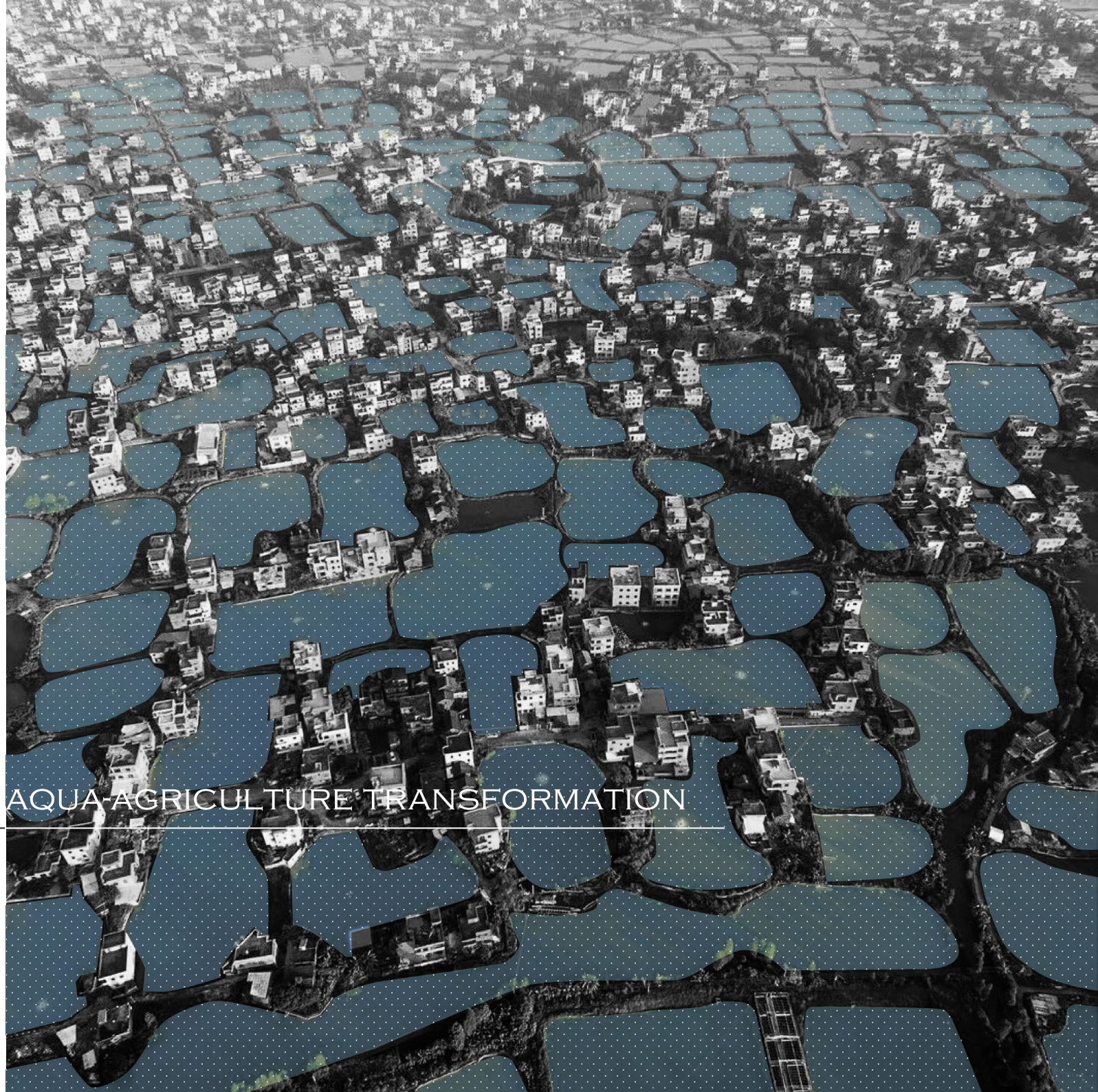

Resilience through aqua-agriculture transformation

towards a multiscale approach for adaptive landscape development in Pearl River Delta

Chuanzhi Sun

COLOPHON

Explore the strategies/design principles for water resilient urban landscape development based on dyke-pond system, ecological water management methods in the floodplain of West River through multiscale

MSc Graduation Thesis
Graduation Studio
Flowscapes

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CONTENT

01.INTRODUCTION

I. FASCINATION
II. PROBLEM STATEMENT
III. RESEARCH OBJECTIVE & QUESTION
IV. METHODOLOGY
V. SCOPE AND RELEVANCE

02.METHODOLOGY

I. RESEARCH APPROACH
II. RESEARCH METHOD

03.ANALYSIS

I. DYKE-FISHPOND AS A SPECIAL AGRICULTURE LANDUSE
II. MULTISCALAR WATER MANAGEMENT
III. MODERN INTERVENTION

04.DESIGN PRINCIPLE

I. DESIGN PRINCIPLES FOR A NEW URBAN LANDSCAPE
II. WATER-SENSITIVE PRINCIPLES THROUGH MULTISCALE
III. CONCLUSION

05.DESIGN EXPLORATION AT REGIONAL SCALE

I.BACKGROUND ANALYSIS
II.PRINCIPLE AND STRATEGY
III.REGIONAL PLAN AND STRATEGY
IV.THEMATIC PLAN AND INTERVENTION
V.VISION

06.ELABORATION AT LOCAL SCALE IN RURAL CONTEXT

I.BACKGROUND ANALYSIS
II.PLAN FOR LOCAL SCALE
III.THEMATIC PLAN AND PHASING
IV.NODE DESIGN
V.DETAIL DESIGN
VI.VISION

07.CONCLUSION AND REFLECTION

I. DISCUSSION AND CONCLUSION
II. STRATEGY AND TOOL KIT SUMMARY
III. REFLECTION

ABSTRACT

The Pearl River Delta (PRD) is a river dominated floodplain in southeast China. Long known as one of the country's richest agricultural regions, in recent years it has also become known as one of the world's most densely urbanized areas. Decreasing space for water through dyke-ring construction, channelization and urbanization has led to increased flood risk from the river, rain, and the sea. To protect residents from flood risk, a more adaptive urbanization strategy is required, one that takes account of ecological agriculture (e.g. the traditional dyke-pond system) as well as historical water-management methods, which uses a multi-scalar approach.

The objective of this thesis is to identify landscape architecture principles for multiscale water sensitive design based on traditional agri-aquacultural practice in this region. In Shunde district, a flood prone lowland located between the West and North rivers in the PRD, there is a century-old tradition in working with water via integrated agri-aquaculture systems. By learning from traditional agri-aquacultural practices, new design principles can be developed to mitigate flood risk while allowing for increased but sustainable urbanization, not just for the Shunde district, but also for the Pearl River Delta, so that they can be more resilient to flood risk in the future.

Keywords

Adaptive urban transformation, Water sensitive design, Multiscale strategies, Dyke-pond system, Landscape design principles



Modern dyke-fishpond in Xingtan county, Shunde district, Foshan city
Photo: Chuanzhi Sun

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01. INTRODUCTION

I. FASCINATION
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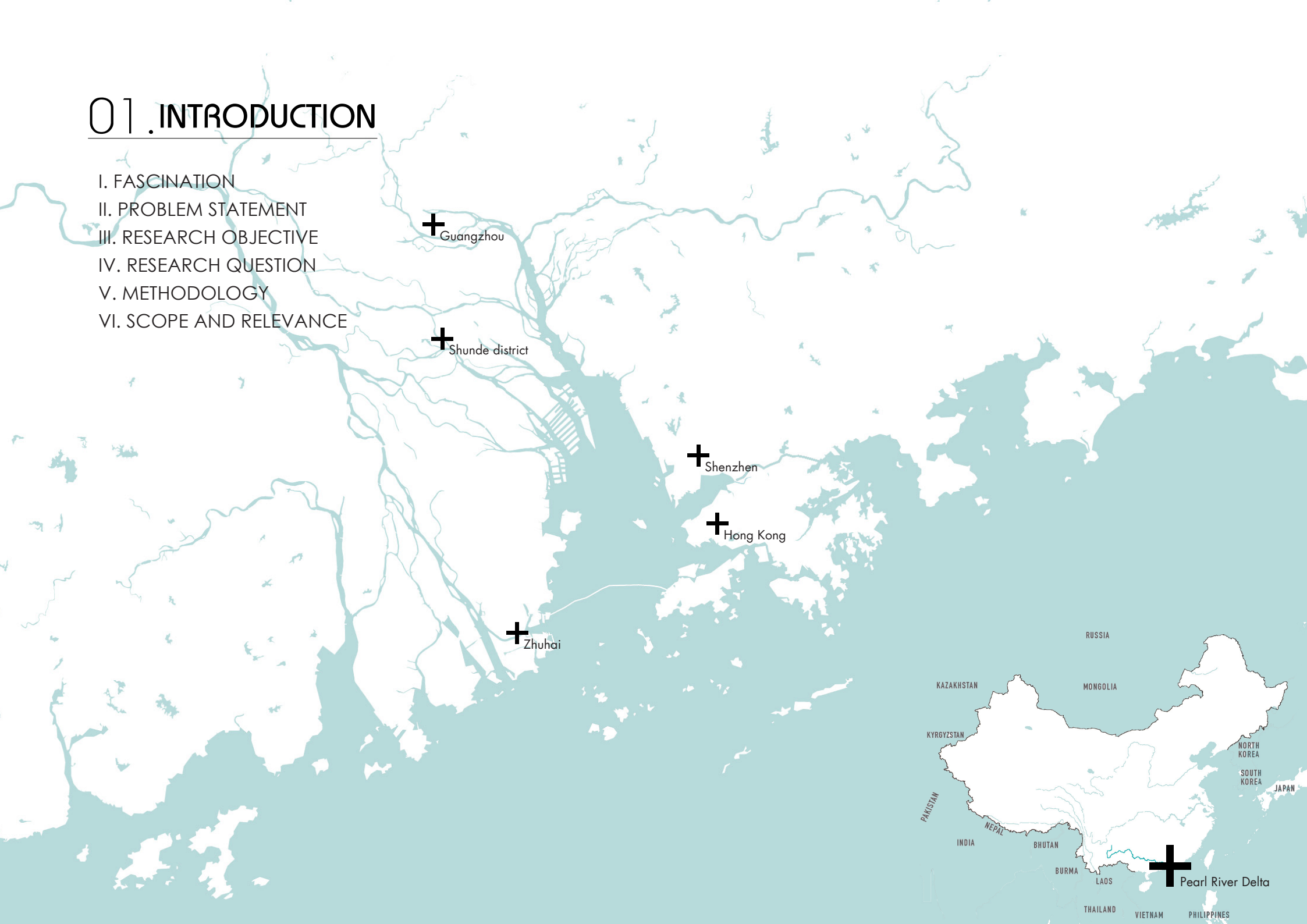
VI. SCOPE AND RELEVANCE



FASCINATION

Since the formation of Pearl River Delta before 1000 years, the people there started to be engaged with agricultural activities. This activity began with an adaptation of the delta environment when people grew fruit trees on higher land. At that time people couldn't make use of the lower land because of its highly salinized, acid sulphate soils (Kenneth&Gongfu, 2015) and continuous flooding. Later because of the water management knowledge gained by the villagers, mud dyke was built to protect lower tidal land.

However, the productive agriculture typology had not been found till an innovative system turned up after years of practice. This system became a perfect solution to the flood inside the dyke ring for storing excessive water during monsoon season. Ponds were made to drain the marshland and fishes were raised inside for a carp-fry production.

Later, after years of experience peole found an integrated agricultural system of mulberry fish pond which is highly efficient and profitable.In addition, this system helps to absorb the excessive water during monsoon season when the ponds were flooded and the dykes remained safe.

During mid-fourthcentury water control measures were started in the lower area around West River with knowledge of water management to prevent the flood from the river. Small watercourse were dyked to make fish ponds, thus reclaiming the lower alluvial



Dike-pond landscape showcasing the intricate relationships between water management, agriculture, ecology, industry, and settlements

Image source: http://www.sohu.com/a/248710222_155251

plain for aquacultural production. The villages were usually built along the higher land besides rivers and some of them were protected by these dykes. From then on, an integrated life paradigm of transporting, living and producing with water was developed and it lasted till now.

Afer the adaptation of the alluvial plain in this delta, settlements were gradually shifted to the lower region which provided fertile soil for agriculture production and convenient water transport. Protected by the construction of outer dykes and village dykes, the economy was increasing rapidly and markets emerged quickly for exchange of extra goods between different settlements. These markets were mostly located close to the river with good access to water transportation so the villagers can use boats to ship fishs, silk and other original products.

The culture here, from the every begining, has had a close connection with water because the local authority itself was originated from the water management agency. Ancient temples were built along the water for the important conference like worshipping ancestors and discussing water related issues. Religion was created based on the worship of water and it raised the awareness of collecting water in important public space. Consequently, the special hybrid of dyke pond system, settlements and transportation were created and we still see this integrated landscape pattern today in this region.



The typical aquaculture, agriculture, settlements and water transportation of Pearl River Delta

Image source: http://pikony.com/account/chuarosalynn/532973074560094342/

PROBLEM STATEMENT

However, the Pearl River Delta is also in great danger of flood because of its natural terrain and human intervention. The whole delta is vulnerable faced with quick urbanization, climate change and etc.

There are three main flood threats that cause this vulnerability: 1. The threat from river; 2. The threat from rain; 3. Sea level rise.







The flood in mega cities like Guangzhou caused by rain storm in monsoon season.

Image source: https://www.standard.co.uk/news/world/typhoon-hato-hong-kong-braced-as-hurricane-threat-set-to-highest-level-a3617861.html

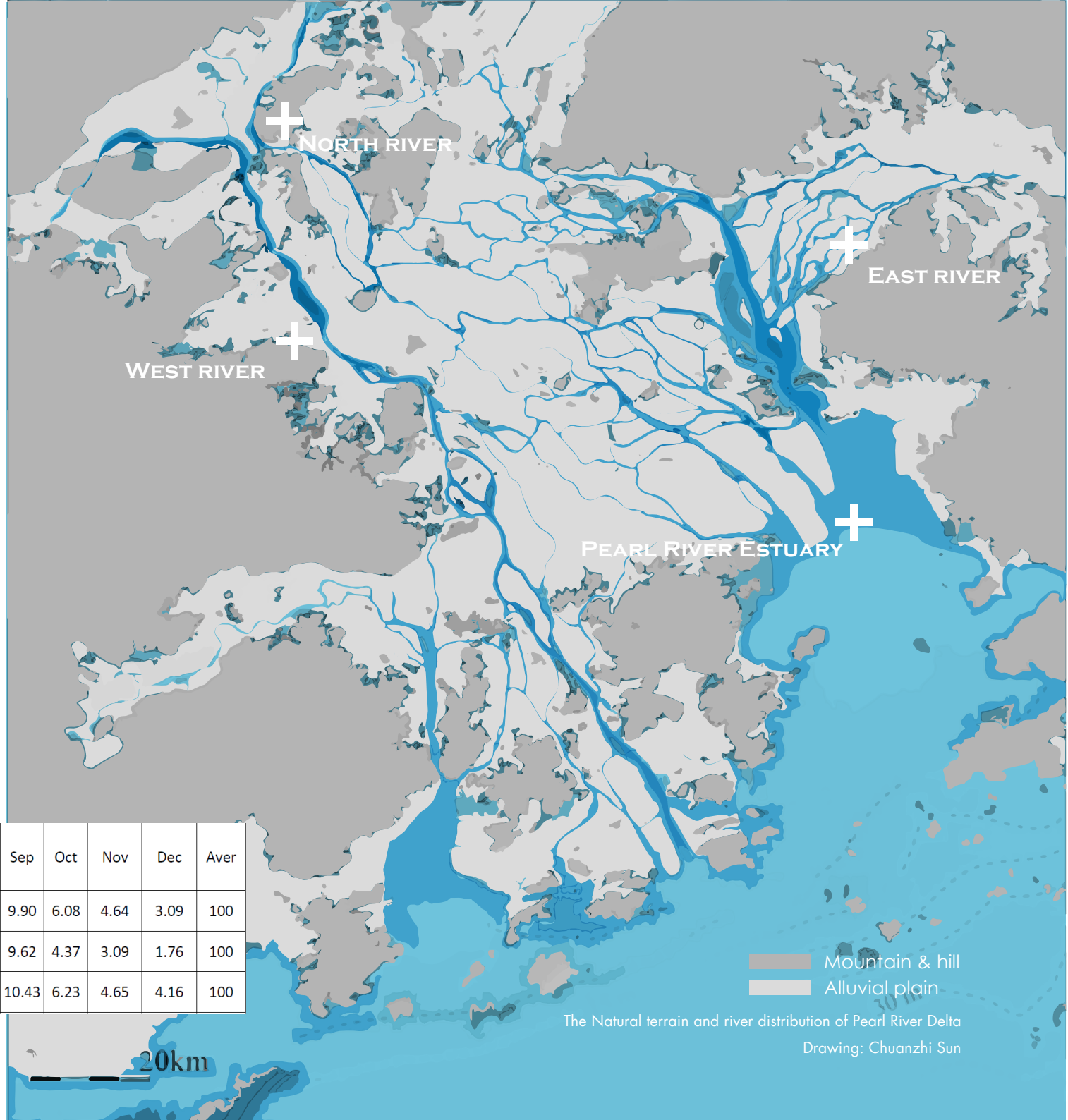
MAIN THREAT I: RIVER FLOOD

The PRD is located in the southeast coastal region of China, with the West, North, and East rivers being its main riverine arteries. This river-dominated delta has been formed by natural processes, such as siltation and deposition, for more than a millennium (Xiong & Nijhuis, 2018). However, due to the high discharge and monsoon season, this region has been witnessed flood issue for a long time. During monsoon season from April to September, the excessive rain water will cause an overflow of water to the river, which increases the danger of flood. The runoff distribution of three rivers are slightly different. Taking West River as an example, the inflow usually happens between May and September with 72.1% annual runoff according to Global Water Partnership (China) WACDEP. The peak month of water distribution is in June for East River, July for West River, which means a high frequency of flood from June to August. To deal with the river flood in this region, a long term of dyke construction has been taken.

Station	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver
Makou	2.73	2.88	3.80	7.04	11.98	16.91	16.58	14.37	9.90	6.08	4.64	3.09	100
Sanshui	1.55	1.77	2.83	6.46	12.35	20.46	19.96	15.79	9.62	4.37	3.09	1.76	100
Boro	3.97	4.23	5.29	8.03	11.16	17.73	12.10	12.02	10.43	6.23	4.65	4.16	100

Runoff distribution ratio in a year.

Chart source: Global Water Partnership (China) WACDEP



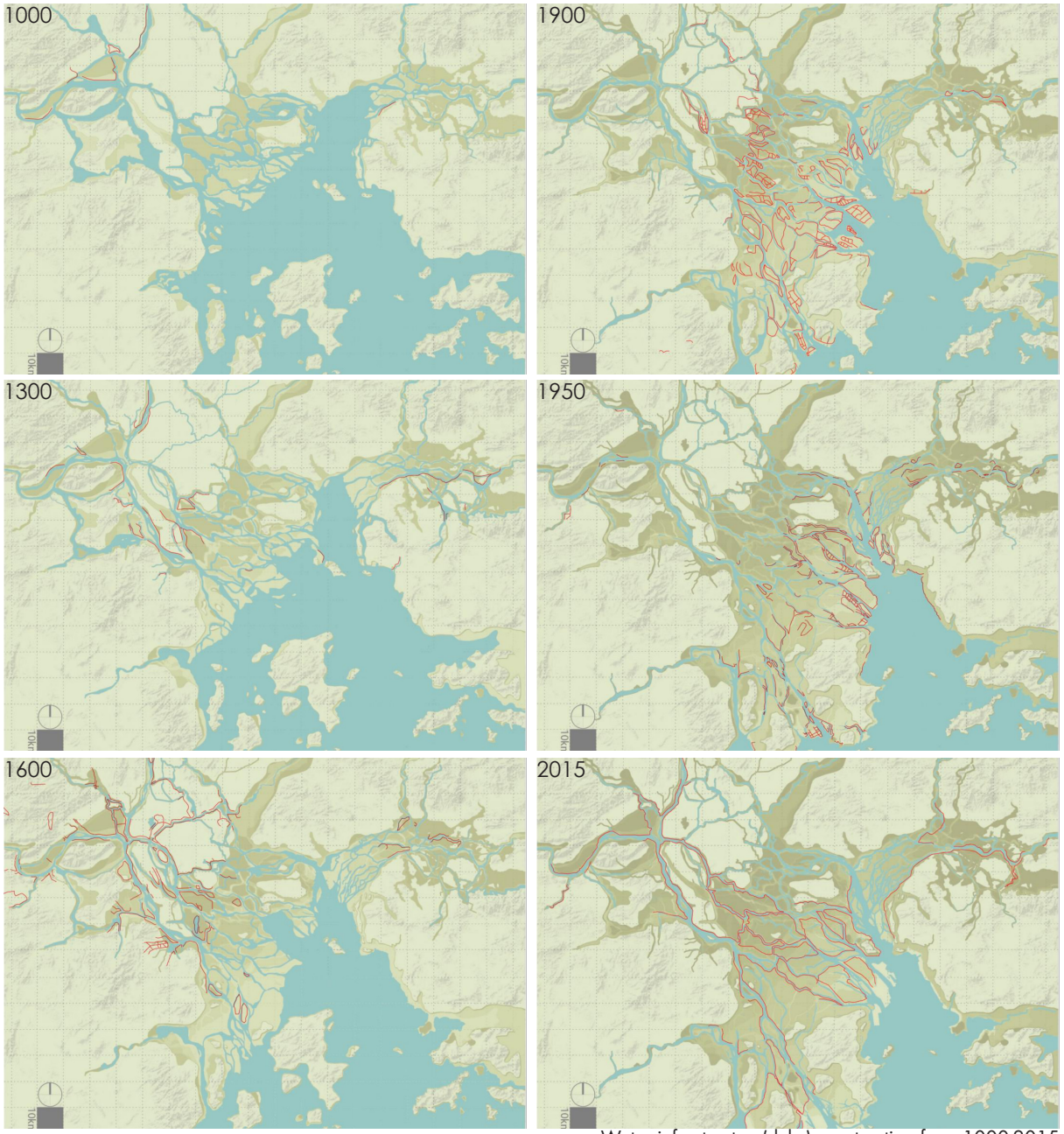
The Natural terrain and river distribution of Pearl River Delta

Drawing: Chuanzhi Sun

INTENSIFIED RIVER FLOOD

To mitigate the flood danger from river, the dyke construction of Pearl River Delta has began around 1000 years ago. The initial dyke construction was only found in the upstream of the delta intending to defend farmland only in the most extremely dynamic zone. Later from 1300-1600, the dyke construction was expanded both in size and scale: from local homogeneity to sub-regional homogeneity(Liang & Steffen, 2019). Till then the dyke construction was still concentrated in the old alluvial plain in order to protect people from river flood risk. However, more and more dyke construction was developed in the newly formed area near the estuary, which is a shift from flood protection to land reclamation since people found the dyke construction helped to reclaim flood plain from the river. The most important change began in 1950 when an integration of smaller dykes into dyke rings was put into practice. this action drastically increased the quality of dike rings while it also extremely decreased the space for discharge of the river by closing all the rivers and creeks inside these dyke rings .

However, the construction of dykes for over 1000 years resulted in a much more narrow watercourse. In addition, human activities like sand dredging caused deeper water bed, stimulating the problem. As a result, the water level in the river becomes much higher and leads to a threat to the dyked cities in this region.



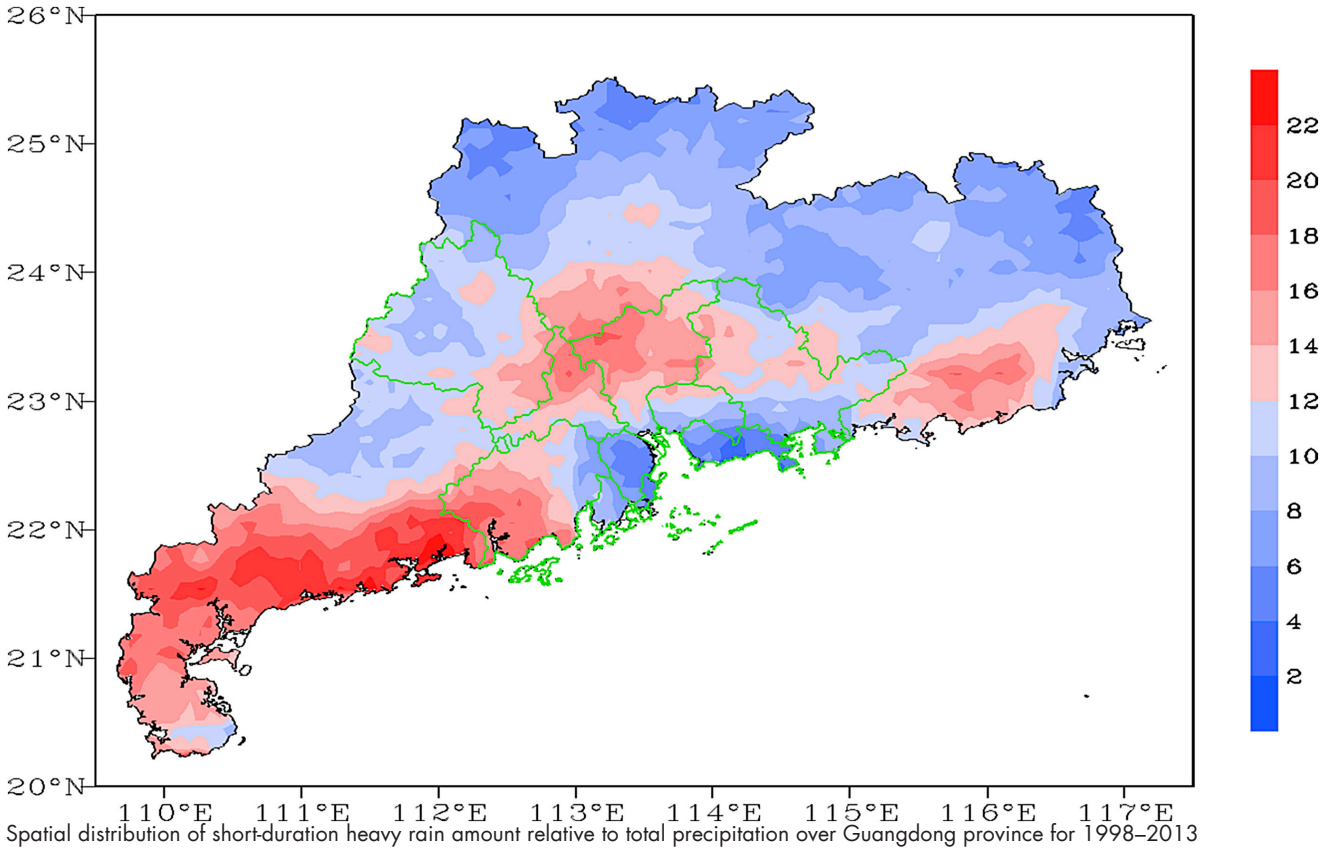
Water infrastructure(dyke) construction from 1000-2015

Image source: L. Xiong and S. Nijhuis(2019), Cities as Spatial and Social Networks

MAIN THREAT II: RAINSTORM

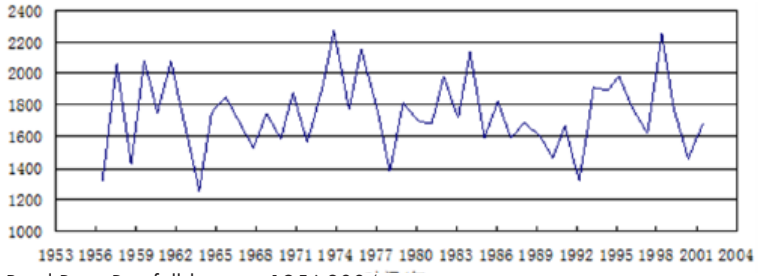
The climate in Pearl River Delta belongs to subtropical monsoon climate with heavy rainfall from April to September every year, when the rain storm usually happens at the same time. Along with the dyke construction, the excessive rain that falls to the urbanized zone could not be quickly drained outside will cause external flood. Pearl River Basin is mild and rainy with average annual rainfall of 1771mm. Its rainfall in flood season accounts for 70% to 80% of annual rainfall with great storm intensity.(Global Water Partnership (China) WACDEP). This climate makes the delta easy to suffer from flood of the rain and the river at the same time. Since the main ratio of runoff usually takes place with the main rainfall distribution at the same time, the excessive rain water inside the flood plain could not be discharged quickly to the main river with a higher water table. As a result, internal flood happens frequently especially in the urbanized zone with not enough water capacity.

To deal with this flood issue, a special pattern of aqua-agriculture was developed about 500 years ago after trial and failure. This landuse is called dyke-fishpond system that includes a pond in the center and mud dykes around it. When the heavy rain happens, the excessive water could be poured into these ponds while the dyke area remains dry. This special landuse became a perfect solution for adaption as well as high production in this region and has been spread widely to the whole Pearl River Delta.



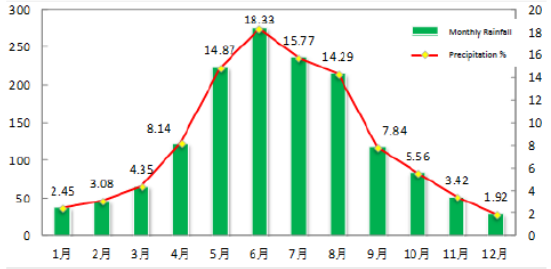
Spatial distribution of short-duration heavy rain amount relative to total precipitation over Guangdong province for 1998–2013

Chart source: ShengChen & Wei-BiaoLi (2015), Urbanization effect on precipitation over the Pearl River Delta based on CMORPH data



Pearl River Rainfallsbetween1956-2004

Chart source: Global Water Partnership (China) WACDEP



Distribution of precipitation in the Pearl River Basin during a year

Chart source: Global Water Partnership (China) WACDEP

Dyke-fishpond pattern in 2005, Shunde.



Industry and infrastructure construction in 2017, Shunde.



INTENSIFIED RAIN FLOOD CAUSED BY URBANIZATION

However, the dramatically quick urban construction within around 30 years has took large part of this aqua-agriculture pattern and construct concrete surface to as a replacement. Since demolishing this dyke-fishpond that could host excessive water means lots of water capacity has been lost, the rain water has nowhere to go but to cause flood, especially in the urban area where there's not enough water network to temporarily store it or hold it. The flood caused by rainstorm has been witnessed in these years for so many times that a gradual realization has been reached that the single city underground drainage system is not able to bear so much water drain in short time. However this problem is less frequently found in the rural area with enough dyke-fishponds. To make a more resilient future, a new development method that could remain this water capacity shall be taken into consideration.

A developing metropolitan area that replaces great amount of agriculture

Drawing: Chuanzhi Sun

Image source:http://www.usocctn.com/archives/4350

THREAT III SEA LEVEL RISING

SEA LEVEL RISING AND URBANIZATION IN FLOOD PRONE ZONE

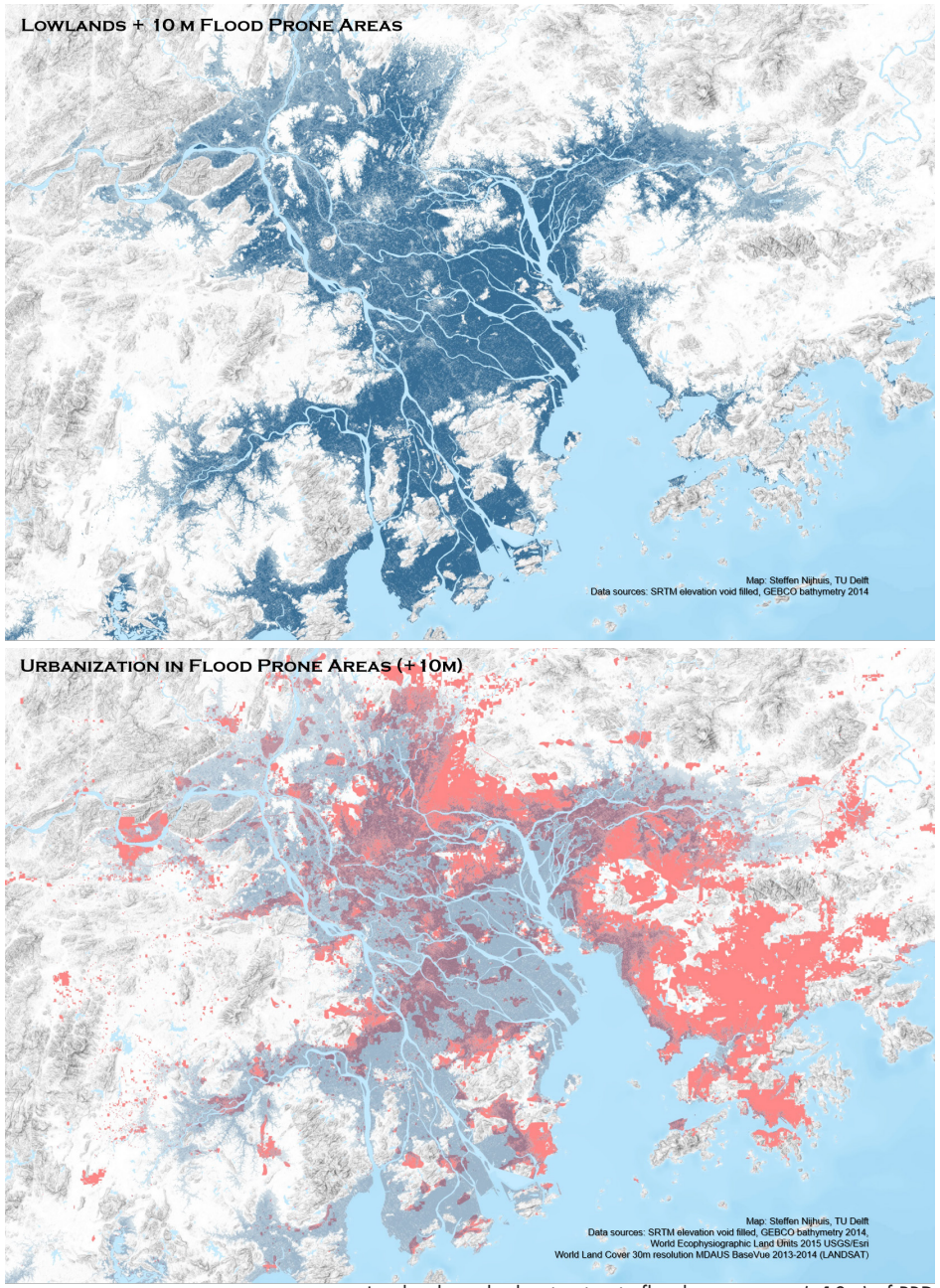
Sea level rising has been regarded as one of the most serious problems which threat the delta future in the world, which also applies to the Pearl river delta. Adding to the fact that large part of the newly formed alluvial plain is below sea level, this problem becomes even more serious.
The fast urbanization in this area took place of large agriculture land and water pond to build cities like Foshan, Zhongshan and Zhuhai, which are now hubs of economy and population in regional scale. As a result subsidence happened because of soil compression and drainage to make surface for the urban construction.

All this makes the flooding issue a huge threat to the urbanized delta.

CONCLUSION

As a conclusion, the Pearl River Delta with a historical aqua-agriculture and water management has been intensely changed to a vulnerable and fragile flood prone zone that is great danger. This puts forward an interesting question based on this special context:

Can we make the urban delta in Pearl River more resilient against river flood and rain storm through aqua-agriculture transformation?



Lowlands and urbanization in flood prone areas(+10m) of PRD

Map: Steffen Nijhuis

RESEARCH OBJECTIVE & QUESTIONS

The objective of this study is to

EXPLORE STRATEGIES/DESIGN PRINCIPLES FOR WATER RESILIENT URBAN LANDSCAPE DEVELOPMENT BASED ON DYKE-POND SYSTEM, WATER MANAGEMENT METHODS IN THE FLOODPLAINS OF THE WESTRIVER THROUGH MULTI-SCALE

This intention combines the historical aqua-agriculture method known as dyke-fishpond with water management method that has been developed and practiced for long time in this region to develop a new framework towards the fast urbanization. It mainly focus on the rural area where there's still a large proportion of agriculture to experiment how the process of urbanization could be changed from a demolished-construction model that caused lots of trouble to a more resilient, and water-sensitive urban landscape model.

In order to develop the thesis, these following questions need to be answered:

UNDERSTANDING QUESTION

-What are the traditional dyke-fish pond system and ecological water management and its social structure through different levels(region, village, building) ?

WHAT TO DO QUESTION

-What are the principles about living with water including water cycles(water storage, drainage and purification), ecology(restoration of biodiversity, dynamic), agriculture(recycling) and social structure(water culture, activities)?

APPLICATION QUESTION

-How to apply principles in design explorations in different geographical environment(plain and mountain) in relation to water management(flood storage and drainage, grey water purification and storage, rain water harvest), ecology(restoration of diversity, dynamic), urbanization(increase of water dynamics, excessive water storage, water reuse, increase of flood resilience) and social structure(recreation around water, new typologies of public space)?

REFLECTION QUESTION

-What are the lessons learned(principles) of connecting agri-aquaculture, water management, urbanization to make a new type of delta urban landscape?

-What is the possibility of its application in other region?

METHODOLOGY

RESEARCH THROUGH DESIGN

Through the research about the principles of ecological water management and agriculture in the Shunde county and other subtropical region which shares similar characteristics, knowledge about how to deal with water can be gained . In addition, other social and economic elements like the method of constructing public space, the method of making circular economy growth can also be generated and certain principles like how to how to make use of waste, how to improve social contact besides the water.

Later strategies and plan can be made based on the knowledge and principles derived from research. At the same time, possibilities of dealing with the water issue can be explored and experimented in the way of visualization and spatial simulation. These vision will focus on how to make a sustainable plan and design for a more resilient future where the cities and people can live with water in an adaptive way. As a result this vision will contribute back to research as a tool box of transforming the landscape in the whole rural are of Pearl River Delta.



SCOPE & RELEVANCE

The objective of this research is to identify landscape architecture principles for multiscale water sensitive design based on traditional aqua-agricultural practice in the sub-delta of the West River, in particular the dike-pond system, to increase flood storage. Since these systems were gradually formed and refined based on practical lessons over hundreds of years by the residents there is wealth of accumulative knowledge hidden in the landscape that can be used for flood protection, ecology and cultural formation in contemporary urban development.

This tacit knowledge is largely unexplored but proved to be very useful. By learning from this traditional aqua-agricultural practices, new design principles can be developed to mitigate flood risk while allowing for increased but sustainable urbanization, not just for the Shunde district, but also for the Pearl River Delta, so that it can be more resilient to flood risk in the future.



REGIONAL SCALE

As a zone between West river and North river, the Shunde district belongs to the whole Pearl River Delta that is located at the southeast of China. The whole region of Shunde district is taken as a regional scale that has influence for every county in it and correspondingly, would be affected by them.



M. COUNTY SCALE

The Xingtan county located in the center of Shunde district is taken as a middle scale, which is most important scale that has direct relationship with the research.



S. VILLAGE AND BUILDING SCALE

The villages and buildings inside the county would be regarded as the implication of small scale, as an application and elaboration scale of research.

02. METHODOLOGY

I. RESEARCH APPROACH
II. RESEARCH METHOD



RESEARCH APPROACH

-TRANSFOMATION PERSPECTIVE

Landscape is a result of long term intervention between nature force and human intervention and it would continue to grow. Thus it's important to take the historical cause into consideration and value the principles and lessons learned from it. Taking a transformative perspective means the context is not a blank canvas that could be planned or designed with any intervention, but full of story made out of different elements: water, soil, vegetation, different landuse and social structure.

-MULTISCALE APPROACH

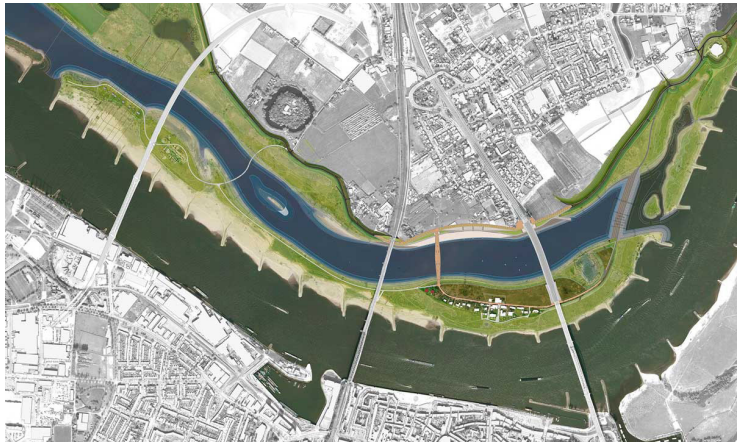
Landscape is widely connected through scales and affect each other. It's important to look at the landscape through different scales and build connection between them.

-LANDSCAPE AS INFRASTRUCTURE

The water has been an important network for flows like transportation, energy and etc. As one of the project belong to the studio of FLOWSCAPE, it's important to understand landscape as an intermediary that connects not only natural elements like water, vegetation, but also human activities and interventions. Thus, regarding landscape as an infrastructure constructs the basement for all the development upon it and make a strong connection between different developments. Theories like landscape urbanism, landscape infrastructure would be taken into consideration and utilized as design principles.

-LANDSCAPE AS PROCESS

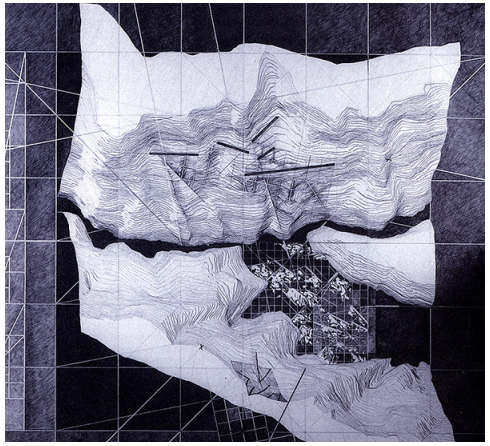
The Pearl River Delta is formed after a long process of natural power and human intervention during which these two system strongly interact with each other. In the Pearl River Delta, the sedimentation process created basement for the special type of landuse pattern such like dike pond system as an unique agriculture system, and later it was changed for urbanization. Historical water management method, based on an understanding of the water dynamics in this estuary, was also generated in process. So to understand this system it's important to recognize the different process in this delta, and there're different dynamics of them which shall be studied. Theories like design with nature would be taken into consideration in order to make time and development sequence as a basic element for design.



Room for river, Nijmegen: Multiscale water strategy
image source: http://www.landezine.com/index.php/2016/08/room-for-the-river-nijmegen-by-hns-landscape-architects/



Wusong riverfront: Water as an infrastructure
image source: https://www.asla.org/2012awards/196.html



Experiment about natural processes of erosion and sedimentation
image source: Michel Desvigne

RESEARCH METHOD

-MAPPING

The long process of landscape caused a complicated system that requires a deconstruction to understand. Mapping is a good method for analysing the complex landscape and extract knowledge from it. In addition, it also helps to find the problem of the site and inspire certain solutions.

-LITERATURE REVIEW AND CASE STUDY

By going through other cases and theories around the world a comparison study could be made in order to gain similar knowledge

-SITE VISIT

A look through the site in real situation would inspire the design ideas as well as showing normal life of the site. In addition, it's a way to know the culture and landscape more precisely.

-TRIAL AND ERROR

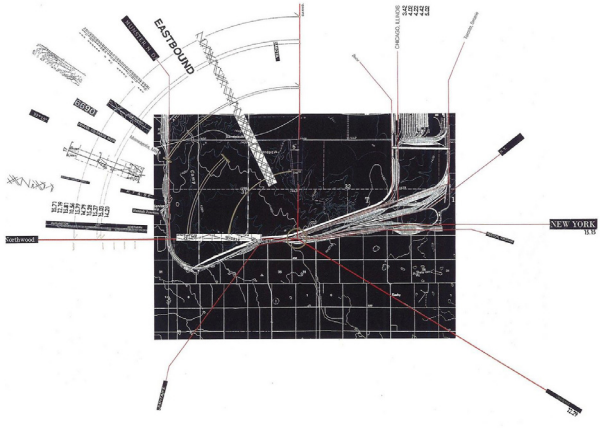
A design exploration is needed in order to get through the process of picking right ideas and principles for the final design. It helps to think critically about the design from all perspectives and draw the common lessons.

-MODEL MAKING

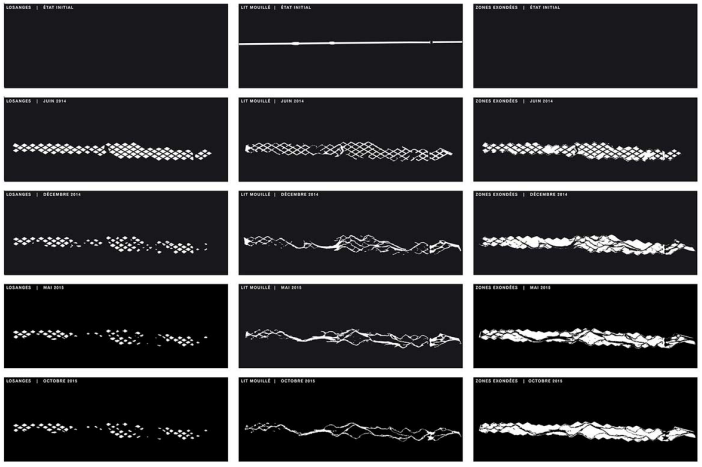
Making a model to test the principle or spatial design helps to define if one intervention could work in the site or to test if one action could affect other things.

-SCENARIOS

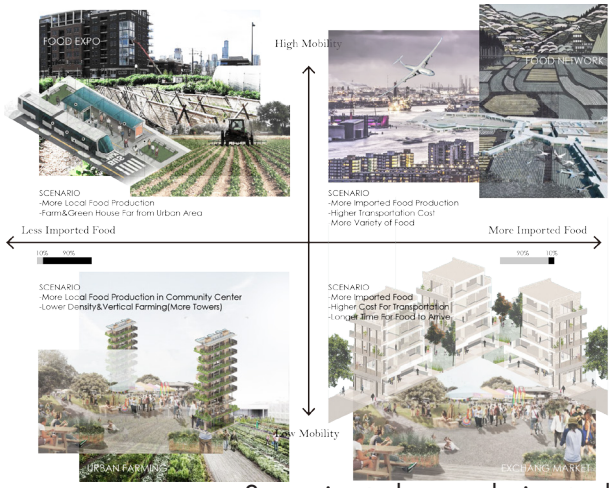
By constructing different scenarios, the similarities of one design or plan could be compared for common intervention extraction.



Mapping as a way of understanding landscape
Map: James Corner



Model to simulate the river morphology in River Aire
Image source: http://www.landezine.com/index.php/2016/06/renaturation-of-the-river-aire-geneva/



Scenario study as a design tool
Drawing: Chuanzhi Sun

03. ANALYSIS

I. DYKE-FISHPOND AS A SPECIAL AGRICULTURE LANDUSE
II. MULTISCALAR WATER MANAGEMENT
III. MODERN INTERVENTION



DYKE-FISHPOND AS A SPECIAL AGRICULTURE LANDUSE

As a unique type of agriculture landuse in the world, it would be interesting to have a close look at the system from its:

I.Distribution and Location
II.Principle of dyke-pond system
III.Transformation and Typology
IV.Historical change study
V.Modern intervention
VI.Conclusion

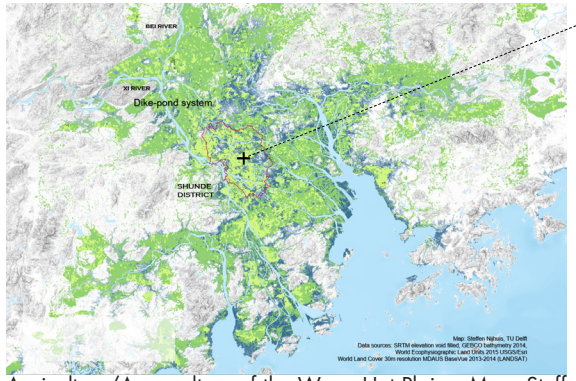


A banana-fisnpond in Xingtan county, Shunde district, Foshan city
Photo: Chuanzhi Sun

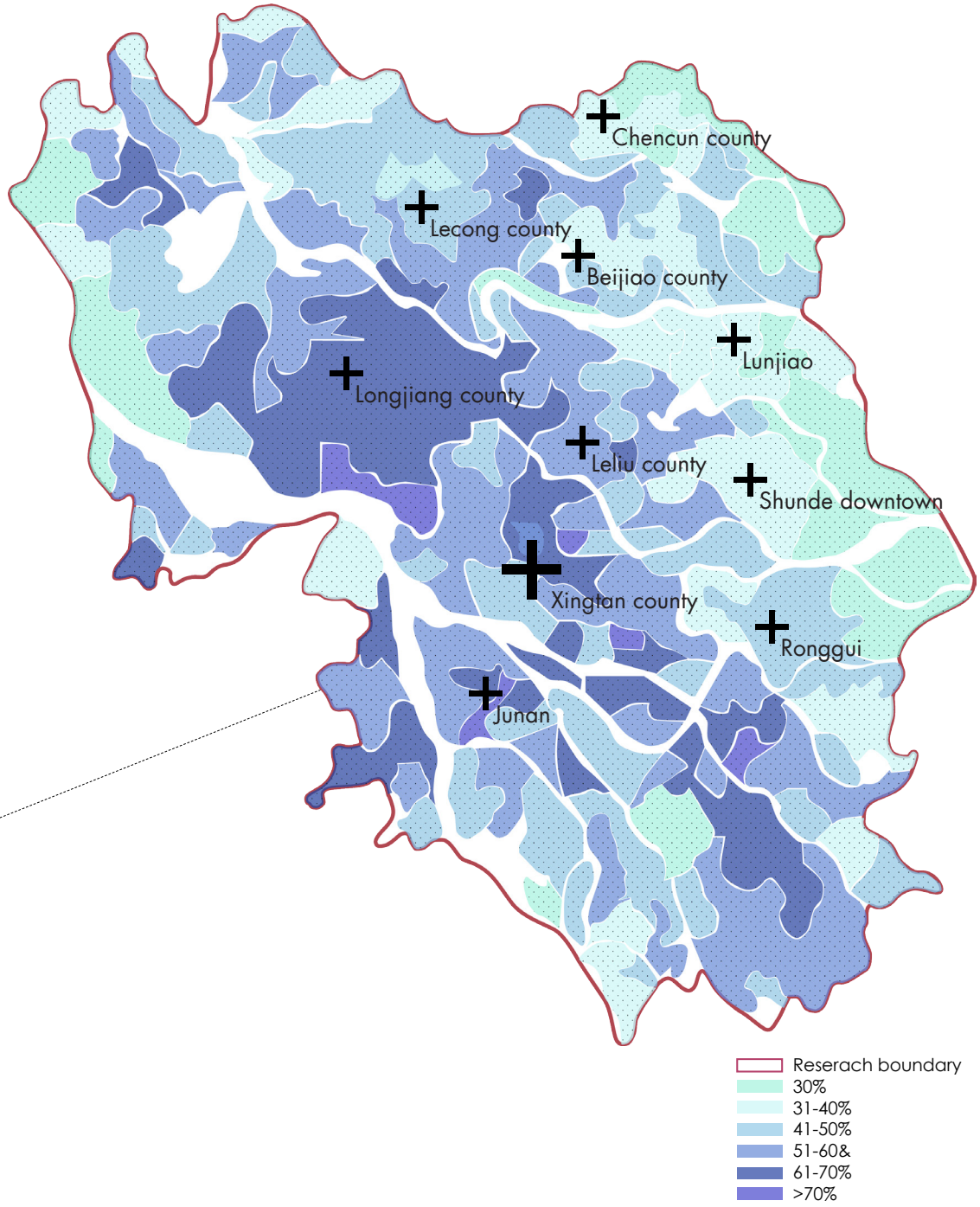
AGRICULTURE DISTRIBUTION IN PRD

The agricultural lowland in the subdelta is characterized by seasonal floods by peaks in river water discharge caused by rain water from upper part of the river basin, as well as the rain in the region itself. Floods occur mainly between June and August as a result from the typical precipitation patterns in the monsoon season from April to September every year. The strong connection between this natural hydrological circumstances, the fertile soil and the need for economic production led to a particular aqua-agriculture known as the dyke-pond system (Ruddle & Zhong,1988).

The dyke-pond system sprouted in 14th century in form of fruit trees on the dyke with fish pond in the center and was later changed into a combination of mulberry planting with four major fish species for silk and fishery economy in 1620. Since then this aqua-agriculture pattern has been witnessed a boom in the PRD region and reached its peak in 1926. After that depression happened due to Japanese aggression and market change when lots of alternative combination was explored and developed.



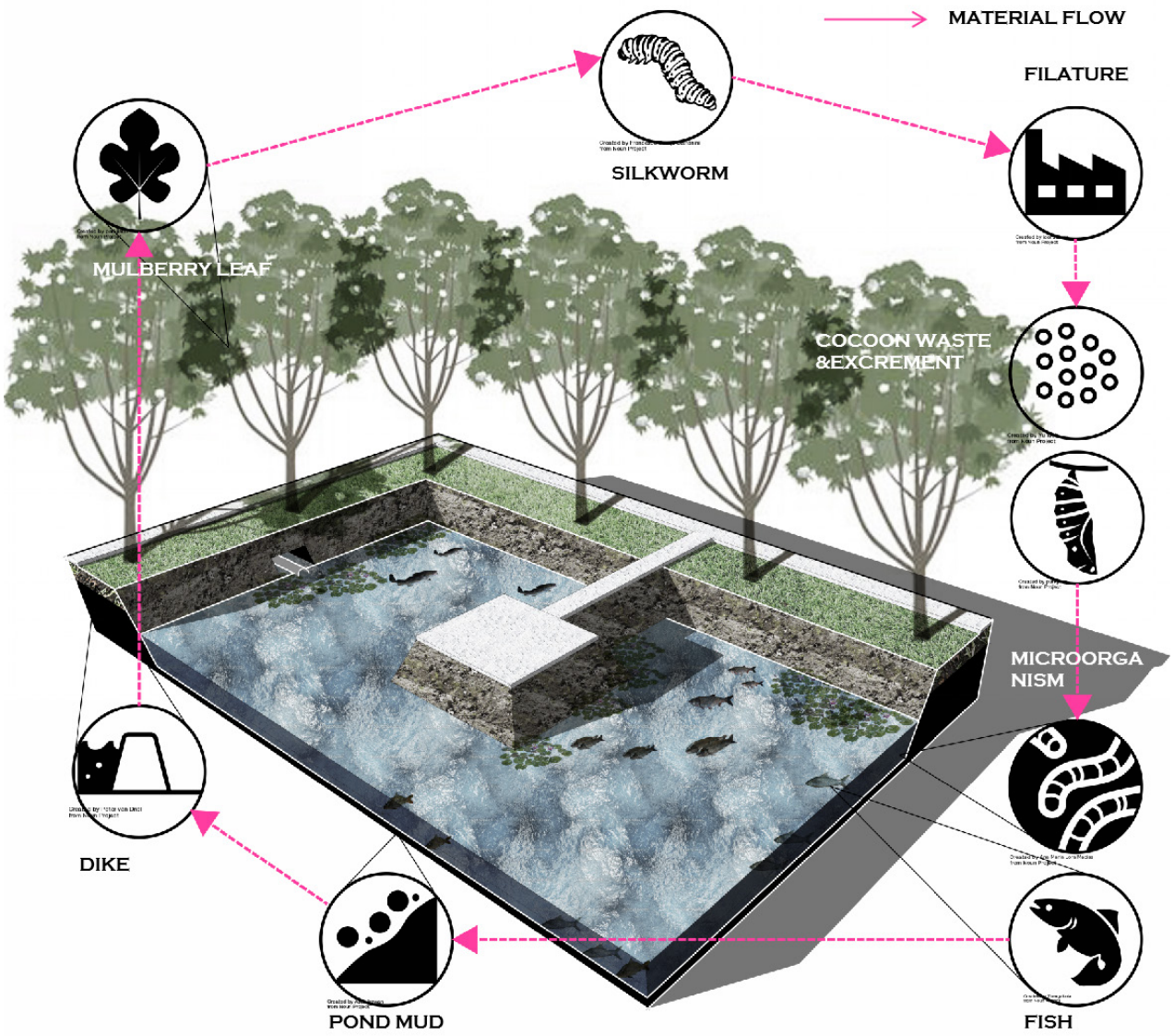
Agriculture/Aquaculture of the Warm Hot Plains. Map: Steffen



PRINCIPLE OF DYKE-FISHPOND

The dyke-pond system has been well-known as a self-sufficient and productive land use because of a closed energy and material circulation. It makes use of the soil dug from the pond to build its surrounding dike, on which mulberry was planted for harvesting leaf to feed the silkworm. After the rearing procedure, the left chrysalis along with leaf and silkworm excrement would be returned to feed the fish, which was proved a very good forage. The left forage and fish manure along with rich organic matter decomposed by microorganisms fall into the bottom of the pond as fertilizer. With the intervention of digging the organically enriched mud 2-3 times per year and putting it back onto the dike top, it offers nutrients to mulberry trees.

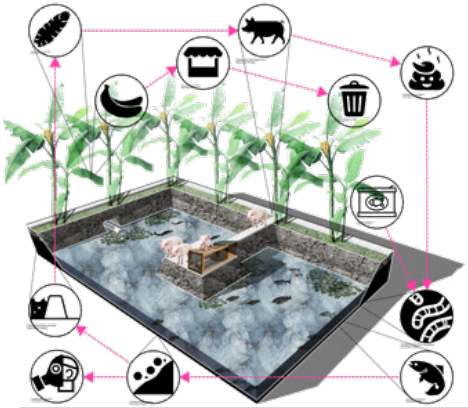
However, this integrated system wasn't developed until around 1350 AD (Wei Guo, 2016), when water-management method was grasped and dike construction already began in riparian area around the old estuary to reclaim the low tidal flat for agriculture. Because of its excellence of flood tolerance and high production, this land use was concentrated in Shunde district, one of the most flood prone lowland located between West River and North River. Later it sprawled all over PRD as a result of water-management system in this region while at the same time, became one of the most important parts of the integrated water-management system. Thus a glimpse of the history of its development and transformationwould help to understand how the functions and principles of it changed through time

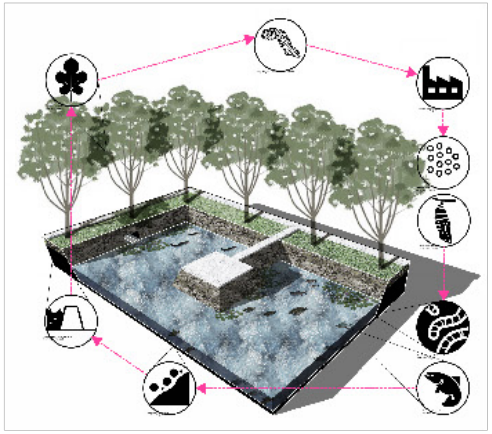


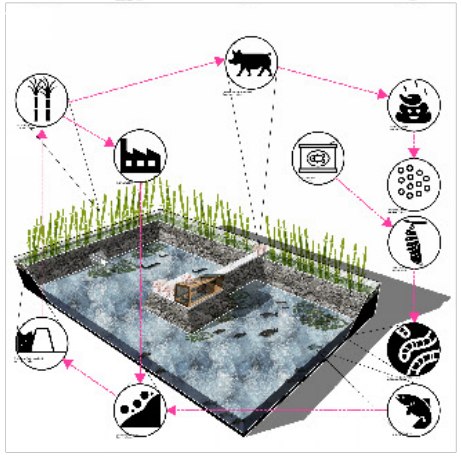
Material and energy flow of mulberry-fishpond

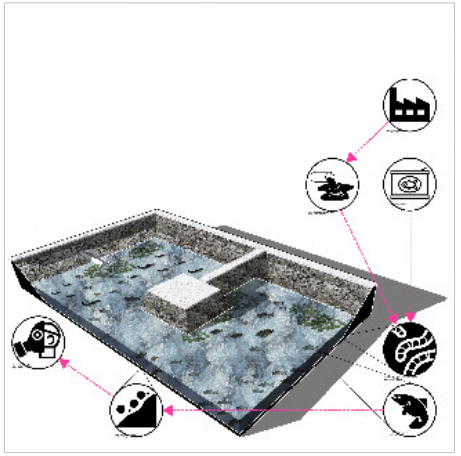
TRANSFORMATION AND TYPOLOGY

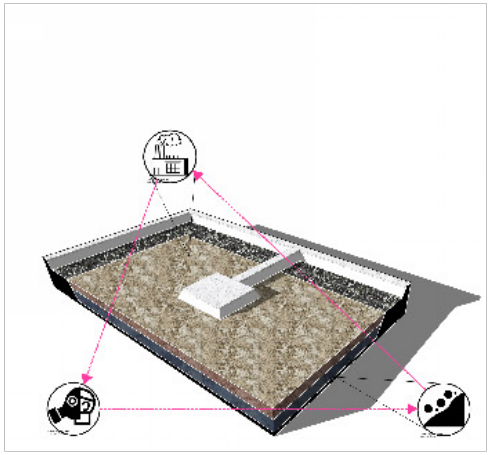
There are totally four types of dyke-fishpond with different combination of material and crops. Three of them are still an aqua-agriculture system with circulation principle with component change. However, this landuse recently has been changed from an integrated system to single system like fishpond for massive production and as basement for industrialization.



















HISTORY OF DYKE-FISHPOND DEVELOPMENT



1018

CAPTURE/COLLECTION

Because of the continual flooding and presence of acid sulphate soil village economies largely dependent on capture and collection from river, sea and the wetland.

1350

FISHERY/FRUIT CULTIVATION

In the middle of 14th century the water management measure was introduced. Dikes were built around Xi river using the mud dug in the pond, which provided opportunities for fish farming. Fruit cultivation was also conducted at higher land and also on the dike which had no relation with the fish pond.

1650

MULBERRY FISH POND

By the 1620s due to the experience of combining mulberry and fish pond, the integrated system was found bringing greater profit than the fruit trees on the dike. Moreover, the pond mud with silkworm excrement and other wastes were superior fertilizer for mulberry bushes. Farmers began to replace fruit trees with mulberry on the dike.

1750

PADDY TRANSFORMATION

In 1750s the Qing dynasty closed all ports except Guangzhou, which was a catalyst to the silk output from Pearl river delta. Later large scale of conversion from ricefields to mulberry fish ponds was witnessed since the economic income from integrated mulberry fish pond was much higher than rice growing.

1866

REVOLUTION PROMOTION

After the industrial revolution, the quility of silk production was highly increased due to application of large machine. In 1866, the first modern filature was built and this again prompted the booming of silk industry.

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1929

GREAT DEPRESSION

During great depression from 1929-1933, the silk market was also witnessed a decline because of the reduced purchase. Around 1000000 silk workers lost their jobs during that period. To find a replacement for the mulberry system, sugarcane species were introduced from Philippine.

1936

MULBERRY TRANSFORMATION

The transformation from mulberry to sugarcane fish pond was found successful and since the first sugar refinery was established in Shunde, wide adoption of this conversion was conducted. Besides, mixed vegetable production and other products.

1945

JAPANESE AGGRESSION

During the aggression of Japan, Chinese silk market was faced with the competition from Japanese raw silk and silk products, which caused a steep decline in price. At the same time the price of rice raised so high that local farmers abandoned the mulberry fish pond and the cultivation of rice and other food expanded.

1949

COMPOSITION TRANSFORMATION

Before 1949 the agriculture in Pearl river delta was mostly determined by the market demand while after that the ecological function of dike pond system was taken into consideration. The main focus converted to the exploration of spatial and temporal composition.

NOW

URBANIZATION

Urbanization was also witnessed in the old delta alluvial plain as a result of urban expansion and industrial migration. Lots of dike-pond system were transformed into land for urban construction, which caused a series of ecological problems such as flood and subsidence.

DECLINE OF DYKE-FISHPOND

The centralization,simplification and rationalization of dyke-fishpond has caused many problems like water purification because of the use of artificial forage and pollution from industry. In addition, without the crops on the dyke the fishpond soil becomes easy to be eroded so that the channelization of dyke-fishpond also took place which totally separated the agriculture from aquaculture. These single systems have caused lots of troubles when separating from an integrated system and the principle of historical dyke-fishpond is gradually changed once and for all.



Channelization



Construction



Deplanting



Eutrophication

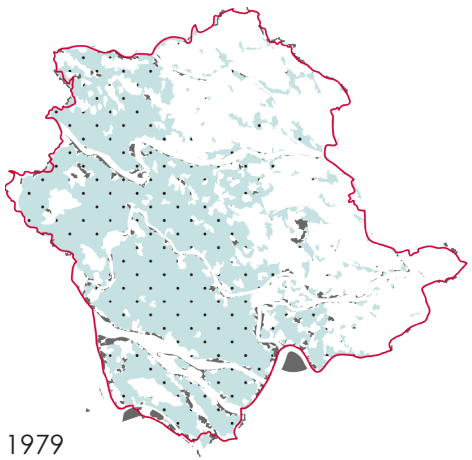


Pollution

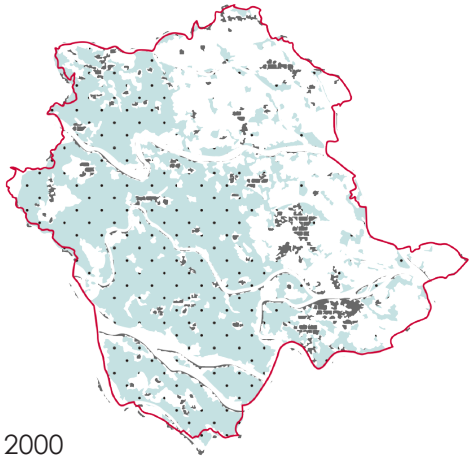


Rationalization

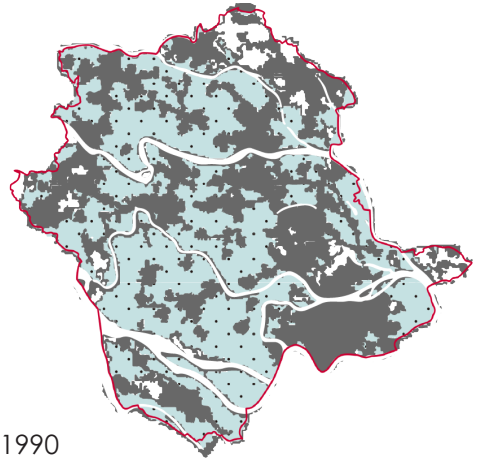
Proportion change of dyke-fishpond in Shunde district



1979



2000



1990

Reserach boundary
Dike fish pond
Urbanization

CONCLUSION

To conclude the principle learned in aqua-agriculture practice in Pearl River Delta. There are mainly two principles:

1. Multifunctional principle. The dyke-fishpond that has been used for hundreds of years after invention is a proof of combining flood defense with agriculture. When flood come to this region, this special landuse pattern helps to mitigate it by providing excessive water space. Thus the dyke-fishpond model provides us a best example of combining water management with agriculture production. In contrast, after the simplification and transformation of this landuse to massive fish production and industry, there are more problems and the integrated benefit does not exist anymore, which means the integrated system works much better than a single system.

2. Circularity principle. The mulberry dyke-fishpond is a typical combination of agriculture and aquaculture, which makes the most use of the by-product like mulberry leaf, fish manure and waste of silkworm. These different components of the dyke-fishpond, whatever how they changed later to sugarcane or banana, form a micro ecological system that has its own material and energy flow. This circularity principle is not only useful for agriculture but also for future urbanism and water clean. The similar case in Indonesia proves the fishpond could be used to clean the water and the study of America thinks the dyke-fishpond wetland could help to absorb carbon.

However, the modern transformation has proved that after abandoning these principles, this system would not work so well and lots of problems could be found.

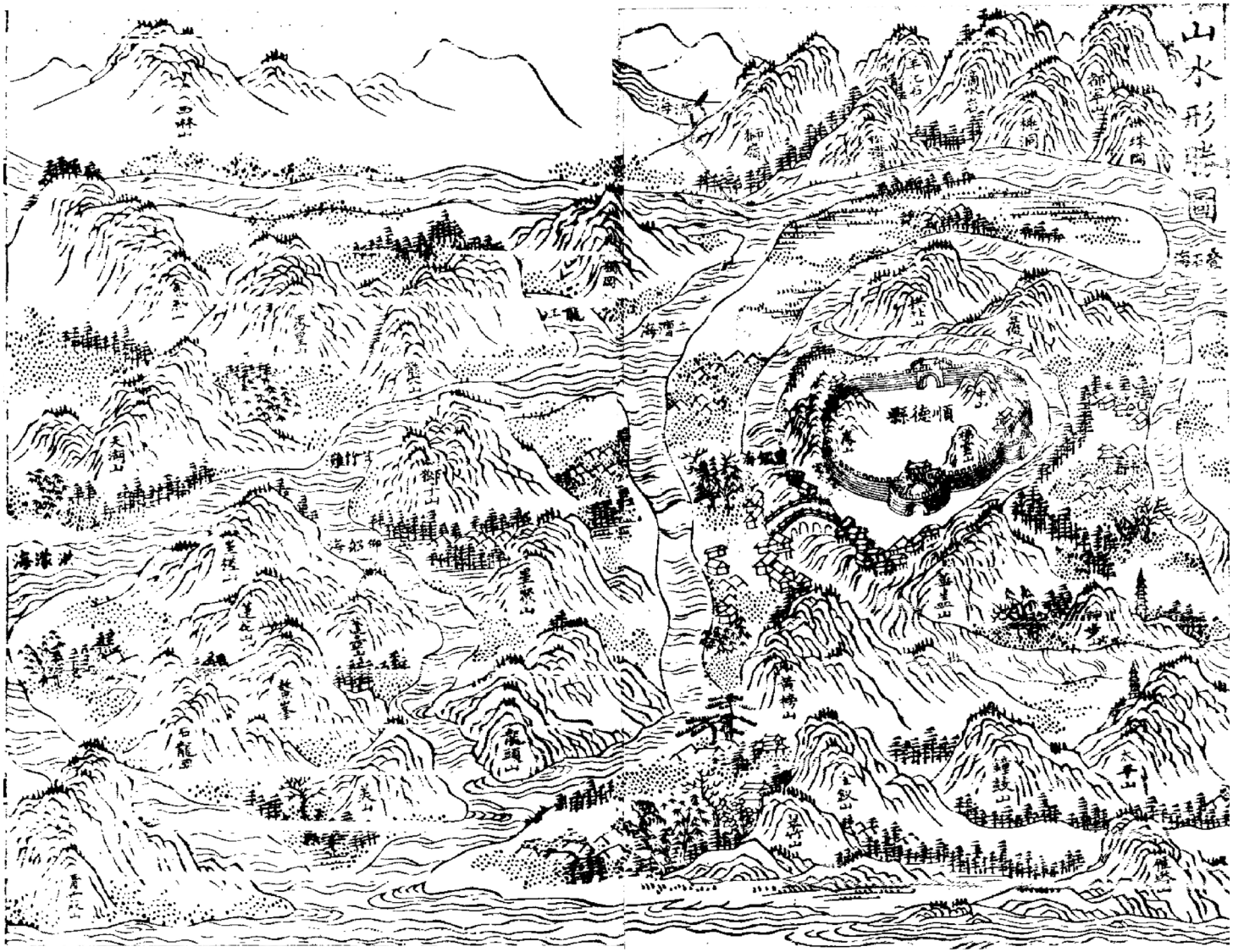
Besides the two principles learned in dyke-fishpond, one of the most important function is to mitigate the flood and it became one of the most important parts of the integrated water-management system. Thus it means a glimpse through the whole system is required to properly understand how this special agriculture pattern functions in the flood protection system.

MULTISCALAR WATER MANAGEMENT

The water management in PRD is a result of long-term development shown through multiscale. So to make a complete study of it, in this chapter the water management in different scales and the principles found would be explained.

I. Four scales of water management
II. Water management at regional scale
III. Water management at county(fort) scale
IV. Water management at village scale
V. Water management at building scale
VI. Conclusion

Ink painting of the landscape of Shunde district in Qing dynasty
source: Annals of Shunde County (順德县志)

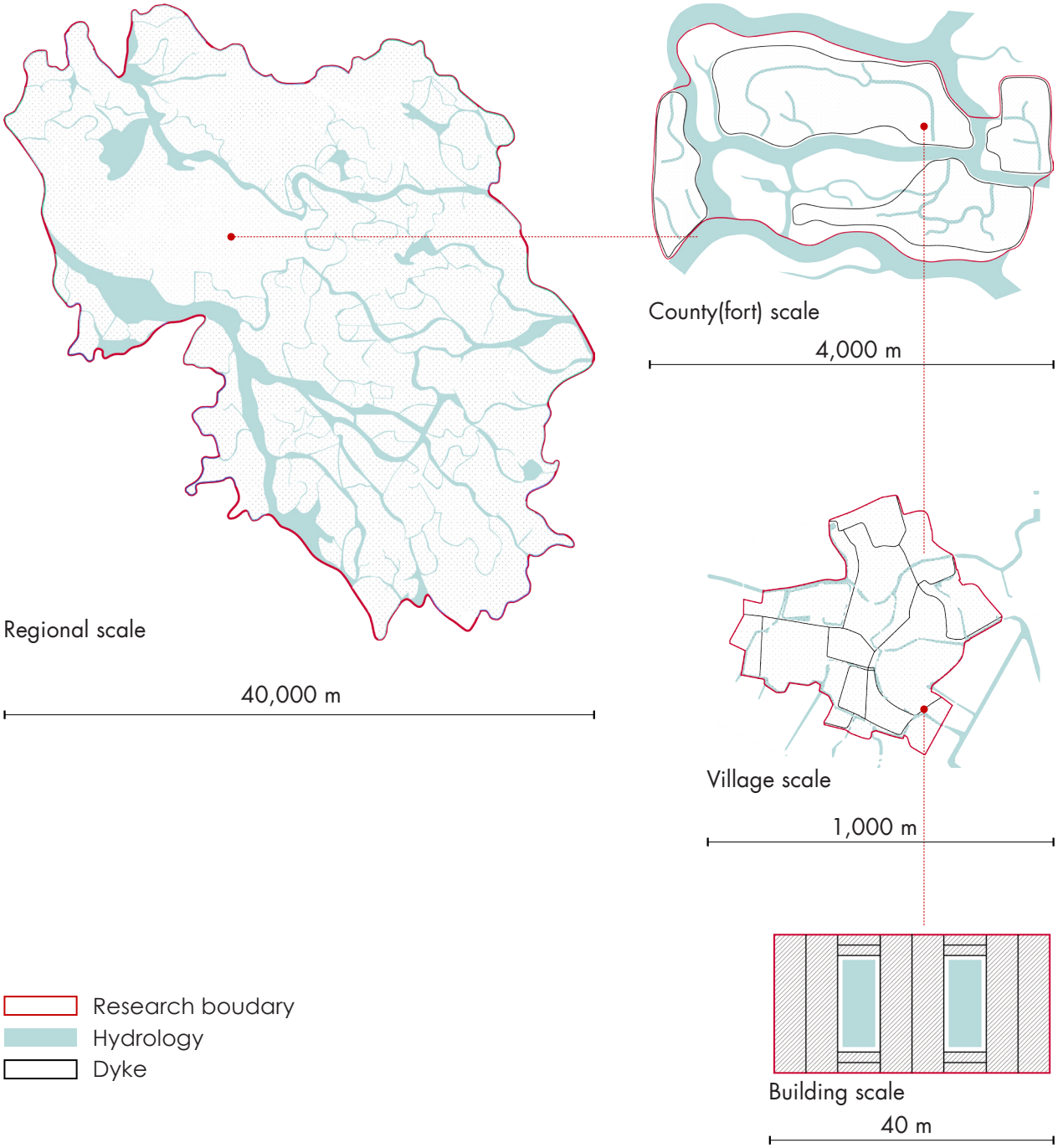


FOUR SCALES OF WATER MANAGEMENT

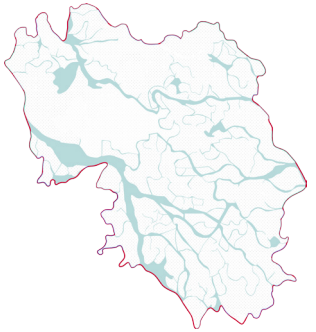
The ancient Pearl River Delta was first formed more than 6,000 years ago, when Shunde was still a vast ocean at that time. In Jin Dynasty, a large amount of the central part was gradually formed from the sedimentation. While in Song Dynasty, the diversion of the West River accelerated the speed of reclamation, forming Xingtan, Junan and other places in the southwest of Shunde (Zhiamin Zhang, 2016). In 1450, Qing dynasty Shunde county was established after a combat between rich farmer and poor fishermen who don't have farmland, which was a result of scarce field source and continuous reclamation.

To mitigate the situation and protect agriculture from flood, Shunde was established with principle of cooperative defense against it. As a result the administrative division was based on the purpose of cooperative water-management: Xiang-Du-County-Village which includes 40 counties and 297 villages. This classification system helped to build up a systematic water management by the joint force of people from different counties, villages and families to protect both the waterfront and the hinterland from flood. The historical water-management system contains interventions from 4 scales: Regional scale, County scale, Village & building scale.

These 4 scales have a strong relationship with each other and together they have been developed step by step to form an integral system functioning in Flood defense, Settlement establishment, Agriculture production and Social structure.Thus it's very important to understand different water-management principles and how they interrelate with each other throughout the scales.



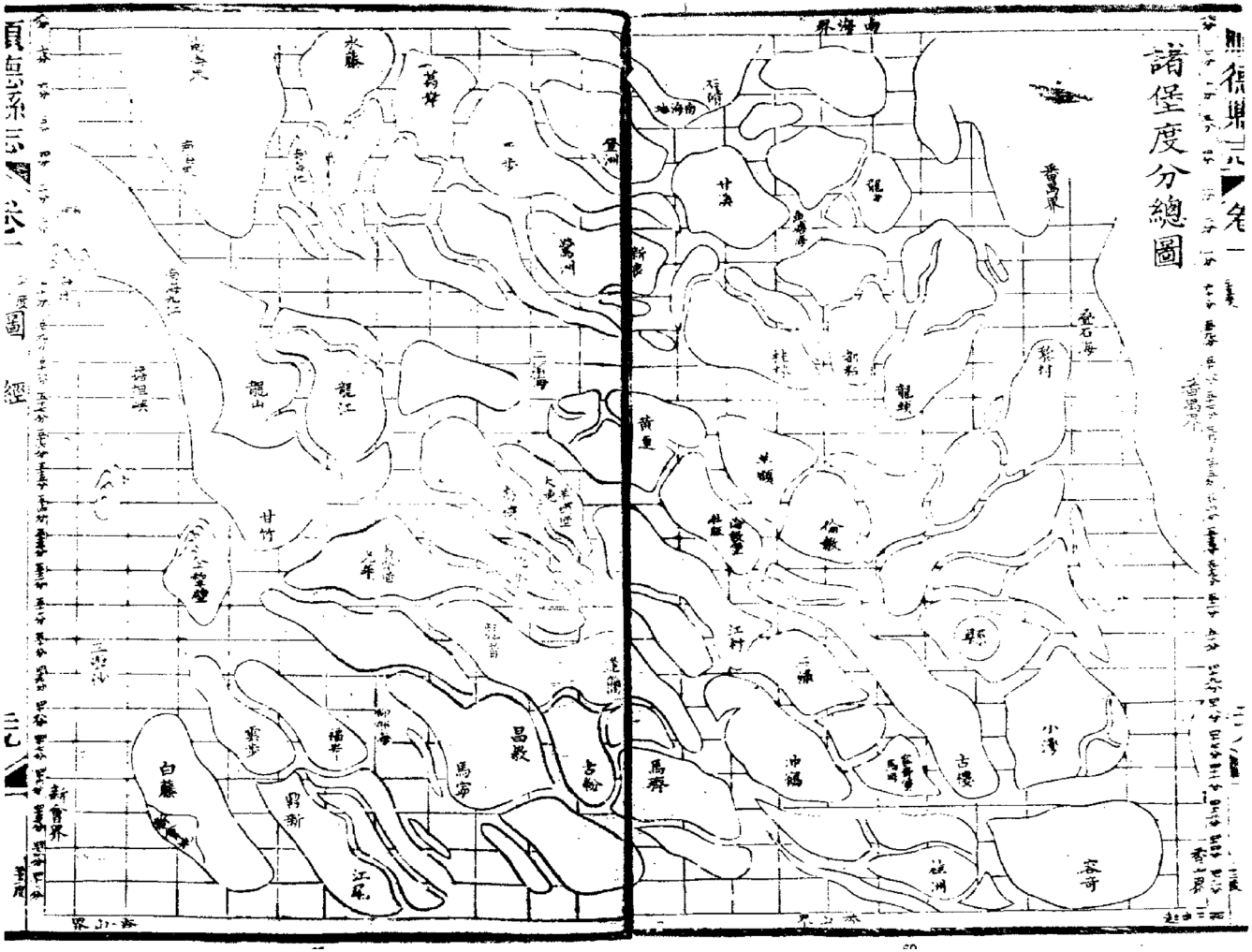
WATER MANAGEMENT AT REGIONAL SCALE



The regional scale includes 40 counties, which manage 297 villages. Each county has 20 to 50 percent of its boundary abutting either the West or the North river (Zhang, 2016), and each tries to balance profit with danger, i.e. balance production and transportation along the river while protecting from the danger of flooding. Flood has been a major threat in the Shunde district for centuries. Floods were recorded on average three times a year during the Ming and Qing dynasties (1368-1644 and 1644-1912 respectively), and this did not include the frequent small floods that happening nearly monthly during the monsoon season (usually April to September). Once invented, dike construction became one of the main measures against flooding. However, due to a lack of technique and human resource at the time, the building of large dikes required cooperation not only within a county or village, but also their joint efforts over a long time period.

Historical map of Shunde district

Source: Annals of Shunde County (順德县志)

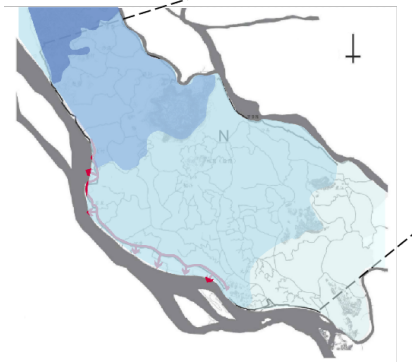


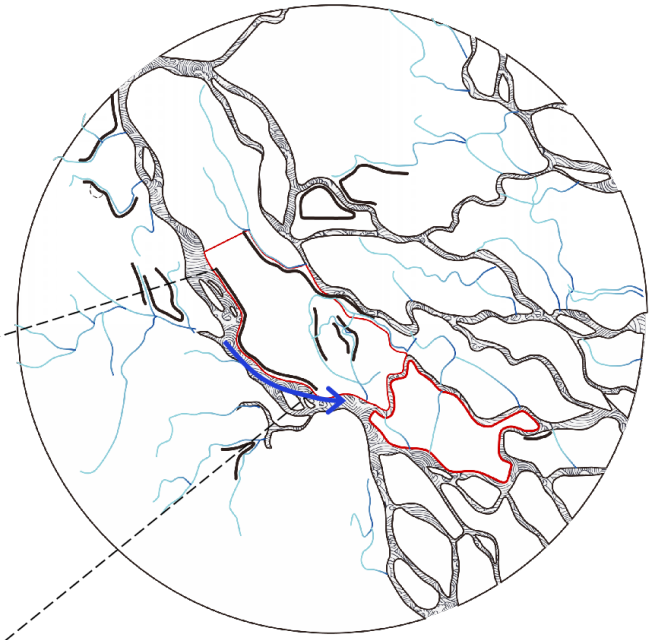
WATER MANAGEMENT IN SONG DYNASTY

Regional dike construction evolved several flood-defence principles, starting in the Song dynasty and continuing through the Qing. During the nearly three centuries of the Song dynasty, people built a large number of dikes (28 in total) along the banks of the West, North, and East rivers (Wu, 2012), particularly along the West river, where the Sangyuan dike was the largest at that time (Qi, 2016). The main function of the dike was to protect settlements from river floods using three main principles (Zhang, 2016):

1.Utilize natural topography (i.e. make it part of the dike to make use of height difference between upstream and downstream for drainage).
2.Keep enough distance from the river.
3.Build temples besides the dikes (for commemoration and as places of deliberation).

Sang Yuan Dyke Ring

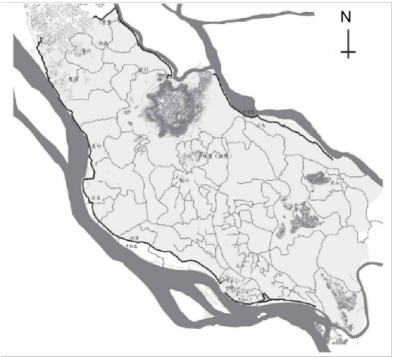


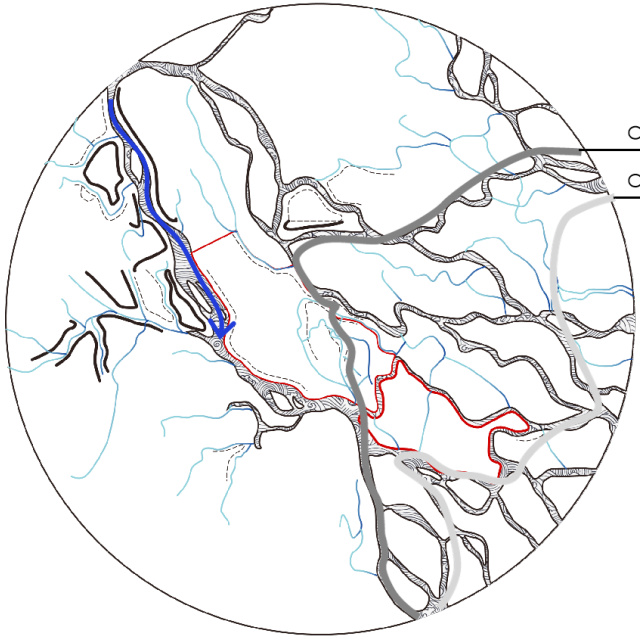


WATER MANAGEMENT IN YUAN DYNASTY

In the Yuan dynasty (1271-1368), old dikes had their heights raised and were reinforced, and new construction of dikes continued along the West river in 11 counties, resulting in 34 new dikes (Wu, 2012). At this time construction tended to focus on the upstream parts of the river due to the more serious floods caused by the extension and siltation of the estuary downstream. Construction techniques were also improved by using stone for the sluices and dikes.

Sang Yuan Dyke Ring





Coastline in Song
Coastline in Yuan

Reserach boundary
Internal river
Dike construction
Historical dike
Fort border
External river

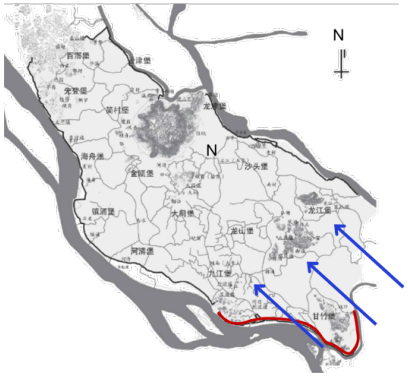
WATER MANAGEMENT IN MING DYNASTY

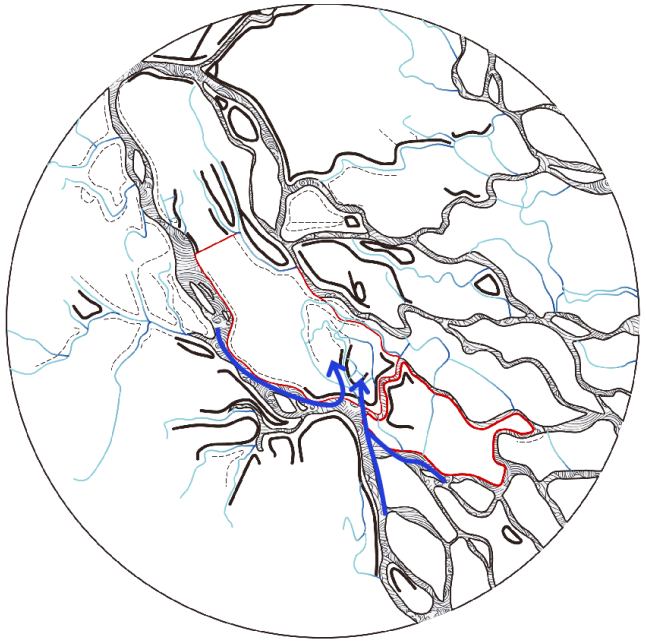
The flourishing of both population and economy during the Ming dynasty meant that this period saw the largest extent of dike construction and land reclamation. Population and economy were witnessing a prosperity which led to an increased demand for land, thus reclamation was widely carried out using dike construction to capture natural sediment. While in former dynasties the dikes were mainly linear, constructed on the west and east sides of islands to protect from river floods, during the Ming this was inverted because reclamation and siltation had caused tidal water infusion from the sea. Thus, the principle changed from open dike construction, to prevent river flooding, to a closed dike-ring system against sea flooding, for example, the Sangyuan dike was closed in the early Ming dynasty by adding dikes on its southeast (Zhang, 2016). However, this series of closed dike-ring constructions caused further flooding problems in the hinterland, especially during the monsoon season, when heavy rainfall could not be discharged effectively. It was at this time that the dike-pond system was invented as a special agricultural land use to mitigate this problem by providing capacity for extra excess water.

WATER MANAGEMENT IN QING DYNASTY

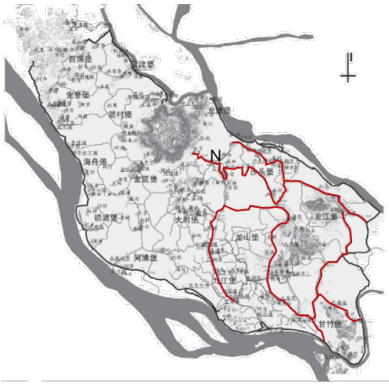
This dike-pond system, which appeared in the late Ming dynasty, prospered into the middle of Qing dynasty (Wu, 2012). The burgeoning of agriculture in this period encouraged more land reclamation downstream, which required more dike construction and connections. However, this caused more serious flooding from the river inside the large dike rings because there was less space for water. As a result, smaller dike rings were constructed inside the large ones to protect settlements from internal floods, which led to a nested loop-like layout. At the same time, to defend from floods from the external river, different dikes were connected to form large stronger and safer dike rings, and sluices were built in them to control drainage. Finally, the whole water-management system was formed into an infrastructure of large connected dike rings with smaller dike rings inside them.

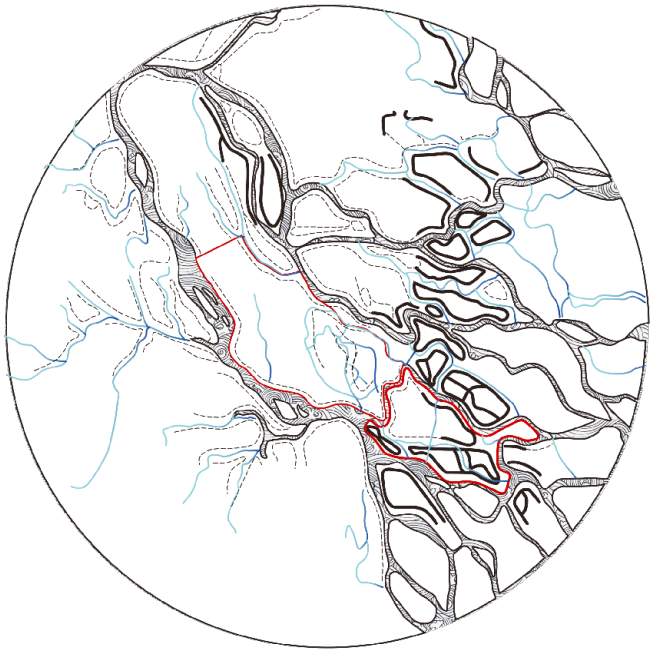
Sang Yuan Dyke Ring





Sang Yuan Dyke Ring





Reserach boundary
Internal river
Dike construction
Historical dike
Fort border
External river

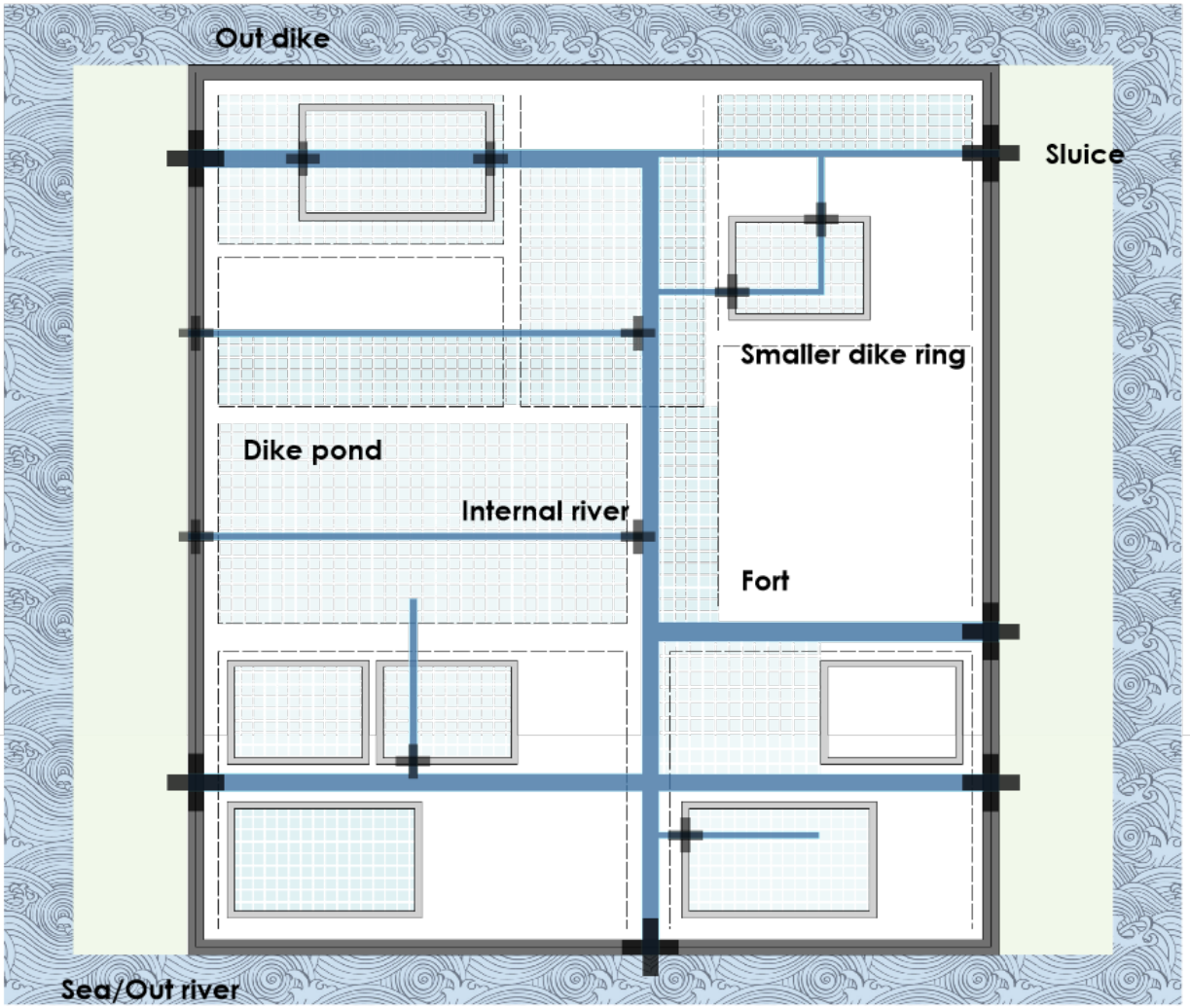
CONCLUSION AT REGIONAL SCALE

While reflecting on the long-term development of the regional water-management system, the following lessons for water-sensitive design can be learned:

1.Water management is a collaborative effort: flood defence can only be effective when different authorities and disciplines team up and jointly plan, design, and construct the water-management system from a regional perspective.

2.It is important to acknowledge that each water source (e.g. sea, river, and rain water) has its own temporal dynamic in the amount of water in each (e.g. changing levels of discharge throughout the seasons) and have specific requirements for water management.

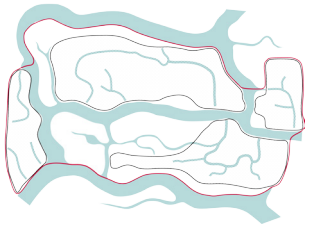
3.As a result of an incremental learning process in this region it was considered important to provide enough space for water and flood storage by incorporating natural water streams and water bodies, have a certain distance between dike and river, and utilize natural topography to build dikes and allocate and orient drainage/irrigation ditches and canals.



Regional water management scheme



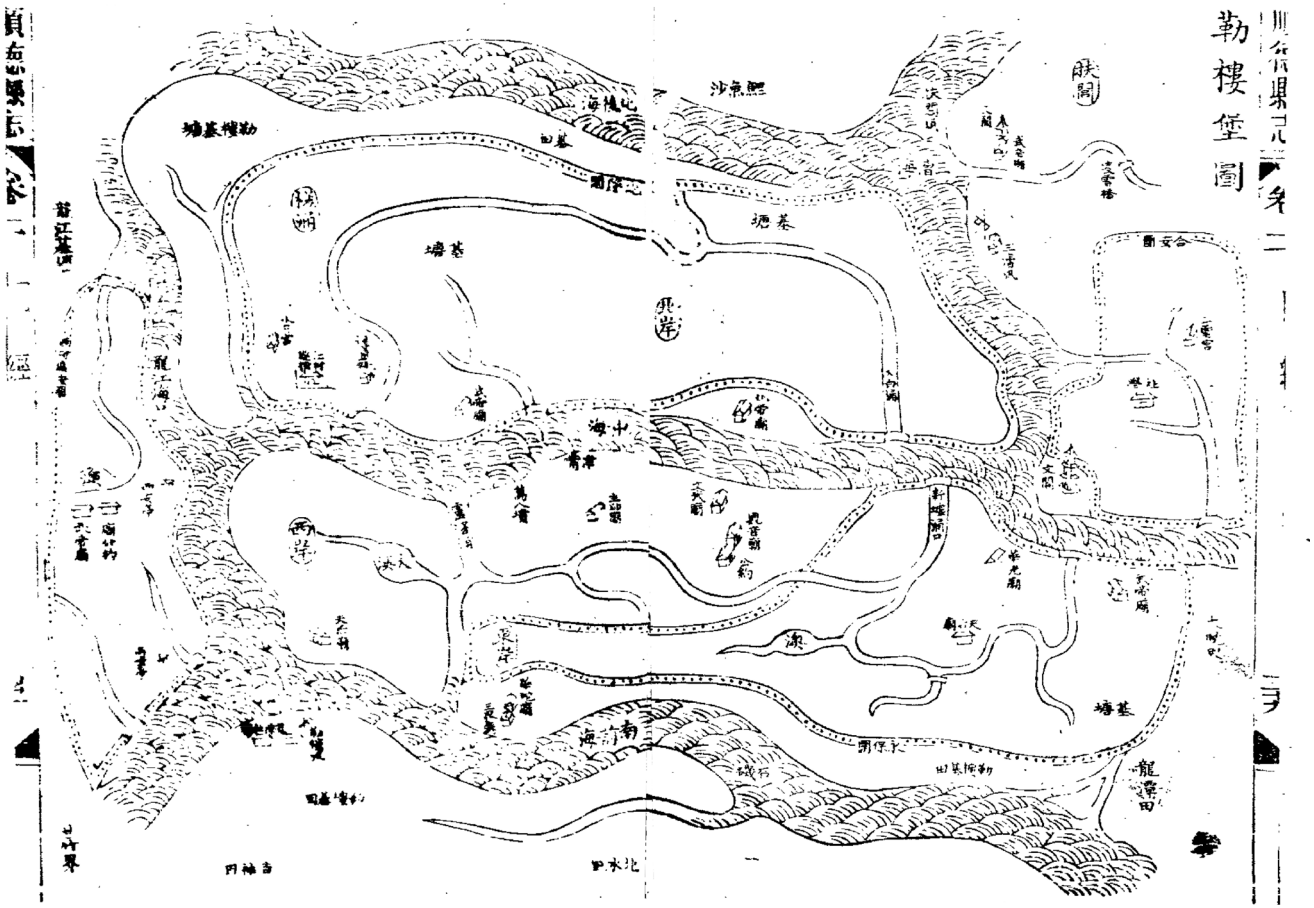
WATER MANAGEMENT AT COUNTY(FORT) SCALE



Water management at the county scale (also known as the Fort scale) interventions focus on regulating internal water. The name "Fort" for a county is used only in Shunde district and highlights a basic unit of division which is strongly related to defence from the two main enemies: flood and pirates (Liang, 2014). Water management inside a Fort consists of three main components in order to form an effective system: dikes, rivers, and connectors. These three elements were closely interrelated. The traditional division of the water management can be summarized as "external river, outer dike, internal river, bay, canal, ditch, drainage system" (Li, 2016).

Historical map of Leliu county

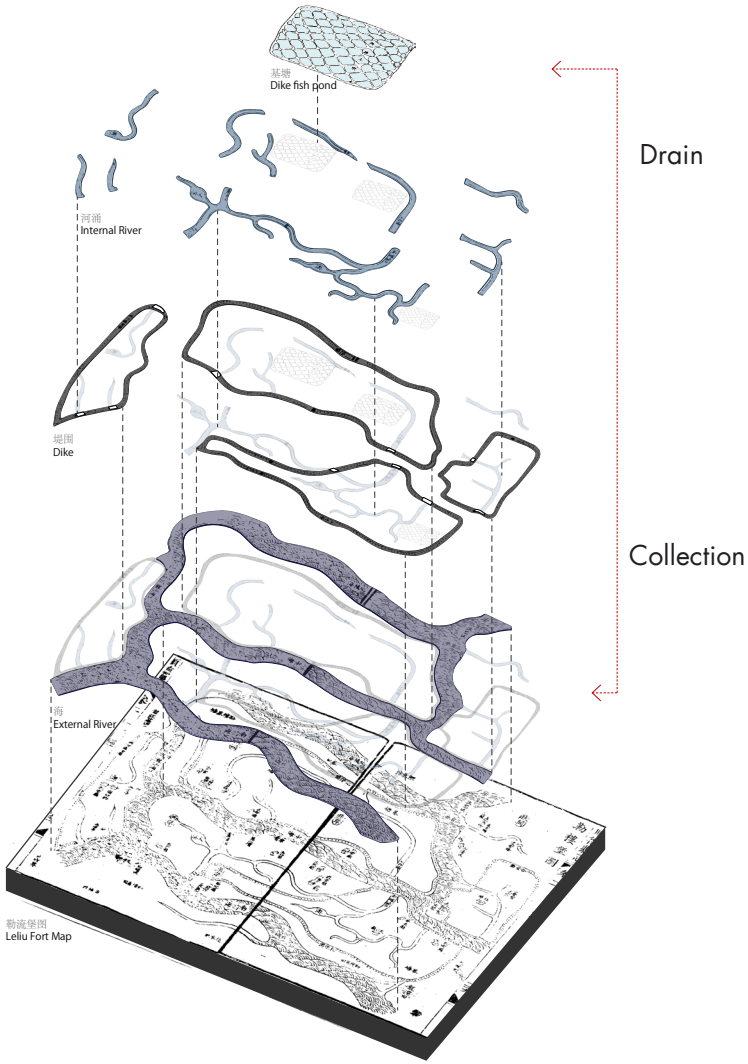
Source: Annals of Shunde County (順德县志)



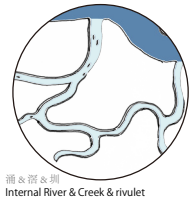
A SYSTEM OF DRAINAGE AND WATER COLLECTION

The water-management system at the Fort scale consists of drainage in the flood season and water storage in the dry season, which also works closely with the daily and monthly tidal change. For example, in the flood season, floods from the external river or the sea will be prevented by the large dikes constructed along the main river course, while the internal flood waters caused by heavy rain can be temporarily stored in internal rivers, canals, creeks, bays, and dike-ponds. During low tide, when the outer water table is lower, this water can be drained from the ponds through drainage holes into canals and thence to internal rivers, creeks, or rivulets. Finally, with the opening of sluices on the outer dikes, it can be drained into the outer rivers. In the dry season this system works conversely to store rain water, using it and river water for irrigation. With this double-sided and regular system, that could be adjusted at any time, the settlements and agriculture inside the Fort were able to deal with both flood and drought. As a result, this water system was not only capable of flood protection, but also of irrigation and transportation. It provided agriculture with water as well as rich sediment and convenient transportation.

Leliu county as a case



Different water and dyke element of county scale water management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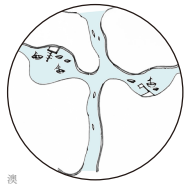
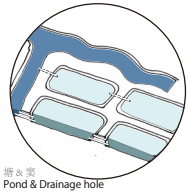
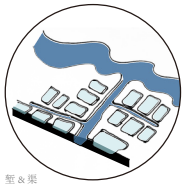
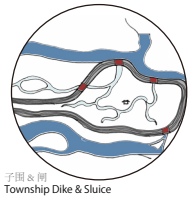
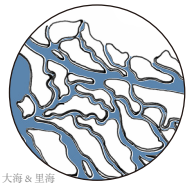
Internal River & Creek & rivulet

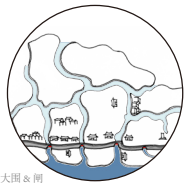

澳
Bay


塘 & 渠
Pond & Drainage hole


堑 & 渠
Canal & Ditch


子围 & 闸
Township Dike & Sluice


大海 & 里涌
External River & Tributary


大围 & 闸
Regional Dike & Sluice

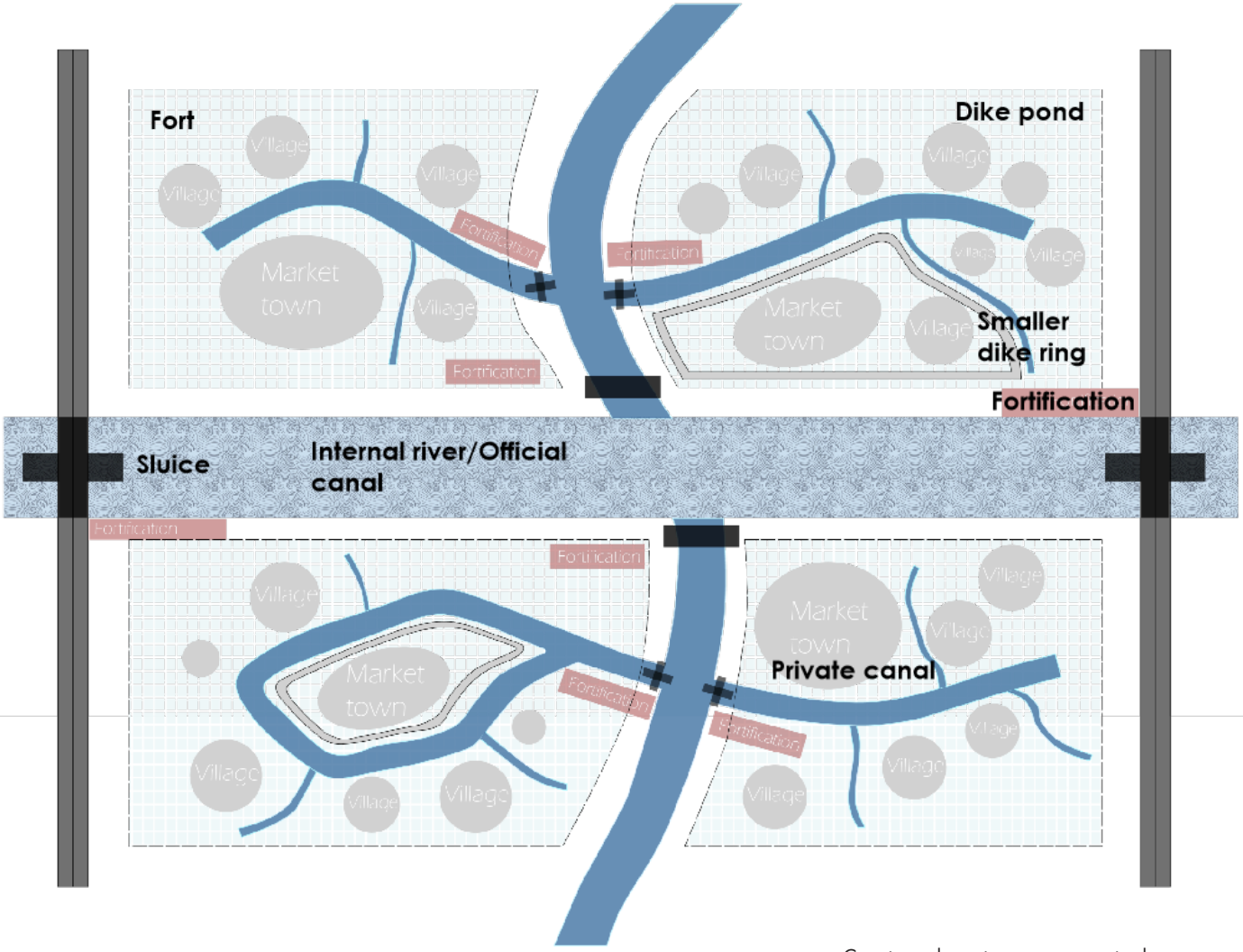
CONCLUSION AT COUNTY SCALE

Based on this understanding the following lessons can be learned for water-sensitive design:

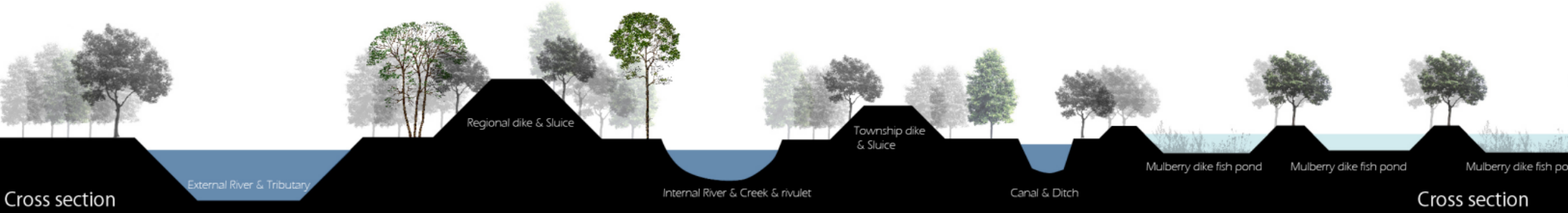
1.Buffering and storing water through a water network: water elements are connected and form a network that provides enough space for temporary storage of rain and river water for irrigation and drainage.

2.The hierarchy in the water network enables adaptive water management through dynamic control between different water bodies enabling the regulation of the water table at any time; the drainage holes, ditches, canals, and sluices all play key important roles in the whole system.

3.Water management requires an integral approach; the water system is multifunctional: flood defence, water storage, agriculture, and transportation are all considered integral to the system and provide conditions for the development of agricultural production, settlement development, as well as enhancing social communication.

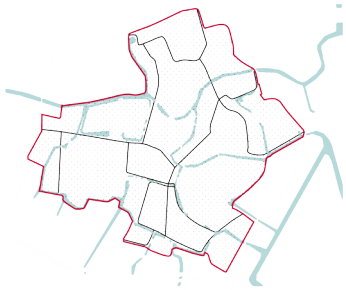


County scale water management scheme

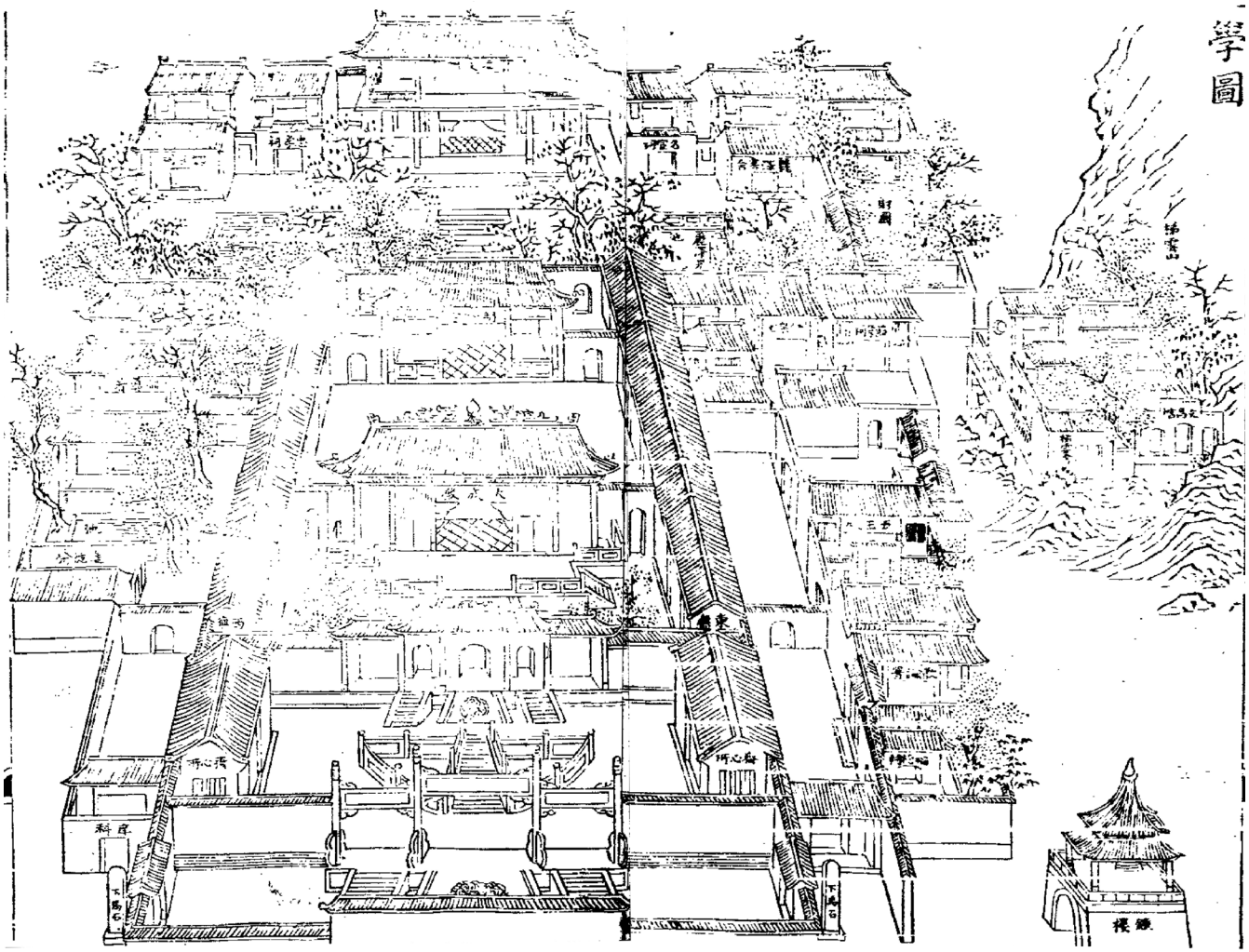


WATER MANAGEMENT AT VILLAGE SCALE

Besides the water-management system that protects the whole Fort from flood risk, the village also has its principles of site selection, layout, and building techniques related to flood protection. These principles not only help people reduce flood risk, but also form a special paradigm for living and interacting with water, and focus on aspects such as the layout of villages in different geographical conditions, methods of water storage and drainage, as well as social structure. First, two main village types are identified in this article, taking their names from their geographical conditions: the mountain village and the plain village.

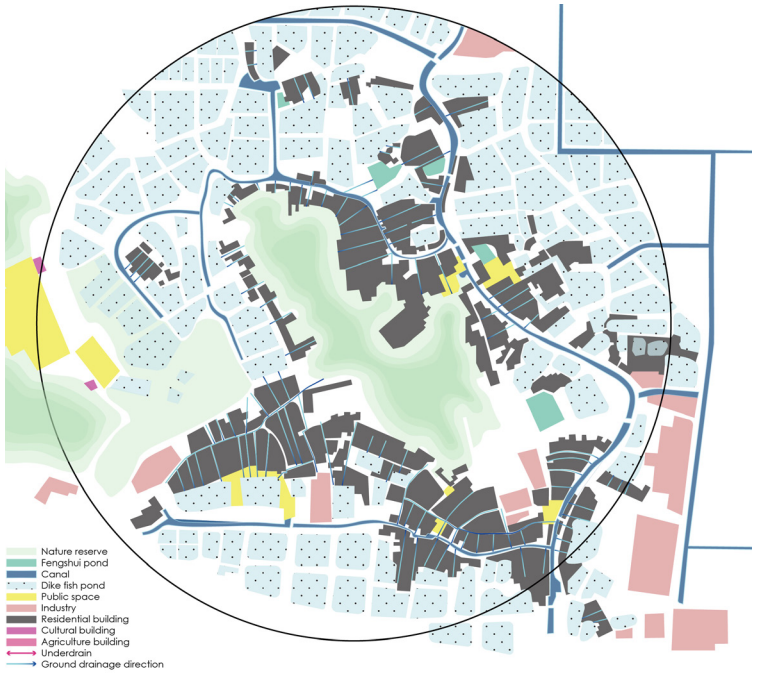


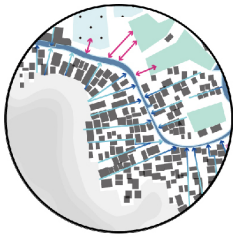
Ink painting of library in Shunde district
Source: Annals of Shunde County (順德县志)



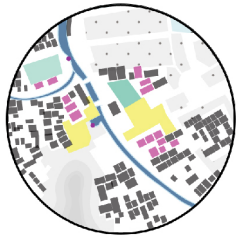
MOUNTAIN(MADONG) VILLAGE

The mountain village is usually arranged perpendicular to the contours of the terrain to make use of it for drainage and catchments . In addition, small alleys are reserved as drainage aisles between perpendicular rows of buildings, which are called “cold alleys” since they aid the circulation of cool air from the water body thanks to differences in air pressure. This principle results in what is known as a “tomb” layout (Yang, 2015) where a main drainage canal is connected to a number of perpendicular houses via the ditches in the alleys that help drain water quickly. Sometimes these drainage aisles are also linked to ponds in front of public buildings like temples, colleges, and schools. These are known as “fengshui” ponds. This type of pond is used not only for rain water collection but also symbolizes wealth and blessings. In addition, public spaces (e.g. small plazas) are arranged around these ponds, offering a place for assembly, communication, and traditional festivals. In that sense they have the multifunctional purpose of storing water and allowing for social connection. Besides the fengshui pond, dyke-fishponds are also found surrounding the mountain villages and are connected to canals or rivers via drainage holes. The water inside these ponds can be easily drained into the canals or rivers through the lower drainage hole and, conversely, water can also be poured into the ponds via an upper





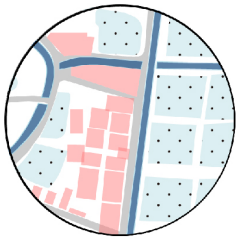
Layout & Drainage



Public space & Cultural building



Agriculture



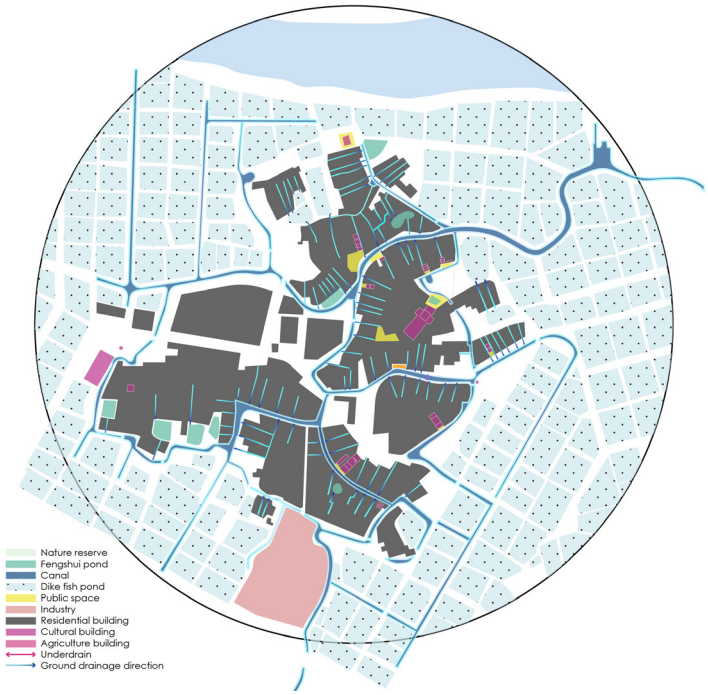
Industry & Infrastructure

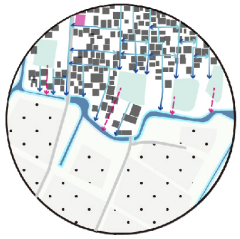


Cross section

PLAIN(FENGJIAN) VILLAGE

drainage hole. Cottages for agricultural production, as well as dwelling, are located on pond dikes which offer convenience for irrigation, fertilization, and harvesting. The canals in the village are always channelized and regarded as an important framework for transportation, social communication, and flood prevention as can be seen by the markets, ports, and temples surrounding them.





Layout & Drainage



Public space & Cultural building



Agriculture



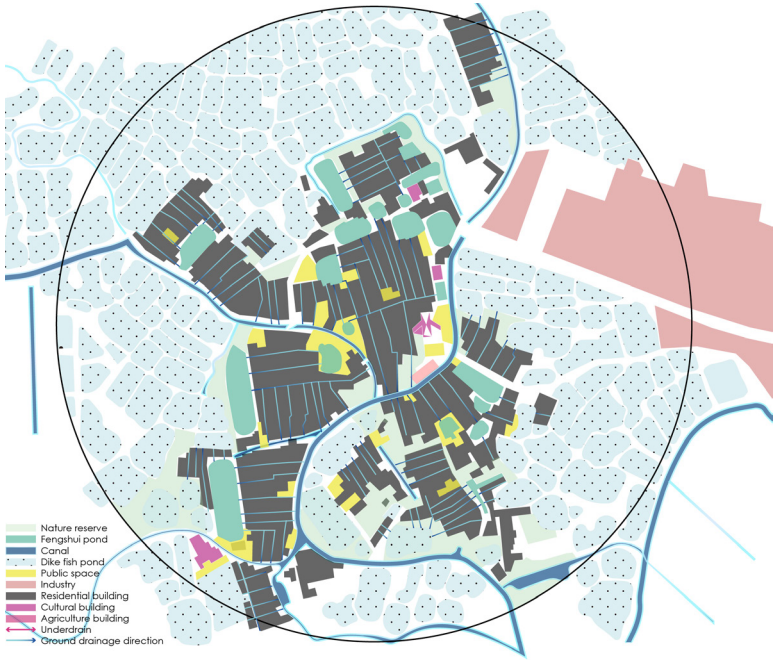
Industry & Infrastructure

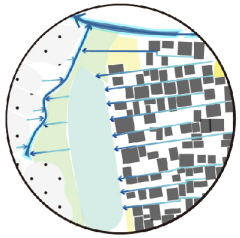


Cross section

PLAIN(FENGJIAN) VILLAGE

The plain villages also follow these principles regarding layout, drainage, and social structure. However, there are two crucial differences with the mountain village: first, the water network is usually denser and sometimes a canal was excavated around the village boundary to protect against flooding and pirates; second, there are more fengshui ponds and dike-fishponds inside the plain villages for the collecting of excess water (in mountain villages, dike-fishponds are usually separated from the settlements)

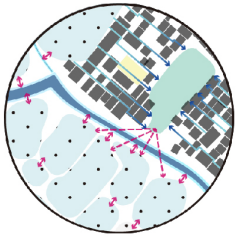




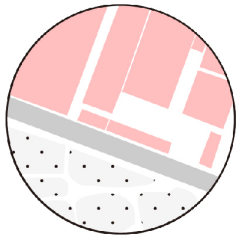
Layout & Drainage



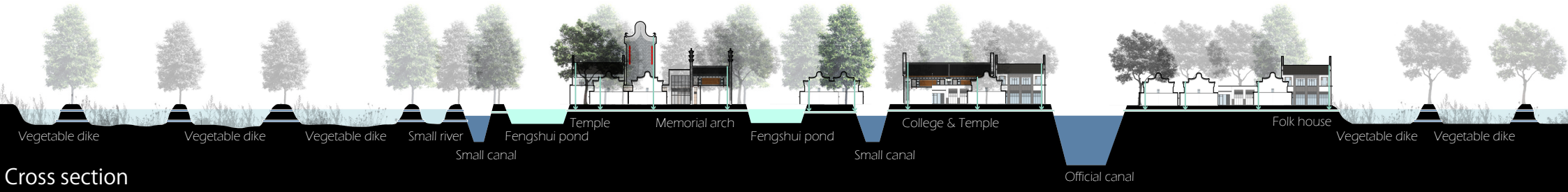
Public space & Cultural building



Agriculture



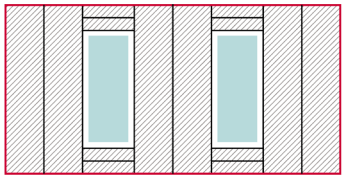
Industry & Infrastructure



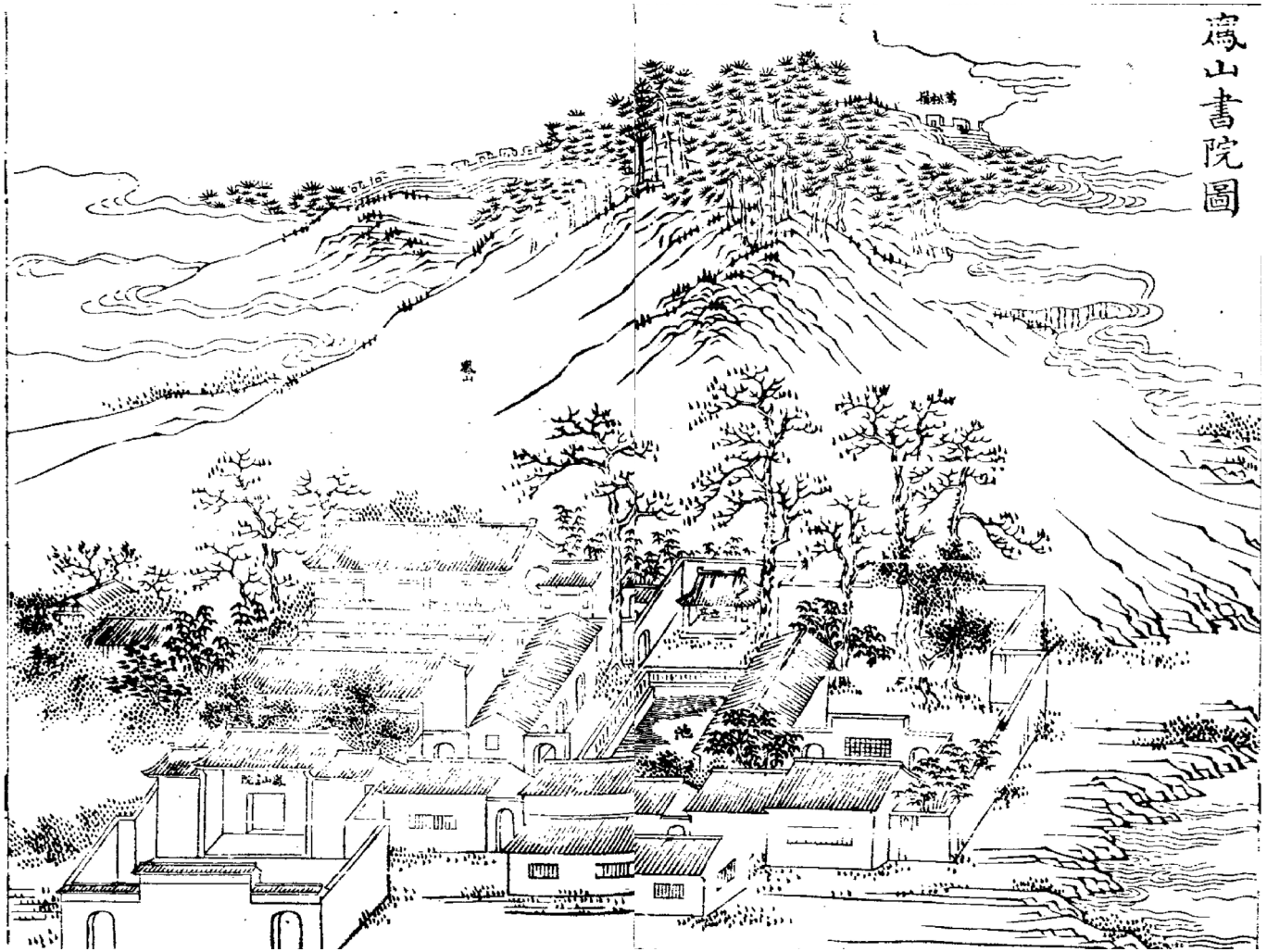
Cross section

WATER MANAGEMENT AT BUILDING SCALE

Temples, folk houses, and cottages are three of the typical building types that play a significant role in the integral water management of the region. Though they have different functions, they share principles of water drainage and storage.



Ink painting of Ningshan library Shunde district
Source: Annals of Shunde County (順德县志)



FOLK HOUSE

Folk houses usually have a smaller courtyard with a water tank in the middle to collect rain water for daily use (Figure 11). Skylights made of mica can be opened or closed to let in sunlight or keep out rain. A drainage ditch is usually laid out between the buildings to collect water and deliver it to a larger ditch or canal.



Mica



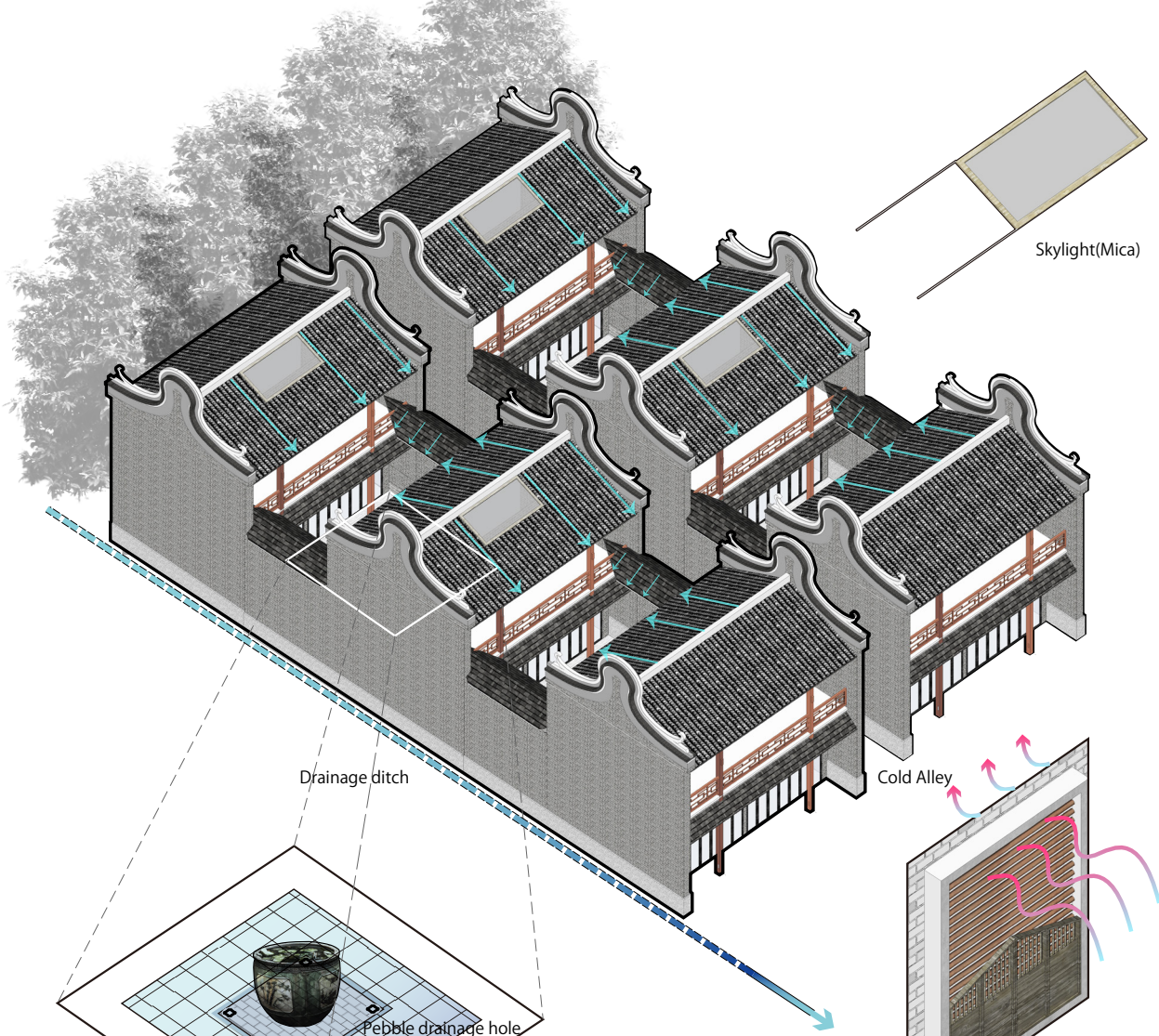
Glazed Tile

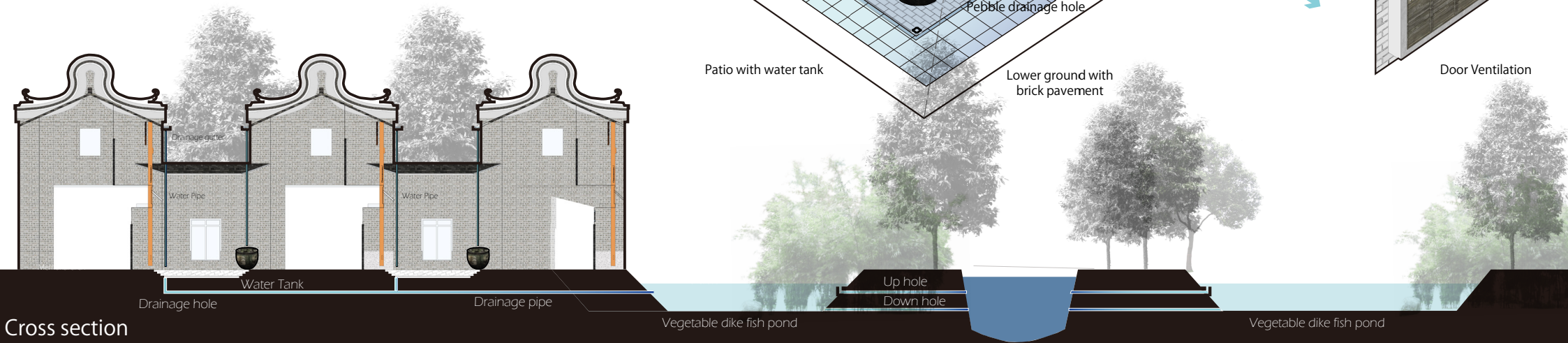


Blue Brick



Pebble





Cross section

TEMPLE

Temples are usually located besides canals or behind fengshui ponds. This helps the rain water that runs off the building to be easily drained into the canal or stored in fengshui pond for daily irrigation use. The inner court serves as a water buffer zone, with a lower-level surface to collect rainwater that drops into it from the roof (which is covered in glazed ceramic tiles).



Oyster shell



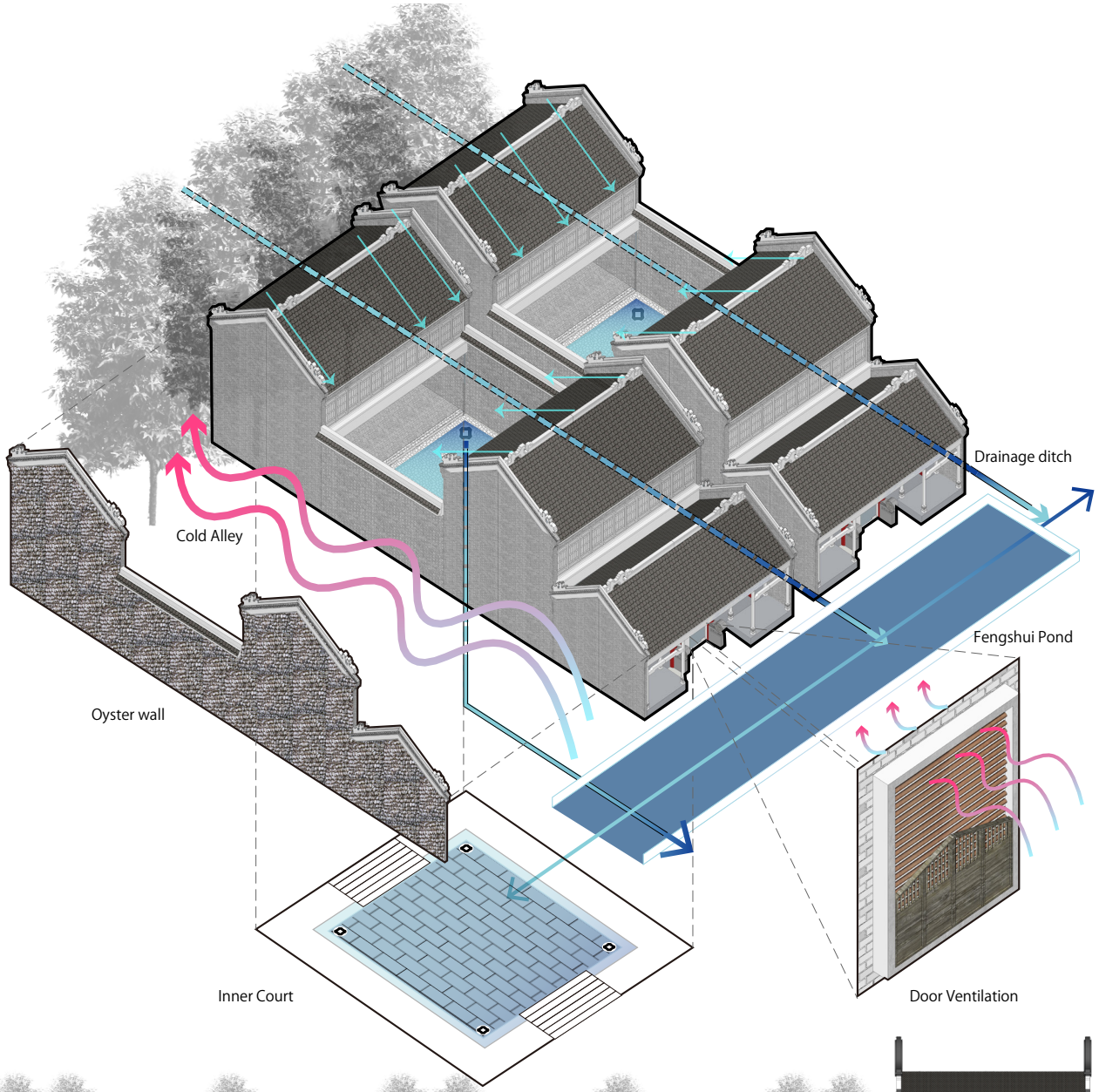
Blue Brick

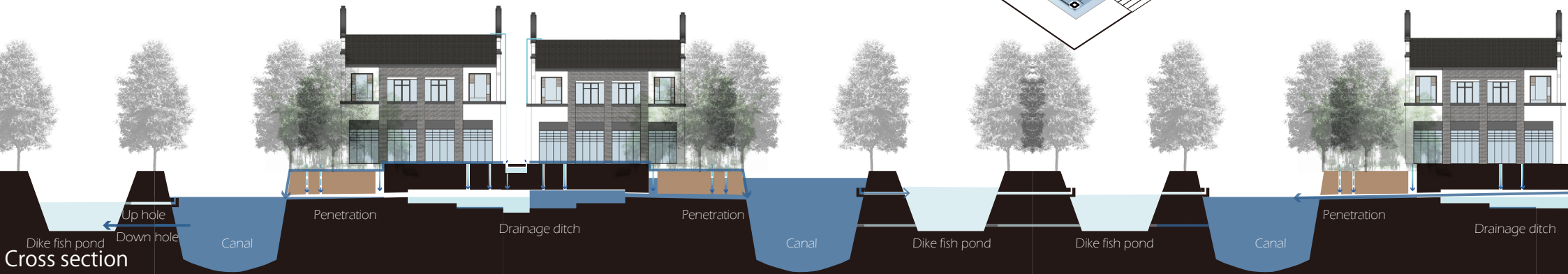


Pebble



Glazed brick





Cross section

COTTAGE

Cottages are typically buildings used for activities related to agricultural production and are usually built besides the dike-ponds and canals to prioritize transportation. Their building materials are also taken from the crops grown on the dikes, like the branches of mulberry tree or rice husks. In addition, the rainwater from the roof and domestic sewage can be drained directly into ponds for irrigation and fertilization.



Chinese fir



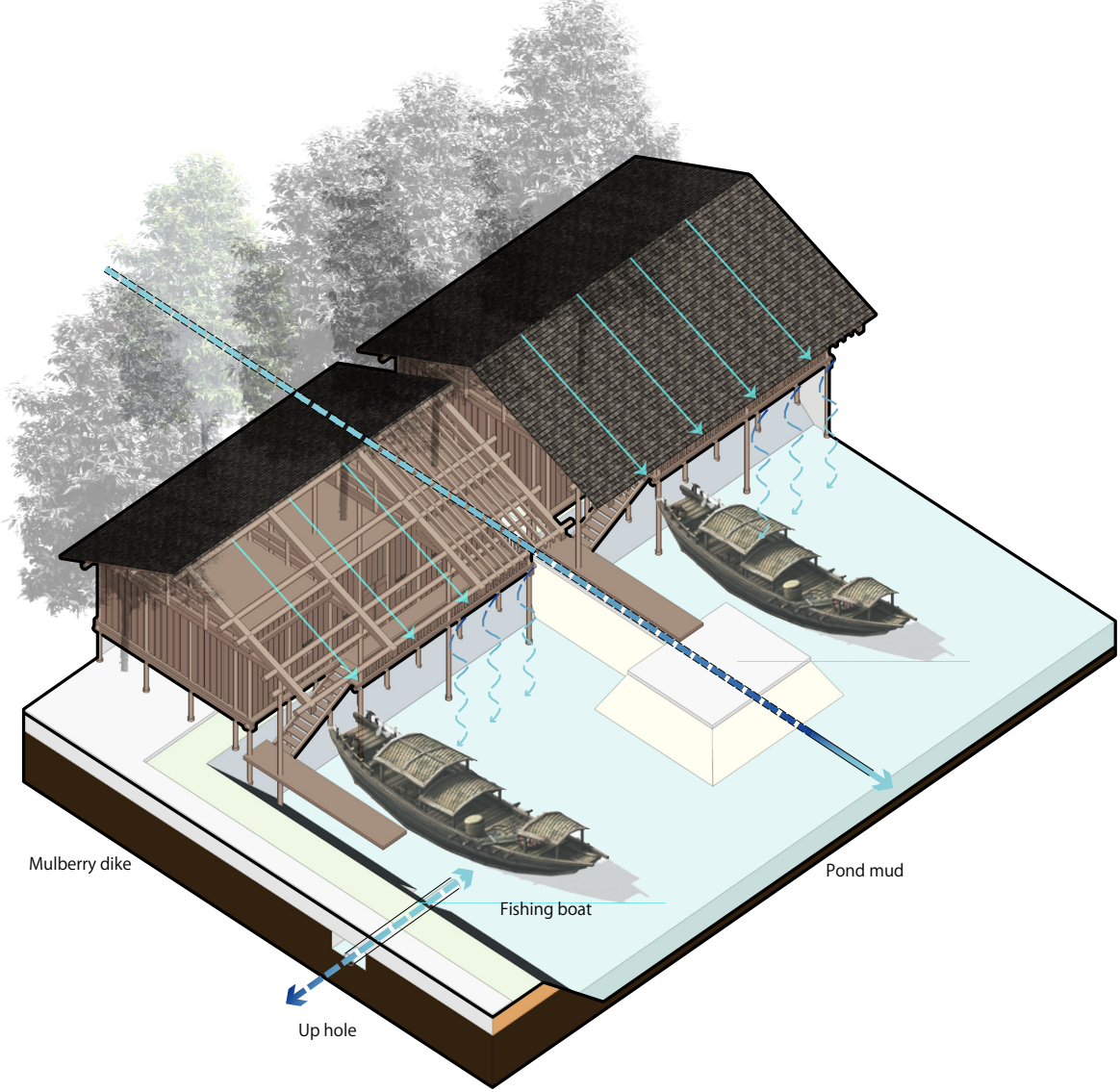
Rice husk



Mulberry tree branch



Pine bark





Cross section

CONCLUSION

PRINCIPLES OF VILLAGE SCALE

Based on this information the following lessons can be derived from the village scale:

1.Terrain-sensitive organization and development of settlements, where the natural terrain serves as the basis for the allocation and layout of the built environment, including drainage, water storage, and agriculture.

2.Public buildings and public spaces are related to the main water bodies, e.g. canals or fengshui ponds, which stimulate social interaction

PRINCIPLES OF BUILDING SCALE

Lessons for water-sensitive design at the building level:

1.Allocation, orientation, layout, and materialization of buildings are based on a deep understanding of climate patterns (precipitation/evaporation, wind, and temperature) as well as water management to provide for cooling effects and fresh water supply via water storage in many different forms, ranging from cisterns, pools in courtyards, or to materials that absorb water.

2.Water is part of a circular, self-sufficient system (e.g. drinking water, cooling water, sewage treatment, symbolic/religious water, etc.).

Ink painting of Tiyun library Shunde district
Source: Annals of Shunde County (順德县志)



MODERN INTERVENTION

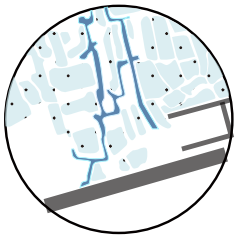
Although the historical method was applied for a long time during which this region witnessed a prosperity and fast development, the quick urbanization and construction brought threat to these traditional systems. In this chapter, the following themes would be discussed by analysis of:

I.Modern urbanization
II.Modern industry and infrastructure
III.Rationalization
IV.Conclusion



URBANIZATION

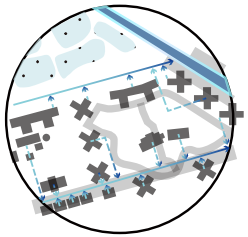
The modern urbanization has taken rid of the current dyke-fishpond pattern and build highrise or housing that has no connection with the historical water system. Instead, a large water supply system and drainage system needs to be built in order to offer good water source and water safety.



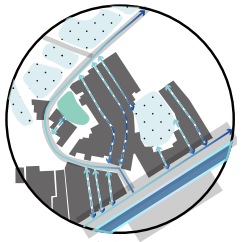
Agriculture Pattern in 2005



Urbanization Pattern in 2019



Layout & Drainage in Town



Layout & Drainage in Village

Modern problems

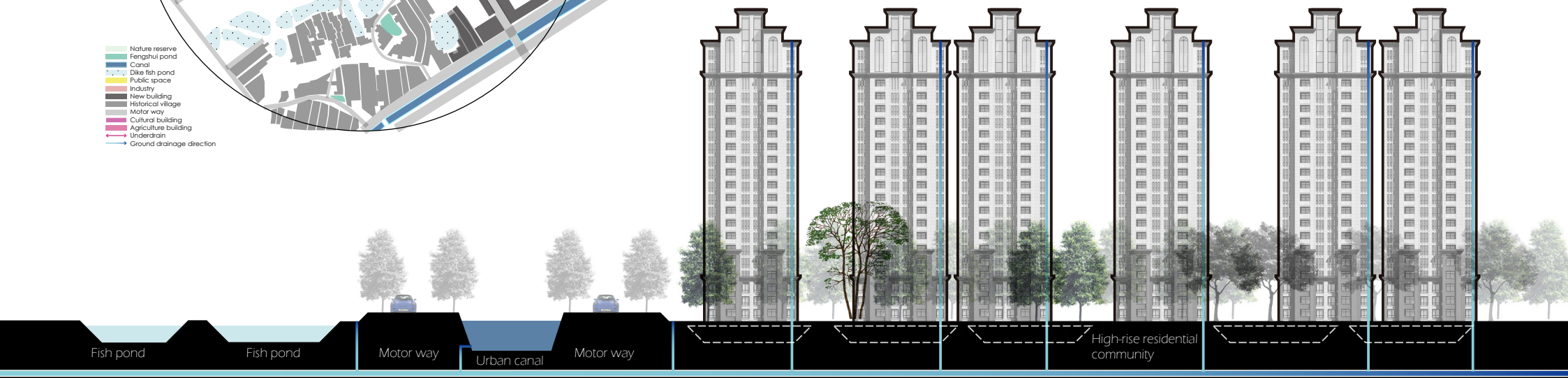












Cross section

INDUSTRIALIZATION

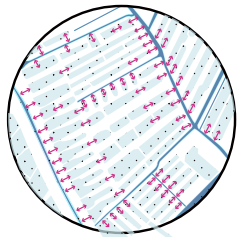
The industrialization has been happening around 30 years ago in large part of Pearl River Delta for economic growth. huge water infrastructure like dyke ring were also built to guarantee its safety. However, the pollution caused more trouble to a segregated water system that has no dynamics and self-cleaning ability. In addition, these infrastructure also separated the residents from the river and caused contradiction between human and the nature.



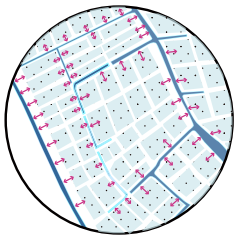
Agriculture Pattern in 2005



Industrialization Pattern in 2019



Agriculture Pattern &Drainage before rationalization



Agriculture Pattern &Drainage before rationalization

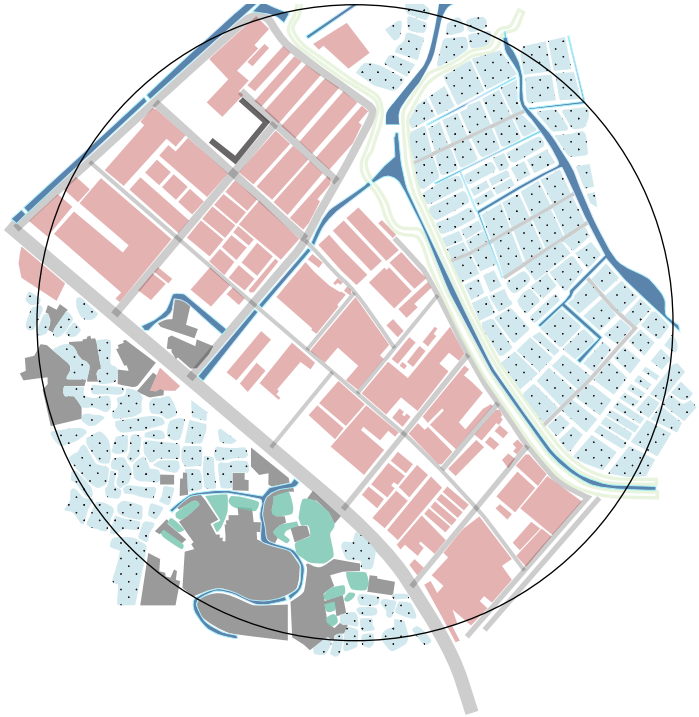
Modern problems

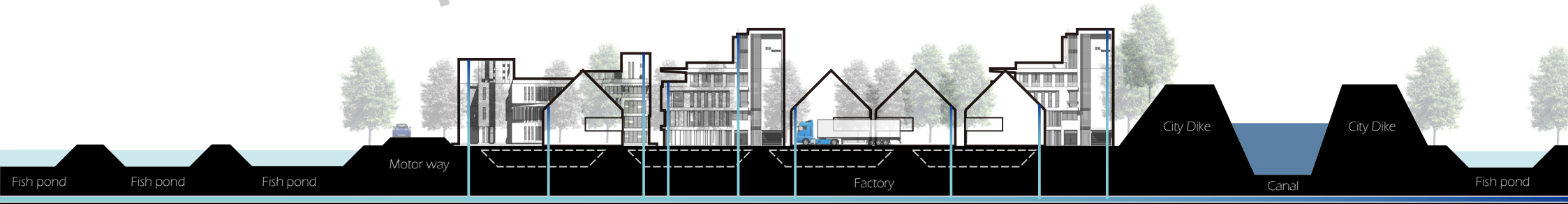












Cross section

Urban sewage&drainage network

RATIONALIZATION

The rationalization has replaced the organic pattern of agriculture with a grid pattern that is more convenient towards transportation, electricity and mass production. However, by channalizing the dyke-fishponds and using artificial forage, lots of pollution was created every year in these ponds that lead to more problems than benefit.



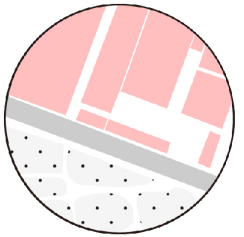
Layout & Drainage



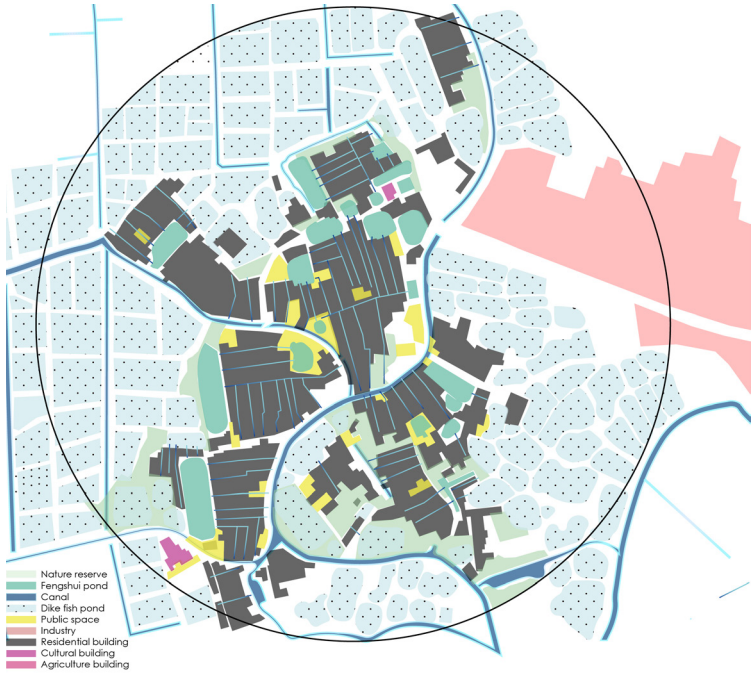
Public space & Cultural building



Agriculture



Industry & Infrastructure



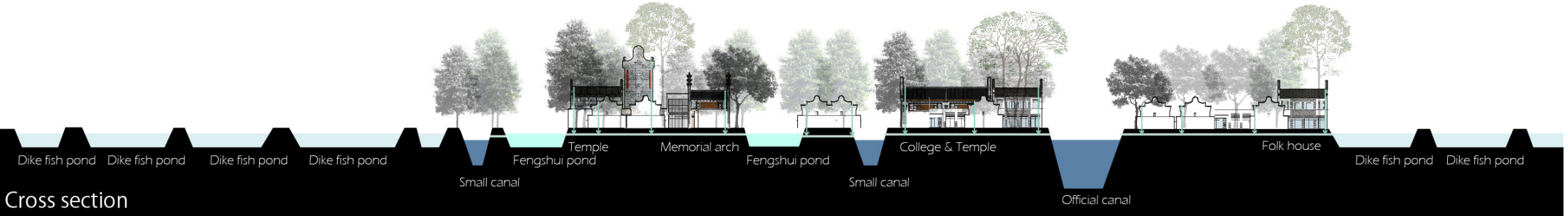
Modern problems











Cross section

CONCLUSION

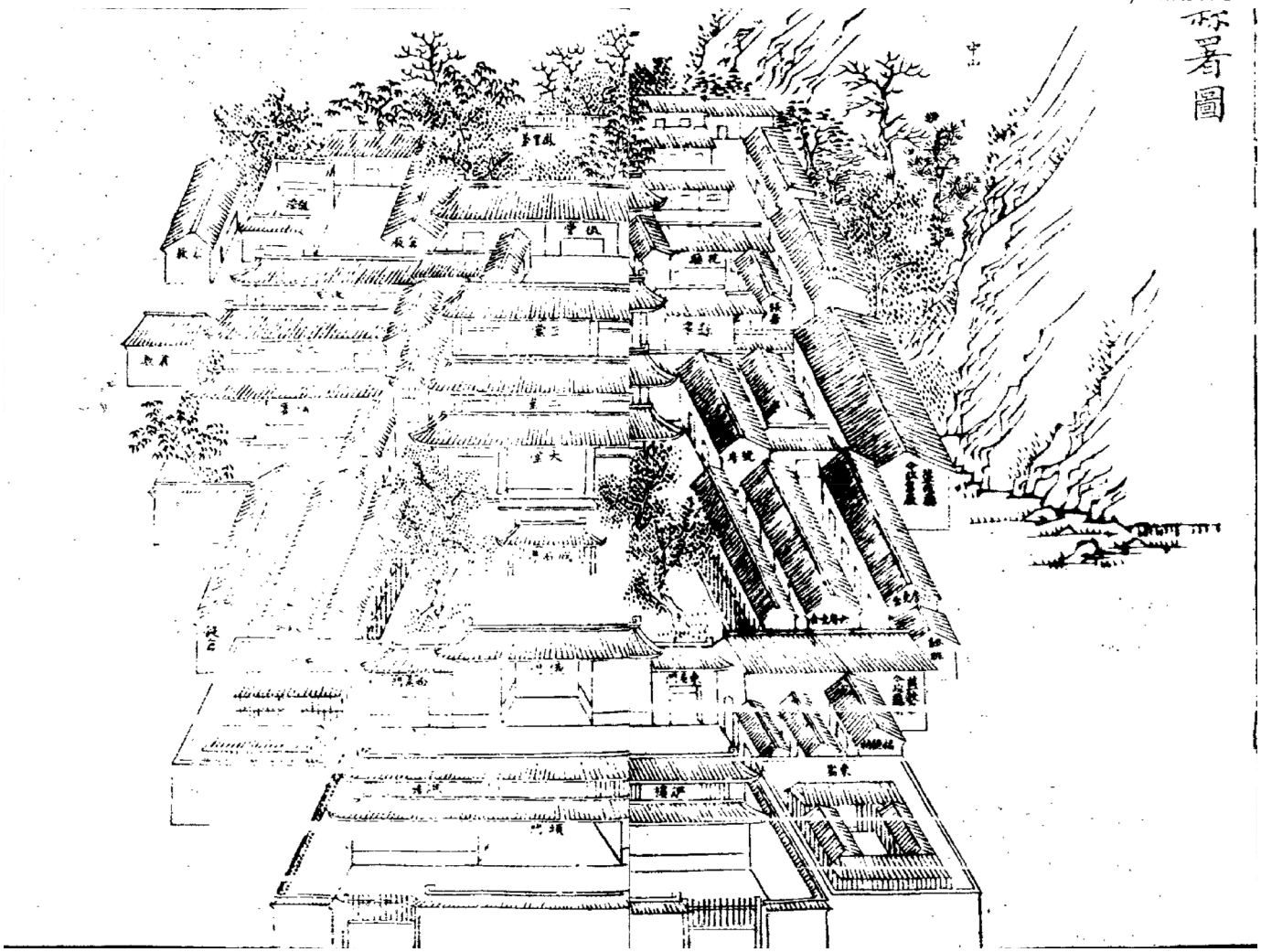
The lessons learned from modern construction could be summarized as two points:

1.The modern practice has taken place of the existing water system and construct itself totally depending on engineer solution: Large dyke ring construction, urban underground drainage system as well as modern dwellings and factories which have no relation with water at all. Thus the flood problem is found especially in these zone and there's no effective method to deal with it.

2. Without an integrated thinking, the multifunctional system of agriculture, transportation and housing has been transformed into single system like mass fish production, industry, large road and water infrastructure construction. These mono-function system has been especially built for single purpose with high cost and could not stimulate development of other things.

Thus, it will be beneficial to learn from the history principle and combine it with modern situation to get to a better and more sustainable resolution for future landscape that could deal with flood problem and stimulate other development at the same time.

Ink painting of government building Shunde district
Source: Annals of Shunde County (順德县志)



04. DESIGN PRINCIPLE

I. DESIGN PRINCIPLE FOR A NEW URBAN LANDSCAPE
II. WATER-SENSITIVE PRINCIPLES THROUGH MULTISCALE
III. CONCLUSION



To develop a new urban landscape based on these principles, it's important to summarize their content and possible utilization through multiscale. These principles would be connected with different scales and application would be explained later in the plan and design. These principles could be summarized as:



Long-term development process

One of the key characteristics is that a water-sensitive landscape is the result of a long-term development process. As has been shown above, the water-management system of Shunde district was the result of incremental experimentation and observation over a millennium, which makes it a valuable basis on which to build for today and the future. However, current practice is focused on fixed engineering solutions, often built in a short time frame and depending exclusively on manmade mono-functional urban-drainage networks and dike construction. This approach has proved to be ineffective, as illustrated by increased flooding events in recent times. In fact, it has brought more trouble than benefits by demolishing the historical water-management pattern, replacing it with an urban texture that has no relation with the existing water network. In that sense, taking into account the long-term development process is vital because it regards the current landscape as a layered entity where different processes and systems influence each other and have a different dynamic of change (Nijhuis, 2013). In the PRD, natural forces like sedimentation and erosion, along with human intervention through water management and agriculture, have constantly changed the landscape, which makes landscape dynamics and transformation a key issue in landscape research and design (Nijhuis, 2013).



Multiscale approach

Another characteristic is that the development of a water-sensitive landscape addresses multiple scale levels that, taken together, make for a complementary system. This might best be illustrated by the following: the water-management system at the Fort scale is a dense water network with different water bodies. This system, by regulating water in rivers, canals, and dike-ponds in both directions (i.e. drainage and storage) makes the settlement more resilient to flooding. In addition, it offers multiple flood defences by combining the large dike ring with the smaller dikes inside, so they protect people from both external and internal flooding. By dividing the water system and the dike system into smaller systems that work to mitigate specific flood dangers (e.g. the outer dike for river flooding, the inner against rain flooding), this principle see water management in the PRD as a complicated issue that should not be addressed by one single solution. Every single element (river, rivulet, bay, dike-fishpond) plays an important role not only in flood defence but also in accommodating greater flexibility (for things like water storage and reserved flood zones). Thus, instead of modern practices which see the construction of one single dike to protect a whole county, which has proved subject to failure, a water system that addresses multiple scales is not only more effective, but is vital for adaptive urban-landscape planning.

Collaborative effort

As illustrated by the Shunde district case, a water-sensitive approach requires a collaborative effort between authorities, experts, and other stakeholders. Their joint efforts, by working together with the different Forts or villages, is also crucial in the regional scale because it reminds us that separate decisions taken by a single county or village will not be enough when it comes to floods in the whole region. The reason for this is that the whole region is closely connected by rivers, tides, sediment, and other energy or material flows which require regional consensus and decisions taken at the macro level. Regional strategies have to be formulated by different local governments working together to put things into practice depending on their different local situations. This requires a collaboration of multiple disciplines, authorities, and other stakeholders to develop common understandings and strategies for a more resilient water system.

Understanding terrain conditions

As highlighted above, terrain conditions such as topography, water courses, and soil determine the allocation and layout of settlements. As a result, the site determines if a settlement is prone to flooding. Traditional villages were therefore usually located at the foot of hills or mountains, on natural river levees, or on the dikes of an agri-aquaculture system. These locations keep the settlements safe from flooding, but at the same time provided access to water, which acted as an effective way of draining rainwater and provided microclimatic benefits, such as the cooling effects of wind and evaporation. However, modern practice usually privileges transportation in its development framework, since this brings convenience and external resources. This approach is beneficial for rapid development but ignores the natural terrain and the specific layout that makes it resilient to flooding caused by rain and river. By reprioritising from a traffic- to a terrain- or water-network-development strategy, future development will have the advantage of being located in places that are safer from flooding.

Working with nature and space for water

Understanding the landscape system and its hydrological and ecological processes is another important characteristic of water-sensitive planning and design. Since water and vegetation have their own dynamics of development, and follow their own processes and cycles, it is important to provide space for development, change, and flexibility in different temporal scales (diurnal, monthly, yearly, etc.). Space for fluctuating water levels, room for rivers, and the development of ecosystems will ease pressure on the water system as a whole, increase biodiversity, stimulate sedimentation of fertile soil for agriculture, create possibilities for recreation, and open up opportunities for the development of site-specific housing typologies. However, modern engineering methods that aim at making strict controls limit the dynamic of water and nature and result in a mono-functional system that contributes to increasing flood risk and ecological damage. Working with natural processes connected to water demands open and inclusive design strategies, not blueprint designs, aimed at guiding development and creating conditions for a more adaptive and water-sensitive (urban) landscape.



Multifunctional water management

Another important characteristic lies in multifunctionality. The water system of Shunde district integrated defence, business, social communication, agriculture, and urban development and was, thus, not merely used for water protection. The water network also contributed to a widely connected transportation network for communication and trading between different villages. Markets were arranged beside sluices or on dikes to make use of their transportation advantages. This principle regarded the issues of flood protection and water management not only as a threat or an engineering problem, it also saw it as an opportunity to offer a new paradigm of living with water, commuting with water, and generally enjoying life with water. As a result, these combined functions promoted each other to provide people with a new experience of delta life. Multifunctionality was also visible in the dynamic use of public spaces, like the fengshui ponds and the private courtyard spaces. It also took fluctuation of weather and seasons into consideration, transforming these into advantages for multiple uses. It combined activities like social communication, recreation, and other public life or events with water drainage and storage and made it part of people's daily life. It brought the seasonal changes in landscape and water to the people, which not only warned them of possible flooding but also provided beautiful scenery. In that respect, the integration of water management with other developments should be utilized by planners and designers to encourage multifunctional use and accommodate more adaptation.



Re-use and circularity

The agri-aquacultural landscape was traditionally one of re-use and circularity. The circulation principle lies in the re-use of grey and black water for irrigation, fertilization, and other purposes. Taking the dike-pond system as the circulation centre, rain water from the courtyard or roof, as well as river water, could be a source of water replenishment for the ponds while the water in these ponds could also be used to irrigate crops on the dike. Sewer water from houses could also flow into the dike-fishpond to act as fertilizer. Later, after a series of bio-degradation processes, nutrients would be absorbed by vegetation or by microbes in the water and purified. This circulation principle could be the inspiration for a series of water collection and purification systems that make the best use of water during the dry season today.

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PRINCIPLE THROUGH SCALES

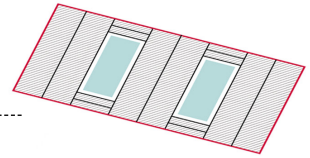




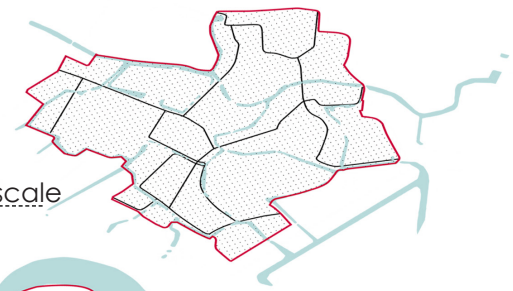




Building scale



Village scale



County scale



Regional scale



CONCLUSION

These characteristics are the basis for an integrated water system that not only functions as flood defence but also serves as a driving force for ecological development, circularity, transportation, agricultural production, settlement advancement, social connection, and governance. From this perspective, water becomes the main condition for growth and prosperity; it boosts culture through water-sensitive planning and design, because not only does it apply "technical" lessons learned but also carries the intrinsic cultural qualities of local adaptations that make up the strong regional identity of the PRD.

By relate these principles to the different scales they were found in history of Shunde water management , this thesis builds up a framework that offers a new opportunity of applying them across scales in modern practice.

In regional scale, the most important principle is to take the whole system of water network, infrastructure and aqua-agriculture development as a result of long process. Each intervention in the next dynasty was built upon practice and experience of previous time and was integrated into the overall system integrated into the overall system. As a result, experiment and observation of nature and water dynamic of this region was learned and put into practice for over millennium. Thus the new intervention has to work with it and make more space for water, as people did in years ago. In addition, collaborative principle requires a share of flooding danger, which means more space for the river in one county could contribute to mitigate the flood danger in the whole region.

In county(Fort) scale, the most important principles include understanding the terrain condition and multifunctional water management. To make a reasonable decision for the future development it would be vital to make use of the natural terrain for gravity drainage or collecting excessive water in low lying zone. While for the higher zone other landuse like urbanization, agriculture could be arranged without being afraid of flood.

In addition, this system also has its multifunctional layer that integrates defense, business, social communication, agriculture, urban development so it stimulates other development based on this flood protection system.This principle regards the flood issue and water management not only a threat or engineering protection, but also an opportunity of offering a new life paradigm that lives with water, commutes with water and enjoy life with water.

In village and building scale , it would be important to follow the natural terrain for arranging layout of the village and single building in order to help drain rain water quickly. Multifunctional principle here is similar but focuses on dynamic use of public space like Fengshui pond and private space like water courtyard. It takes fluctuation in different weather and season into consideration and transform it into an advantage for multiple uses. Circulation principle lies in the reuse of grey water and black water for irrigation, fertilization and other purpose.

As a conclusion, being aware of the principles applied in multiscale could help to make a better decision for a sustainable plan and design.

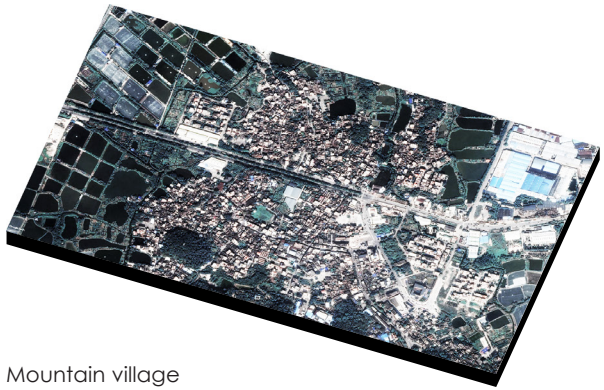
05. DESIGN EXPLORATION AT REGIONAL SCALE

I.BACKGROUND ANALYSIS
II.PRINCIPLE AND STRATEGY
III.REGIONAL PLAN AND STRATEGY
IV.THEMATIC PLAN AND INTERVENTION
V.VISION

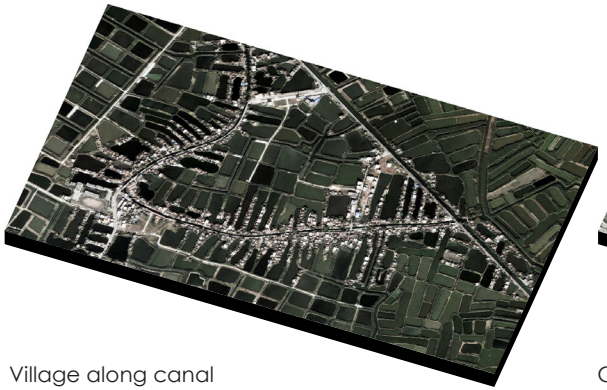



BACKGROUND OF XINGTAN
0
1km
2km
5km

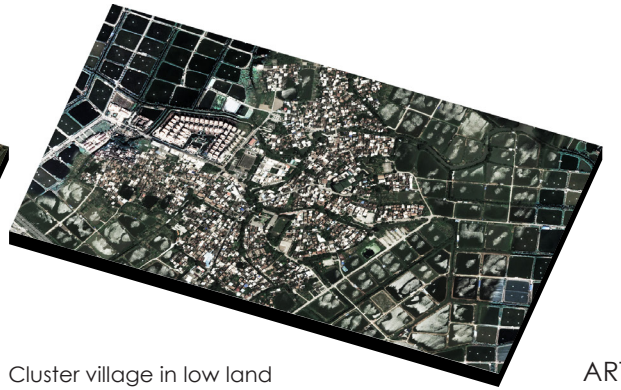
TYPICAL LANDSCAPE OF XINGTAN



Mountain village

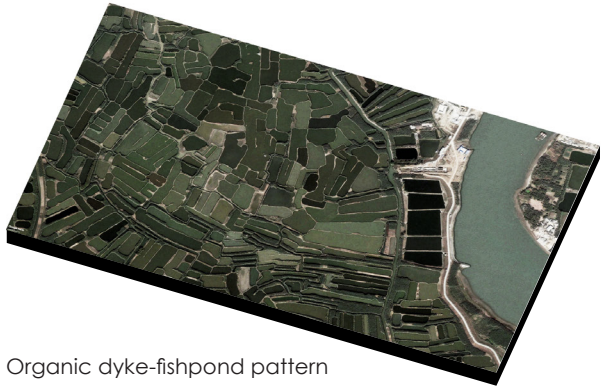


Village along canal

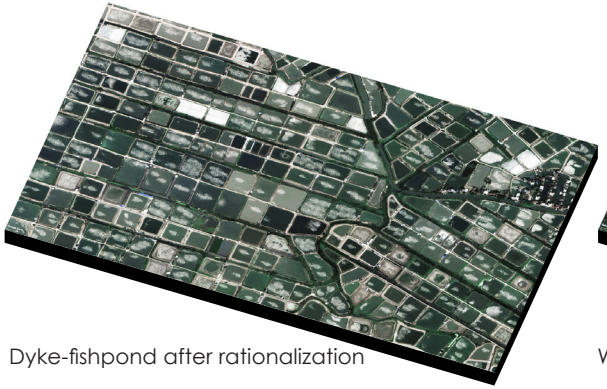


Cluster village in low land

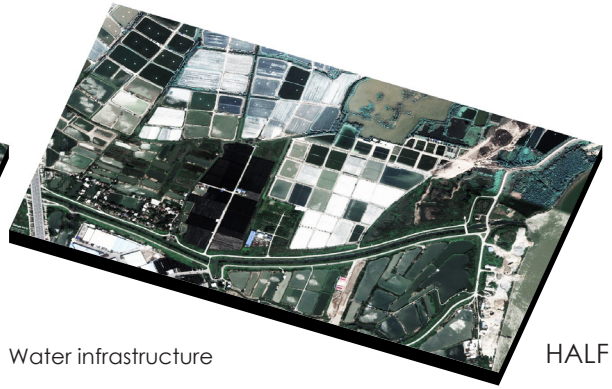
ARTIFICIAL LANDSCAPE



Organic dyke-fishpond pattern

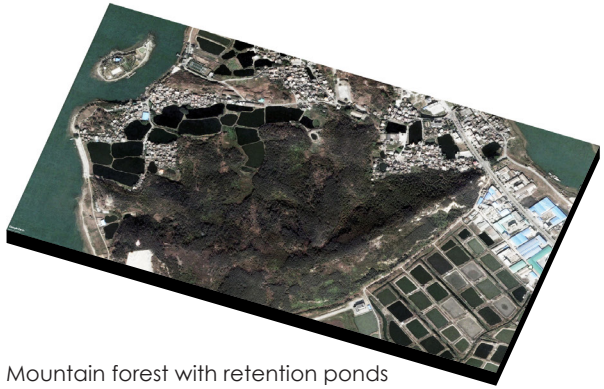


Dyke-fishpond after rationalization

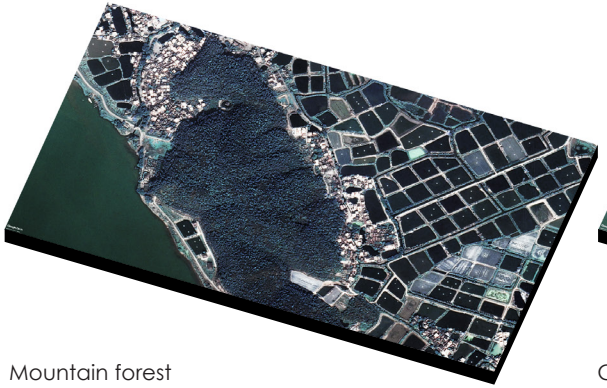


Water infrastructure

HALF NATURE LANDSCAPE



Mountain forest with retention ponds

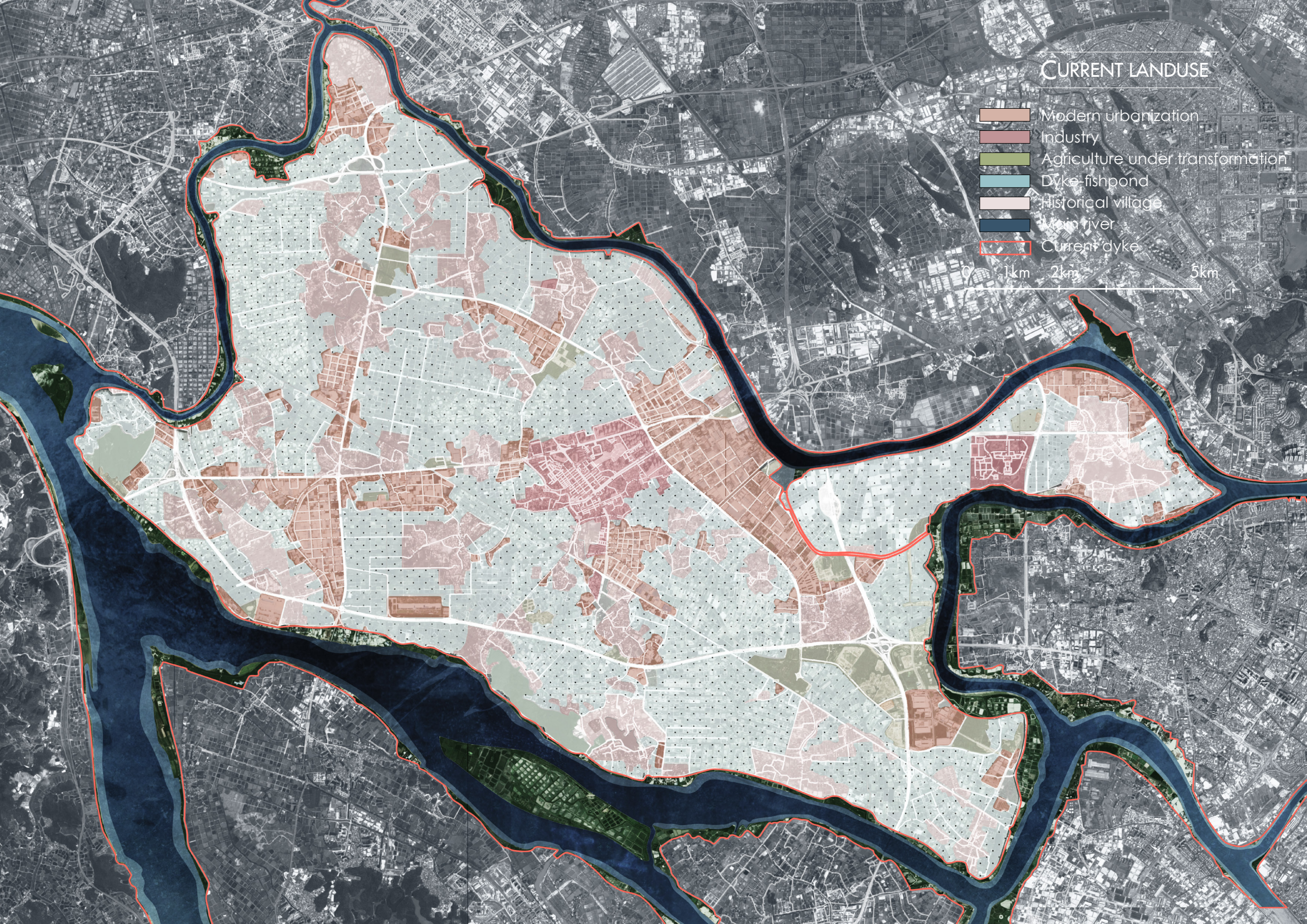


Mountain forest



Coastal landscape

NATURAL LANDSCAPE

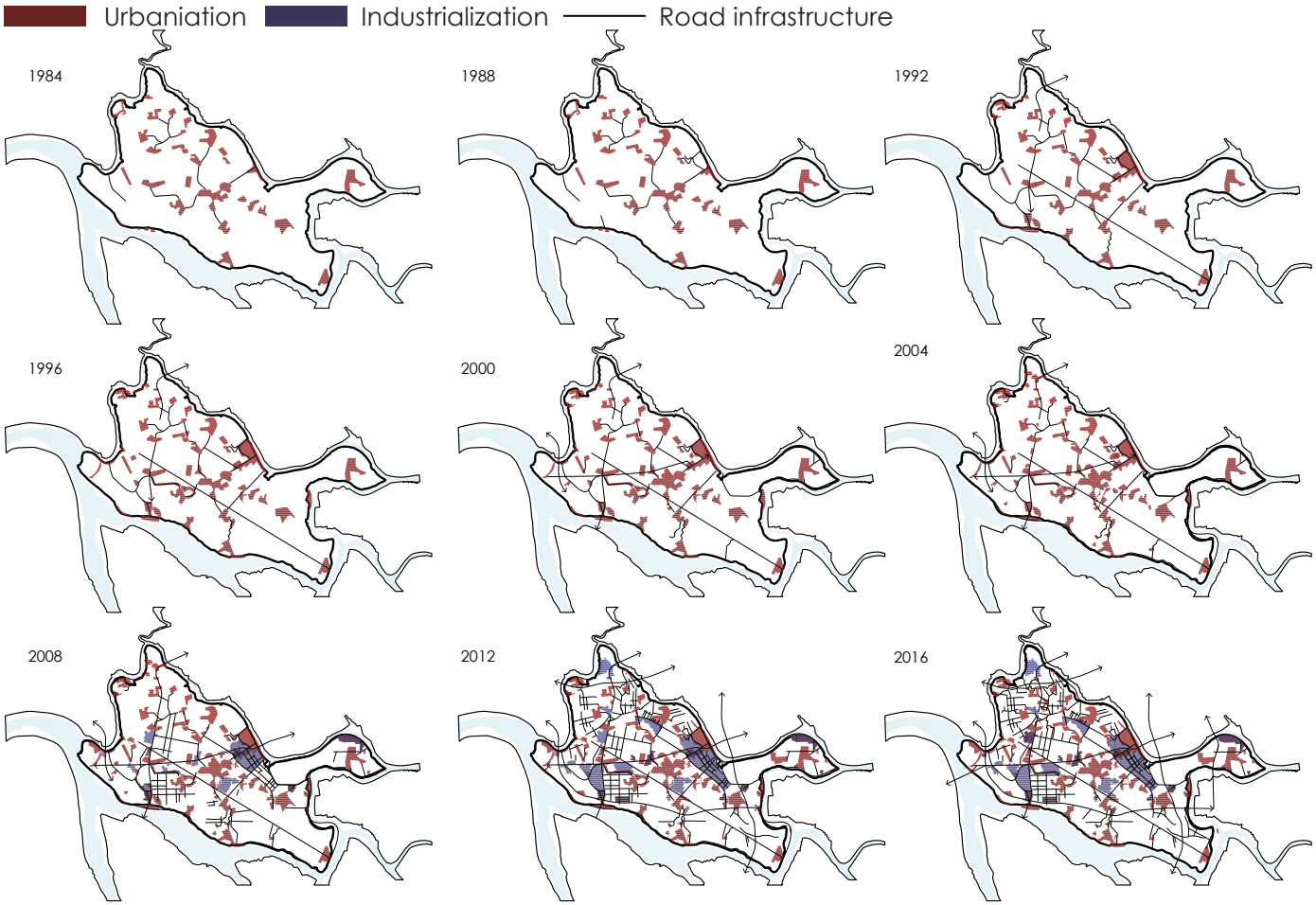

CURRENT LANDUSE
Modern urbanization
Industry
Agriculture under transformation
Dyke-fishpond
Historical village
Main river
Current dyke
0
1km
2km
5km

Background of Xingtan county

Xingtan county is located in the southwest of Shunde district and in the flood prone zone between North river and West river, with a low urbanization process and high proportion of agriculture. The county consists of many historical villages that used to have very close relationship with the water, along with the surrounding dyke-fishpond that contributes to gain most of the economy here. The natural landscape is hard to find here while playing a vital role in biodiversity and eco-system. However, the future plan to urbanize and industrialize most of the county has been made and it threats the historical agriculture as well as already weaken water and ecology system. The site requires a new developing framework which can contribute to enhance the water system, eco-system and benefits for agriculture and urbanization.

Historical development of Xingtan county

Diagram shows that the continuous modern urbanization and industrialization in 30 years. The developing method totally depends on the road infrastructure and takes large part of aqua-argiculture system.



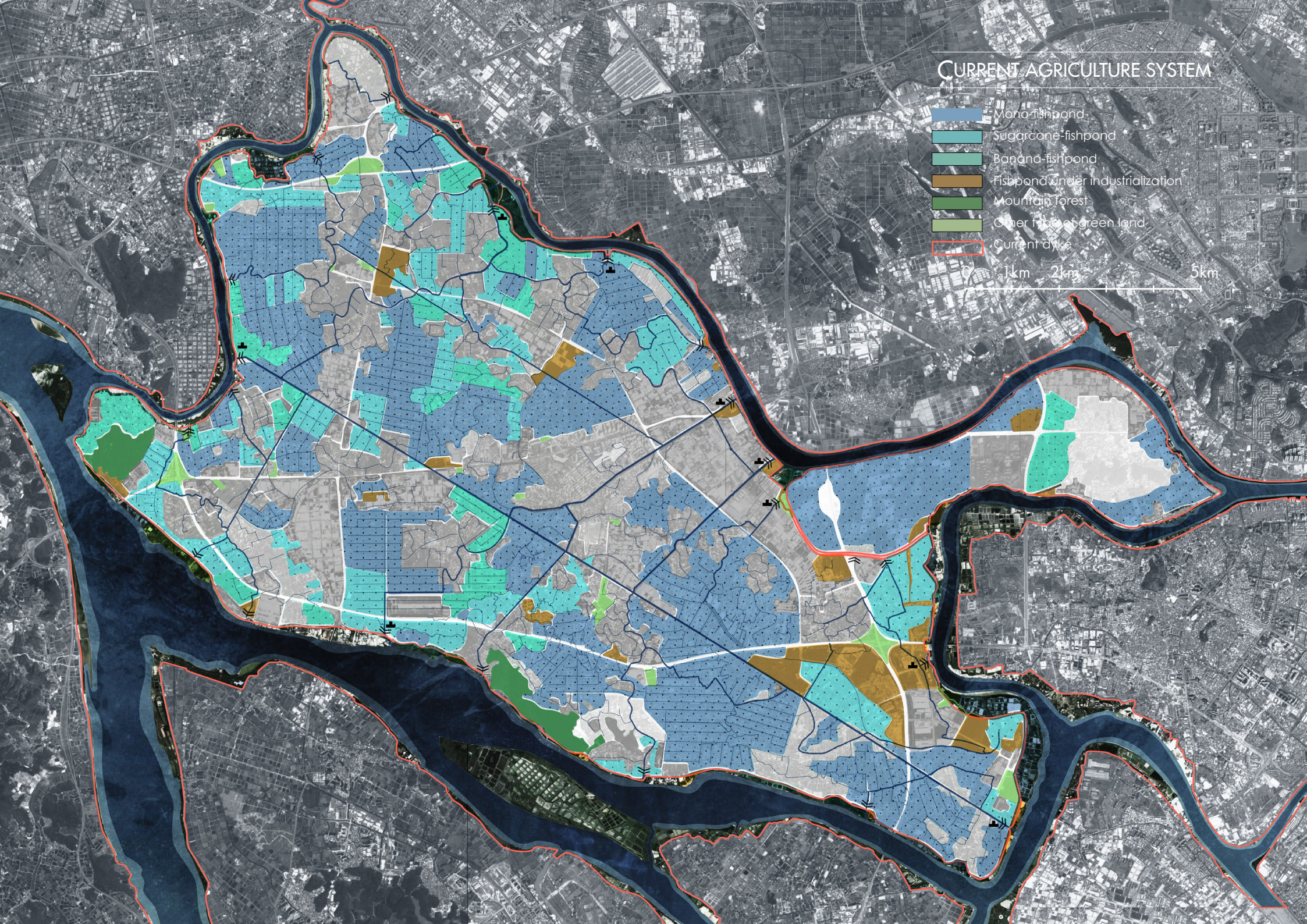

CURRENT WATER SYSTEM
Water sluice
Pump station
Ditch and creek
Canal
Dyke-fishpond
Main river
Current dyke
0
1km
2km
5km

The water system of Xingtan is characterized by a dense creek and ditch network and pattern of dyke-fishpond. This network used to contribute to economic production, transportation by water as well as water dwellings and most importantly, water safety. However, after constructing the united dyke closing all the county boundary and canals that are only for drainage purpose. The new water system not only lots its function of drainage and water collection, but is also transformed from a multifunctional system to a mono system.

The aqua-agriculture system, which was part of the flood defense system and remained close connection with external water system like ditch, creek and main river, is now a separated from other water body. The instant water table adjustment in historical time worked well in reacting to water fluctuation in rain season and dry season to pump water from fishpond to external river or let it in through water holes in the dykes. While now the open creeks and ditches are shut from the external river, it's not possible to adjust the water table positively as a strong flood defense method. As for the new urban zone and industrial zone which takes place of the old dyke-fishpond and water network, there would be more trouble of getting the excessive water out quickly and thus it becomes the most flood prone area in the county.

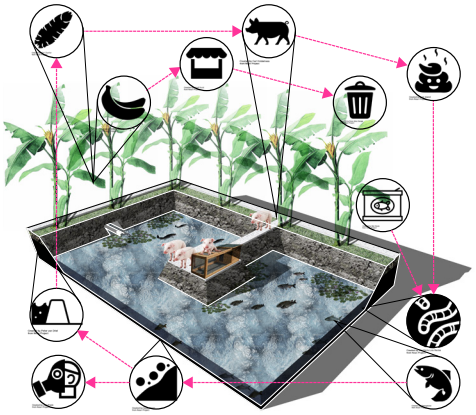
The water system needs to be enhanced for flood protection and also for stimulating multifunctional development like ecology, agriculture and new water urbanization.

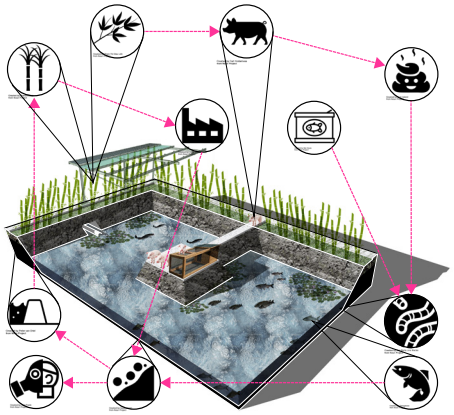


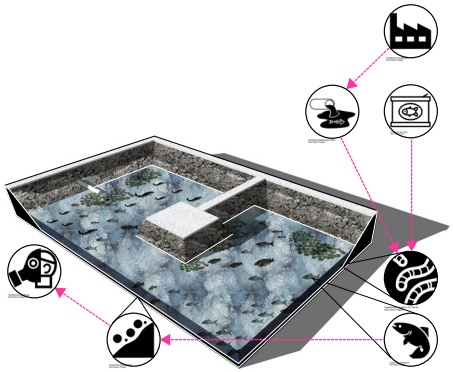

CURRENT AGRICULTURE SYSTEM
Mono-fishpond
Sugarcane-fishpond
Banana-fishpond
Fishpond under industrialization
Mountain forest
Other type of green land
Current dyke
0
1km
2km
5km

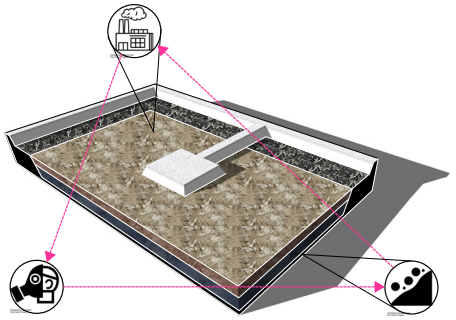
The aqua-agriculture system used for over hundreds of years has been transformed from a circular system that produces multi-products without external energy and material input to a mono system specialized in fish production in order to make maxim benefit. A rationalization took place around 20 years ago to normalize all the dyke-fishponds from an "organic" pattern to a grid pattern which aims to improve fishpond size for mass production, road system for transportation and electricity for oxygenation equipment.
However, the biodiversity dramatically decreased and the circular eco-system was replaced with artificial forage and oxygenation equipment.




Banana fish-pond

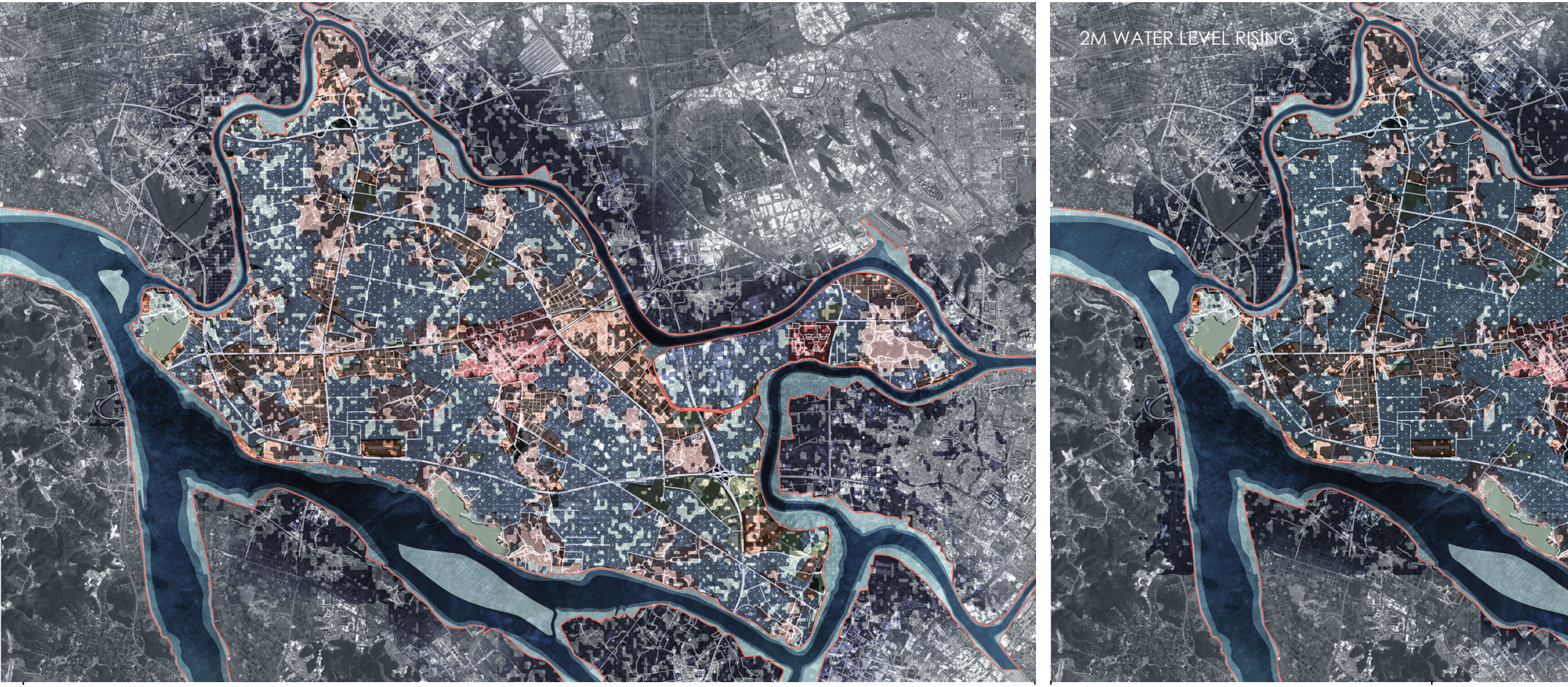

Sugarcane fish-pond


Mono fish-pond for mass production

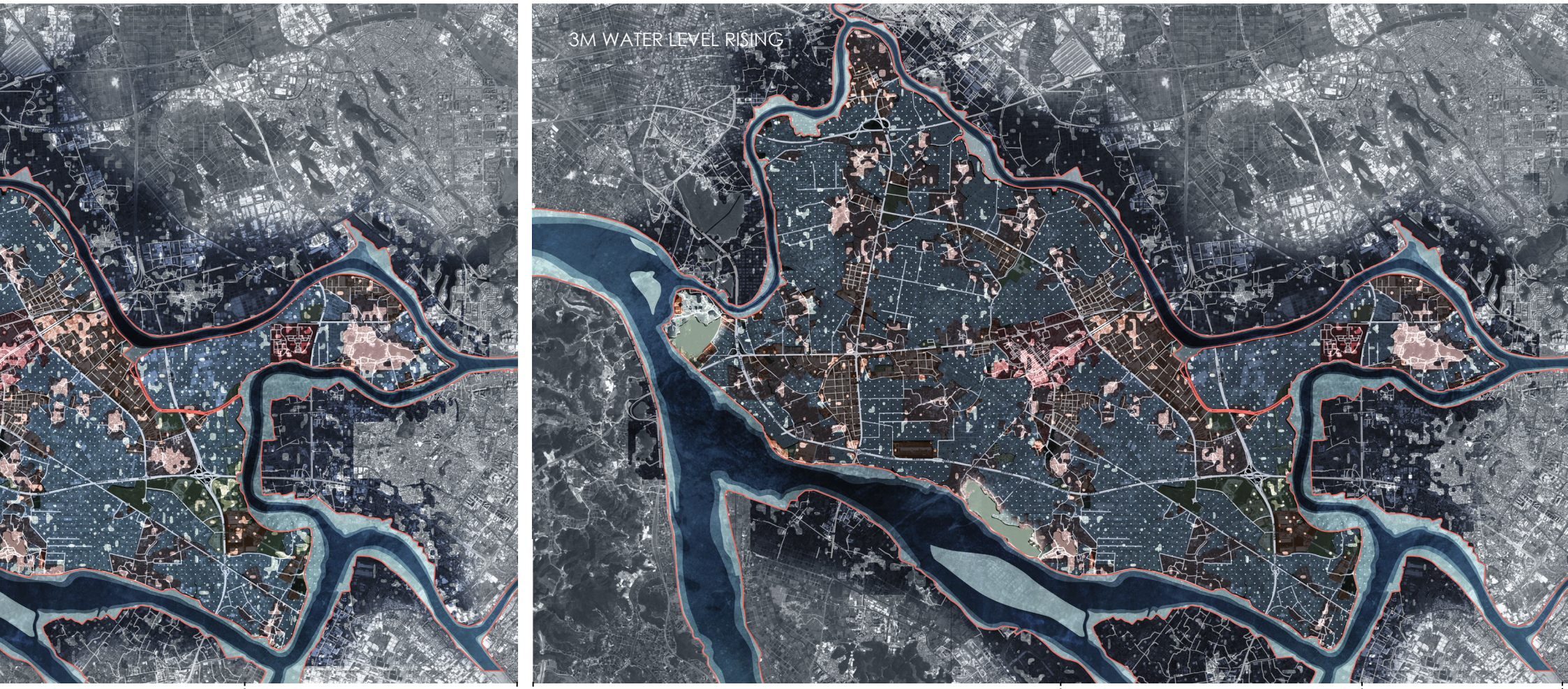

Fishpond under industrialization

FLOOD SEQUENCE

The flood problem has been a threat for a long time during rain season because of high river discharge and heavy rain fall, which causes danger to boundary dyke and internal low lying zone. In addition, these two threat intensify each other when happening at the same time from April to September when the external water table is raised drastically because of high discharge from upstream of West river and east river. At the same time the internal flood also happens because of of poor drainage system, especially in the urbanized and industrialized zone where the dense water network is demolished. While in dry season, the daily use water is in



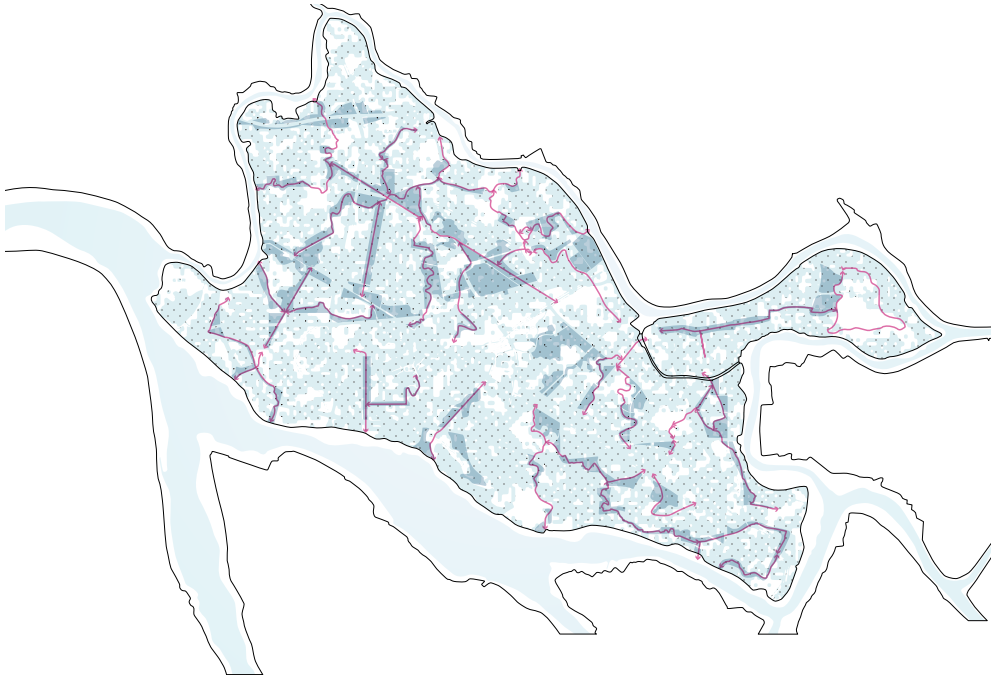
poor condition from industry waste and poor water infrastructure in villages with no space to store clean rain water. For future urbanization that requires not only water safety, but also more space for dwelling and more water for daily use, a new model of development must be introduced.



PRINCIPLE AND STRATEGY

MAIN PRINCIPLE	STRATEGY
Process principle	-Consider design phases instead of blueprint plan -Water and infrastructure as the basic developing framework for agriculture, ecology and urbanization
Collaboration principle	-Consider flood danger in large scale and share danger between different counties
Multiple scale principle	-Connect water-management across scales and make use of systematic thinking
Understanding terrain conditions principle	-Make reasonable plan for safe and high ground(urbanization) -Define main drainage corridor according to natural terrain -Different typo-morphology of urbanization based on various terrain
Working with nature and space for water principle	-More space for the flood -Make use of river dynamic and natural succession for water network development
Multifunctional water management principle	-Integrated water management with other function and development
Re-use and circularity principle	-Re-use existing material for sustainable and circular development

UNDERSTANDING TERRAIN PRINCIPLE

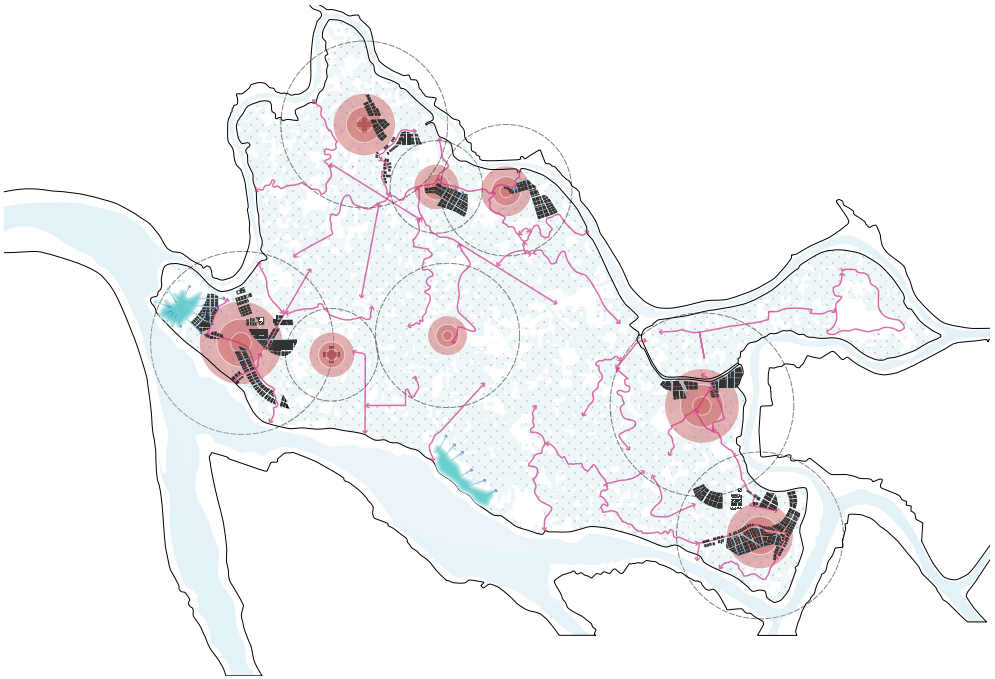


Strategy I: Make use of flood prone zone for drainage and water collection

To deal with the flood positively and turn the threat into opportunity, the natural terrain must be taken into condition. Instead of let the flood going everywhere once the water table rises, it would be better to divide the temporal flood zone and safe zone for different purpose. For instance, the lowlying zone could be digged to create a wetland collecting excessive water, while the soil could be reused for making terps or mounds that could serve as urbanization basement. In addition, in local(village) scale the urban morphology shall follows the terrain in order to drain water quickly into canal, fishpond or wetland.



Strategy II: Make use of higher ground for urbanization

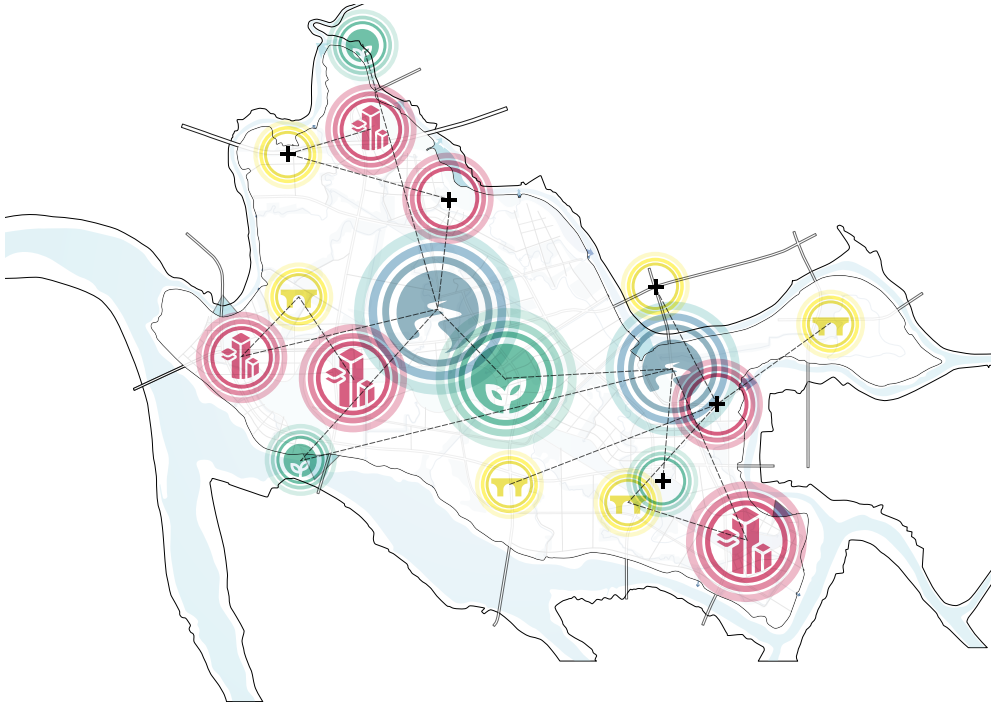


Strategy III: Different typo-morphology according to terrain

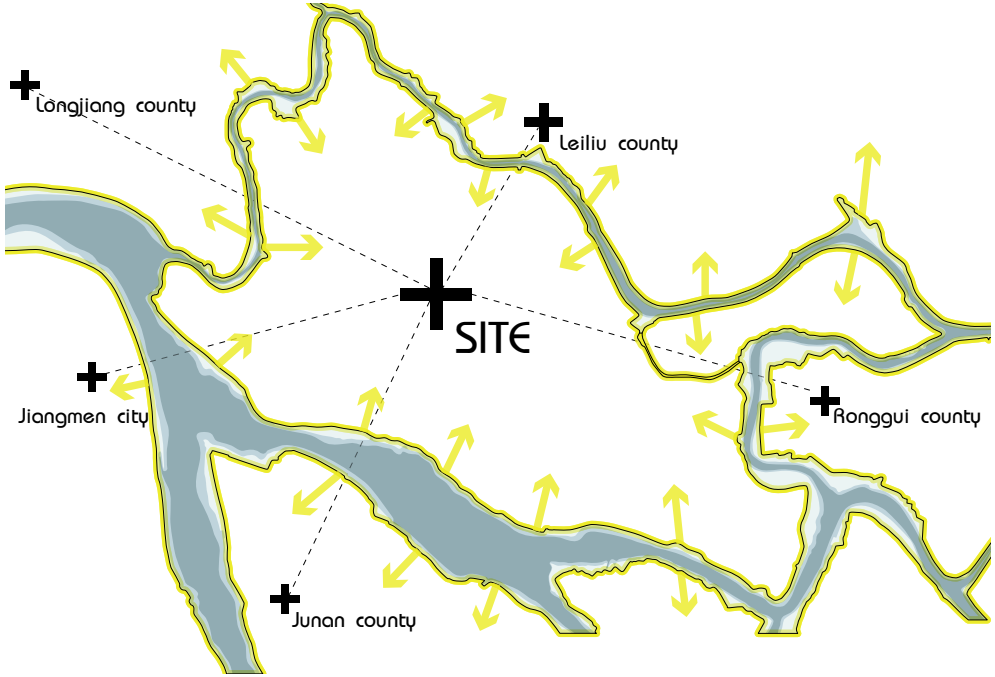
PROCESS PRINCIPLE & COLLABORATION PRINCIPLE



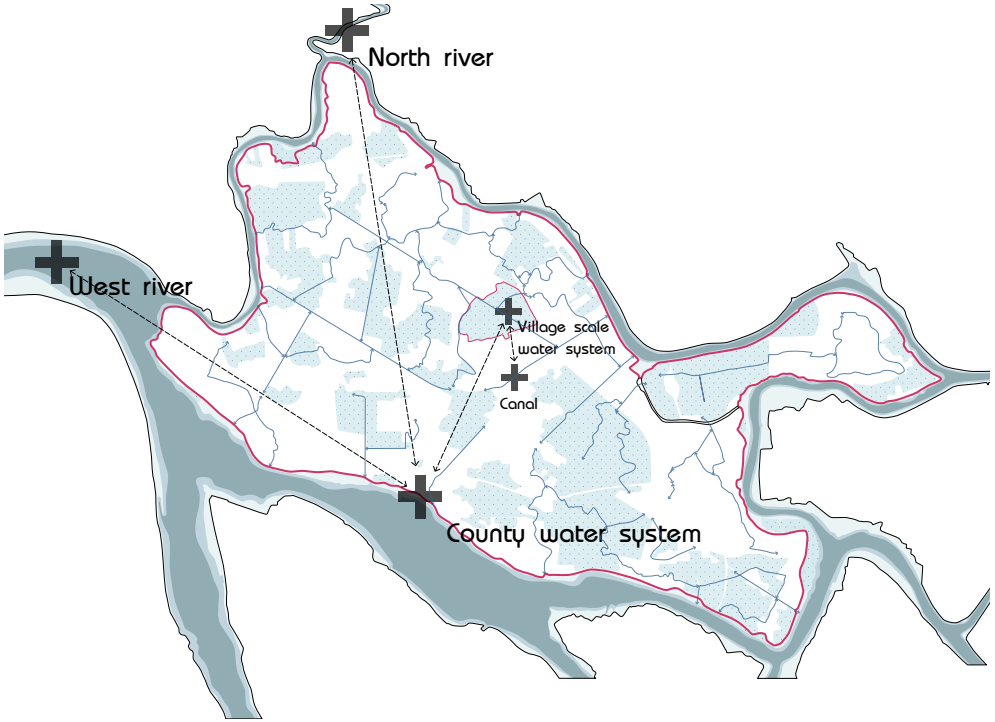
The new water management requires a phase plan so it's adaptive to different scenario of climate change and urban development. In addition, the natural water and ecology system takes time to thrive, as well as urbanization and infrastructure. Collaborative strategy means the water threat shall not be regarded as a problem of one county or village, which means the plan shall include as much periphery area as possible. Finally, the water management will only work when the method is applied in multiscale and closely connected.



Strategy IV: Make phase plan based on water and ecology take the time development into consideration

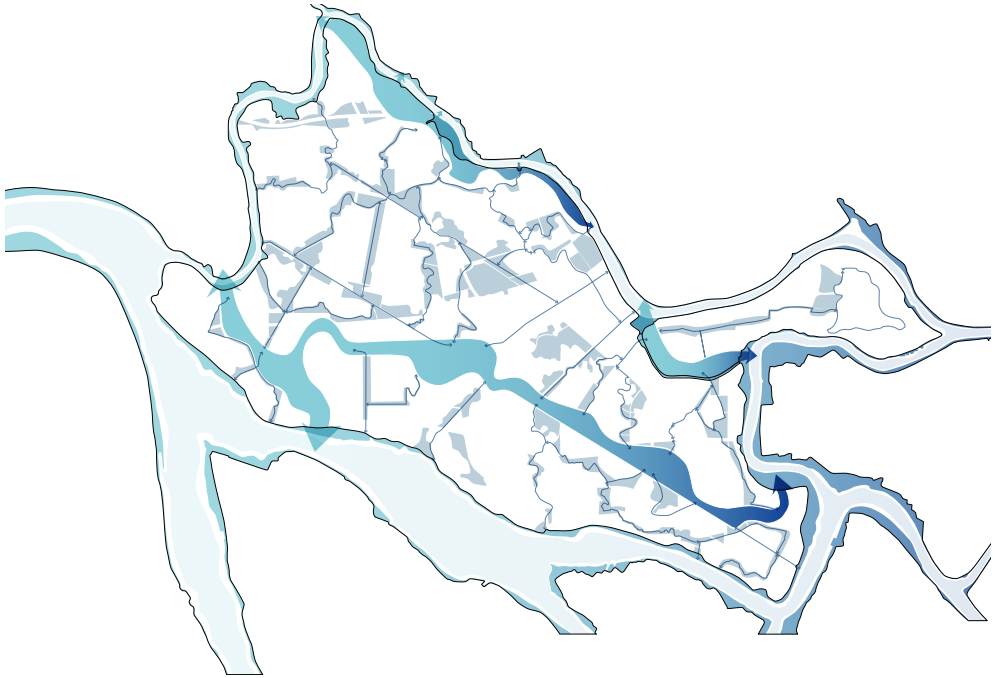


Strategy V: Collaborate with surrouding counties for cooperative flood defense against the river and share danger as well as profit



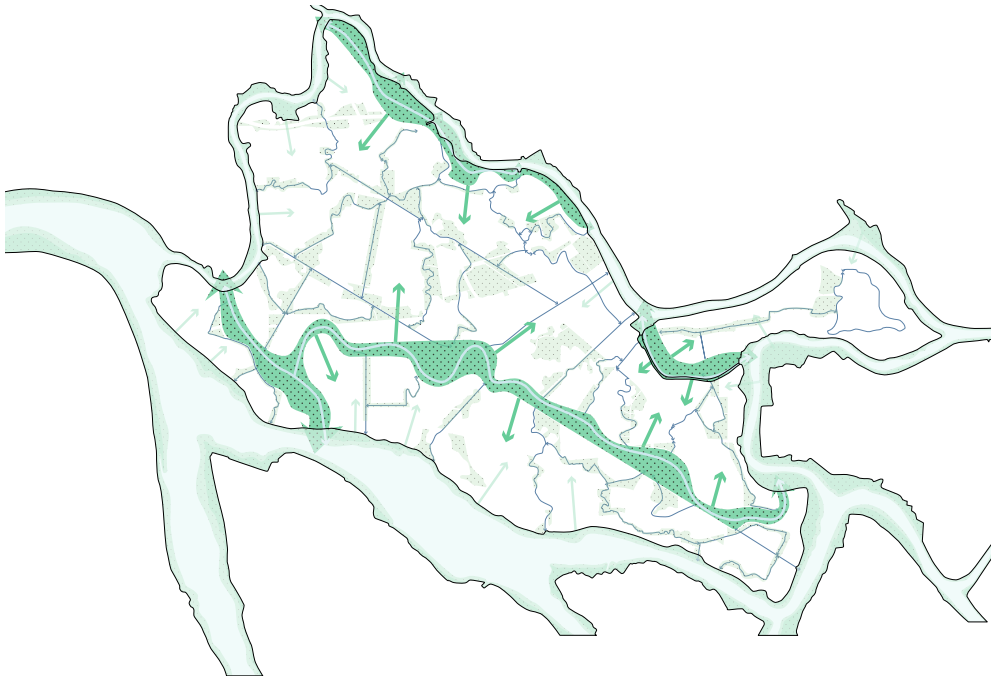
Strategy VI: Connect water management through regional scale, county scale and village scale to form a robust water system.

WORKING WITH NATURE AND MORE SPACE FOR RIVER & MULTIFUNCTIONAL WATER MANAGEMENT



Strategy VII: Create more space for river flood and rain storm.

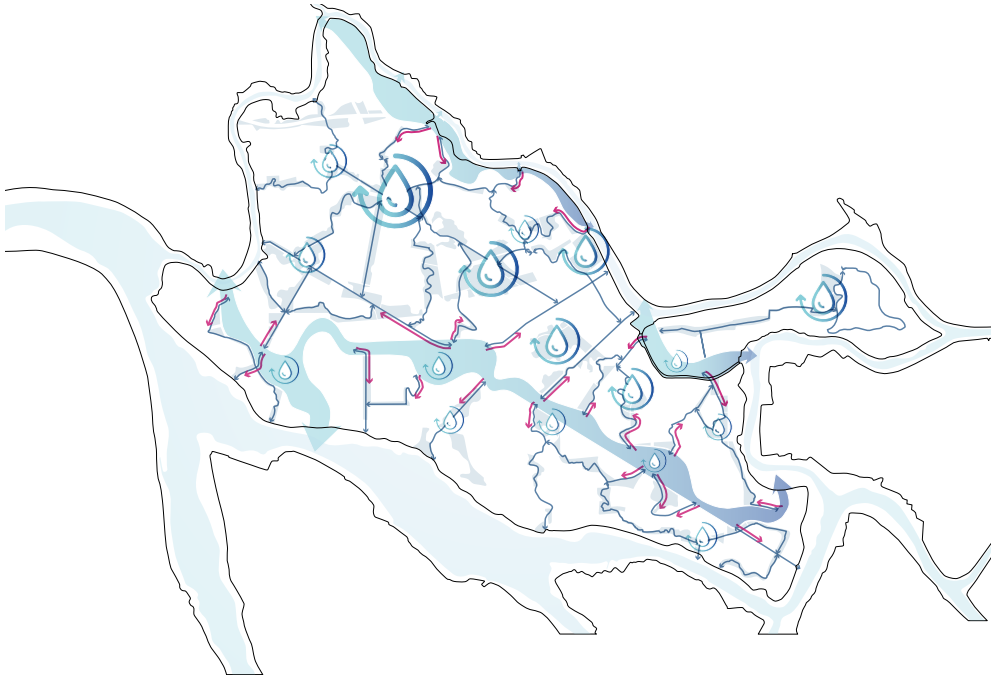
There are two main flood from river and from the rain and they often happens at the same time,so the corresponding space shall be created to collect or temporarily store them and release them later. In addition, the modern water network is highly channelized and a new plan needs to work with the nature to restore their dynamic for enhancing water capacity, biodiversity and purification. Finally, the new water management provides new possibilities for water infrastructure, aqua-agriculture, water recreation and water urbanism that shall be integrated.



Strategy VIII: Work with the natural process to restore eco-system.



Strategy VIIII: Integrate infrastructure, ecology, recreation, aqua-agriculture and urbanization into water-management.



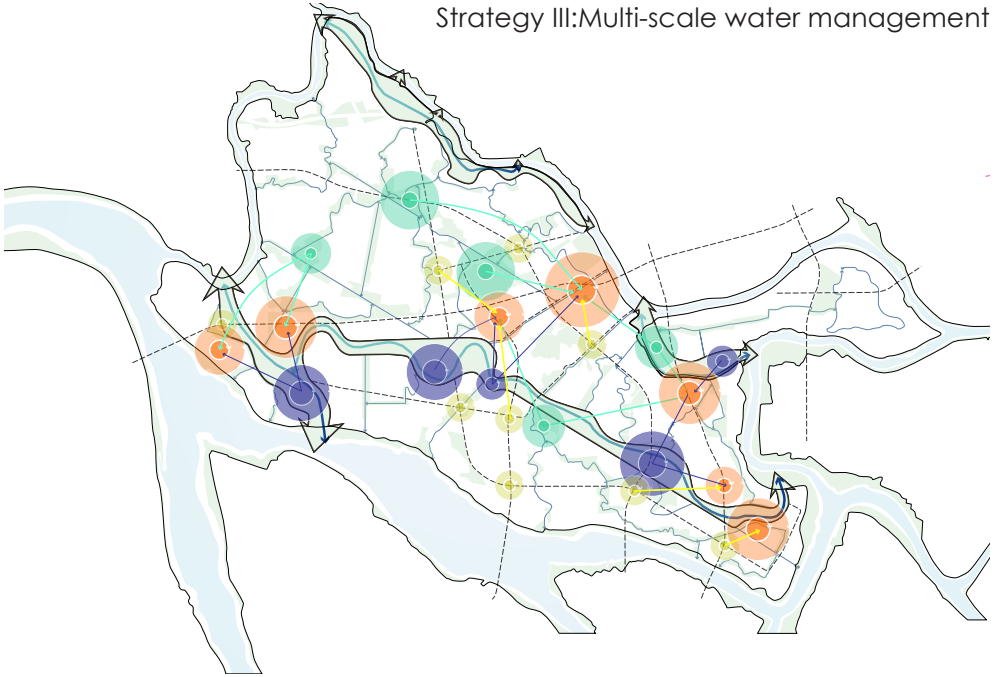
Strategy X: Make water circulation between river water, rain water and grey water to support daily use and irrigation

To deal with the flood positively and turn the threat into opportunity, the natural terrain must be taken into condition. Instead of let the flood going everywhere once the water table rises, it would be better to divide the temporal flood zone and safe zone for different purpose. For instance, the lowlying zone could be digged to create a wetland collecting excessive water, while the soil could be reused for making terps or mounds that could serve as urbanization basement. In addition, in local(village) scale the urban morphology shall follows the terrain in order to drain water quickly into canal, fishpond or wetland.



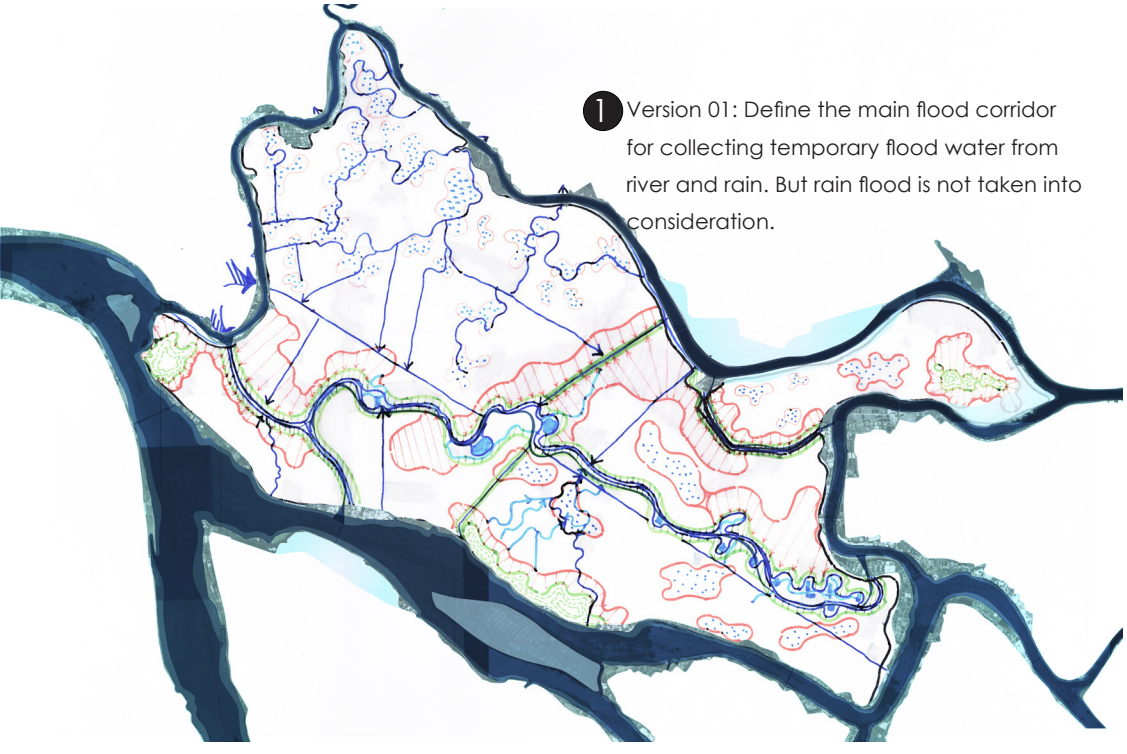
Strategy XI: Work with the natural water dynamic to get sedimentation instead of high cost of dredging and sand mining.

Strategy III:Multi-scale water management

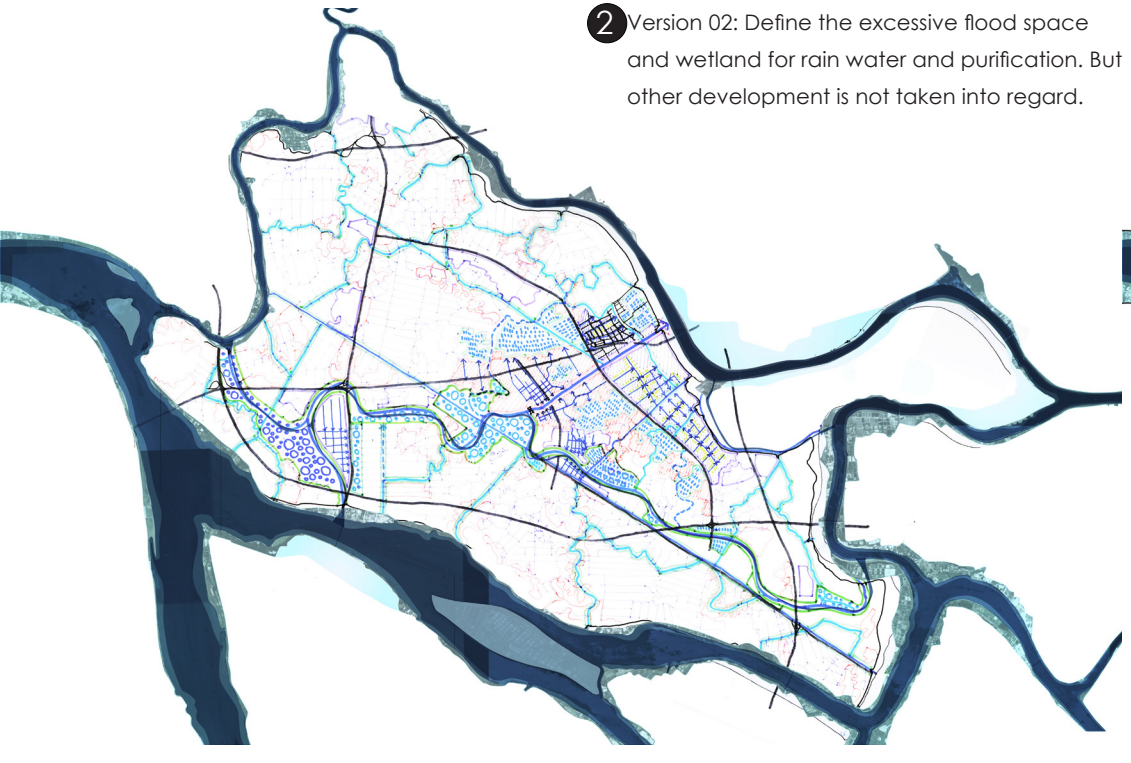


Strategy XII: Apply the circulation system of dyke-fishpond in large scale to form new urban metabolism to sustainable development.

PROCESS OF THE PLAN



1 Version 01: Define the main flood corridor for collecting temporary flood water from river and rain. But rain flood is not taken into consideration.



2 Version 02: Define the excessive flood space and wetland for rain water and purification. But other development is not taken into regard.



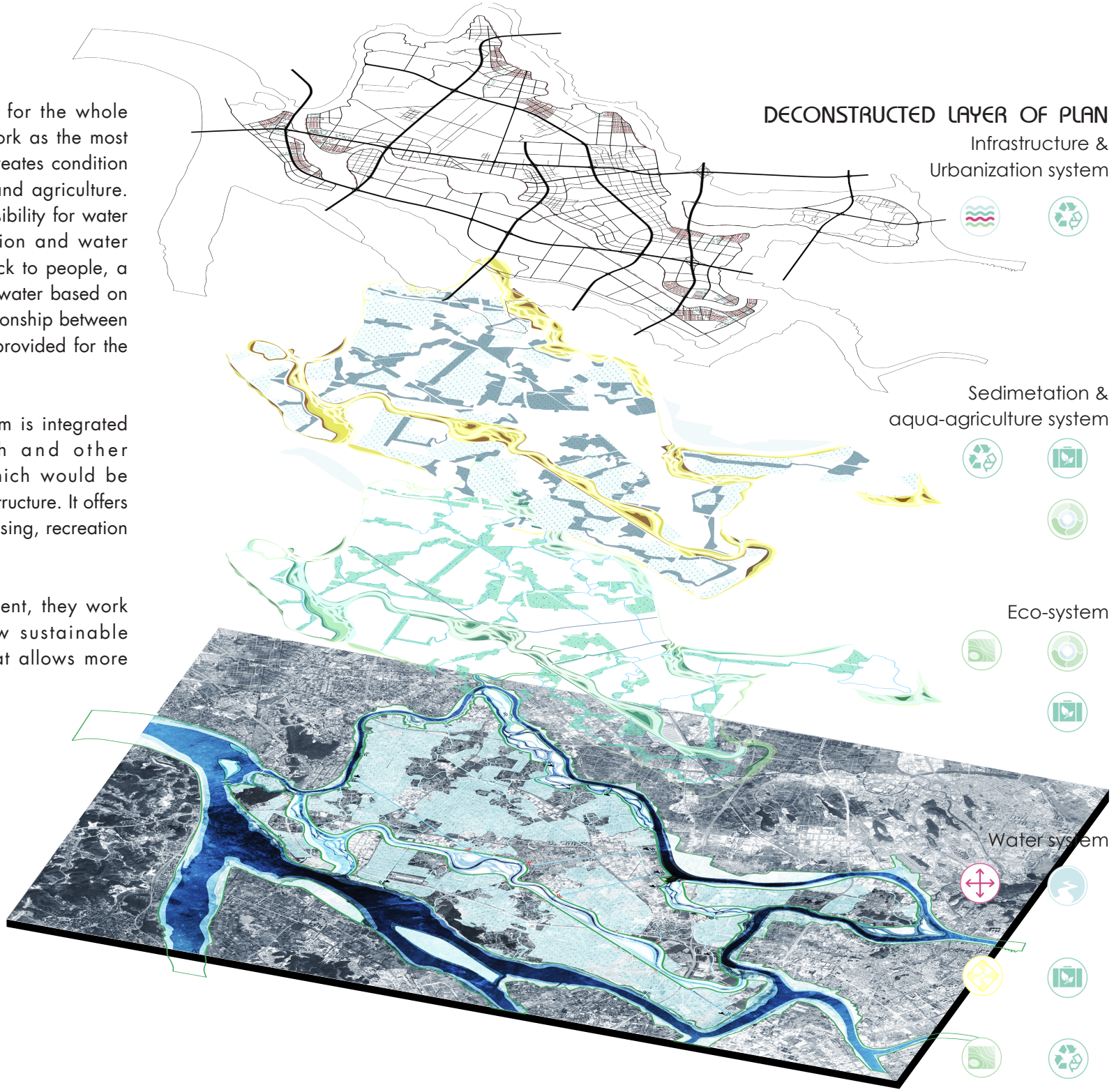
3 Version 03: Infrastructure is completed and new possibilities for ecology urbanization, and recreation is integrated into the whole plan. But the whole plan is not finished yet.

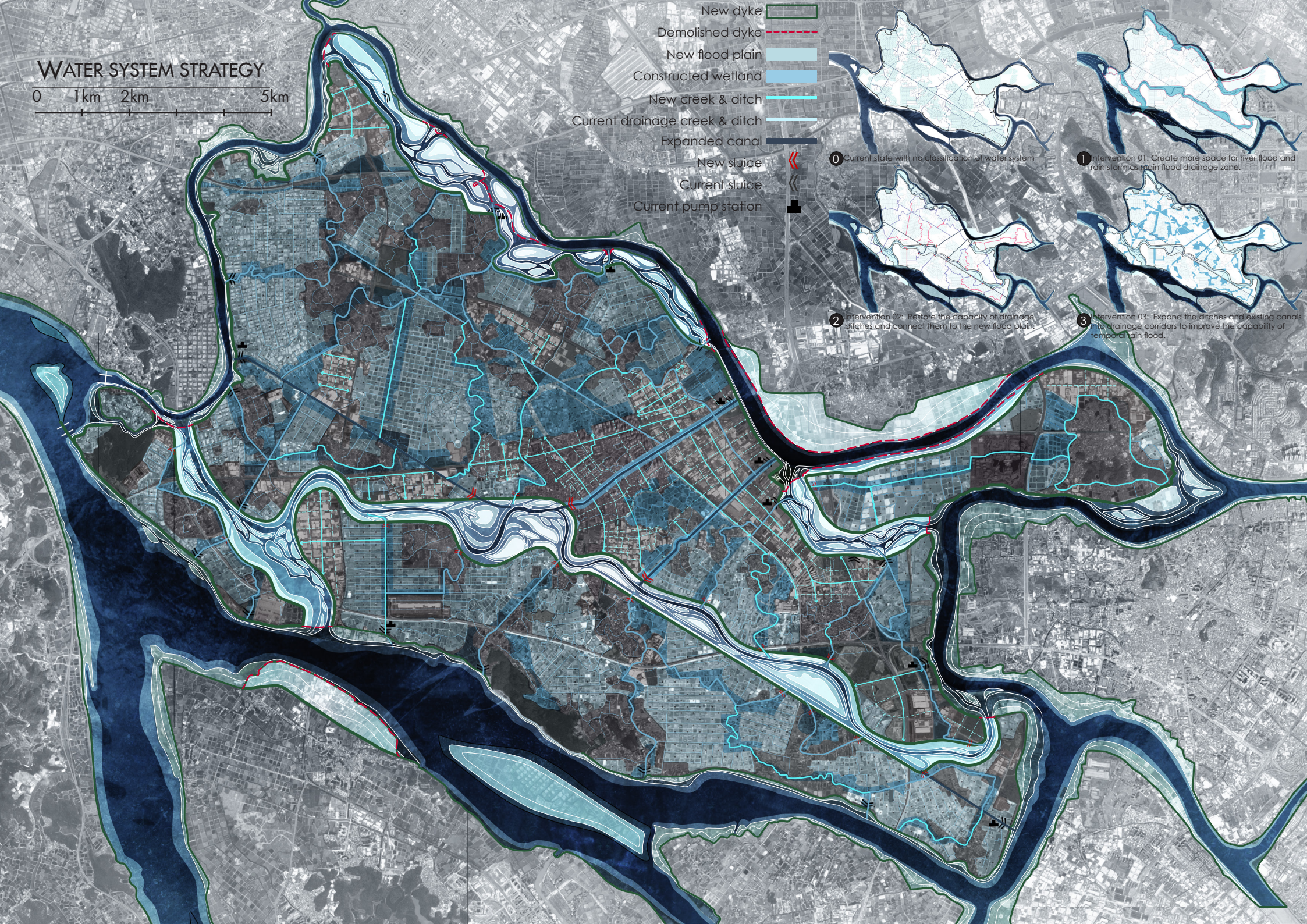

REGIONAL PLAN AND STRATEGIES
0
1km
2km
5km
New dyke
Main road
New urbanization
Constructed wetland
New creek & ditch
Current drainage creek & ditch
Expanded canal
New sluice
Current sluice
Current pump station
Dyke-fishpond

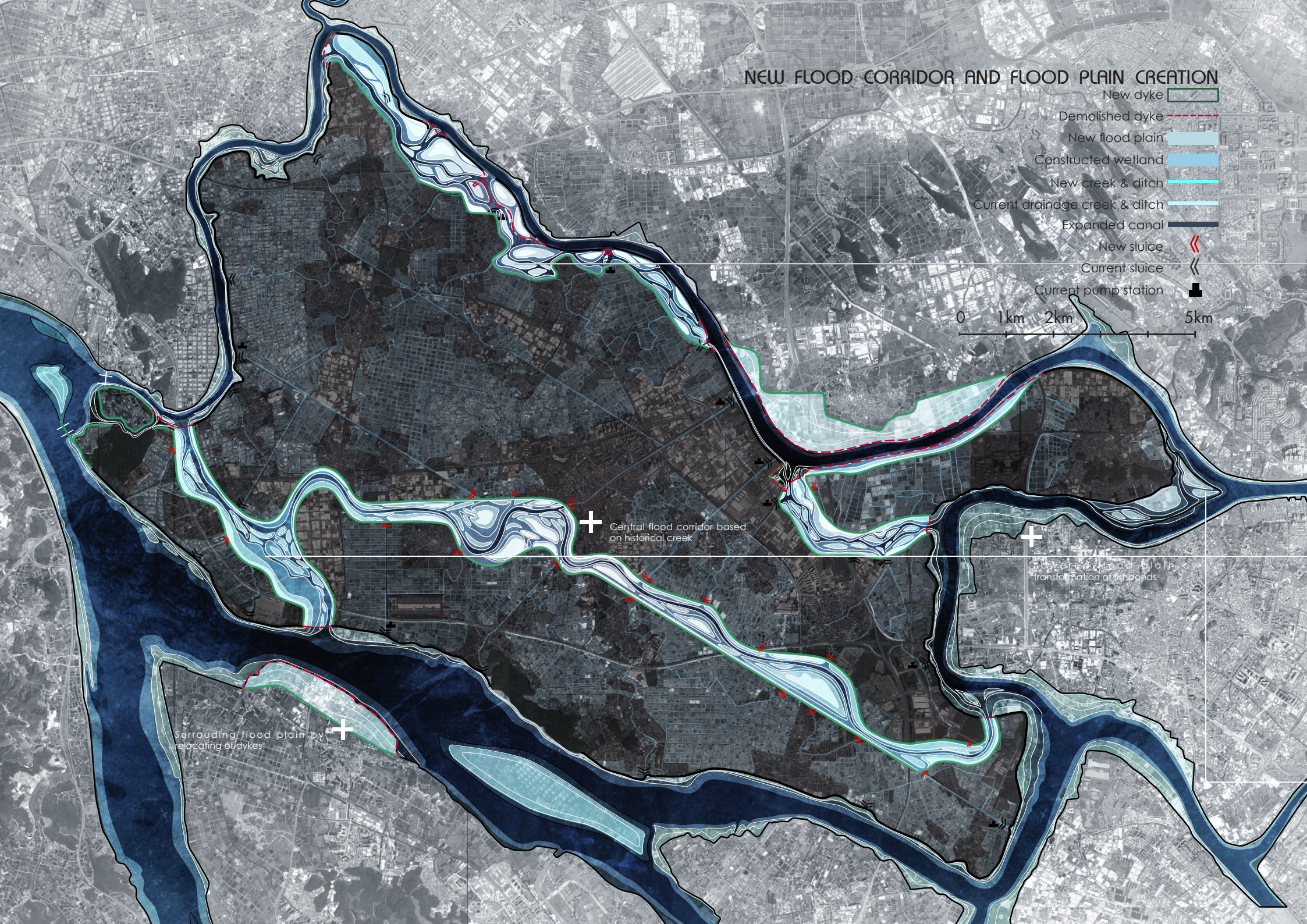
The strategic regional plan for the whole county takes the water network as the most important backbone which creates condition for sedimentation, ecology and agriculture. In addition, it offers new possibility for water transportation, water creation and water safety. By bringing water back to people, a new paradigm of living with water based on traditional philosophy of relationship between human and water would be provided for the residents.

Besides, the new dyke system is integrated with tram, biking path and other transportation method, which would be regarded as the core of infrastructure. It offers new accessibility to future housing, recreation and other development.

Along with water management, they work with each other as a new sustainable development framework that allows more flexibility and resilience.

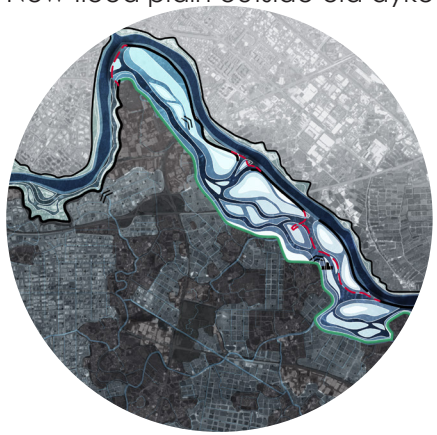



WATER SYSTEM STRATEGY
0 1km 2km 5km
New dyke
Demolished dyke
New flood plain
Constructed wetland
New creek & ditch
Current drainage creek & ditch
Expanded canal
New sluice
Current sluice
Current pump station
0 Current state with no classification of water system
1 Intervention 01: Create more space for river flood and rain storm as main flood drainage zone.
2 Intervention 02: Restore the capacity of drainage ditches and connect them to the new flood plain.
3 Intervention 03: Expand the ditches and existing canals into drainage corridors to improve the capability of temporal rain flood.


NEW FLOOD CORRIDOR AND FLOOD PLAIN CREATION
New dyke
Demolished dyke
New flood plain
Constructed wetland
New creek & ditch
Current drainage creek & ditch
Expanded canal
New sluice
Current sluice
Current pump station
0
1km
2km
5km
Central flood corridor based on historical creek
Lowered flood plain by transformation of fishponds
Surrouding flood plain by relocating of dykes

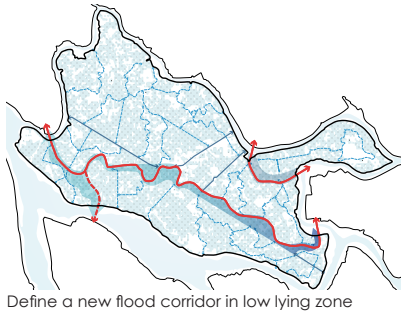
TYPOLOGY AND INTERVENTION

New flood plain outside old dyke





Renovate the historical creek

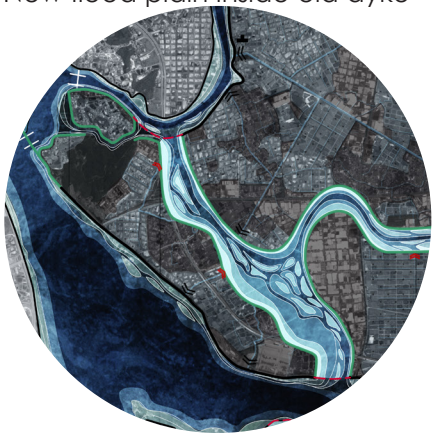


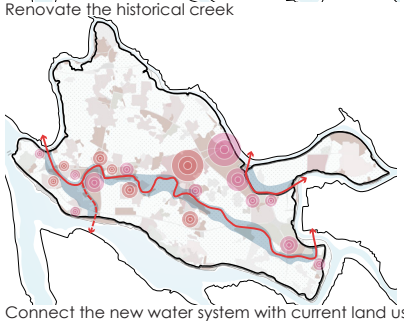
Define a new flood corridor in low lying zone

By relocating the current dyke landward, new flood plain for excessive river water could be created along the boundary of Xingtan county.

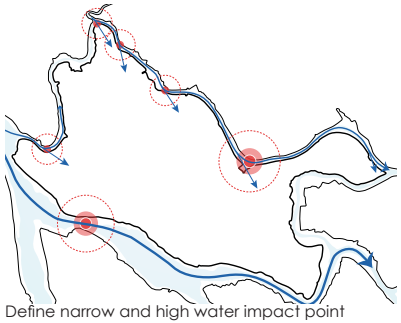


New flood plain inside old dyke



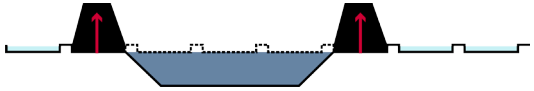


Connect the new water system with current land use



Define narrow and high water impact point

A central new flood corridor could be created by demolishing part of the existing dyke in fishpond pattern and re-use the soil for higher dyke construction.



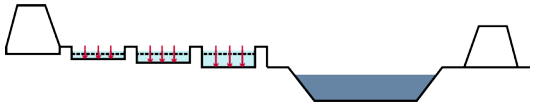
Lowered flood plain





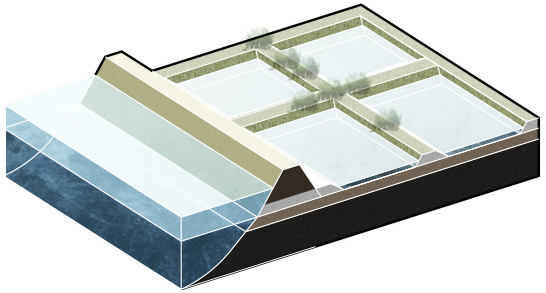
Lower the zone between dyke and river

The existing space between main river channel and dyke could be lowered to make excessive flood space for the river.

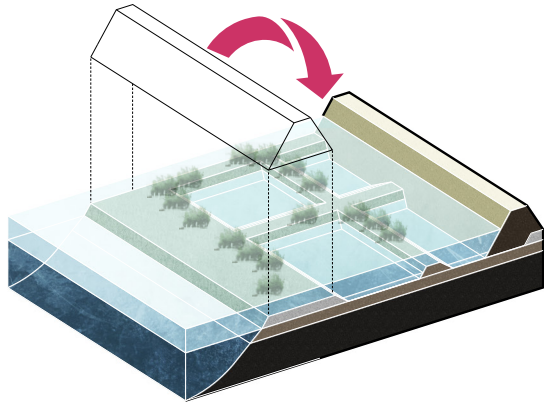


CREATE A NEW FLOOD PLAIN NEAR THE NORTH RIVER BRANCH

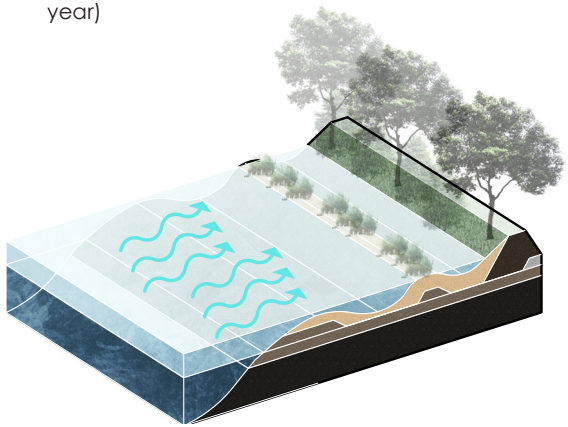
The flood not only comes from the nearby main watercourse of West river, but also from the branch of north river. However, the discharge is too narrow with a cape against its main direction. To mitigate the bottleneck effect and decrease the height of discharge in rain season, the current dyke was broken at three points to let the river flow into this zone, creating more space for temporal flood as a new water bypass.In addition, new possibilities are created for vegetation, birds and recreation in this zone because of its half open condition that makes the sediments from north river slow down and fall into this bottom between two dykes. Thus, the new ecologic flood plain would created soon in around 5 years as a new riverfront for people, animal and vegetation. The intervention mainly includes two phases: relocating the dyke and let the river flood inside to resotre the natural water dynamics. First, the dyke shall be relocated landward to create more space for river. Second, making use of the dyke-fishpond pattern and other method could increase the speed of sedimentation and create condition for ecology.



1 Current state (0 year)

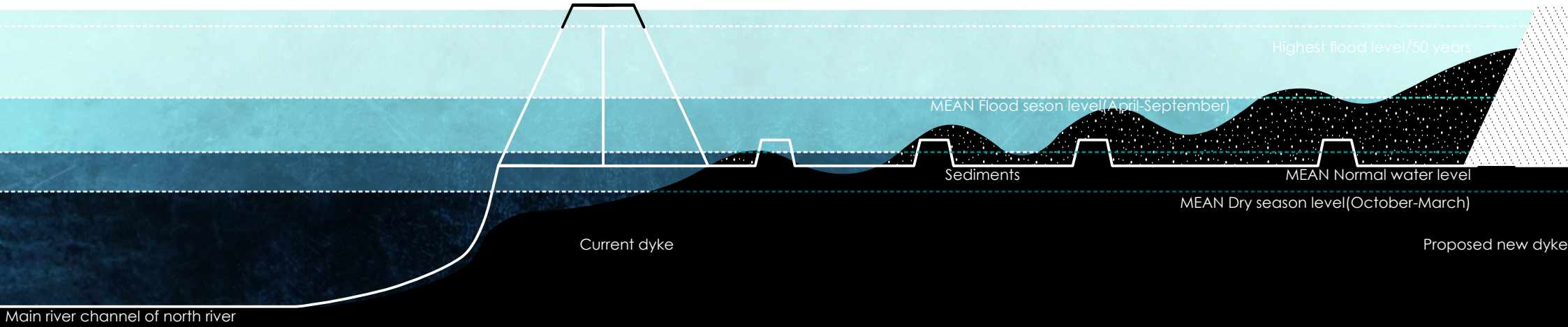


2 Relocate dyke landward to create flood plain (0-1 year)



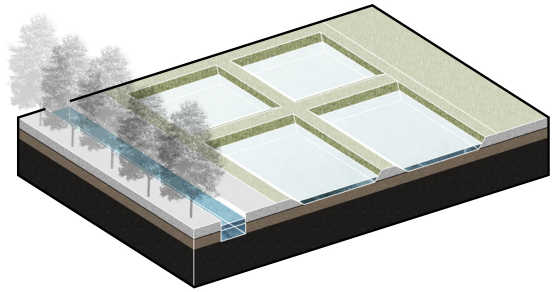
3 Make use of natural river dynamic to get sediments and let the marsh forms itself(1-5 year)

Sedimentation(sand & clay)
Concrete
Subsoil
Bottom soil

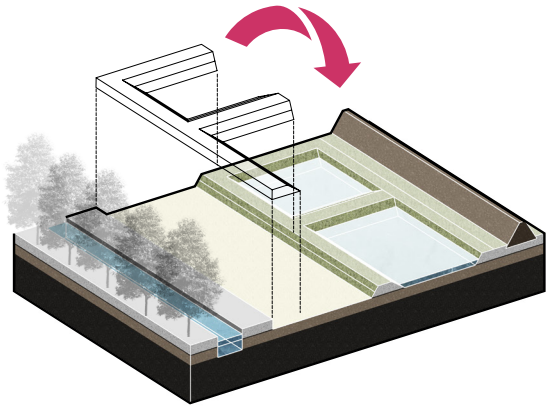


CREATE A NEW FLOOD PLAIN INSIDE THE DYKE

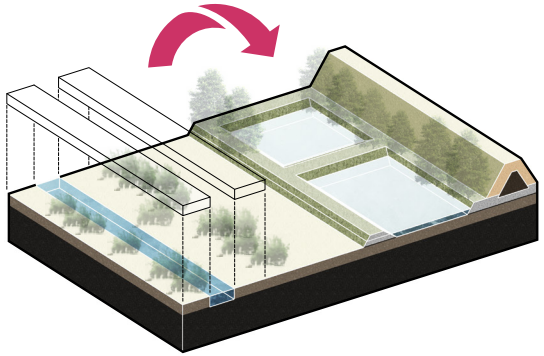
The creation of a new flood plain in the center of the county based on the historical creek would help to absorb excessive flood water and release it to the outer river when its water table falls. This intervention helps to solve the rain water flood and river flood at the same time by providing a new "room" for both water source. In addition, because the most dangerous time of a year for flood comes usually at September, when the external discharge and internal water table rises drastically at the same time, this flood plain offers a vital buffer between them. In addition, after construction and restoration, water dynamics could be brought back to the county which stimulates eco-system recovery.The main method of creating the flood plain is to connect the existing canal with surrouding dyke-fishpond. By partly relocating the dyke soil to make a higher and stronger dyke, this intervention makes a new flood corridor for the river to come inside the large dyke ring again. Thus current aqua-agriculture pattern could be transformed into a natural riparian zone step by step.



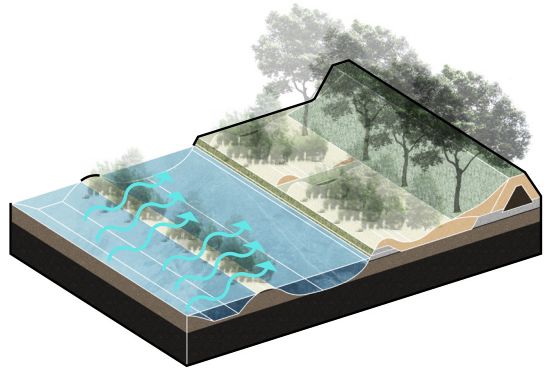
1 Current state (0 year)



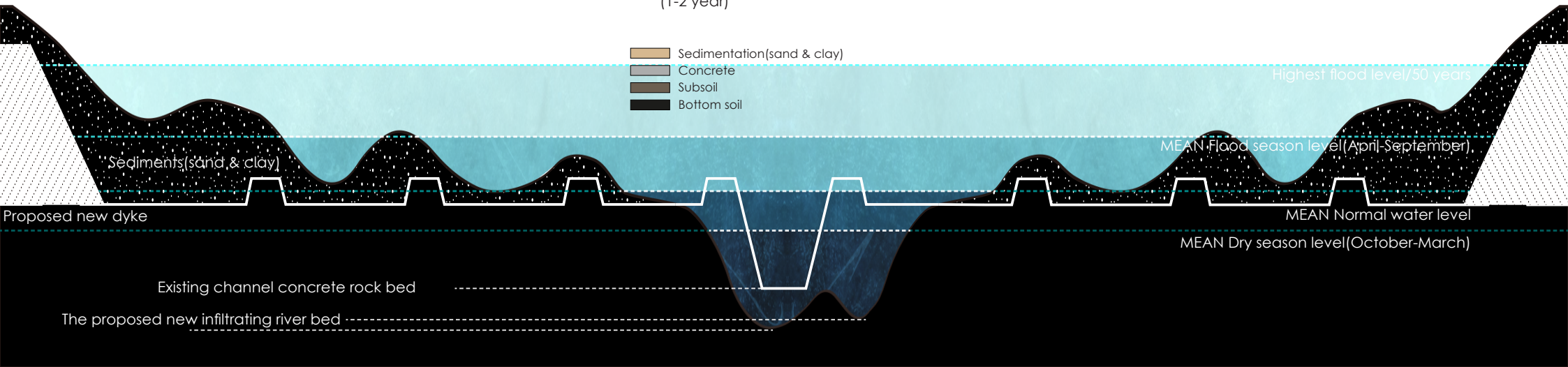
2 Relocate the small dykes (0-1 year)



3 Lower the flood plain and re-use the sandy soil (1-2 year)

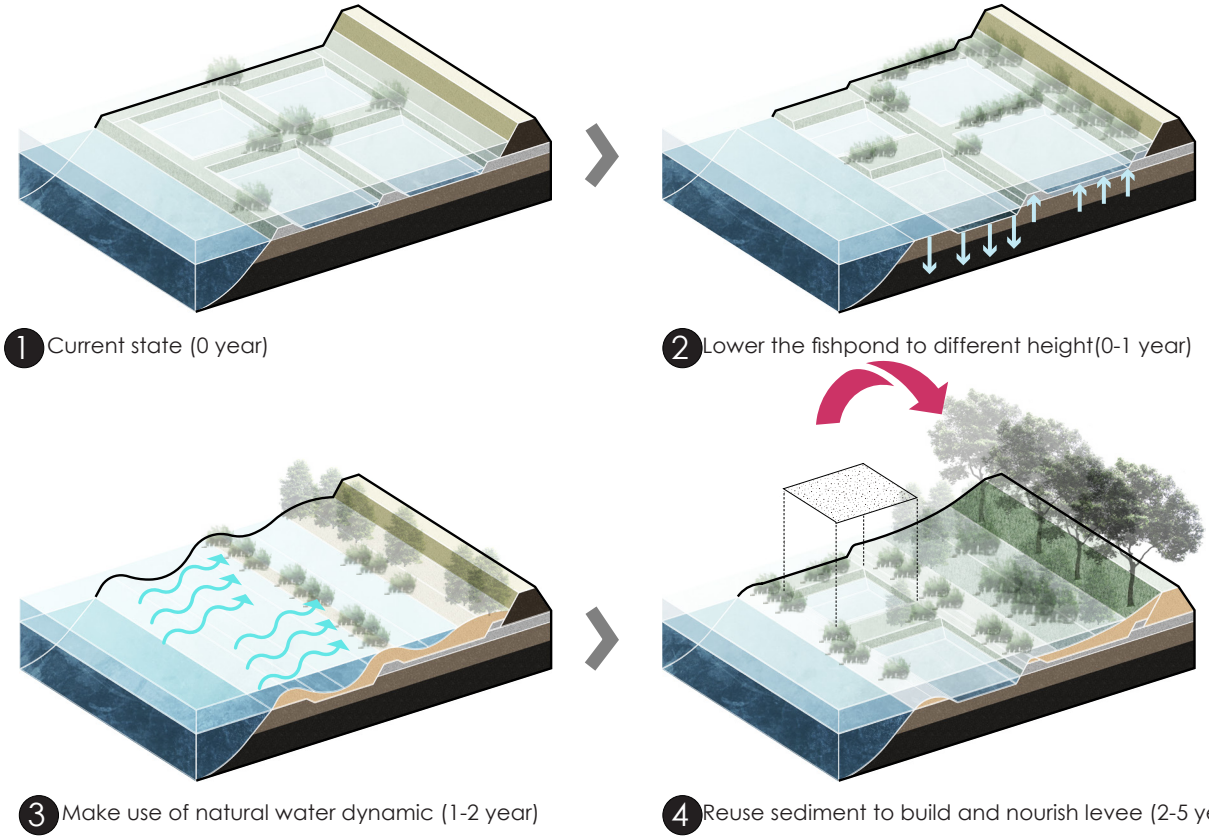


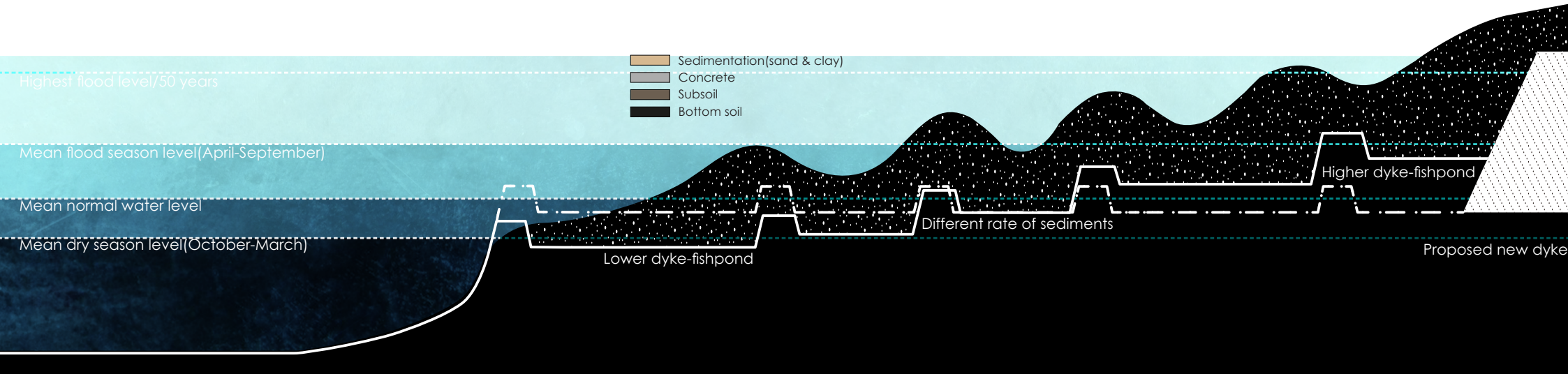
4 Work with natural flood (2-5 year)



CREATE NEW FLOOD PLAIN BETWEEN CURRENT DYKE AND RIVER

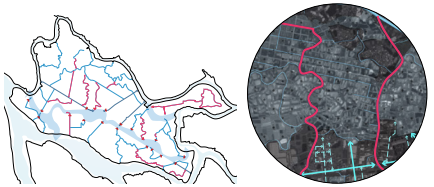
To make the most use of space around the main river, the zone between watercourse and dyke could be transformed in order to absorb more water and create condition for agriculture as well as sedimentation. The current space is filled with industry and dyke-fishpond with a rather high ground from the water table. Thus the intervention focuses on lower the ground level and reuse the soil to create a terraced dyke-fishpond profile. This action increases the gradient of flood frequency as well as sedimentation rate in different ponds with various height condition. By creating the subtle difference the fishponds near river could be flooded now and then, it's good for aquaculture where the fishs could feed on Shrimp and microbes from the river. In addition, the higher ponds remain safe for longer time and get more sediments from the river, which is a good condition for agriculture.



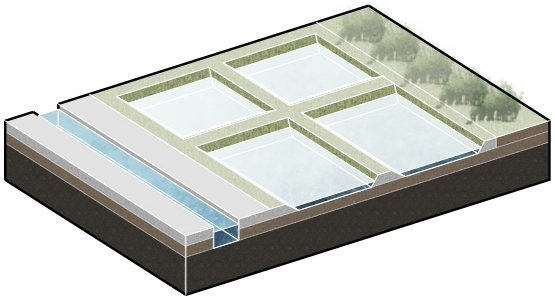



RESTORATION OF DITCH AND CANAL EXPANDING
New dyke
New urban drainage ditch & creek
New urban drainage ditch
Expanded urban canal
Current drainage creek & ditch
New sluice
Current sluice
Current pump station
0
1km
2km
5km

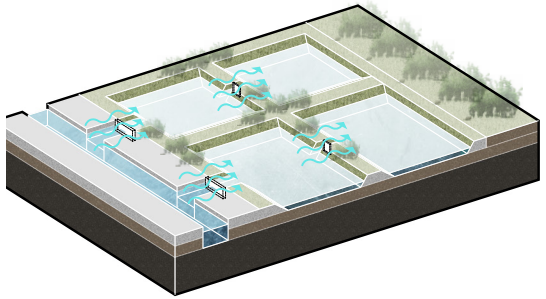
TRANSFORM A NEW RURAL DITCH SYSTEM TO A DRAINAGE AND PURIFICATION SYSTEM



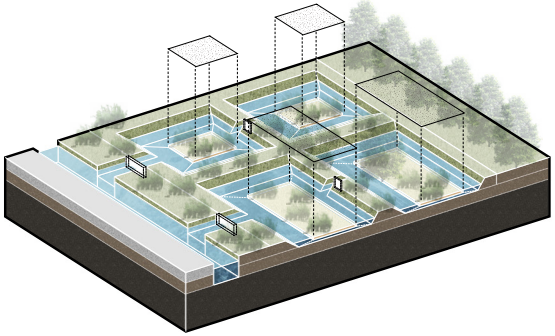
After creating the central flood plain and surrouding flood plain that offers more space for river flood. the drainage ditch inside the dyke shall be connected to these flood plain so the excessive rain water cloud also be drained quickly into the flood plain. When there's not enough water inside the dyke for daily use and irrigation, these ditches are vital to bring river water from the new flood plain into villages and towns, so that people could use them after purification process. This intervention regards these drainage ditches or creeks as important connections that can work in both direction. In addition, by creating constructed wetland in the fishpond near them, the water coming inside could be temporarily stored and cleaned in them. After that, it could be used for irrigation, or pumped out with better quality to the river.The intervention mainly includes three phases: First, make open connection between canal and surrouding fishponds with controllable sluice so that the river water could flow into ponds by openning them. Second, build a floating platform that could trap sediments with local material like bamboo and tree branchs for a floating wetland. Third, make use of natural process to let the river water inside ponds for nutrient sediments that could serve as a base for wetland vegetation to come.



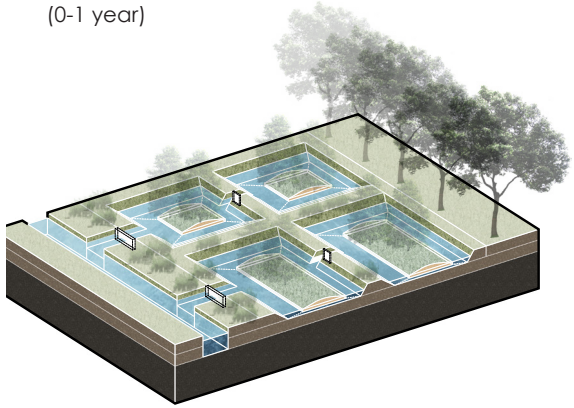
1 Current state (0 year)



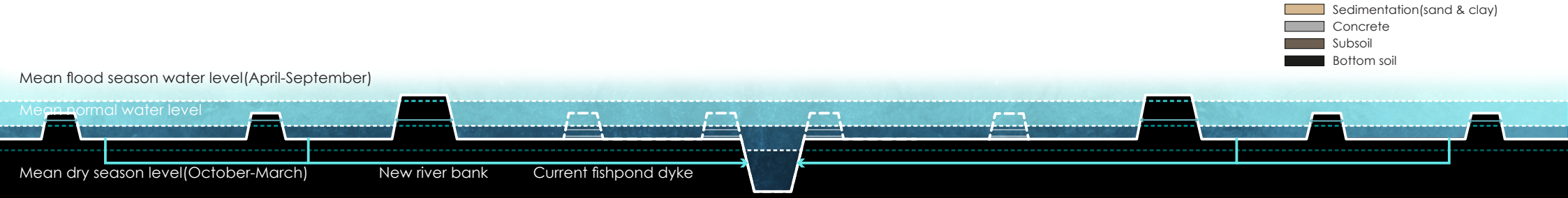
2 Connect the fishponds with ditches via water sluice (0-1 year)



3 Construct floating frame to trap nutrient and soil for wetland vegetation(1-2 year)



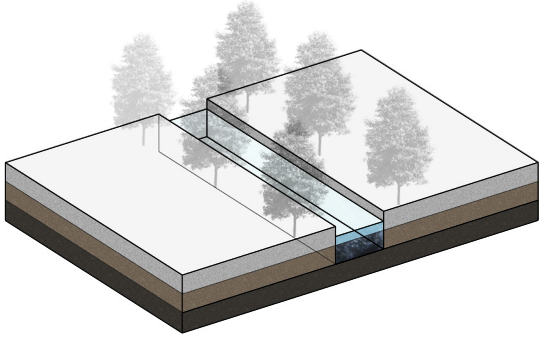
4 Make use of the natural process to construct wetland (2-5 year)



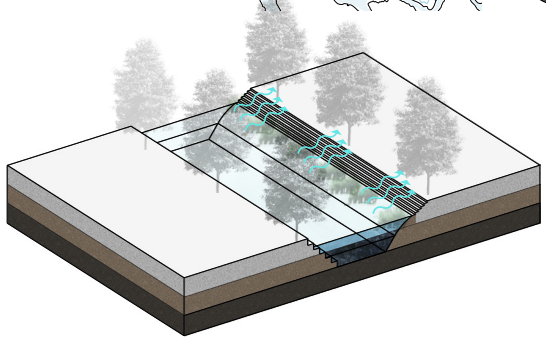
TOOL KIT AND INTERVENTION PHASES



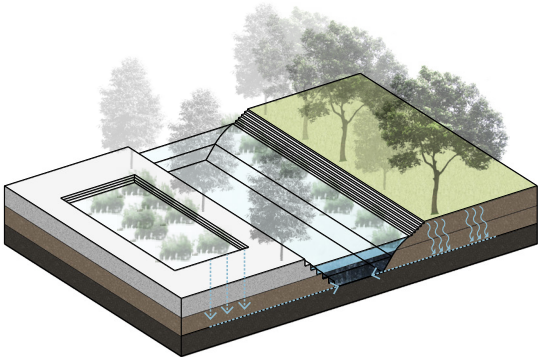
Not like in the rural context where there are enough space for water, the urbanized zone is condensed and it's hard to find more space. Thus the method is to make the most use of current city canal by expanding the capacity and create natural river bank along it. In addition, the street profile could also be enhance towards water absorbing by integrating water ditches into it. In addition, intervention like water plaza and roof park could also be utilized to store temporal rain water during flood season. Last but not least, the existing dyke-fishponds around the city could be connected to these ditches so the excessive water could be drained quickly to them.The intervention mainly includes three phases: First, expand the current canal creating more space for water. Second, break the concrete river bank and create a soft edge with permeable soil that let the rain water absorbed by it. Third, make water plaza and roof parks and connect them to the canals and water ditches in the city.



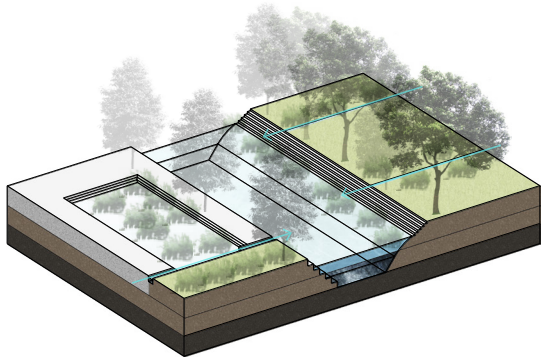
1 Current state (0 year)



2 Expand the canal and create terrace (0-1 year)

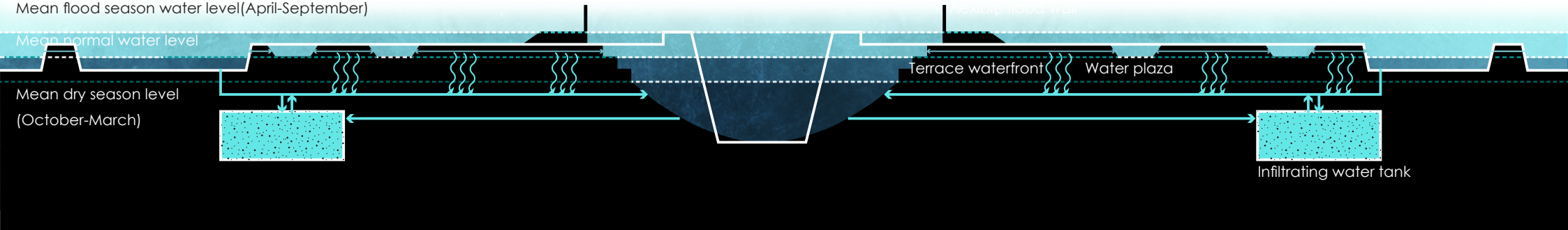


3 Dechannelize the bank into soft edge and build water plaza (0-1 year)



4 Connecting the city drainage to canal and restore the water dynamics(2-5 year)

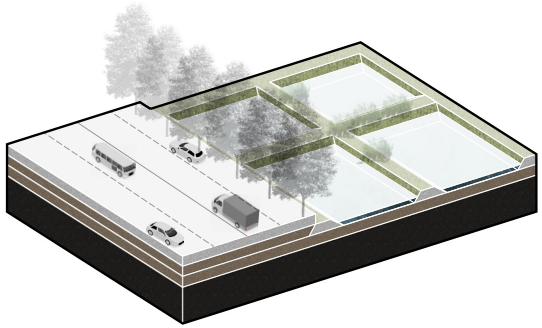
Sedimentation(sand & clay)
Concrete
Subsoil
Bottom soil



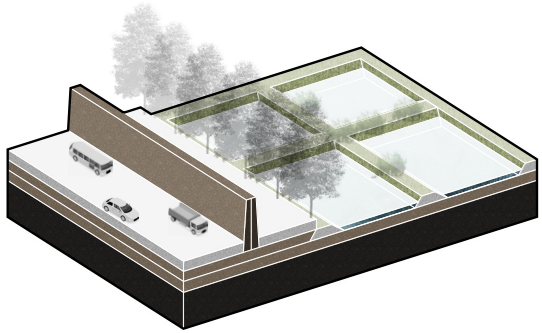

INFRASTRUCTURE STRATEGY
0 1km 2km 5km
Demolished road
Main road
Secondary road
Existing road
0 Intervention 01: Demolish roads for new flood plain.
1 Intervention 02: Create new road infrastructure(public transportation) based on the new dyke as a core of infrastructure.
2 Intervention 03: Connect the main road to the new core infrastructure and define linkages to the existing roads.
3 Intervention 04: Define a new secondary road system based on the dyke-fishpond pattern and walking&biking distance.

INTEGRATE THE INFRASTRUCTURE INTO WATER MANAGEMENT

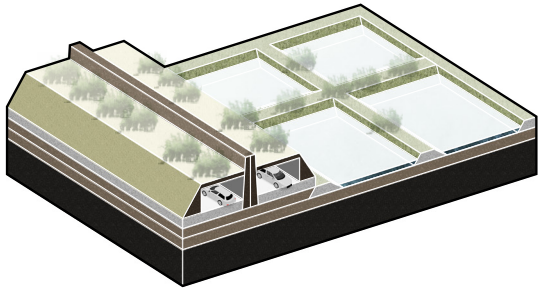
The main intervention of infrastructure is to create a integrated system with water management and multiple transportation like boats, bikes and public transport. After constructed, the new central dyke could be combined with current road system and the new tram line and bike path could integrated on the dyke top. In addition, the new pier that offers water transportation could be arranged with the sluice to make use of the transportation priority. In addition, the current main road could be linked with part of the dyke top and a new road system of car and biking path would be combined.



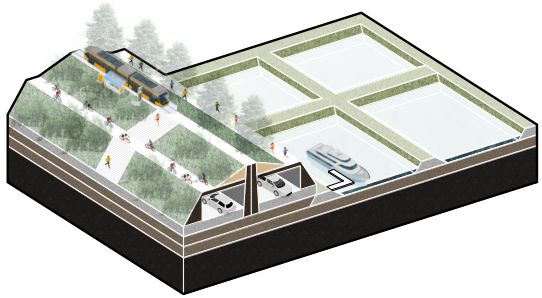
1 Current state (0 year)



2 Build up the dyke core (0-2 year)

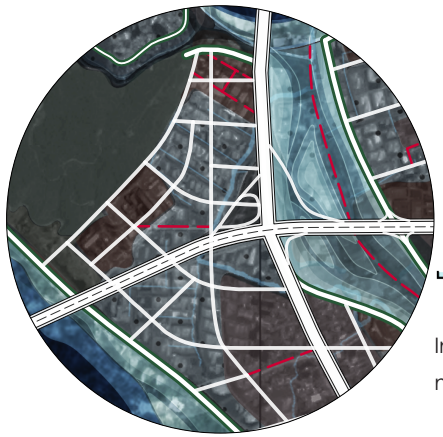


3 Cover the existing road with the dyke (2-3 year)



4 Integrate tram, biking path, pedestrian path and new pier to the dyke (3-5 year)

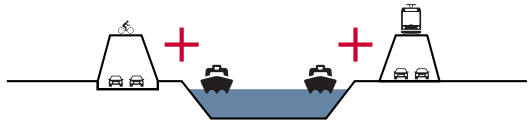
Sedimentation(sand & clay)
Concrete
Subsoil
Bottom soil





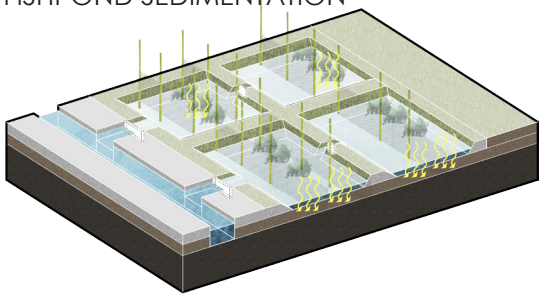
Integrate the current road infrastructure into water management



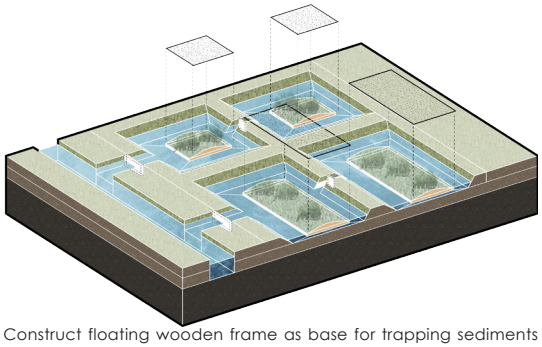


Renovate water transportation and integrate it with new public transport

FISHPOND SEDIMENTATION

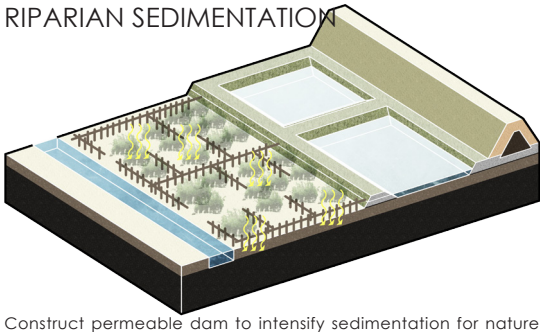


Use the fishnet to trap the nutrient-rich soil in fishpond for agriculture

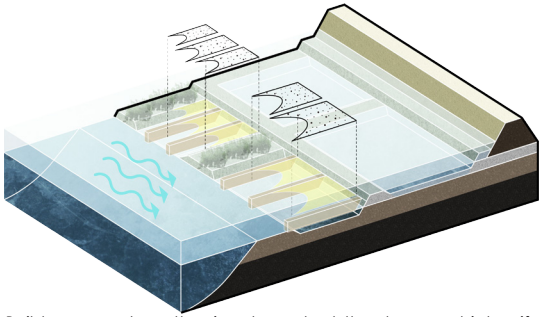


Construct floating wooden frame as base for trapping sediments and wetland construction
water purification

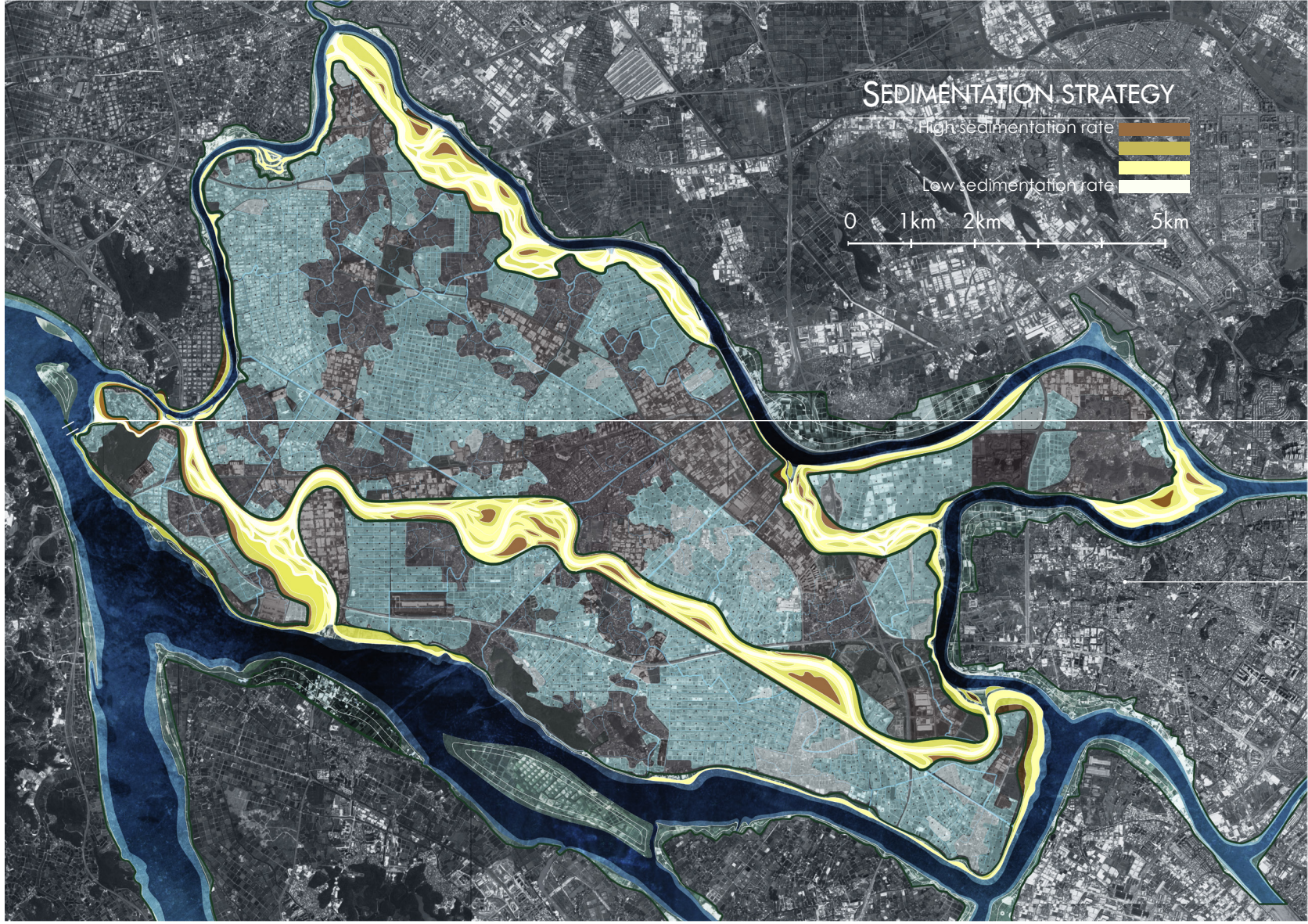
RIPARIAN SEDIMENTATION



Construct permeable dam to intensify sedimentation for nature restoration



Build groyne along the river to protect the shore and intensify sedimentation for river ecology restoration





Fishnet



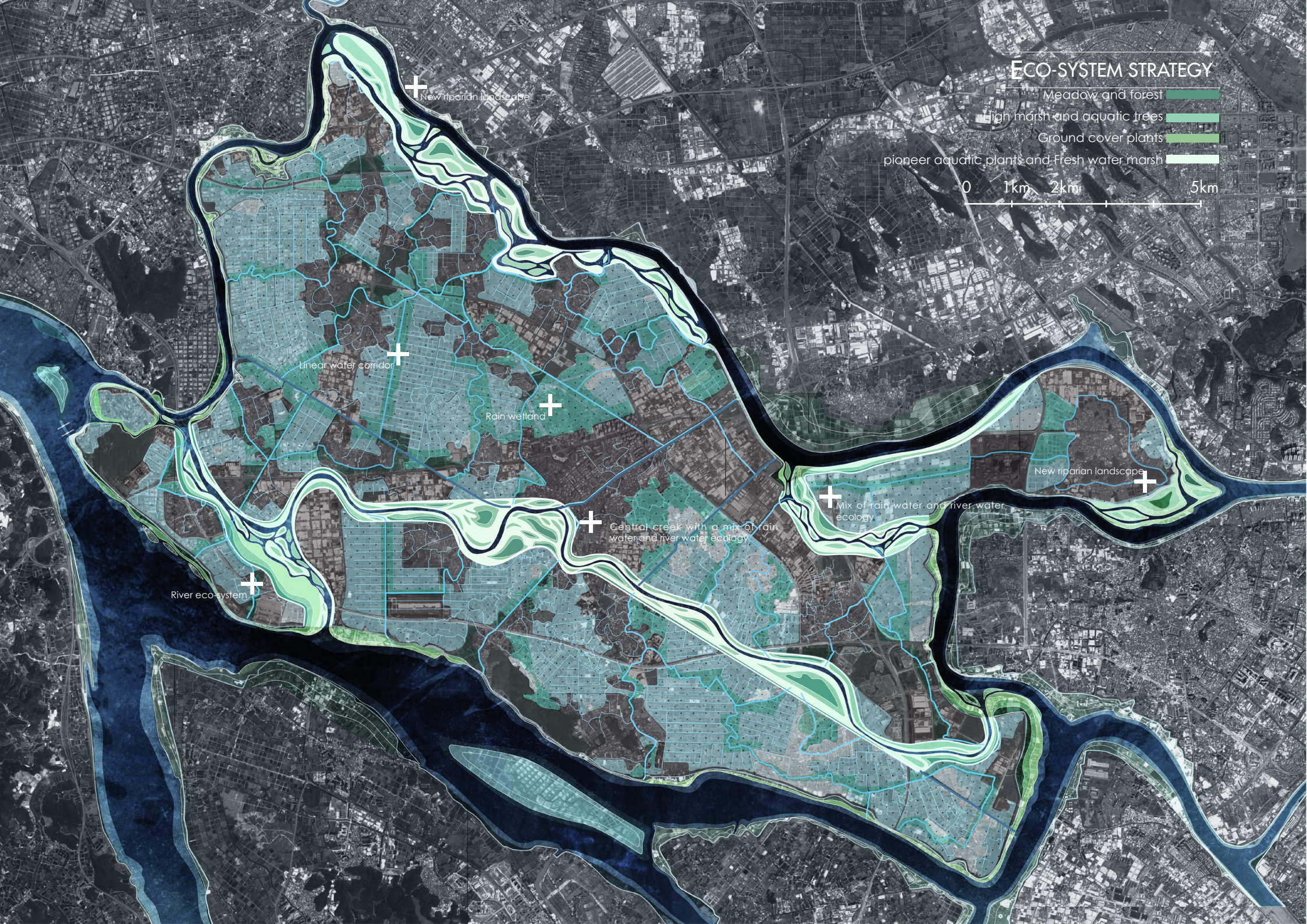
Floating wetland



Permeable dam



Groynes


ECO-SYSTEM STRATEGY
Meadow and forest
High marsh and aquatic trees
Ground cover plants
pioneer aquatic plants and Fresh water marsh
0
1km
2km
5km
New riparian landscape
Linear water corridor
Rain wetland
Central creek with a mix of rain water and river water ecology
Mix of rain water and river water ecology
New riparian landscape
River eco-system

ECO-SYSTEM AND PHASING

After the condition is made for different rate of sedimentation and flood frequencies, vegetation succession could happen naturally from aquatic plants to meadow which provide various biotopes for flora and fuana to thrive. Biodiversity could be enhanced for a more steady eco-system and this riparian zone would serve as a ecological corridor as well as flood buffer that offers recreation and multiple use.

Fauna



Flora



0. Current dyke-fishpond

1. Pioneer aquatic and low marsh plants

Ceratopteris thalictroides
BraseniaschreberiJ.F.Gmel
Nymphaea tetragona
Glennia littoralis Fr. Schmidt ex Miq

2. Ground cover plants and high marsh plants

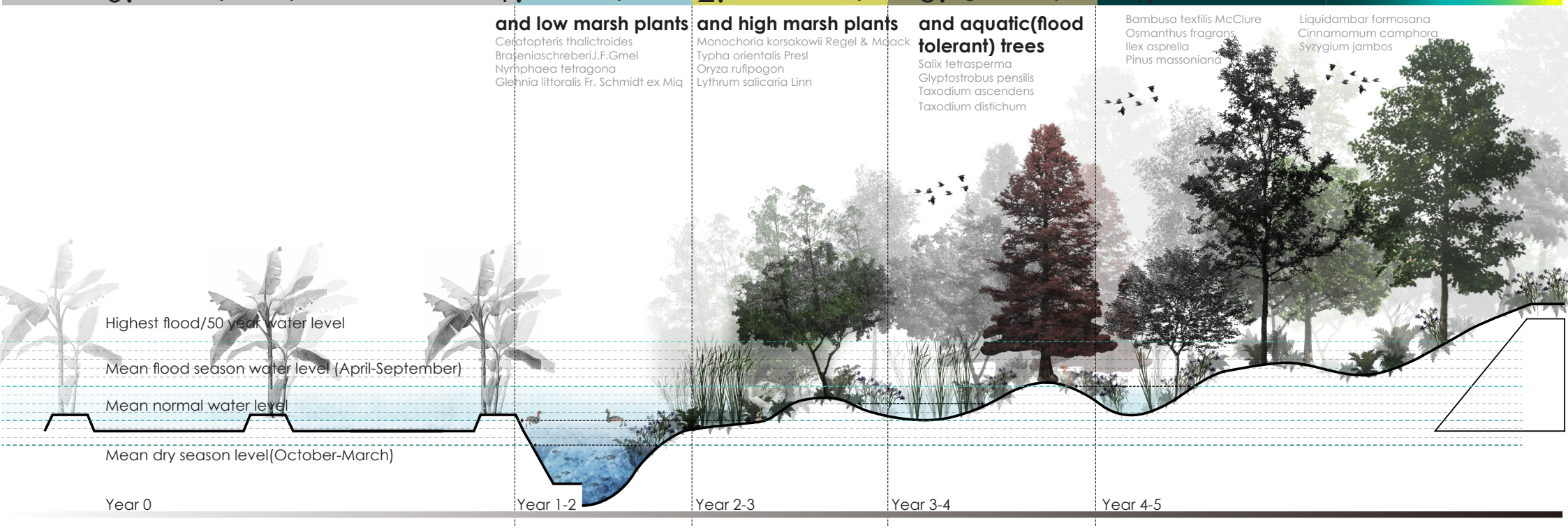
Monochoria korsakowii Regel & Maack
Typha orientalis Presl
Oryza rufipogon
Lythrum salicaria Linn

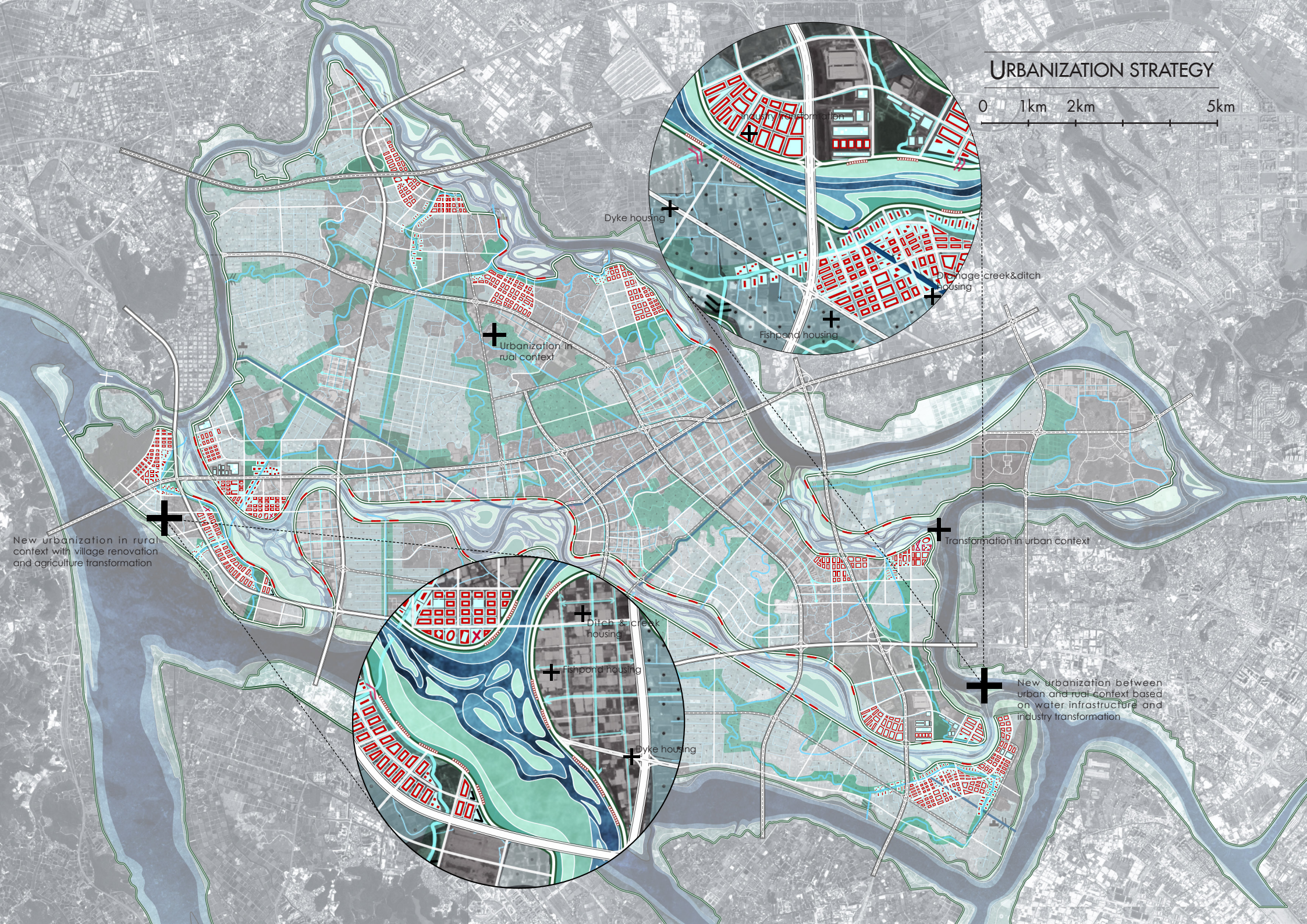
3. High marsh plants and aquatic(flood tolerant) trees

Salix tetrasperma
Glyptostrobus pensilis
Taxodium ascendens
Taxodium distichum

4. climax community

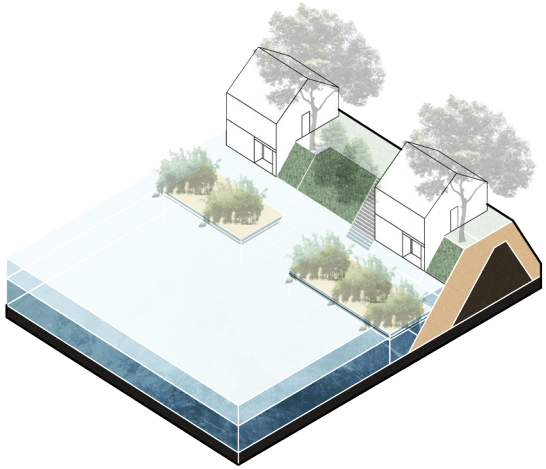
Bambusa textilis McClure
Osmanthus fragrans
Ilex asprella
Pinus massoniana
Liquidambar formosana
Cinnamomum camphora
Syzygium jambos



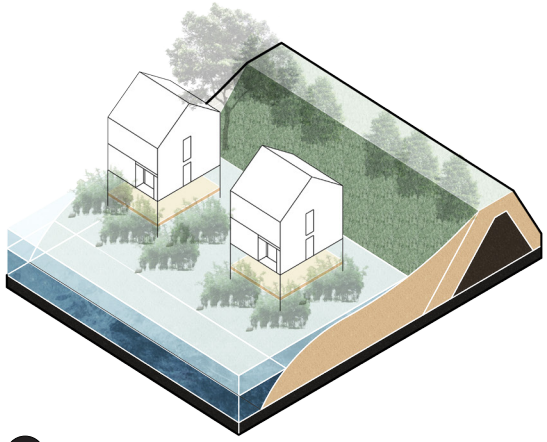

URBANIZATION STRATEGY
0 1km 2km 5km
Industry transformation
Dyke housing
Drainage creek&ditch housing
Fishpond housing
Urbanization in rual context
New urbanization in rural context with village renovation and agriculture transformation
Transformation in urban context
Ditch & creek housing
Fishpond housing
Dyke housing
New urbanization between urban and rual context based on water infrastructure and industry transformation

HOUSING TYPOLOGY

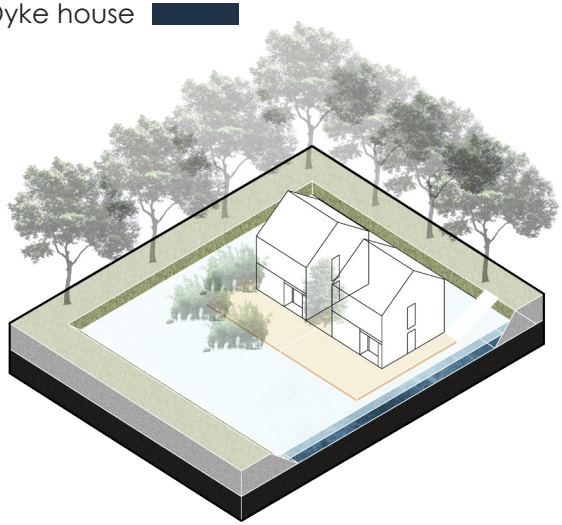
The new type of urbanization is arranged between infrastructure and water manageement zone so that it could utilize the facilities from urban zone and recreation from natural riverfront. In order to deal with different fluctuation and remain the water capacity, the principle is to construct new housing without taking place of the current pattern. Four housing typology is developed here in order to deal with different fluctuation in the new flood plain, along the drainage ditches or creeks and inside the dyke-fishponds.



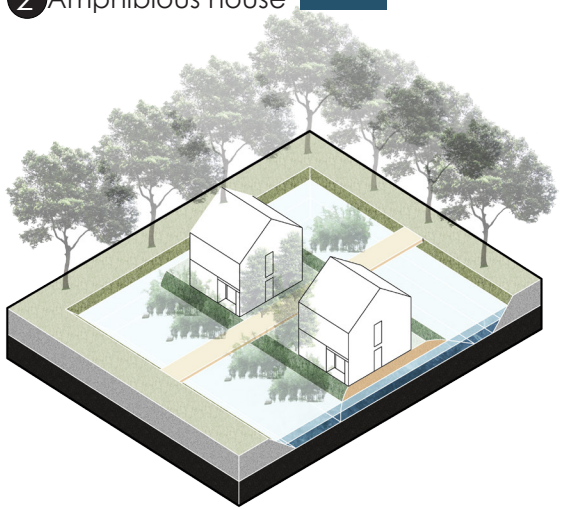
1 Dyke house



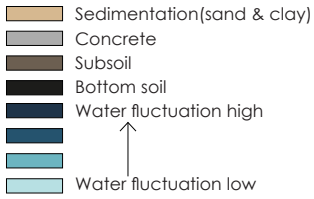
2 Amphibious house

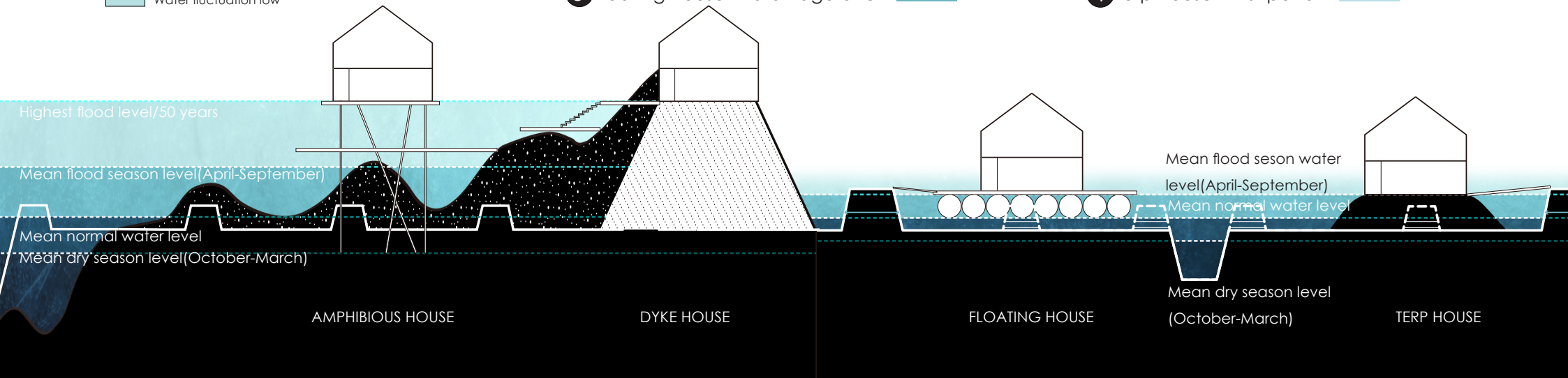


3 Floating house in drainage ditch



4 Terp house in fishpond



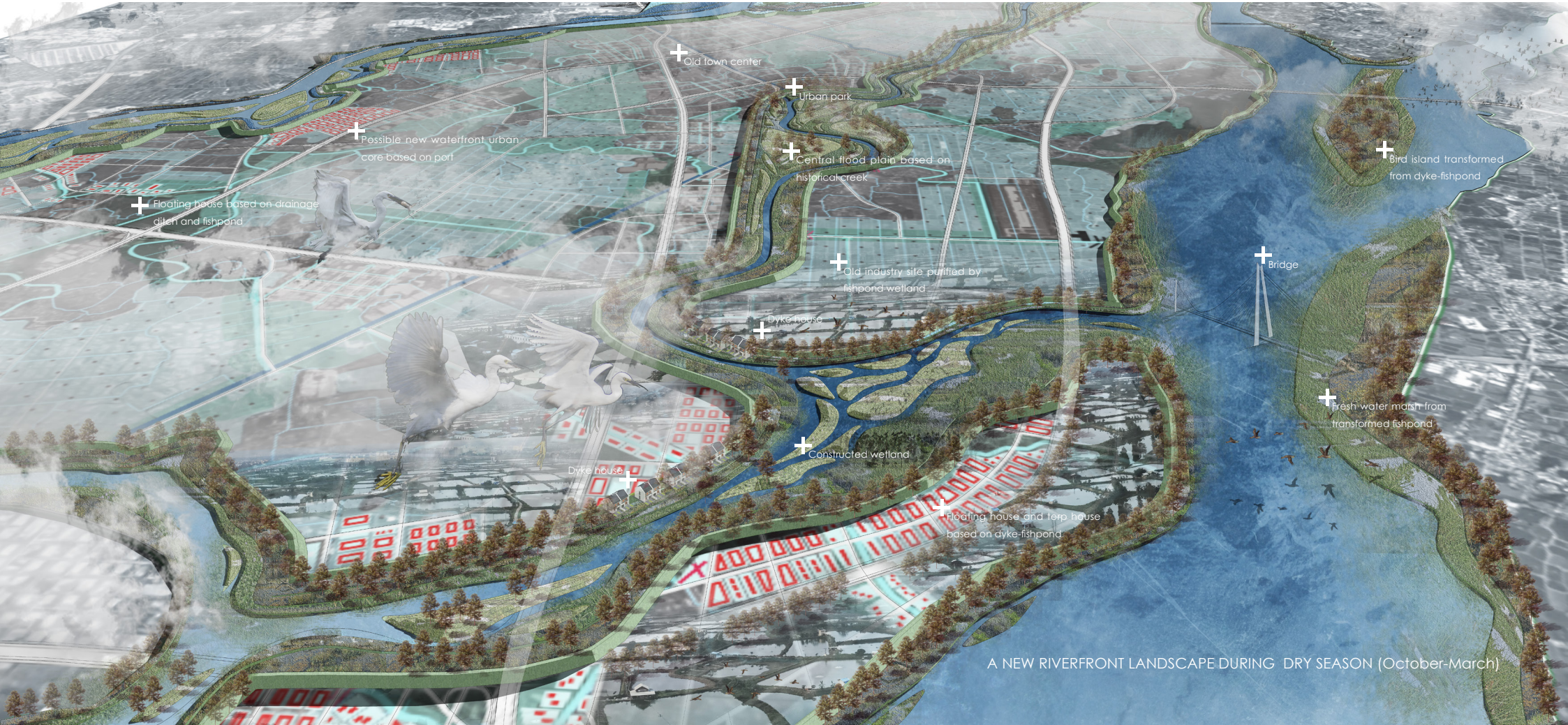


VISION

A NEW RIVER DELTA LIFE

The new water management and infrastructure not only makes a sustainable framework that could contribute to water safety, ecology and urbanization, it also illustrate a "new" paradigm of living with water, which has been witnessed for over millennium. As a result, this intervention restore the relationship between human and pearl river delta from confrontation to symbiosis by binding river landscape, public life and new dwellings together. The fluctuation of water and changing landscape is shown to people living here again, as it did thousands of years ago.

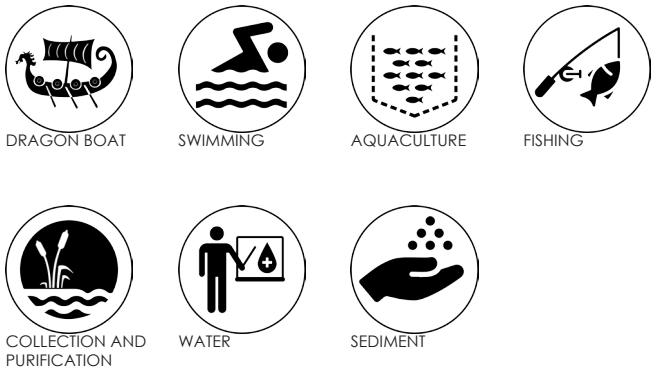


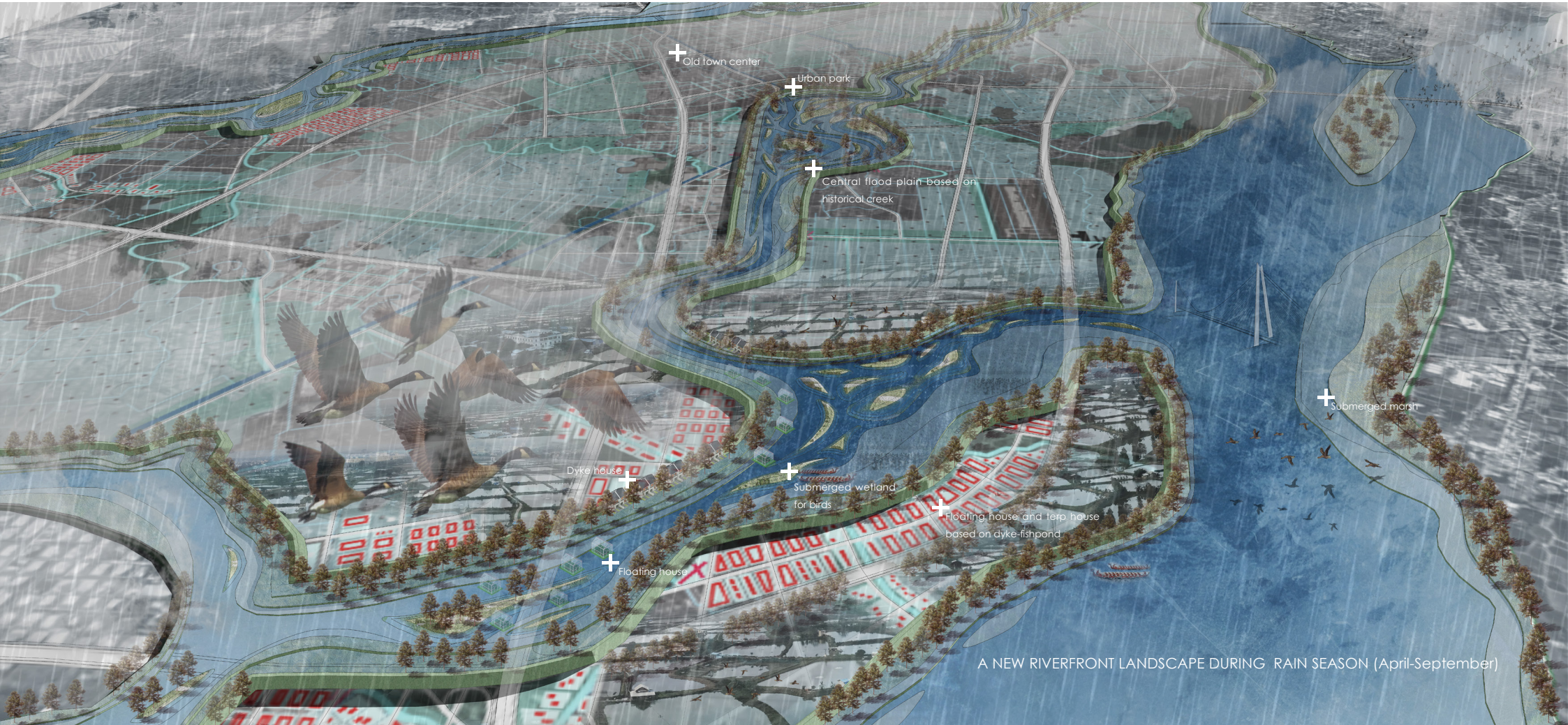


A NEW RIVERFRONT LANDSCAPE DURING DRY SEASON (October-March)

AN ILLUSTRATION OF WORKING WITH FLOOD

As is witnessed for a long time, the river has always been a threat to people living here. However, this awareness was gradually lost recently by the huge engineer construction of dyke system. This method was yet proven not working well after serious flood in the whole region. This intervention takes a stand that water flood is more an opportunity than a disaster which shall be covered from people. A positive host of excessive water is far more effective than negatively defending it, as is proven in countries like Netherlands. This intervention illustrates a new way of dealing with flood based on traditional principle in this region and aims to offer a tool kit for future urbanization not only in Shunde district, but for the whole Pearl River Delta.





A NEW RIVERFRONT LANDSCAPE DURING RAIN SEASON (April-September)

VISION

RECREATION AND TRANSPORTATION IN FLOOD PLAIN

During dry season, the higher flood plain could be reached by the connected transportation and activities like biking, jogging and camping could happen.


JOGGING


BIRD WATCHING


FISHERMAN MARKET

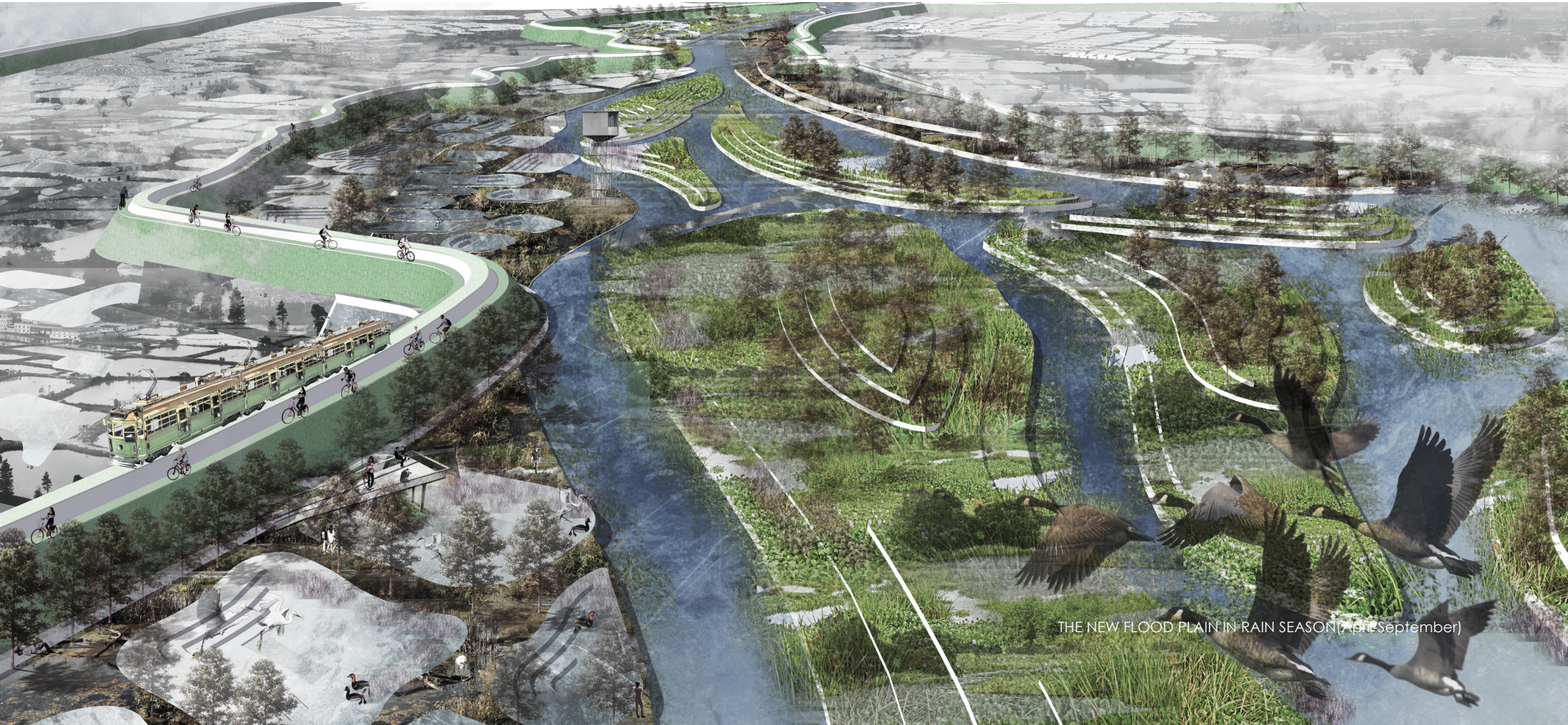

BIKING


CAMPING


OUTDOOR SPORT


RIPARIAN AGRICULTURE


AQUACULTURE


THE NEW FLOOD PLAIN IN RAIN SEASON(April-September)

RECREATION AND TRANSPORTATION IN FLOOD PLAIN

During rain season, activities like water sport, especially the traditional water festivals like dragon boat match could be host. Bird watching and ecology observation & education could also take place.


DRAGON BOAT


SWIMMING

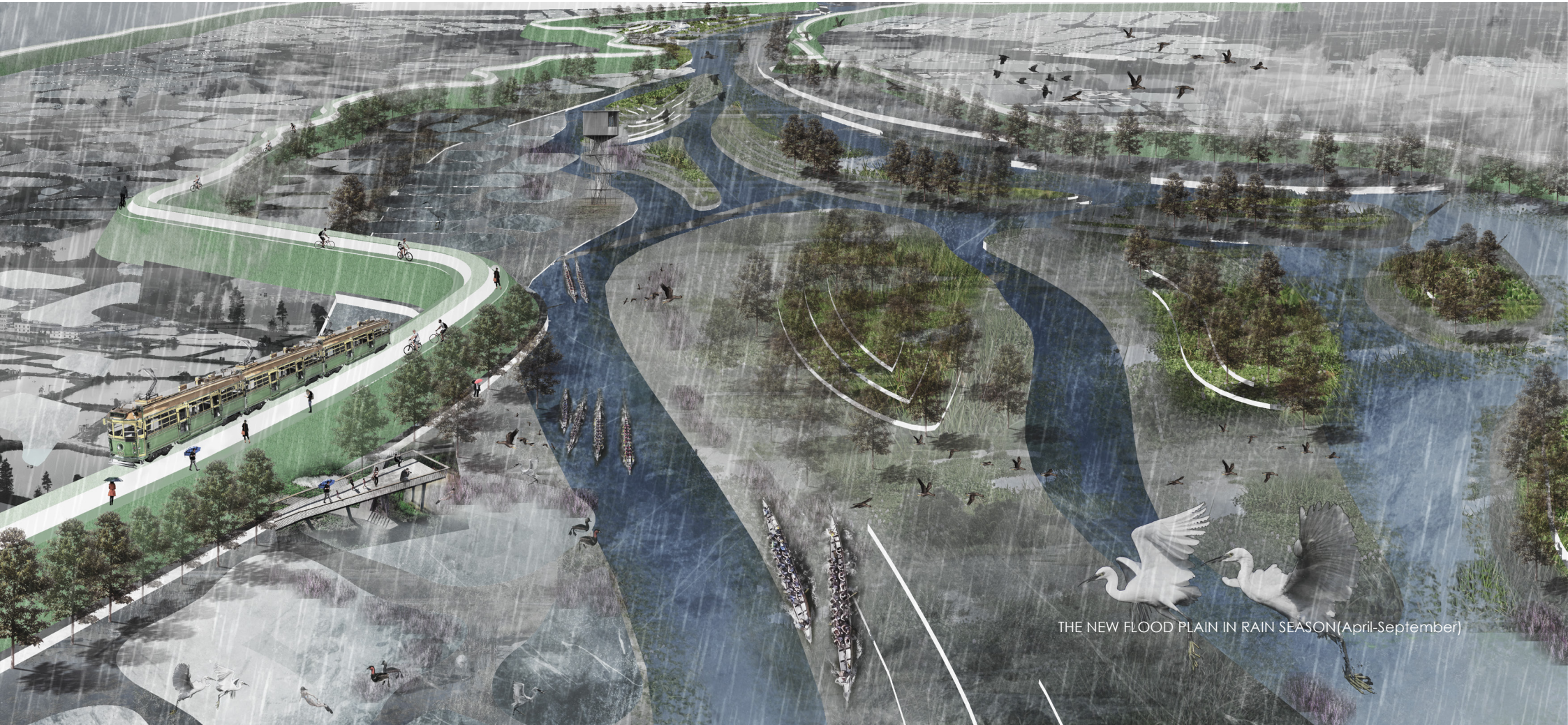

AQUACULTURE


FISHING


COLLECTION AND PURIFICATION


WATER


SEDIMENT

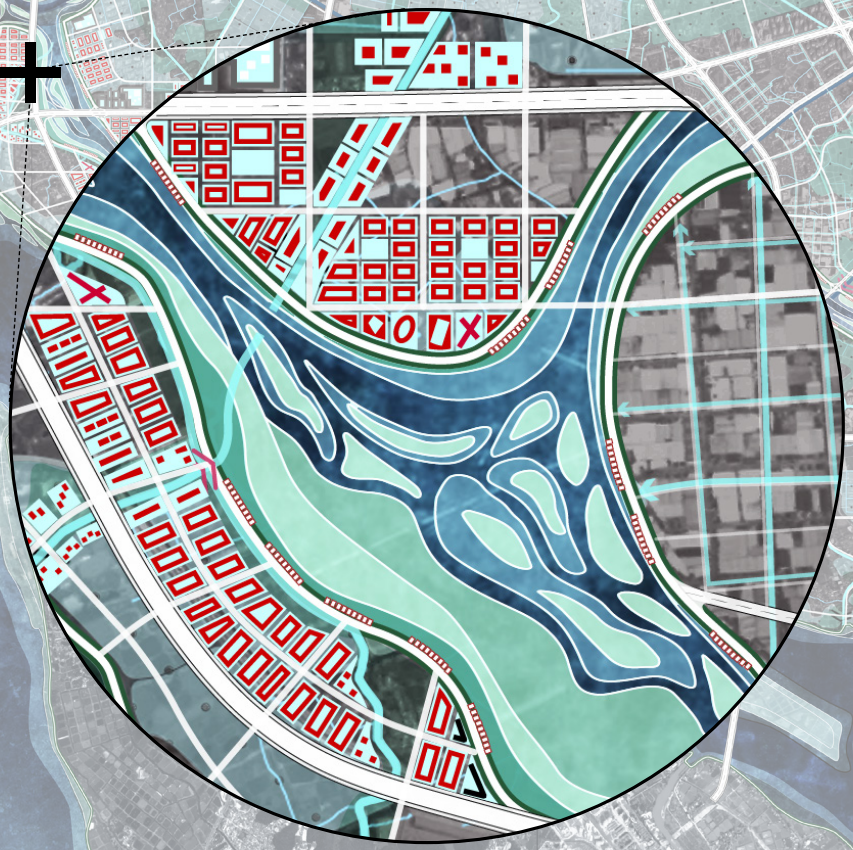


THE NEW FLOOD PLAIN IN RAIN SEASON(April-September)

06. DESIGN EXPLORATION AT LOCAL SCALE IN RURAL CONTEXT

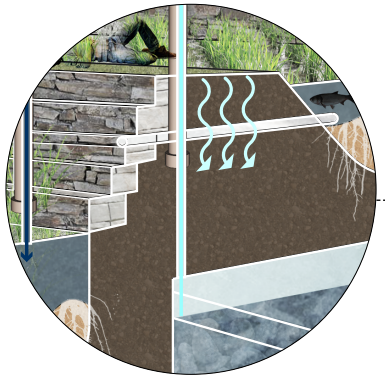
I.BACKGROUND ANALYSIS
II.PLAN FOR LOCAL SCALE
III.NODE DESIGN
IV.THEMATIC PLAN AND PHASING
V.DETAIL DESIGN
VI.VISION

ELLABORATION OF RURAL CONTEXT

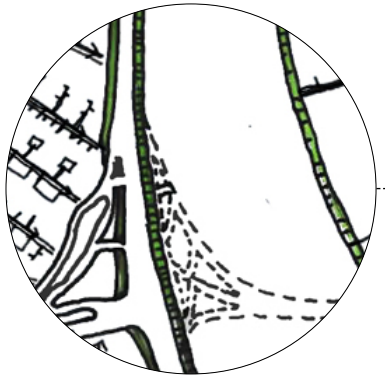



Dyke
Dyke-fishpond
Canal
Ditch
Historical creek
CURRENT LANDUSE
Current dyke
Canal
Dyke-fishpond
Modern urbanization
Industry
Forest
Current dyke
Infrastructure
Water sluice
Port
0
0.5km
1km

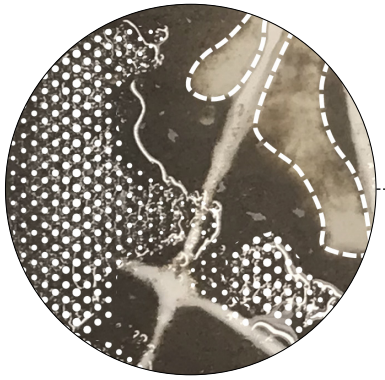

PLAN FOR LOCAL SCALE
0
0.5km
1km



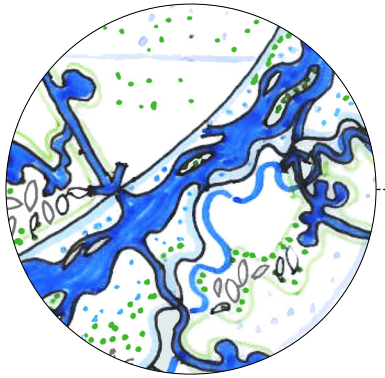
Amphibious housing and water circulation



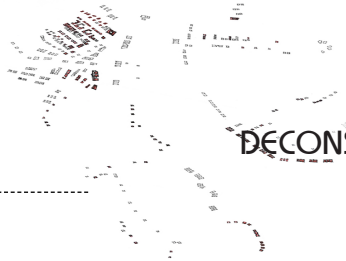
Transportation development



Ecology development(sedimentation pattern)



Water dynamic study



DECONSTRUCTED LAYER OF PLAN

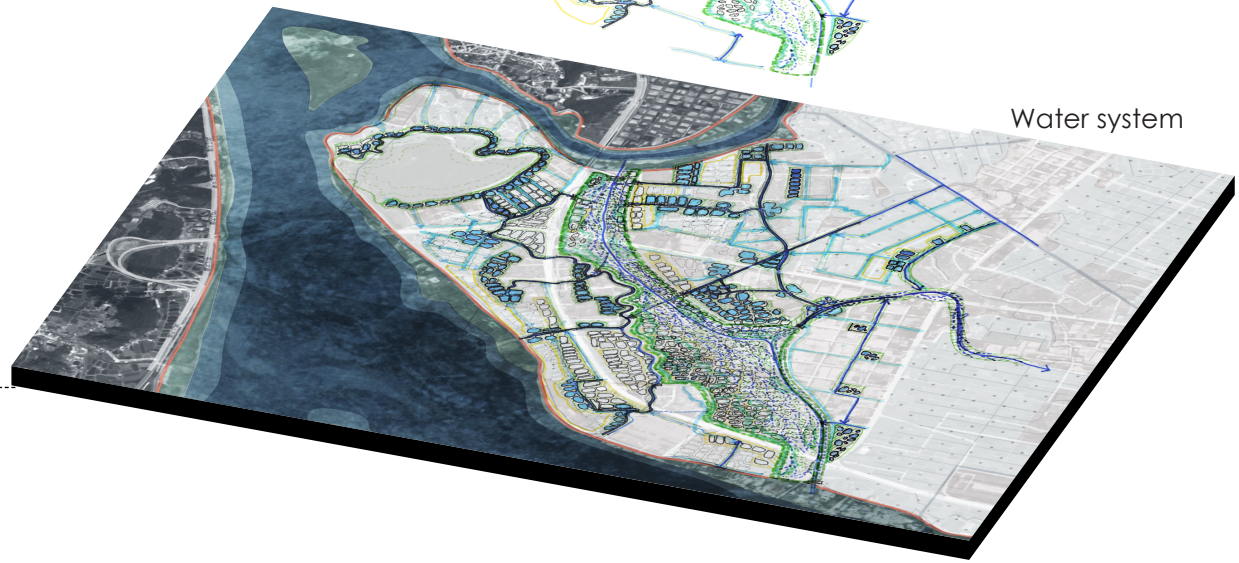
Urbanization system



Infrastructure system



Sedimentation&
Eco-system



Water system

WATER SYSTEM STRATEGY

The river takes its time to restore itself after proper condition is created, so it's important to take the process into consideration, during which the different erosion and sedimentation would happen. In addition, the river morphology decides where is the possible place for new vegetation and where is better for new housing development.

New dyke
Expanded canal&creek
Drainage ditch
Restored historical creek
Current drainage creek & ditch
New sluice

0 0.5km 1km



1 Develop phase 01(0-1 year)

Create new flood plain for the river and expand the canal by combining dyke-fishponds around it



2 Develop phase 02(1-3 year)

The river flourishes itself during flood season and a braided water system is gradually formed due to the topography. The surrouding ditches are connected to the flood plain combining with fishponds.



3 Develop phase 03 (3-5 year)

By controlling the flood into new flood plain and drainage ditch, the natural dynamic is gradually restored and a new braided river system is formed. When connecting it to smaller ditches it could be used for drainage and water collection.

SEDIMENTATION EXPERIMENT

01(concrete dyke)

In order to test the sedimentation pattern to trap sediments in proper place, a lay model was built with sand on the top of it. Since large part of the dykes are made out of concrete in the county as a stable boundary for mass fish production, there would be more sediments harvested in these ponds without getting rid of the concrete. The experiment found that more sediments tend to be aggregated in the ponds close to the dyke. Thus making good use of this knowledge means we can trap more sediments for ecology using the current pattern.



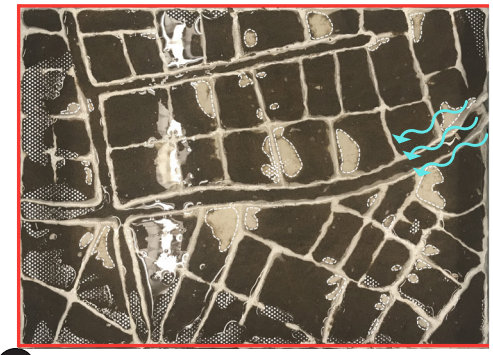
0 Develop phase 00 (0 year)

Current state with dyke-fishpond pattern. Large part of the dyke now is made out of soil with concrete surface to prevent erosion.



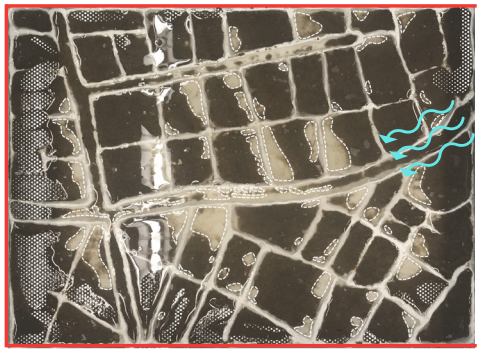
1 Develop phase 01 (0-1 year)

After the river comes into the flood plain again, the sediments will aggregate in ponds in different rate. The erosion happens in the ponds near the canal.



2 Develop phase 02 (1-2 year)

The sediments in the river would be carry further into ponds around dyke. In addition, the erosion caused soil lost in ponds near the canal and they would be pushed by river into the ponds at the end of dyke edge.

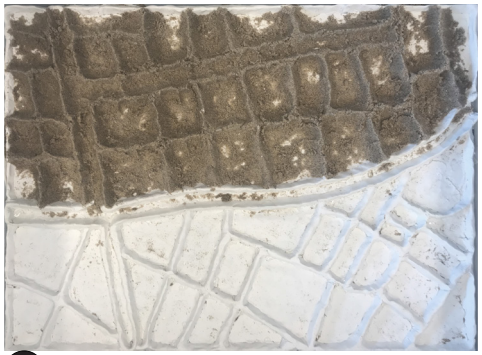


3 Develop phase 03 (2-5 year)

The final sedimentation pattern after several times of river flood simulation

02(mud dyke)

After demolishing the concrete surface of dyke-fishpond, an experiment was made especially for testing the erosion pattern after bringing the river into the flood plain. The result is that the conjunction point of current mud dykes could remain for longer time where the pioneer vegetation might happen. As time goes by the pattern of dyke-fishpond would be totally transformed by water dynamics into a braided river morphology. Thus a consideration of initial recreation place for first several years could be taken on these stronger points.



0 Develop phase 00 (0 year)

Current state with demolished concrete dyke surface.



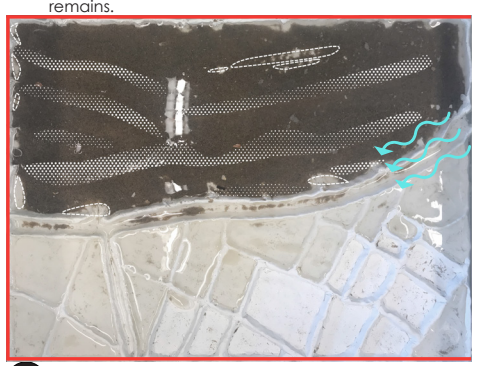
1 Develop phase 01 (0-1 year)

The river comes into the flood plain and make a erosion to the grid pattern. The main erosion happens around the linear dykes while the conjunction part remains.



2 Develop phase 02 (1-2 year)

The conjunction part is also gradually eroded by the river and a natural river morphology starts to take place.



3 Develop phase 03 (2-5 year)

With the subtle height difference, the sediments start to appear following
braided river morphology.

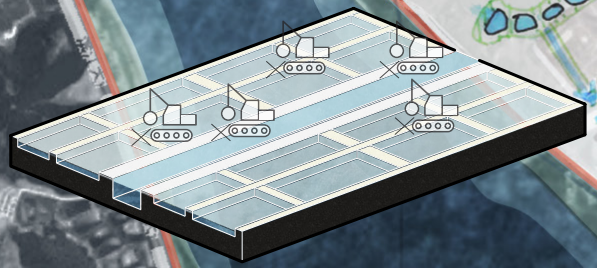
Sedimentation
Erosion
Subsoil
Flow direction
New dyke

ECO-SYSTEM STRATEGY

Combining the two experiments, the author proposes a demolishing at the front part of the fishpond's concrete and remaining of the fishpond pattern along the dyke. Thus a different condition has been created for different speed of water dynamics.

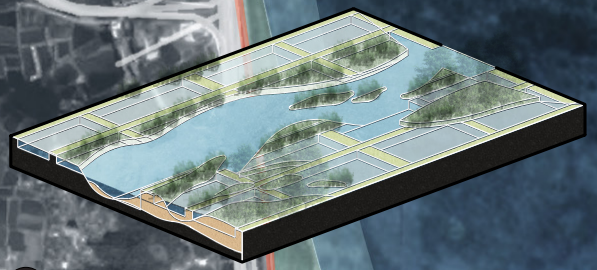
New dyke
Restored historical creek
River development
Fishponds with floating wetland
New agriculture using sediments
Constructed wetland
Sediments aggregation

0 0.5km 1km



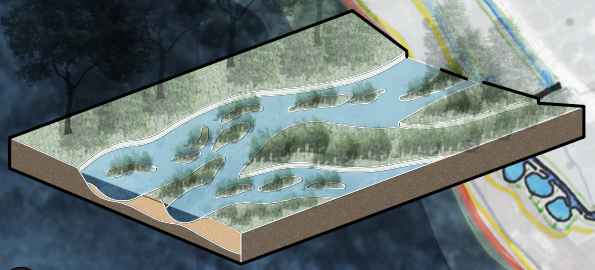
1 Develop phase 01 (0-1 year)

Demolish the first role of concrete dykes and let the river flood inside.



2 Develop phase 02 (1-2 year)

The river dynamics would further erode the dyke soil and at the same time, more sediments would aggregate in the second and third role of fishponds, which stimulate the eco-reconstruction in them.



3 Develop phase 03 (2-5 year)

A natural riverfront would be formed after years of sedimentation and erosion, which appears to be a gradient of different landscape from the high meadow to the low fresh water marsh.

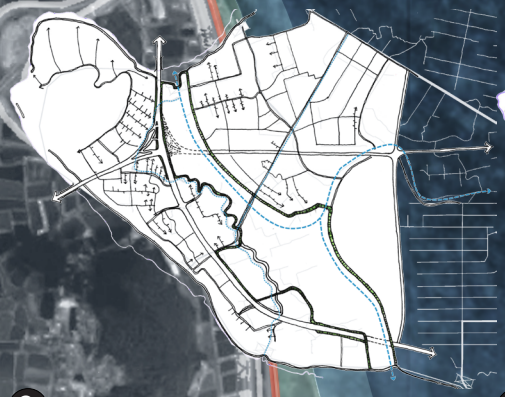
INFRASTRUCTURE SYSTEM STRATEGY

The infrastructure provides the housing project with accessibility. The public transportation would be integrated firstly with dyke for tram and biking path. After that, the main current road would be covered under the dyke and connected to secondary road system which leads to the housing. In addition, the water transportation would be renovated as main access to water urbanism like floating house, terp house and amphibious house.



1 Develop phase 01(0-2 year)

Construct the new dyke and rise part of the main road to integrate it with dyke. Break the existing dyke and create an open connection with river



2 Develop phase 02(2-3 year)

Develop the secondary road based on a grid of biking distance(1.5km) and make accessibility for housing.



3 Develop phase 03 (3-5 year)

The road could continually develop as a "Rhizome" model for a sustainable and flexible development. The road network could be adjusted according to different housing or recreation project.

New dyke

Main road

Secondary road

Water transportation

0 0.5km 1km

URBANIZATION SYSTEM STRATEGY

The urbanization process would follow the infrastructure construction and water management as basic framework. The ideal new place is the intersection between eco-system and the infrastructure system, where the urbanization could make use of both system for recreation, water source and good transportation.

0 0.5km 1km

Terp and amphibious house in fishponds

Floating house along drainage ditch

Dyke house

Transformed amphibious house in fishponds for villagers

Transformed amphibious house in flood plain





1 Develop phase 01(0-2 year)

The dyke house could be placed along the water infrastructure after finishing the new flood plain.

2 Develop phase 02(2-5 year)

New urban core zone could develop along main road infrastructure and new typologies of amphibious house or floating house could be constructed.

PHASING

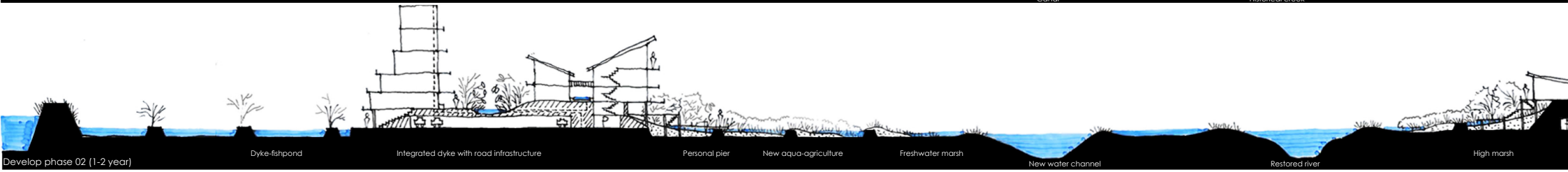
1 Develop phase 01(0-1 year)
Water infrastructure construction

The intervention provides a development model for a sustainable urbanization and environment. Phases of different development are taken into consideration according to various dynamics. It provides a series of development possibilities and scenarios instead of a blueprint that could be adjusted based on different rate of urbanization and climate change thus it's more suitable for a fragile place like PRD.

2 Develop phase 02 (1-3 year)
Water dynamic restoration,
infrastructure construction
Housing

3 Develop phase 03 (3-5 year)
Eco-system restoration
Infrastructure and water system complete
Housing

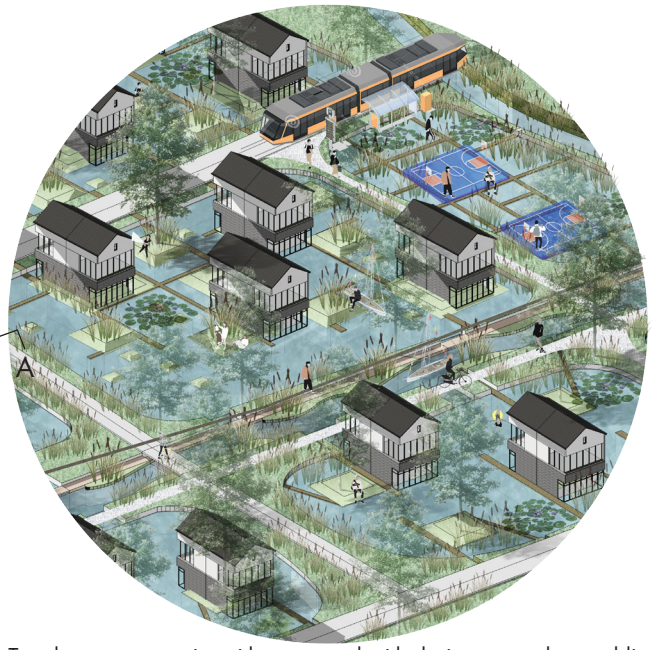






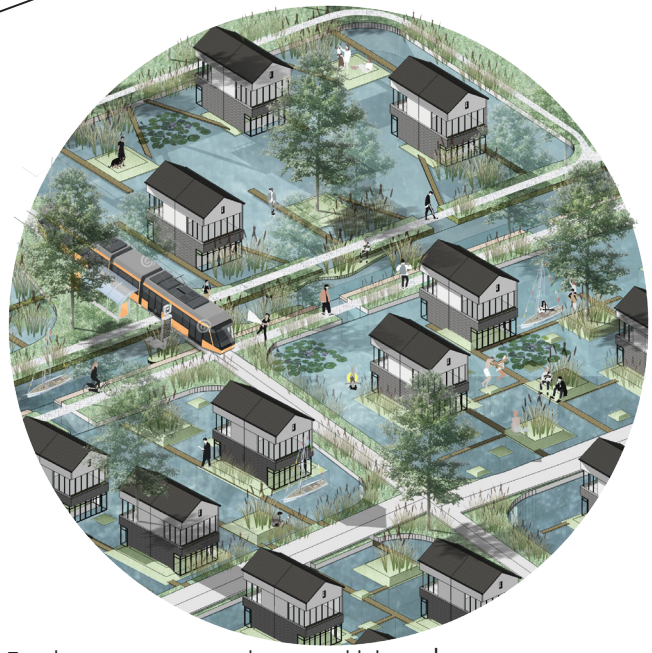
URBANIZATION IN FISHPOND PATTERN



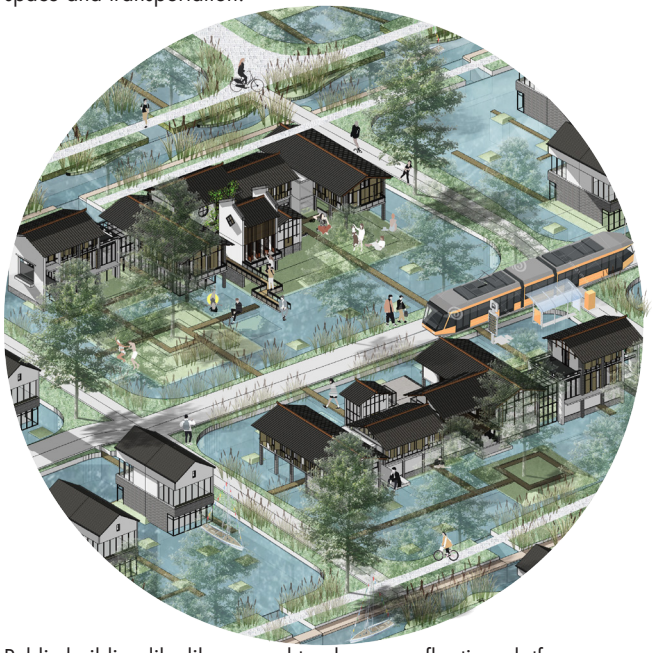


Terp house community with connected with drainage creek as public space and transportation.

To further explore and demonstrate the spatial quality of this new way of urbanization based on dyke-fishpond pattern, one of the key nodes is chosen for a detail design. The existing fishponds are maintained in order to keep as much water space as possible for collecting excessive water from the creeks in rain season and water supplement in dry season. At the same time, the dykes would be transformed for road infrastructure where the water trasportation is not enough. Constructed wetland is built through transformation of dyke-fishpond near the conjunction point of two creeks and meant to provide residents with chance for playing, relaxing and education.



Terp house community with tram and bike path



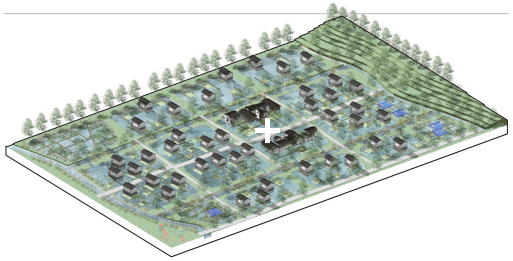
Public building like library and tea house on floating platform

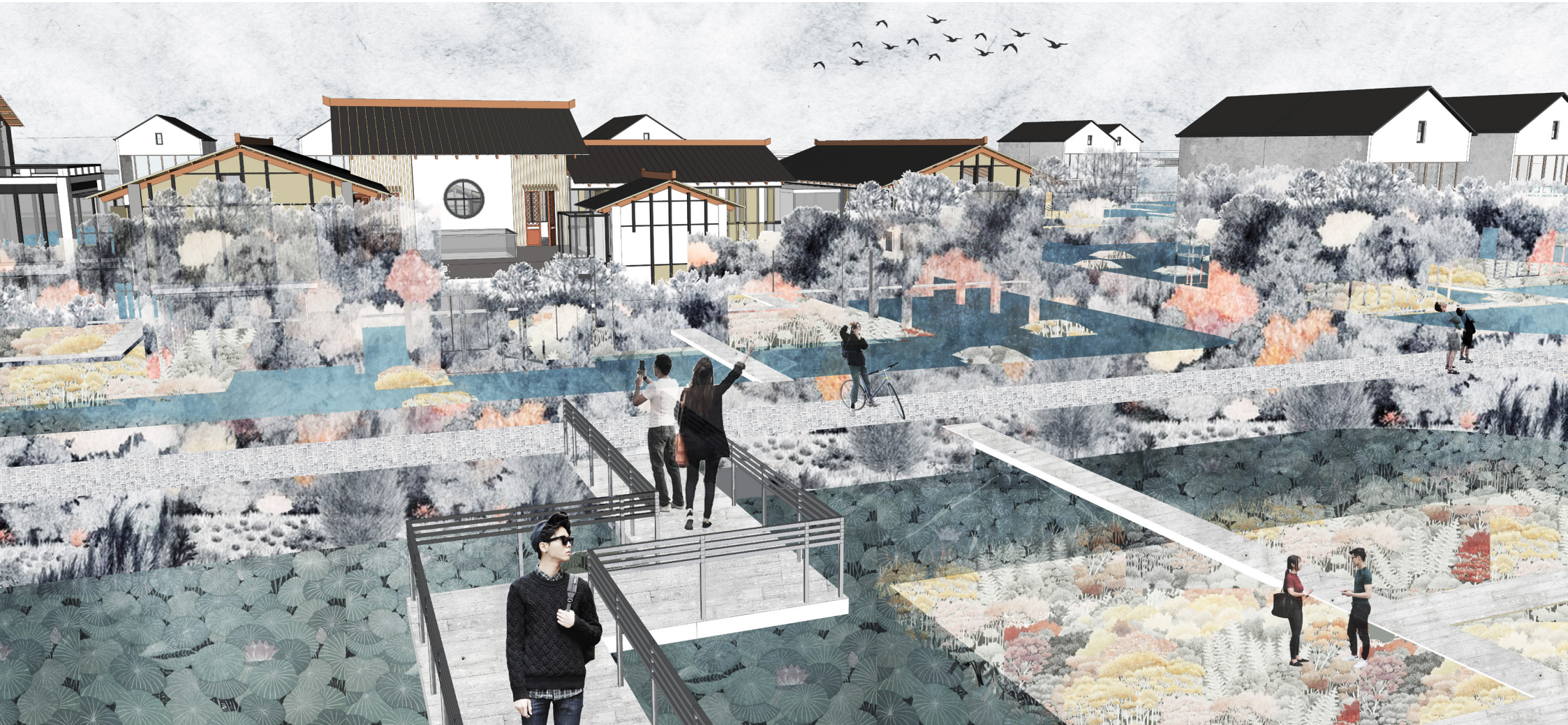


Section A-A
1:2000

PUBLIC BUILDING IN COMMUNITY CENTER

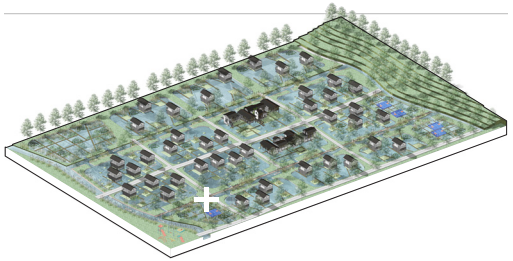
The new community would have public building like community center, library and tea house located in the center of fishpond surrounded by water, which provides people with not only water activity, but also microclimate and cultural needs.

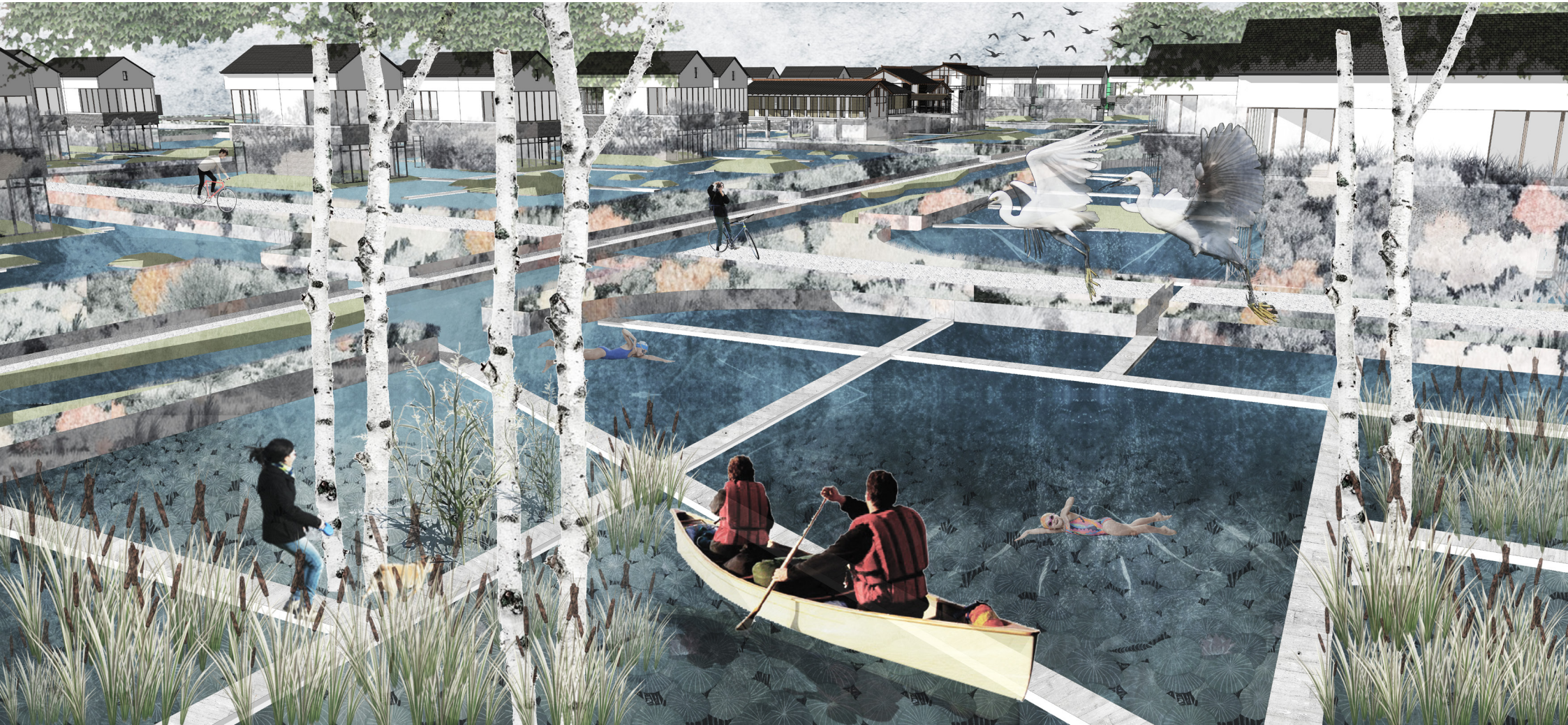




CONSTRUCTED WETLAND AND WATER COMMUNITY

The existing dyke-fishponds would be transformed into wetland or water community to offer new opportunity of water life including bird watching, boating and relaxing, etc.In addition, it also increase the water circulation and the biodiversity of various flora and fauna.





DYKE HOUSE AND DRAINAGE CREEK



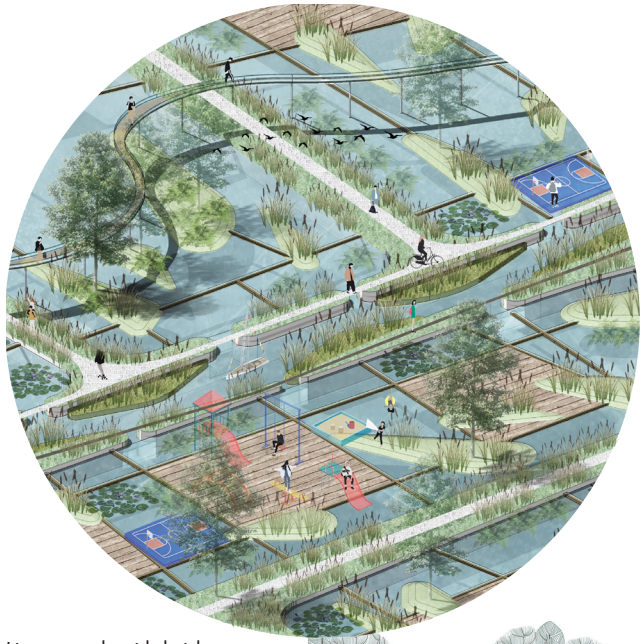


Drainage creek with transformed fishponds via open connection

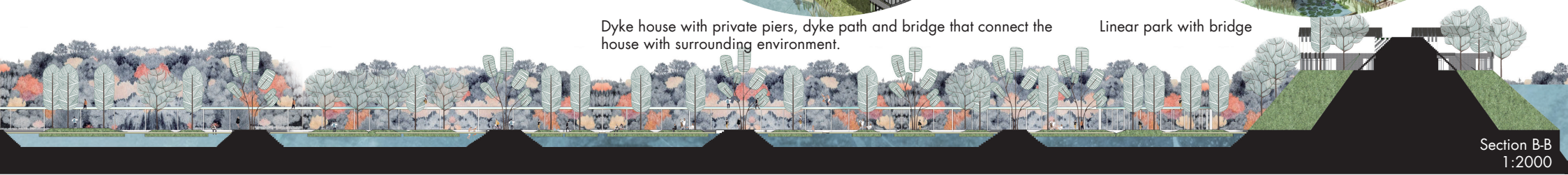
Along the new water infrastructure for the new flood plain, dyke house could also be developed as a new type of residential building which has advantages like good view of river landscape, close relationship with water and nature as well as safety and transportation. The main drainage canal would be transformed into a linear water park by combining surrounding dyke-fishpond pattern. In addition, a bridge connecting the dyke with wetland behind it offers people an unique view of this new landscape based on historical agricultural and cultural landscape.



Dyke house with private piers, dyke path and bridge that connect the house with surrounding environment.



Linear park with bridge



Section B-B
1:2000

VIEW FROM THE DYKE HOUSE

The new dyke house provides people with an unique view of the transformed dyke-fishpond pattern as well as dynamics of water and vegetation in different season, which not only reminds people of this historical landscape, but also make them aware of the flood danger and developing possibility they are faced with.





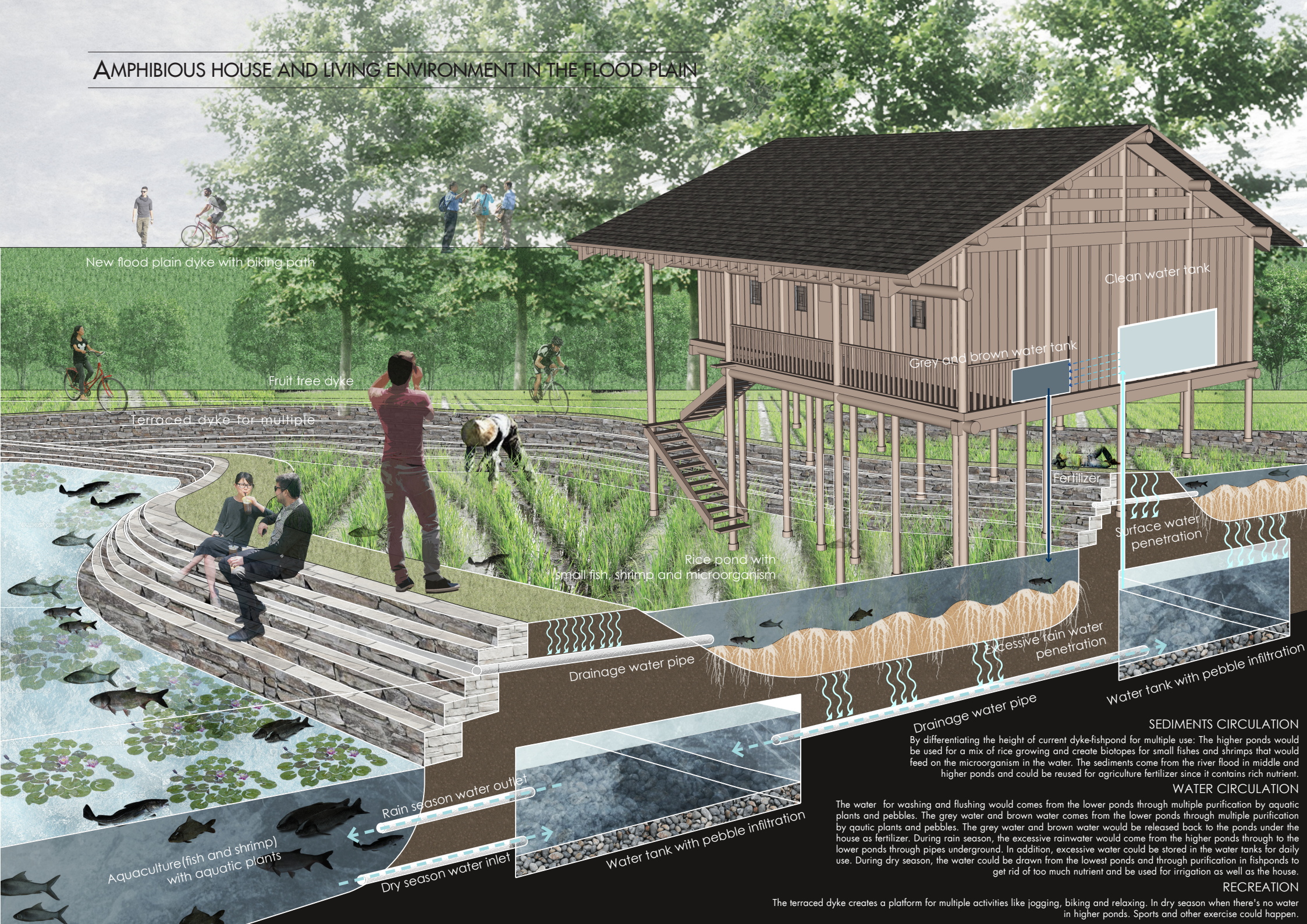
VIEW ALONG THE DYKE PATH

The path and public transportation along the dyke provides residents with good acessibility and fantastic view point to watch the water dynamic. In addition, it would also be integrated with linear park like green belt to enhance the quality of living, playing and relaxing.





AMPHIBIOUS HOUSE AND LIVING ENVIRONMENT IN THE FLOOD PLAIN



SEDIMENTS CIRCULATION

By differentiating the height of current dyke-fishpond for multiple use: The higher ponds would be used for a mix of rice growing and create biotopes for small fishes and shrimps that would feed on the microorganism in the water. The sediments come from the river flood in middle and higher ponds and could be reused for agriculture fertilizer since it contains rich nutrient.

WATER CIRCULATION

The water for washing and flushing would comes from the lower ponds through multiple purification by aquatic plants and pebbles. The grey water and brown water comes from the lower ponds through multiple purification by qautic plants and pebbles. The grey water and brown water would be released back to the ponds under the house as fertilizer. During rain season, the excessive rainwater would come from the higher ponds through to the lower ponds through pipes underground. In addition, excessive water could be stored in the water tanks for daily use. During dry season, the water could be drawn from the lowest ponds and through purification in fishponds to get rid of too much nutrient and be used for irrigation as well as the house.

RECREATION

The terraced dyke creates a platform for multiple activities like jogging, biking and relaxing. In dry season when there's no water in higher ponds. Sports and other exercise could happen.

07. CONCLUSION AND REFLECTION

I.DISCUSSION AND CONCLUSION
II.REFLECTION



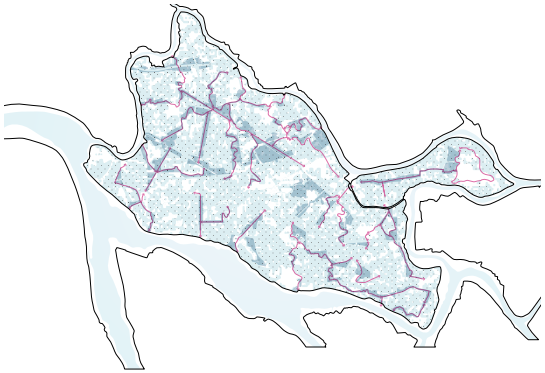
DISCUSSION AND CONCLUSION

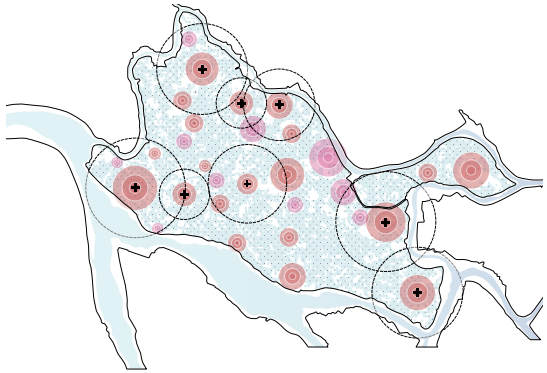
The most vital contribution of this thesis is to build a bridge between traditional practices in agri-aquaculture and future urban development to offer a transformative perspective that takes landscape as the basis for spatial strategies and interventions. The difficulty with this research consists in the incompleteness of some of its information due to the inaccuracy of some local historical maps (even a lack of these in some cases). However, the research does provide clues for a more water-sensitive approach that includes the characteristics listed above. By learning from traditional agri-aquacultural practices new principles for water-sensitive planning and design can be developed which can mitigate flood risk while also allowing for increased but sustainable urbanization and agricultural development, not just for the Shunde district but the PRD as a whole. This perspective requires a proper understanding of landscape, and the principles behind it, to build on such a system, instead of taking a tabula rasa-development model, which can be seen everywhere in China's recent urbanization (as can the problems associated with this approach).

In conclusion, a proper application and adaptation of the above-mentioned principles and characteristics would not only provide a transformative perspective for urban landscape development but would also offer a new paradigm for planning and designing for a more resilient and adaptive Pearl River Delta.

SUMMARY OF PRINCIPLES AND STRATEGIES

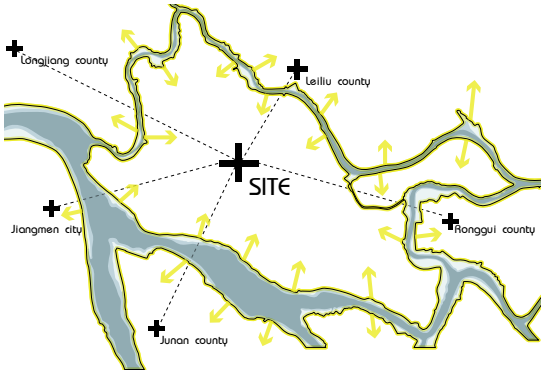
UNDERSTANDING TERRAIN



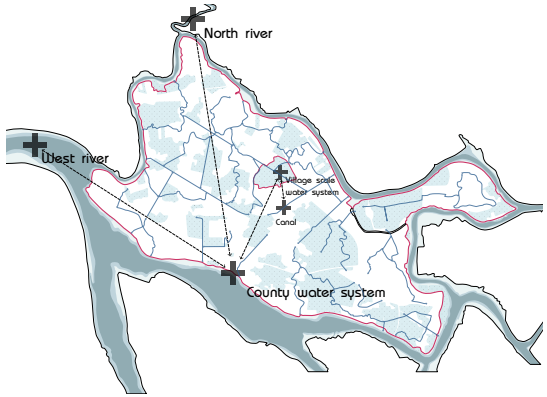




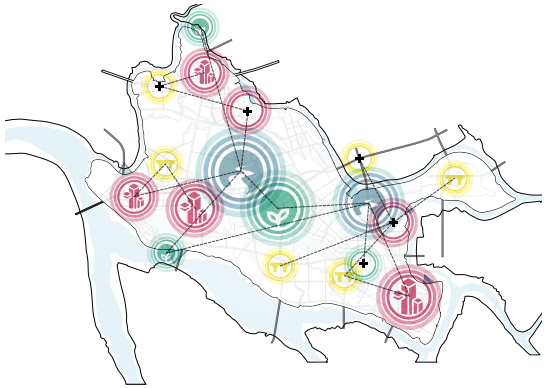
COLLABORATIVE PRINCIPLE



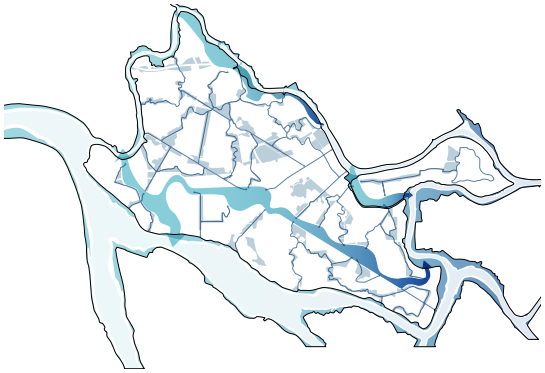
MULTISCALE WATER MANAGEMENT



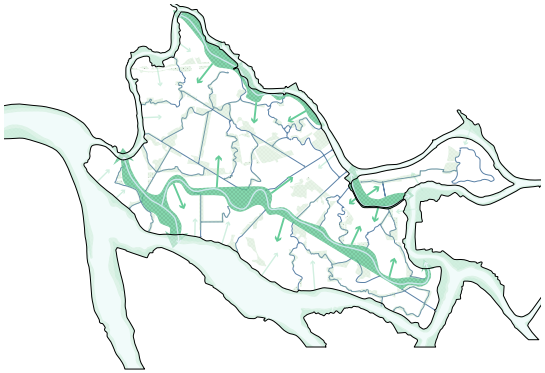
PROCESS PRINCIPLE



MORE SPACE FOR WATER



WORK WITH NATURE

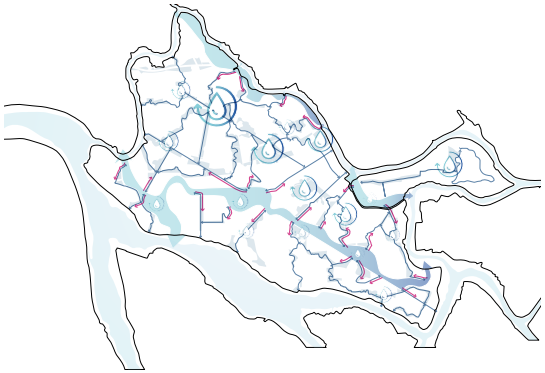


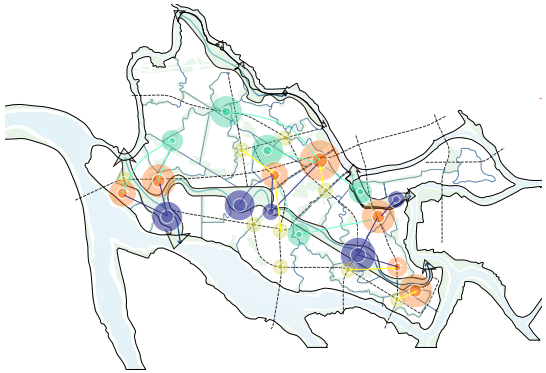
MULTIFUNCTIONAL WATER MANAGEMENT



RE-USE AND CIRCULATION



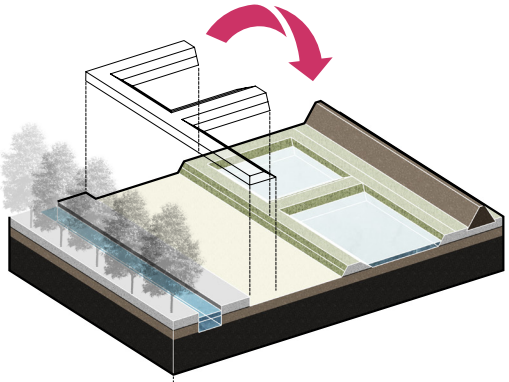




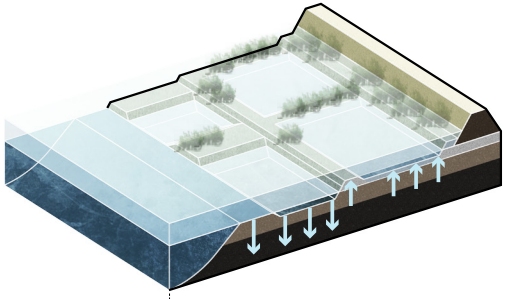
TOOL KIT
FOR WATER MANAGEMENT

UNDERSTAND THE TERRAIN AND MORE SPACE FOR WATER

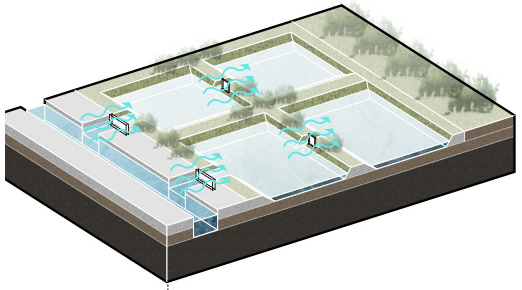
BASED ON HISTORICAL CREEK



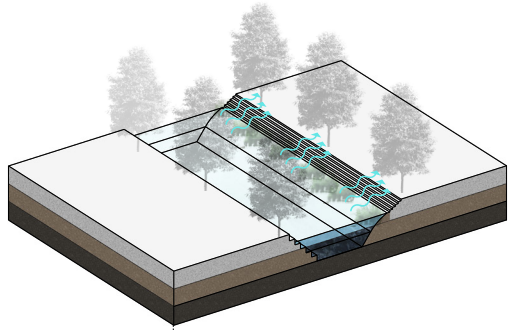
OUTSIDE THE DYKE



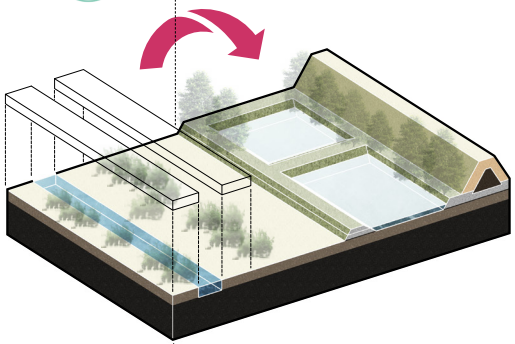
ALONG THE DITCH

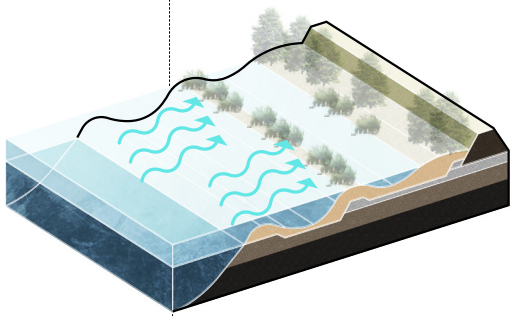


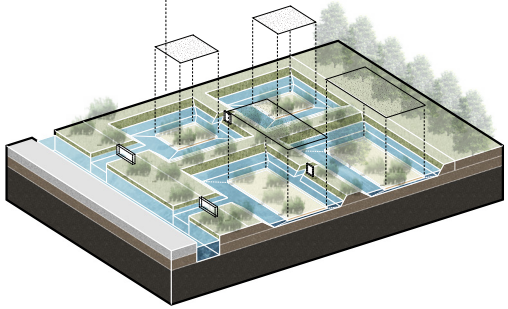
CITY CANAL

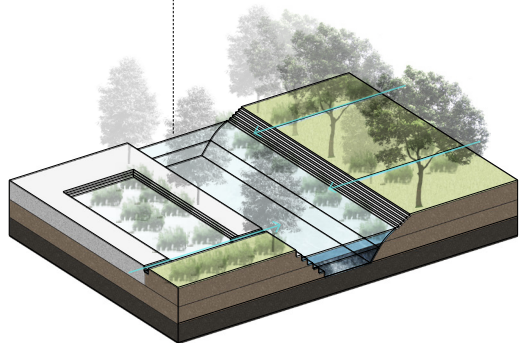


REUSE AND CREATE CONDITION FOR NATURE

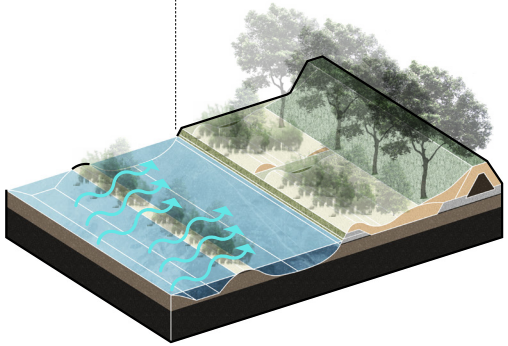


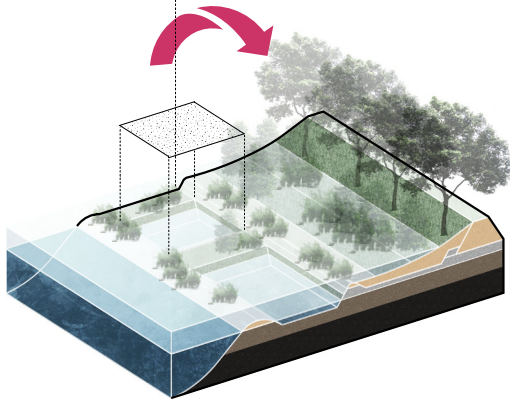


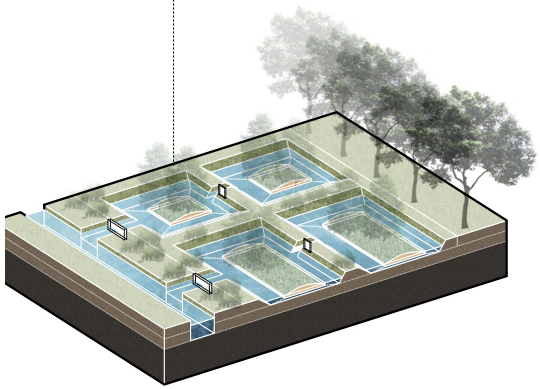


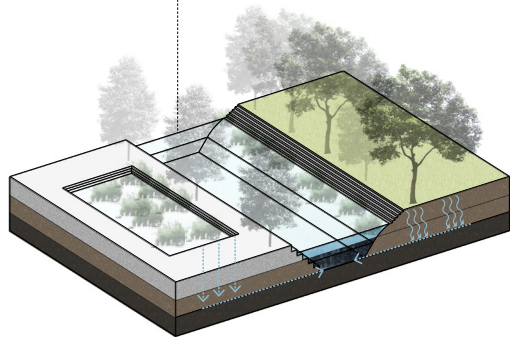


WORK WITH NATURE AND MULTIFUNCTIONAL WATER MANAGEMENT



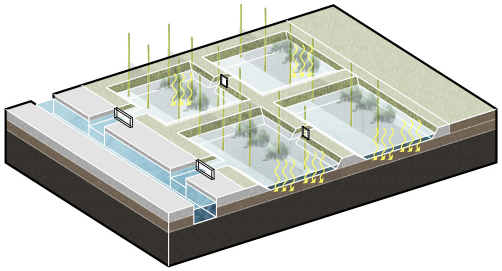




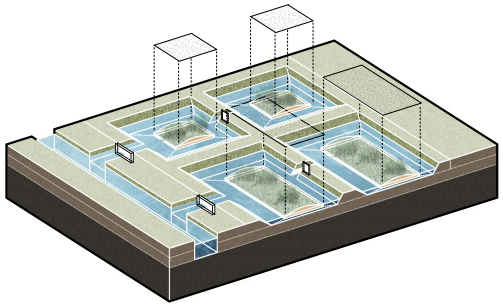


WORK WITH NATURE AND ENHANCE DIFFERENT ECO-SYSTEM

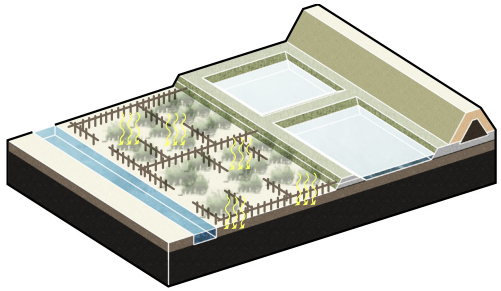
FISHPOND ECO-SYSTEM



FISHPOND ECO-SYSTEM



RIPARIAN ECO-SYSTEM



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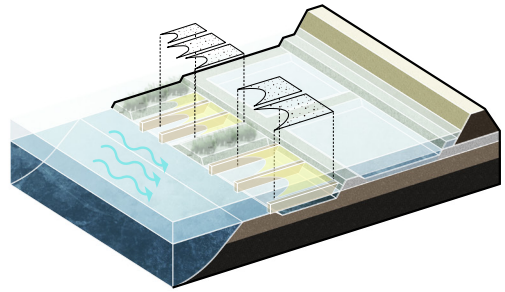
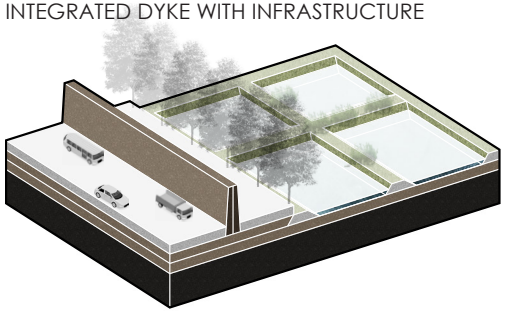
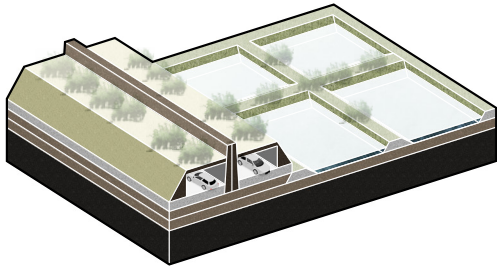
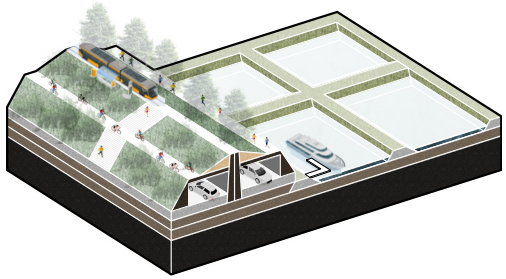


MULTIFUNCTIONAL WATER MANAGEMENT

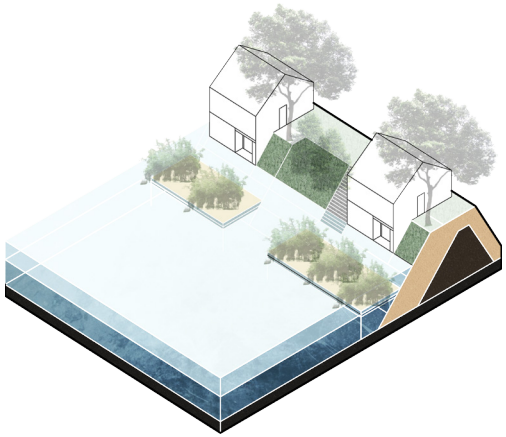
INTEGRATED DYKE WITH INFRASTRUCTURE

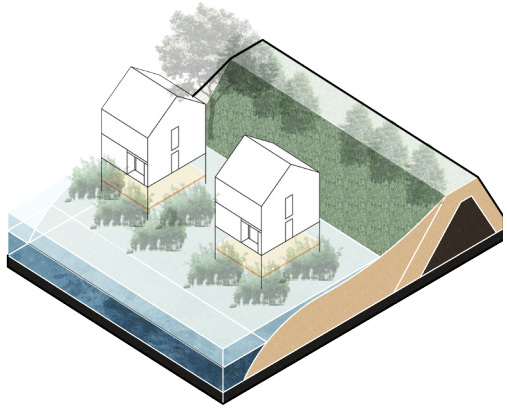


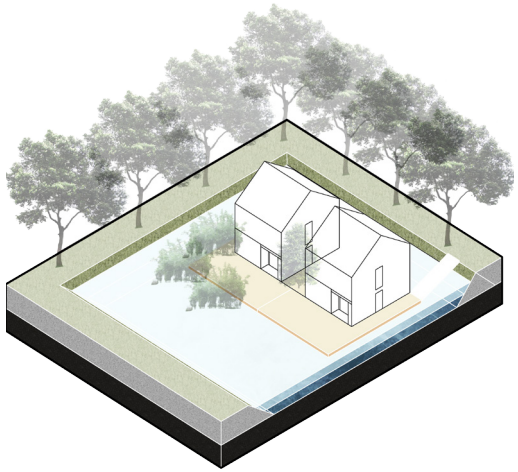


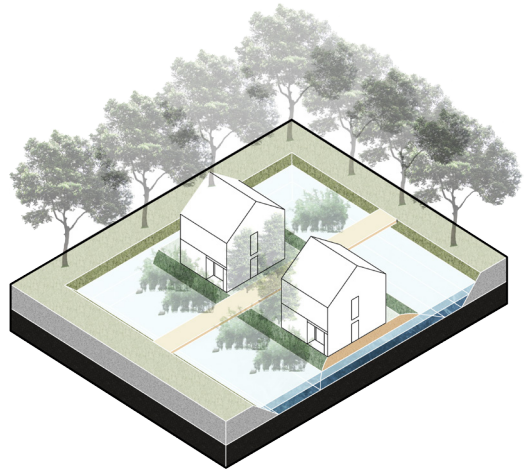


INTEGRATED HOUSING TYPOLOGY









REFLECTION ON THE RESEARCH OBJECTIVE

OBJECTIVE

TO EXPLORE STRATEGIES/DESIGN PRINCIPLES FOR WATER RESILIENT URBAN LANDSCAPE DEVELOPMENT BASED ON DIKE-POND SYSTEM, WATER MANAGEMENT METHODS IN THE FLOODPLAINS OF THE WESTRIVER THROUGH MULTI-SCALE

The result of the research has met this objective through developing the follow sub-questions:

1 -What are the traditional dyke-fish pond system and ecological water management and its social structure through different levels(region, village, building) ?

The lessons from different system are learned through taking a deep look at the result and process of history practice in relation to water management, agriculture and urbanization. The result has shown that these different elements are closely connected to each other to form a layer system that has its own dynamic and would affect each other in different levels.

2-What are the principles about living with water including water cycles(water storage, drainage and purification), ecology(restoration of biodiversity, dynamic), agriculture(recycling) and social structure(water culture, activities)?

The result has shown that a cross-scale principle and multifunctional water management principle is vital for all the different system to work closely and effectively. In addition, other principles like: Long-term development process; Collaborative effort; Understanding terrain conditions; Working with nature and space for water; Re-use and circularity are also found very important towards the research. All these principles are learned from historical practice in this region and could be related to practice in other places of the world like Netherlands, Indonesia.

3-How to apply principles in design explorations in different geographical environment(plain and mountain) in relation to water management(flood storage and drainage, grey water purification and storage, rain water harvest), ecology(restoration of diversity, dynamic), urbanization(increase of water dynamics, excessive water storage, water reuse, increase of flood resilience) and social structure(recreation around water, new typologies of public space)?

This question is answered by multi-scale plan and design of a new water landscape in Xingtan county, Shunde district as an example. The result includes a strategic plan for the future water management, ecology development, infrastructure and urbanization in Xingtan county and a series of tool kit showing how to transform the current landscape to it. An elaboration in Village and building scale helps to explain how the water management could benefit for the spatial quality, water living and public life.

SPECIFIC LESSONS AND PRINCIPLES FROM THE RESEARCH

4-What are the lessons learned(principles) of connecting agri-aquaculture, water management, urbanization to make a new type of delta urban landscape?
-What is the possibility of its application in other region?

The general knowledge extracted from the research has a very important application also for other region in Pearl River Delta and other places among the world towards a new paradigm of living with water and developing with water. The water management through multiscale has proved that once applied to larger context of the delta, it would also work because of similarity in the existing situation. However, the Pearl River Delta is a large delta with different affection from the sea, river and rain water. For example when applying to the sea shore of this region like Shenzhen and Zhuhai, other principles should also be brought forward towards problems like sea level rising, salt tide infusion and hurricane.

1. Dyke-fishpond
A special agriculture pattern

The dyke-fishpond system is a very special form of aqua-agriculture that is never found in other places in the world. It only appears by over thousands of observation and fighting against the flood in Pearl River Delta and becomes a specific agriculture landuse in this region.

2. A special human settlement closely connected to water

As a large amount of Pear River Delta is formed from the water as fluvial plain, all the public life, production, transportation and even religion and political system is originated from water. For instance, the house is located in the dyke of fishpond and public buildings like temples and libraries are connected with Fengshui ponds for collecting water. Water is not only a nature in this region but also a belief of fortune and luck. It became a form of god (the turtle god) to be worshipped and the dealing with water issue generated the initial government in this region from the bottom to the top.

3. A broken chain with history and dramatic urban development

Because of the good natural condition and political concessions, the Pearl River Delta has been witnessed a great change from rural situation to one of the fastest developing area in the world. This fast development has brought a dramatic transformation and demolishment of the native landscape that has been formed step by step. This arises a consciousness of how to protect the historical heritage and develop upon it, instead of destroying everything and build from zero. Thus it becomes a very interesting case to elaborate and as a result, the proposal in this thesis could contribute to the plan and design exploration for a more sustainable future for this delta.

GENERAL LESSONS AND PRINCIPLES FROM THE RESEARCH

1. Long-term development process
Phase plan & design

The formation of the special water management and urbanization in Pearl River Delta takes over millennium and it also applies for other region of the world to value the process. Landscape is a process of different layers: water network; topography; soil ; infrastructure; landuse like agriculture and urbanization. These layers affect each other and have their own dynamics. This knowledge could also applied to other region to take the landscape development as a process instead of a result. Thus, to deal with the uncertainty and to offer more flexibility, it's important to take the design phase into consideration. The nature and built environment have different speed of growing or construction so the different development stage shall be planned.

2. Multiscale approach
Design across scales

The water system is a continuous system that conects different watershed and flooding area together, which means a simple change in one level would affect the others. The historical water management of Pearl River Delta has been applied from regional scale, county scale and village & building scale as a complete system. It also applies to other river or sea zone in the world to think across scales and deal with water as a large system. In addition, for a broader context that has less relationship with water, it's also important to work through scales that have influence on each other.

3. Collaborative effort
Design for connecting political system

The water management in Pearl River Delta has been formed by a cooperation from different local governments and regional plan to work across political border. It also applies to other context because the landscape is usually highly connected to each other without a clear border. Thus it's important for a landscape architect to think beyond given site boundary.

4. Understanding terrain conditions

The natural topography and terrain condition provides a place with special development not only for water, soil and vegetation, but also for urbanization. A proper understanding of the terrain would help to plan the different development reasonably.

5. Working with nature and space for water

As the climate change becomes more and more serious, it would be vital to draw lessons from all over the world. The Pearl River Delta lessons of working with nature such like: keep proper distance between river dyke and the main water course; Work with the natural sediments to create islands would be very helpful for other region that has flood problem. This principle has also been applied in Netherlands as the project "Room for river". In the result of the plan a new flooding zone is created for hold excessive river and rain water which would be transformed by nature into a river flood plain. Besides, the modern practice

has shown failure in broad context that controlling nature is not possible and heavy price has been paid. Instead, working with nature means landscape planner or designer should respect the natural law and design with it and use it as a powerful tool.

6. Multifunctional water management

The historical water management in Pearl River Delta not only works for drainage and water collection, but also stimulate transportation, agriculture and housing. As is also shown in other cases around the world(eg. the multifunctional dyke in Netherlands), an integrated design and plan of water infrastructure offers multiple benefit for living, recreation and eco-system developing and it works well. The modern practice of single system is neither effective nor attractive to other development, which proves to be high cost and not working. Thus when thinking about the water management in a broader context it's always important to think what is the development that could be stimulated by it.

7. Re-use and circularity

The dyke-fishpond system works very well in its material circulation. To plan and design a more sustainable future, it's very important to take this principle into consideration in world wide context. This principle could also be used through scales from a circulation in rain garden to an urban metabolism in a city. The lesson learned here contained special crops, animals and soil condition while the principle of making circular design is very important towards limited source in the world.

ROLE OF DESIGN IN RESEARCH

1. Design as a research orientation

The design plays an important role in this research by setting a clear target for the it. Since the research area is so large that one could spends a whole life on it, it helps a lot to first set a design target and narrow down the research field. For instance, the design intention was set up during P1 as a new framework for resilient urban landscape by transformation of historical aqua-agriculture and eco water management. This target has defined a clear direction for the research and put forward categorical questions that needs to be answered in order to get there. Thus, to set up a design proposal in the beginning helps a research in determination of direction.

2. Design as a test tool for research

To test if the principles and strategies resulted from a research could work, design is a good tool. In addition, it's also a good opportunity to transform the knowledge from research and put it into practice. The result is not often satisfactory yet it illustrates a possibility of the solution to certain problems. In addition, one principle found in specific site that seems not be working well anymore might be utilized in another place. Sometimes it even works better. In that sense, the design is a very useful tool that could help research from all aspects based on this case.

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