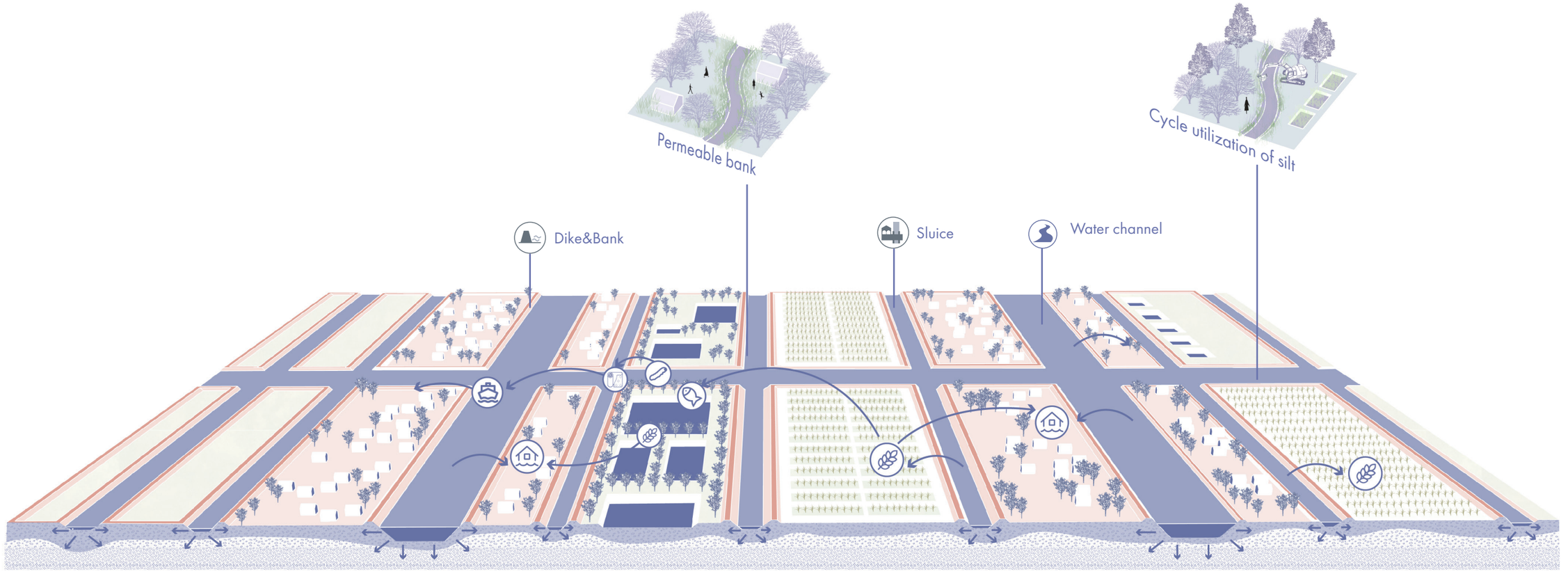


Figure4. 12 Water system of Lougang polder

4.4.2 Agriculture system

Due to the population growth in the Song dynasty, the mulberry dike fish pond was introduced during this phase, which is a type of efficient artificial aquaculture system that uses a man-made dyke to divide a body of water into separate ponds used for cultivating fish.

The mulberry dike fish pond is a sustainable way of aquaculture production. The leaves of mulberry trees are used to feed silkworms. The waste produced by silkworm rearing is used as fish food, and the fish excrement is deposited at the bottom of the pond to become nutrient-rich humus sludge, which can be used as fertilizer for mulberry and other economic trees. The ponds are often filled with water from a nearby river or canal, which helps to maintain the right water temperature and quality. The mulberry dike fish pond in Huzhou has become an important cultural heritage in the world recently.

Generally speaking, the development of the mulberry dike fish pond has historically played an important role in the economic and social development of the regions, not only promoting the sericulture and fish culture but also driving the development of silk reeling and other processing industries, developing into a complete and scientific ecosystem.

Figure4.13 Water system of Lougang polder

Cropland

Figure4.14 Cropland in Huzhou
Source: https://www.baike.com/wikiid/7093524642245716760?from=wiki_content&prd=innerlink&view_id=40pcfvkn9ma000

Dike pond

Figure4.15 Dike pond in Huzhou
Source: http://www.dili360.com/ch/article/p5ba3369cb5a5754.htm

Mulberry dike fish pond

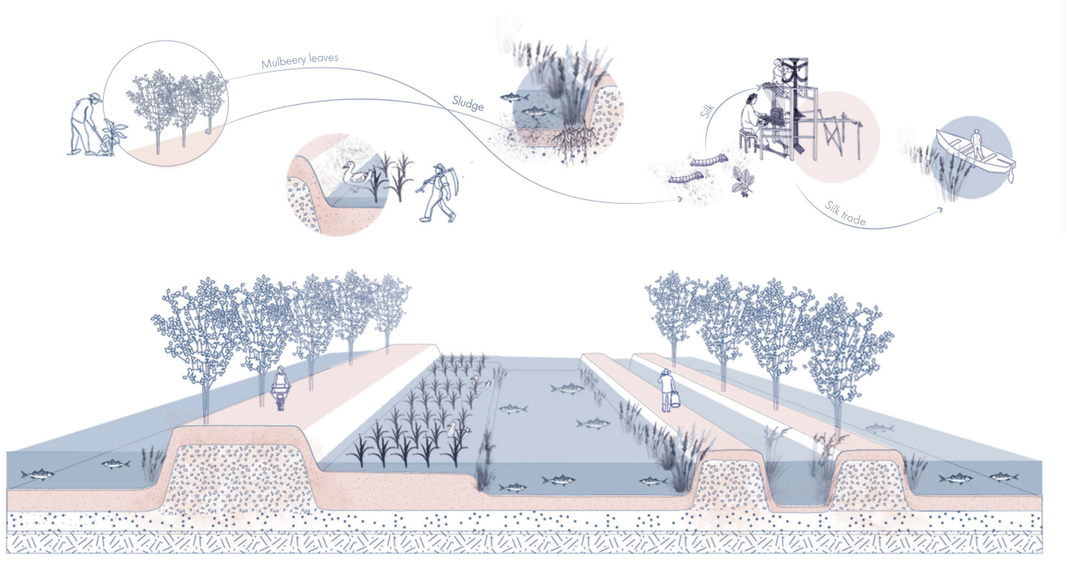


Figure4.16 Mulberry dike fish pond system

4.4 Understanding Lougang polder

4.4.3 Settlement system

The historic villages are mainly along the lake shoreline on the dike. Those villages which were adjacent to cities were removed and invaded because of city expansion.

Prior to the 1980s, water transport was the primary mode of transportation in the Taihu Lake Basin, which led to the development of towns, markets, and villages along the waterways. The linear structures of the Lougang canals played a significant role in shaping settlement patterns in this lakeshore area, as roads and dwellings were constructed parallel to the canals (Xie,2017).

Since it is common for houses to be oriented towards the south to capture maximum sunlight, public spaces and courtyards are often situated between these dwellings to encourage social interaction. These spaces not only serve as gathering places for residents but also provide ventilation and natural light to the buildings, which is essential for maintaining a comfortable living environment.

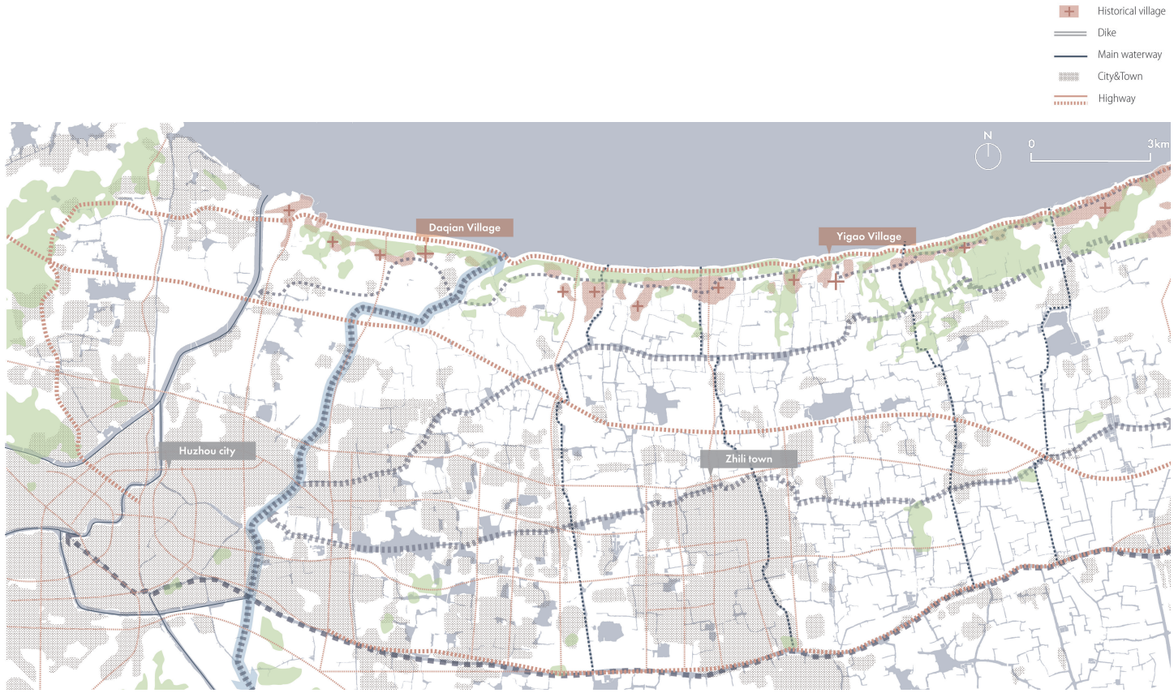


Figure4.17 Settlement system of Lougang polder

Traditional settlement

Figure4.18 Boating on ditch
Source: https://fashion.sina.cn/l/ds/2022-04-28/detail-imcwipii6764679.d.html

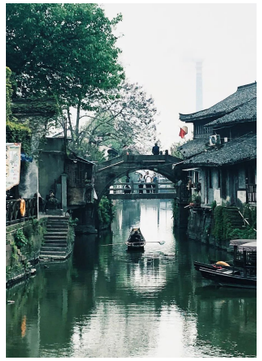


Figure4.19 Boat and bridge
Source: https://fashion.sina.cn/l/ds/2022-04-28/detail-imcwipii6764679.d.html

Figure4.20 Public space among buildings
Source: https://fashion.sina.cn/l/ds/2022-04-28/detail-imcwipii6764679.d.html

Figure4.21 Public space under gallery
Source: https://fashion.sina.cn/l/ds/2022-04-28/detail-imcwipii6764679.d.html

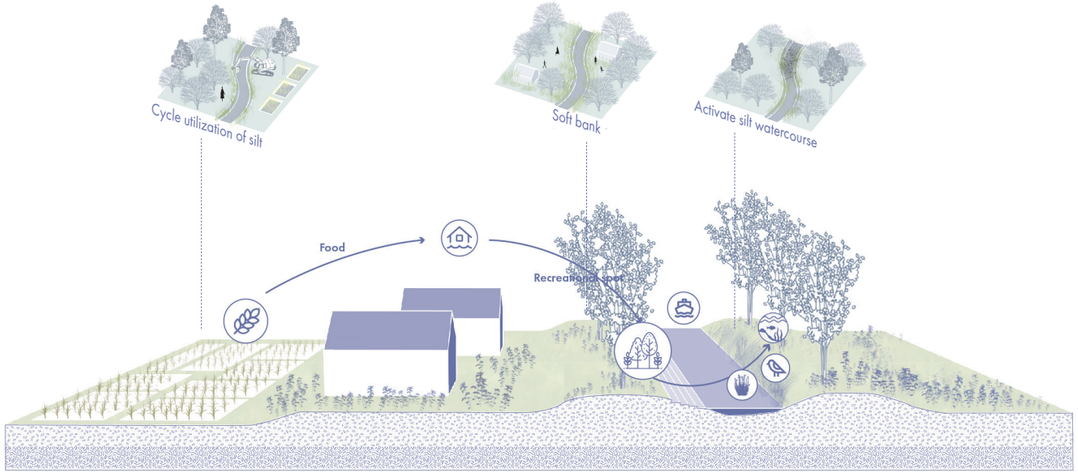


Figure4.22 Settlement system of Lougang polder

4.5 Historical experience

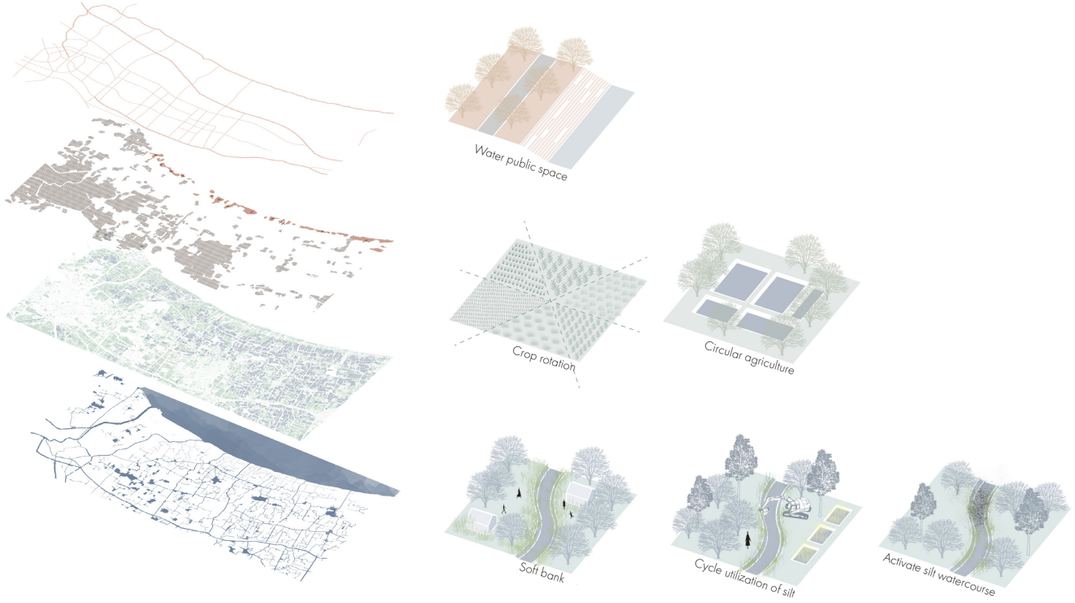


Figure4.23 Historical experience in Lougang polder

Historical experince01--Bamboo permeable dike

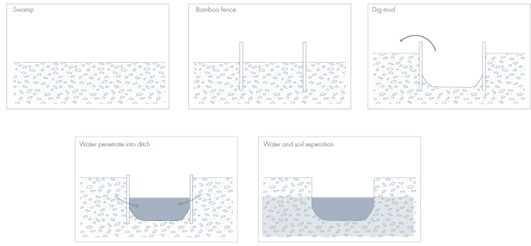


Figure4.24 Dike construction process

Historical experience02--Dredging

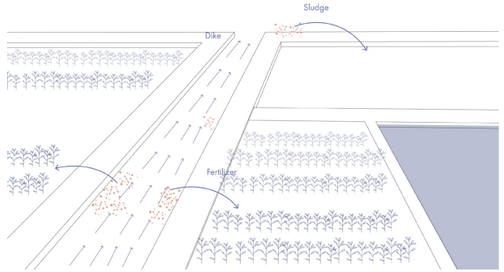


Figure4.25 Water system of Lougang polder

Water provides a solid base for both agricultural production and human settlement. Moreover, the canals provide essential amenities to the living environment in this area, such as access to fresh water for irrigation and transportation, and serve as a source of natural beauty and recreation. Overall, the canal system is a vital component of the region's infrastructure and has played a crucial role in shaping its unique cultural and economic landscape.

In each layer, I try to sum up some historical experiences. In regards to the water system, sponge water networks are constructed by implementing soft banks that allow water to infiltrate the soil, dredging sediment to activate silted water courses while enhancing dikes. For the agriculture system, the circularity in aquaculture and crop rotation improved production efficiency and kept the water relatively clean. As for the settlement system, how to create public space alongside the water channel and private gathering space within dwellings is instructive for spatial design.

Overall, the integration of water resources and agricultural practices in the Lougang polder has enabled the development of a unique and sustainable ecosystem that has supported human settlement and economic growth for generations.

4.6 Challenges in Lougang polder

Nowadays, the rural polders have undergone a transformation and become a mixture of agricultural, urban, and industrial areas. This includes not only fields and settlements within the polders but also new infrastructure, urban housing, etc. The challenges the polder landscape is facing contain three aspects: flood, aquaculture water pollution, and city expansion.

4.6.1 Flooding

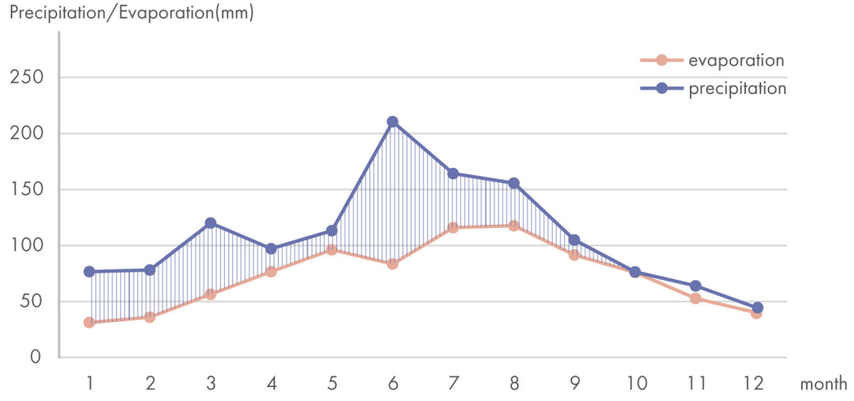


Figure4.26 Precipitation and evaporation of Huzhou city in 2021

The region experiences a higher amount of precipitation than evaporation. Through the topography map and section, it becomes apparent that the majority of the water originates from the mountains on the southern side. However, due to the presence of a large dike, the water is obstructed, resulting in flooding issues along the shoreline of the lake.

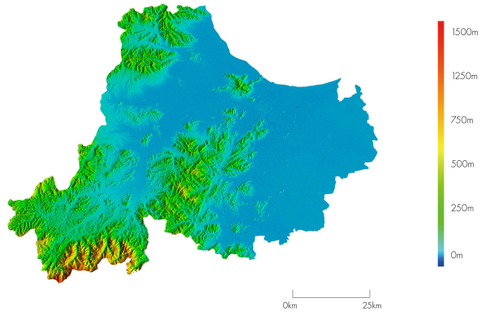


Figure4.28 Topography map of Huzhou

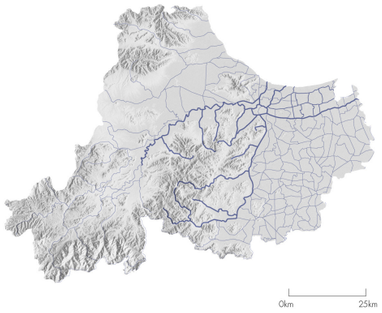


Figure4.29 Main water courses of Huzhou

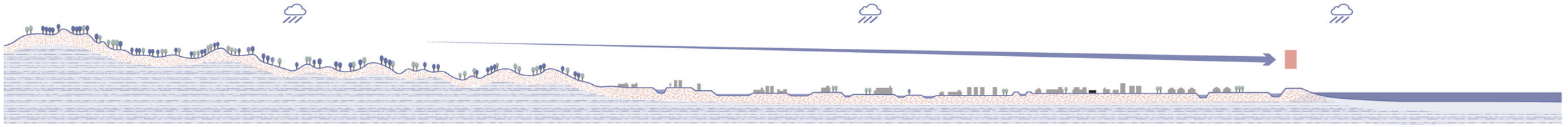
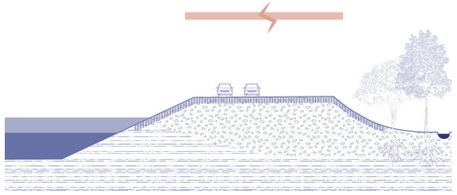


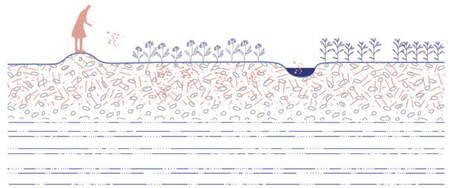
Figure4.27 Section of Huzhou from mountain to Taihu lake

4.6.2 Three challenges in Lougang polder

Challenge1: Flooding



Challenge2: Monoculture& Aquaculture water pollution



Challenge3: Road segregation & City expansion

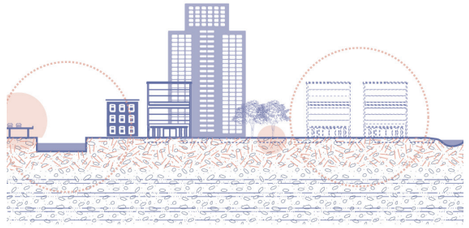


Figure4.30 Challenges of Lougang polder

Although the production of mulberry dike pond has a lot of advantages, this traditional wisdom has become a forgotten cultural heritage. On the one hand, many young and middle-aged rural workers go to cities for employment, leading to a decline in agricultural production. This, in turn, has resulted in the monoculture of crops.

On the other hand, the structure of dike ponds has undergone changes, and the area of high-quality freshwater aquaculture fish ponds has increased significantly. Research indicates that a dike-pond ratio of 4:6 is optimal from an ecological perspective. However, the current ratio is 3:7 or 2:8 due to the higher profits generated by ponds.

As a result of this imbalance, crops on the foundation cannot provide sufficient bait for aquaculture, and the pond mud cannot be fully absorbed and utilized by the crops. This incomplete transformation of material and energy results in silting of the pond and shallowing of the water body, leading to a gradual deterioration of the ecological environment.

Additionally, the discharge of wastewater from fish ponds into nearby water bodies and the overuse of pesticides and fertilizers in crop cultivation can lead to the accumulation of harmful chemicals in the soil, water, and aquatic organisms, contributing to water pollution. The high nutrient content in the wastewater can lead to algal blooms and decreased oxygen levels in the water.

Affected by social and economic development, rapid industrialization and rural urbanization increasingly occupy rural land resources, and the area of rural cultivated land and fish pond decreases by 4.6% per year. Huzhou City has the tendency to expand to the north side, resulting in the filling of many water channels and fish ponds, as well as the removal of several villages for industrial construction purposes. This has resulted in the transformation of soft banks into hard banks, and permeable surfaces into hard surfaces, ultimately decreasing the water resilience of the region. Moreover, the construction of roads has passed through rural areas, leading to the separation of villages and cropland, and increasing fragmentation.

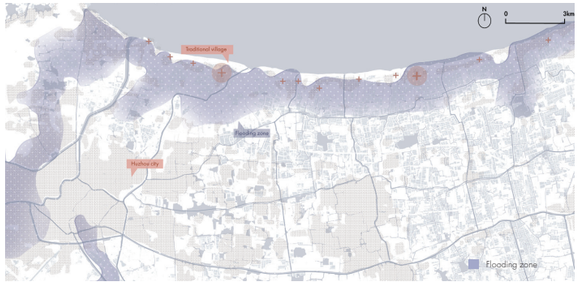


Figure4.31 Flood zone in Lougang polder

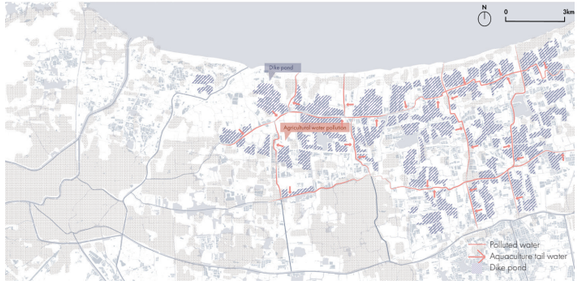


Figure4.32 Agriculture water pollution

Figure4. 33 Huzhou City expansion

Flood

Huzhou, located between the mountain range to the south and Taihu Lake to the north, is susceptible to flooding. In recent times, the issue has become more frequent due to the silting of the waterways and the construction of large embankments.

Aquaculture water pollution

The aquaculture tail water contains a high level of nutrients which cause the eutrophication of water. Since fish ponds are mainly located near waterways, the discharge of aquaculture tailwater will directly pollute the surrounding water. In addition, the overuse of chemical fertilizer in cropland worsens pollution.

City expansion

Huzhou City is expanding towards the north, which has led to the filling of water channels and fish ponds, as well as the traditional villages to make way for industrial development.

4.6.3 Challenge maps of polder landscape

Basically, the challenges in the polder landscape include three aspects, flood, agriculture water pollution, and city expansion. In the past, the water systems, agricultural systems, and settlement systems were treated as interdependent units. Nevertheless, these three systems have been built into three separate units in recent years(-Figure4.35). Higher dikes are built for flood protection; fish pond expansion has occupied the space of dikes; industrial development invades the traditional villages and dike ponds. All of these constructions turn polders into the less resilient and fragmented landscape.

In conclusion, it is crucial to learn from historical experience and summarize the design principles. In the next chapter, I will explore the potential of polder that helps to alleviate these challenges while bringing more possibilities to this region, making it a sustainable and resilient complex system.

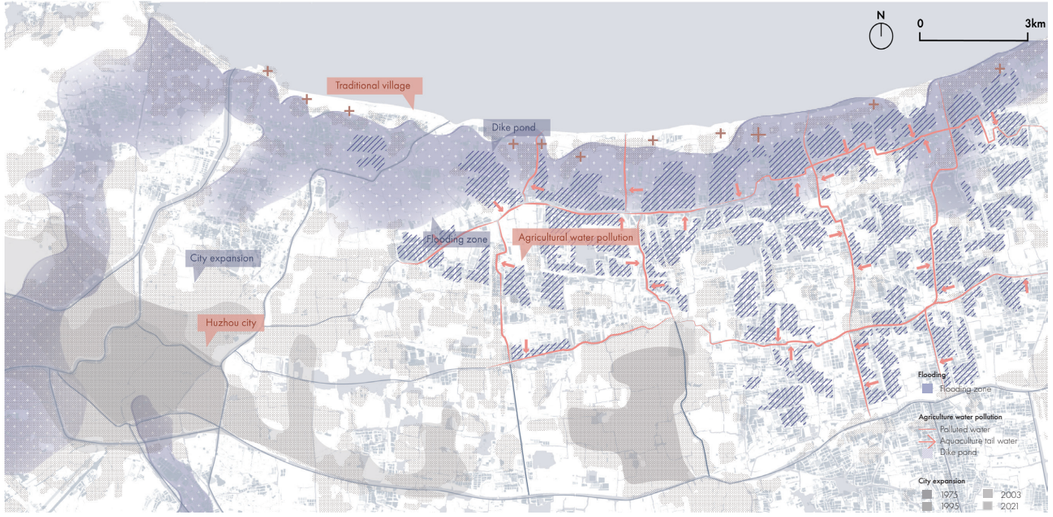
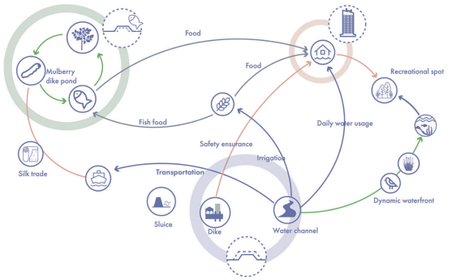


Figure4.34 Challenge map of Lougang polder

4.7 Conclusion

Lougang polder is known for its sophisticated system of dikes, sluices, and canals, which have allowed it to withstand floods over the centuries. Its success has provided a wealth of traditional polder wisdom that continues to be valuable to this day.

From the rice agriculture landscape to the dike pond agriculture landscape to the fragmented modernized landscape today, the water, agriculture, and settlement systems have undergone continuous changes. By understanding how these three systems worked and their interrelationships, we could get some inspirations and clues from historical experience and apply them to the design, thus generating a landscape that is more in line with the local context.



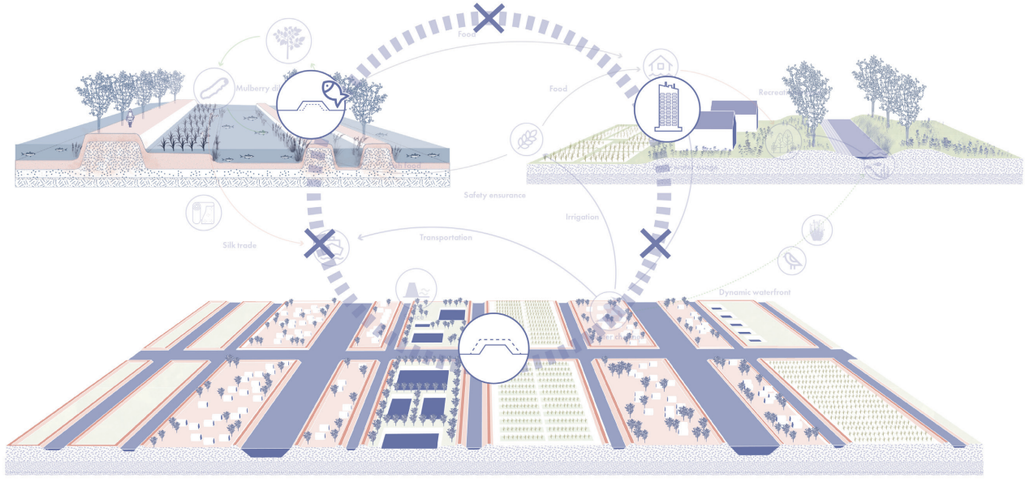


Figure4.35 Three separate systems

Figure5.1 Polder landscape fragmented by highway
Source: https://ishare.iteng.com/c/s/7qtIRdCKnH

05 Regional Strategy&Principle

5.1 Case study
5.2 Design principles for resilient polder landscape
5.3 Design Strategy
5.4 Design assignment
5.5 Conclusion

5.1 Case study

5.1.1 Bishan-Ang Mo Kio Park

Bishan, Singapore | Ramboll Studio Dreiseitl | Client: Public Utilities Board / National Parks Board, Singapore

Figure5.2 Birdview of Bishan park
Source: https://www.asla.org/2016awards/169669.html

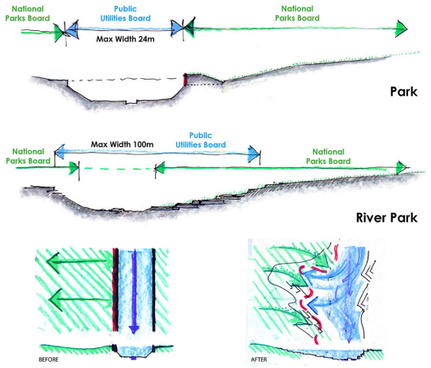


Figure5.3 Multi-functional opportunities for social, cultural and environmental benefits.
Source: https://www.asla.org/2016awards/169669.html

Bishan-Ang Mo Kio Park, one of Singapore's largest urban parks, is a popular spot for social interaction and recreation in addition to serving as a drainage and water supply. The Active, Beautiful, and Clean Waters Programme, a long-term initiative to turn the nation's water bodies into dynamic, fresh spaces for socializing and leisure, was launched in 2006 by Singapore's national water agency, PUB.

The design breaks down the concrete channel, turning it into natural waterways. When the water level is relatively low, people will be able to get close to the river for recreation. During the storm event, parkland will be flooded, carrying the water flow downstream. After the design, the river cross-section spread from 17-24m at flood capacity to almost 100m in width, increasing the resilience capacity by approximately by 40%. In addition, the river's restoration has produced a wide range of microhabitats, increasing not just the biological diversity but also the adaptability of species inside the park, greatly enhancing their chances of long-term survival.

The park is a wonderful illustration of how a city park can serve as ecological infrastructure, combining water supply, flood control, biodiversity, and recreational opportunities.

5.1.2 The Oostvaardersplassen

Flevoland, Netherlands | Feddes/Olthof Landscape Architects

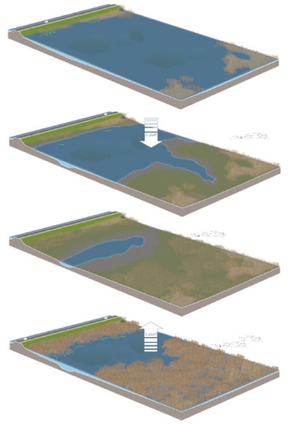


Figure5.4 The principle of the marshland reset
Source: https://www.staatsbosbeheer.nl/-/media/oostvaardersplassen/oostvaardersplassen-beheer/2019-brochure-oostvaardersplassen-in-the-picture.pdf

The Oostvaardersplassen is one of the largest nature reserves located in the province of Flevoland in the Netherlands. It resides on reclaimed land from the Zuiderzee, the former inlet of the North Sea, supposed to be an industrial park at that time. Because of the persistence of a group of ecologists, the region was established as a sanctuary where the natural environment could flourish and restore the Dutch landscape. Now it is a varied marshland area of global importance for breeding and migratory birds. The constantly changing water levels create a highly dynamic habitat including reed lands of marsh, wet grassland with shallow water, dry grassland, and woodland.

The design task here contains three aspects: 1) Preserving and enhancing the habitat of special bird species; 2) Creating a diverse and aesthetically pleasing landscape featuring clusters of trees and shrubs, expansive grassy areas, and moist grasslands; 3) Integrating the area into a newly established national park, alongside the Markermeer, the Marker Wadden, and the Lepelaarplassen.

Figure5.5 Plan of the Oostvaardersplassen
Source: https://www.staatsbosbeheer.nl/-/media/oostvaardersplassen/oostvaardersplassen-beheer/2019-brochure-oostvaardersplassen-in-the-picture.pdf

5.1.3 Jianyang lake wetland park

Zhejiang,China | AECOM

Figure5.6 Birdview of Jianyang wetland park
Source: http://www.archina.com/index.php?g=works&m=index&a=show&id=11468

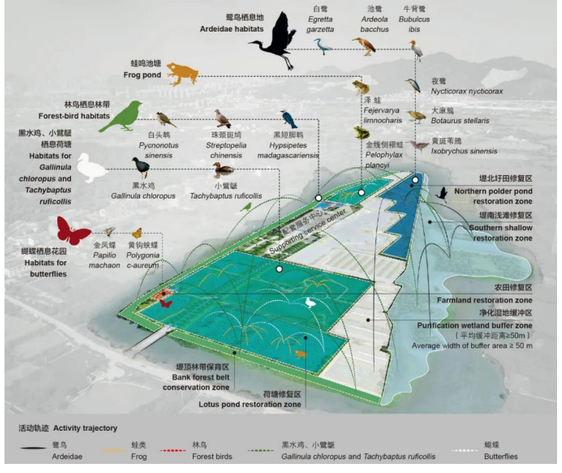


Figure5.7 Restoration zones and purification wetland buffer zone
Source: http://www.archina.com/index.php?g=works&m=index&a=show&id=11468

Due to the rapid urban development and historical fisheries, Jianyang Lake in the Zhejiang province in China has been under dramatic ecological resource threat. As a result, the original landscape of this site has been damaged, while the water in the lake is polluted, thus causing the degradation of the habitats of Ardeidae habitats. The designers utilized Nature-Based Solutions to restore the existing polder wetlands and established a 16 hm2 Start-up Area within the Jianyang Lake Wetland Park.

By applying the proposed design concept of "Retaining-Breaking-Integrating," an integrated ecosystem composed of forest, pond, farmland, lake, and island was formed (Tao & Xiong, 2021). A high-efficiency wetland purification system is introduced, emerging into its surrounding environment, being climate-resilient, and requires little upkeep, enabling the optimization of the habitats for Ardeidae.

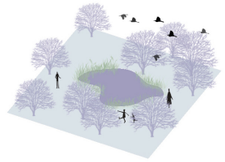
5.1.4 Principles learned from case studies

1) Bishan-Ang Mo Kio Park

Floodplain

The multifunctional use of floodplains not only relieved flood problems in extreme conditions, but also provide lively waterfront space for people nearby. With low maintenance, various habitats are created for flora and fauna.

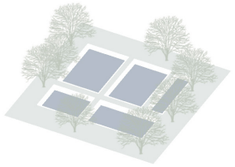
2) The Oostvaardersplassen



Wetland ecosystem

Creating different water environments to attract special birds and trigger the natural succession, rewilding a varied marshland area.

3) Jianyang lake wetland park



Fish pond circulation

Wetland purification

Located in the same region as my project, it illustrates the potential of dike ponds to be transformed into ecological restoration and water purification zones.

5.2 Design Principles for resilient polder landscape

Based on historical experience and case studies, several principles have been identified and categorized into three perspectives: water & ecology principles, agriculture principles, and settlement & public space principles.

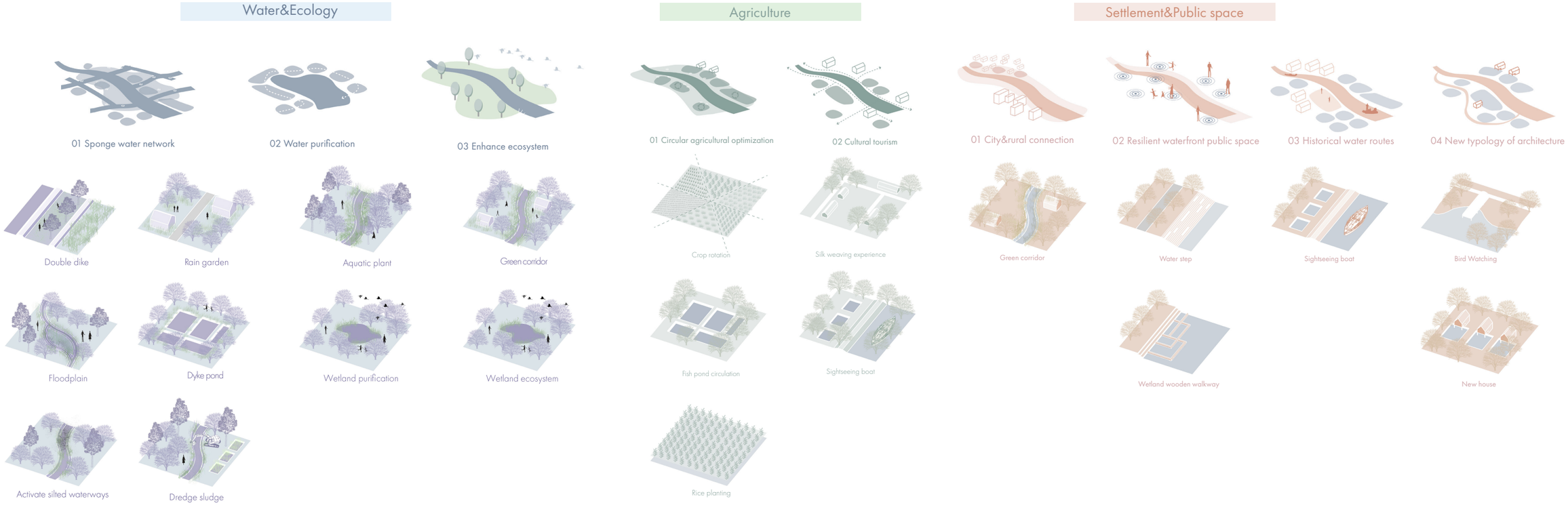
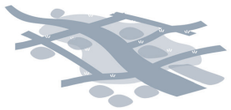


Figure5.8 Design Principles and tool kits

5.3 Design strategy

5.3.1 Sponge water network



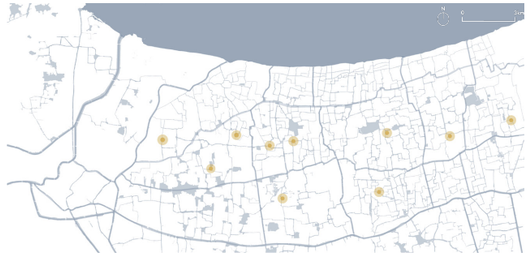
01 Sponge water network

02 Water purification

03 Enhance ecosystem

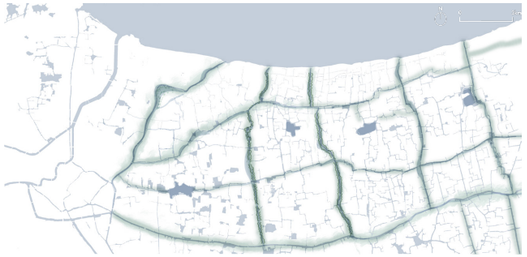
Strategy 01

Activate silt watercourse and complete water network



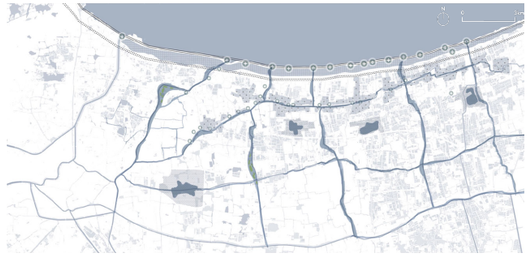
Strategy 03

Slow down the runoff(ecological floating islands, aquatic plant)



Strategy 02

More space for water



Strategy 04

Ecological water purification (dike pond, wetland)

Figure5.9 Water strategies

According to the previous analysis, it was determined that the flooding problem is mainly caused by the fast flow of water from the mountain. To create a resilient water system, it is crucial to increase the capacity for water storage and decrease the speed of runoff.

Considering the issue of silt watercourse caused by city construction, the sludge will be excavated to create a water vein system that can discharge water during the rainy season. Secondly, more spaces like floodplains will be created for an emergency. Ecological floating islands and aquatic plants will be incorporated along the main waterway to slow down the runoff. Additionally, to further improve water quality in the region, the small lake will be converted into a wetland and, together with the surrounding dike pond, a water purification center will be established.

5.3.2 Sustainable agri/aquaculture

01 Circular agriculture　　02 Cultural tourism

Strategy 05

Make use of vegetation, and sludge to build circular agriculture

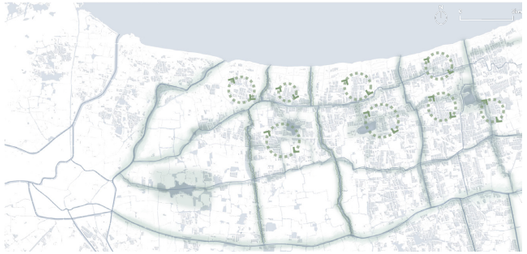
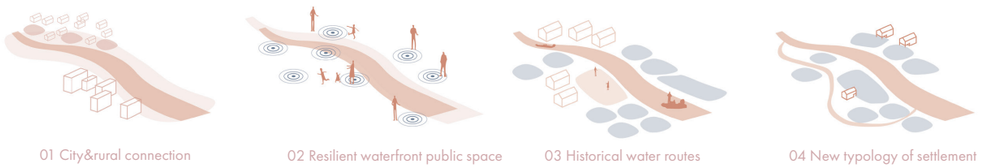


Figure5.10 Agriculture strategy

Learning from history, the success of the mulberry dike fish pond teaches us that the key aspect of a sustainable agriculture system is to utilize waste effectively in creating a circular ecology and economy.

Based on the current status of fish pond expansion and dike narrowing, the design strategy is to follow the ecological rule and embed aquaculture in an artificial ecosystem where mass and energy cycle between water and land through the basement pond system and the mixed symbiosis in the pond, so as to make the best use of materials and recycle materials, thus guaranteeing the stable output and economic benefits.

5.3.3 Slow waterfront space



01 City&rural connection　　02 Resilient waterfront public space　　03 Historical water routes　　04 New typology of settlement

Strategy 06

More waterfront public space

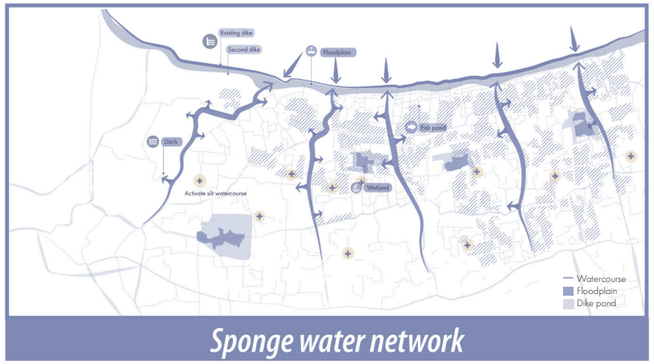
Strategy 07

Slow traffic tourism　Agriculture civilization tourism

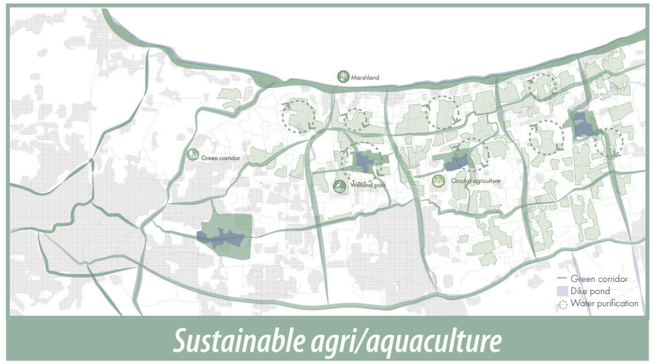
Figure5.11 Public space strategy

With the fast encroachment of city industries in the rural areas, Huzhou has been losing its cultural identity during the process. The poor spatial quality of the landscape exacerbates the disconnect between people and the polder.

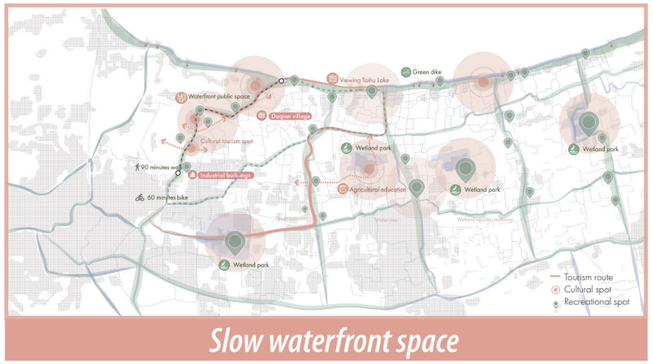
To address this, a strategy for settlement and public space must prioritize the creation of more public spaces and a slow traffic system to restore the close relationship between people and water. Furthermore, agricultural civilization tourism will be introduced to remind people of the precious value of mulberry dike ponds in this region, which not only existed in history but also have a profound influence on future agriculture production.



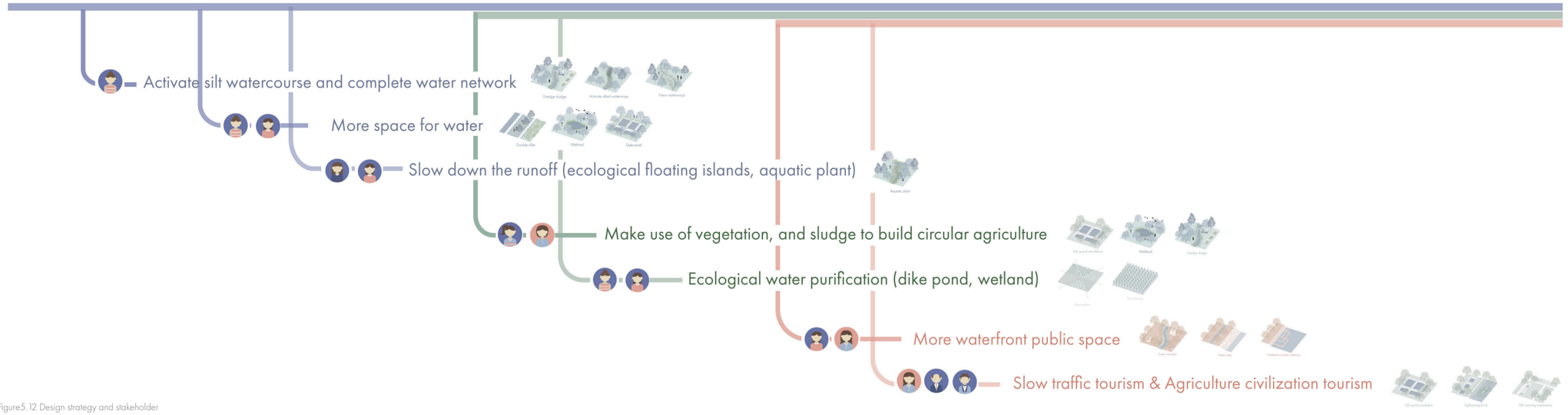
Sponge water network



Sustainable agri/aquaculture



Slow waterfront space



Water conservancy bureau

Natural Resources Department

Planning and Design Institute

Agricultural bureau

Rural Revitalization Administration

Cultural Tourism Department

Housing and Urban-Rural Development Department

Village Collective

Farmer

Figure.5.12 Design strategy and stakeholder

5.4 Design assignment

+RESTORE resilient water system

+RENEW the public space in rural area

+REMIND people of cultural value

Enlarge water storage capacity

Improve water quality

Improve spatial quality

Cultural heritage protection

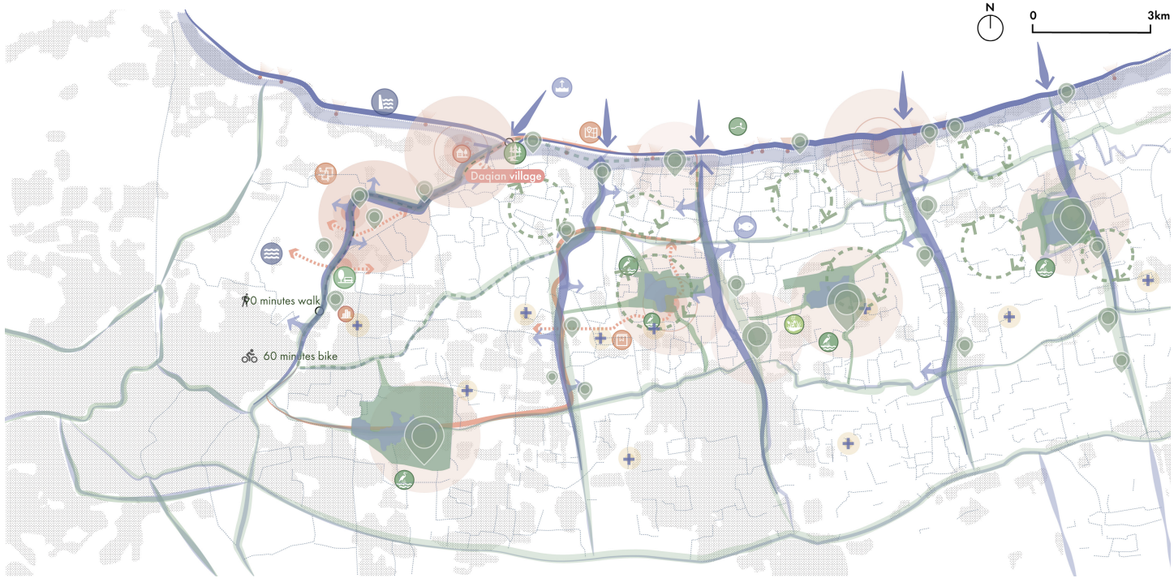


Figure5.13 Design Assignment of Lougang polder

The design goal consists of three aspects: 1. restore resilient water systems; 2. renew the public space in the rural area; 3. remind people of cultural values. By integrating the water, agriculture, and settlement systems into one complex unit, a resilient polder landscape will be created. Various stakeholders, including public entities such as the water conservancy bureau and rural revitalization administration, as well as private actors such as village collectives and farmers, will be involved in accomplishing these goals. The participation of different stakeholders will be determined by the time phase.

For the first phase, emphasis will be placed on the sponge water system, which will involve enlarging water storage capacity and improving water quality to alleviate water crises like floods and pollution. The water conservancy bureau, Natural Resources Department, and Planning and Design Institute will participate during this phase.
In the second phase, the agricultural bureau and farmers will collaborate to improve the existing agricultural structure. While the current dike pond ratio allows farmers to maximize their income in the short term, it is crucial to adjust the proportion of dike and pond for the long-term balance between ecology and economy.
The third phase relates to the spatial quality of the region. Cultural Tourism Department, Housing and Urban-Rural Development Department and Village Collective are the major participants. The water heritage, dike pond heritage, and settlement heritage will serve as key features that showcase the rich history and cultural values of the region while enlightening the new idea of vernacular landscape and bringing vitality to the future landscape. Overall, the third phase of the project seeks to bring new life to the landscape through innovative design and planning.

5.5 Conclusion

The three case studies focus on different aspects of water resilience including the multifunctional use of floodplains, diverse ecosystems based on different water levels, and the potential of dike ponds to be transformed for water purification. In addition, the lessons learned from historical experience also give some inspiration for principles.

In this chapter, the design principles of resilient polder landscape systems are demonstrated from the perspective of water, ecology, agriculture, and settlement systems. Based on those principles, seven strategies will be applied to the regional design which could further give instructions on detailed design.

Figure6.1 Dike pond in Taihu Lake basin
Source: https://share.ifeng.com/c/s/7qTIlRdCCnH

06 Design exploration

6.1 Vision map--Resilient polder landscape
6.2 Local scale design exploration
6.3 Sponge lakeshore line
6.4 Sponge agri/aquaculture
6.5 Sponge peri-urban
6.6 Design exploration conclusion
6.7 Strategic phasing

6.1 Vision map--Resilient polder landscape

+RESTORE resilient water system

Enlarge water storage capacity

-Second defence of water infrastructure
-Dike pond as water retention

Improve water quality

-Green corridor
-Agriculture optimization
-Wetland purification center

+RENEW the public space in rural area

Improve spatial quality

-City&rural edge
-More waterfront public space

+REMIND people of cultural value

Cultural heritage protection

-Tourism(Water route/ water culture)
-New possibilities of dike pond

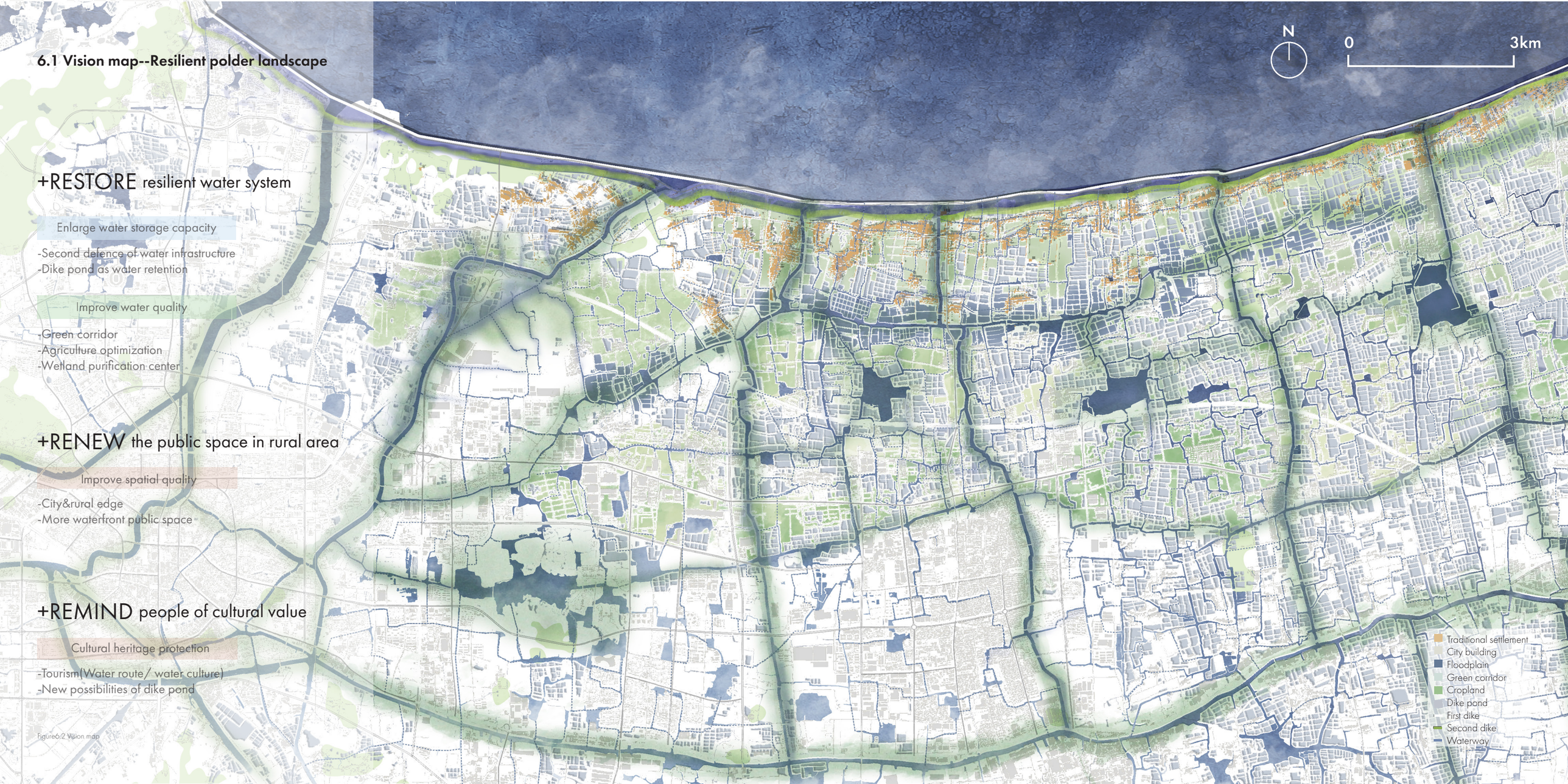


Figure6.2 Vision map

6.2 Local scale design exploration

To achieve the Restore, Renew, and Remind goals, it is essential to rebuild a robust connection among the water, agriculture, and settlement systems. Therefore, I intend to undertake a design exploration on a local scale to assess the effectiveness of the historical principles I have acquired.

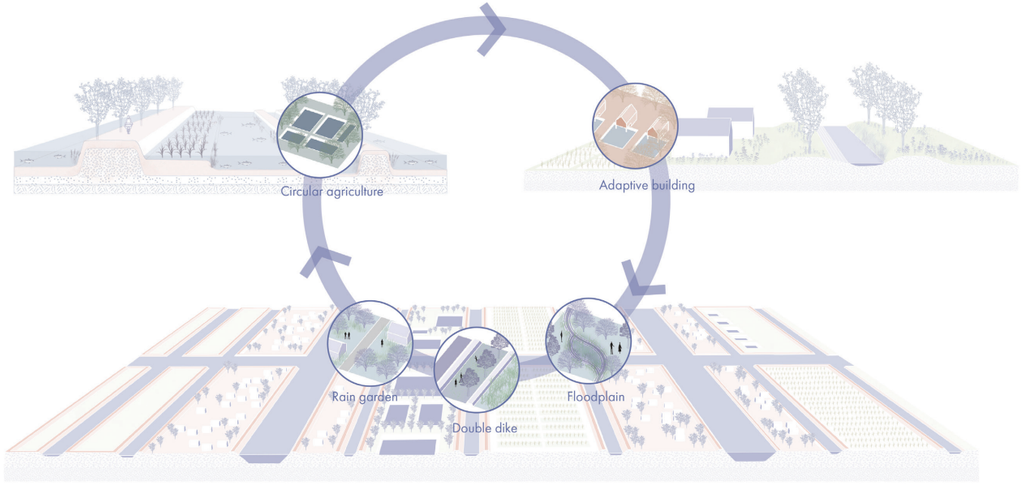


Figure6.3 Rebuild robust connection among the three systems

According to the calculation of existing water storage capacity and the difference between precipitation and evaporation, it is evident that the existing water storage space is insufficient to address the recurring summer floods and the rising water level in Taihu Lake. The remaining water level will be at approximately 140mm during summer, but the presence of cropland and impermeable surface in the urbanized area prevents water retention, which causes a threat to the safety of local residents.

As a result, in the local scale exploration, I choose three sites to test the principle I got in Chapter 5 and demonstrate the potential of the sponge polder, which relates to three topics: sponge lakeshore line; sponge agri/aquaculture, and sponge peri-urban.

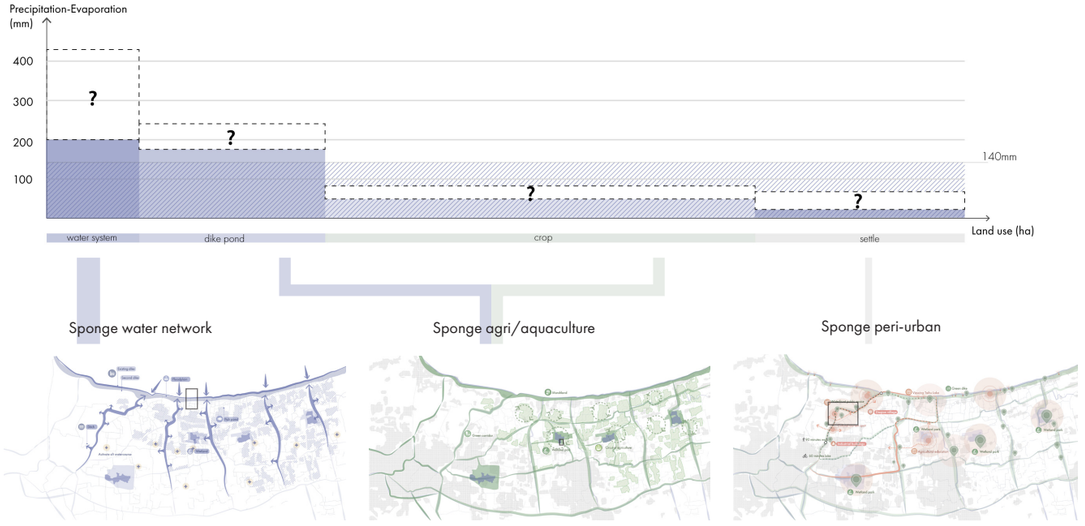


Figure6.4 The chosen three sites

Figure6.3 Local scale exploration

6.3 Sponge lakeshore line

+RESTORE resilient water system

Enlarge water storage capacity

The first detailed design site is on the north side of the region, near Taihu Lake. With a ring dike in the north and traditional dwellings and cropland in the south side, this area remains the historical landscape. From regional analysis, we found that the lakeshore line zone is prone to be flooded, however, it also has the potential to build a second dike and floodplain to relieve the large water pressure in the summer season. Here I am going to explore the natural succession in the floodplain and elaborate on the landscape experience in this area.

As a result, there will be more water storage space to contain the excess water in the rainy season, which creates various habitats for flora and fauna. Additionally, the double dike will be equipped to manage the possible rising water level in Taihu Lake.

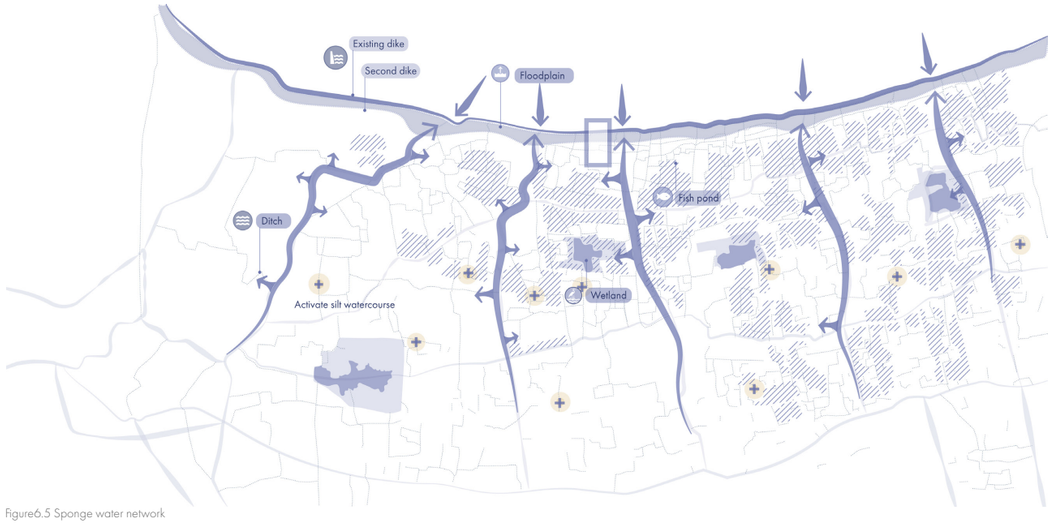


Figure6.5 Sponge water network

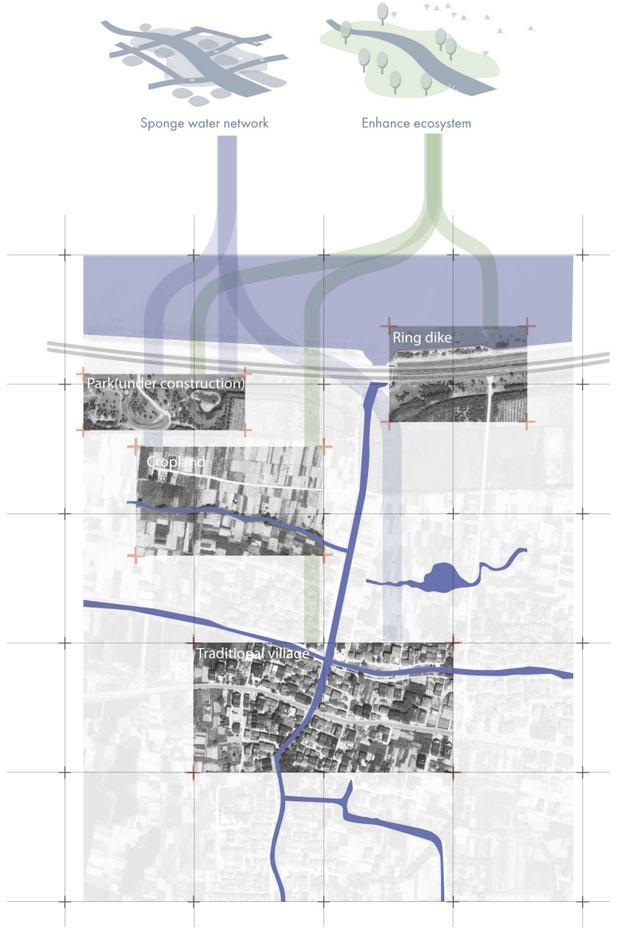


Figure6.4 Lakeshore map

Challenges of lakeshore line

Dike segragation

By the 11th century, a dike had already been constructed along Taihu Lake to protect against flooding. During the 2000s, significant construction efforts were undertaken to enhance the dike system along the lake's shoreline. This transformation resulted in the original unpaved footpath being replaced with a concrete road, resulting in the separation between the local people and Taihu Lake.

Lack of public space

The presence of rigid embankments and paved surfaces significantly limits the availability of green spaces, consequently depriving the local community of ample recreational areas.

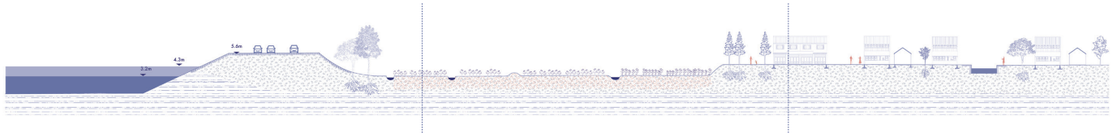
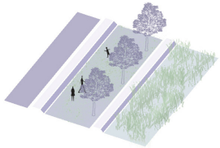


Figure6.5 Challenges of the lakeshore line

Pilot1 Double dike and floodplain



Double dike

The series of section drawings show how it has changed in the past 10 years. From 2009 to 2012, the government build a big dike along the river, later around 2017, the crop and trees were removed to build a park here. However, the construction of the dike and park squeezed the wide water channel, thus making this area vulnerable to flooding in the rainy season. Meanwhile, the big dike separates people from the lake.

What I propose in my design is to dig out the soil to create a floodplain. The soil will be used to raise the land nearby to build a double dike. Later the flood water will bring sediment, which will help to create different ecosystems for flora and fauna. Thus, the double dike not only assures water safety in this area but also gives opportunities for people who walk on the dike to get a good view of the lake. For the floodplain, at first, the water quality is at a eutrophication state. Then the ecosystem here will be eutrophic marshland. Since the double dike can be in different heights and widths, here I try to explore the different possibilities in natural succession when I create different topography.

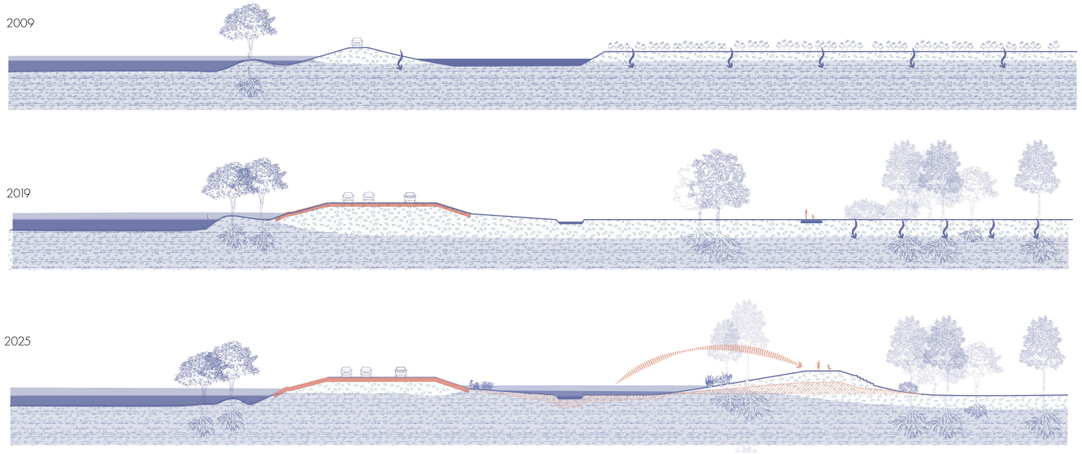
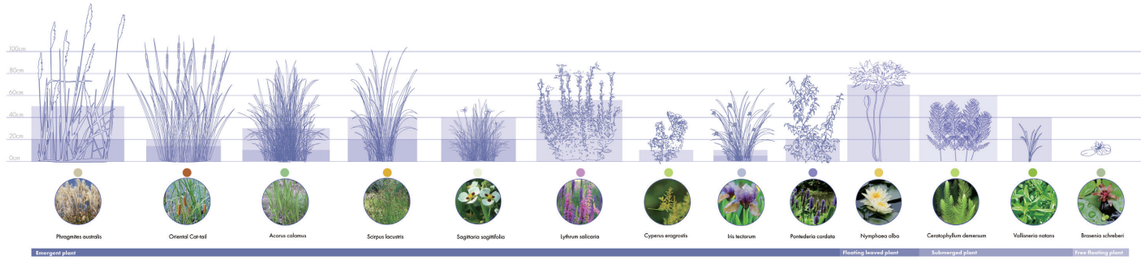
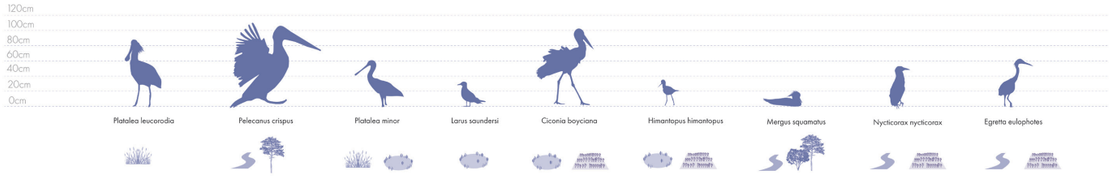


Figure6.6 Dike changes from past to now to future

Native species





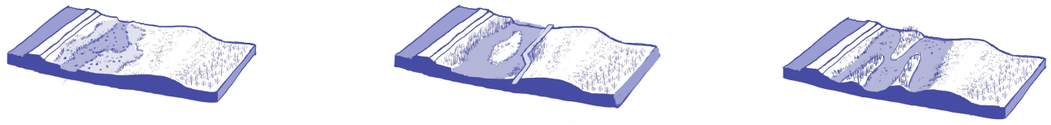


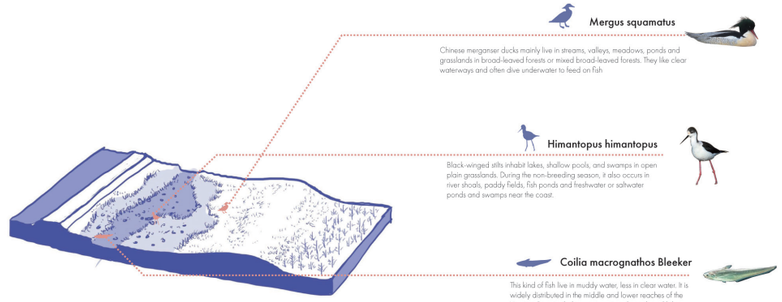
Figure6.7 Native flora and fauna and their habitats

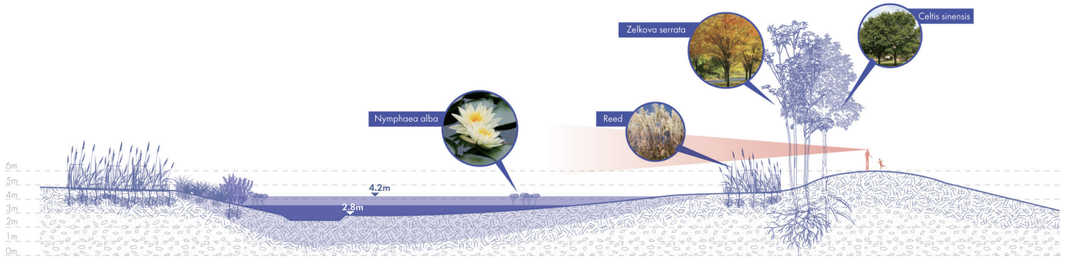
Natural succession

01

Since the water will bring sediment and the water level will fluctuate during summer and winter. Vegetation may start to grow at the edge of the water line. The hydrophyte here will be reed and loosestrife. At first, the reed is relatively short, and visitors will be able to see the open water, later when the reed grows higher, their view will be blocked.

After 4-5 years, the water quality may be improved, then the reed will be cut down, and visitors will get the open view again. Meanwhile, as the water quality get better, bird like Chinese merganser will come here.





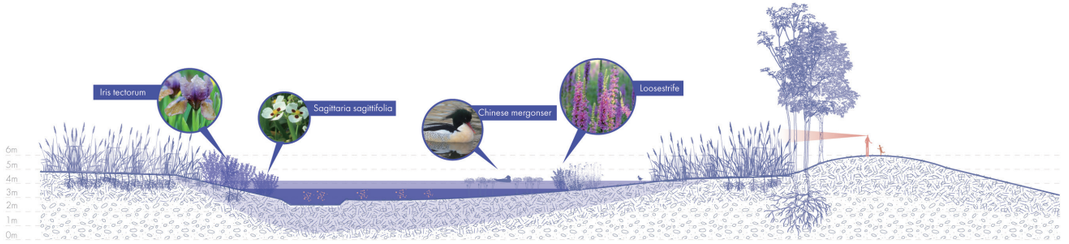
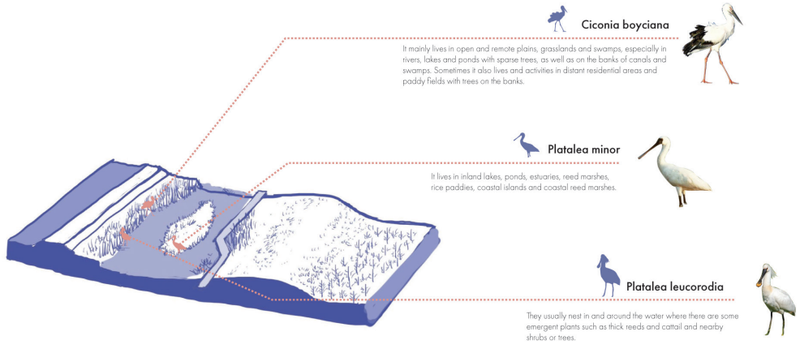
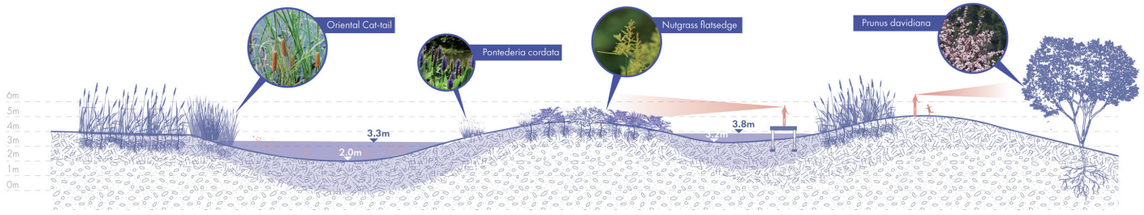


Figure6.8 Natural succession1

02

People will be able to walk within the marshland. And because of different water levels, emergent plants, floating plants, and submerged plant will grow here. Including oriental cattail and hornwort,ect





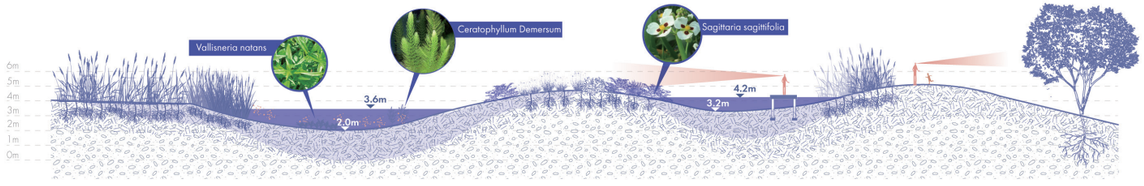
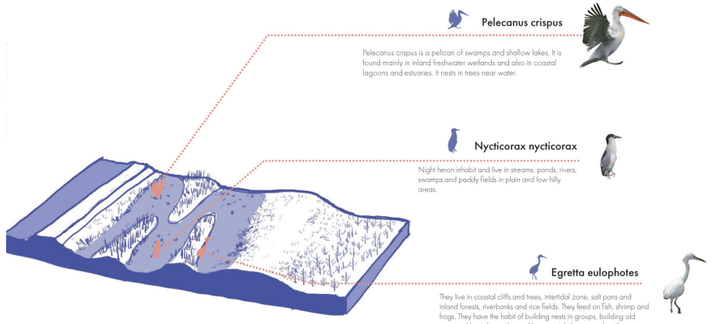
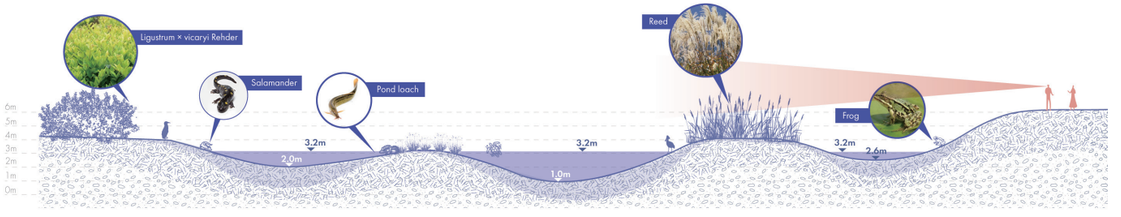


Figure6.9 Natural succession2

03

Various water levels will be created and shrubs and aquatic plant will be planted to attract amphibians and insects. It is more like a nature reserve that visitors won't be allowed to get into it. At first, amphibians and insects will come, later, this will attract birds like night herons





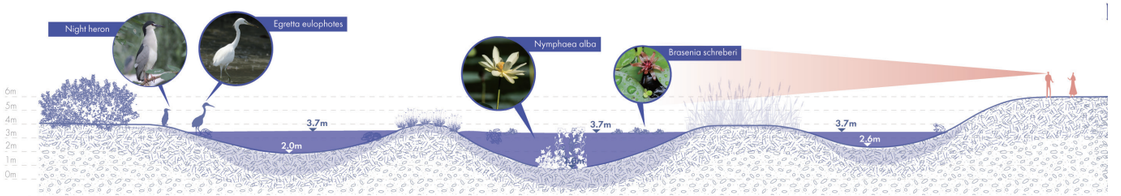


Figure6.10 Natural succession3

6.3 Sponge lakeshore line

Floodplain in normal season

Figure6.11 Floodplain in normal season

Figure6.12 Floodplain in dry season

6.3 Sponge lakeshore line

Floodplain in Rainy season

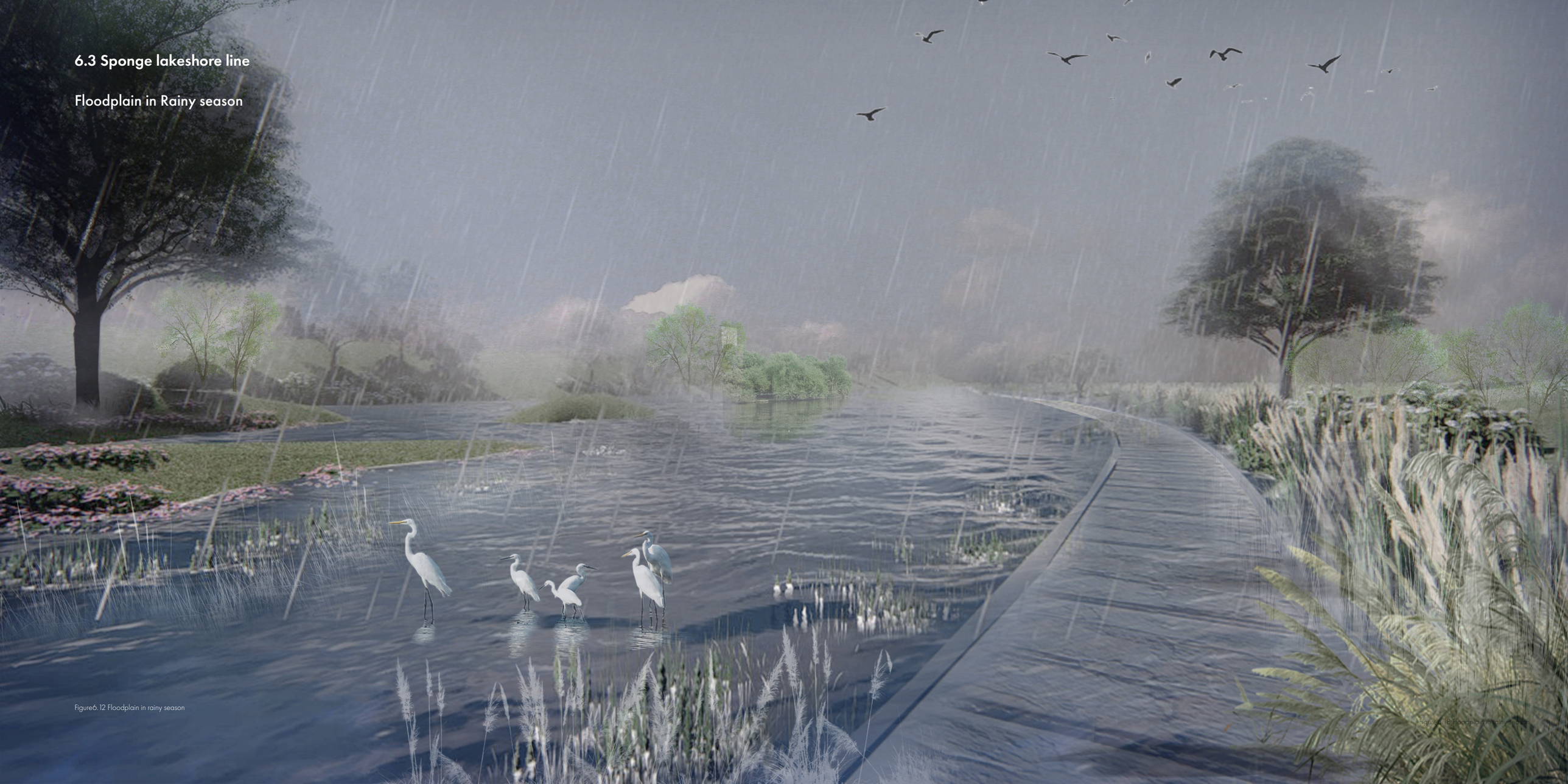


Figure6. 12 Floodplain in rainy season

Plan

Figure6.13 Neighborhood design plan

Water management

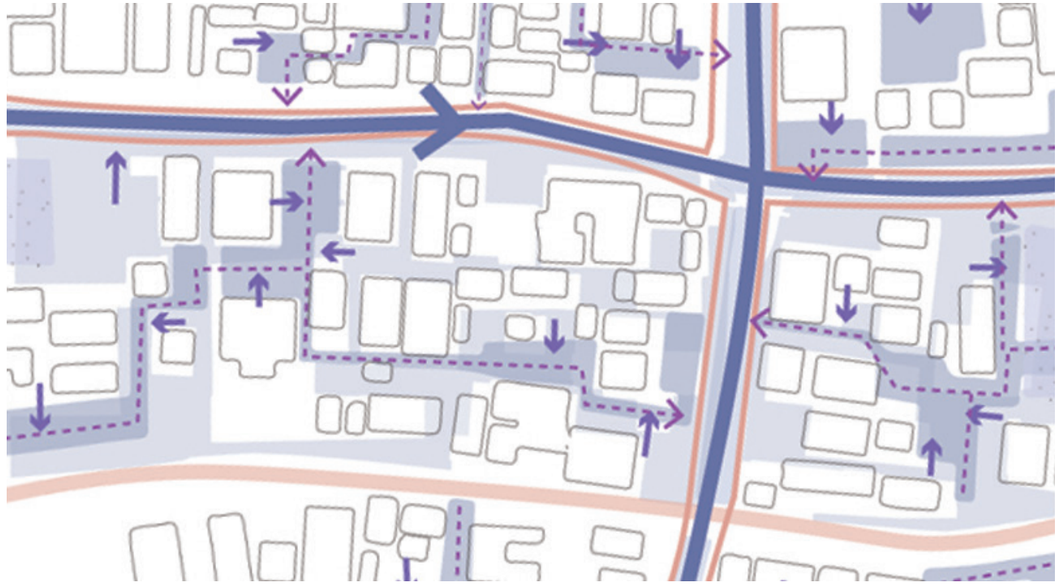


Figure6.14 Neighborhood design water management

Existing condition

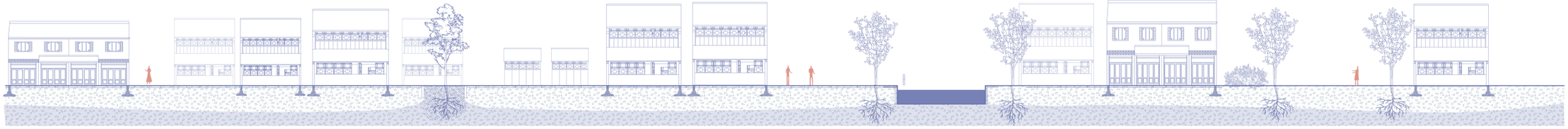
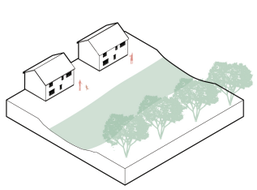
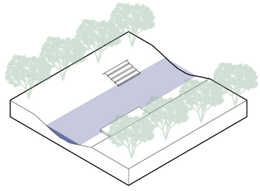


Figure6.15 1-1' section

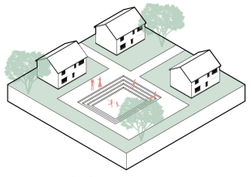
Dry season



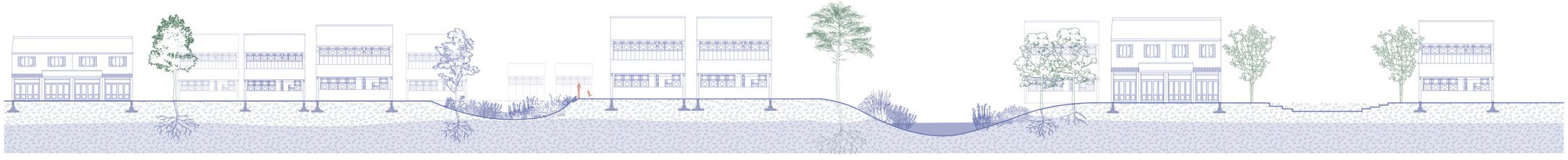
Bioswale



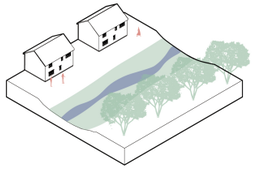
Soft bank



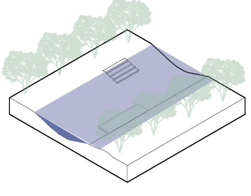
Water square



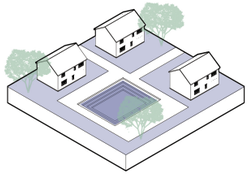
Rainy condition



Bioswale



Soft bank



Water square

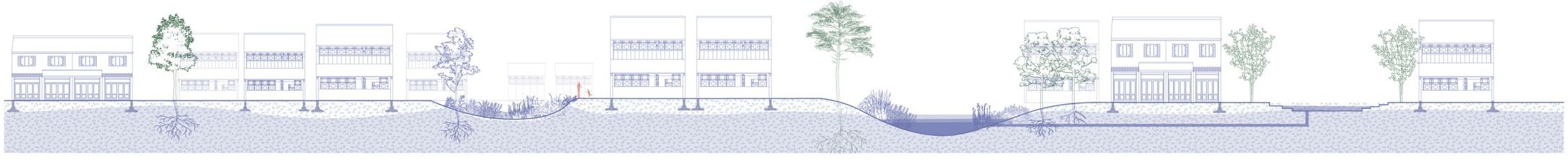


Figure6. 16 Public space among traditional seetlements in dry and rainy season

6.3 Sponge lakeshore line

Bioswale in neighborhood

figure6.17 Bioswale in neighborhood

Sponge lakeshore line water management

Existing water system

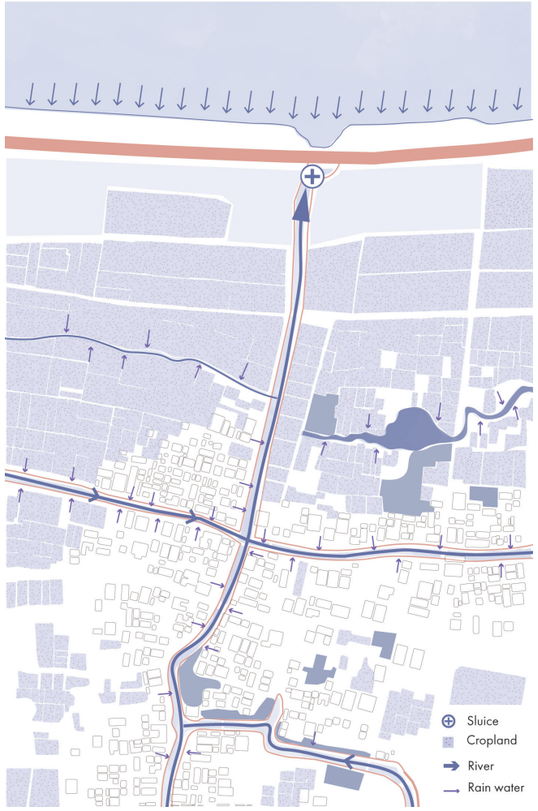


Figure6.18 Existing water system

Proposed water system

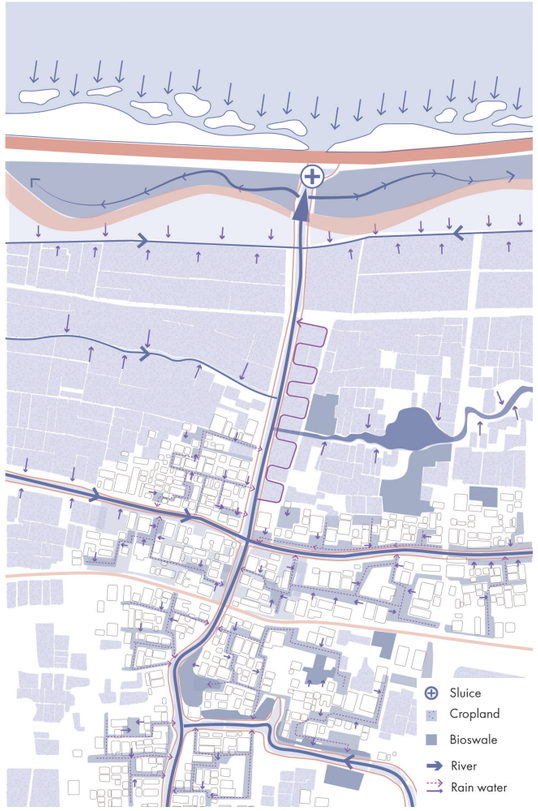


Figure6.19 Proposed water system

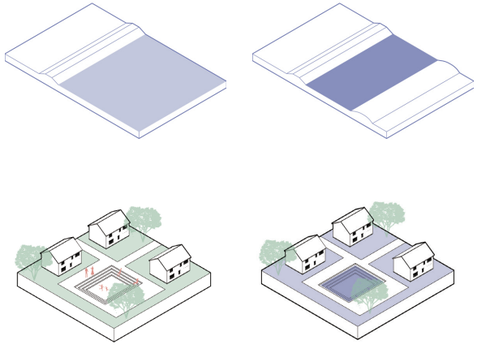
Sponge lakeshore line plan

Rainy season

Figure6.20 Plan of sponge lakeshore line in rainy season

Sponge lakeshore line birdview

-Double dike protect lake shoreline, ensuring the water safety;
-Space between two dikes become **floodplain**, which not only enlarge water storage capacity, but also provide habitats for flora and fauna, enhancing the ecosystem;
-**Natural succession** after water level change in floodplain;
-Rain garden and bioswale among neighborhood together with water channel form hierarchical water network system.



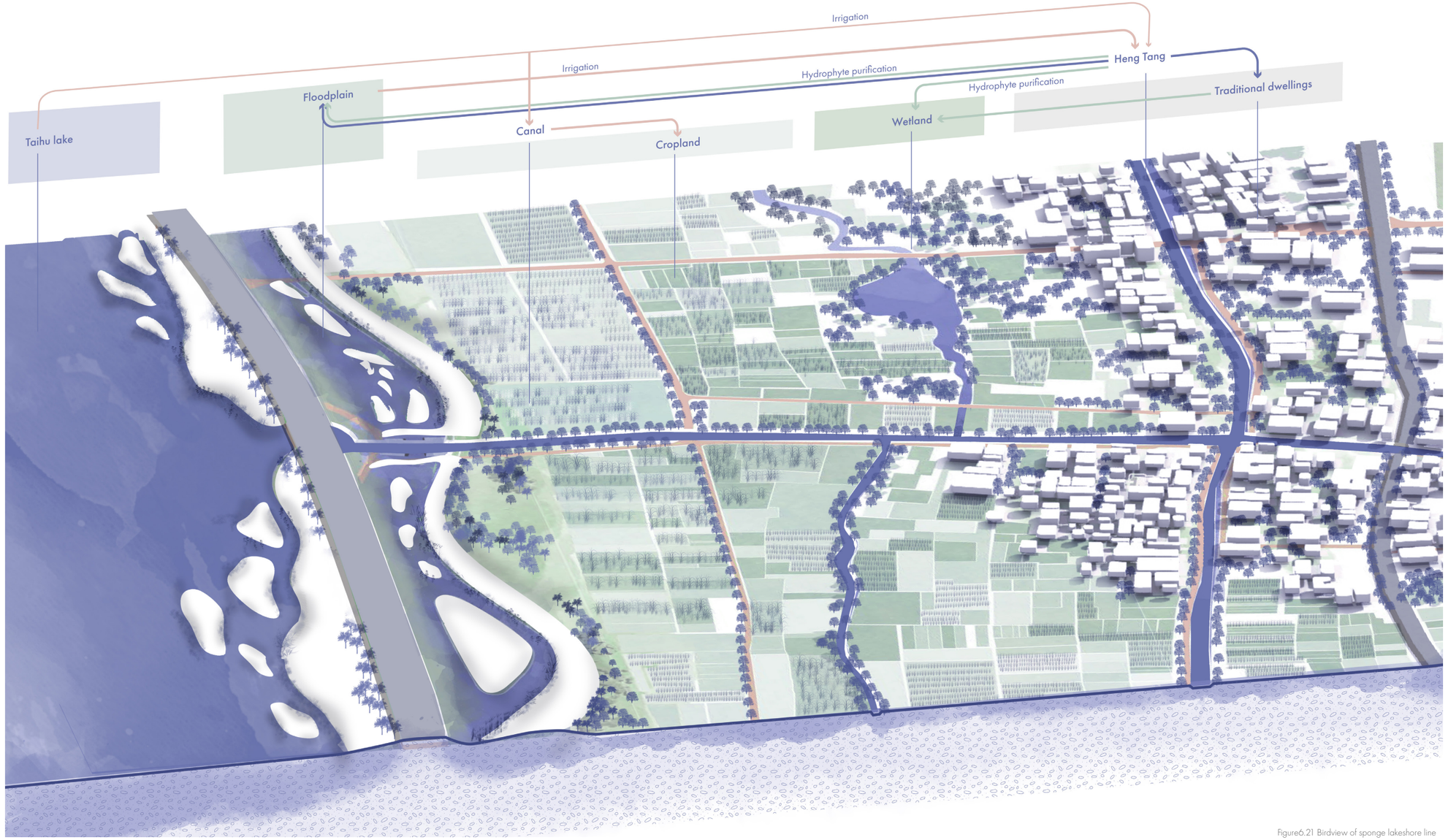


Figure6.21 Birdview of sponge lakeshore line

6.4 Sponge agri/aquaculture

+RESTORE resilient water system

Improve water quality

The second site is situated within the aquacultural zone adjacent to a small lake, primarily comprising dike ponds. These ponds are utilized for raising a variety of fish, such as bighead carp and grass carp, which serve as a significant source of fish supply for the city and a key economic activity for local farmers. As farmers yield higher profits, the dike ponds lost their circularity because of the expanding fish ponds over maintaining dikes, which has resulted in water pollution issues within the area.

The challenge lies in exploring the potential for transforming dike ponds to adapt to modern ecological and economic development, ensuring their viability in the current context.

Figure6.22 Sustainable agqi/aquaculture

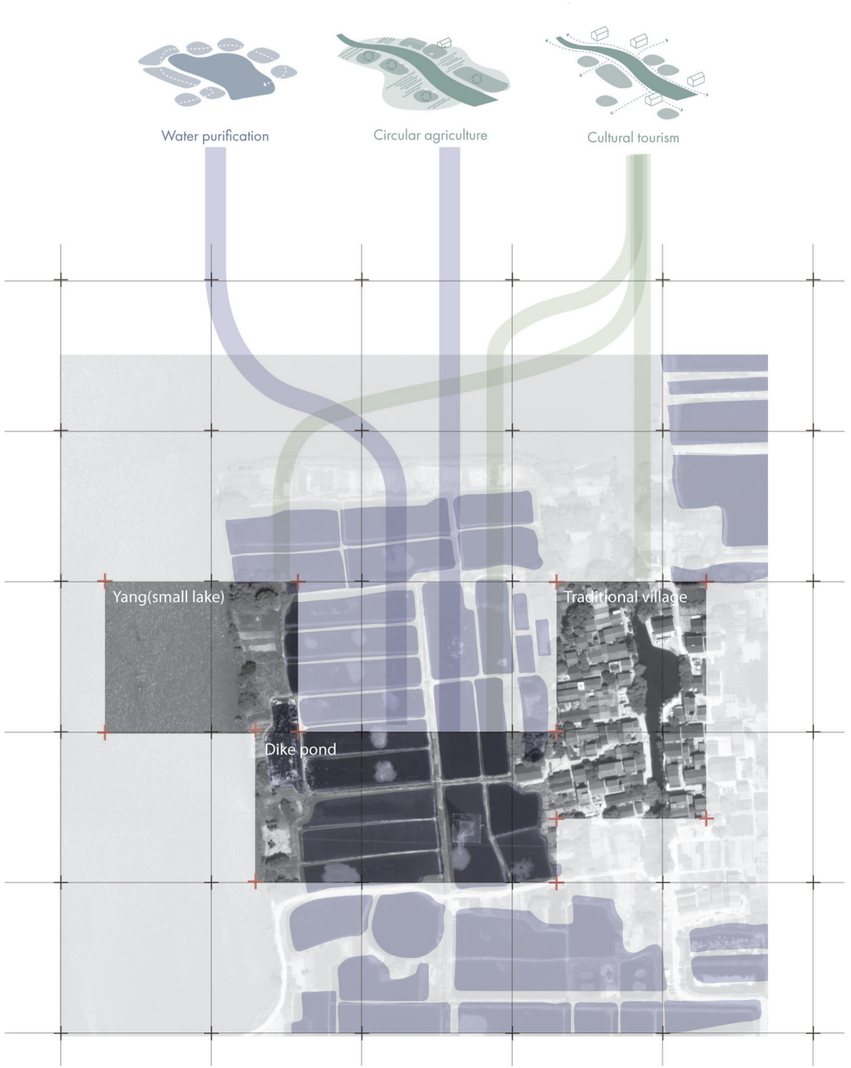


Figure6.23 Aqaculture zone

6.4 Sponge agri/aquaculture

Challenges of aquaculture

Pond water pollution

With the ponds' expansion, the ability to purify and utilize pollutants from fish within the dike pond has diminished. Consequently, the tail-water is now directly discharged into the outer water system.

Fragile dike

The narrow dikes make it unsafe when the water level rise or during heavy rain. In the meantime, no trees or vegetables are planted in the dike to enhance the soil, making it even more fragile.

Hard bank

The hard banks separate the dike pond from the lake as well as obstruct the water connectivity within the system. Consequently, the local community experiences a loss in their intimate relationship with water.

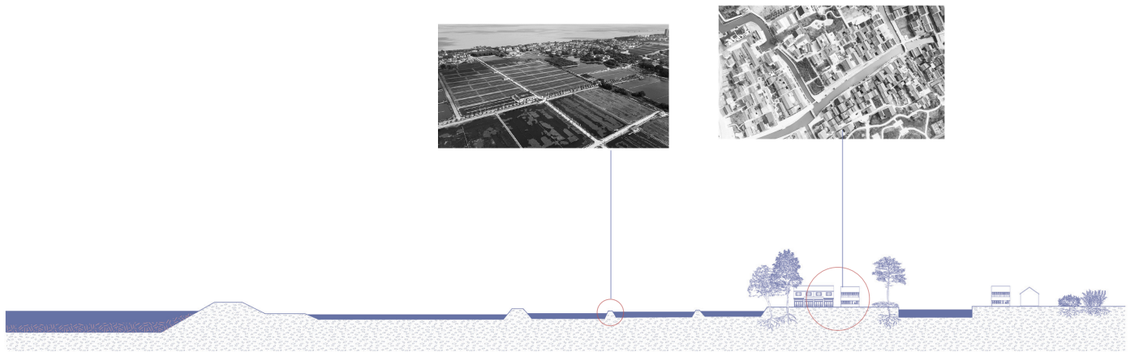


Figure6.24 Challenges of aquaculture

The mulberry dike pond, as a good example of traditional agriculture wisdom, now facing challenges from ecological and cultural sides. To improve the water quality, the concept of circular agriculture will be reintroduced in this area. In my proposal, some of the dike ponds will be transformed into purification ponds, where helophytes will naturally purify the aquacultural tail water, which can also serve as fish food. Additionally, the ratio of dikes to ponds will be adjusted in some areas to allow for vegetable cultivation on the dikes.

Simultaneously, educational activities centered around dike fish ponds will be incorporated into this region. Bio restaurants and fishing spots, in conjunction with existing fish industries, will serve as appealing destinations for urban dwellers.

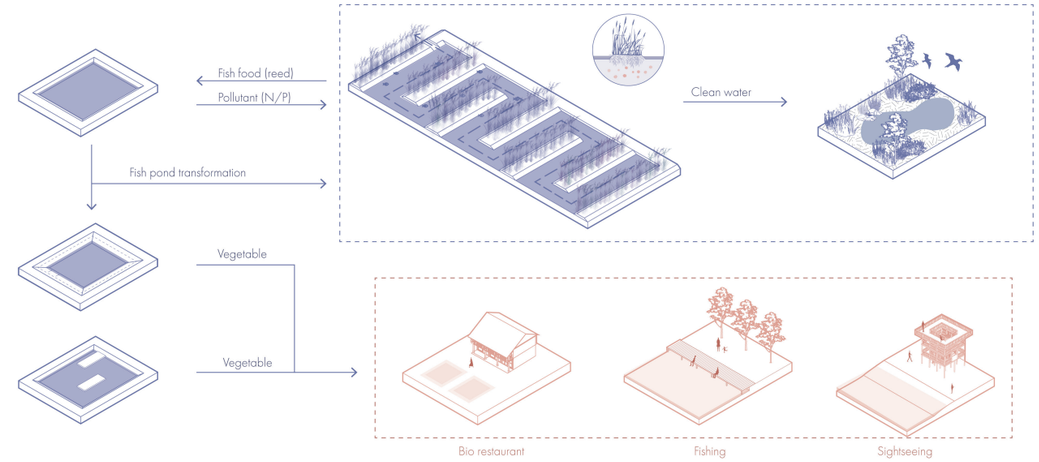


Figure6.25 Dike pond optimization and transformation

6.4 Sponge agri/aquaculture

Circular agriculture vision

Figure6.26 Circular agriculture vision

6.4 Sponge agri/aquaculture

Purification pond recreation

Figure6.27 Purification pond recreation

6.5 Sponge peri-urban

+RENEW the public space in rural area

Improve spatial quality

+REMIND people of cultural value

Protect cultural heritage

The third site is located in the northern part of Huzhou City, where the Tiao River flows, acting as a link between urban and rural regions. The peri-urban area faces challenges from multiple fronts. During the rainy season, the fast runoff from the south mountain exerts significant pressure on the Tiao River. In the meantime, the traditional buildings and dike ponds have been removed due to rapid urbanization.

The challenge is to explore the potential of peri-urban areas as a blue-green buffer, offering benefits to both urban and rural areas. This approach aims to strengthen urban-rural synergy while also preserving and promoting the cultural value of the area.

Figure6.28 Slow waterfront space

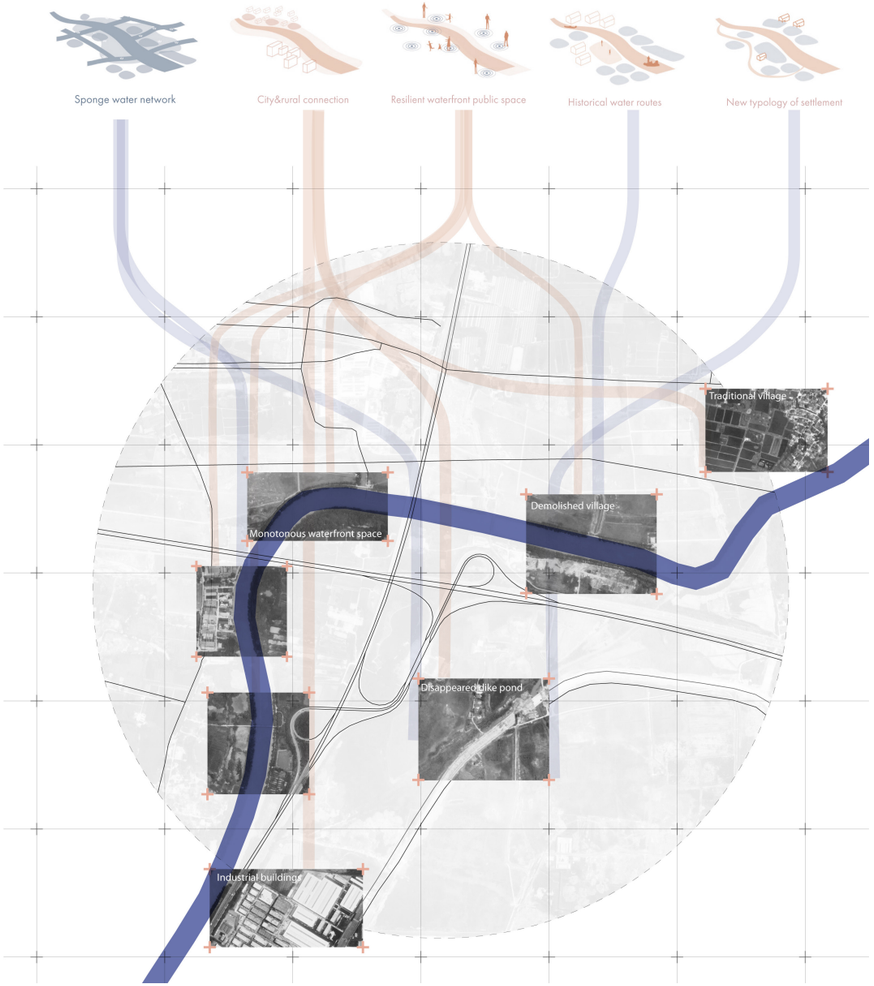


Figure6.29 Existing condition in peri-urban and applied principles

6.5 Sponge peri-urban

Monotonous waterfront space

The current monotonous hard river bank significantly contrasts with the soft and permeable banks of the past. This change not only reduces water resilience but also distances people from the river bank, limiting their interaction with it.

Disappeared dike pond

Huzhou City has been expanding to the north since 2001. Canals and dike ponds were filled and villages were removed to get more land for real estate and industrial development. Unfortunately, this approach has neglected the cultural significance of the water and agricultural heritage in the region.

City expansion

The traditional agriculture practice of Mulberry dike ponds, which was once prevalent in this region, has been demolished in the peri-urban zone to make way for urban development. Consequently, the cultural value associated with dike ponds has been neglected and forgotten.

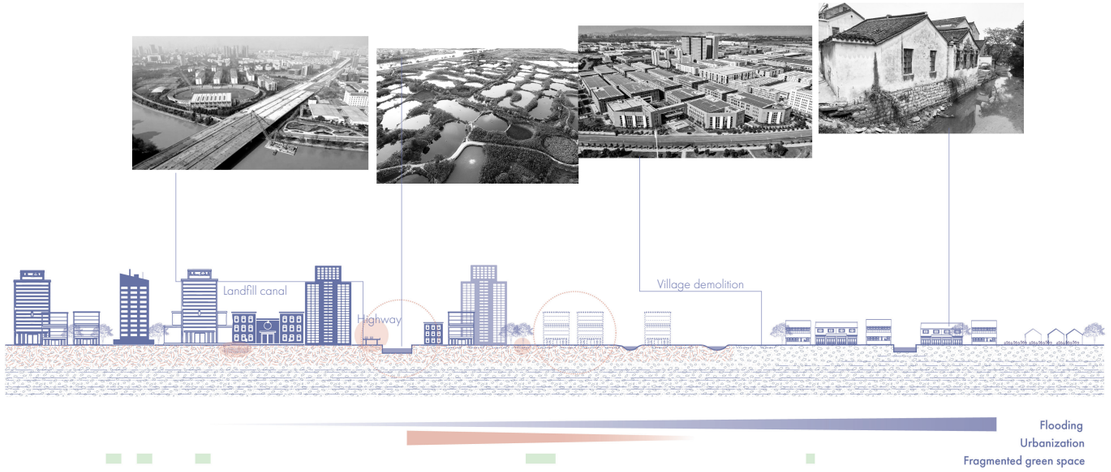


Figure6.30 Challenges of peri-urban zone

Potential

Natural

High volume of water from mountain

Social

City expansion from south side

Cultural

Reed culture

Concept

Natural

Slow down and discharge runoff

Social

Adaptive house allow for sustainable urban expansion

Cultural

Reed and dike pond landscape combined with slow traffic

Figure6.31 Potential and design concept of peri-urban zone

Sponge peri-urban water management

Water system in 2016

Figure6.32 Water system in 2016

Back in 2016, the water system in the peri-urban area was characterized by a robust network, with dike ponds evenly spread along the ditches for water collection. However, by 2021, significant changes occurred in the water system as a consequence of city development. Some of the ditches and ponds were filled in to make space for the construction of industrial buildings. Consequently, the available area for water storage and circulation has diminished.

My proposal involves establishing a well-connected sponge water system in this region. Simultaneously, I suggest revitalizing the vanished dike ponds by transforming them into visible recreational spaces with additional water purification capabilities, enhancing both the functionality and aesthetic appeal of this area.

Water system in 2021

Figure6.33 Water system in 2021

Proposed water system

Figure6.34 Proposed water system

Waterfront space

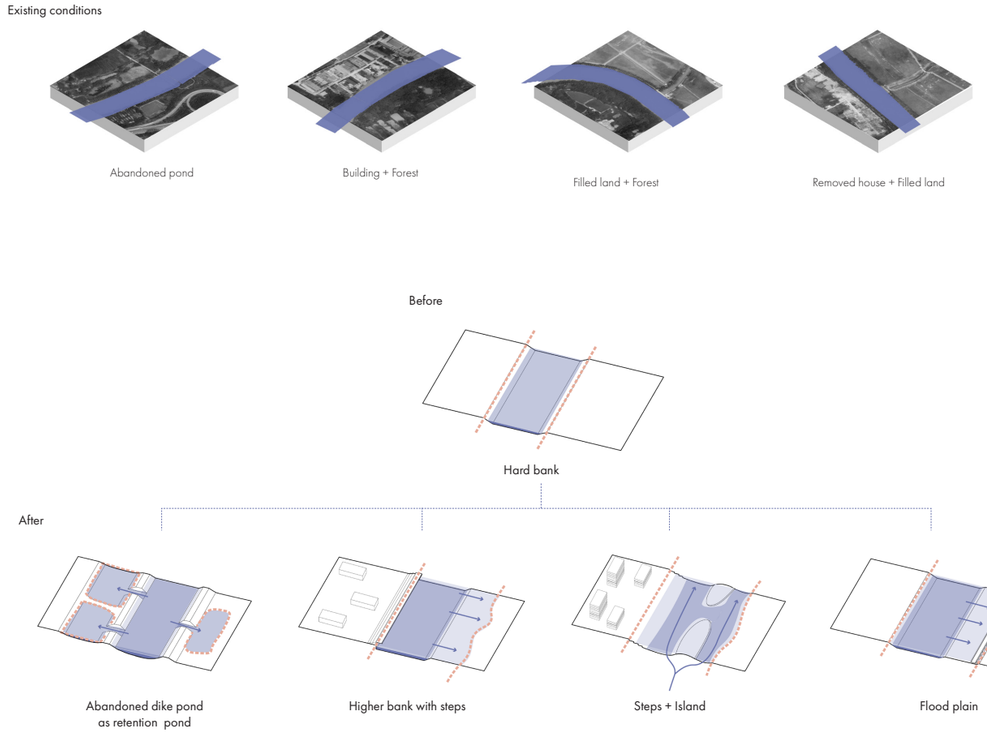


Figure6.35 Existing and proposed waterfront design

Sponge peri-urban plan

Dry season

Normal season

Rainy season

Figure6.36 Phasing plan of Peri-urban

6.5 Sponge peri-urban

Peri-urban waterfront public space in normal season

Figure 6.37 Peri-urban waterfront public space

6.5 Sponge peri-urban

Peri-urban waterfront public space in rainy season

Figure6.38 Peri-urban waterfront public space during storm

6.5 Sponge peri-urban

Pond space design

The concept entails translating the space of the dike pond into a purification park. The restored pond will purify the wastewater from industrial buildings on the south side. In the meantime, this area will give visitors the same enclosed feeling of a dike pond to remind people of its value.

Figure6.39 Pond space

6.5 Sponge peri-urban

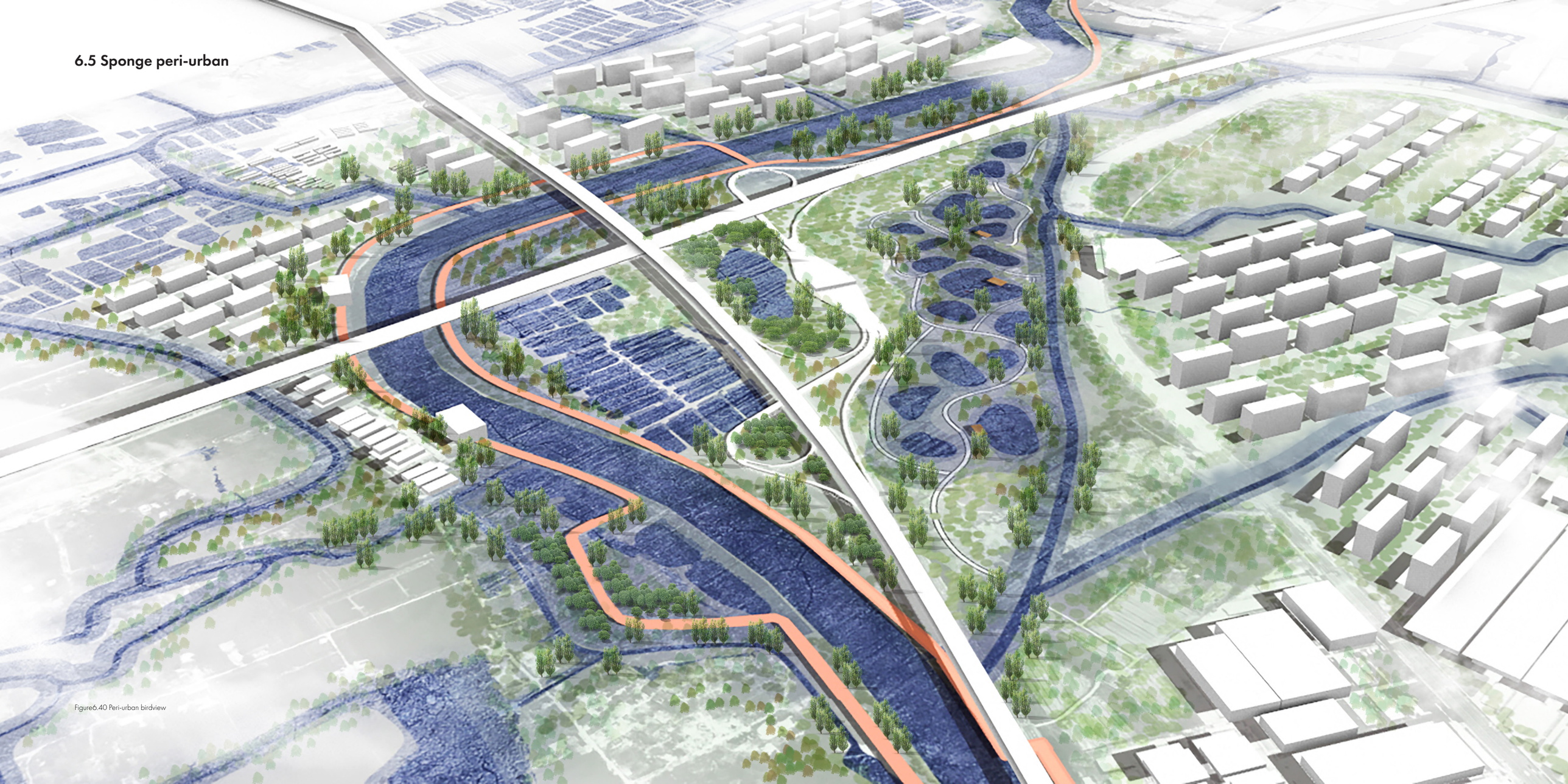


Figure6.40 Peri-urban birdview

Water adaptive building

Learn from traditional settlement in Taihu lake basin

Figure6.41 Water adaptice house in history
Source: Retrieved from website:https://www.shuge.org/ebook/geng-zhi-tu/

Figure6.42 Traditional settlement in Jiangnan region
Source: https://zhuanlan.zhihu.com/p/78456686

Water adaptive building exploration refers to the house typology in the past (Figure 6.41) and integrates it into a contemporary context. The water adaptive building in my design is divided into three types: commercial building, viewing building, and residential building.

Water adaptive building typology

01 Commercial building

Waterfront open public space

02 Viewing building

Semi-open pond space

03 Residential building

Community space

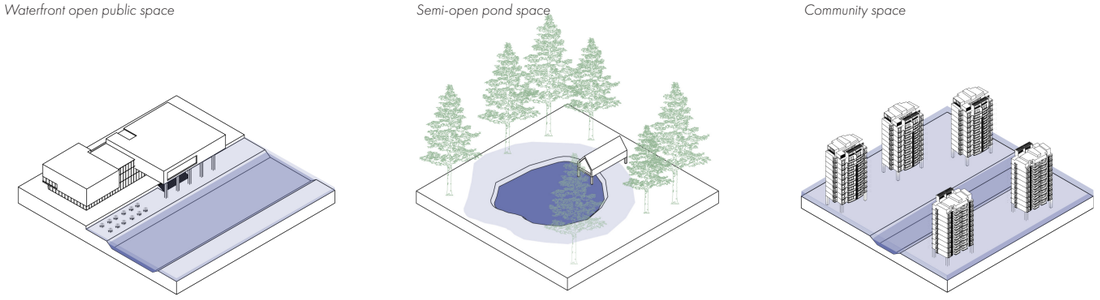


Figure6.43 Water adaptive building typology

6.6 Design exploration conclusion

These three sites highlight diverse aspects of sponge polders. Different historical experiences and principles are applied in these sites, which contribute to varying interpretations of resilience. The first site relates to the sponge lake shoreline, enlarging the water storage capacity as well as generating natural succession to enhance the ecosystem. The topic of the second site is sponge agri/aquaculture, trying to improve the water quality by reintroducing sustainable agriculture wisdom. The third site aims to design a blue-green buffer for both urban and rural zones to allow for sustainable urbanization.

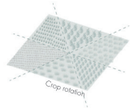
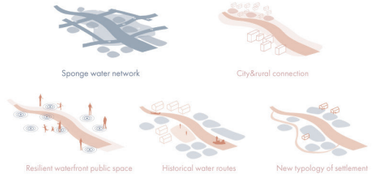
	Historical experience	Assignment	Regional Principle	Strategic significance in the region	Resilience
Sponge lakeshoreline Flooding	Flexible allocation of water resoure 	+RESTORE resilient water system Enlarge water storage capacity -Second defence of water infrastructure	Water&ecology 	Sponge lakeshore line **increases water resilience** in the region as well as **generates natural succession** and benefits for the **spatial quality** among traditional settlements.	-More water storage space to contain the excessive water in rainy season. -Preparing for the possible rising water level in Taihu lake **Mulitifunctionality** **Biodiversity** **Redundancy**
Sponge agri/aquaculture Agriculture water pollution	Circular agriculture 	+RESTORE resilient water system Improve water quality -Agriculture optimization -Wetland purification center -New possibilities of dike pond	Agriculture 	Sponge agriculture transforms **agriculture** into a more **sustainable and ecological** form, integrating **social and cultural function** into it.	-Circular agriculture to reduce the pollutant from crop and pond **Mulitifunctionality** **Biodiversity** **Modulization**
Sponge peri-urban City expansion	Water adaptive bank and building 	+RENEW the public space in rural area Improve spatial quality -City&rural edge -More waterfront public space +REMIND people of cultural value Cultural heritage protection -Tourism(Water route/ water culture)	Settlement&Public space 	Sponge peri-urban water management combines with the **waterfront public space** and allows for **sustainable urbanization**.	-Resilient to city expansion,allow for sustainable urbanization **Adaptive planning and design** **Social diversity**

Figure6.44 Local-scale design comparison and summarize

6.7 Strategic phasing

2023-2025

Figure6.45 Strategic phasing plan(2023-2025)

1. Activate the silt watercourse and create a well-connected water network;
2. Commence the construction of a secondary dike and floodplain adjacent to the primary watercourse, thereby expanding more space for water;
3. Construct ecological islands and plant aquatic plants along the watercourse to slow down the runoff from the south side;
4. More waterfront public space will be constructed to rebuild the close relationship between local people and water.

2025-2030

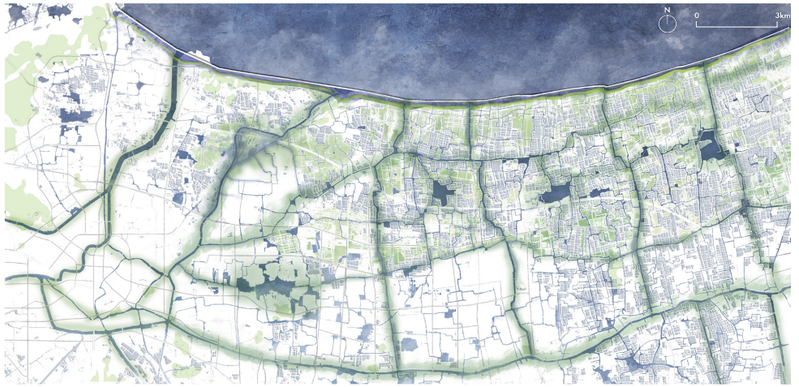


Figure6.46 Strategic phasing plan(2025-2030)

1. Utilize the sediment from the ponds as a nutrient-rich fertilizer for cultivating vegetables on the dike;
2. Transform some of the fish ponds into purification ponds for water treatment purposes;
3. Introduce the new dike pond to the public, converting it into a recreational area and combining it with the educational function.

2030-2035

Figure6.47 Strategic phasing plan(2030-2035)

1. A variety of appealing recreational areas, such as wetland parks and water bridges, will be constructed;
2. Visitors will have access to leisurely tourism routes that combine slow traffic exploration and agricultural civilization experiences.

FigureZ1 Dike pond in Taihu Lake basin
Source: https://ishare.ifeng.com/c/s/7aTlRdCKnH

07 Conclusion&Reflection

7.1 Conclusion
7.2 Reflection

7.1 Conclusion

SQ1: What is the traditional polder system and how is the polder system connected to Taihu Lake?

The traditional polder system formed in the Taihu Lake basin due to the low-lying topography compared to the surrounding land. Understanding how water, agriculture, and settlement systems work and how these three systems collaborate helps me find the challenges and potentials of the polder landscape. The water conservancy system, including dikes, ditches, sluices, storage and drainage systems, and pumping systems promise the water safety of the region, playing an essential role in connecting to Taihu Lake. The crisscrossed water network together with the Taihu Lake formed the resilient water systems in the Taihu Lake basin.

SQ2: What are the design principles of resilient polder landscape systems from the perspective of water, ecology, agriculture, and settlement systems?

The design principles mainly summarize from historical experience and case studies. What I learn from historical experience in terms of the water perspective is the flexible allocation of water resources during rainy and dry seasons and the complex water network of canals, bridges, and sluices. The circular agriculture mode of mulberry dike pond makes full use of the energy and decreases water pollution, which gives a good example and a solid foundation for future agriculture development. As for the settlement systems, the traditional settlement which coexists with the polder gives us clues on sustainable urbanization on polders.

In conclusion, three types of principles from three layers contribute to a water-resilient polder landscape. The water and ecology principles contain:1) sponge water network, 2) water purification, and 3) enhance ecosystems. For the agriculture layer, they are 4) Circular agriculture, and 5) Agriculture tourism. The settlement principles contain: 6) city and rural connection, 7) resilient waterfront public space, 8) Historical water routes, and 9) New typology of settlement

SQ3: How to apply the design principles in Lougang polder in the Taihu Lake basin?

With principles from water, agriculture, and settlement layers, the strategy will guide those principles to form regional planning, which further influences the site-specific design. The principles and strategies bridge the gap between regional planning and site-specific design.

Multi-scale design in my project answers this question. The three site-specific design performs different roles in clarifying regional planning. The first site design in the lake shoreline helps to explain how the sponge water network system increases the water resilience in the region as well as generates natural succession and benefits for the spatial quality. The second detail design in the aquaculture zone demonstrates how sponge agriculture transforms agriculture into a more sustainable and ecological form. Spatial quality improvement and cultural heritage protection are elaborated on in the third detail design, explaining how water management combines with the waterfront public space and allows for sustainable urbanization.

SQ4: To what degree do the strategies and principles increase resilience in polder landscapes?

To restore the resilient water network in the Taihu Lake basin, water storage capacity will be enlarged and water quality will be improved. The resilience capacity theory provides five strategies, which help me to evaluate my design.

(1) Multifunctionality. The sponge peri-urban (site 3) designs a blue-green buffer for both urban and rural areas, the edge space between the river and the dike could be recreational spots during the dry season, and could also be flooded in the rainy season.
(2) Redundancy and modulization. The design of the three specific sites all take water fluctuation into account, creating spare space for water. The idea of a double dike provides redundancy space for excessive water.
(3) (Bio and social) diversity. The sponge lakeshore line design (site 1) explores the different possibilities of the floodplain, which could offer various habitats for flora and fauna due to the changing water level.
(4) Multi-scale networks and connectivity. The design connects the blue-green network not only on a regional scale but also on the local scale. The vision for the regional landscape framework offers a reliable foundation to direct future sustainable ecological and economic development. The detailed design provides more practical views on the implication and local context.
(5) Adaptive planning and design. From the lens of the time process, the strategy will be implemented in several phasing with different emphases in each stage, which can't realize without the participation of varying stakeholders. In terms of the design, providing different possibilities for the possible challenges and the following management is crucial to ensure the adaptivity of the whole system.

In conclusion, the principles summarized from traditional practice reflect the vernacular wisdom. The strategies put them into practice through the application of those principles in regional design, while the site-specific design translates those principles into the local context.

Structure of report

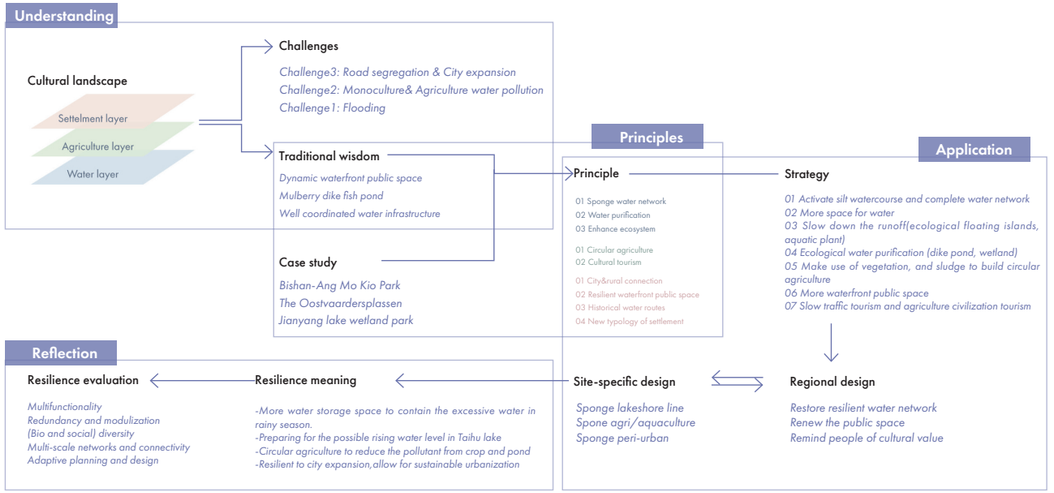


Figure7.2 Structure of report

7.2 Reflection

Relation between my graduation project topic, Flowscape Studio, and Resilient Coastal Landscape lab

The landscape architecture track focuses on flowscapes. 'Flow' refers to the time process and xx while 'scape' relates to space and experience. My project focuses on the water resilience of the polder landscape in the Taihu basin, which is facing climate challenges and urbanization. Resilient design, the main topic of the Resilient coastal landscape lab, helps me to identify the landscape approach for climate adaptation, and explore the different landscape possibilities to solve or alleviate the water crises through constructing an integrated blue-green network.

The resilient design takes into account the fluctuating water levels in the area, which naturally leads to the flow of water, energy, flora, and fauna. By incorporating this into my design, I aim to create unique spatial experiences that enhance the ecological and social functions of the landscape. Through my research, I try to explore the potential for landscape architecture to address environmental challenges. By integrating resilient design principles and working with natural processes, sustainable and adaptive landscapes will be created that benefit both ecological and economic communities.

Cultural Landscape and resilience capacity theory

The layers approach from cultural landscape theory inspired me to understand the polder landscape as a layered entity from water, agriculture, and settlement perspectives and figure out the historical development in each layer and their relationships.

The resilience capacity theory guides me to think about being resilient to what and being resilient for what. In the past, the water, agriculture, and settlement systems were interrelated with each other, forming a relatively resilient unity. Later, because of the city construction, higher and wider dikes are built to prevent flooding; dikes became narrower and narrower to get more profit from aquaculture; traditional dwellings are removed to build factories and high residential buildings. As a result, the water, agriculture, and settlement systems are separated, no longer integrated units. It is vital to restore resilient unity with interrelated three systems for future ecological and economic development.

In terms of water crises, resilience means being capable to live with fluctuating water levels and preparing for the possible rising water level. From the perspective of urban expansion, resilience means allowing for sustainable urbanization in the future.

Lessons learned

(1)Research and design are back-and-forth processes. With a deeper understanding of the site, I modify my research objective and questions several times, making them more clear and consistent. The regional design gives instructions on the design idea of the site-specific design, while the site-specific design gives inspiration for the regional design. The two-way influences and modification and iteration of design make the whole project more coherent. In general, the regional planning and site-specific design explain the same idea of restoring resilient water networks, renewing public space, and reminding people of the cultural value, but show different levels of detail.

(2)Learn from local traditional wisdom. The Lougang polder has a history of over two thousand years of living with water, which left precious polder wisdom on the land. The design should respect the local culture and integrate it into the contemporary context with the demands of the present and the uncertainties of the future. By employing these time-tested techniques, we could create a design that honors the past, accepts the present, and gets ready for difficulties in the future.

(3)Multidisciplinary cooperation in landscape design. Knowledge of hydrology, ecology, agriculture, and sociology is required during the research and design process. As landscape architects, we couldn't know every knowledge from those subjects, the most important thing is to keep the research objective in mind and integrate those disciplines into design to find out the solutions to challenges.

Research and design

Research and design are the two main methods in my project. Research involves gathering different aspects of information like water, agriculture, and settlement systems of the site, figuring out how these systems work and what challenges it is encountered, and their potential, which forms the foundation for effective design assignments. Design, as the creative and problem-solving method, utilize the information gained from research and develop solutions to address the challenges.

Research and design interact and influence each other. The research influences my design by providing insights into the cooperation among three systems and guides me to choose the three locations for detailed design, while design outcomes generate new questions for further research, including the excavation of vegetation culture and agricultural culture in the region.

To sum up, the combination of research and design leads to a robust and convincing outcome, enabling the organization of diverse elements into a cohesive narrative.

Method and approach

The layer approach and mapping are two of the most important methods in the project. With the combination of these two methods, I figure out the mechanism of water systems and the distribution of agricultural and settlement systems, and how they influence each other, providing me with a deeper understanding of the polder landscape. This holistic perspective elucidates the symbiotic relationship among the three layers, ultimately establishing a resilient water network.

Limitation

Due to covid, there is a limitation for the on-site survey, which causes inconvenience in the design, especially for the local scale design. I try to get as much information as possible from the theses, news, websites, and government documents. In addition, the open sources data are relatively less. Sometimes I have to speculate based on common sense or experience from other places. Secondly, modeling and experimental exploration are missing in my project, which allows for testing the proposed strategies and principles from another angle.

Outlook

The project offers solutions to settle the three main problems in the polder landscape in the Taihu Lake basin: flooding, agricultural water pollution, and city expansion. Compared to the civil engineering method, landscape intervention costs much less, builds up a more adaptive and resilient system, and brings aesthetic experience as well. Learning from historical practice to protect precious cultural heritage while restoring the water resilience in the Taihu basin through landscape approaches is the key challenge in the design.

Starting from the base layer like soil and water, this project aims to provide landscape approaches to solving or alleviating the environmental and social challenges and creating a sustainable social-ecological system as well as being flexible enough to adapt to future uncertainties. The project could give examples for future lake shoreline protection and sustainable urban expansion in other regions.

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