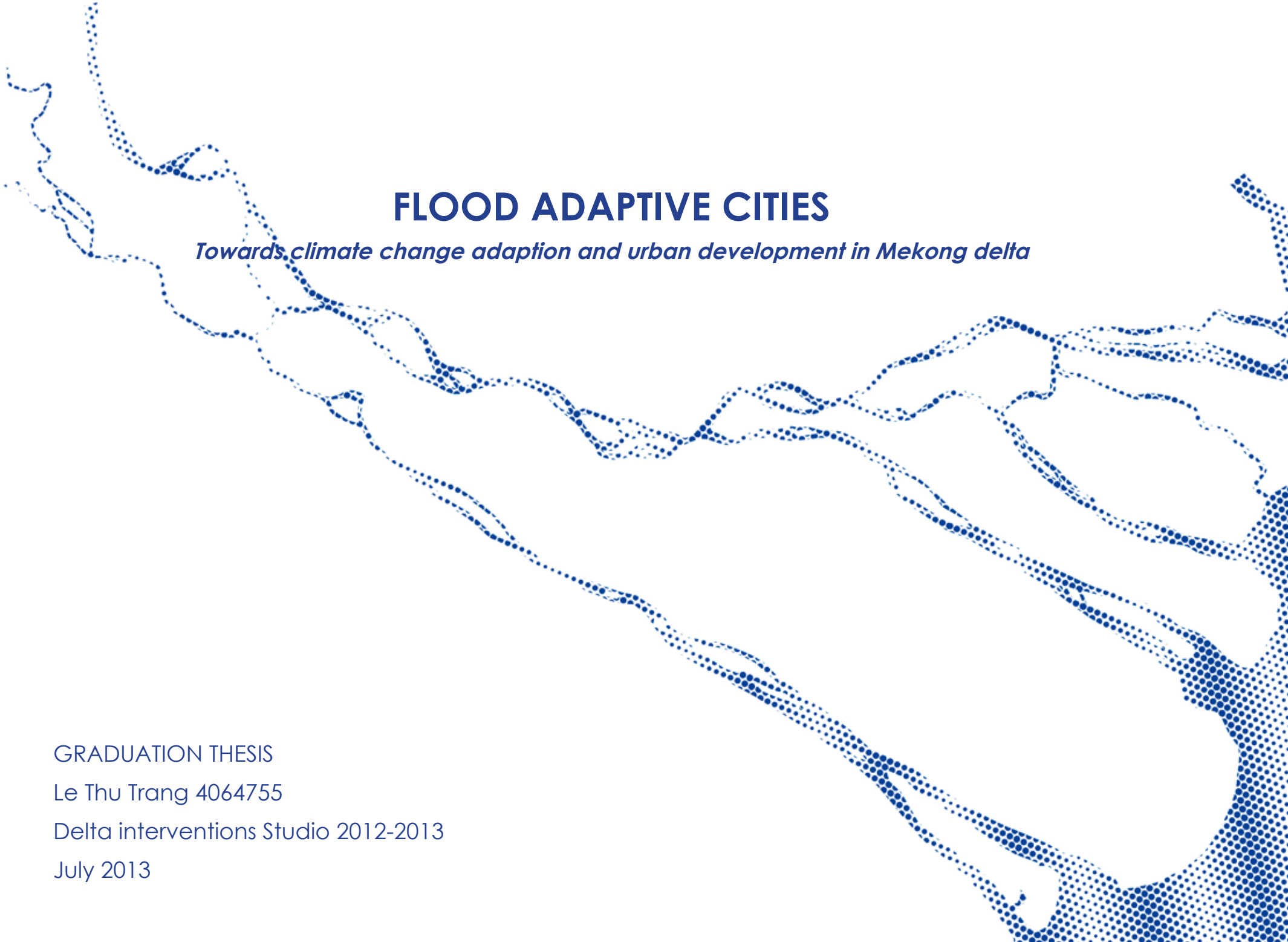
FLOOD ADAPTIVE CITIES

Towards climate change adaption and urban development in Mekong delta



GRADUATION THESIS

Le Thu Trang 4064755

Delta interventions Studio 2012-2013

July 2013


FLOOD is not threat
...*FLOOD* is opportunity

Colophon

Flood Adaptive Cities
Towards climate change adaption and urban development in Mekong delta
MSc thesis

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Delft, July 2013

Cover image by author in 2012

TU Delft Delft University of Technology Delta Interventions

Preface

This thesis is based upon studies conducted during September 2011 to June 2013 at Department of Urbanism, Faculty of Architecture, Delft University of Technology, Delft, Netherlands.

I would like to express my sincere gratitude to my two mentors Prof. dr.ir. V.J.Meyer and Ass.prof.S.Nijhuis. Without their advices and supports, this project would never have become a reality. Further, I would to thank my colleague, Dieu Pham for his great help.

Finally, I wish to express my greatest thanks to my family and friends who have supported me, especially my beloved mother, Thuy Hoang.

Le Thu Trang
30th of June, 2013

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Introduction

Climate change is now widely recognized as the major environmental problem. Several disasters happened in the last decade, for examples: Indian Ocean Tsunami 2004, Hurricane Katrina 2005 and Japan tsunami 2011, have warned people of the risks to be flooded. Thus, people all over the world are now searching for innovative ideas to protect themselves from floods such as making polders, heightening the dykes, constructing huge water defence systems et cetera. However, water causes disasters but it is also a source of life.

The Netherlands, as the best protected delta in the world, has developed sustainable systems for water safety, water supply and water landscape in response to climate change. Giving up on higher dykes, the government policy "Room for the river" (or Ruimte voor de Rivier in Dutch) is to accept the presence of water by moving dozens of dikes back to make room for swelling rivers. Thanks to this policy, idea 'Design with Nature'; 'Working with water' has now shifted human actions toward nature from Control to Adaptation.

In the developing world, Vietnam has developed significantly in recent years, especially in Mekong Delta, where is by far Vietnam's most productive region. However, climate change, population growth and the requirements for economic growth put too much pressure on environment and the unique landscape that was formed by a long process of living and adapting to the vagaries of water. Moreover, investments in flood defence system protecting inhabitants and securing agriculture are relatively expensive. There is a need for a more sustainable development strategy that addresses different disciplines: hydraulic engineering, urbanism and landscape architecture.

Studying in Graduation Studio Delta Interventions at Delft University of Technology offered me a chance to rethink about the relationship between City and River, to scientifically research about water and urban issues and to access to different solutions in planning and design towards urbanizing delta cities. My graduation project focuses on generating a development strategy for Mekong delta cities. Finally, this strategy is applied in the case study of Cao Lanh City.

Working through scale
Source: www.maps.google.com

If source is not mentioned, the pictures and illustrations are made by the author.

Chapter I. Project background

Delta cities worldwide
Mekong Delta
Cao lanh City

Project background

1. Delta areas worldwide

Introduction

Deltas, where river flows into the sea, ocean, lake or reservoir, are the magnetic areas to inhabit for half of the world's population and also half of the world's urbanized areas (UN-Habitat, 2006) because of the most fertile land for agriculture and the most strategic locations for industrialization and urban development. Living close to the waterfront is now attracting a new stream of inhabitants, tourists, services and business to the cities. Since most of the large cities are located in delta region, an unintended side effect of the growth and the ensuing concentration of population is the increased challenge. The changing global climate recently puts additional pressure on this challenging situation.

Drivers of change and pressure

Urbanized river deltas demonstrate different characteristics depending on their local climate, geographical condition, economic and political circumstances. Therefore not all deltas can easily be compared to other deltas. But many deltas have developed along the same patterns and have experienced the same problems as other deltas did at the same phase in their development.

Climate change:

The most important driver in the deltas studied is climate change, which is a global issue with diverse consequences throughout the world. Climate research has verified that the global temperature will be increase by a few degrees, resulting in the more extreme weather in many places, with more flood events, storm and changed river discharges (IPCC, 2001). The sea level also rises faster of 3mm a year and brings growing fluctuation in dry and wet seasons.

Human interventions:

However, following the technological development of water management, human interventions as adaptive measures for the complexity of natural system have now led to continuous effects on the natural landscape within the deltas. Deltas are losing their natural flexibilities and no longer able to changing circumstances.

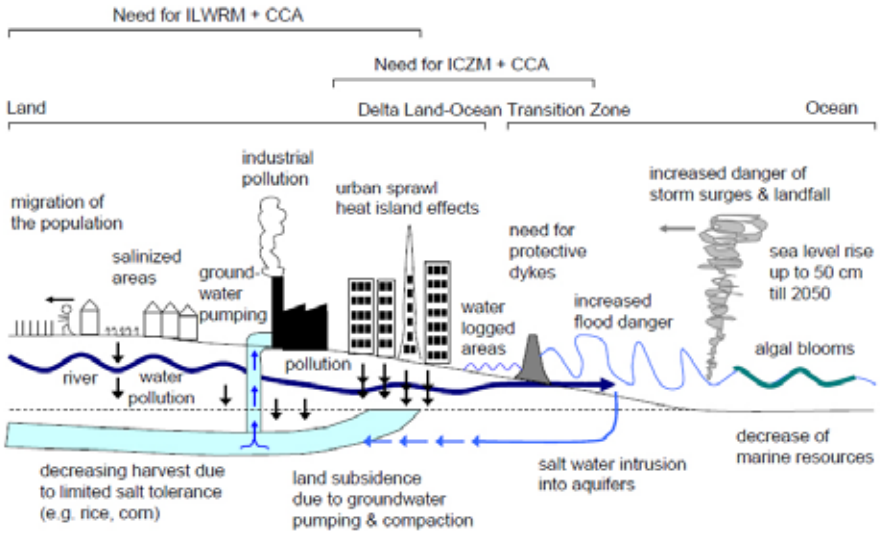
Demographic trend:

Most of the deltas in the world are now densely populated, especially deltas in Asia, such as: Ganges, Yangtze and Mekong delta (See table 1). As human population increases in deltas, so does pressure on delta nature landscape through increased demand of natural resources (fresh water), land for construction and increased pollution.

Economic development:

The deltas of the world are multi-functional landscapes that can support a multitude of economic activities, such as agriculture, industry, services, transport and energy production. Despite the current financial crisis, economic development is expected over longer periods of time, resulting in larger demands to be met, higher values to protect, more energy to be generated and more goods to be transported.

40 Major river deltas on earth
Source: Dr. Claudia Kuezen, IWRM conference, Dresden 2011

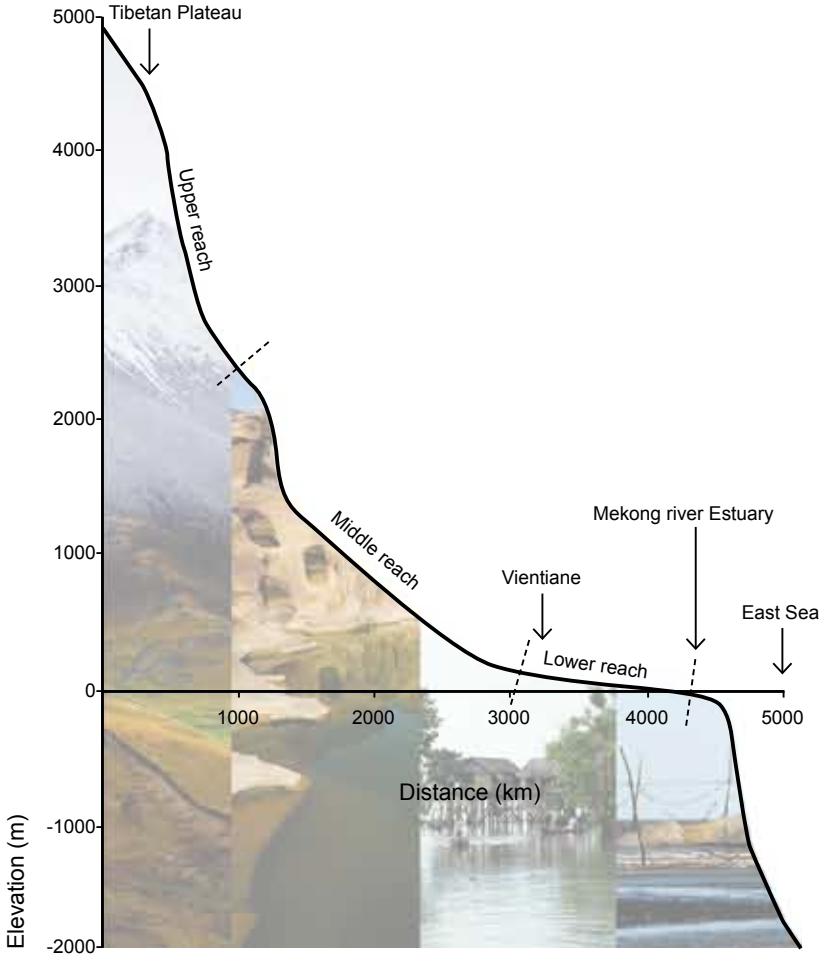


Drivers of Urbanization and Transformation in Deltas:
1. Climate change
2. Human interventions
3. Demography trend
4. Economic development

Source: Dr. Claudia Kuezen, IWRM conference, Dresden 2011

However, in most deltas, intensive agriculture and industrial development strongly compromise water and soil pollution. Moreover, large demands on spaces for agricultural, industrial and port development in recent years have also resulted in the loss of natural delta ecosystems.

Therefore, sustainable development is crucial in deltas all over the world. This is not solely relying on technical solutions to fight against and control the delta environment, but a new approach that utilizes natural processes for water safety and sustainability for both the delta and its inhabitants. This approach is targeted at different disciplines: hydraulic engineering, urbanism and landscape architecture.



Mekong river basin topography from Tibetan to East Sea

2. Mekong delta

Mekong River Basin

The Mekong River is the 7th longest river in Asia and 12th longest river in the world. Its estimated length is 4,350 km (2,703 mi), and it drains an area of 795,000 km2 (307,000 sq mi), discharging 475 km3 (114 cu mi) of water annually (MRC, 2010). Mekong River as the hydrological backbone of its basin travels 4200 km from its headwaters in the Tibetan plateau to China, Myanmar, Thailand, Laos, Cambodia and to its delta in Vietnam. The complexity of Mekong delta is ecologically shaped by water of the Mekong River, monsoon climate and tide of the South China Sea (Hans Dieter, E. and Simom, B, 2009).

Annually, Mekong River carries 16 million tons of sediment. This sediment transport has created a fertile soil for agriculture production that provides food for approximately 60 million people living in riparian countries (Pham, forthcoming). Moreover, the natural process of sedimentation resulted in 'natural levees' of the river banks and other natural heights like river dunes, sandy ridges and barrier beaches that offered dry and safe land for the first urban settlements (Meyer, H.et al.2009).

Mekong Delta

The Mekong River Delta, one of the largest deltas in the world, was formed by the deposition of sediments transported from the Mekong River. Mekong Delta is defined as a vast triangle plain, beginning at the downstream of Phnom Penh (Cambodia) (Pham, 2011). For two third the Mekong Delta is situated in southern Vietnam and for one third in Cambodia. It is one of the most productive and intensively cultivated areas in Vietnam (known as 'Rice basket') and a priority area for economic development (Bucx, T., Marchand, M., Makaske, A., Van de Guchte, C., 2010).

The Mekong Delta is a wave- and tide-dominated delta; as a result of meeting of the two branches of the Mekong River: Tien river and Hau river (or Bassac river).

Typology of Mekong delta

Project background

TERRITORIES

LENGTH

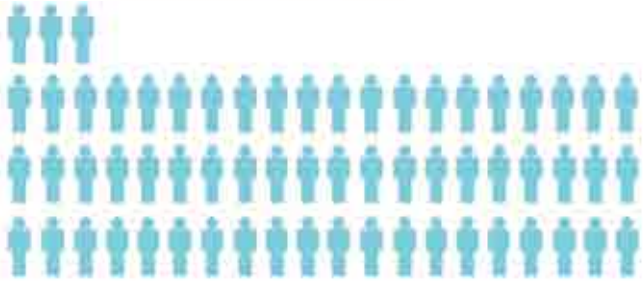
POPULATION

FISH

SEA LEVEL RISE

Rhine river bassin

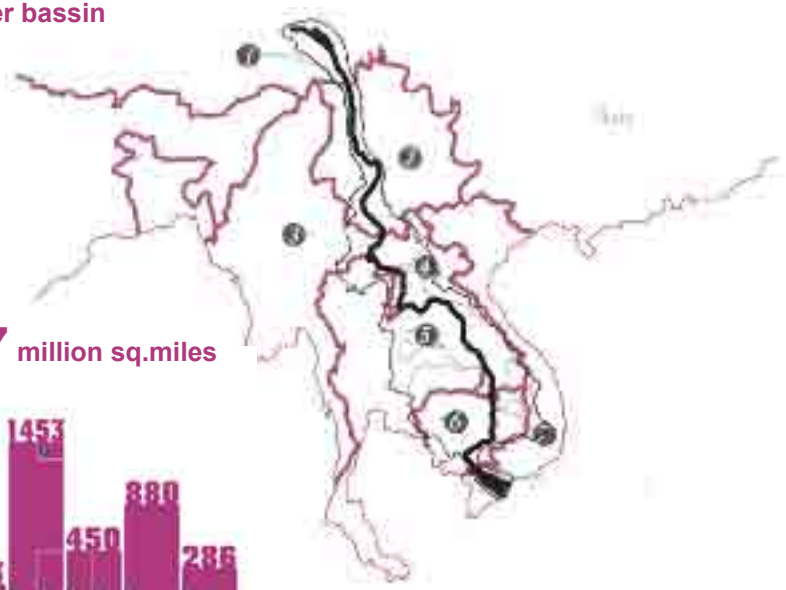
0.007 million sq.miles



63 million

60 species

Mekong river bassin



0.307 million sq.miles

57 million

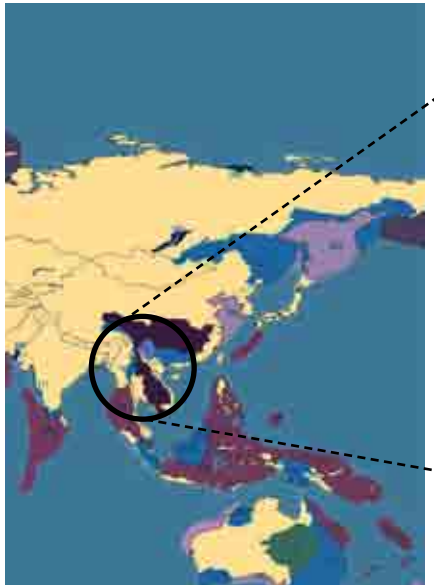
1200 species

Source: www.deltas-watersheds.com

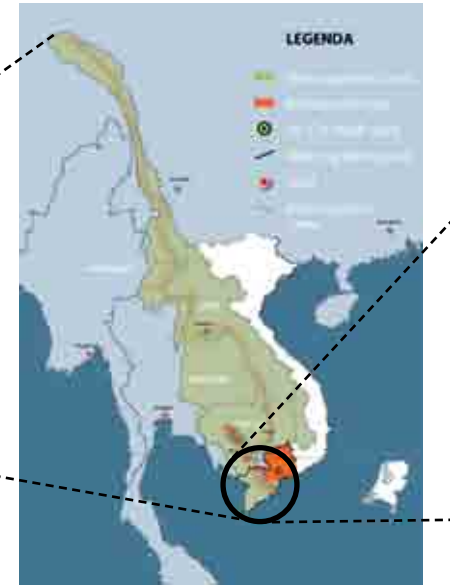
Mekong Delta in Vietnam

Mekong Delta or "Cuu Long" Delta ("Cuu Long" refers to "Nine Dragon" in Vietnamese) is the region in south-western Vietnam where the Mekong River approaches and empties into the sea through a network of nine estuaries. The natural processes of erosion and sedimentation processes, which are influenced by sea current from both the South China Sea and Gulf of Thailand and annual flood condition, form complexity of the delta. A variety of delta landscape is displayed in this region: river landscape, floodplain and coastal landscape.

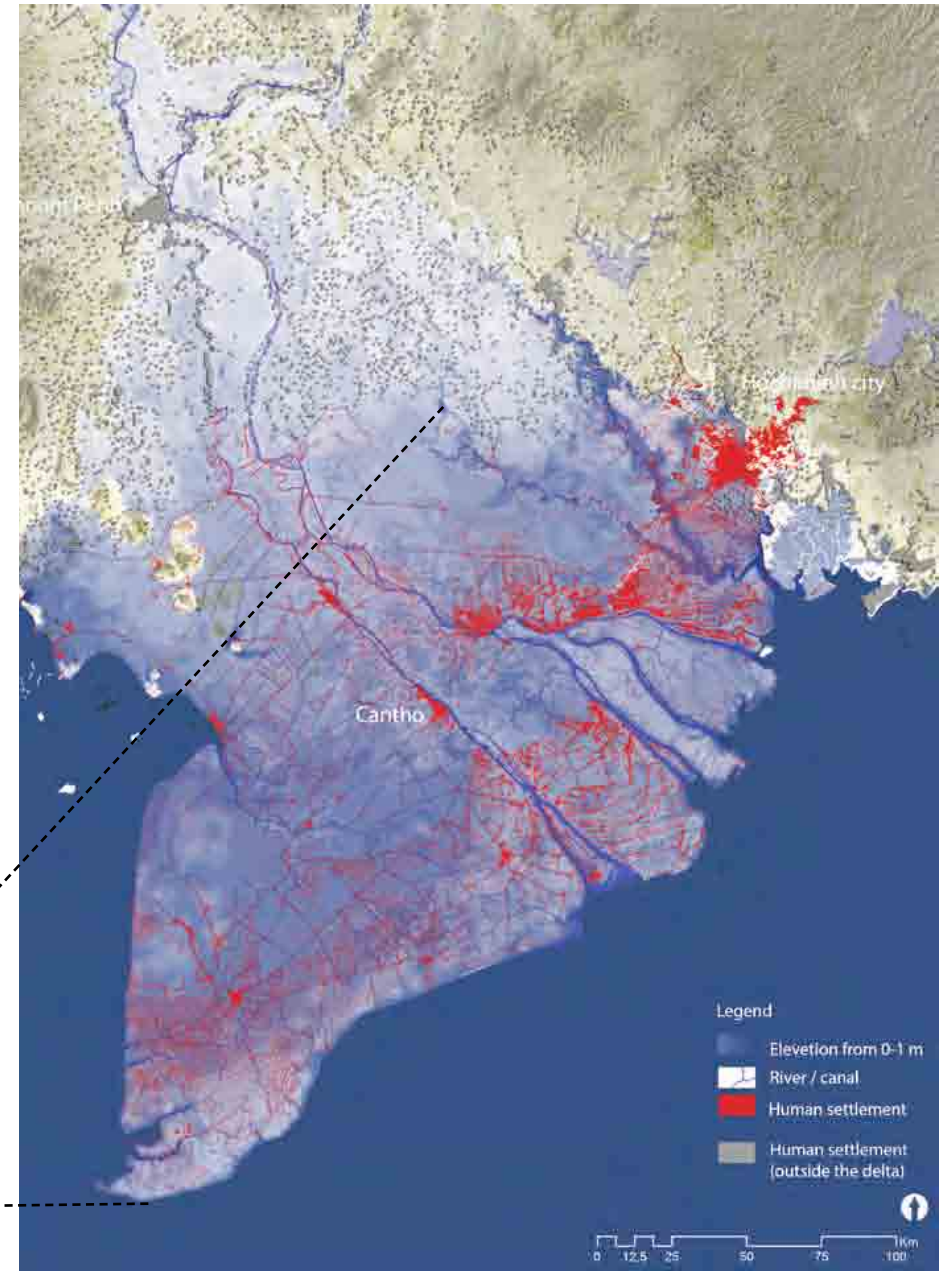
Furthermore, the Mekong Delta not only creates its unique landscape; it is also the result of the adaptive strategies that people use to reduce damage of frequent flood events and exploit the dynamic environment (Biggs, 2009; Lebel et al., 2009). On one hand, water serves as main transportation, communication as well as bringing a variety of benefits to the area, such as soil fertility and productivity. On the other hand, the delta has been exposed to daily threat of water disasters in the form of floods in the wet season and water shortage and saline intrusion in dry season. Over three centuries, people in the delta consider these processes to be normal phenomenon and have generally adapted their lives to their presence. As the result, the very specific and unique water-based landscape was built up by a historical mix of different approaches. (See Appendix 2)



Asia
Source: www.google.images.com



Mekong river basin



The Mekong Delta
Source: maps by Q.D. Pham

Project background

River city in Mekong delta
Source: www.google images.com

Fishery in Mekong Delta
Source: www.google images.com

Village along canal
Source: www.google images.com

Land parcelization
Source: www.google images.com

Mouth of Mekong River
Source: www.google images.com

Melaleuca forest in Dong Thap province
Source: www.panoramio.com

Mekong delta in flood season
Source: www.panoramio.com

Can Tho Floating market
Source: www.google images.com

Developments of Mekong Delta in history

The Mekong Delta has only been occupied by the Vietnamese for about three centuries. Nevertheless, this short history has experienced a variety of changing regimes, warfare and revolution:

The Holocene landscape as a foundation

The high terraces of Mekong delta is believed to have formed as early as 1 million years ago (Gupta, 2008). The natural processes of sedimentation, change of sea level, tidal and current effects for approximately 8000 years created different delta landscapes in this region (Pham, 2011). According to Milton Osborne, a Southeast Asian historian, the delta was 'a largely waterlogged world of black mud and mangrove trees, bordered by thick tropical forests where the land rose away from the flooded plain'.

Throughout thousands years, the natural process of sedimentation resulted in 'natural levees' of the river banks and other natural heights like river dunes, sandy ridges and barrier beaches that offered dry and safe land for the first urban settlements (Meyer, H.et al.2009).

Pre-colonial period: Nguyen dynasty (1802-1867)

The delta started to form its own landscape since the mid of 16th century when Nguyen Lords introduced a policy of land reclamation and breaking fresh ground to create villages (Pham, 2011). A large amount of inhabitants from the north and centre parts of Vietnam had come and reclaimed new lands. Therefore, the first type of settlement was created: villages around high ground areas along rivers (natural levees) and watercourses where the fresh water could be collected and the settlers could survive from flooding. At the same time, a system of canal and small ditches were built up for transportation and irrigation purposes. This process played an important role in transforming the uncultivated area of the delta into a fertile plain for wet paddy productions.

French colonial period (1867-1960)

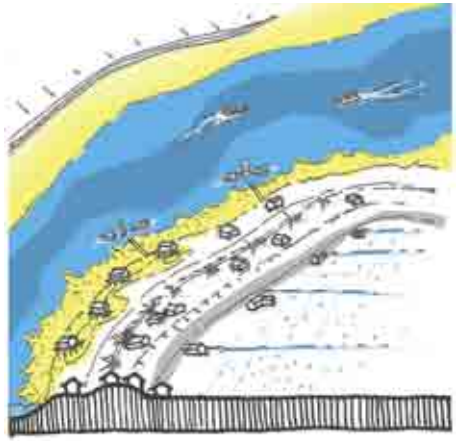
The canalization process were introduced far later in the Mekong delta. Until the 19th century, canal systems were introduced and played a key role in the development of new urban form. Silt from digging these canals created high manmade levees for settlements. In these cities, waterways as rivers and canals were mainly transportation and goods exchanged routes. Moreover, they were also used for irrigation, drainage and fresh water supply purposes. Aware of the changing environment conditions, inhabitants in these cities developed adaptive strategies, often called "shaking hand with floods", that accepted rather than resist the potential catastrophic risk (Miller, 2006).

These strategies resulted in a typical delta image with stilt houses, boat houses, floating markets, three sided canoes that are still visible in the current delta cities.

From American war to present

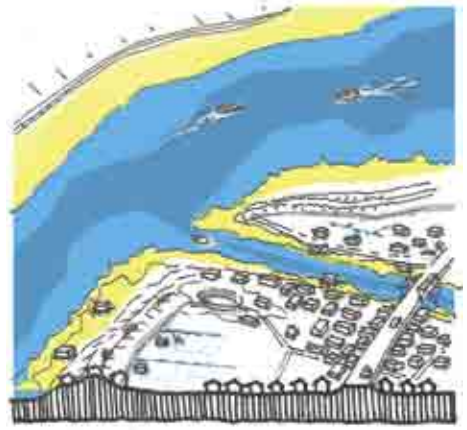
Starting from the sixties, the system of land-based infrastructure and flood-control became a national concern for economic development. Settlements and cities developed at the meeting points of motor roads and waterways that are high and dry places in times of flooding. The road replaced the water as the domain of city and played a role in the embellishment of the city (Pham, 2011).

Before 1800



1802-1867

1867-1960



1960 to present

Project background

Current developments in Mekong delta, Vietnam

Vietnam:

In the few decades, Vietnam has experienced significant development changes, especially urbanization and industrialization. The application of Doi Moi policy has opened market orientation and private sector development, which enabled a transition of the economic structure from agriculture based economy to industry and service based economy. As the result, annual GDP growth rates has increased to 6-8%, poverty rates have decreased, population has doubled,…etc.

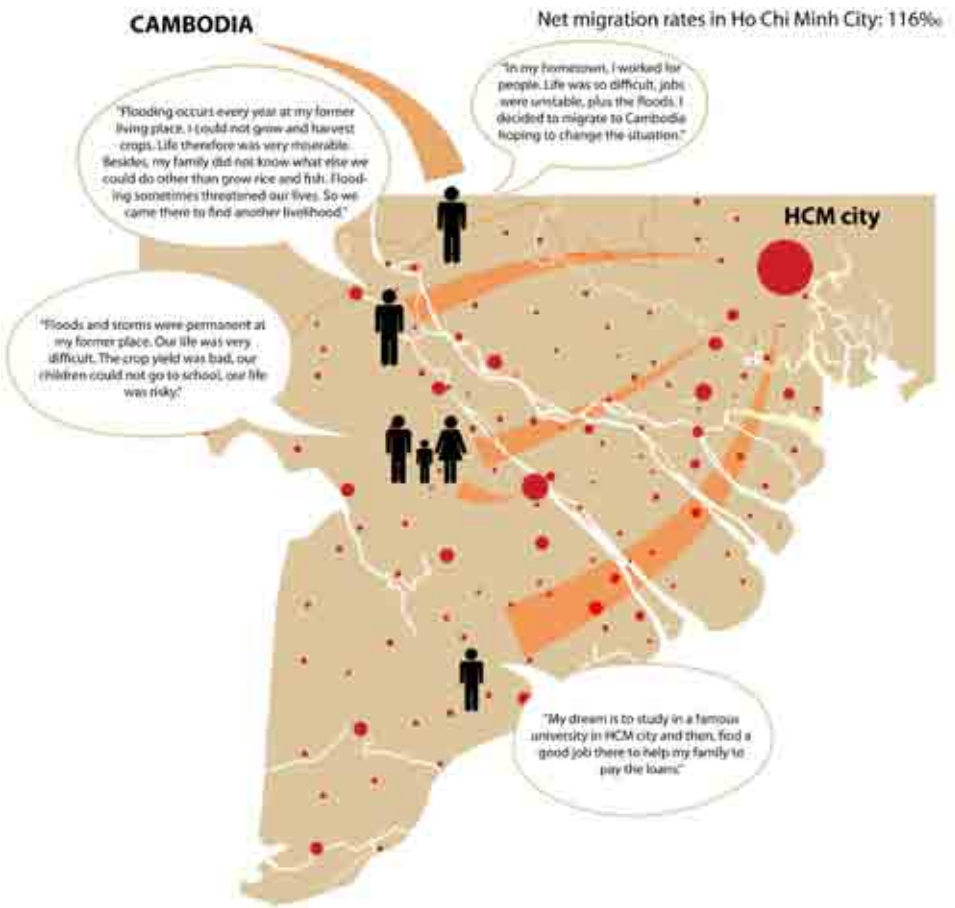
Mekong Delta:

Following the development of technology and the increasing need for urban development, infrastructure has become more powerful with dykes, artificial canals, pumping station, etc. Thanks to these interventions, urbanization in the delta grew dramatically as well as economy. Nowadays, there are 17,4 million inhabitants (2009) living in Mekong delta, Vietnam which is about 22% of Vietnamese population, compared with only 2,7 million in 1910. The introduction of water controlled infrastructure resulted in the enable of most of the land in the delta for agriculture and aquaculture purposes. It plays important roles in food security and economy development by contributing 50% of the country's agricultural production, 50% of rice, 60% of fruit and 65% of seafood products. Consequently, industries such as food and fishery processing, transporting, trading and associated services have a lot of potentials to develop…

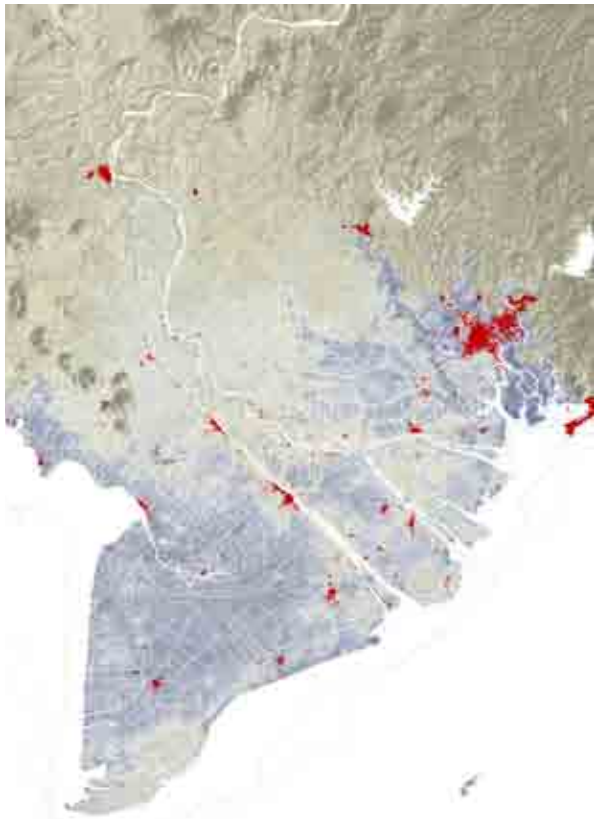
However, development also brings challenges. These challenges are similar to all deltas in the world. 'Most delta-areas in the world are dealing with increasing complexity and changing dynamics, because of two reasons: first, the changes in the natural dynamics of the delta due to climate change and human interventions, and second, the changes in the dynamics of land-use, dominated by urbanization, industrialization, port-development, agriculture and leisure/tourism' (Meyer, H. and Nijhuis, S., 2011). In Mekong delta, these challenges are presented:

Urban development and economic growth

The process of urbanization interferes population and life in Vietnam. Rural areas used to have agriculture as the main economic activity and non-agriculture such as handicraft and retailing. After "DOI MOI" policy (innovation), due to the investment, industrial zones are set up, infrastructure is upgraded here; agricultural land is converted into urban land, economic activities shift to non-agriculture, rural culture is replaced by urban culture (TRAN, 2009). Urban sprawl takes place rapidly as the result of liberal policy for immigrant increase in response for labour need of the booming invested industries, infrastructure, non-state retail market and urban services (Duong, 2008). Immigrants often find higher income compared to farming in the agricultural land. Not only in the city centre, they also cluster in densely informal settlements next to industrial zones, transportation routes, markets in the city fringe. This unattended urban sprawl leads to common problems that countries in all over the world have to deal with nowadays: inefficient land uses, traffic jams, poor housing qualities, environmental pollutions, etc… Collectively these urban sprawls will hamper sustainable urbanization and slowdown socio-economic development process.

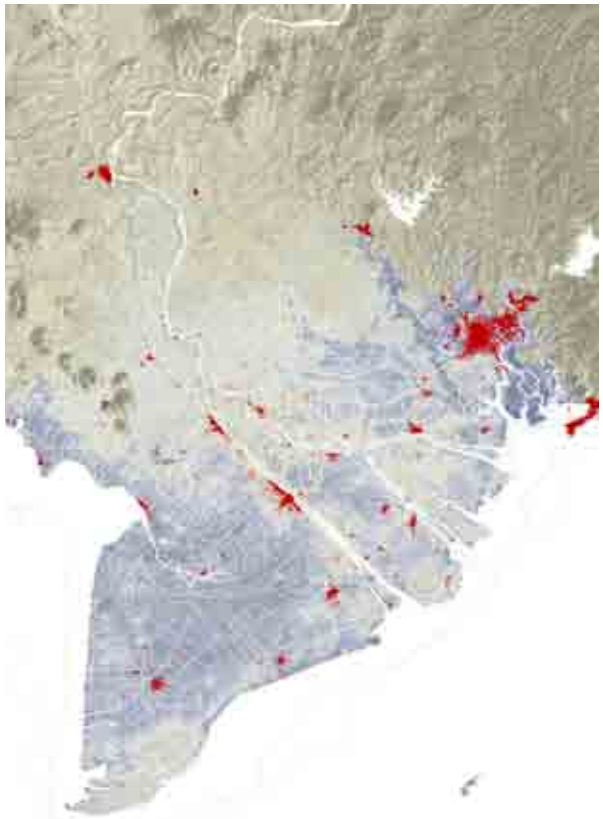


Immigration trend in Mekong delta
Source: based on Interview document EACH-FOR

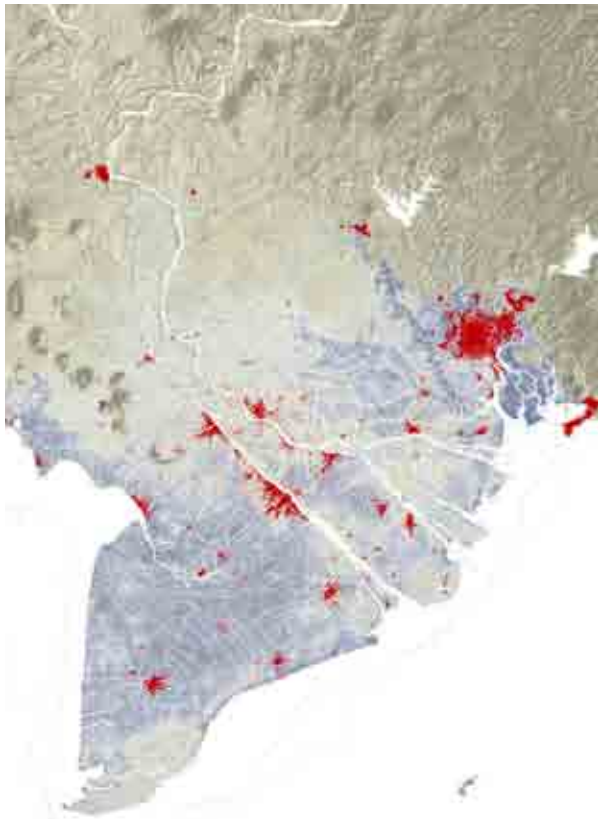


Urban growth in Mekong Delra

2010
Population: 17.4 millions
Urbanization rate: 30%
Source: based on Mekong Delta Construction Planning



2020
Population: 20-21millions
Urbanization rate: 33-35%



2050
Population: 30-35 millions
Urbanization rate: 40-50%

Especially in Mekong Delta, the natural resources have been considerably diminished due to the exponential increase in population and urban sprawl. High population growth is leading to increasing demand of drinking water and food. Water quality of the Mekong is affected by such factors as industrial pollution, urban waste disposal and sewage, use of fertilizers and pesticides, soil erosion and salt water intrusion. In rural areas only a minority of the population have access to clean drinking water. Chemical and organic pollution pose serious threats to human health and the environment. Human pressure on arable lands and wetlands is deteriorating natural protection, fisheries and biodiversity.

In addition, new development challenges have emerged, including social inequity, migration from rural to urban areas, epidemic outbreaks, loss of cultural values. Most of young people in rural areas have migrated to the big cities to work, Ho Chi Minh City as an example. However, being poorly equipped with a low education level and technical skills, the rural young oftentimes end up selling their simple labor and fetch low incomes (Duong, N. et al., 2010).

Project background

Inundation ans salinization map in 2010
Source: Base map by Q.D. Pham

Inundation ans salinization map in 2020
Source: Base map by Q.D. Pham

Human interventions

Human interventions throughout three centuries brought many benefits for inhabitants. Investments in this sector are a key driver for economic growth. Number of roads, waterways and dikes are invested in order to facilitate growing economy and population as well as limit high risks on flood damages and casualties.

However, in the last decades, actions toward the environment have shifted strongly from adaptation to control. Large scale hydraulic control structure have built to target floods in the upper part of the delta and saline intrusion in the coastal area, at the same time, many canals have transformed into motor-roads and new dike rings have built to protect new urban areas. The modified distribution of water has required a huge amount of money and also created different risks. The question remains however, if there has to be a strategy of more control or rather adaptation, or as Mira Käkönen states 'the Mekong Delta is now at the crossroads' (Käkönen, 2008). There is the need for a new thinking and collaboration of water engineering/ management and design.

Climate change

There are two main impacts caused by climate change to the Mekong delta, namely sea level rise and extreme climate conditions: more serious and earlier flood and longer period of drought (Bucx, T., Marchand, M., Makaske, A., Van de Guchte, C., 2010). The climate in the Mekong Delta is influenced by both the southwest and northeast monsoons. In general the dry season runs from December to April while the wet season spans May to November. In the wet season almost 50% of the Delta is flooded (1,900 km2). In the dry season, flow in the Mekong is insufficient to prevent saline intrusion and extensive salinization of waterways occurs in the south of Mekong delta, especially in Ca Mau Peninsula where is salinized for almost 6 months.

Climate change adds to the already substantial sources of risk. The average temperature is predicted to rise by 2°C in 2050. Until 2100, the temperature is projected to rise and by 3°C in 2100. This will cause an increase of the discharge of the rivers. It is also one of the causes of the rising sea level.

As the consequence, climate change will increase the flood risks in Mekong Delta due to the integration of above factors: sea level rise, higher water discharge, more extreme rainfall. Approximately 20 per cent of the land will be flooded when sea level increase 1 meter in 2100 (Monre, 2003). On the other hand, in dry season, fresh water availability will decrease due to less rainfall, less water discharge, salinity intrusion and higher water demands in the future. (See Appendix 4)

3. Cao Lanh city

Introduction

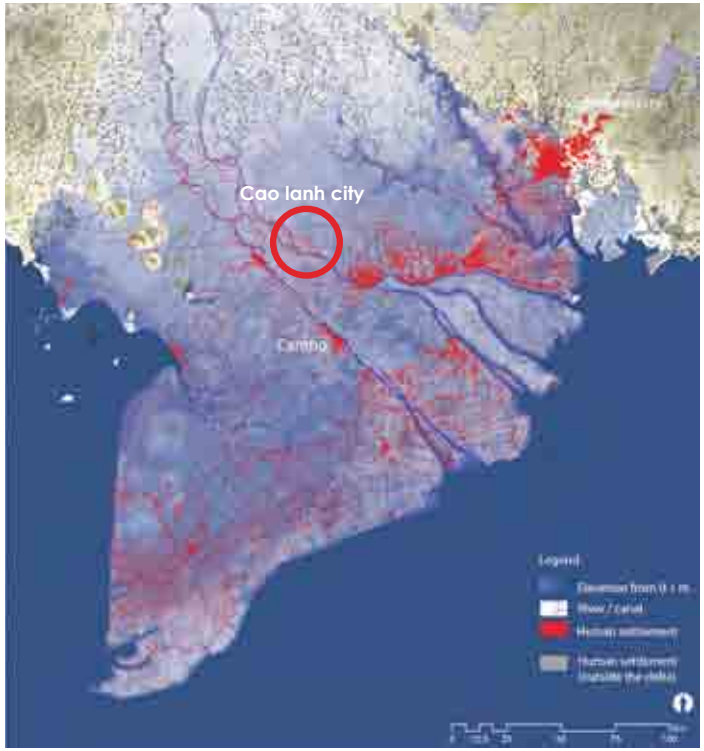
The case study for the project is Cao Lanh city which are now experiencing the delta's problems: climate change, urban development, economic growth and the effects of human interventions. Cao Lanh city is the capital of Dong Thap (also known as "Plain of Reeds") province one of the 13 provinces, also the deepest flooded zone of the Mekong Delta. It is located on the Northern side of Tien River, a main branch of Mekong river system. The city started to grow in the 19th century from a very small village. However, it has just been developed to a commercial city since the late 1970's and become the important market of Dong Thap– a huge granary of the delta.

At present, the city is made up of three different characters:
_ A compact city center which is well structured by an orthogonal network of roads.
_ A large rural zone between the center and Tien River which is criss-crossed by small canals. Settlements follow the very narrow strips and are covered by orchards and paddy fields.
_ An industry zone in the North of the city which is served by the road and the river transportation.

Problems

Annually, Cao Lanh is affected by floods from both river and upstream. Floodwater from upstream overflows directly through the oriented canal system constructed for agricultural purpose in Dong Thap. At the same time, floodwater on Tien River overflows its banks and causes serious damage to the city. Moreover, floods, together with acid soil are considered as a major problem.

The development of Cao Lanh city experienced in the last decades shows an unintended expansion of the city towards the rural zone and the floodplain areas which might result in addition problems. Moreover, the proposed of a new connection to Ho Chi Minh City and East-West connection offered Cao Lanh a lot of potentials to rapidly develop. In response, new flood defence system has to be developed and new spatial planning and design has to be proposed that can balance urban expansion, water safety, ecological preservation and economic development.



The Mekong Delta
Source: maps by Q.D. Pham

Development of Cao Lanh, Mekong Delta
Source: maps by Q.D. Pham

Project background

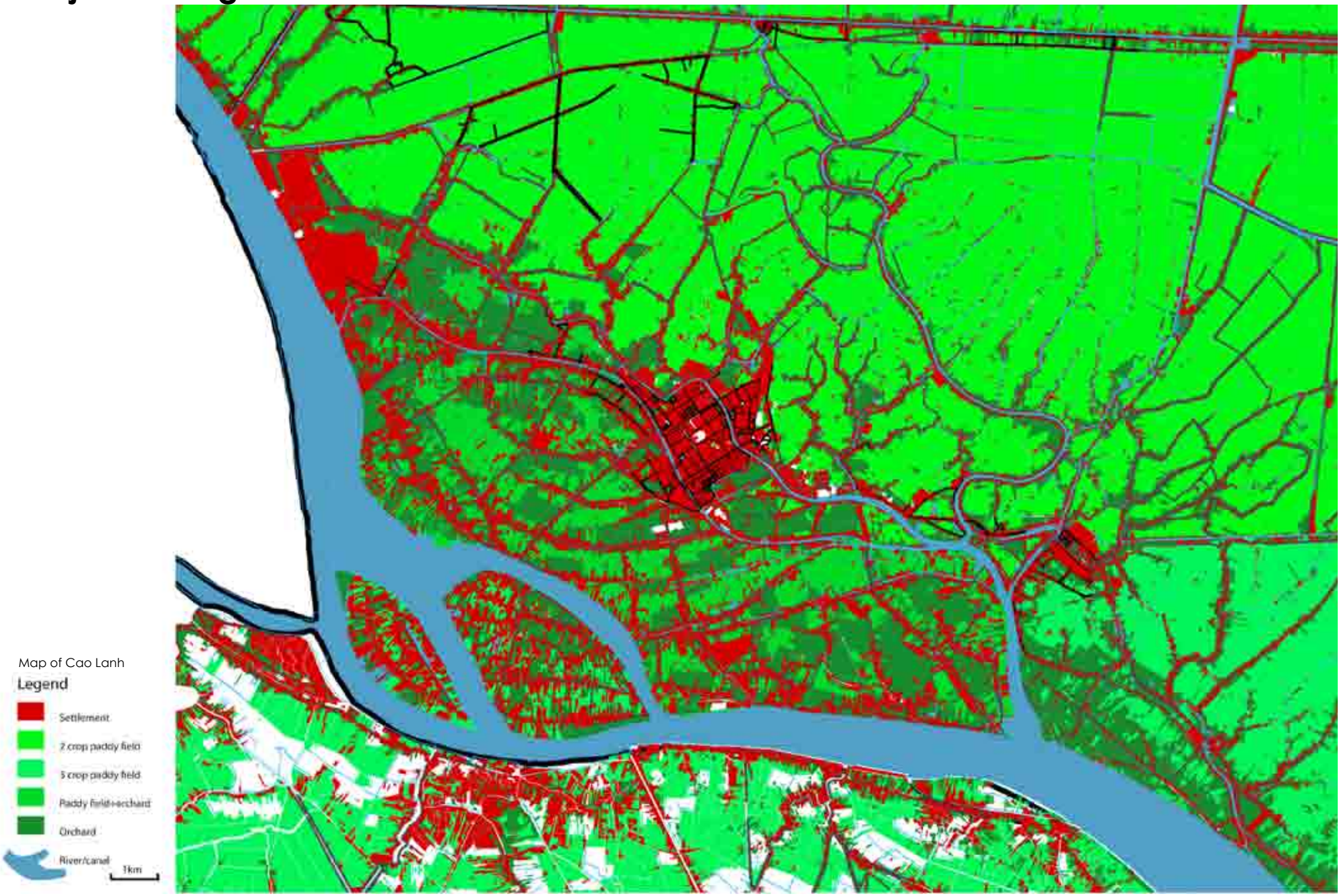


PHOTO BY TANNOBI

Chapter II. Project implementation

Problem statement
Aims and research question
Relevance
Involve disciplines
Methodology
Time schedule
Literature review

Project implementation

1. Problem statement

For three hundred years, Mekong delta has become a water society where inhabitants in this region developed adaptive strategies, often called "shaking hand with floods", that accepted rather than resist the potential catastrophic risk (Miller, 2006). Historically, people first settled on the lightly higher terraces and later on the levees along the river. With the digging of canals, people started to settle along the canal banks; such settlement has formed a typical pattern of ribbon-like settlement (Pham, 2011). At the confluences of network system, intensified urban expansion is occurring.

Over twenty years after the introduction of "DOI MOI" policy (innovation), Mekong delta in Vietnam has experienced significant expansion of cities and rapid growth of population. The water cities are transforming into the road cities in which the role of water in the city structure is going to be neglected. Thus, the cities are losing its unique characteristic and inhabitants are facing more vulnerable to flooding. Furthermore, the consequences of human interventions into natural process have caused an essential change in the natural landscape (Meyer, H. and Nijhuis, S., 2011). The transformation from a natural dynamic water system in which people adapted to the forces of nature into an infrastructure system in which the forces of nature are attempted to be controlled, turns out to be more problematic.

Finally, climate change will have a serve impact on the natural system of the delta and in the lives of those living in these areas, namely: flood events, storm surge, water scarcity, subsidence and salinization.

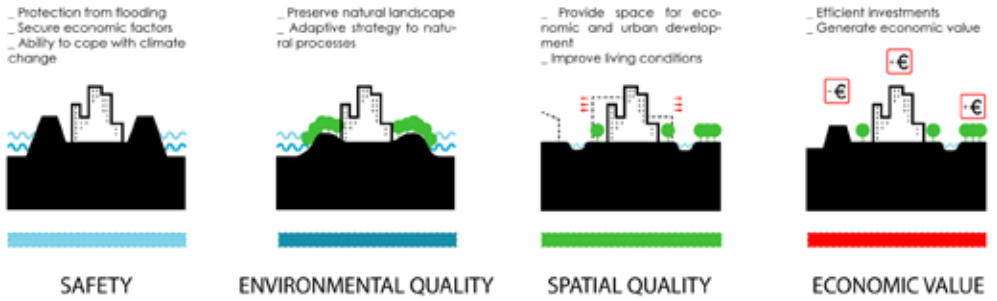
In Cao Lanh city, the construction of new connection to Ho Chi Minh City is going to modify the urban patterns of the city and its connection to other delta cities in the region. Situated in along the river, Cao Lanh is in a strategic position to benefit from the new tendency. But the development also set a new challenge: what is the future for Cao Lanh city in which, the natural system of the delta and its unique landscape will be preserved, inhabitants will be provided safe and liveable environment to live and economy will grow.

A new urban development strategy needs to be adopted.

2. Aims of the project

By understanding the complex system of Mekong delta cities including nature system and urban system, the project want to show that the preservation of delta landscape, water management and urban development can be integrated. In addition, the project will explore the possibilities to apply different strategies, such as: "Design with Nature", "Room for the River" and "Working with nature" to the Mekong delta in Vietnam.

Finally, these studies will contribute to a more sustainable and less vulnerable form of urban development that addresses flooding in combination of hydraulic engineering, urban planning and environmental qualities: "Flood adaptive cities" through the example of Cao Lanh city.



?

3. Research question

Main research question

How a new form of urban development for the Mekong delta can provide a water safety condition, preserve environment, improve the spatial quality and meanwhile provide economic value for its inhabitants?

Sub research questions

Mekong Delta analyses :

1. What are the unique characteristics of Mekong delta landscape?
2. How did its nature landscape, infrastructure and urban layer transform throughout three hundred year history?
3. What are the characteristics of cities in Mekong Delta today? (including city typology and urban settlement typology)

Cao Lanh City analyses:

4. What are the problems of Cao Lanh city? What are the challenges in the future?

Regional development:

5. What can be the development strategy for Mekong delta region in dealing with climate change and urban expansion?

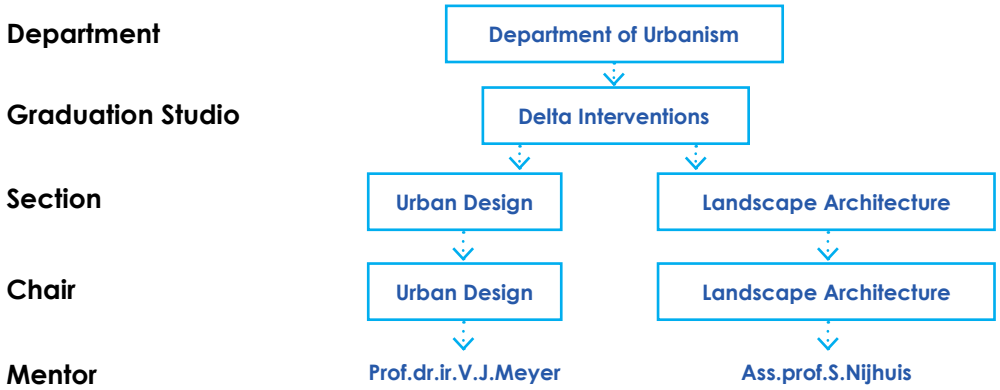
Urban structure plan:

6. What would be a more sustainable and less vulnerable form of urban development in Mekong delta?
7. How the unique nature landscape of deltas can be repaired and combined with future urban pattern in respond to the rapid changing environment?

Urban design (city part):

8. What are the hydraulic principles and measures suitable to apply in Cao Lanh city?
9. How do they improve the spatial quality and economic value of the city?

4. Involved disciplines



5. Societal and scientific relevance

Like the Delta plan in the Netherlands, Mekong Delta in Vietnam has its own Delta plan that in now still developing with the technical and educated support from Dutch experts. The plan is expected to be ready by the end of 2012; however, the process seems to be not going smoothly (van de Tol, 2011). There is a need to carefully look at the delta from different points of view, integrate and cooperate in order to find sustainable solutions.

Societal relevance

Deltas were attractive areas because of favorable conditions for agricultural and trading development. Since most of the large cities are located in delta region, an unintended side effect of the growth and the ensuing concentration of population is the increased challenge. The changing global climate recently puts additional pressure on this challenging situation. These challenges have led experts and policy makers to rethink their development strategies. At the same time, people all over the world are seeking practical, innovative, sustainable solutions to adapt to the impacts of climate change and facilitate sustainable development of delta cities.

In South East Asia, Mekong delta with its 17 million inhabitants is now coping with the negative effects of climate change, urbanization and economic development. People living in the delta who used to wait for the flood season every year are now threatening by its increasing damages. In 2011, flood had killed 20 people and damaged property worth $47.62 million in Dong Thap province. In 2012, already natural disasters have caused damage worth more than $1.7 million. Therefore, in order to grow, delta cities in this region have to find the way back to their tradition approach "shaking hand with flood" in combination with a sustainable urban development strategy.

Scientific relevance

Sustainable development is crucial in deltas all over the world. This is not solely relying on technical solutions to fight against and control the delta environment, but a new approach that utilizes natural processes for water safety and sustainability for both the delta and its inhabitants. This approach is targeted at different disciplines: hydraulic engineering, urbanism and landscape architecture. Although there already exists a large body of knowledge on the characteristics and functioning of many deltas, most of this information is of a mono-disciplinary. There is relatively little knowledge that enables an overview of delta management in which these disciplines would be integrated.

Project implementation

6. Methodology

In order to answer the research and sub-research question, several methods have been used. They will be described briefly below:

Literature review

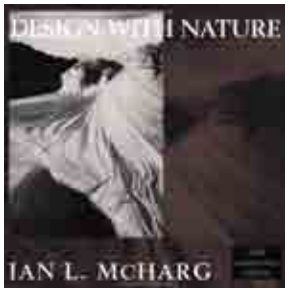
Research question can be answered by several theories and approaches coming from books, reports, conference proceedings and other official documents (shown in the list of references).

Important authors are:
_D. Biggs: Associate Professor of History at the University of California, USA. In his book, Quagmire, Biggs focused on the landscapes and waterscapes in Mekong delta in Vietnam and their relationship to the complex colonial history of transformation (Biggs, 2010).
_H. Meyer: Professor of Theory and Methods of Urban Design, TU-Delft since 2001. In 2010, he published Urbanism: The Netherlands. It is a detailed history and overview of how one low-lying country has developed the policies, tools, technology, planning, public outreach, and international cooperation needed to save their populated deltas.
_R. Campanella: Geographer / Senior Professor of Practice in Tulane school of Architecture. Delta Urbanism: New Orleans
_K. Shannon: Associate Professor of Urbanism at the Katholieke Universiteit Leuven, Belgium. Most of her work has focused on the evolving relation of landscape, infrastructure, and urbanization in South and Southeast Asia.
_D. Pham: PHD student about Mekong delta
_Ian Mcharg (1920-2001): He was the founder of the department of landscape architecture at the University of Pennsylvania in the United States. His 1969 book "Design with Nature" pioneered the concept of ecological planning. It continues to be one of the most widely celebrated books on landscape architecture and land-use planning.

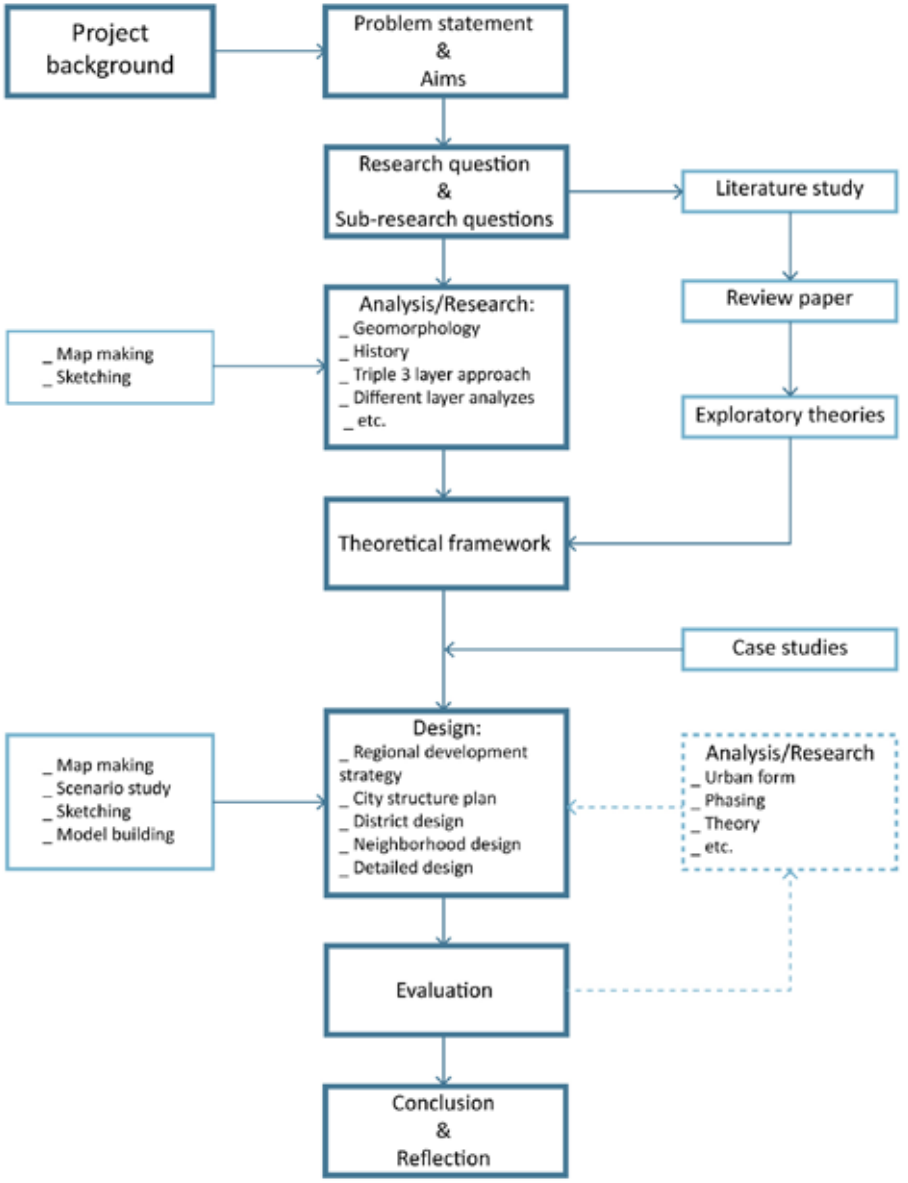
Quagmire

Delta Urbanism
The Netherlands

Delta Urbanism
New Orleans



Design with Nature



Methodology

Important theory and approaches are:
_Ruimte voor de Rivier/Room for the River: "Rooms for the River" (Ruimte voor de Rivier 2007) policy was proved by Dutch government in 2007. The policy outlines numerous designs to provide more space for the river and lower high water levels. Its two main objectives: Safety "Improving flood protection in the Rivers Region up to the required level" and Spatial quality "Contributing to improving the spatial quality of the Rivers Region".
_Working with nature: The new concept "Building with nature" (De Vriend, H.J. and Van Koningsveld, M., 2012) aims to be proactive, utilizing natural processes and providing opportunities for nature as part of the infrastructure development process.
_ Compact city: the term Compact City was first coined in 1973 by George Dantzig and Thomas L. Saaty, two mathematicians whose utopian vision was largely driven by a desire to see more efficient use of resources. The concept, as it has influenced urban planning, is often attributed to Jane Jacobs and her book The Death and Life of Great American Cities (1961).
_ Transit Oriented Development: The concept of Transit Oriented development originates from North America and now is widely implemented in cities all over the world.

Layer approach

Urban delta is a complex system. In order to explore a better solution, understanding this system is needed. The relationship of natural landscape, human interventions and urban patterns can be investigated by using 'Layer approach'. This approach firstly was introduced by Ferdinand von Richthofen (1833-1905) to describe the chorological and topological relationships in the landscape. In the late sixties, Ian McHarg, a landscape architect, applied and developed it into 'layer cake model' for reasons of spatial analysis and planning in his seminal work: Design with Nature (McHarg, 1969).
Recently, "Triple 3 layers approach", a more comprehensive planning and design oriented approach towards urban delta landscapes, was introduced by Meyer and Nijhuis (2010). This 'Layer model' presents a physical hierarchy in the sense that the layers enable and/ or constrain activities in another layer.

Case studies

Not all delta cities can easily be compared to other delta cities. But many delta cities have developed along the same patterns and have experienced the same problems as other delta cities did at the same phase in their development. Therefore, it will be beneficial to study various case studies to explore not only their systems but also how these cities develop to cope with the dynamic changing environments.
In this project, there are three types of case study are done.
_The first type of case study is to understand the context of Mekong delta and the general development of delta cities in this region. Can Tho city, as the biggest city in Mekong delta are chosen because of its experiences in rapid urban development and water problems.
_Secondly, case studies such as: Tokyo Super levee (Japan), Nijmegen (Netherlands) is more towards water solutions in combination with spatial solutions.
_Thirdly, Curitiba as the last case study provides a sustainable way of development in which city develops compactly, liveable and safe.

Use of Toolbox

The book of "River. Space. Design" is the product of a multi-year study that subjected more than fifty Western European projects to a comparative analysis (including "Room for the River). In this book, multi-dimensional strategies for riverside and water design that benefit river ecology, improve flood protection and expand human amenities. These strategies involve different disciplines such as: landscape architecture, ecological science, engineering and planning.
In this project, the toolbox giving by "River. Space. Design" is used as a great source for shaping design ideas. Based on the characteristics of designed site and proposed design strategy, different measures are chosen and combined in order to get four targets: safety, environmental quality, spatial quality and economic value. (See Appendix 5)

Scenario study

The aim of scenario study is to test a more strong and adaptive design.
In this project, different scenarios can be found based on different possibilities of climate change and urban development in Mekong Delta until 2050. Proposed design and strategy should be flexible enough to adapt to different scenarios.

Map making

In a planning and design project, map making plays an important role in understanding the context of the current or proposed plans. However, there is a lack of knowledge and enable data of Mekong delta that results in some difficulties during the project.

Sketching

Instead of drawing maps and making photos on computer, sketching offers a lot of potentials to discover new ideas. In this project, sketching is used in expressing author's thinking about the Mekong delta, illustrating city's impressions, testing the possibilities of strategic planning and design.

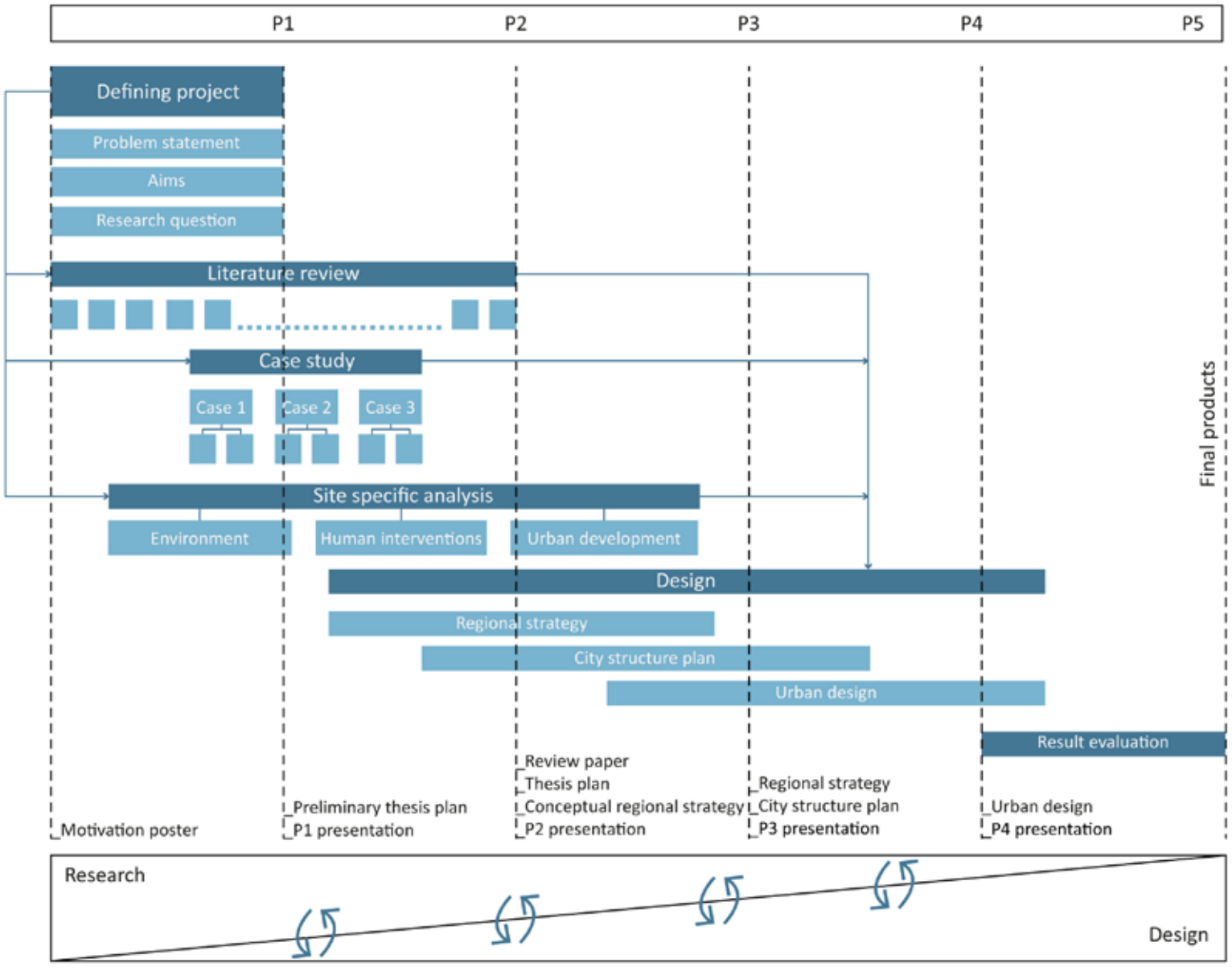
TV series

"Mekong mermoir" (which is known as "Mekong ky su" in Vietnamese) is the famous documentary about Mekong river basin. With 92 parts, it gives a strong impression of the landscape, people and their lives in Mekong delta.

Model building

Project implementation

7. Time schedule



Chapter III. Mekong Delta Analysis

Methodology
Time schedule
Literature review

Mekong Delta Analysis

1. Natural drivers in Mekong delta

Geomorphological forming of the Mekong delta

The main channel of the Mekong River was believed to have formed between 2 and 50 million years ago in the late Tertiary period. From this time, Mekong River started to carry and deposit sediment to its delta that reflects the delta typology: fluvial, tide and wave interaction. During 9 thousand years before, the sea level rose from -120 meters (21 thousand years before) to -60 meters (13 thousand years before) and to -20 meters (Hanebuth, T., Stattegger, K. & Grootes, P. M., 2008). Around 7 thousand years ago, because of the development of mangrove forest, human activities upstream and sea level rise, the amount of sediment material increased. Consequently, delta's shape began to be formed. From 6.3 thousand years ago, the delta had expanded more than 200 km southward (Ta et al., 2002, Tamura et al., 2009, Nguyen et al., 2000).

During the late middle Holocene (about 3 thousand years before), the morphological delta changed from tidal delta into wave dominated delta. The increase of sediment from upstream once again has resulted in the rapid development of the Mekong delta toward the sea. Until the XII-XIII century, the coastline has almost reached the present coastline (Pham, 2011).

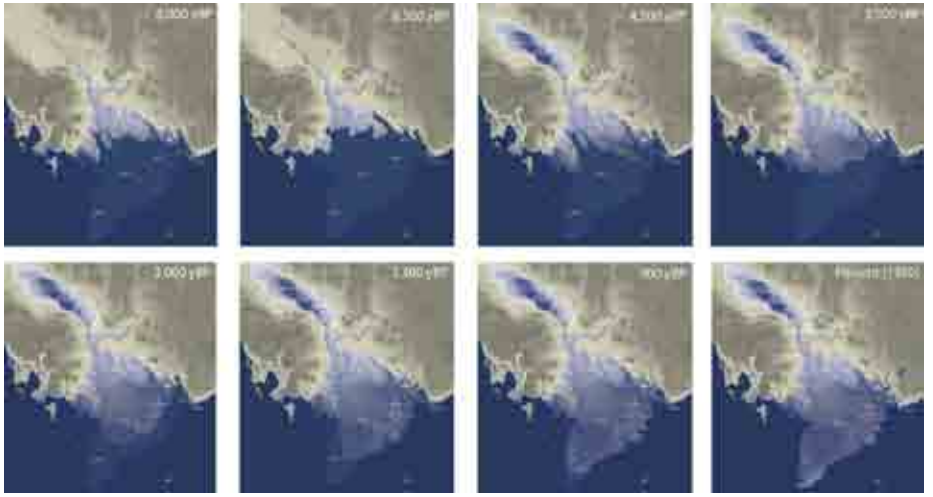
Climate

The Mekong delta in Vietnam lies within the humid tropics, characterized by high monthly temperature (25-29oC) and high seasonal rainfall (1200-2300mm) (Hashimoto, 2001). Seasonal climatic variations are controlled by monsoons: during the wet season (May-November), bringing over 90% total annual rainfall and during dry season (December-April), characterized by long lasting sunshine and high temperature.

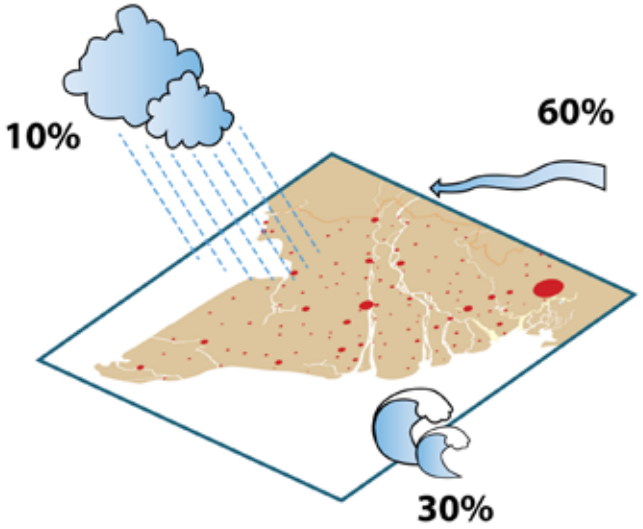
Flood

The annual floods caused by high flow discharge from upstream, heavy rainfall and high tidal from the sea, forms a vital part of life in the delta. The flood areas are ranged from 1.2 to 1.4 million ha in years of low and medium flooding and about 1.9 million in years of high flooding. The flood season in Mekong Delta starts from July, increases significantly during August and September and reaches its peak in October.

As other deltas in the world, Mekong delta is submerged by flood events: loss of life and economic damage. There are other flood damages recorded: erosion, navigation hazard, pests and health risks (Miller, 2006). However, floods also bring a lot of benefits for inhabitants in Mekong delta. Historically, it can be seen that the natural form of Mekong delta is always linked with floods. And several natural resources are brought by the flood events annually:

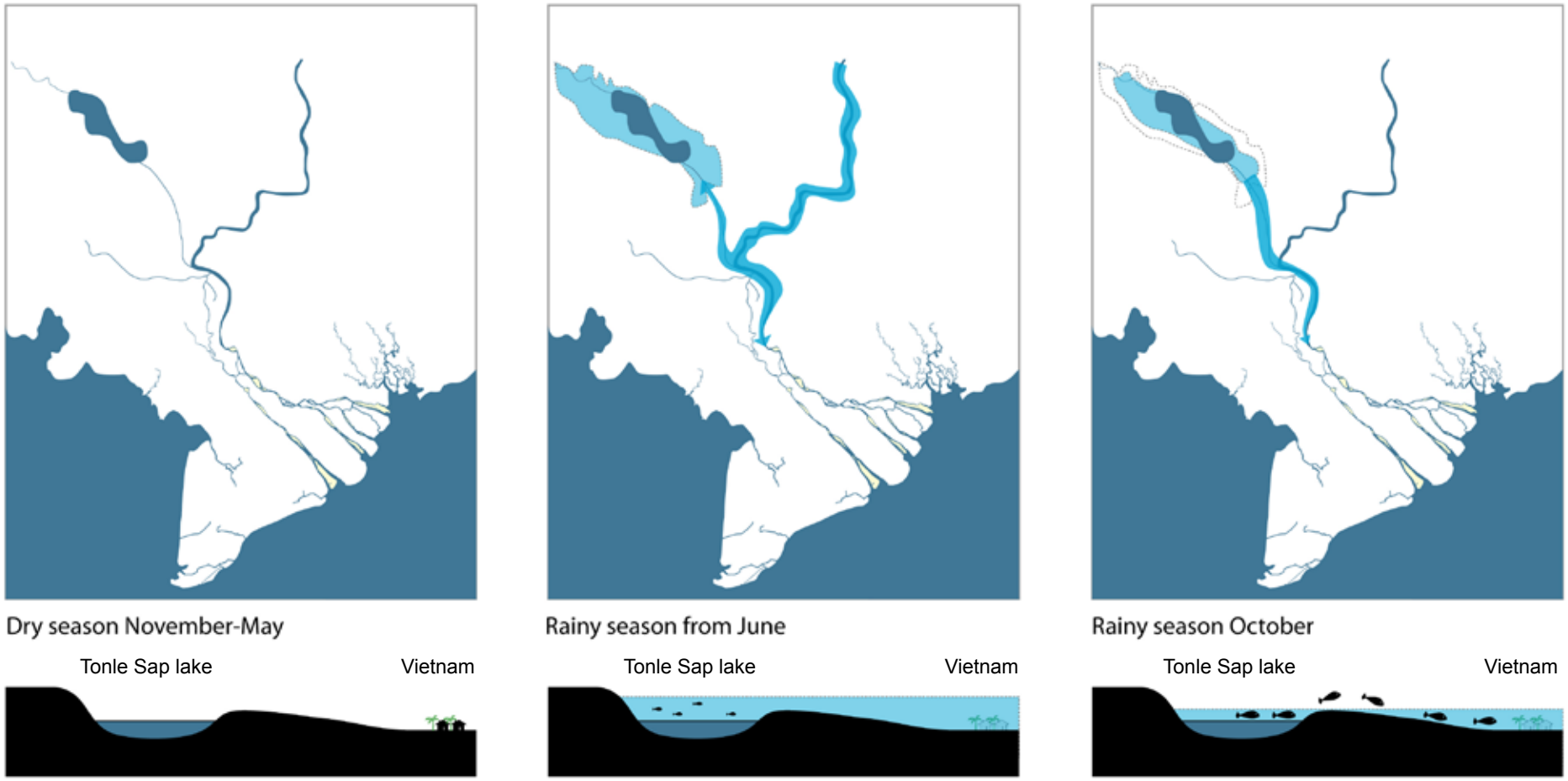


Paleogeography stages in the Mekong Delta.
Source: Maps by D. Pham



FLood typologies in Mekong delta
1. Heavy rainfall continously
2. High flow discharge from upstream
3. High tidal flow from East Sea

Flood typologies in the Mekong Delta



Water discharge from Tonle Sap lake, Cambodia to the Mekong Delta, Vietnam

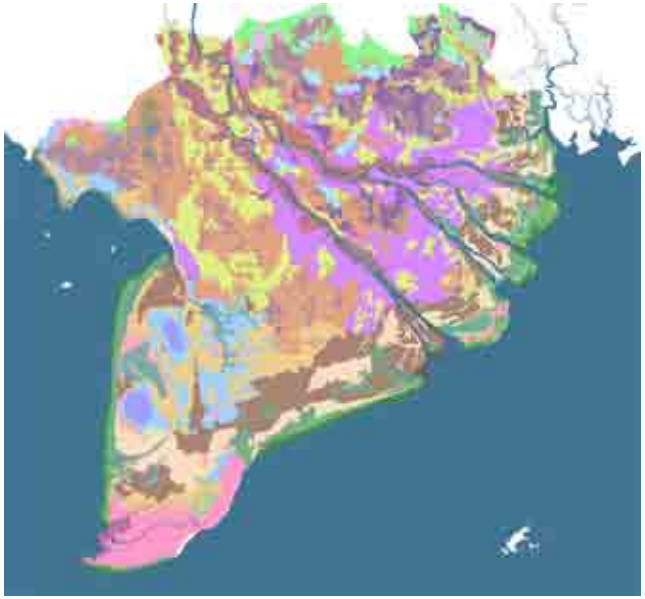
_Fertile sedimentation: Floods carry a huge amount of sediment from upstream and then deposit this material on fields as natural fertilizer for crops and fruit.
_Fish: when the flood season comes, level of water in Tonle Sap Lake (Cambodia) increases. And when it discharges to the sea, young fish from Tonle Sap Lake follow the flow to Tien and Hau rivers.(image shown on next page)
_Aquatic products: farmers catch snakes, snails, rats or harvest wide floating rice and vegetables from floodwater .

Mekong Delta Analysis

2. Layer approach

Pre-colonial period: Nguyen dynasty (1802-1867)

The delta started to form its own landscape since the mid of 16th century when Nguyen Lords introduced a policy of land reclamation and breaking fresh ground to create villages (Pham, 2011). A large amount of inhabitants from the north and centre parts of Vietnam had come and reclaimed new lands. Therefore, the first type of settlement was created: villages around high ground areas along rivers (natural levees) and watercourses where the fresh water could be collected and the settlers could survive from flooding. At the same time, a system of canal and small ditches were built up for transportation and irrigation purposes.



Mekong delta from 1802 to 1867

Water network

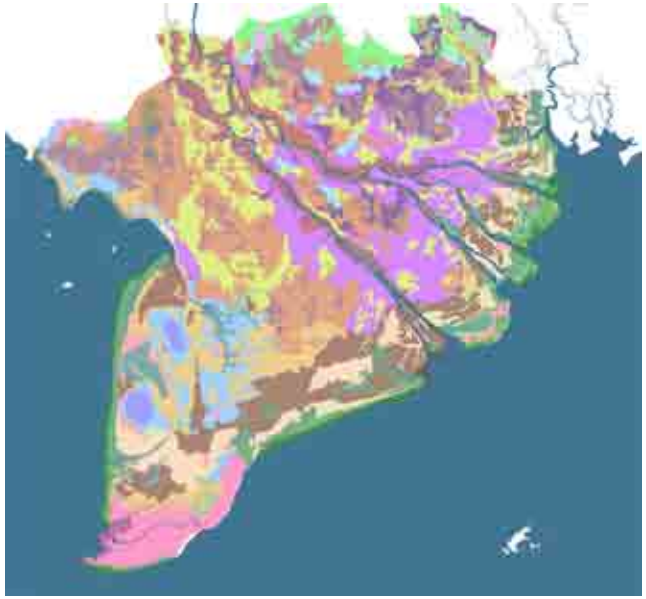
Urban pattern

Soil

Road network

French colonial period

The canalization process were introduced far later in the Mekong delta. Until the 19th century, canal systems were introduced and played a key role in the development of new urban form. Silt from digging these canals created high manmade levees for settlements. In these cities, waterways as rivers and canals were mainly transportation and goods exchanged routes. Moreover, they were also used for irrigation, drainage and fresh water supply purposes.



Water network

Urban pattern

Soil

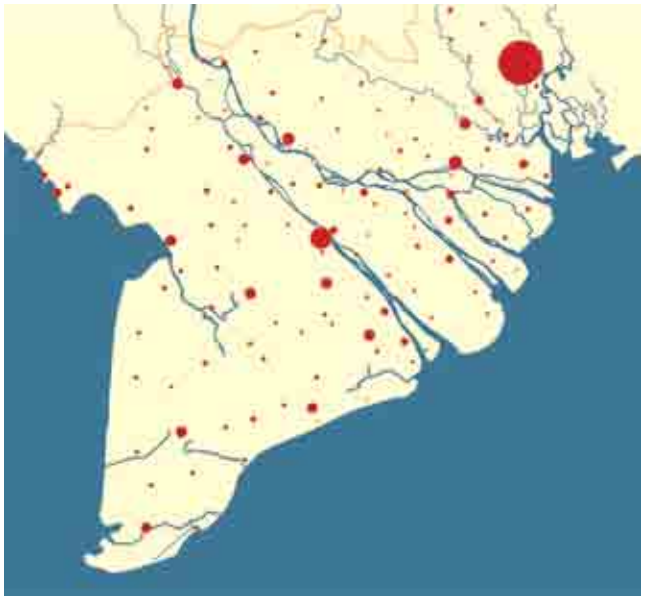
Road network

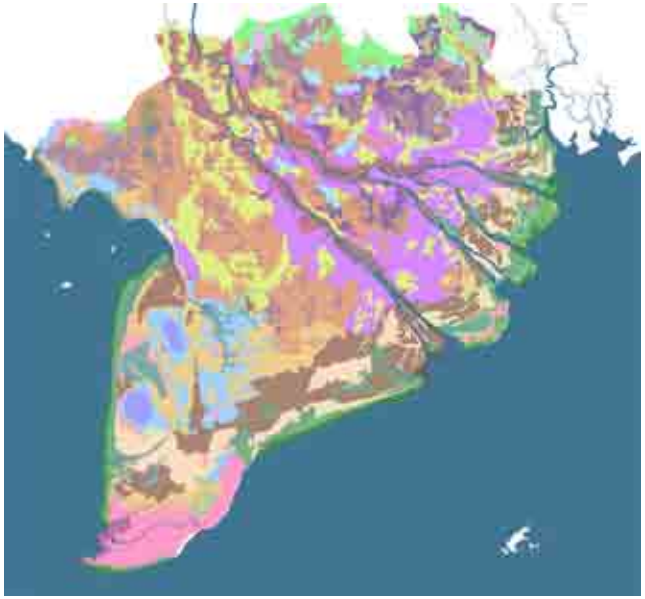
Mekong delta from 1867 to 1960

Mekong Delta Analysis

From American war to present

Starting from the sixties, the system of land-based infrastructure and flood-control became a national concern for economic development. Settlements and cities developed at the meeting points of motor roads and waterways that are high and dry places in times of flooding. The road replaced the water as the domain of city and played a role in the embellishment of the city (Pham, 2011).





Mekong delta from 1960 to present

Water network

Urban pattern

Soil

Road network

Mekong Delta Topographic map
Source: Maps by D. Pham

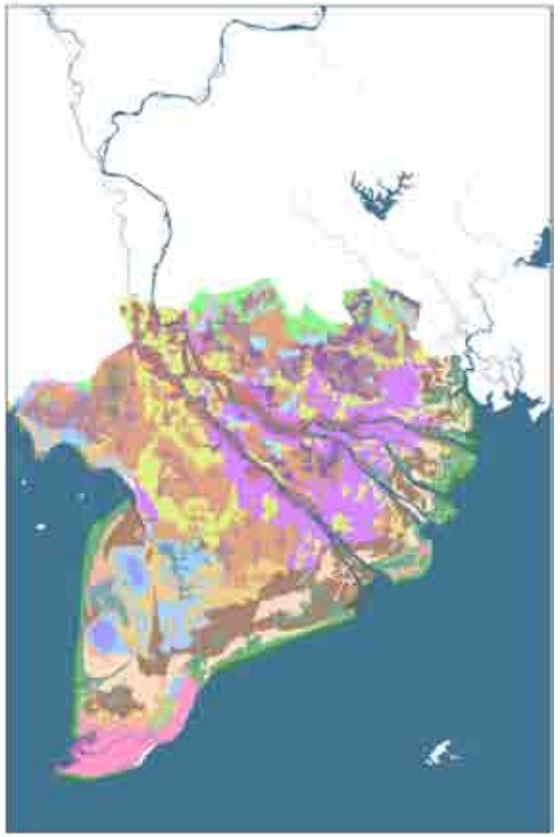
Topography map

The Mekong delta in Vietnam is a low-lying region with average height of about 5m above the sea level. Some regions of this delta as Long Xuyen quadrangle, Dong Thap Muoi (Plain of Reeds) and western Hau River are lower than average sea level. Therefore, about 1 million hectares of the delta is often covered by flood water for 2-4 months per year.

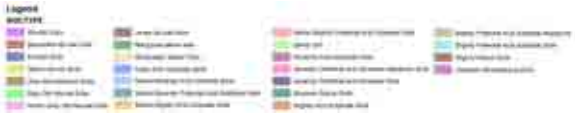
Mekong Delta Inundation map
Source: Maps by D. Pham

Inundation map

There are two main areas in Mekong delta heavily damaged by flood in the rainy season, namely Long Xuyen quadrangle and Plain of Reeds, although these two areas are higher than surrounded areas. Every year, Long Xuyen quadrangle and Plain of Reeds are affected by annual flooding by over-flows from the river and overland from Cambodia across the Vietnam border. The inundation depth can reach high peak level at 2-5 meters. The flat to-pography of the delta and narrow width of the river result in the long period flood in this region.



Mekong Delta Soil map
Source: Maps by D. Pham



Soil map

Dominant soil types of Mekong Delta are sandy, alluvial, degraded grey, saline and acid sulphate. Apart from alluvial soils with an area of about 1.2 million ha (more than 30 % of the area of Mekong Delta); most of the remaining area is with “problem” soils, in which the acid sulphate soils and saline soils occupy the largest area (about 60 % of the area of Mekong Delta).

Mekong Delta Analysis

3. Natural landscape analysis

For thousand years, the natural processes of sedimentation, change of sea level, tidal and currents of the sea have structured a unique Mekong delta landscape with different landscape zones (Pham, 2011). From upstream to the sea, the Mekong delta landscape can be divided into 3 main landscape zones: River landscape, floodplain landscape and coastal landscape.
Each of these natural landscapes is best suited for different land uses, such as: agriculture, recreation and urbanization.

River landscape

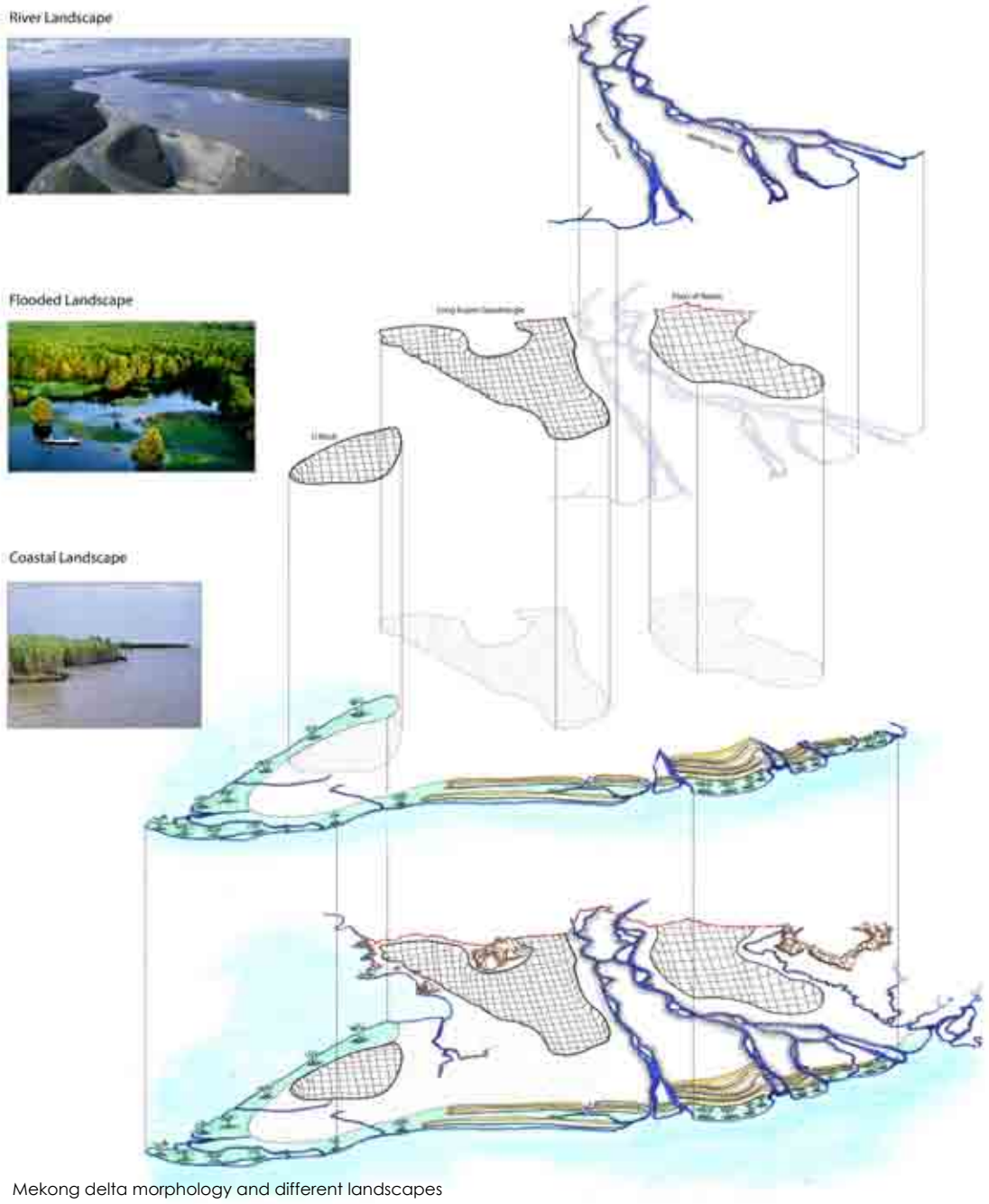
The centre zone of the delta located between Tien and Hau River predominated by fluvial deposit. In flood season, the two rivers overflow their riverbanks and create the nature levees. Their elevations are ranged from 3.0-3.5 m high above sea level on the North-western and decrease seawards. This process produced the river landscape.

Floodplain landscape

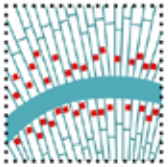
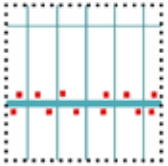
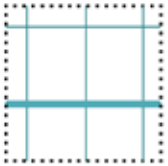
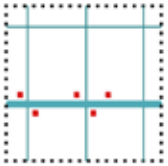
From 7 thousand years ago, according to Milton Osborne, a Southeast Asian historian, the delta was 'a largely waterlogged world of black mud and mangrove trees, bordered by thick tropical forests where the land rose away from the flooded plain'. At this time, Long Xuyen quadrangle and Plain of Reeds were salty swamps, inundated and stored wetland under a shallow level of floodwater in both rainy and dry season. These areas have slowly changed into freshwater areas in recent times.

Coastal landscape

The coastal plain covers large areas in the eastern coastal area and the Ca Mau Peninsula. As the result of the sediment deposited by the rivers under the influences of mix of waves- and-tides from South China Sea and Gulf of Thailand, they were coastal plain, beach ridges and sand dunes, marsh, mangrove marsh, silt marsh, tidal flat and sandy spit deposit (Nguyen et al., 2000). This natural process created the coastal landscape. The elevations are ranged from 0.5-10 m in Ca Mau Peninsula to 2.0-2.5 m in coastal plain areas.



Mekong delta morphology and different landscapes

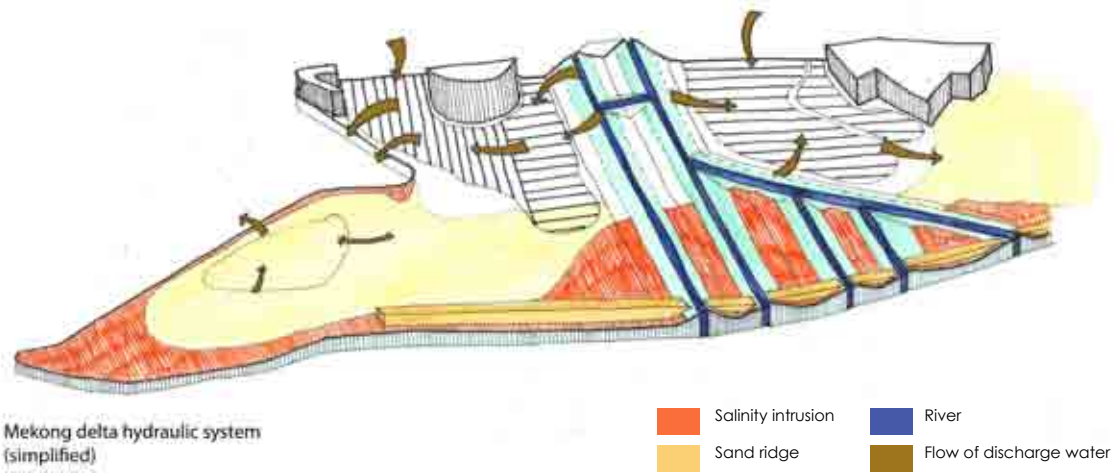
Photos	Main soil type	Main land parcelization	Potentials	
			Products	Urbanization
	RIVER LANDSCAPE Alluvial soil Deposited Alluvial soil Gleyic Alluvial soil	The soil in these areas is extremely fertile, as it is of fine grain and deposited from the river over thousands of years. Parcelization of the land was dictated by the river since every property wanted and needed access. This has resulted in long, narrow lots.  		
	FLOODPLAIN LANDSCAPE Slightly Acid sulphate soil Saline severely Acid sulphate soil SeverelyAcid sulphate soil	The soil in these areas is often affected by acid sulphate that might not suitable for cultivating. However, annual flood events help to flush the acid and deposit sediment, these areas also attract inhabitants. Parcelization of the land was dictated by the canals and have wider and longer lots.  		
	COASTAL LANDSCAPE Mangrove saline soil Slightly saline soil Moderately saline soil	In coastal zone, soil is mainly saline which contains a lot of salty materials. Irrigation system can not supply enough fresh water for agriculture. Consquently, these area are not dense cultivated. Parcelization of the land follows the canals and have huge lots. In the last decades, fish and shrimp farming was introduces that results in the transformation of paddy fields into shrimp and fish ponds.  		

Mekong Delta Analysis

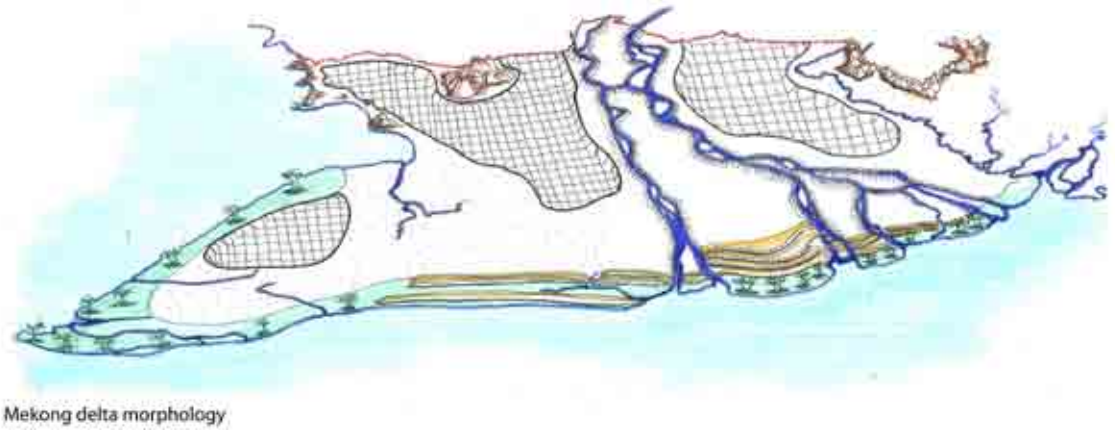
4. Infrastructure analysis

The Mekong Delta is a waterlogged delta region, in which water infrastructure plays an important role in creating conditions for the development of the urban systems meanwhile balancing this development with the nature system. Naturally, the delta can be seen as an hydraulic machine that offers high and safe land for people to inhabit (levees), protect inland from the flow of river water (river banks), prevent storm surges (sand ridges, mangrove forests) and purify water (wetlands). So first human intervention, such as: manmade canals are the result of an adaptive strategy which ensured human survival from floods and generated new conditions to support new living conditions. The hydraulic system of Mekong delta (shown on the right) used to harmony these two effects.

Thanks to these interventions, urbanization in the delta grew dramatically as well as economy. Especially, starting from the sixties, the system of land-based infrastructure and flood-control became a national concern for economic development. Settlements and cities developed at the meeting points of motor roads and waterways that are high and dry places in times of flooding. In addition, the August flood control dyke systems and several excavated canals protected from 900,000 to 1,000,000 hectares of two crop rice fields and nearly 200,000 hectares of three crop fields during 1976-1987. As the result, Mekong Delta became Vietnam's main productive agricultural region (Pham, 2011).

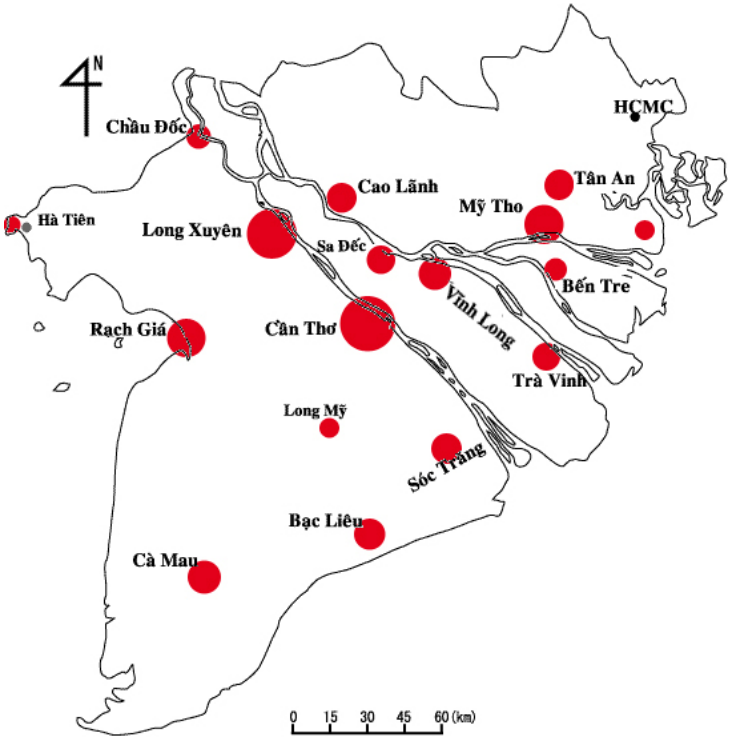


Mekong delta hydraulic system (simplified)

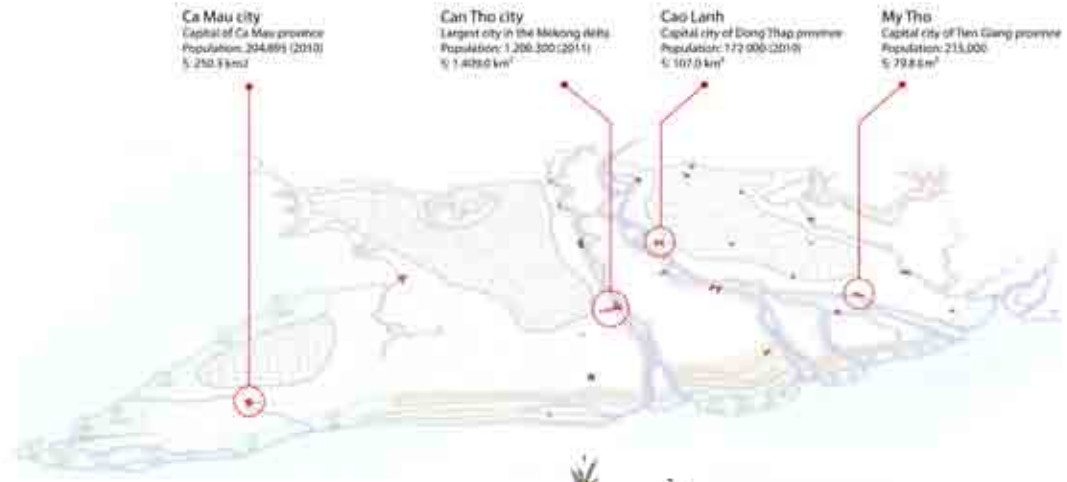


Mekong delta morphology

Water measures in Mekong Delta throughout its history

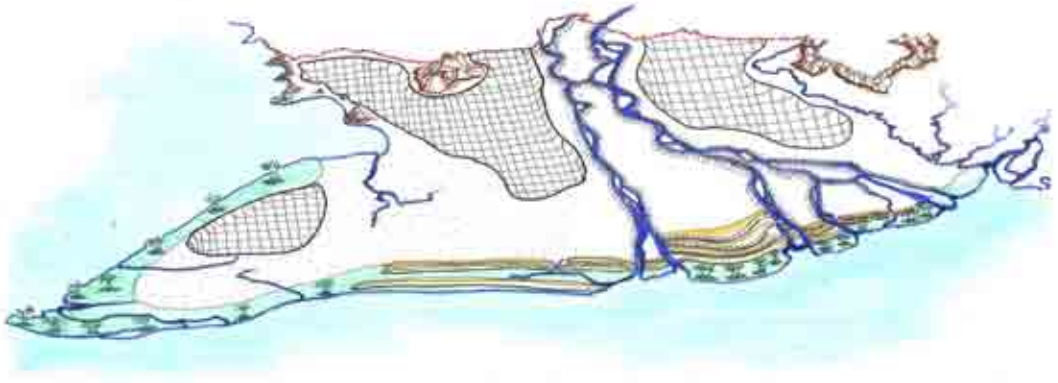


Cities and towns in Mekong Delta



Towns/cities Mekong delta

Land use Mekong delta



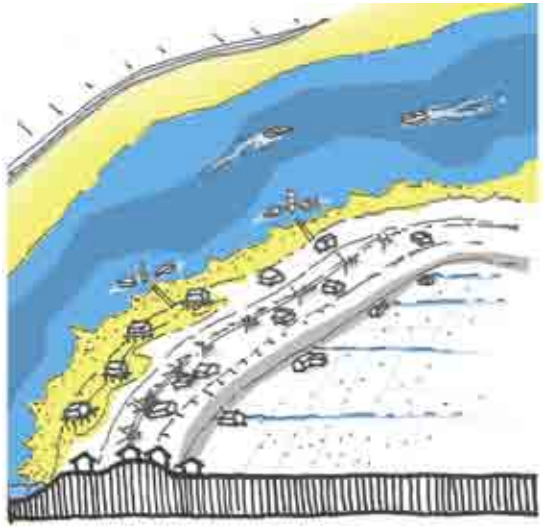
Mekong delta morphology

Mekong Delta Analysis

5. Urban analysis

3 types of delta city

Based on 3x3 Based on 3x3 layer approaches, it can be seen that cities in Mekong delta are growing, undergoing continuous transformation and development to facilitate spaces for living, producing and recreation to meet the increasing needs of the population. These processes of urbanization result in different types of delta city in Mekong delta that are still visible nowadays and continuing their processes.
Currently, major cities in Mekong delta, such as: Can Tho City, Cao Lanh City and Long Xuyen city are categorized in the river city type which is the very first type and has the most potential to develop. This has to be taken into account in order to propose a development strategy for the whole region.



River city and its development

Starting from Pre-colonial period (1802-1867)

_ Urban areas are located on natural river levee
_ Well-connected to trading routes.
_ The settlements often developed linearly, following the alluvial, non-salted high land banks of rivers.

Canal city and its development

Starting from French colonial period (1867-1954)

_ Urban areas are located at the intersection of waterways (canals) and on man-made levees.
_ Waterway dominated as main transportation routes.
_ Floating market is the centre of cities.
_ The settlements developed along the canals.

Cross-road city and its development

Starting from American war to present

_ Urban areas are located at the confluence point of waterways and roads.
_ Canal remain a strong connection with the surrounding agricultural product area.
_ From the intersecting point, the city expanded parallel both road and river, which formed a geometric shape.

4 types of settlement

Zooming in the current delta cities, there are 4 main types of settlement, namely: riverside, outer dyke, behind dyke and city settlement. Each of these settlements represents different ways of living and different of behaviors towards the water. This research not only aims at understanding the patterns of the cities but also predicting the transformation and future development trend of all the delta cities in the same context.

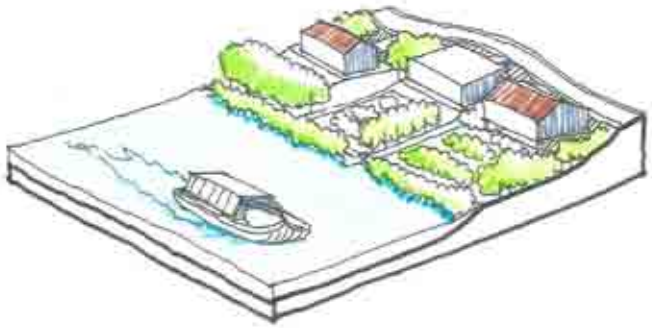
Most of the settlements in current Mekong delta are behind-dyke settlements which are basically the previous form of the city center settlement. Urbanization is expanding unintended to the rural area following road network. As the consequence, urban sprawl might be experienced in the next decades.

Riverside settlement

Adaptive house on water

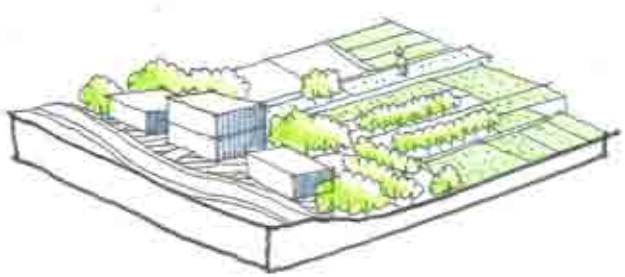
Adaptive house on higher ground

Outdyke settlement



Adaptive house on higher ground

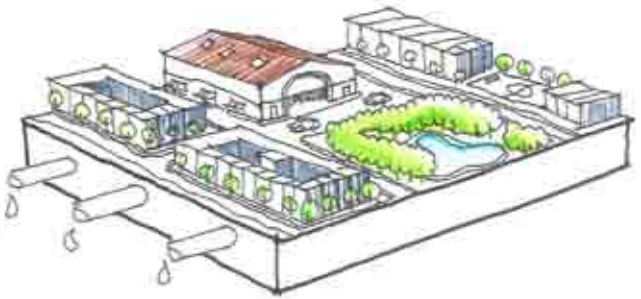
Behind-dyke settlement



Low quality house along road

Row-house along road

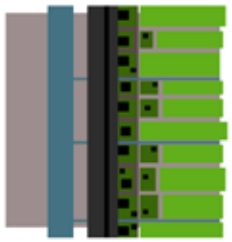
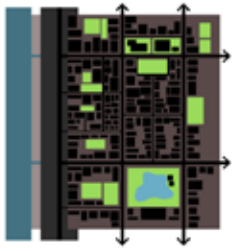
City center settlement



Row-house along road

Different types of urban settlement and housing typology

Mekong Delta Analysis

	Settlement typology	Characteristics	Problems
		 _ Houses are located on the high levees along the river. _ People protect themselves by heightening their houses (floating houses, stilt houses). _ Fish/ shrimp ponds, orchards and paddy fields _ People use river water for agriculture, drinking, cooking... _ Connection mainly through water transportation	_ No fresh water supply _ High flood risk from river and inland flood water discharge. _ Poor connection
		 _ Houses are located in outer-dyke areas, along the canal _ Main houses are in higher platform in order to protect from flood. _ Fish/ shrimp ponds, orchards _ Houses face to roads located on the dyke, and face their backs to the water. _Peope use ground water, storage water instead, canals, creeks... are used as sewage system. _ Connection through both water and road network.	_ Lost of relation to water _ Flood risk from river and inland flood water discharge. _ Water pollution
		 _ Houses are located in high platform behind the dykes and seperated from water. _ Orchards and paddie fields _ Houses face to roads. _ People use ground water, storage water. Canals and creeks are just used for agriculture. _ Connetion through road network.	_ Seperated from water environment. _ Flood risk from inland flood water discharge. _ Urbanization leads to the loss of agricultural land _ Water pollution
		 _ City centers are located in high platform. _ Dense urban structures: Shop houses, markets, offices, small parks... instead of orchards and paddy fields. _ People use ground water for drinking, cooking, industry purposes. Waste water is not full-treated before discharging to canals and rivers through pipes. _ Connection through road network.	_ Lack of spaces for plantations and water. _ Flood risk from inland flood water discharge. _ High density structure creates pressure on environment. _ Poor living conditions _ Fresh water scarcity _ Urban heat island _ Losing unique delta landscape

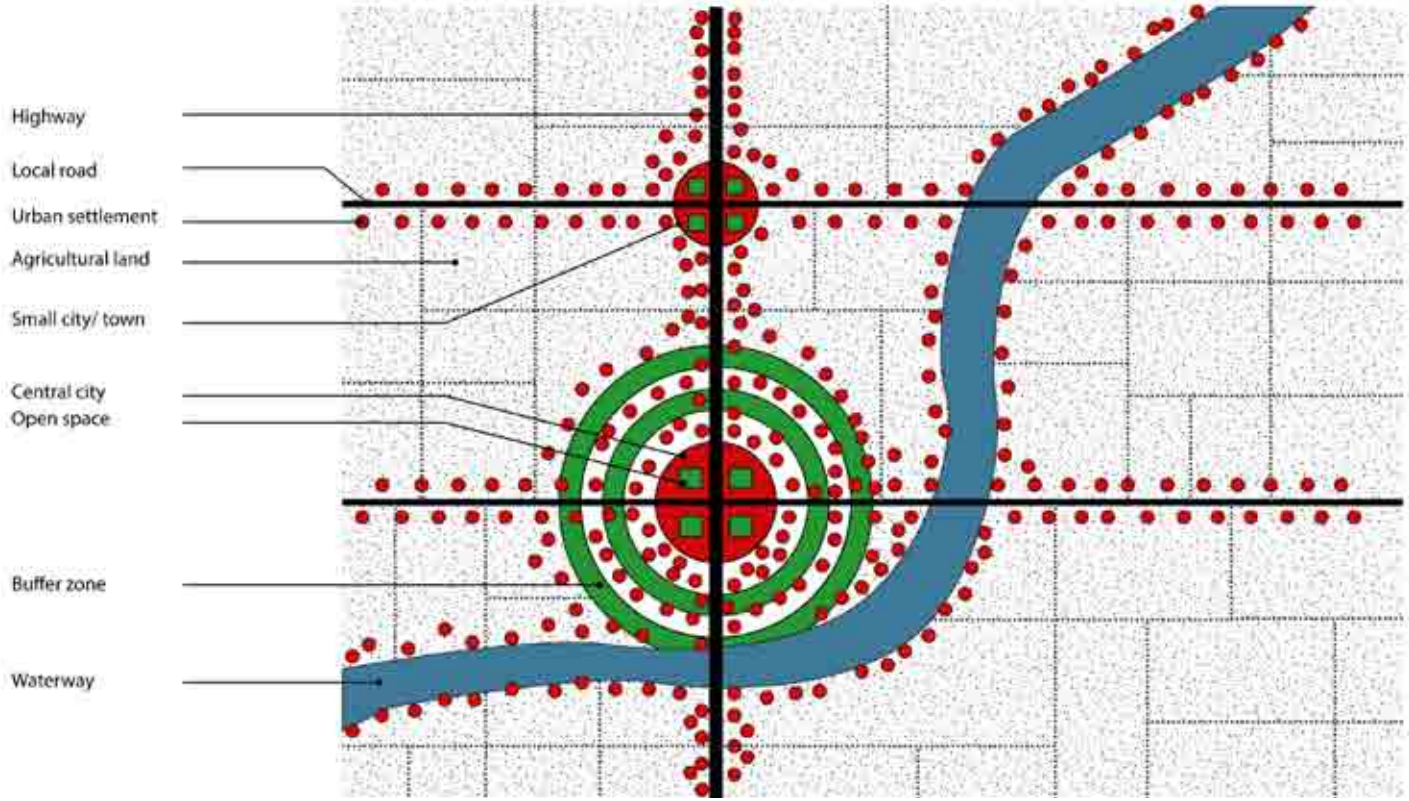
6. Conclusion

Developed image of Mekong Delta

Meyer states 'the urbanized deltas can be considered as areas with a double complexity: the complexity of the deltas, as the meeting of rivers and sea, with the complexity of urban pattern, as result of economic, cultural and social life creates unique areas with a double complexity' (Meyer, 2009). Understanding this double complexity is crucial for the next step "Design".

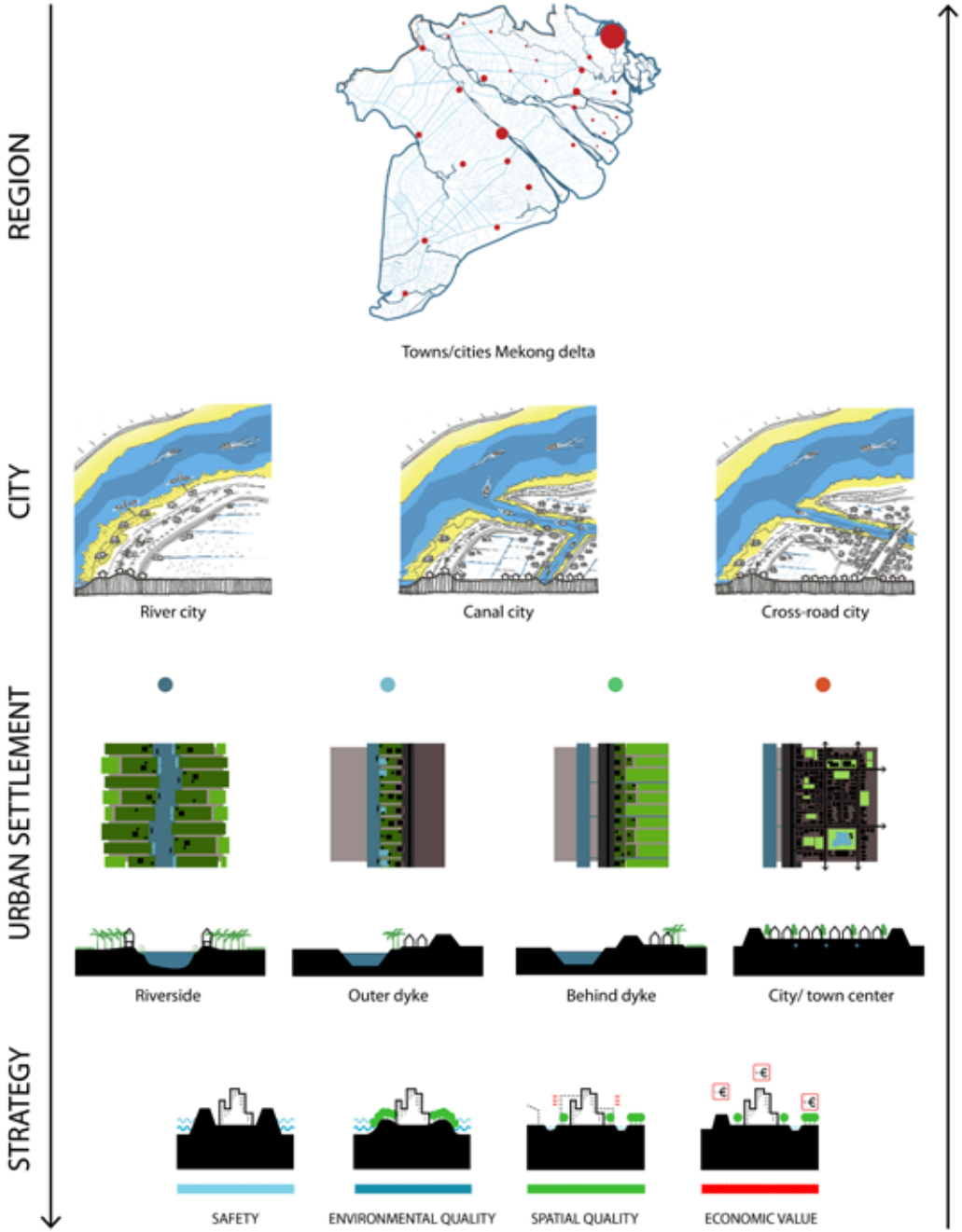
In this project, different layers (natural landscape, infrastructure and urban layer) are looked at in different scales (region scale, city scale and urban pattern scale). The result of these analyses shows a clear image of the current development in Mekong delta. In this image, urbanization and climate change are going to eclipse. The water cities are transforming into road cities in which the role of water in the city structure seems to be neglected. Outside the cities, urban patterns are sprawling into agricultural lands. Delta landscapes are losing its unique characteristics and inhabitants are becoming vulnerable to flood.

The outcome of this study is the answer for sub-research questions: *What are the unique characteristics of Mekong delta landscape? How did its nature landscape, infrastructure and urban layer transform throughout three hundred year history? What are the characteristics of cities in Mekong Delta today?*



Urban development model in Mekong Delta

Mekong Delta Analysis



Back to the main research question of this project *"How a new form of urban development for the Mekong delta can provide a water safety condition, improve the spatial quality and meanwhile provide economic value for its inhabitants"*, the new proposed strategy and design has to concern:

_ River cities are still developing, expanding along the riverside, towards each other. Controlling this expansion is needed and moreover, connecting these cities can somehow promote a new and sustainable image of Mekong delta cities.

_ As a developing country, Vietnamese economy cannot support for large scale infrastructure and high cost flood control project. Using natural processes of the delta can help to make flood risk management more sustainable and cost-effective than hard, engineered defenses.

_ "Flood is not threat, Flood is opportunity". Flood needs to be maintained in the development strategy of Mekong delta.

_ Preserving the unique delta landscape of Mekong delta is crucial for future development.

The proposed strategy in planning and designing urbanized delta need to create new balances between economic activities, ecological protections and communication's benefits in all urban pattern, city and regional scales.

Research and design scale

Chapter IV. Cao Lanh City Analysis

Introduction
Impression
Current structure
Challenges

Cao Lanh City Analysis

Cao Lanh City street
Source: www.google images.com

Cao Lanh in 1970s
Source: www.google images.com

1. Introduction

History

Cao Lanh city is the capital city of Plain of Reeds province, located 154km from Ho Chi Minh City and 80 km from Can Tho City. Historically, during the French colonial period, Cao Lanh found some supporters for the national appeal of IndoChina Times (a Vietnamese language newspaper in Saigon) founded in May 1923 (Philippe, 2012). Later, in initial resistance to the French in 1945, the Vietnamese Nationalist Party and others in the South formed into the Third Division of the popular army. In Cao Lanh, the troops were reorganized into 23 units, each of 500-600 men. From 1956 to 1975, Cao Lanh was the capital of Kien Phong province in Mekong delta region. In 1976, Kien Phong was merged with Sa Dec province to become Dong Thap province (Plain of Reeds). At this time, Sa Dec was the capital city of the new province. In April 24 of 1994, Cao Lanh replaced Sa Dec as the capital and became a city since 2007.

Administration

Cao Lanh is divided into 15 units: 8 Phuong (urban units) 7 Xa (rural units). The city covers an area of 10 720 ha, with a population of over 150,000 inhabitants and 172,000 inhabitants with 87,000 inhabitants living in the urban area. The natural growth rate of the population in 2008 was 1.05%, including 1.7% birth rate of 0.55% mortality, and migration growth rates of 1.29%. Total growth rate of the city is 2.34%.

Economy

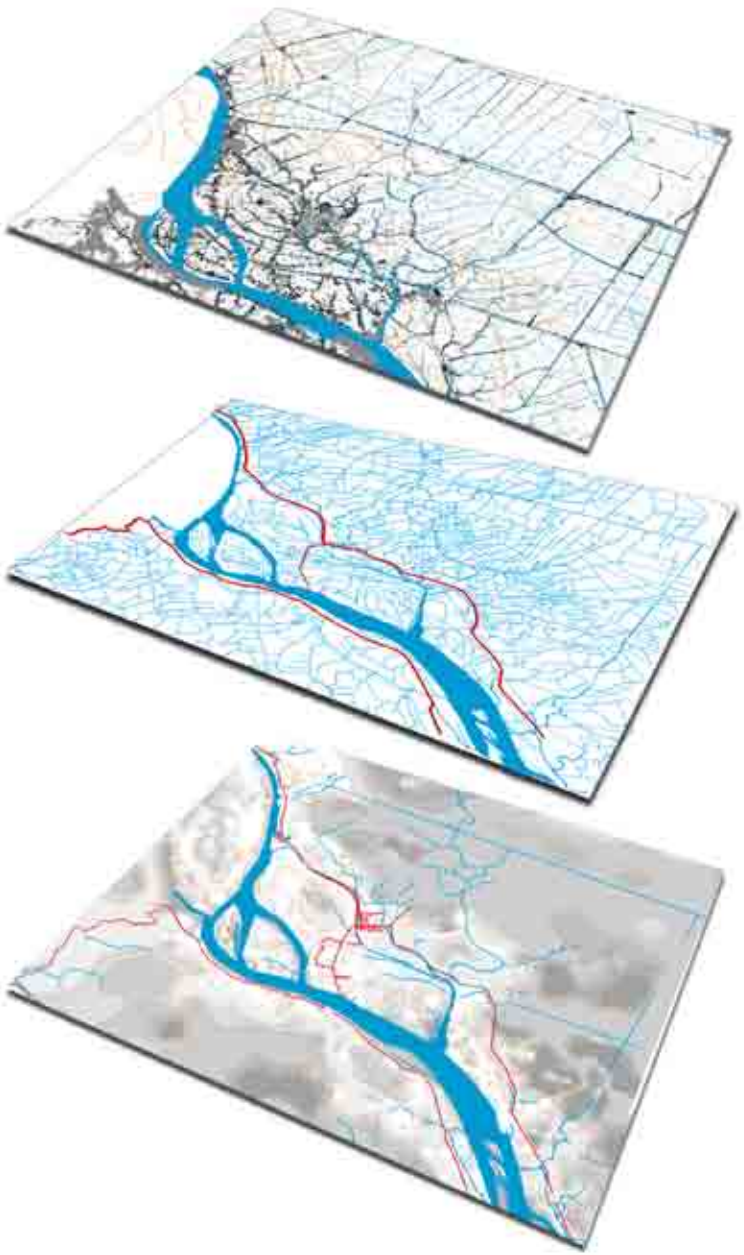
Cao Lanh is the capital of the large agricultural province of Dong Thap. The province's economy is dominated by agriculture: 2/3 of the labors works in this sector. Forestry and fish farming are the two major activities. However, the industrial and service sectors are developing greatly. In terms of GDP, the economic growth of the province in 2010 should reach 14.52%, with the agricultural and fisheries sector growing by 6.84%, the building and industrial sector by 31.16%, and the finance, services and business sector by 15.30%.

Climate

At the beginning of wet season (May-November), mean monthly rainfall is between 150 and 200mm and gradually increases each month until it peaks in October at about 280mm. After this peak, rainfall drops sharply in November, making the start to the dry season. In January and February, rainfall is at lowest point with average monthly amounts of less than 20mm. Temperatures in Cao Lanh are stable throughout the year. Average monthly temperatures range from 25oC to 29oC.

Flood

Flood levels in Cao Lanh are highest from September to November, peaking in October. Flood levels depend to a large extent on climatic conditions upstream, in Tibet, Myanmar, Thailand, Laos and Cambodia. Moreover, new constructions of large hydropower dams upstream are probably related to more water retention.



2. Impression of Cao Lanh city

Urban quality

A compact city center, structured by an orthogonal grid roads
Source: www.google images.com

Stilt houses along Cao Lanh River
Source: www.google images.com

Urban park
Source: www.google images.com

Infrastructure network

River dyke
Source: www.google images.com

Transportation in main canals
Source: www.google images.com

CaoLanh ferry
Source: www.google images.com

Natural landscape

Tien River
Source: www.google images.com

Paddy fields
Source: www.google images.com

3. Current structure and problems

At present, the city is made up of three different characters:
_ A large rural zone between the center and Tien River which is criss-crossed by small canals. Settlements follow the very narrow strips, sprawl to the river and to 2 small isles and are covered by orchards and paddy fields. .

_ An industry zone in the North of the city which is served by the road and the river transportation.

_ A compact city center which is well structured by an orthogonal network of roads. In the center, the canals are little present; shape part of the city is protected by dikes.

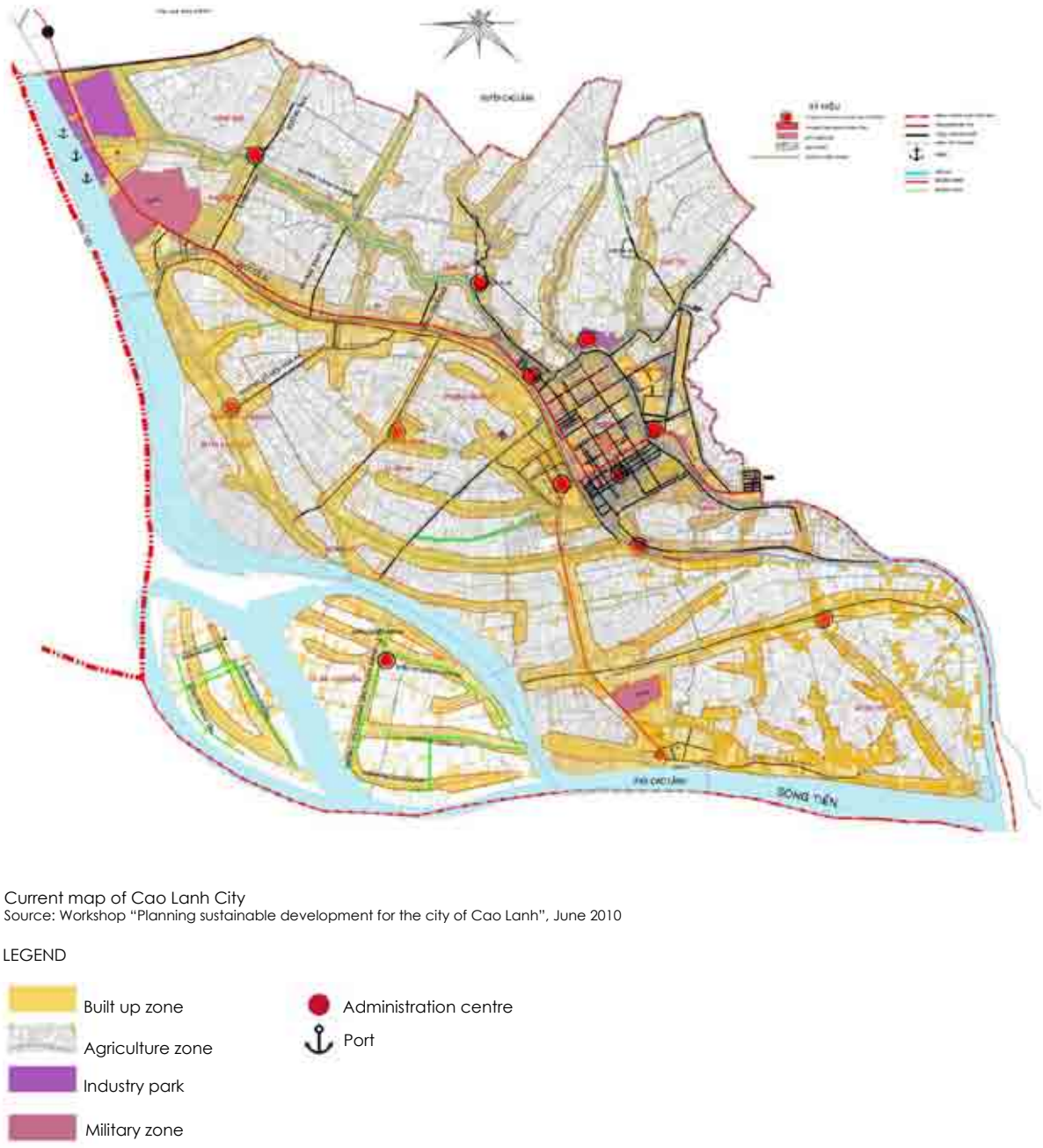
Although it was built recently (late 1970's), the city center is built according to a road grid inherited from the colonial town model. With large-scaled avenues, alignment gardens, and remarkable parks, the city presents an adequate urban quality.

However, current structure of Cao Lanh city also addresses some problems:
_ Currently, inhabitants' incomes of the city are quite low ($439 in 2006), it might be the result of unattractive economic environment.

_ Sprawling urban settlements to rural zone is now occurring unintended. Poor rural houses follow new roads by small shops, markets and handicraft activities.

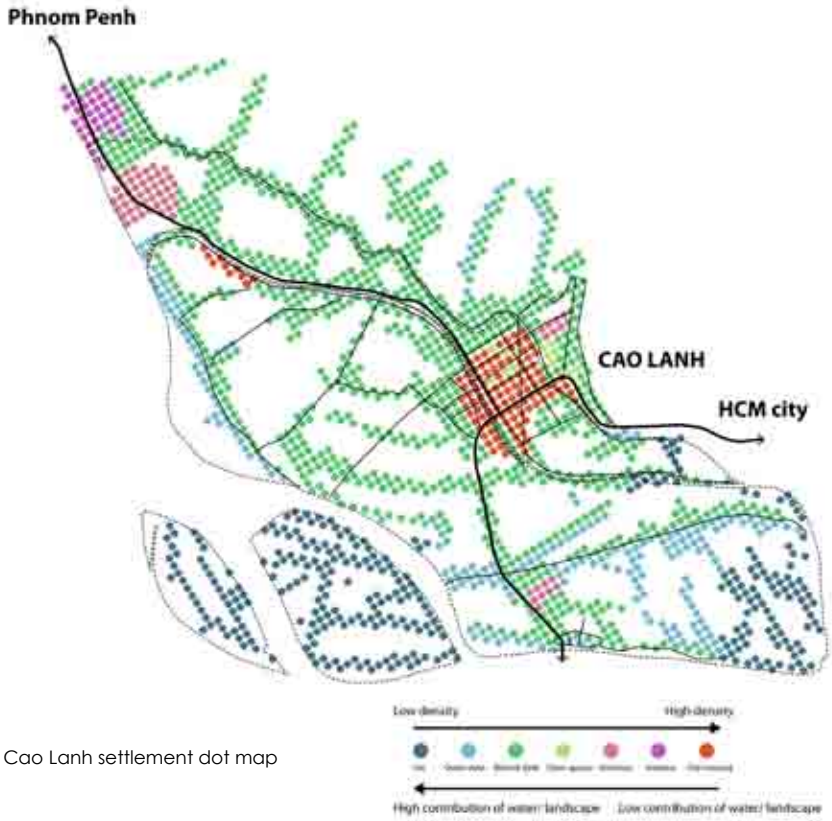
_ Water problems: the problem of water in the city of Cao Lanh includes several aspects ranging from overuses of water resources (surface and groundwater), direct discharge of wastewater (from agricultural and domestic purposes) to water body and floodwater during rainy season because of inefficient drainage system (the city of Cao Lanh and its surroundings are partly under water for 120 days of the year with floods ranging between 70 and 140 cm).

_ In the city, the development of land-based infrastructure replaced waterways as a main factor dominated urban pattern. Although the city was designed with landscape, water was no longer the city's concern.



Current map of Cao Lanh City
Source: Workshop "Planning sustainable development for the city of Cao Lanh", June 2010

Cao Lanh City Analysis



Cao Lanh settlement dot map

Cao Lanh settlement dot map
This map shows current settlemet in Cao Lanh city. Tradition settlement living along river are now replaced by settlements along roads. The development of the city in next decades might results in an unpredictable sprawl image with mainly urban settlement.

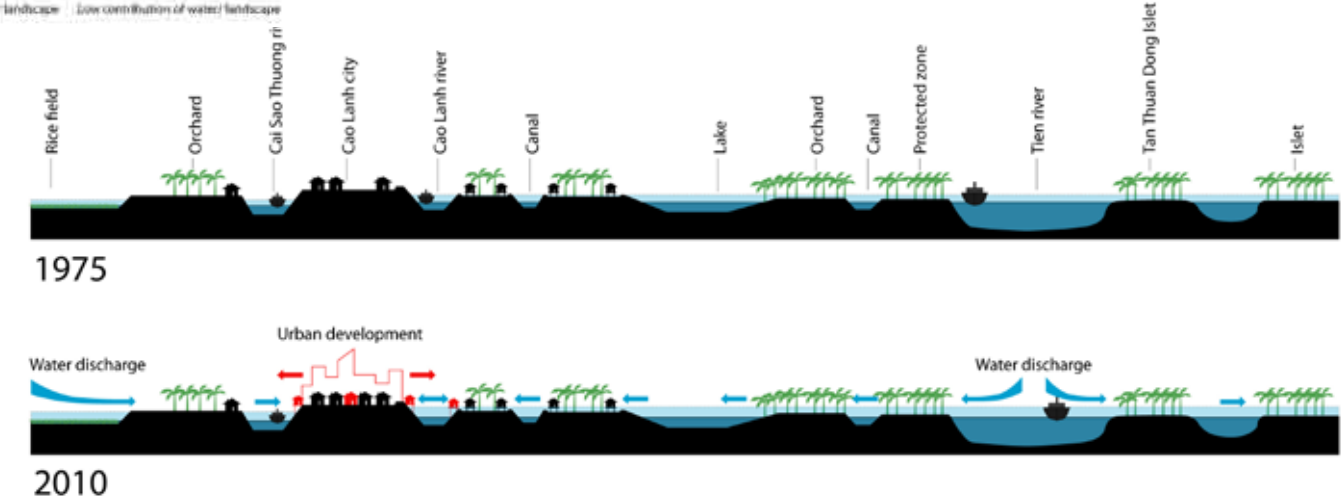
_ Local government tried to integrate the dikes and road along canals into urban pattern as main strategy to reduce the threats of floods. The result has been a fundamental transformation of the urban landscape. The new dikes were fences that prevented citizen easy access to the open water.

4. Challenges

Several challenges must be overcome to remedy the weak points in the next 10 years:

_ Climate change: Mekong delta has a rich ecosystem; however, it is threatened by the accumulated effects of climate change. It is predicted a rise in sea levels by 1 meter and a rise in temperature by 3oC in 2100. Consequently, Cao Lanh will have to deal will higher level floods in rainy season and during dry season, salinity water and acid water may become major problems for the supply of fresh water in the city as well as agriculture. Sufficient water-networks are necessary not only part of urban fabrics but also for drainage water during rain strom and storage of water during droughts.

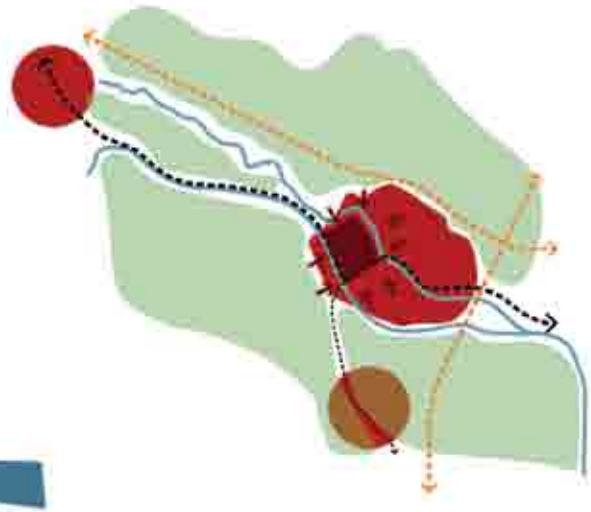
_The economic and urban future of Cao Lanh can only be constructed by situating themselves in the entire Delta up to Ho Chi Minh City, in which Cao Lanh holds a central position. A major change has begun throughout Vietnam with the building of a road infrastructure network. New flows are also going to be felt due to the opening up of the country to the world. The construction of new roads is going to modify the network of cities and their hierarchy. All the more so since the new roads include bridges to cross the branches of the Mekong.



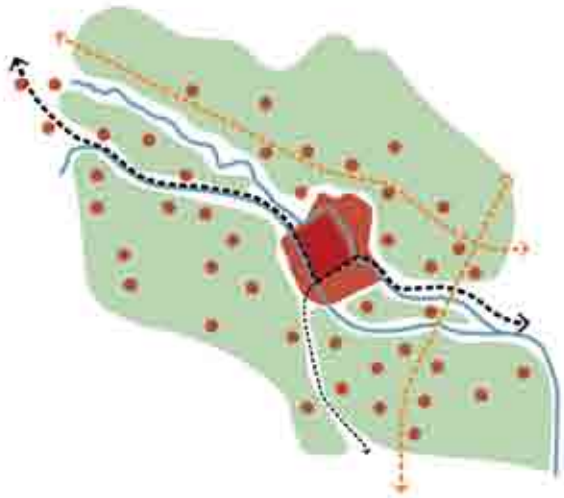
Section of Cao Lanh City in 1975 and 2010

What is the future of Cao Lanh city?

Current situation of the city with new proposed road network



Making the city more compact



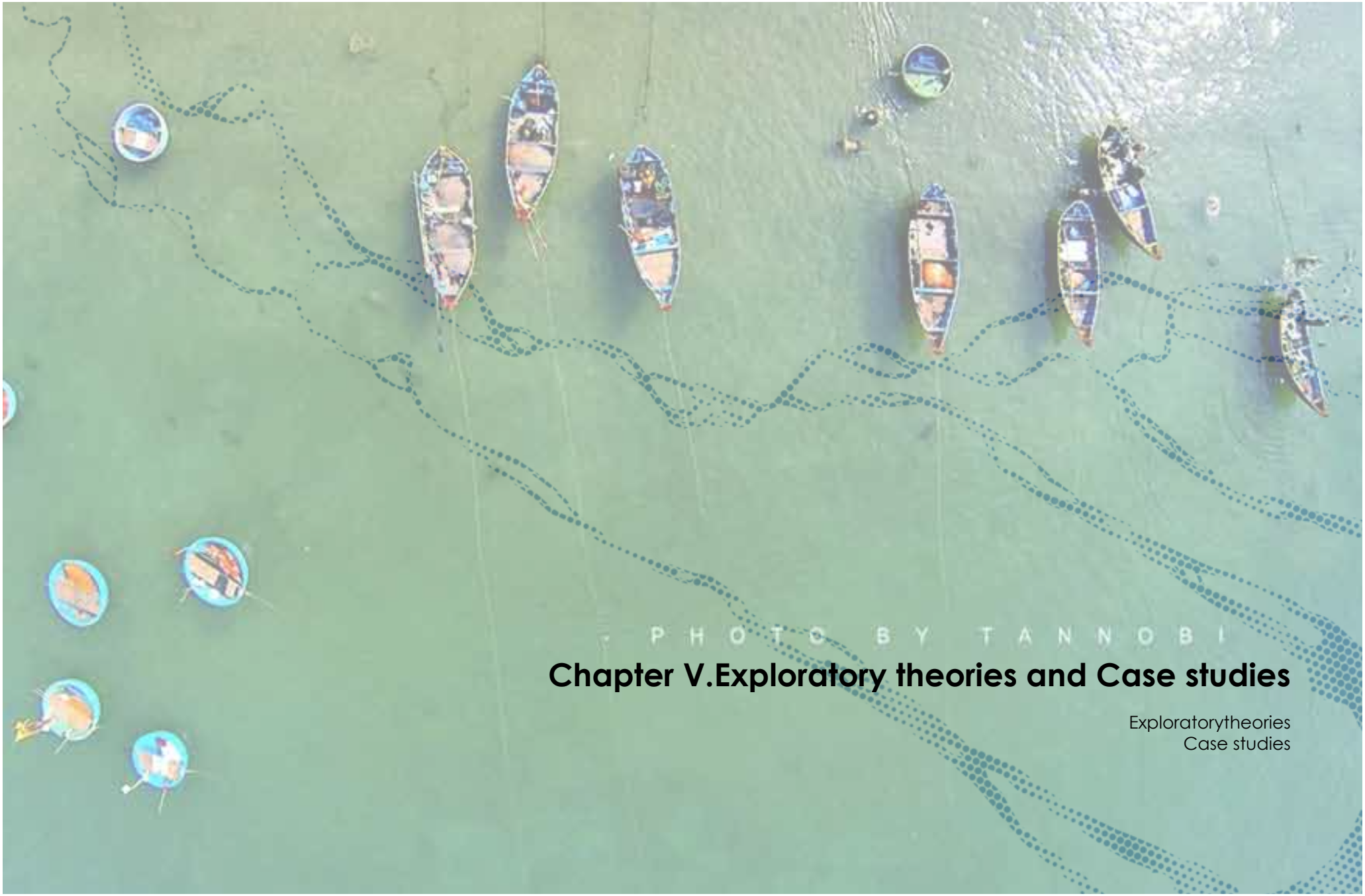
Sprawling the city

_ The modernization of industries and ways of life are going to speed up with the change in the mode of transport. In a region that was relatively self-suffi¬cient until recently, due to the nearly exclusive river mode of transport, the use of road transport will have a major impact. This development sets a new challenge: that of working with, rather than destroying natural and agricultural elements. They are great riches in terms of GDP, as beyond their direct production, they also gave rise to a food-processing industry.

What is the future of Cao Lanh city?

The questioning about the development of Cao Lanh City itself calls for answers about the alternative urban forms and of the choices of expansion in order to cope with climate change and support economic development. These answers cannot be apprehended only in the scale of Cao Lanh City, but in different scale: neighborhood scale, city scale and the entire Delta.

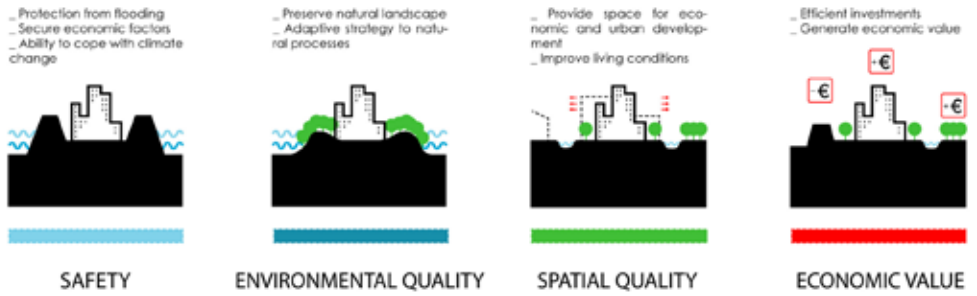
Many delta cities around the world are facing the challenges of sustainable living and development and are exploring ways to enhance their ability to manage an uncertain future (Zecenbergen, 2010). In the next chapter, theories and case studies are used to explore their solutions and define the possibilities to apply in Cao Lanh city and Mekong delta.



Chapter V.Exploratory theories and Case studies

Exploratorytheories
Case studies

In this chapter, the project explores different theories and related case studies that might relevant for the development of Mekong Delta. The case studies are evaluated on four criteria: safety, environment quality, spatial quality and economic value.



The outcome serves as a framework to decide which principles can be applied to Mekong Delta and Cao Lanh City.

1. Expolatory theories

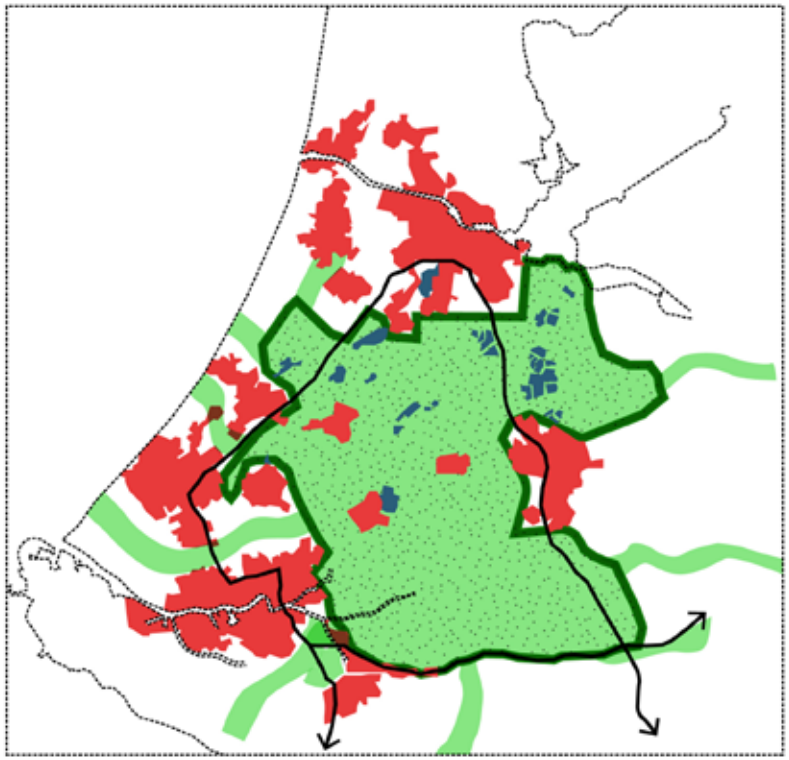
1.1. Compact City

An important result of the search for sustainable development has been resurgence of interest in compact city theories and policies. "Compact City" is an urban planning and urban design concept which was first coined in1973. It aims for a more efficient use of land through higher density planning. In light of rapid urbanization, many cities are shifting to compact development as a means to more efficiently use scarce of resources required for economic and social activities.

Although, the term was coined by American writers, it has been used widely by European. In the Netherlands, urban planning has highly influenced by the "compacte stad" since more than half a century. In many spatial policy documents, different concepts for urban compaction and urban densification have taken a noticeable role. The Second and Third National Policy Document on Spatial Planning (1966 and 1973) introduced a concept of "clustered dispersal" and "growth centers" while the Forth national Policy Document on Spatial Planning (1988) was based on the concept of "compact city". Recently, the National Spatial Strategy (2004), set specific goals for "compact areas" around urban conurbations and "urban densification" in existing urban areas (Nabielek, 2012).

However, the situation in developing countries is totally different from developed countries such as: US, European Community, Japan …etc. The problems of developing countries are:
_ High rates of population growth
_ Lack of social infrastructure
_ Land speculation
_ Increase of squatter
_ Limited financial resources for urban investments
_ Lack of planning capacity…

In spite of these problems, many cities in developing countries are still striving to adopt compact city concept in their sustainable development strategy.



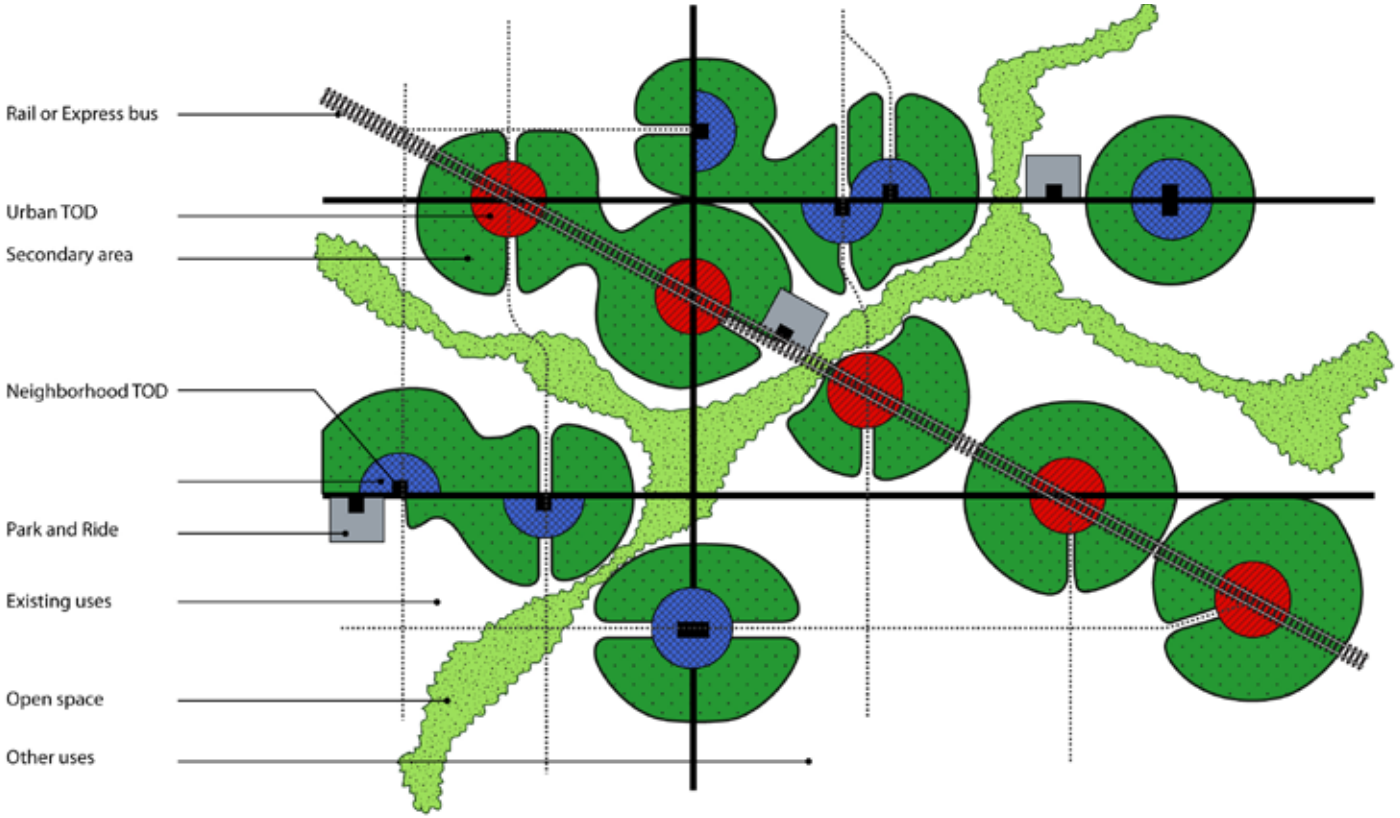
Randstad, Netherlands: Compact development around a "Green Heart"

Exploratory theories and Case Studies

Transit Oriented Development

In the simple term, *'Transit-Oriented Developments (TODs) are compact, moderate to high intensity and density, mixed use areas within one half mile (800 meters) of a transit stop or station that is designed to maximize walking trips and access to transit. They also are characterized by streetscapes and an urban form oriented to pedestrians to promote walking trip to stations and varied other uses within station areas.'* (Quigley, 2011)

The concept of Transit Oriented development originates from North America. Nowadays, many cities throughout the world are developing TOD policy, such as: Portland, San Francisco, Vancouver, Curitiba...etc. It requires fulfilling a number of preconditions, including a high level of land use diversity and density, beautiful urban design and cityscape, constraints on automobile use, good transit service qualities, good urban governance, and a real estate market that provides affordable and mixed types of housing.



TOD Urban development model

TOD in Virginia, US
Source: www.google images.com

TOD open space in California, US
Source: www.google images.com

TOD walkable downtown in Oregon, US
Source: www.google images.com

1.2. Design with Nature

Today, most delta areas in the world are dealing with the increasing complexity and changing dynamics, because of two reasons: first, the changes in the natural dynamics of the delta due to climate change and human interventions, and second, the changes in the dynamics of land-use, dominated by urbanization, industrialization, port-development, agriculture and leisure/tourism (Meyer, H. and Nijhuis, S., 2011). Traditional approaches "protecting against flooding" or "building in nature" have not only separated nature from human and their urban development, but also damaged damaging to the nature system and human civilization. Therefore, these damage forces people to take a step back rethink about the problem, about their relationship with nature and understand intensely the natural landscape before impacting nature. 'Man and nature are indivisible, and our survival and health are contingent upon an understanding of nature and processes' (McHarg, 1969, p.27).

In "Design with nature", Ian McHarg defined "ecological method" as a way of studying natural landscape and using this understanding to guide regional planning and design (McHarg, 1969). The method proposes to identify and evaluate the value of different aspects of the natural landscape, for example: surface water, floodplains and marshes. Each of these natural landscapes is best suited for different land uses, such as: agriculture, recreation and urbanization. This ecological method developed by Ian McHarg to apply "Design with nature" theory was seized upon and used throughout the world.

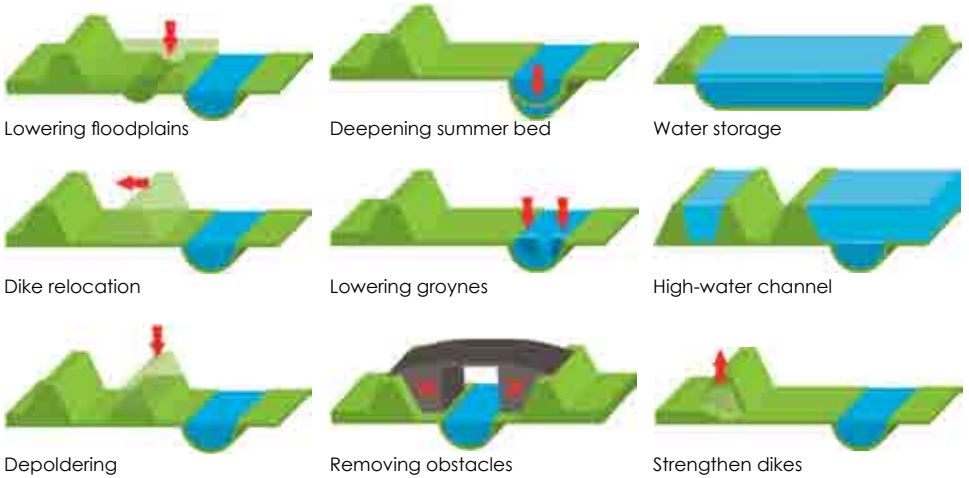
In the Netherlands, numerous long term planning studies and policies have been implemented. The new approach is no longer about "protecting against flooding" but instead respecting it and giving space for water and its natural landscape. Based on a clear understanding of the delta system, the Dutch attempt to plan their future with natural landscape, creating both healthy ecosystems and a safe country.

Room for the rivers: combination of technical and spatial measure

Throughout a thousand years of protecting against flood, space for the rivers in the Netherlands has become only more limited. Drivers of change put greater threats on the development of the country. So to make the Netherlands a safe, comfortable and pleasant place to live, trend has to be reversed. The answer lies in the plan to make more room for the river. As the Spatial Planning Key Decision, "Rooms for the River" (Ruimte voor de Rivier 2007) policy was proved by Dutch government in 2007. The policy outlines numerous designs to provide more space for the river and lower high water levels. These designs present an integrated spatial planning with the main objectives of flood protection, master landscaping and the improvement of overall environmental conditions.

Conclusion: integrated flood management and urban development

Exploratory theories shown in this chapter can be categorized in two targets: urban development (Compact City and TOD) and water management (Design with Nature). However, the achievement of "Rooms for the River" in the Netherlands recent years has proved that in order to develop sustainably, the integration of flood management and urban development is needed. Especially in the context of Mekong Delta, this integration is much more crucial.



Room for the River: Type of measures
Source: www.ruimtevoorderivier.nl

2. Case studies

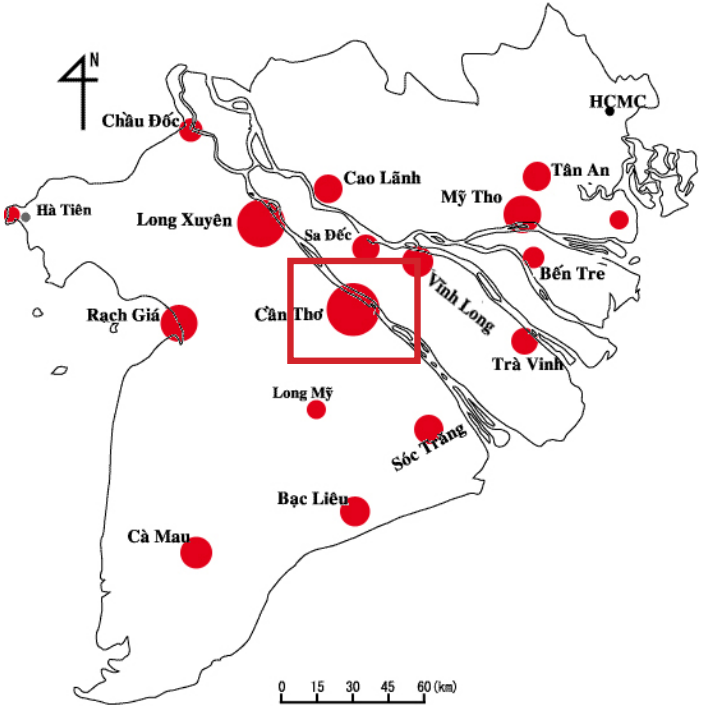
2.1. Can Tho City

Introduction

Can Tho city is a suitable case to explore because of its experiences in urbanization and flood defense application.
Can Tho is the fifth largest city in Vietnam and the largest city is Mekong delta. It is noted for its typical water based landscape with floating markets, rural canals and stilt houses along waterways. The city is located along the Southern benches of Hau River, the southern branch of Mekong River.

Early settlements date back to the 17th century and were developed at the meeting point of the Mekong River and the Can Tho River. Around 1900, the first canals were dug by the French which offered opportunities for people to cultivate and explore the delta. The excavated ground digging from canals were used to heighten the canal banks which then became new favorable places to inhabit. Until the sixties, the American started to construct a road network expanding to the whole delta for military purposes. With an important military airport, the city played an important role in the region.

Because of its advantages, Can Tho developed to become a center of Mekong delta for cultural and economic exchanges with other cities in this region and moreover, with the important economic areas in Southern Vietnam (Pham, 2011). Within the last 30 years, Can Tho has experienced a rapid change. Its population has increased from 180,000 in 1979 (same population as Cao Lanh city nowadays) to approximately 1.2 million in 2011. By 2015, it is forecasted to rise to 1.5 million and 2.1 million in 2030 (Nedeco, 1993).



Location of Can Tho CIty, Mekong Delta

Development of Can Tho CIty, Mekong Delta
Source: maps by Q.D. Pham

Can Tho is striving to become a city of industry-trade-service and high-tech agriculture. The city maintained an average GDP growth rate of 16% per year for the 2006-2010 period, and is expected to have a GDP growth rate of 17.1% for the 2011-2015 period and 18% for 2016-2020 period.

The infrastructure of Can Tho City has rapidly developed. Together with the urbanization, many large scale and high quality infrastructures have been constructed, such as Can Tho Bridge, Can Tho Airport, Cai Cui Port; residential areas, resettlement areas, new urban areas etc. These urban infrastructure works have contributed much to the changing of the city's appearance.

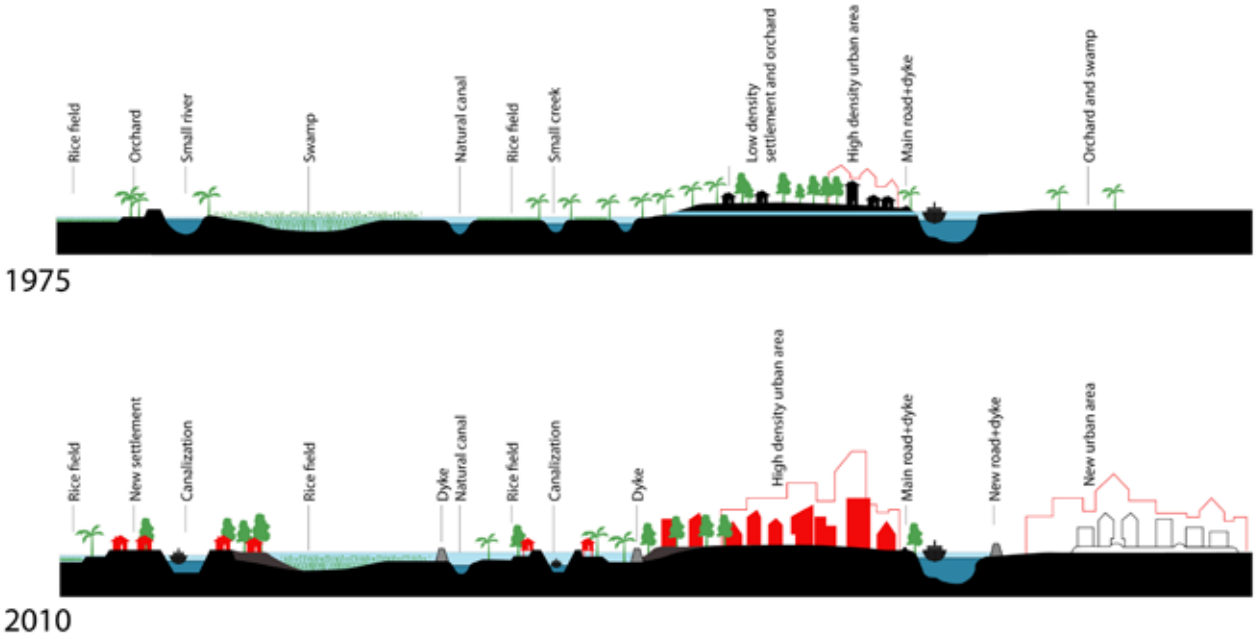
Problems

As the other river cities in Mekong delta, Can Tho had to transform to support the increasing population and economic development. City is becoming larger and denser. During 20 years, the urban areas have expanded double in size. The population growth led to the development of unplanned areas in the inner cities. This population movement promoted an increasing of risky settlements located on lands sensitive to flooding.

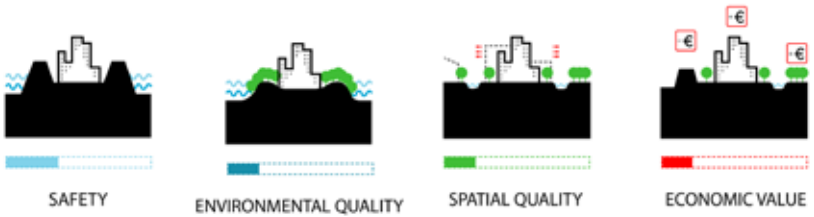
Historically, the system of canals inside the city worked as a sewage system that helps to drain off floodwater quickly to the rivers and store rainwater to other uses. This system, however, did not work anymore in the dense urban areas. Many of the waterways were polluted and cause health's problems. They were filled and replaced by underground drainage system that is not sufficient for the high rainfall in Mekong delta. As the consequence, in 2006 rainy season, more than 80 percent of the city was flooded, water level reached to 0.5 meters.

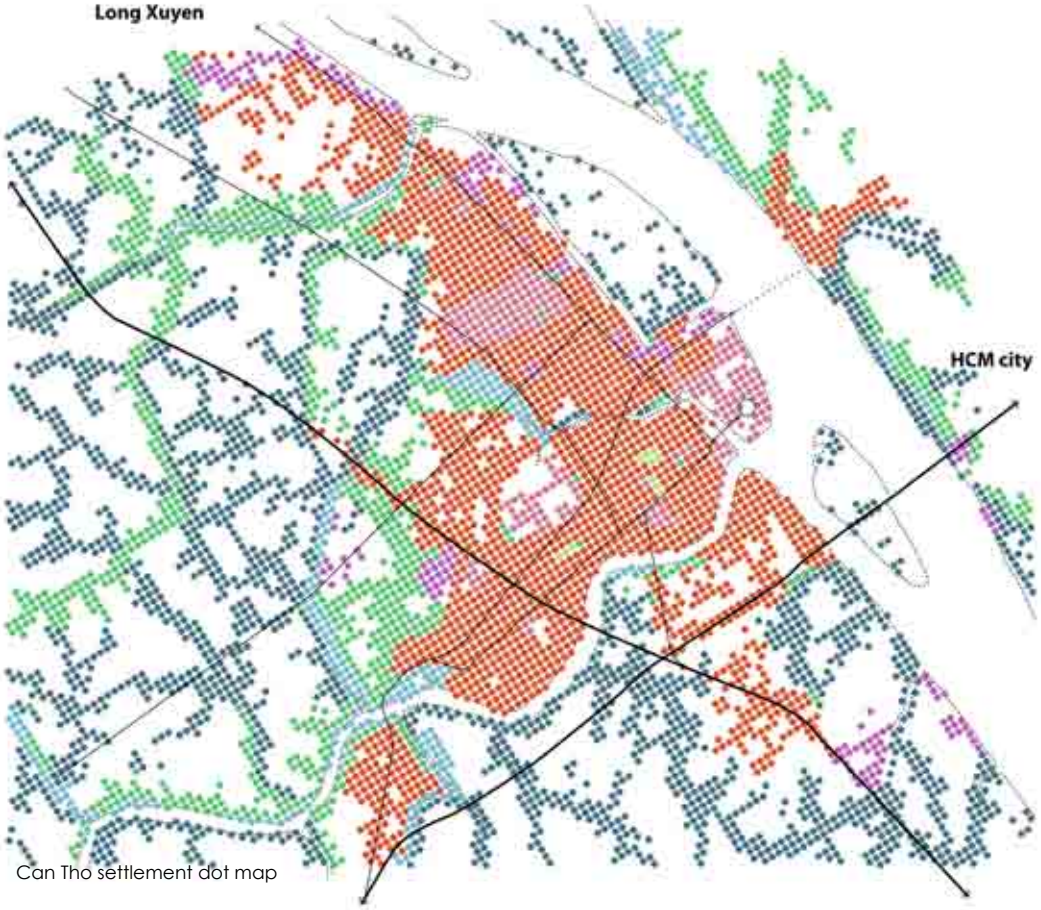
Current development led to the loss of the relation between people and delta natural land-

Flood in Can Tho CIty 2010
Source: www.panorama.com



Section of Can Tho City in 1975 and 2010





Can Tho settlement dot map

scape. Inside the city, former creeks were filled up, people built their houses turning back to the water bodies and industry zones dominate the waterfronts. As climate change is occurring, there is much more addition problems that Can Tho has to deal with.

Dyke system in Can Tho City

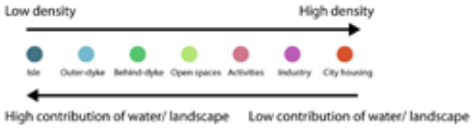
The historic flood of 2000, in particular, destroyed many rice crops, aquaculture farms, housing and other infrastructure in the flooded areas. The local government's response to this disaster was to build a dyke system which should prevent such negative impacts and after 2004, dykes were constructed throughout the province. Although the new dyke system helped to reduce flood damages in whole of Can Tho city and the lower flooding areas such as Kien Giang, Hau Giang, Soc Trang, Tra Vinh provinces and secure agriculture in the flood protected areas, it also has disadvantages to other areas in various ways.

Previous studies show that the dyke system is one of the main causes leading to erosion, plant diseases, soil fertility decline and natural degradation in the protected flooding areas of the MD (Tran Nhu Hoi 2005; Duong Van Nha 2006; Sarkkula et al 2008). Other negative impacts are changes in flow velocity and annual flooding levels with negative effects in both protected and non-protected flooding areas. Especially the high dyke system obstructs the fine-sediment flow into agricultural lands that causes a big conflict between Can Tho City with the whole region.

It is clear that dyke construction has threatened the sustainable development of Can Tho City and Mekong delta. Safety, spatial quality and economic value are not effective.

Despite new techniques, however, the question then remains whether such an enormous control strategy is the better option, knowing that indigenous solutions where rather based on adaptation, as Miller call it 'shaking hands with the floods' (Miller, 2006). There is a crucial need to develop an innovative and multi-disciplinary approach to Can Tho City's urban water design, engineering and management in relation to the predicted consequences of climate change.

Can Tho settlement dot map
This map shows current settlemet in Can Tho city. Tradition settlements living along river are now replaced by the city type settlements. This type of settlement dominated the whole city that represents a rapid urbanization process.



2.2. Curitiba, Brazils

Introduction

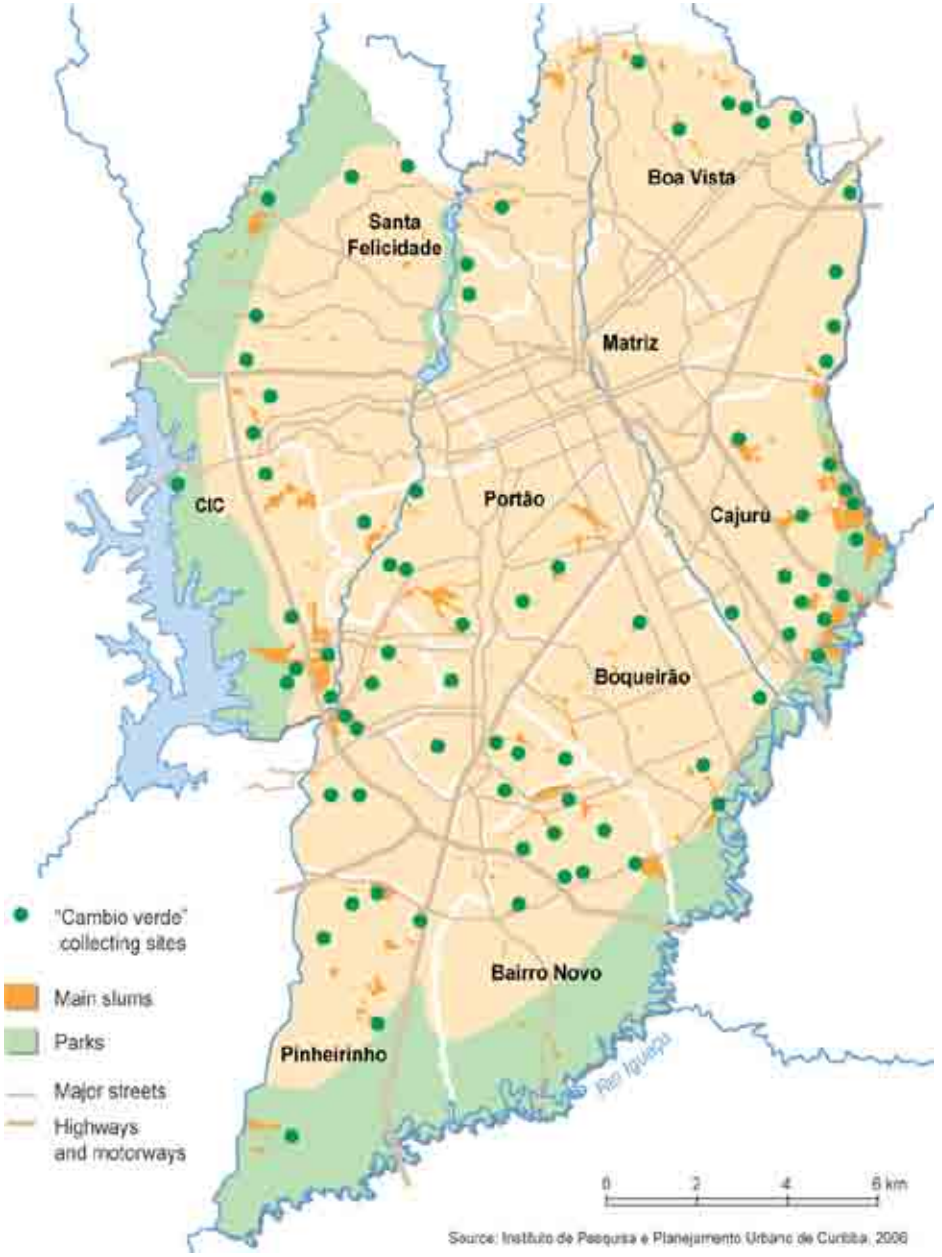
In 2010 the Global Sustainable City Award was given to Curitiba. It might be much easier for cities in the developed world to invest in the sustainable development and it is a surprise to many people that the award went to a city in Brazil where, in spite of rapid industrial growth in recent years, income levels are still relatively low.

Curitiba is regarded as an excellent example of Transit Oriented Development (TOD), which implies that residential, business and recreational areas should be built in high density areas and close to public transport stations.

During the second half of 19th century, Curitiba's population tripled due in part to immigrants from Japan, Lebanon and Syria. As the consequence, the city experienced high unemployed rates, impoverished conditions and congestion. Once an agricultural center, Curitiba became an "industrial and commercial powerhouse". In 1964, Jaime Lerner, Curitiba city's major, introduced a difference vision that to minimize urban sprawl, reduce downtown traffic, preserve Curitiba's historic district and provide affordable public transit. In 1974, the first BRT line was opened along one of the transit corridors to increase public transport uptake. The BRT is the heart of this transit-oriented development.

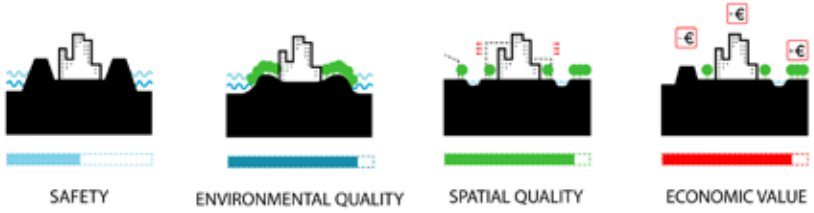
Today, Curitiba has a unique transportation system, developed locally and generating much interest worldwide. A good achievement in Curitiba is the higher GDP and a lower unemployment rate than the Brazilian average. Another achievement of the city is the large amount of green space per head of population (52 square metres) which is remarkable in a city that has seen its population triple in the last 20 years.

Flood in Curitiba
Source: www.google images.com



Curitiba map
Source: www.google images.com

Exploratory theories and Case Studies



Curitiba bird's eye view
Source: www.google images.com

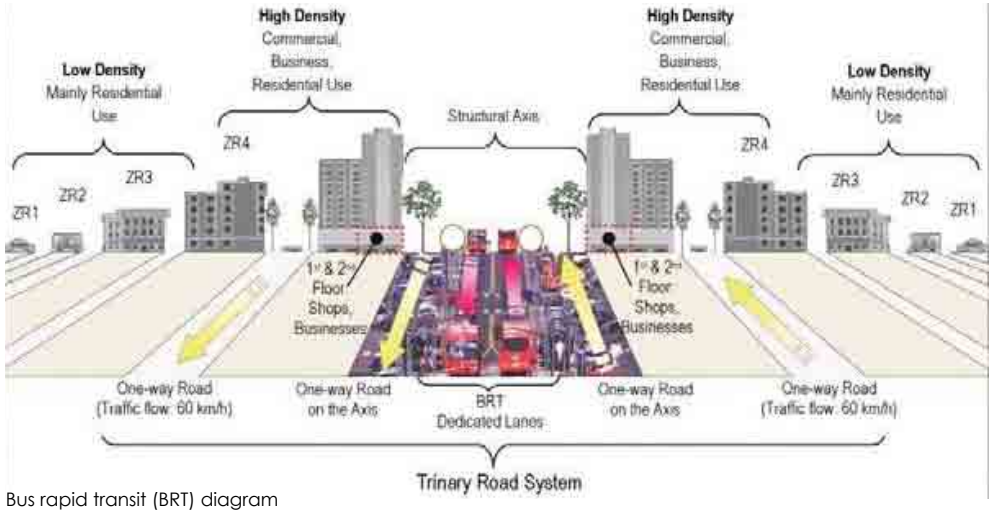
Bus rapid transit (BRT) lines in Curitiba
Source: www.google images.com

Much of the green space was achieved by using national funds for flood control to build small dams across rivers, creating lakes and parks for the city population. There are 28 parks and wooded areas in Curitiba, creating a city landscape which is unlike any other in a developing city.

Other benefits from TOD:

-Higher quality of life
-Better places to live, work, and play
-Greater mobility with ease of moving around
-Increased transit ridership
-Reduced traffic congestion and driving
-Reduced car accidents and injuries
-Reduced household spending on transportation, resulting in more affordable housing
-Healthier lifestyle with more walking, and less stress
-Higher, more stable property values
-Increased foot traffic and customers for area businesses
-Greatly reduced dependence on foreign oil
-Greatly reduced pollution and environmental destruction
-Reduced incentive to sprawl, increased incentive for compact development
-Less expensive than building roads and sprawl
-Enhanced ability to maintain economic competitiveness
(Alexandria, 2013)

Transit Oriented Development in Curitiba can be a model for other cities in the developing world which are trying to achieve more sustainable development.



Bus rapid transit (BRT) diagram
Source: www.google images.com

Typhoon Kathleen (1947)
Source: www.wikipedia.com

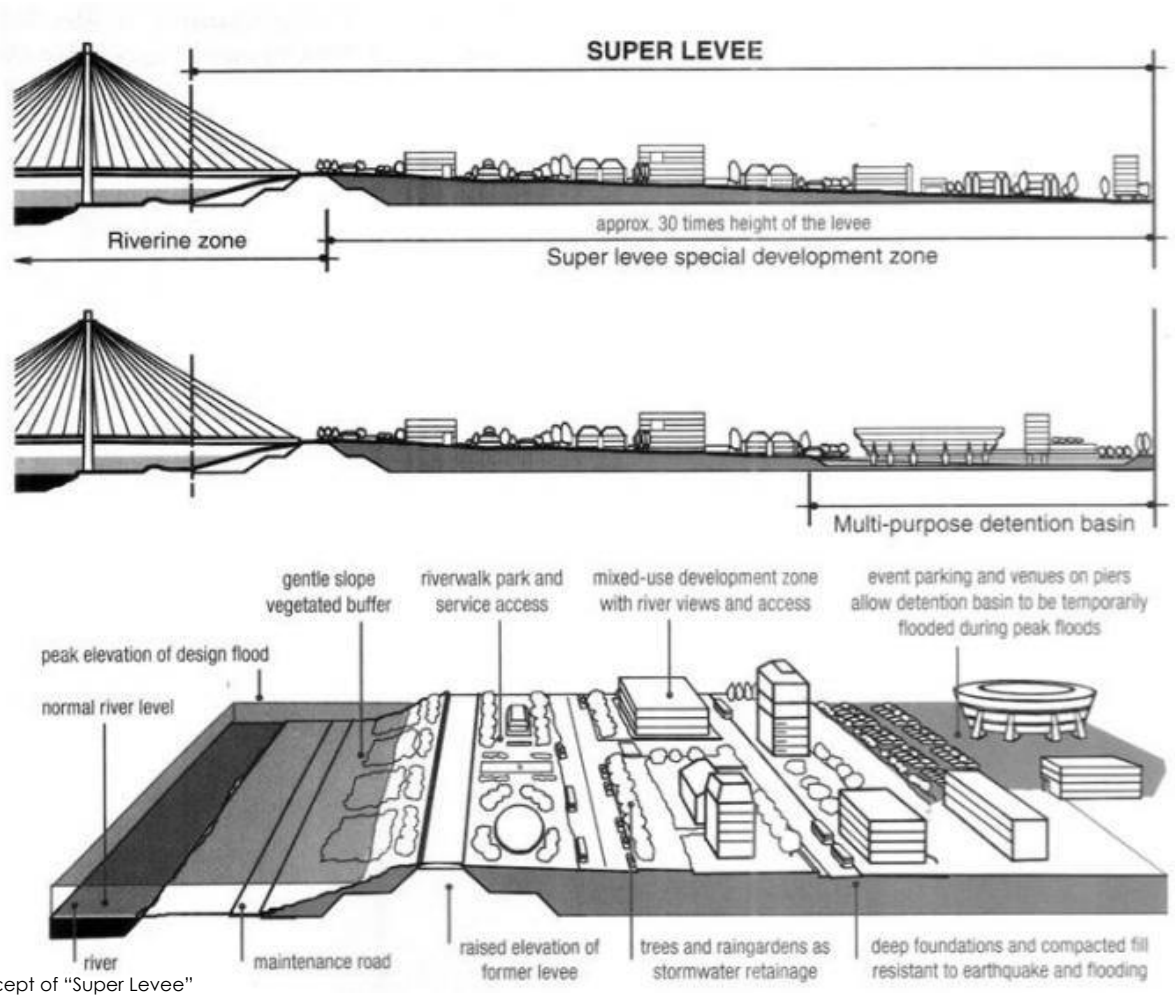
Local Heavy Rain (2005)
Source: www.wikipedia.com

Typhoon Kitty (1949)
Source: www.wikipedia.com

2.3. Tokyo Super levee

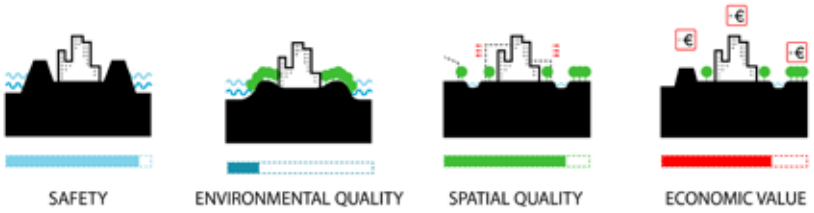
Introduction

Tokyo is the capital of Japan and is located in the Kanto region of Central Honsu, next to Tokyo Bay. The city is located on a floodplain of three large rivers: the Sumida River, the Ara River and the Edo River. Large parts of Tokyo are now located below the flood level of its main rivers.
Japan has an annual precipitation of roughly 1800 mm. Heavy precipitation takes place during rainy season in June and July. As Japan is a narrow and highly mountainous country, the rivers are short, steep and flow rapidly. After high rainfall events, the discharge can be a 100 times higher than the minimum discharge.



Concept of "Super Levee"
Source:www.mradwlive.wordpress.com

Exploratory theories and Case Studies



Park on Super Levee
Source: www.google images.com

In response to the growing demand for housing in Tokyo Metropolis the residential areas are expanding towards the less elevated western region and the flood prone eastern area. As climate change is projected to increase peak river discharge and peak frequencies, extreme floods are bound to occur on a more frequent basis in the future. As the result, the concept of a super levee is designed especially for extreme events in dense urban areas, such as Tokyo Metropolis.

Super levee

A super levee is an especially wide embankment built in cooperation with urban redevelopment projects. The construction of super levees enable effective utilization of land, reinforcement of flood control and earthquake disaster prevention measures, development of healthy river environments and enhancement of urban environments.

To ensure the levee is strong enough to prevent erosion, the toe (refers to the top and the slope which facing river) has been reinforced with a concrete slab and a steel sheet pile. The super-levee is an efficient solution in Tokyo in several reasons: firstly, the super levee is resistance to earthquakes which hit Japan frequently. Secondly, due to the mild slope of a super levee, during large flooding events, wave will lose energy when overtopping the levee, thus it will not hit the inner slope with large forces. Thirdly, as the super levee is much wider than traditional levees, seepage is reduced, and erosion on the super levee cannot damage the protection.

From the urban planner's point of view, the advantage is that the inward slope can be incorporated into the urban landscape, so that these super levees can actually add to the quality of the urban environment.

Different zones of the inner slope are planned to have different land uses regarding both the needs of flood protection and the desires in the aspects of urban planning which is a result of interests of different stakeholders. However, to build and maintain such a super levee requires a huge amount of money.

TOOLBOX

Differentiating resistance:
_ Dike parks
_ Trees on dikes
_ Reprofiling the dike section
_ Dikes as path networks
_ Dike steps and promenades
_ Superdikes

2.4. Nijmegen

Introduction

Nijmegen is a municipality and a city in the East of the Netherlands. It is known as the oldest city in which first settlements were found before the Romans discovered the ground. The city is located along river Waal, surrounded by hills and forests. In 1230, the city constructed its fortification in order to prevent from hostile attack and flood events. Since the end of 19th century, car and train were introduced and became more important for trading. As the result, the city shifted landward where is not well protected from flooding, especially when the fort was taken down. During 1980s, a flood wall was constructed. This construction results in even higher water levels and more vulnerable to flood as clear evident in 1993 and 1995.

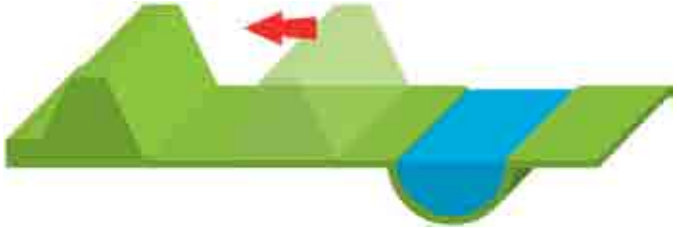
Adequate meassures are necessary in order to protect the inhabitans of the city against the strength of the water.

The present situation with the existing dike.

The dike is to be moved 350 metres inland.

An ancillary channel is to be dug in order to give the river more room. This will create an elongated island.

Bridges across the ancillary channel.



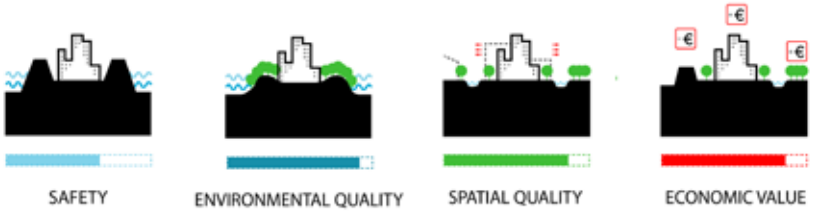
Main measure in Room for the River Waal: Dyke relocation

Source:www.ruimtevoorderivier.nl

The measure at Lent shown in phases (left) & Flood in Nijmegen (above)

Source: www.woophy.com

Exploratory theories and Case Studies

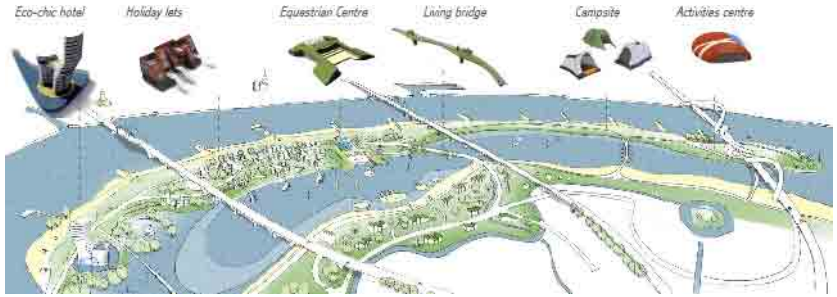


Room for the River Waal

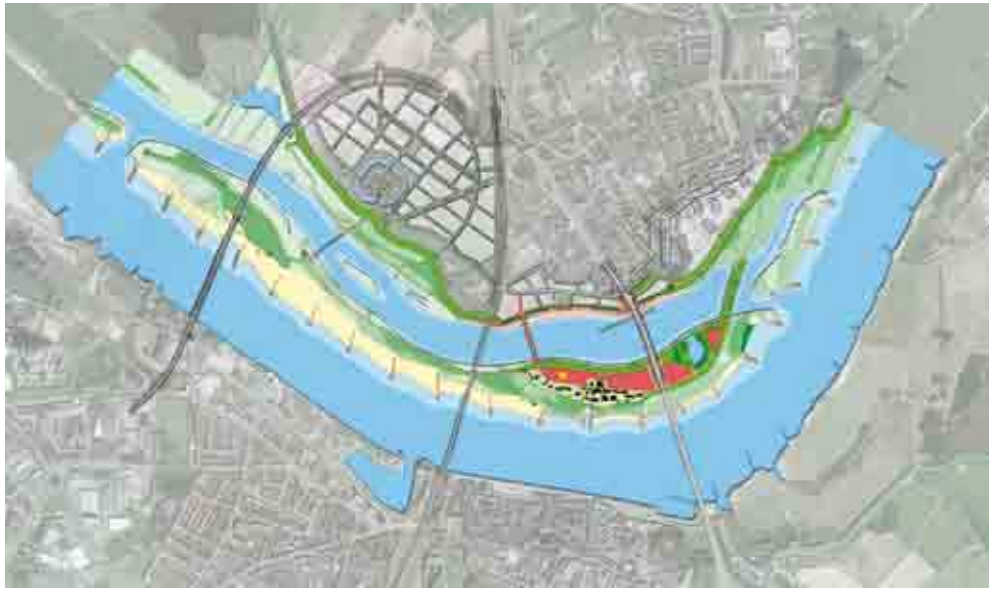
Room for the River Waal includes several steps: Moving the Waal dike Lent and constructing an ancillary channel in the floodplains. This will create an island in the Waal and an unique urban river park in the heart of Nijmegen with room for living, recreational activities, culture, water and nature. The actual digging will be started in 2013. The relocating of the dike, the construction of the ancillary channel and the raising of the island are expected to finish in 2016. The area will be further developed after that to allow for recreation, housing facilities and other urban functions (Ruimte voor de Rivier 2007) .

The project "Room for the River Waal" is far-reaching, yet sustainable. With more room for the river, level of water discharge will reduce that improves safety for inhabitants in the future. Moreover, natural landscape will be preserved and enhanced in the development of the city. Therefore, spatial quality can also be improved.

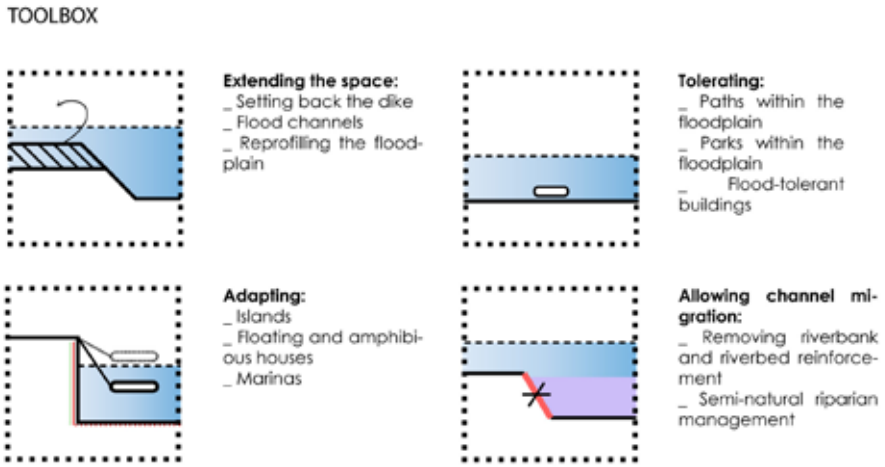
It goes without saying that measures involving the creation of more room for the river involve high costs (about EUR 2,200 million). That might not be supported by government in the developing countries with much lower GDP, such as Vietnam.

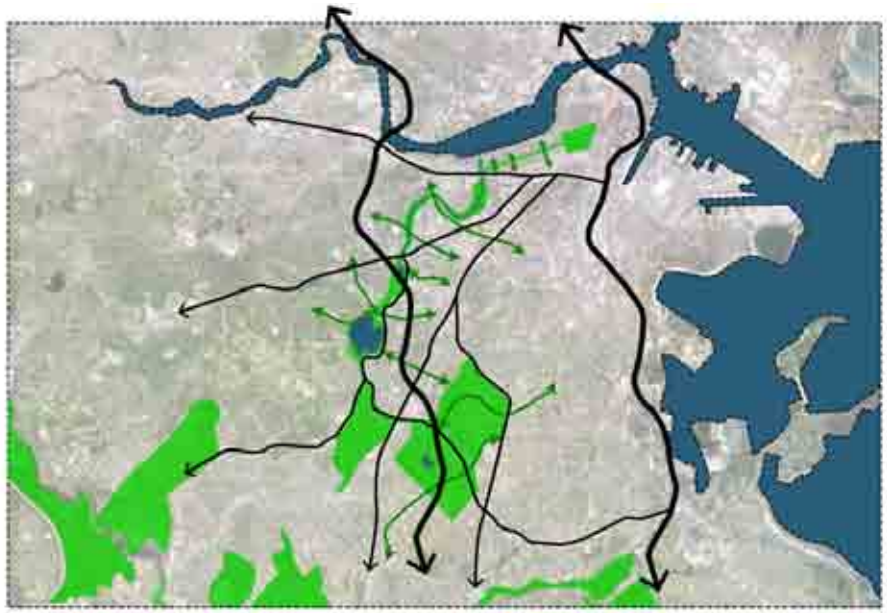


Elements of project "Room for the Waal River"
Source: www.baca.uk.com

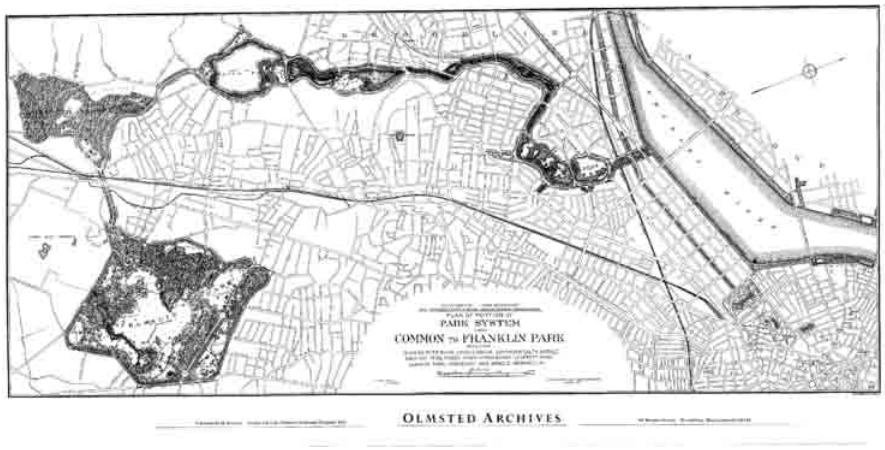


Project "Room for River Waal"
Source:www.ruimtevoorderivier.nl





Structure of Boston
Source: *www.wikipedia.com*



Original plan Of Boston Park system from 1894
Source: *www.wikipedia.com*

2.5. Emerald Necklace in Boston

Boston

Boston is the capital and the largest city of Commonwealth of Massachusetts in the United States. Boston is situated in topographic lowland, referred to as the Boston Basin. This lowland is surrounded by a ring of hills and contain/adjacent to five rivers: the Charles River, the Muddy River, the Neponset River, the Chelsea River, and the Mystic River. In Boston, wetland serves a vital function. They assist in flood control, storm water run-off, and provide food and shelter to fish, birds, amphibians, and other important animals. For a long history, Bostonians have protected and preserved their nature wetlands. One of Boston's stunning projects is Emerald Necklace, part of Metropolitan Park System of Greater Boston.

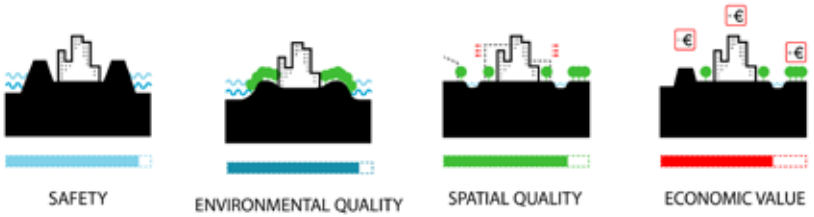
Emerald Necklace

The Emerald Necklace consists of a 1,100-acre (4.5 km2) chain of parks linked by parkways and waterways in Boston and Brookline, Massachusetts. It comprises half of the City of Boston's park acreage, parkland in the Town of Brookline, and parkways and park edges under the jurisdiction of the Commonwealth of Massachusetts. More than 300,000 people live within its watershed area. The Emerald Necklace is the only remaining intact linear park designed by Frederick Law Olmsted (1822-1903), America's first landscape architect. Olmsted had been responsible for the development of Central Park in Manhattan and with Charles Eliot (1859-1897) had worked to create Boston's Emerald Necklace. The Emerald Necklace consists of several components: Boston Common, Public garden, The Riverway, Olmsted Park, Back Bay Fen, Jamaica Pond, etc.

Frederick Law Olmsted began his first Boston park project in 1878 in the newly created open land known as the Back Bay Fens (marshy area or swamp.) His design proposed a continuous flow of water by using flood gates to control the levels of the water and clean up the marshy area. In 1880, Olmsted proposed that the Muddy River, be included in the park plan. The Muddy River was diverted to flow into the Charles River. The result was a landmark in city planning and environmental design. A large storm-water basin had long been part of the city's plan for the Back Bay Park.

However, Olmsted felt that a masonry storage basin big enough to hold floodwaters from Muddy River would be ugly and expensive. Instead he designed the entire park as a flood storage basin with gently sloping banks covered by marsh grasses and other plants that could tolerate changing water levels. The resulting design was revolutionary, a synthesis of environmental engineering and aesthetics. (Zaitzevsky, 1982). By 1900, the system had expanded to include several constructed or planned parkways and added beach reservations at King's Beach in Lynn, Nantasket Beach in Hull, Quincy Shore, Revere Beach, and reservations along the Charles, Mystic and Neponset Rivers (Boston,Mass., 1900, p. 34).

Exploratory theories and Case Studies

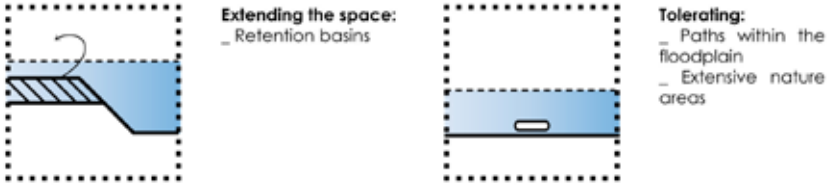


Over the past decade, almost $60 million in capital expenditures for parks and waterway improvements have been made in the Emerald Necklace by the City of Boston and the Town of Brookline. They have included improved pathways, plantings and signage, bridge repairs, and the restoration of boardwalks and buildings.

The park system created by Olmsted has provided great benefits for people, wildlife and the economy. It helps connect people and neighborhoods, provides opportunities for exercise, and enhances emotional well-being by bringing nature "close to home". It is also important to plan and protect urban green infrastructure as a city grows. Moreover a system of green infrastructure as Emerald Necklace can help to shape urban form and buffer incompatible uses,

Perhaps the greatest value of park system is storm water management, flood control, transportation and other forms of built infrastructure. Instead of high cost underground storm sewers, interconnected green space system can store, carry, and filter storm runoff efficiently. Parks and other green spaces are a basic necessity that should be planned and develop as an integrated system not isolated ones.

TOOLBOX



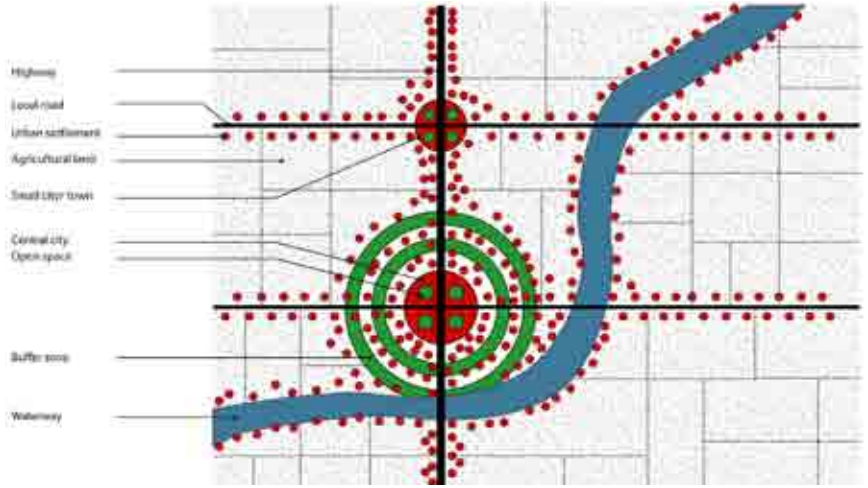
Park landscape in Emerald Necklae
Source:www.emeraldnecklace.org

3. Conclusion

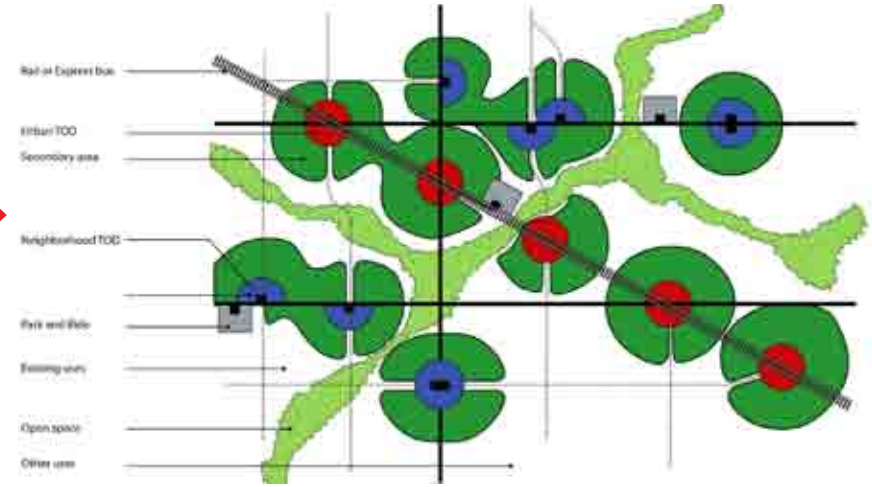
Can Tho City as a specific case study in Mekong Delta that shows serious problems of flooding and urban sprawl. These consequences are not only coming from unstable urban development strategy or insufficient water management, but also from the lack of the integration between these two disciplines. Without this integration, other delta cities in Mekong Delta are predicted to develop in the same way and experience the same problems as Can Tho City does in recent years.

Therefore, relevant strategies that can be visible the interaction between climate change adaption, water management and urban development have been explored in this chapter. The outcome provides an answer for sub-research questions:

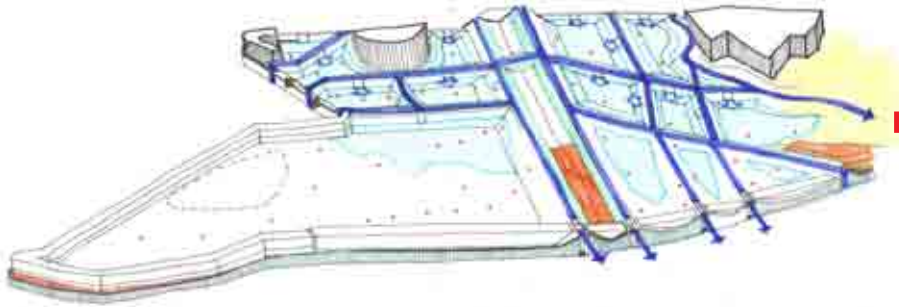
What can be the development strategy for Mekong delta region in dealing with climate change and urban expansion?
The answer is:
_Compact city can replace sprawl as the dominant development pattern in the future (TOD).
_The combination between technical measures and spatial measures (Super levee, Room for River Waal) is a comprehensive solution for cities in Mekong Delta. This solution created a new balance between urban expansion, water safety, environmental preservation and economic development.
_Including water as part of city's development (Park system) is not only needed for Mekong Delta but also crucial solution to adapt to flood and climate change.



Current sprawled image



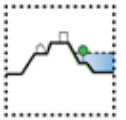
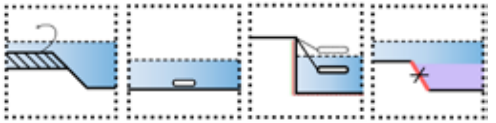
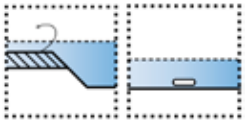
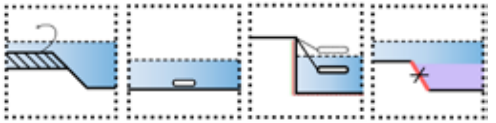
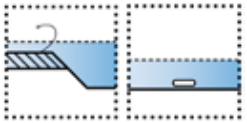
Alternative image: Compact urban development



Controlling water: loss of wetland, higher water level, higher flood risk, no more sedimentation, uncontrolled city expansion (sprawl), etc.

Adaptive solution: Landuse planning, local flood defense, room for river, floodwater storage, adaptive design...

Exploratory theories and Case Studies

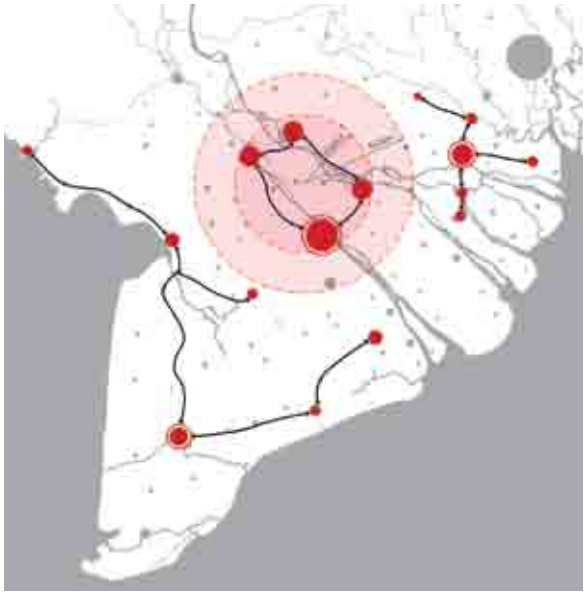
Case study	Advantages	Limitations	Adaption
Dyke system Can Tho	_ Reduce flood damage and secure agriculture in flood protected areas. _ High dykes are combined with roads in order to ensure safe connections.	_ Erosion, plant diseases, soil fertility decline and natural degradation. _ Unintended changes in flow velocity and annual flooding levels with negative effects in both protected and non-protected flooding areas. _ Causes conflicts between different provinces and cities in the whole delta region. _ Not contribute for the urban spatial quality _ Require multi-discipline aprroaches and integrated spatial plans.	To achieve a suitable goal of flood protection and urban development, combinations of different principles is necessary.  
TOD Curitiba, Brazils	_ Multi-discipline approaches and integrated spatial plans _ Reduce traffic congestions, car accidents, pollution, dependence of foreign oil. _ Reduce urban sprawl, increase compact development _ Improve living conditions _ Protect and restore natural environment	_ Need great effort of negotiations among different groups, land owners	
Super levee Tokyo	_ Break-proof _ Seepage-proof _ Earthquake-proof _ Provide a barrier-free connection from inland to waterfront _ Improve quality of the urban environment	_ Huge among of earthwork required _ Subsidence is accelerated _ Need great effort of negotiations among different groups, land owners _ High cost	
Room for River Waal Nijmegen	_ Flood-proof: provide safe conditions for inhabitants and urban development _ Lower water level and strength of river flow _ Preserve natural landscape and bring it back to the city. _ Develop recreation, housing facilities and other urban functions	_ High cost _ Need great effort of negotiations among different groups, land owners _ Require multi-discipline aprroaches and integrated spatial plans.	
Emerald Necklace Boston	_ Preserve natural landscape and bring it back to the city. _ Store, carry and filter floodwater runoff _ Different use of open spaces in dry and wet period _ Shape urban form and buffer incompatible uses. _Reduce public costs for stormwater management, flood control, transportation... _ Improve urban spatial quality	_ Need to be maintained frequently _ High cost in maintainance _ Regional planning is required, need cooperation between land owners.	
Current flood adaption "Shaking hand with flood" Mekong delta	Including adaptive strategies such as: stilt houses, boat houses, floating markers, etc. _ Flexible in both dry conditions and wet conditions. _ Relatively low cost _ Can be done quickly	_ Not ensure safety _ Limit in capacity _ May pollute environment _ Low living conditions _ Difficult to control and develop	

Comparisions between different case studies

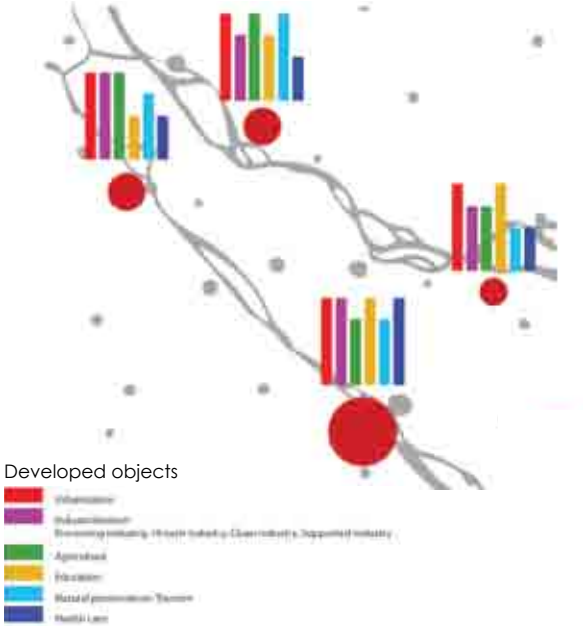
Chapter VI. Development strategy

Regional development
Applied region
Different scenarios

Development Strategy



Urbanized zones



Developed objects

Mekong delta construction planning until 2020, vision by 2050
1581/QĐ-TTg

1. Regional development

Delta cities in Mekong Delta are still growing in order to facilitate their inhabitants and economic development. Based on previous research and analysis, it can be concluded that river cities such as: Can Tho City, Long Xuyen City, Cao Lanh City, Vinh Long City and other cities along Tien and Hau river, as the basic form of city in Mekong delta, are still the main attractive areas to economic activities and urban development. There is a need to concentrate in these cities, control and orient them to a sustainable development.

Today, Mekong Delta in Vietnam has to cope with rapid changing environments: climate change, urban development and population growth. Especially, until 2020, the construction of new highway and new hi-speed railway that enhances the connection of Mekong delta to Ho Chi Minh City and neighbor countries will gradually offer a new geography of the Delta. In this new geography, Can Tho City, Long Xuyen City, Cao Lanh City, Vinh Long City become the center of Mekong delta. They are used to be separated by the 2 branches of Mekong River, namely: Tien and Hau River, and now going to be linked by the new network.

Taking the advantages of the new geography, this project will generate a development strategy for the new center of Mekong delta in which Can Tho, Long Xuyen, Cao Lanh and Vinh Long city interconnect. Although each city has its own identities and opportunities, it all contributes for a sustainable development of the whole region.

Towards Transit Oriented Development

Much of the research on TOD has focused on the developed countries, particularly the United States. The opportunities and challenges for such policies in the developing countries were examined, in Mexico, China and India as examples, and it is argued that these policies might have greater benefits in the developing countries than in the developed countries.
In the developing countries, where cities are growing rapidly and rates of automobile ownership are still low, TOD provides an opportunity to design a transit-oriented urban form. Inhabitants can be supported by cheap, high-capacity transit; spend less of their income on transportation; and have better access to jobs. In the long term, TOD may slow down motorization and mitigate its effects (Gilat, M. and Sussman, J.M., 2003).

Especially, in Mekong Delta, as the requirement for a sustainable development is getting more important, TOD can be the most promising strategy to reverse the trend of urban sprawl, advance environment sustainability, economic growth and social inclusive development.

Towards Climate change adaptation

Following the development of technology, nowadays, controlling water level in the delta is much easier than in the past through a system of flood control, such as: dikes, sluices and pumping stations. However, millions of people are still in the threat of floods. Especially, as the increasing demands on urban spaces, areas that used to be floodwater storage: rice fields, wetlands, orchards… were converted into urban land. Canals, ditches and water retentions were silted up for new housing projects.

In order to dealing with climate change, heightening dike, river embankment and other hard-engineered structures are no longer enough to ensure water safety, on the other hand, increase flood risk. Flood man-

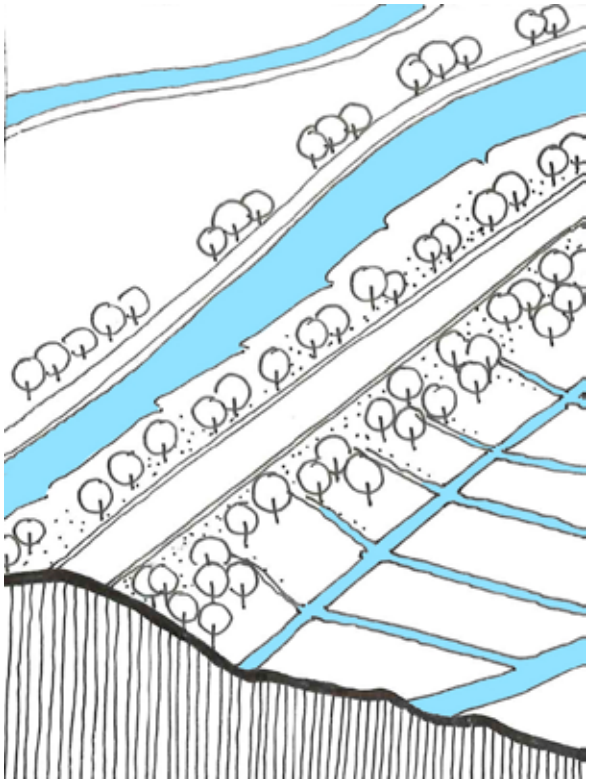
agement strategy once again altered from controlling to "living with flood".

Affecting by "Room for the River", "living with flood" solution is to bring back water to the development of Mekong delta and provide it with new functions. There will be more rooms for the river and for floodwater. In the regional scale, floodwater from upstream will be store in planned lowlands that are being used as agriculture lands or wetlands and leave the higher land for urban development (TOD). These lowlands can work as nature wetland parks or diverse productive landscape. In the city scale, making river visible to its inhabitants by designing outer-dike areas with parklands and recreation activities.

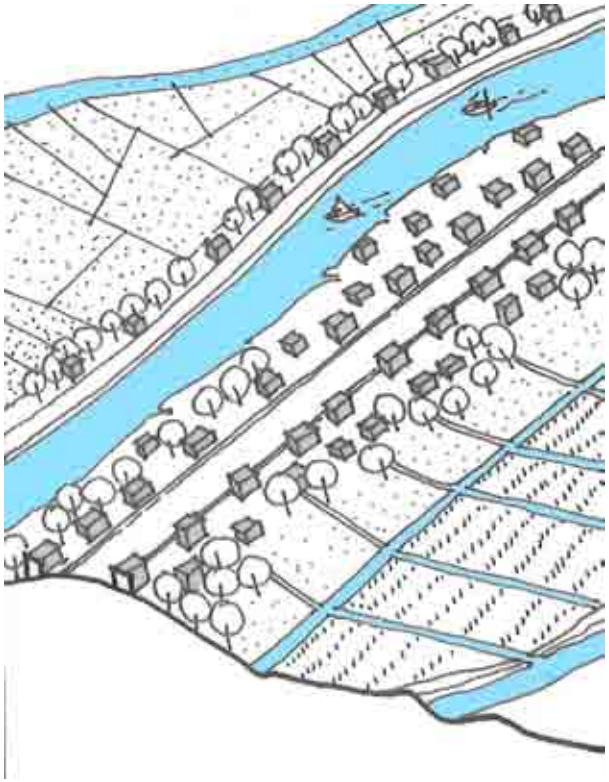
In the city scale, making river visible to its inhabitants by designing outer-dike areas with parklands and recreation activities. Stormwater and floodwater will be drained off and stored in designed water retentions such as rain-garden, urban farms, urban waterways, urban wetlands…etc.

In this urban water management system, inhabitants adapt their lives to the change of water level and improve environment quality in the river basin region, as Meyer(2012) stated: "the complexity of the effects of climate change and the increased concern with environment in the urbanized delta areas makes a comprehensive approach necessary, which combine the problems and challenges concerning safety against flooding with a strategy concerning economic and urban development and environmental improvement of delta landscape".

Developed framework

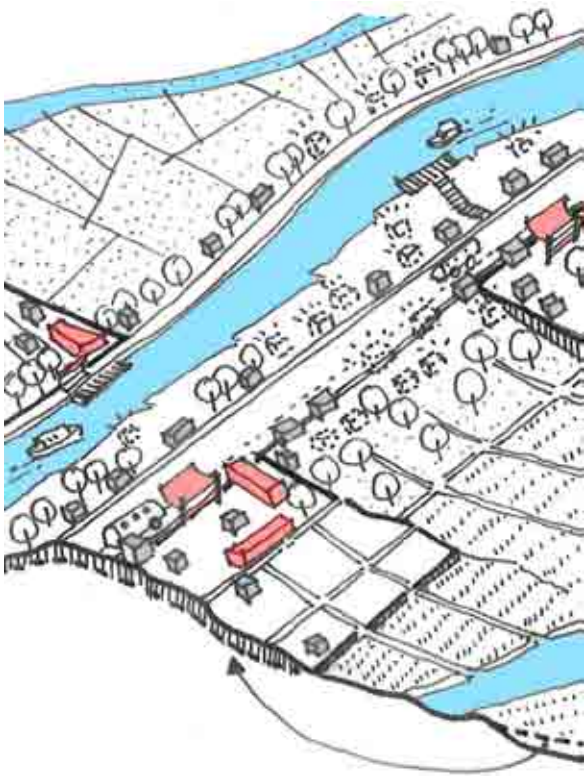


Natural levee
Annual flood in Mekong Delta allowed the river to deposit a thick layer of sediment along its bank. Throughout thousand years, this natural process has built up large natural levees that are the only high and safe land in the delta for development.



Urban settlements along main road
Urban patterns (roads, houses) started to follow the natural levees. Population growth and new demands for economic activities and connections added a huge number of unplanned settlements that increased the danger of flooding to inhabitants (urban process).

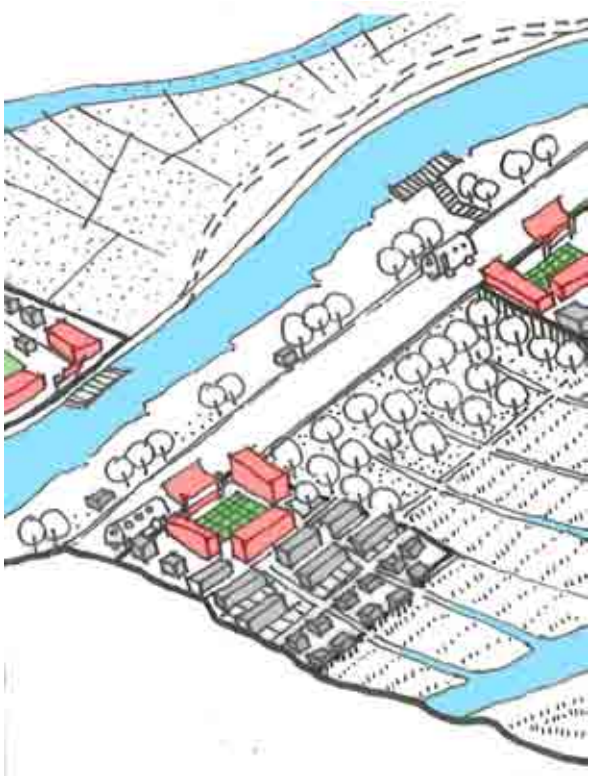
Development Strategy



Introduction of Public transport (Bus rapid transit or Light rail transit)

The concept of TOD starts by introducing a high performance public transport bus service, known as Bus rapid transit (BRT) which combines bus lanes with high quality bus station, vehicles, amenities and branding to achieve the performance and quality of light rail or metro system. The capital costs of implementing BRT lines can be lower than up-front costs of constructing LRT lines. By doing so, BRT and traditional water bus system could connect traffic flows between new developed areas and existing cities.

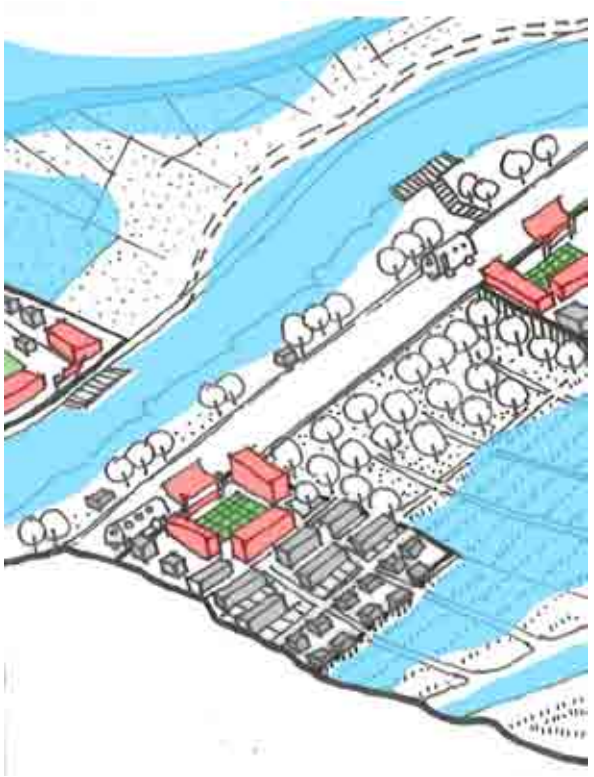
Together of introducing public transport system, measures are taken: a cut and fill principle is used to heighten natural levees at least to the designed safe height (0.5 meter above maximum flood level in 2000) and lower floodable areas.



New urban node on high platform

Bus transit station becomes urban node which contains a mixture of uses in close proximity including office, residential, retail, and civic uses. TOD can enable a region to use market forces to increase densities near stations, where most services are located, thus creating more efficient urban areas and minimizing sprawl.

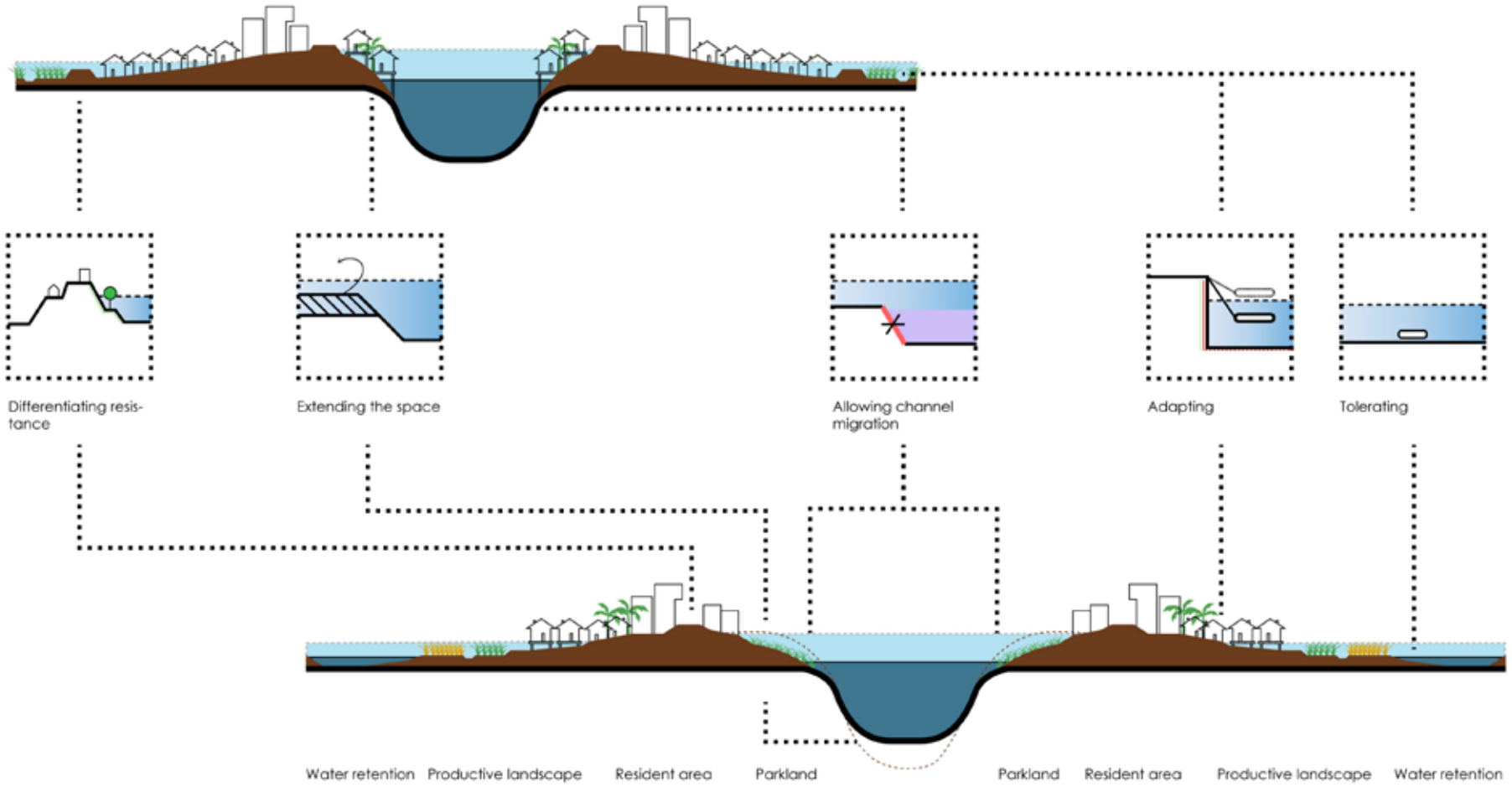
As Mekong Delta is one of the biggest rice growing regions in the world and also the biggest rice growing area in Vietnam, towards a sustainable development, agriculture has to be remained its main power in the delta. And TOD offers a chance to develop its power by supporting import and export activities, constructing agricultural service centers, agricultural product markets and maintaining agricultural lands. Moreover, in TOD, natural landscape can be preserved from the urbanization process that takes place in the compact urban areas.



Flood adaption

Compact TOD urban area develops on higher platform and surrounded by orchards and paddy fields. In the rainy season, floodwater and storm water overflow into water retentions areas and wetlands that will be filtered partly into groundwater, drained off to the main canals or river and stored for the dry season.

In the urban areas, several principles are applied, shown in the next page.



Design principles

Flood adaption principles

There is not a single solution that promised to solve the flooding problem all by itself. To achieve a suitable goal of flood adaption, combinations of different principles is necessary.

Differentiating resitance:
_ Dikes as road networks (transit lines)

Extending the space:
- Removing unplanned houses
- Retention basins

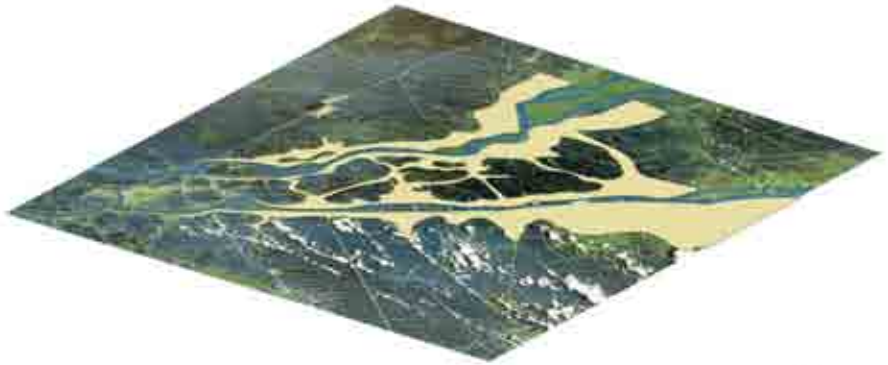
Allowing channel mitigation :
-Removing river bank and riverbed reinforcement

Tolerating:
- Paths within the floodplain
- Sport facilities and playgrounds

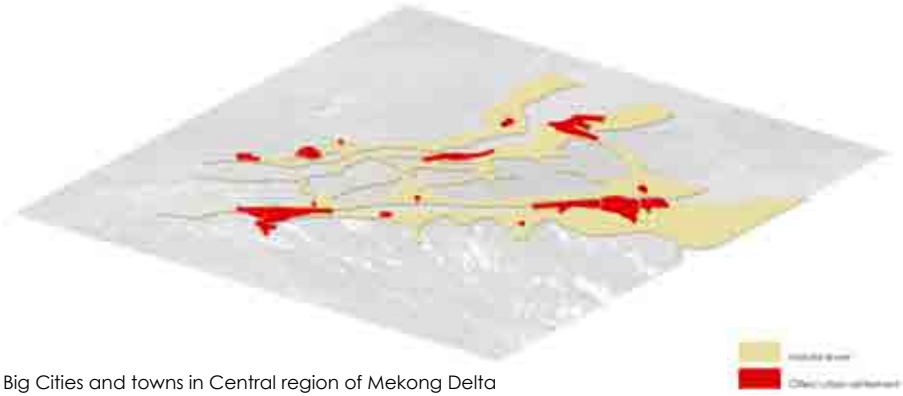
Adapting:
- Marinas
- Floating and amphibious houses
- Flood-tolerant building
- Parks within the floodplains
- Extensive natural areas
- Agriculture
- Event grounds

2. Applied region

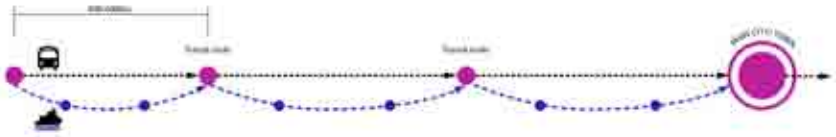
Natural levees with low flood risk (created by combining topography map and inundation map) are suitable areas to urbanize.

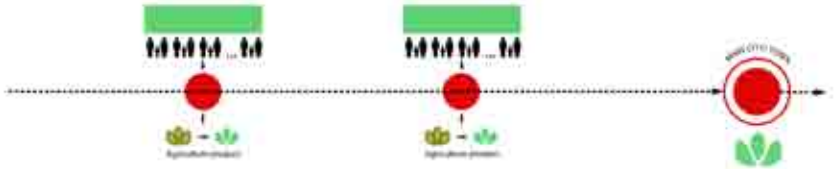


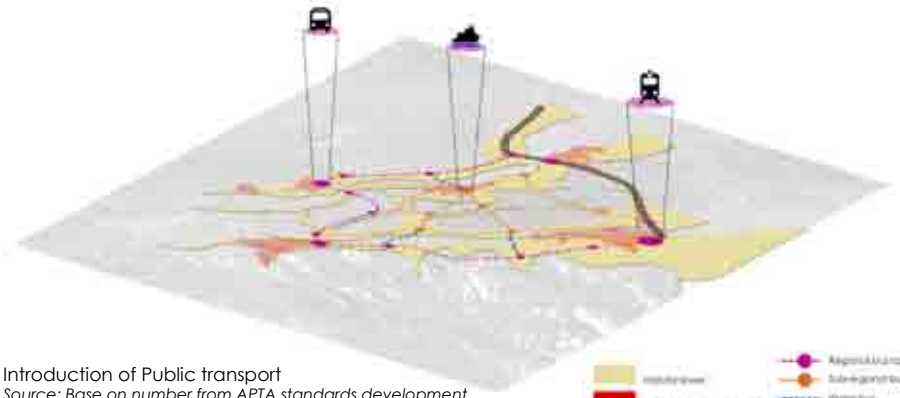
Natural levee with low flood risk in Mekong Delta



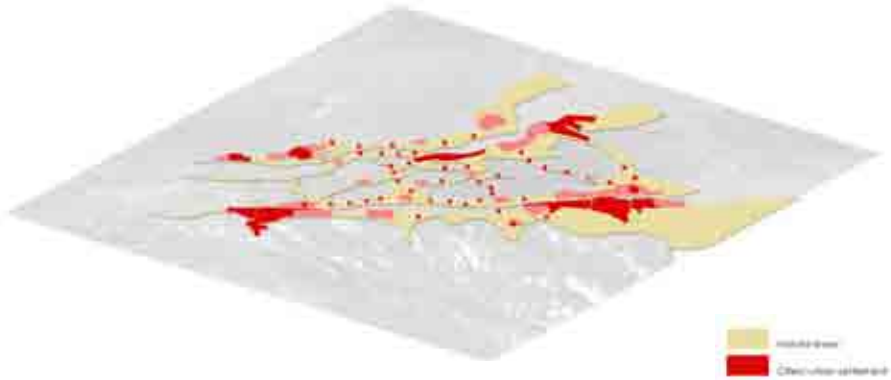
Big Cities and towns in Central region of Mekong Delta
Source: Base on number from Institute of Agricultural Science for Southern Vietnam
www.iasvn.org



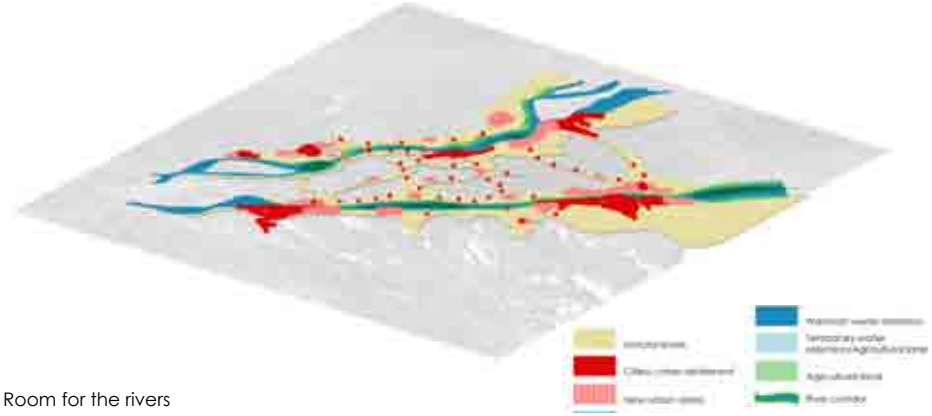




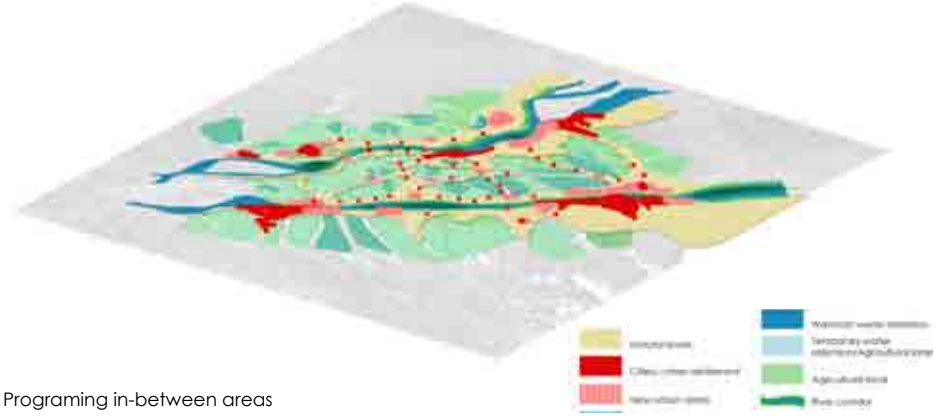
Introduction of Public transport
Source: Base on number from APTA standards development program
www.apta.com



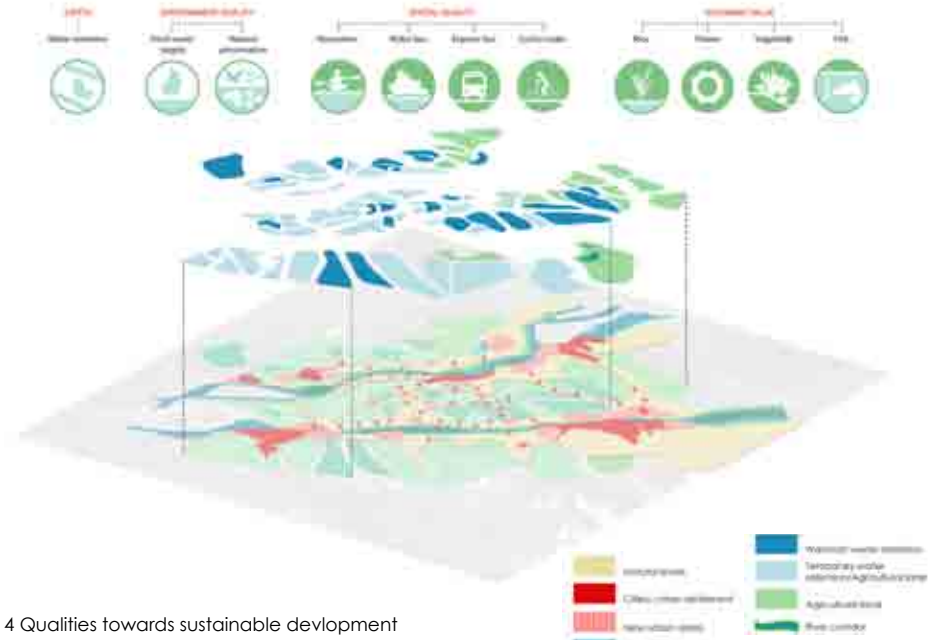
New planned urban areas with collective environment



Room for the rivers



Programing in-between areas



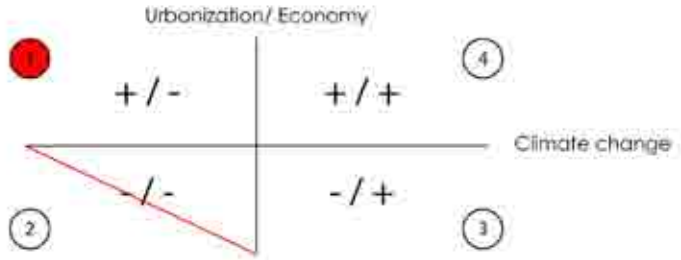
4 Qualities towards sustainable devlopment

Development Strategy

3. Different scenarios

From the first chapter, it can be seen that there are two main challenges for Mekong Delta in the current situation, namely urban development and climate change. Different scenarios are set up based on different predicted levels of challenge until 2050. In these scenarios, a comprehension view on the various possible futures for the central urban zone of Mekong Delta is presented. The purpose of this step is to approve the feasibility of proposed development strategy.

Scenario



Number

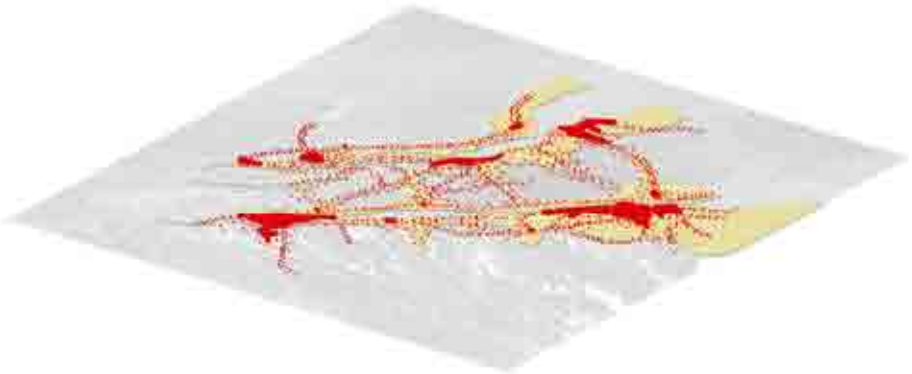
Scenario 1: Extreme urbanization with the population growth to 35 million inhabitants

Source: Mekong delta construction planning until 2020, vision by 2050

Implementation:

In this scenario, the central urban zone of Mekong delta will be more suffered from urban sprawl. This problem just can be solved by applying project's development strategy: Transit oriented development. The development of the region will be based on its public transport system. Living, working and recreation will be increasingly blended in the compact cities and urban nodes. The delta landscape will be preserved and the river is an integral part of the public space.

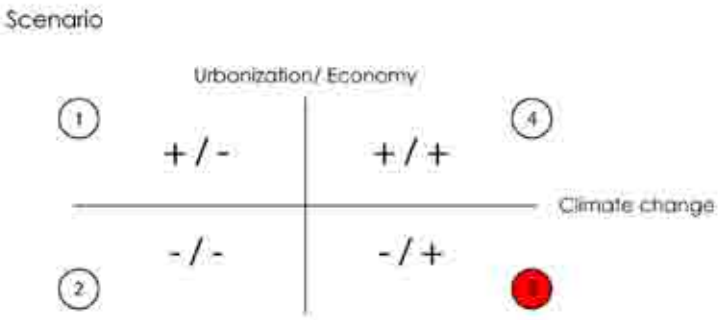
Without planning/ Interventions



_ Uricontrolled population growth leads to Urban sprawl
_ Low quality life
_ Loss of nature: wetland, waterway and species
_ Loss of agriculture land
_ Overused of nature resources
_ Dependence on car

Planning/ Interventions

_ Compact development
_ Higher quality life
_ Space for natural preservation
_ Promote public transport



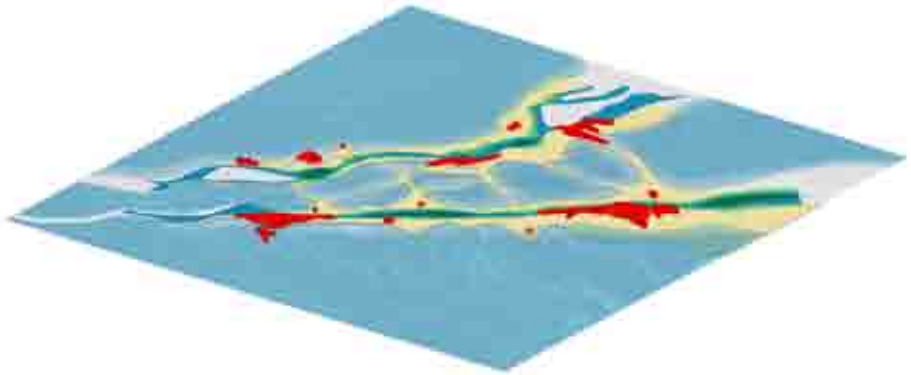
Scenario 2: not change
Scenario 3: Extreme climate change with sea level rising to 30-50 cm and normal population growth to 21 million inhabitants

Source: Mekong delta construction planning until 2020, vision by 2050 and Vietnam Academic for Water Resources

Implementation

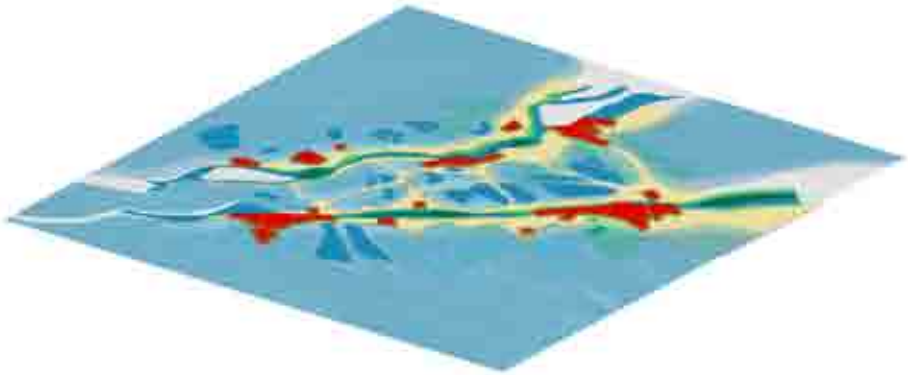
The increase threat of water makes it necessary that the cities and other urban areas are well protected within dikes and embankments. Remaining landscape such as paddy fields and wetlands can be used as water retentions, recreation and natural preservation areas. Affecting by the "Room for the River", this solution includes more room for floodwater and more room for the river. Cities will continue to grow in safe protections and connect with each other by safe road network.

Without planning/ Interventions



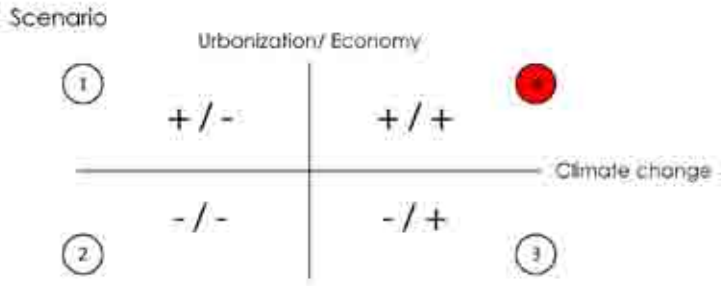
_ Damage from flood events: life and economic value

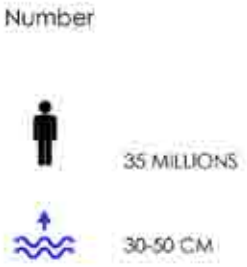
Planning/ Interventions



_ Local water defense system : dike, embankment
_ More room for flood water
_ More room for river
_ Ensure traffic connection
_ Preserve delta landscape

Development Strategy





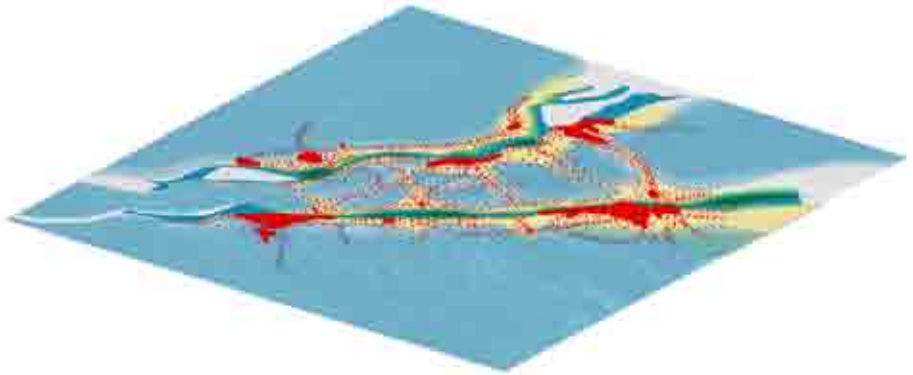
Scenario 4: Extreme climate change with sea level rising to 30-50 cm and extreme population growth to 35 million inhabitants

Source: Mekong delta construction planning until 2020, vision by 2050 and Vietnam Academic for Water Resources

Implementation:

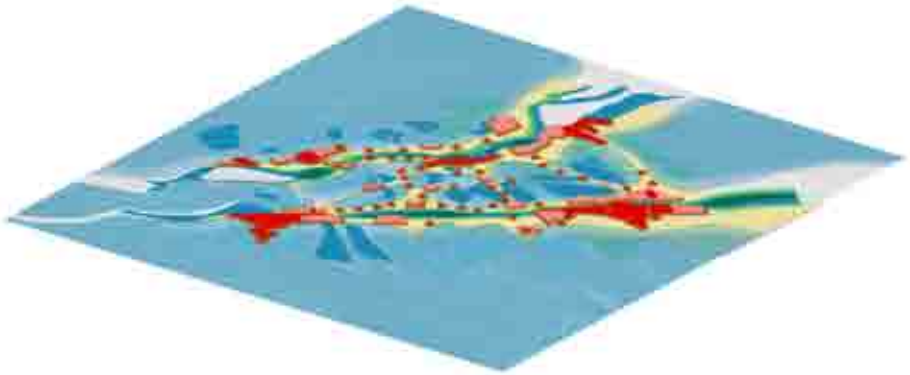
In this extreme situation, urban development and economic growth will experience many difficulties. The rising sea level and floodwater level will force the region to give priority to the protection of its inhabitants and the most economically parts. Compact urban areas are well protected and attract inhabitant by their offered jobs, affordable housing, high living conditions, easy accessible to their workplaces. The parts that are frequently exposed to water will be used for water retention (room for floodwater and room for the river) and diversified their uses for economic purpose.

Without planning/ Interventions



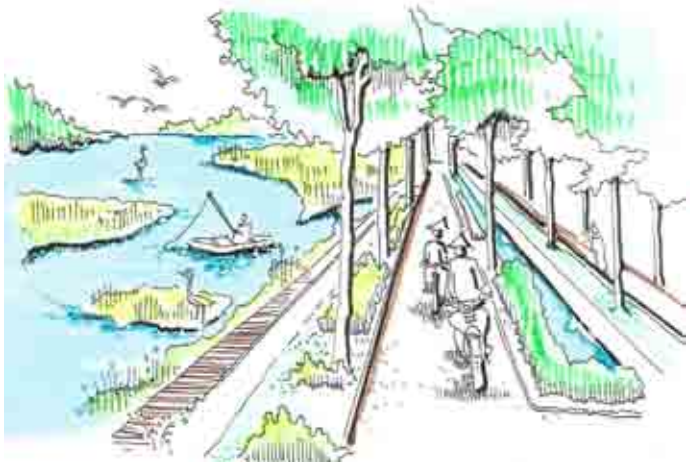
_ Uncontrolled population growth leads to urban sprawl
_ Not enough room for flood water and river
_ Damage from flood events: life and economic value
_ Stagnation of traffic connection

Planning/ Interventions

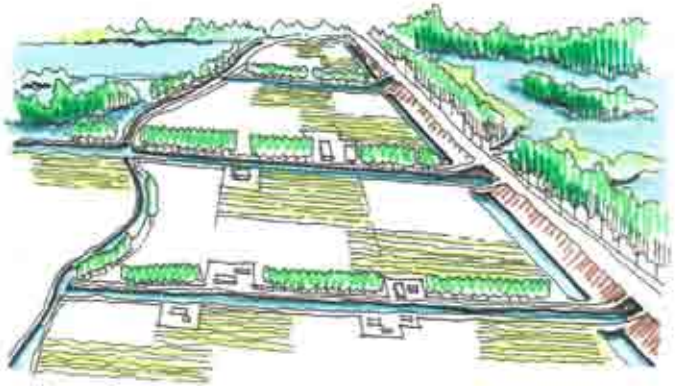


_ Compact development
_ Local water defense system
_ Enough room for flood water
_ Enough room for river
_ Ensure traffic connection
_ Preserve delta landscape

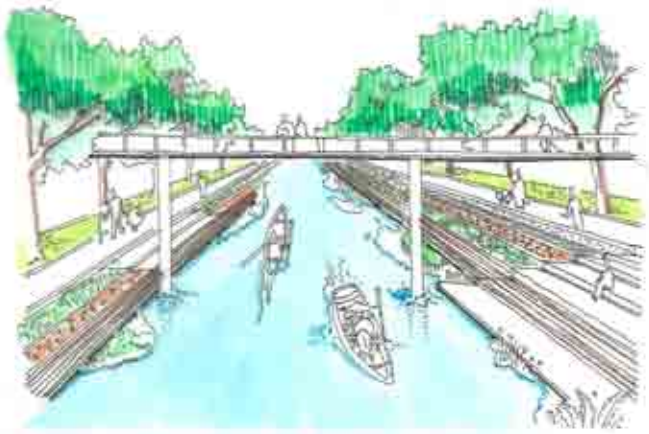
4. Impressions



Water retention



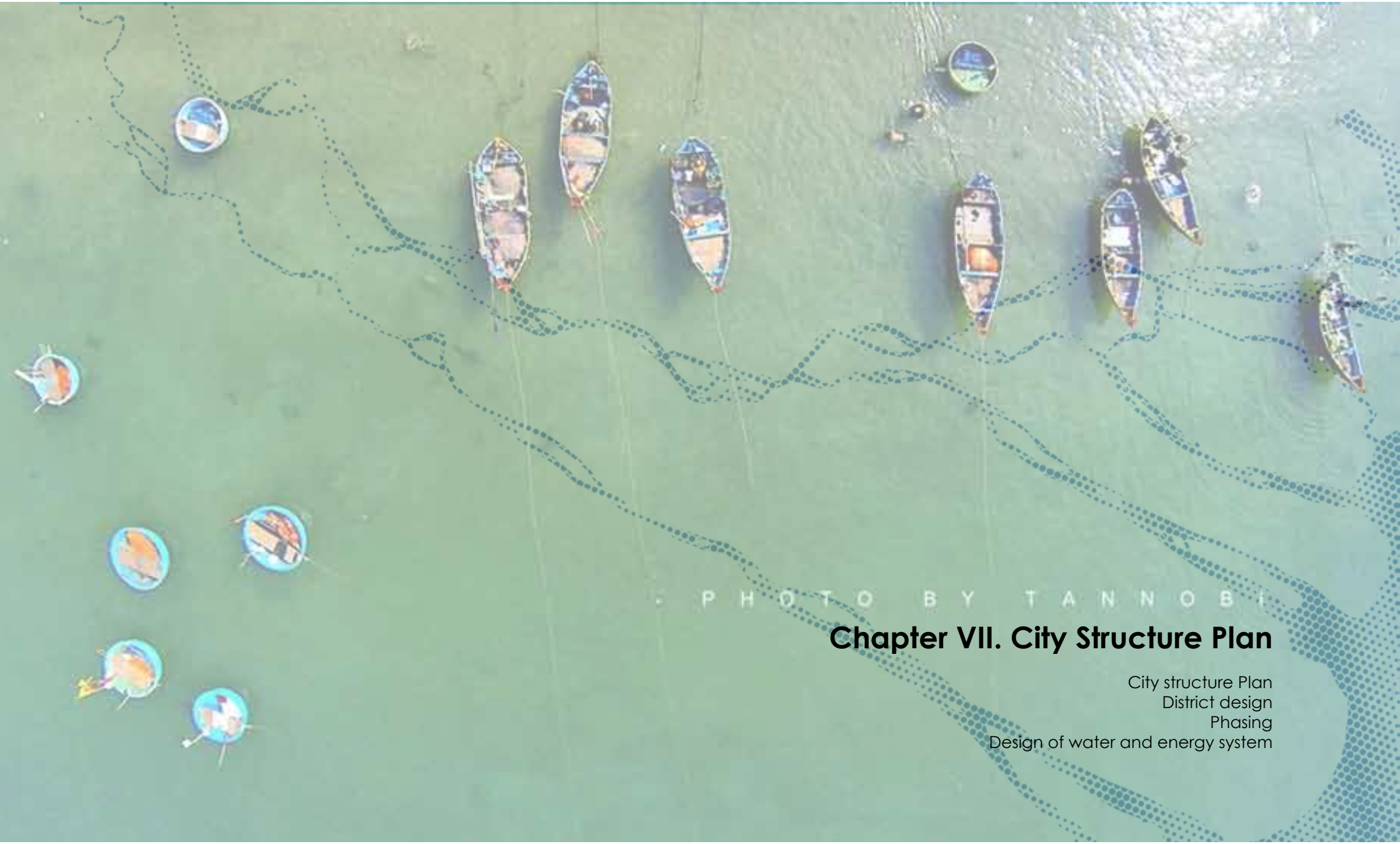
Agriculture



Urban waterway

Room for River

Wetland park



Chapter VII. City Structure Plan

City structure Plan
District design
Phasing
Design of water and energy system

1. City structure plan

The combination of Transit Oriented Development and water management shown on previous chapter can be a costly plan to implement in full but formed the basis for future developments in Mekong Delta. This strategy can also be developed at city scale in which the urban area is composed by numerous neighborhoods mutually connected by transit lines.

Cao Lanh City is a chosen case study and also the most potential city to apply this project's strategy as its strategic location in the new Mekong Delta's geography and its new challenges in the near future. In order to pursue sustainable development, Cao Lanh City needs an alternative urban forms and a direction of expansion in order to cope with climate change and support economic development.

Also based on topography map and inundation map of Cao Lanh City, natural levee with low flood risk map is generated to define the safe areas for urban development. It can be seen on the map of current structure of Cao Lanh City (shown on the next page), the city center, industrial zones, Plain of Reeds University, small town of My Tho and areas surrounded these four main parts have already built on the high levees. However, the remained areas with ribbon houses and orchards are still in a high flood risks.

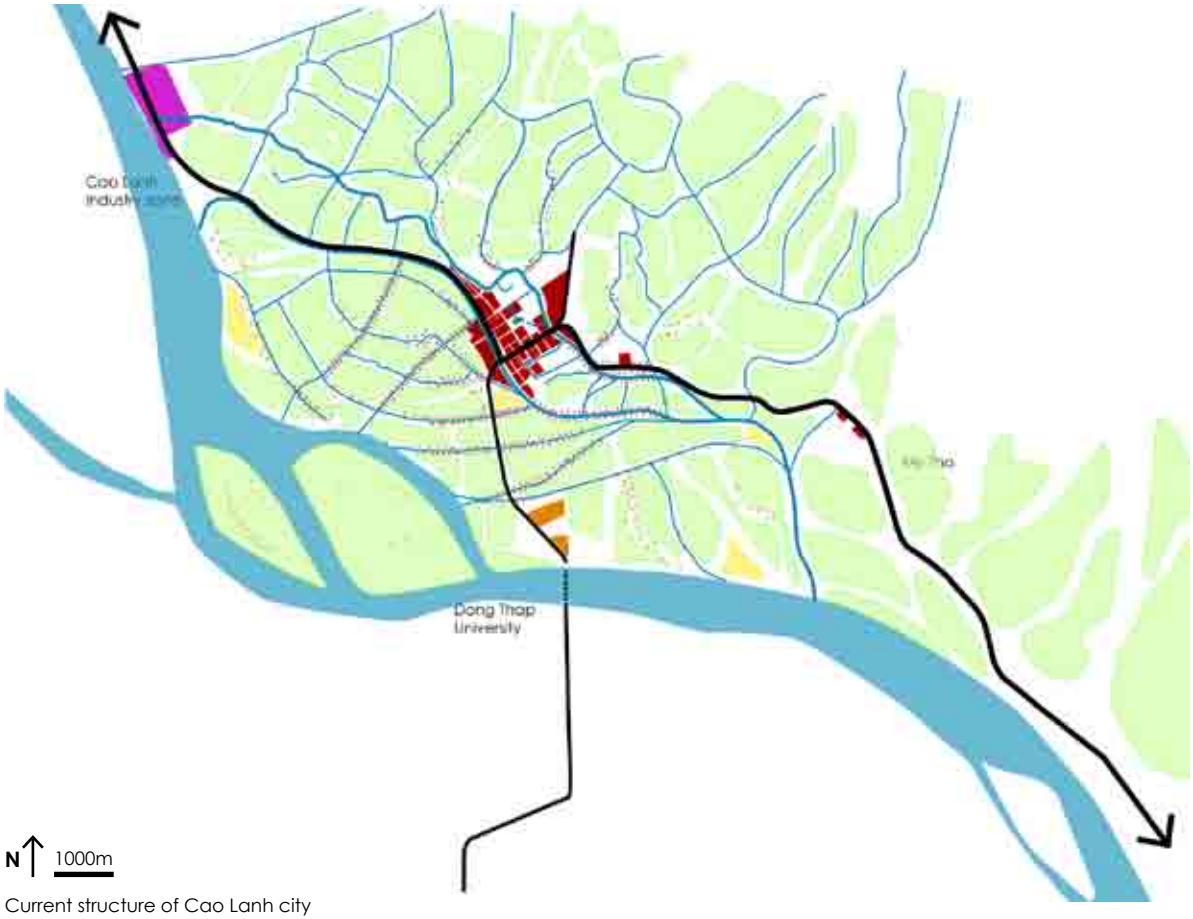
Natural levees with low flood risk

Cao Lanh city in normal water condition

Cao Lanh city in high water condition

City Structure Plan

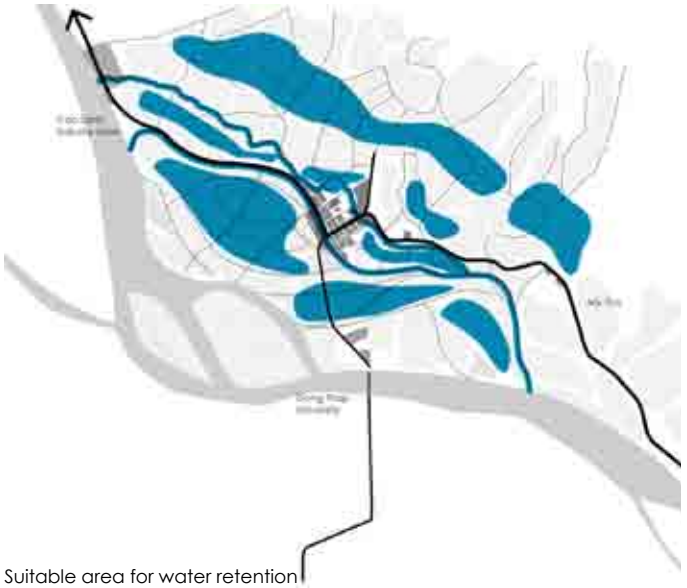
For the first step of urban development, it is important to define areas that are suitable for storing water and areas that meet the requirement for new urban settlements.



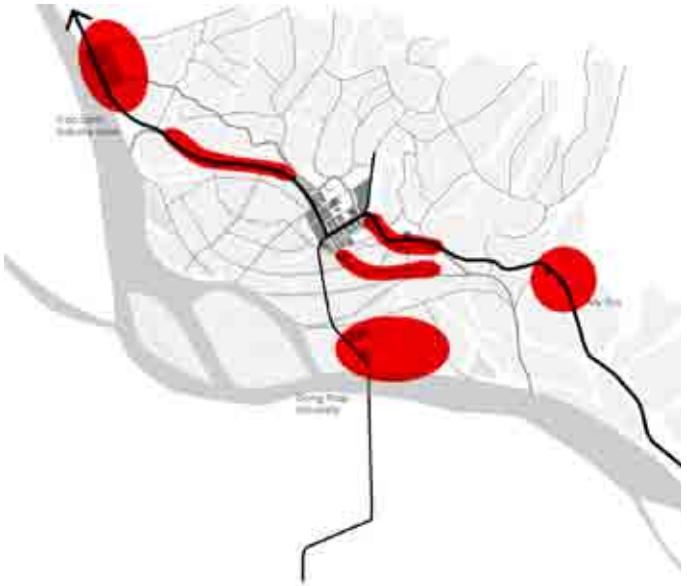
Current structure of Cao Lanh city

LEGEND

- Existing resident area
- Education
- Industrial park
- Water surface
- Ribbon house
- Paddy field
- Cultural/ religion area
- Existing road
- Waterway

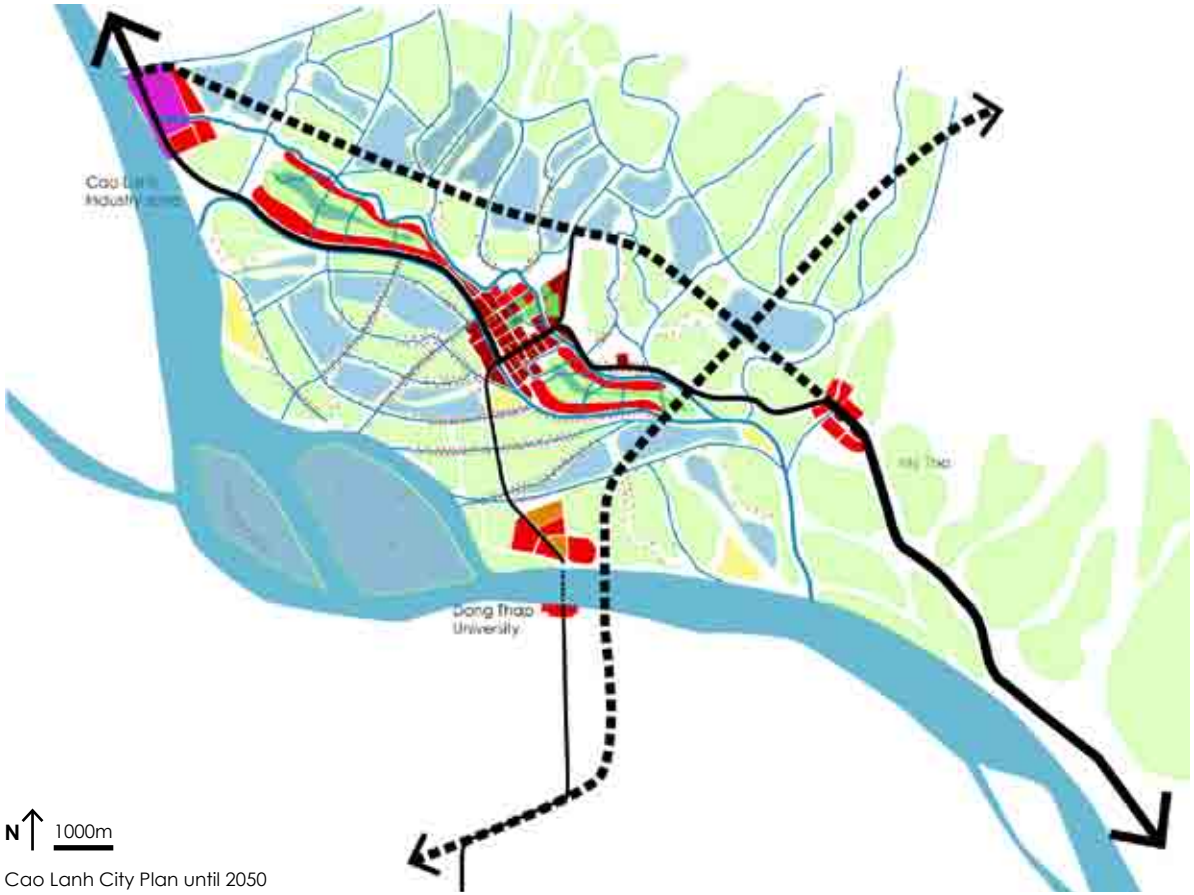


Suitable area for water retention



Suitable area for urban expansion

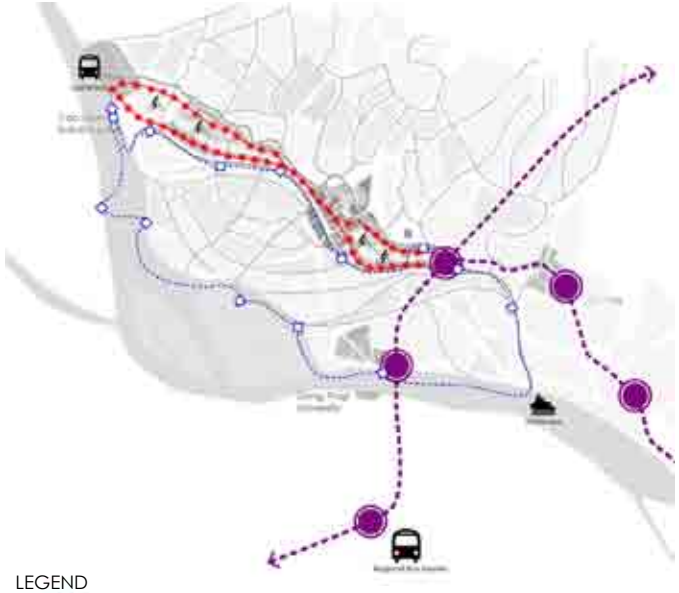
The second step is to introduce new public transport system including regional bus rapid transit, city bus rapid transit and water bus. This system will connect efficiently different parts of the cities and different developed neighborhoods. It helps to reduce dependence on the automobile, reduces traffic congestion and last but not least, to densify the safe areas in the city.
In the third steps, the city will have new urban structure with green and river corridor. Different programs will be adjusted to adapt to climate change.



Cao Lanh City Plan until 2050

LEGEND

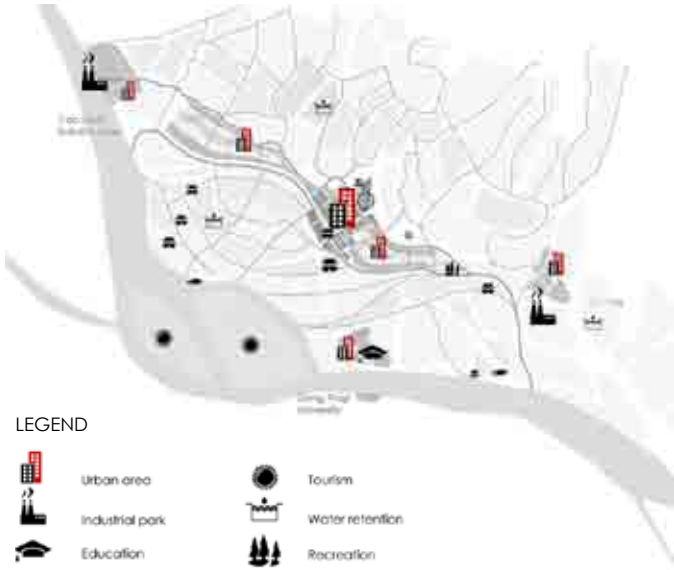
- Existing resident area
- New resident area
- Education
- Industrial park
- Water surface
- Ribbon house
- Paddy field
- Water retention
- Isle
- Cultural/ religion area
- New road
- Existing road
- Waterway



LEGEND

- Regional Bus rapid transit
- City Bus rapid transit
- Waterbus

Public transport



LEGEND

- Urban area
- Industrial park
- Education
- Cultural/ religion area
- Tourism
- Water retention
- Recreation

Program

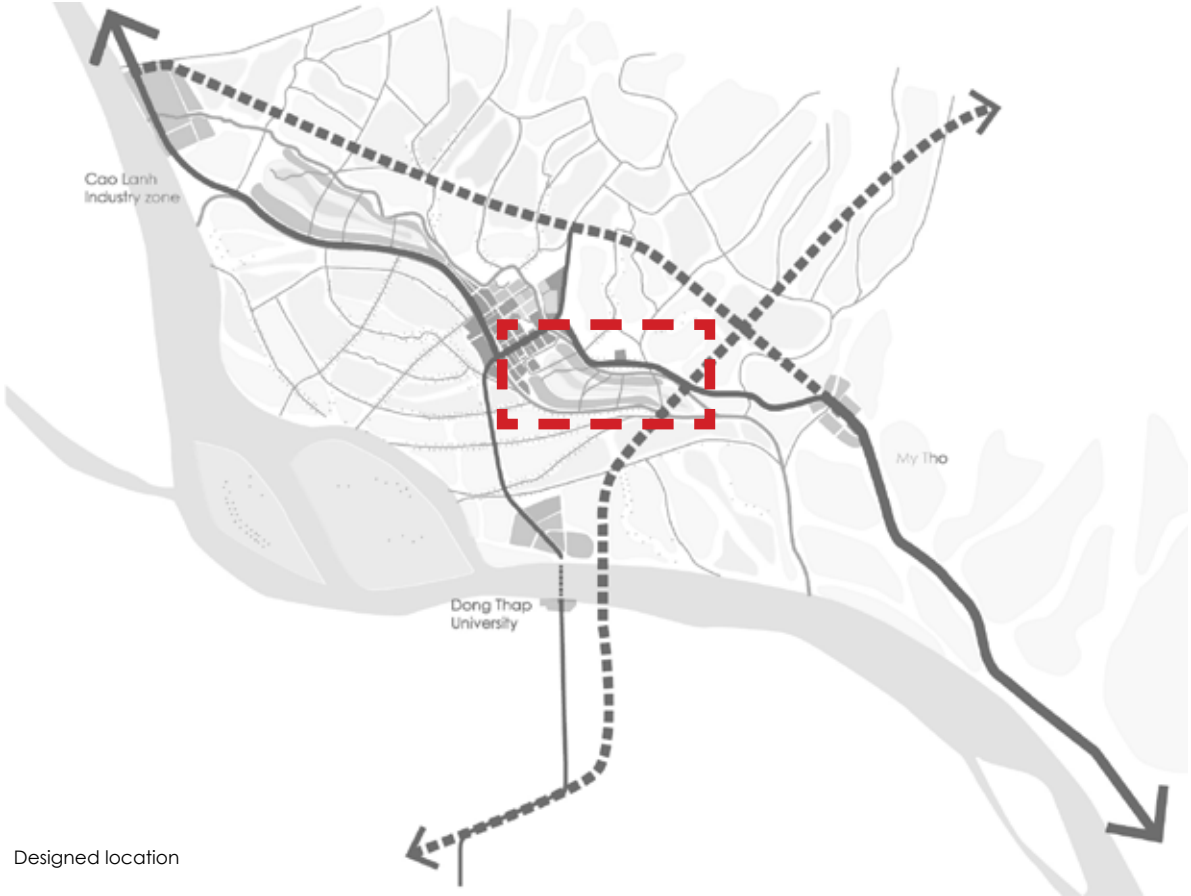
City Structure Plan

2. District design

Strategic project

District 3 in Cao lanh City is chose to generate a design for the project's strategy. This district will be one of the quickest growing areas because of the introduction of new highway directed to Ho Chi Minh City until 2020. This area is also an inundation area which is exposed to flood in every rainy season. This strategic project will shows how the Transit Oriented Development and water management will work on smaller scale.

District 3 is located adjacent to the densest area in Cao Lanh City and on the way to My Tho town. The current structure of this district is urban settlements along waterways and in-between areas used for agricultural activities. Recently, a master plan of district 3 has been purposed by Plains of Reeds Department of Construction. In this master plan, paddy fields are replaced by dense urban patterns, waterways are silted up and transformed into asphalt roads.



Designed location

The image of water city has been no longer visible for its inhabitants,

Based on the characteristics of District 3, the design has to concern:
_ Preserve delta landscape
_ Improve accessibility to water and more room for water
_ Remain agricultural activities
_ A mixed rural and urban environment

District 3 in current situation
Source: www.maps.google.com

District 3 Master plan proposed by Dong Thap (Plains of Reeds) Department of Construction
Source: www.sxd.dongthap.gov.vn

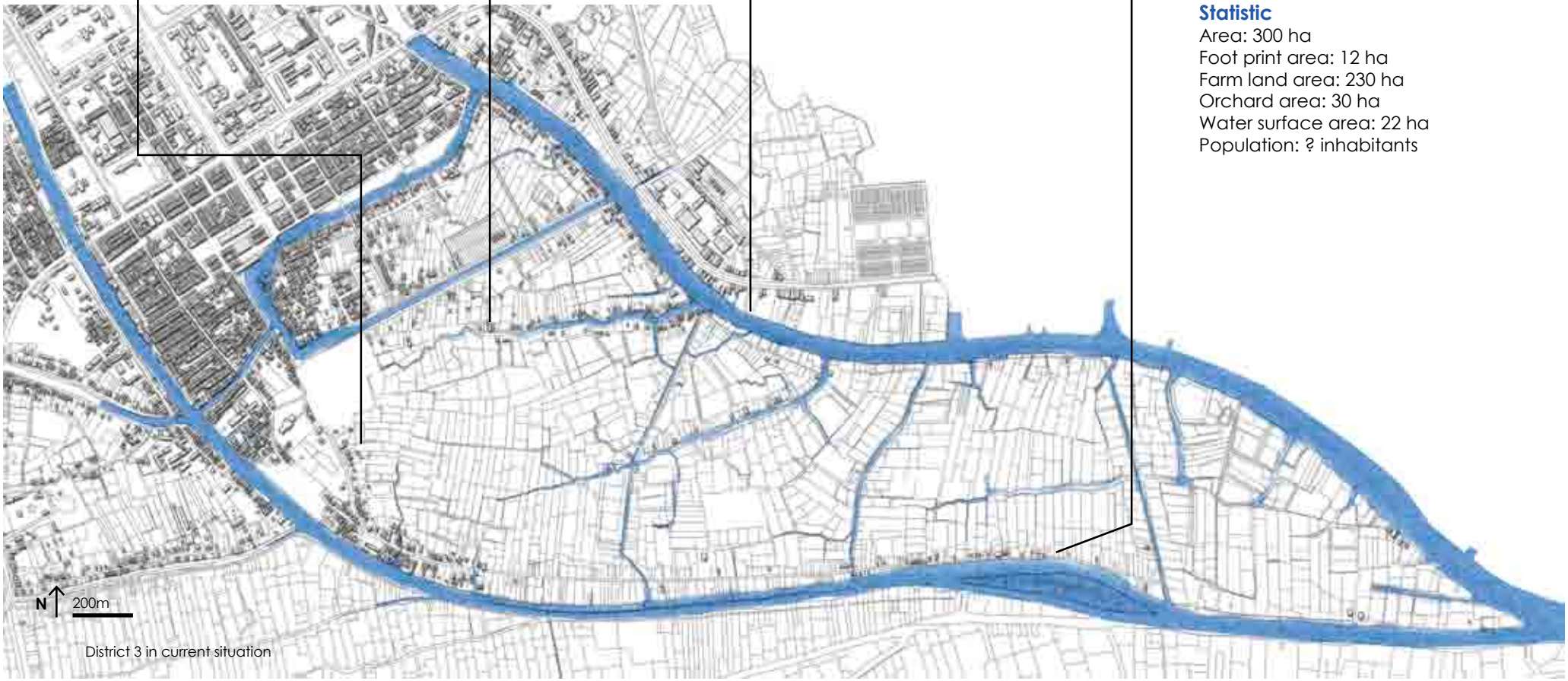
Rural road
Source: www.google images.com

Aquaculture and agriculture
Source: www.google images.com

Cao Lanh River and unplanned settlements
Source: www.google images.com

Flood adaptive house
Source: www.google images.com

Statistic
Area: 300 ha
Foot print area: 12 ha
Farm land area: 230 ha
Orchard area: 30 ha
Water surface area: 22 ha
Population: ? inhabitants

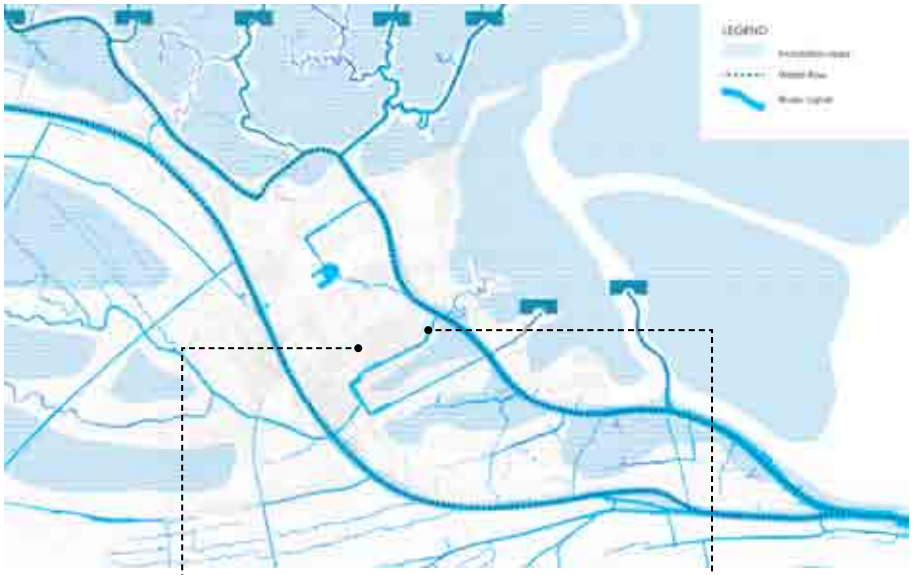


District 3 in current situation

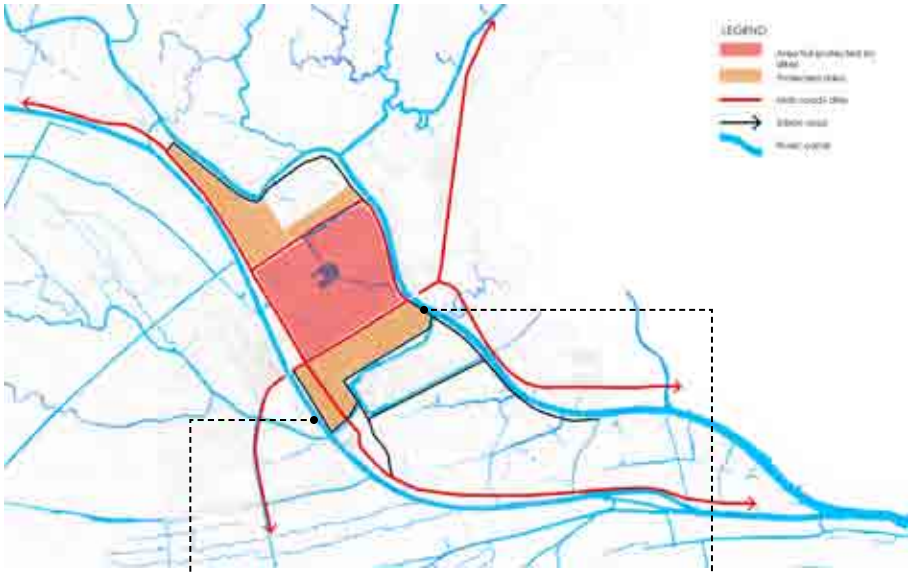
City Structure Plan

Spatial Analysis

3225 m3/s



Water flow and inundation map



Protected areas

Flood in Cao Lanh market
Source: www.google images.com

Flood in Cao Lanh street
Source: www.google images.com

Cao Lanh River and unplanned settlements
Source: www.google images.com

Dike structure along Cao Lanh River
Source: www.google images.com

Green spaces and access to river

Green structure

Unplanned settlements block public access to the waterfront
Source: www.google images.com

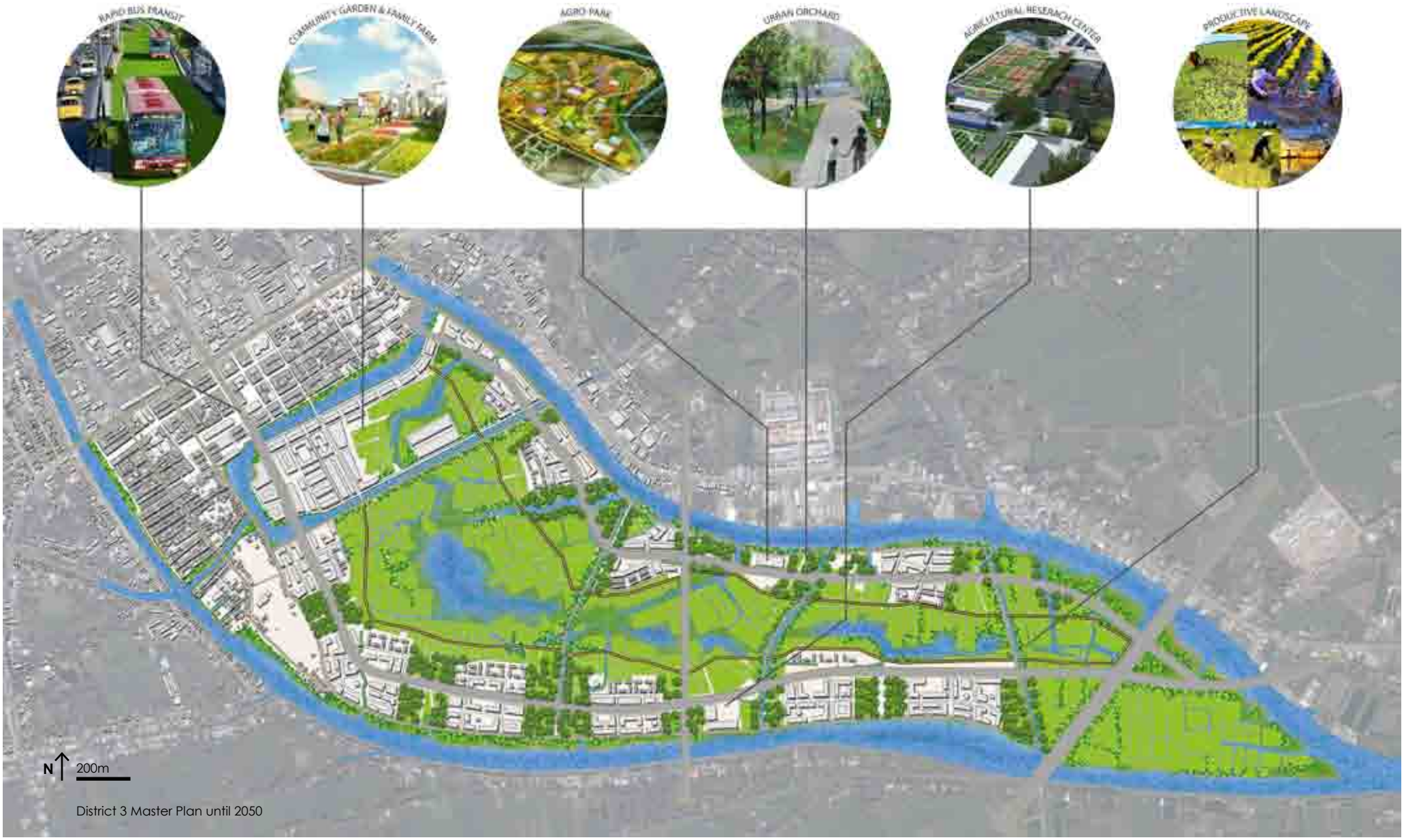
Boulevard along Cao Lanh River
Source: www.google images.com

Cao Lanh's central park
Source: www.google images.com

Ly Thuong Kiet street_main city axis
Source: www.google images.com

City Structure Plan

Master Plan



District 3 Master Plan until 2050

Master Plan

Instead of removing all the rural parts of the area as the government's proposal, the project tried to preserve and strengthen its delta landscape with paddy fields, floodplains and waterways and create mixed urban-rural environment.

A new TOD neighborhood has a center with a Bus rapid transit station, surrounded by high density development with a mixture of uses in close proximity including office, residential, retail, and civic uses. Each neighborhood is located within 400 meters of bus station as this is considered to be a comfortable distance for pedestrians..

By concentrating development in TOD neighborhood, it helps to preserve city's natural landscape and provides a structure of green spaces. This structure includes private green spaces: farm land, orchard; semi-private space: community gardens; public spaces, such as: river park, agricultural park, urban wetland…etc. Moreover, this green structure contributes to create a flood adaptive city, in which each space has its own function on dealing with flood and other urban water issues. For examples:

_ urban wetland: water retention, storm water bio-filtration, enhancing bio-diversity

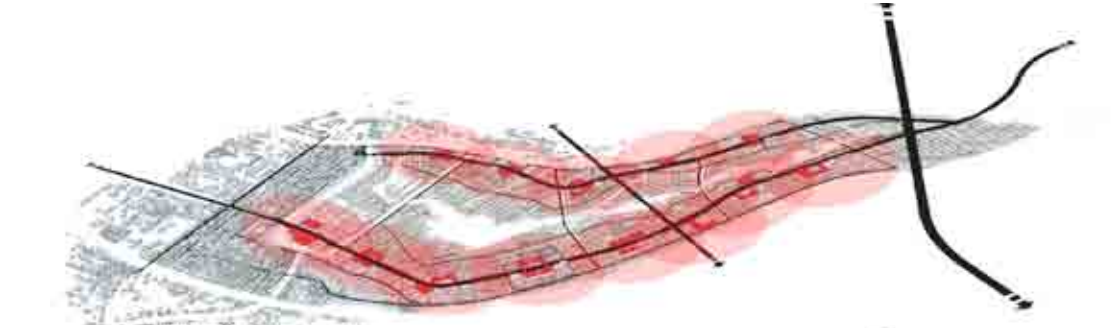
_ urban orchard, farmland and community garden: storm water bio-filtration, local waste water recycling

_ river park: water retention, storm water bio-filtration…

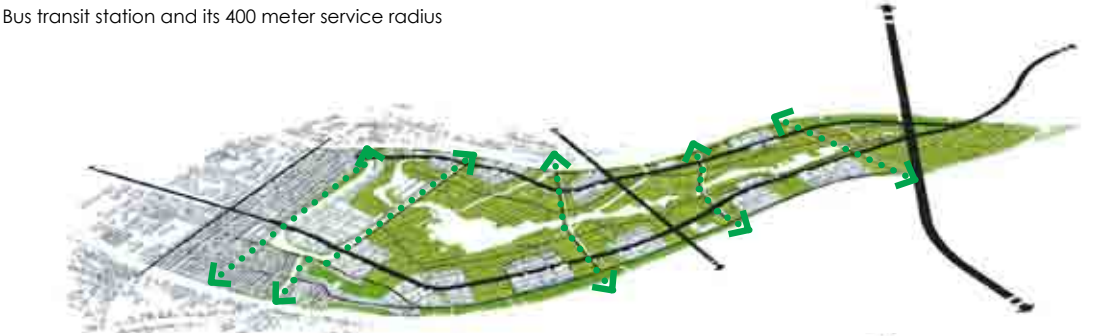
As the result, this design provided an attractive living and working environment with safety, environmental quality, spatial quality and economic value.

Statistic

Area: 300 ha
Foot print area: 60 ha
Farm land area: 150 ha
Orchard area: 45 ha
Water surface area: 45 ha
Floodable area: 133 ha
Urban unit: 12
Average area: 5-6ha
Average population per unit: 2000-3000 inhabitants
Population: 12,000-18,000 inhabitants

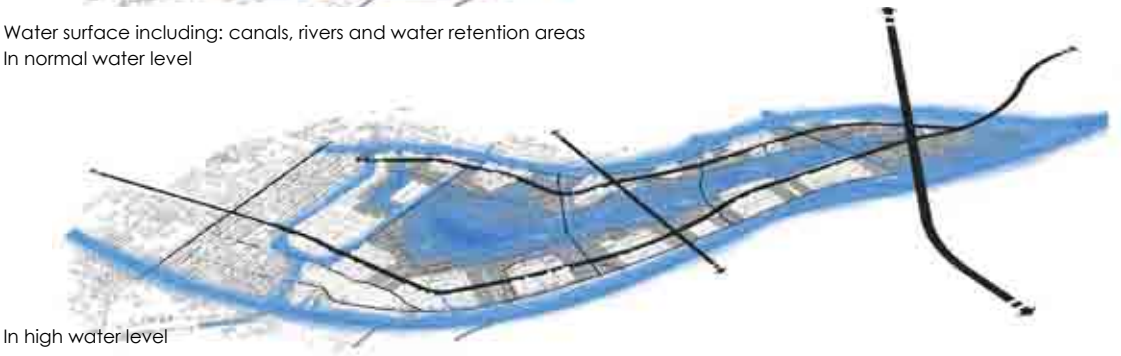


Bus transit station and its 400 meter service radius



City's green structure

Water surface including: canals, rivers and water retention areas
In normal water level



In high water level

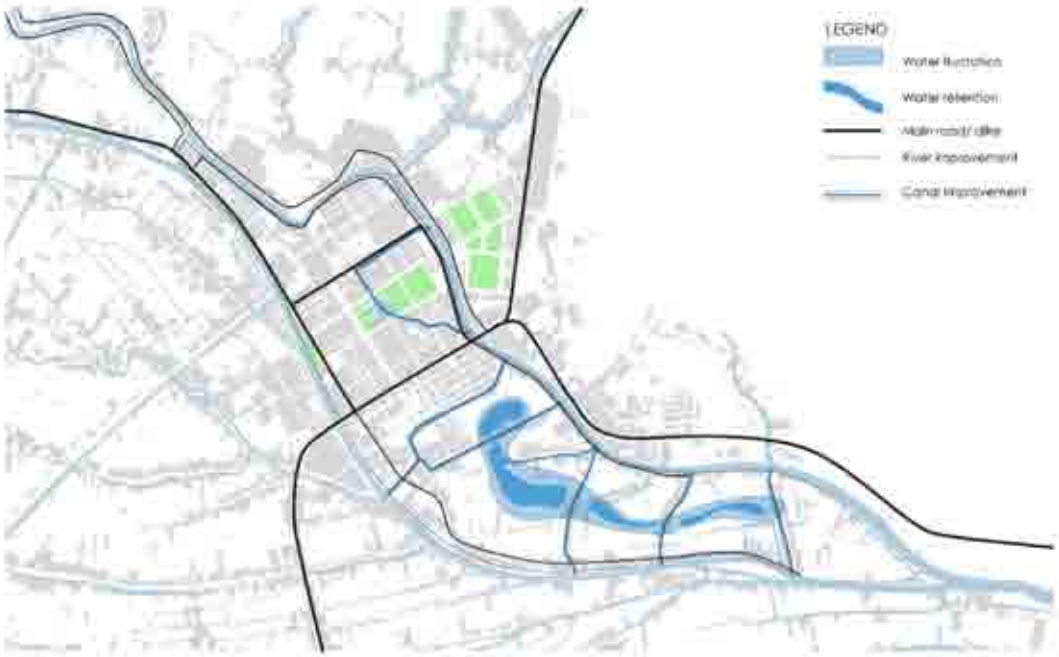
Cao Lanh City in 2050...

3. Phasing

Phase 1:

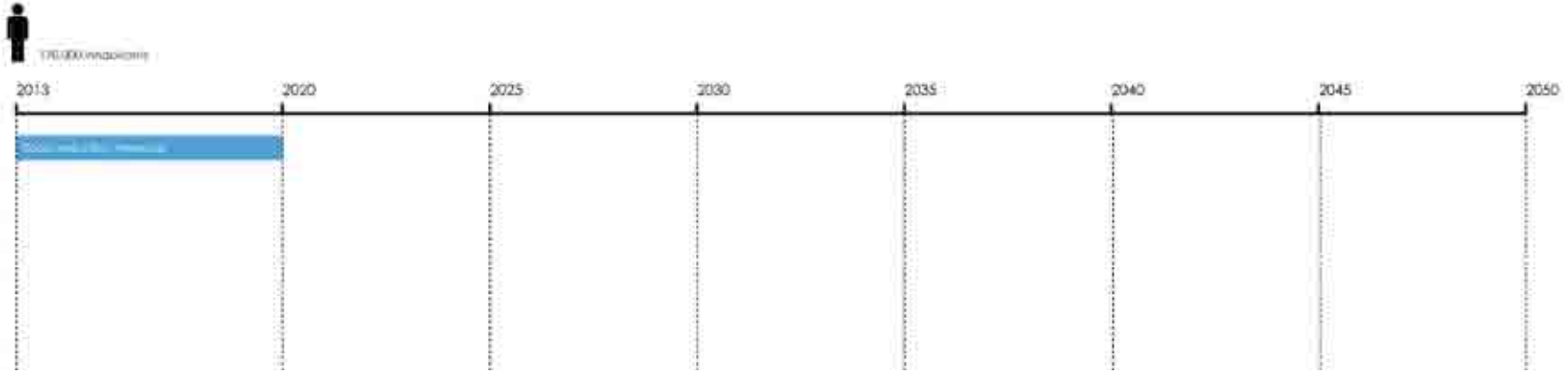
Unplanned and informal settlements are encroaching into existing riparian zones which degrade the water quality, increase susceptibility to flooding as well as barrier the access to the river. In the phase 1, these settlements will be removed and leave space for river improvement. Besides, there will be more rooms for floodwater by accepting the overflow of floodwater into the in-between area in the rainy season. Canals will be dredged to ensure the flow of water discharge.

Stakeholders: Government, local residents



Cao Lanh river in current situation
Source: www.google images.com

Cao Lanh river with parkland

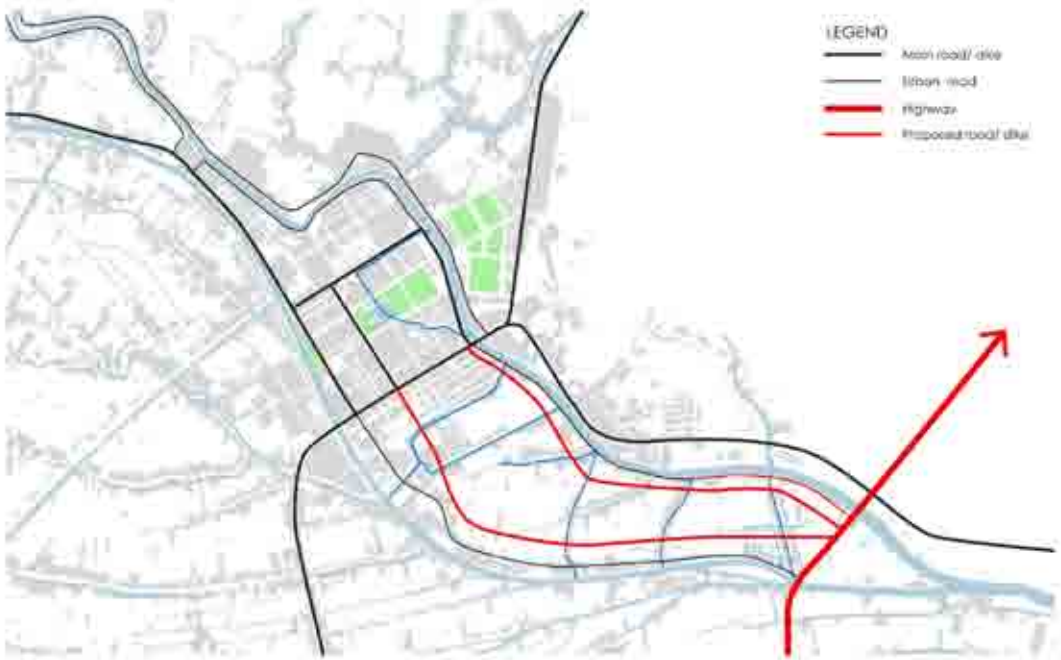


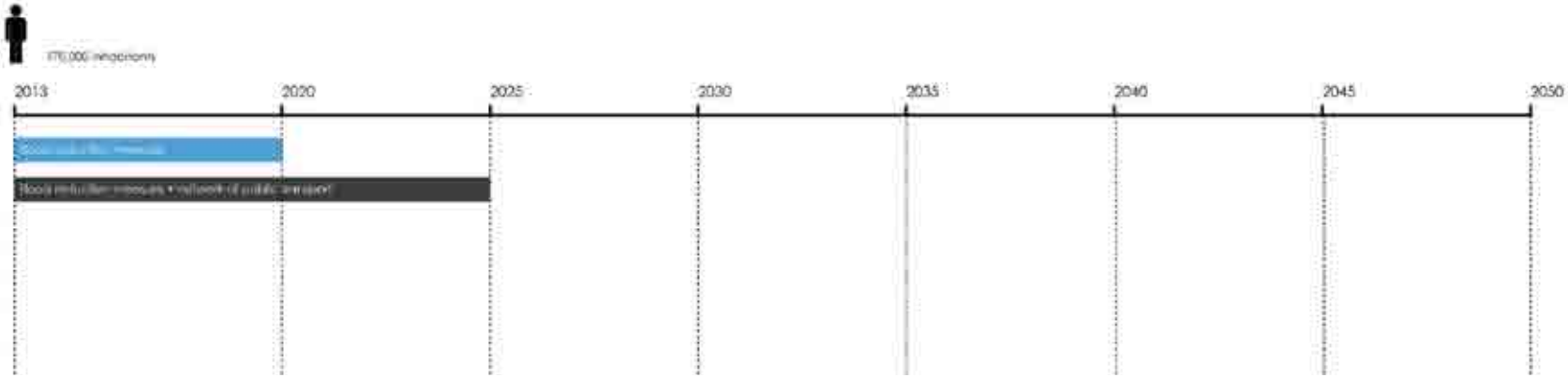
Phase 2:

As the new highway to Ho Chi Minh will be soon introduced by 2020, Cao Lanh City is now developing southwards. However, the current dikes in District 3 are not continuous and high enough to ensure safe conditions in the future.

In Phase 2 of this project, two roads will be built up starting from main roads of current city center to the new proposed highway. These roads will support for the bus rapid transit lines and work as extra dikes to protect the district from flooding.

Stakeholders: Government, Transport department, transit agencies



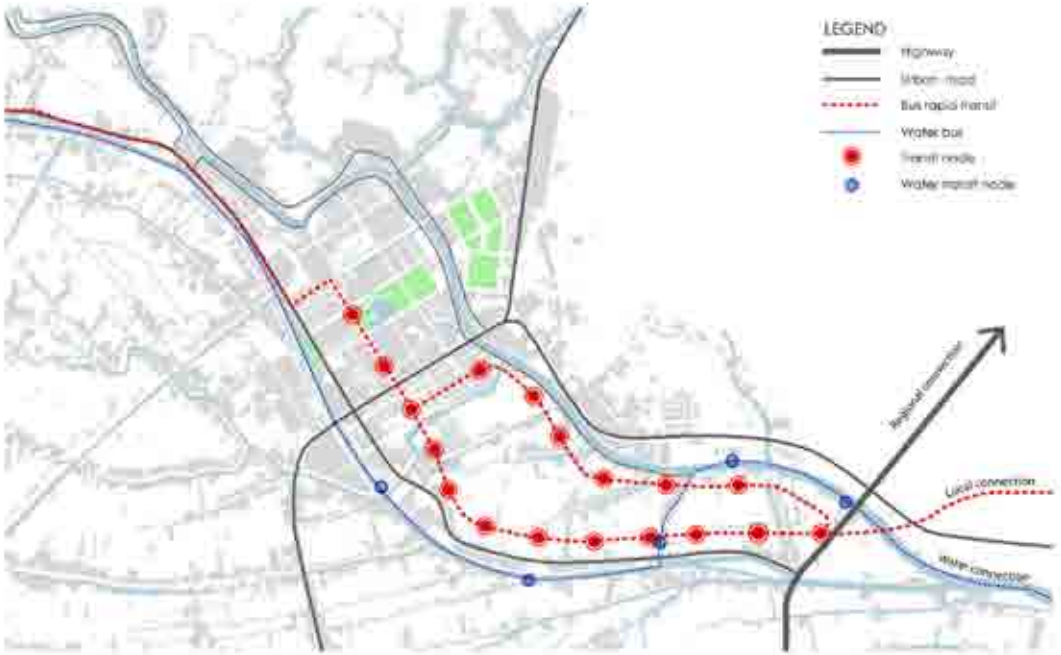


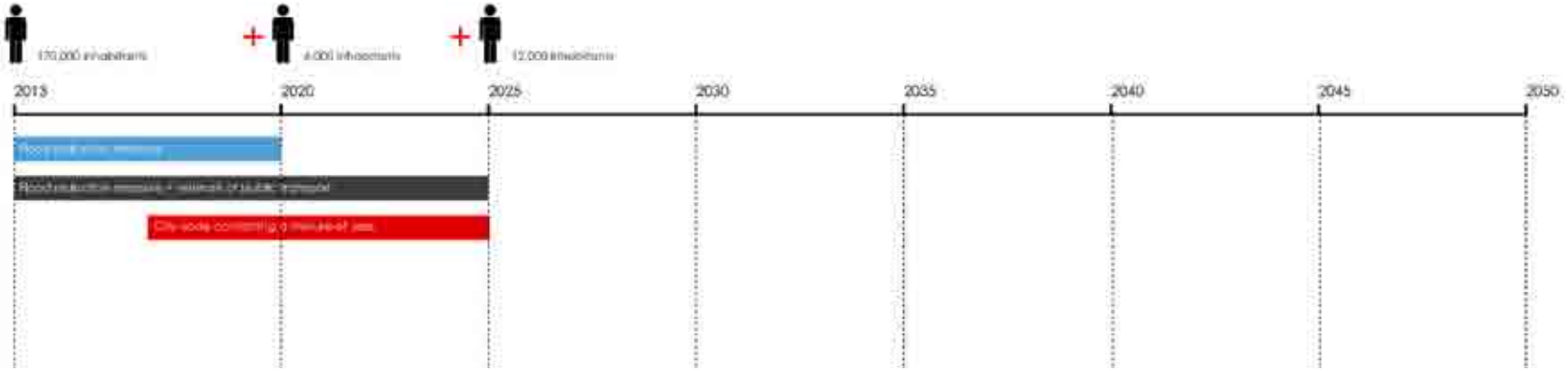
City Structure Plan

Phase 3:
As the result of water and road infrastructure upgrade, bus rapid transit together with water bus system will be introduced. Areas surround transit stations will become new urban nodes with a mixture of uses: commercial center, agricultural center, offices, residential and other civic uses.
Stakeholders: Government, transit agencies, private developers, small business owners, local residents

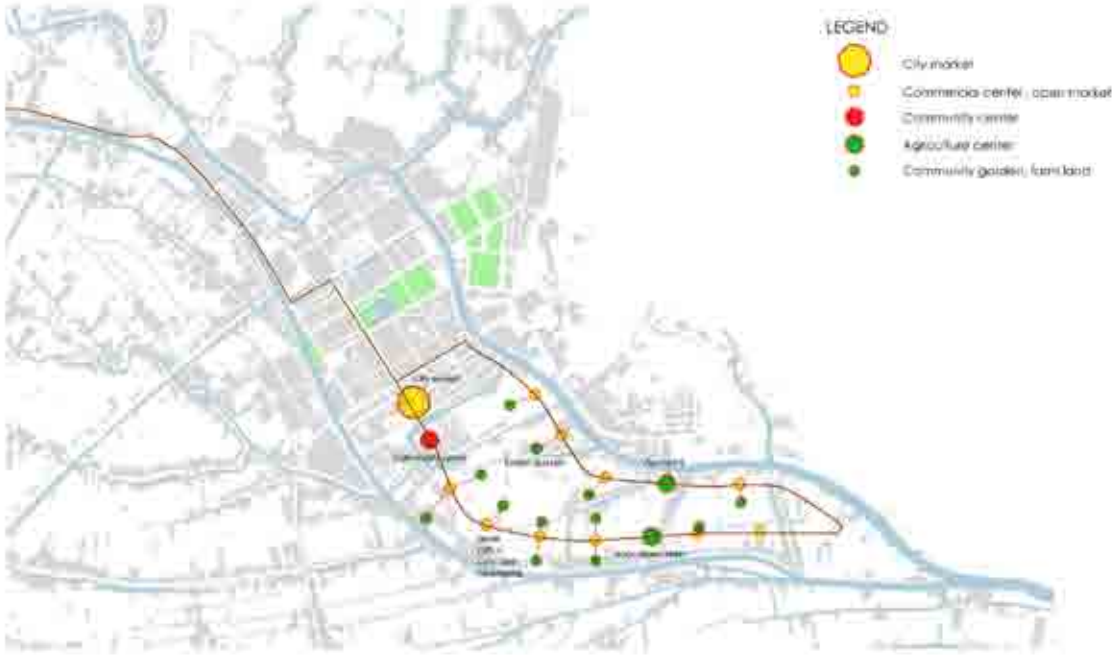
Cao Lanh main street in current situation
Source: www.google images.com

Cao Lanh main street with transit line and bus stop



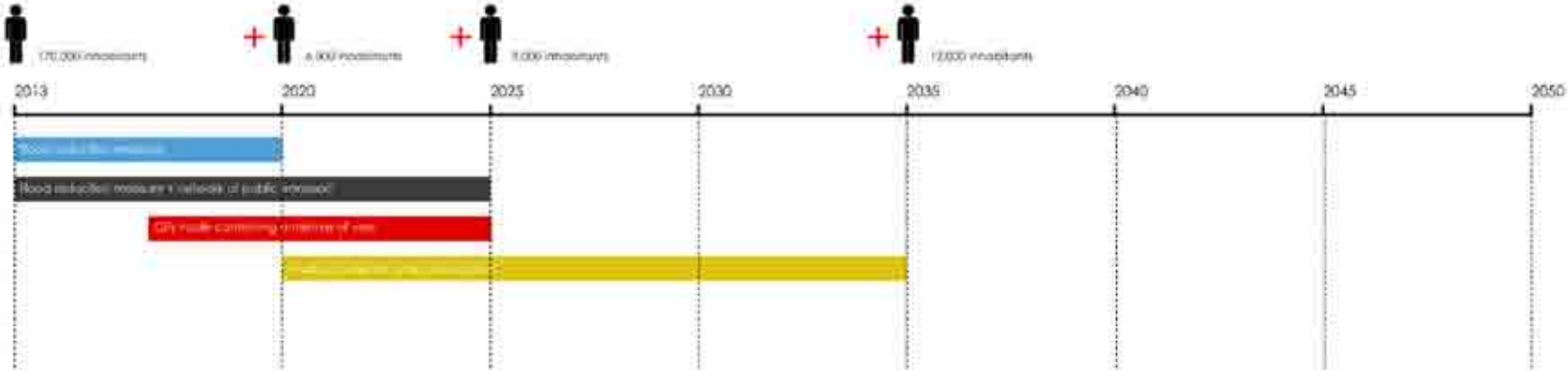


Phase 4:
Compact TOD neighborhoods offer spaces and support for other economic activities, especially agriculture which is the basic economic sector in Mekong Delta. They will be the areas to collect agricultural products from adjacent orchards and farmlands and trade at the neighborhood and city markets or export to other cities and region.
Also in this phase, an agro-park and agricultural center will be introduced.
Stakeholders: Government, private developers, small business owners, local residents




Market square
Source: www.google images.com

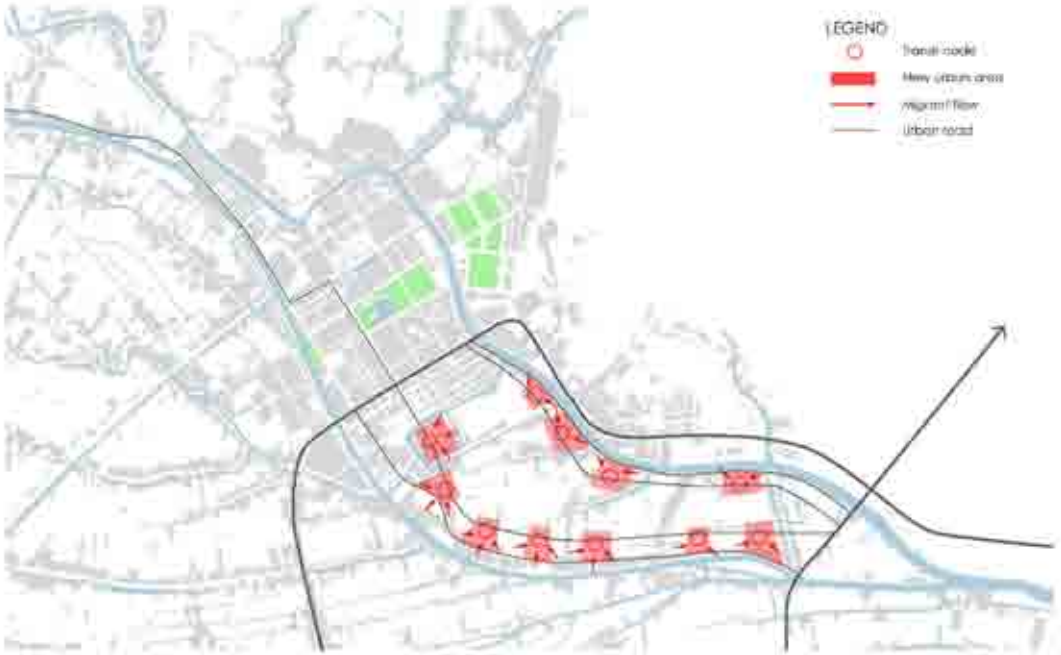

Wetland park

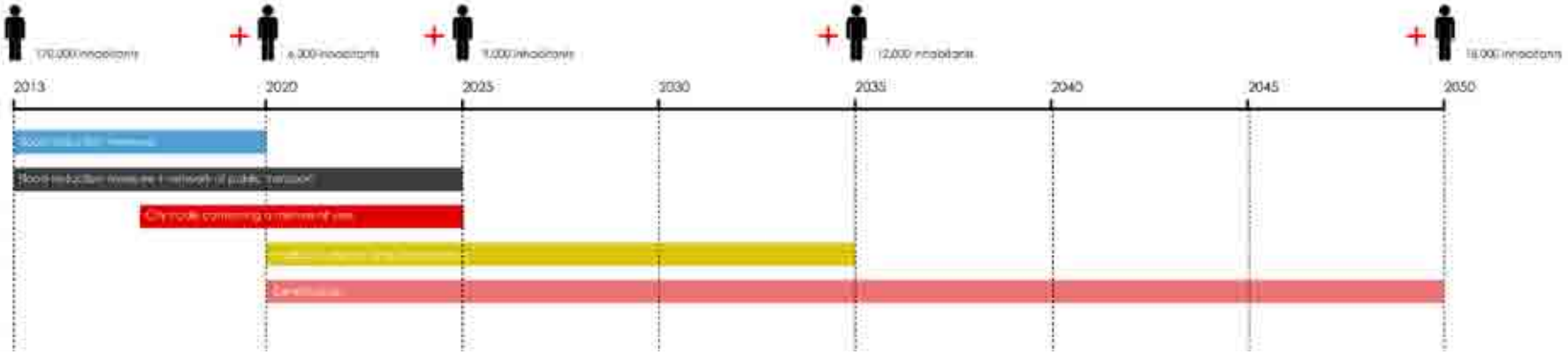


City Structure Plan

Phase 5:
Affordable housing, jobs and high living quality are three main drivers attracting residents to inhabit. There will be a great increase of population in District 3 since the previous 4 phases are introduced, for example: local residents who used to live in informal settlements along the river or live in inundation areas, residents from other cities and town who are attracted by a numerous offers of jobs, by green environments and convenient connections…etc.
Stakeholders: Local residents, regional residents

Community garden





Phase 6:
These neighborhoods will create value through a productive landscape with paddy fields, orchards, community gardens, fish ponds, flower and vegetable fields. This productive landscape combines with river parkland and public spaces inside the neighborhood will form a new structure of the city.
Stakeholders: Private developers, small business owners, neighborhood organization, local residents


Water lily
(Bong Sung)


Neptunia Oleracea
Lour (Rau Dut)


Sesbania sesban
(Bong Dien Dien)


Trapa
(Cu Au)


Eichhornia crassipes Solms
(Luc Binh)

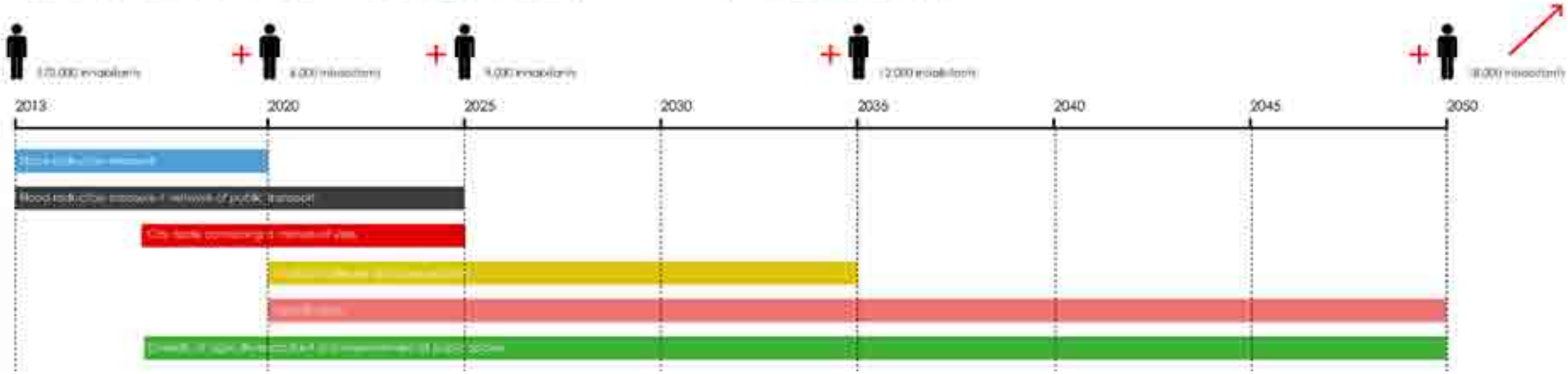

Allium ramosum
(He)


Cirrhinus caudimaculatus
(Ca Linh)


Anabas testudineus
(Ca Ro)


Synbranchidae
(Luon)

Diverse species
Source: www.google images.com



4. Design of Water and Energy system

Water system

One of the main current environmental issues in Cao Lanh City and Mekong Delta links to the water usage, particularly regarding availability of water for agriculture and lives. Water quality of the Mekong is affected by many factors as industrial pollution, urban waste disposal and sewage, use of fertilizers and pesticides, soil erosion, flood, acid sulphate and salt water intrusion (WISDOM, 2010). Nowadays, inhabitants use water from rainwater, groundwater and directly from river. In rural areas, only a minority of population is supplied by fresh water.

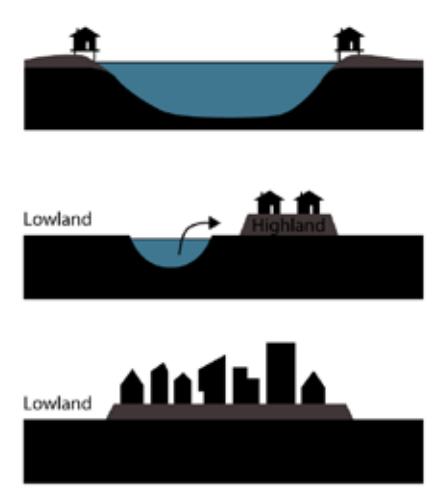
As the result, there is an increasing need of fresh water storage and water purification system that can help to provide fresh water in the dry season, clean water and drainage floodwater in the rainy season.

The designed water system includes:
_ Building scale: Building water storage, rain water harvesting and recycle of grey water.
Annual rainfall in Mekong Delta is approximately 2000mm. As rainy season lasts from May to November, it is needed to store water from November to April. If every day each Vietnamese person needs 5l rainwater for drinking and cooking, annual rainwater use for a four people household in Mekong Delta is:
5L/day/person x 4person/household x 365days/year = 7.300L/household/year
Therefore, a 3.700L water storage box is enough for each household in dry season. Public water uses requires bigger water storages, such as: lake, water retention…etc. (Mai, 2009)
_ Urban design: Bio-swale and green surface water runoff, permeable paving.These elements are designed to remove silt and pollution from surface runoff water in urban areas.
_ Landscape: Water reuse for agriculture, water purification through various natural systems, wetland as rainwater and floodwater storage.

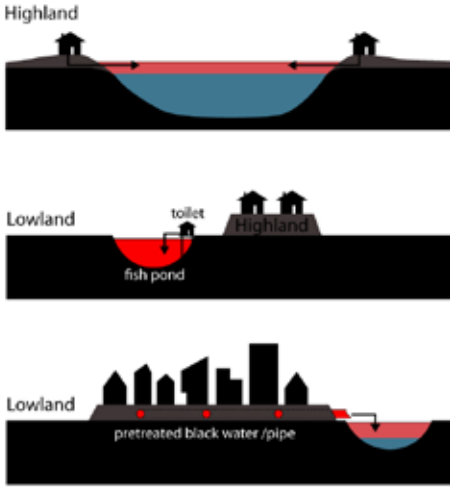
Wetland is the main feature of the landscape water system. Beneath the wetland, an efficient water treatment system ensures reclaimed water and circulating water purification quality, and creates balanced ecosystem above ground with flowers, trees, aquatic plants, fish… Moreover, this areas is designed as a wetland park that attracts tourists by its beautiful landscape and natural education.

Energy system

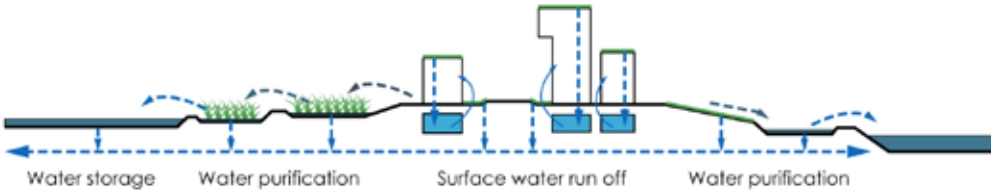
New TOD neighborhoods can use solar energy in addition to city electric system. Solar panels will be set up on roof of buildings, in orchards or on streets. Although solar panels are costly than other electric systems, in the long term, the output is much more efficient and sustainable.



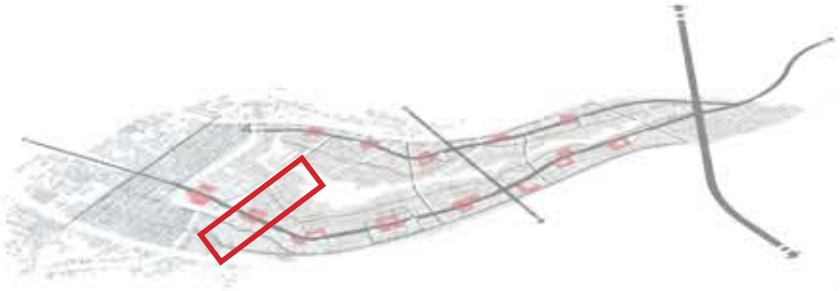
Types of urban settlement



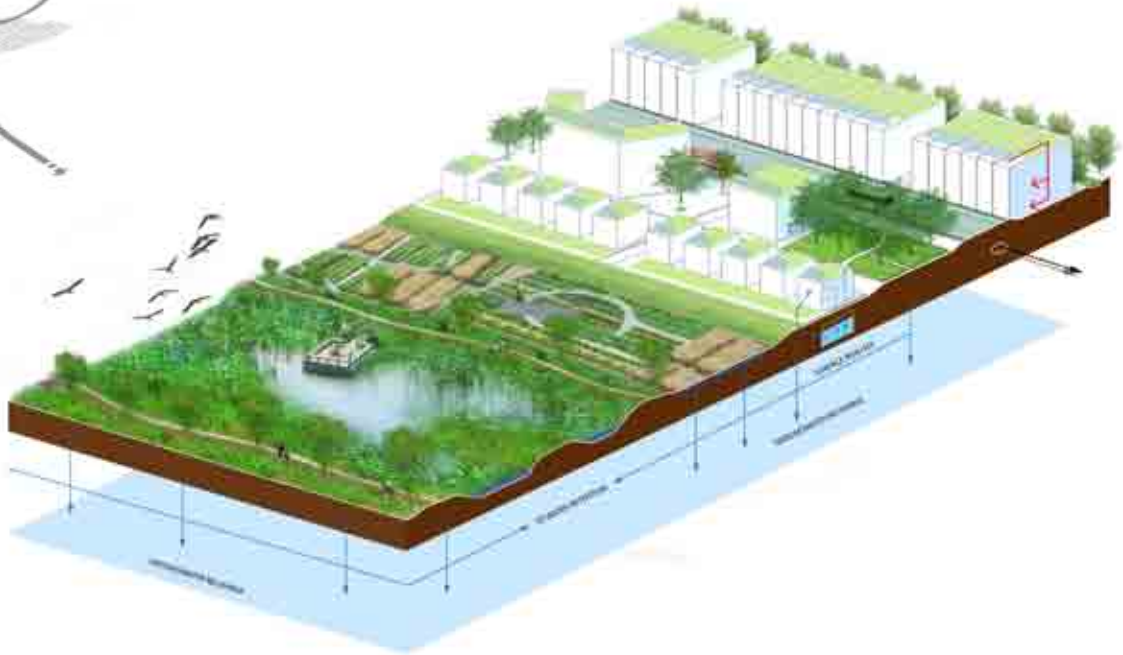
Wastewater treatment



Water system scheme for designed area



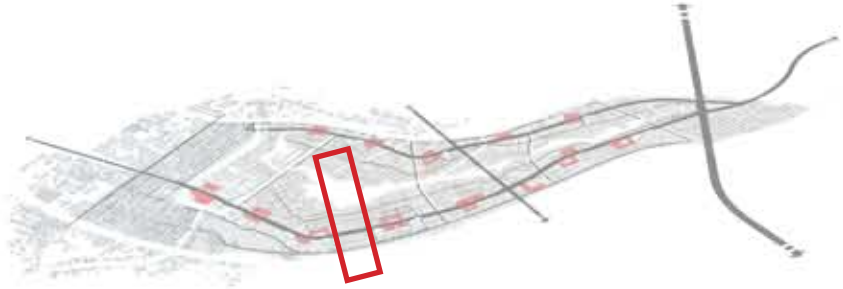
Map shown designed location



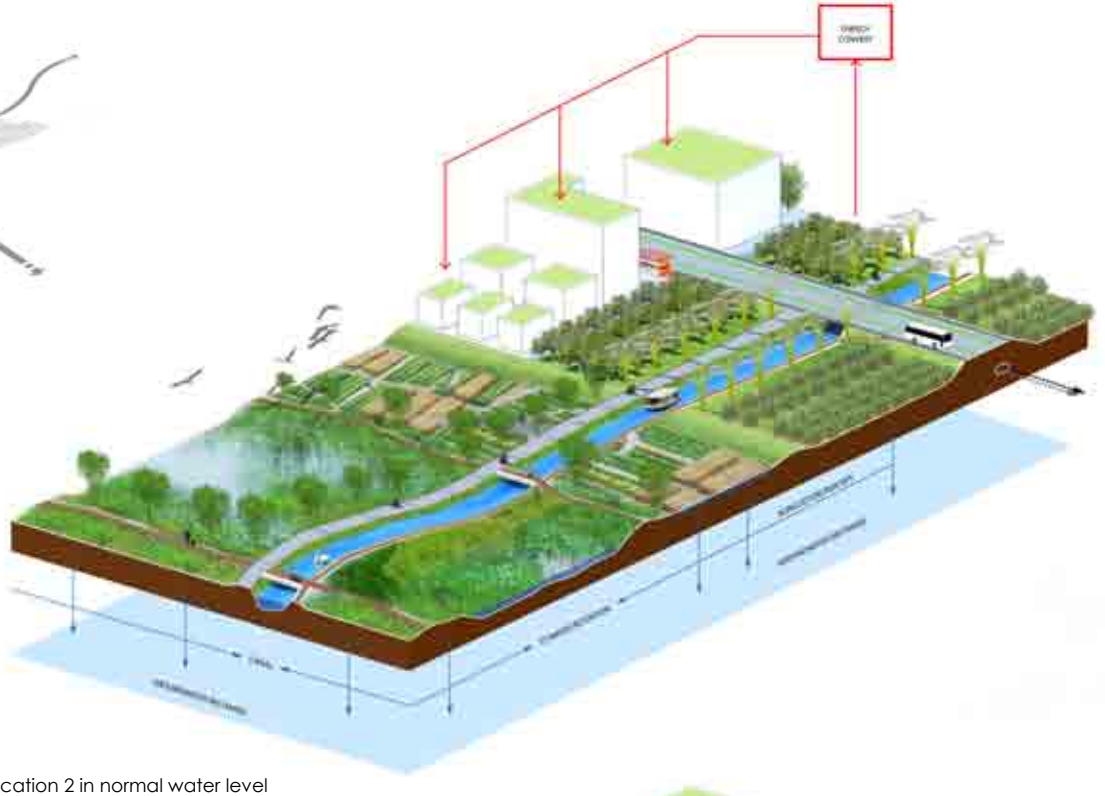
Location 1 in normal water level

Location 1 in extreme water level

City Structure Plan



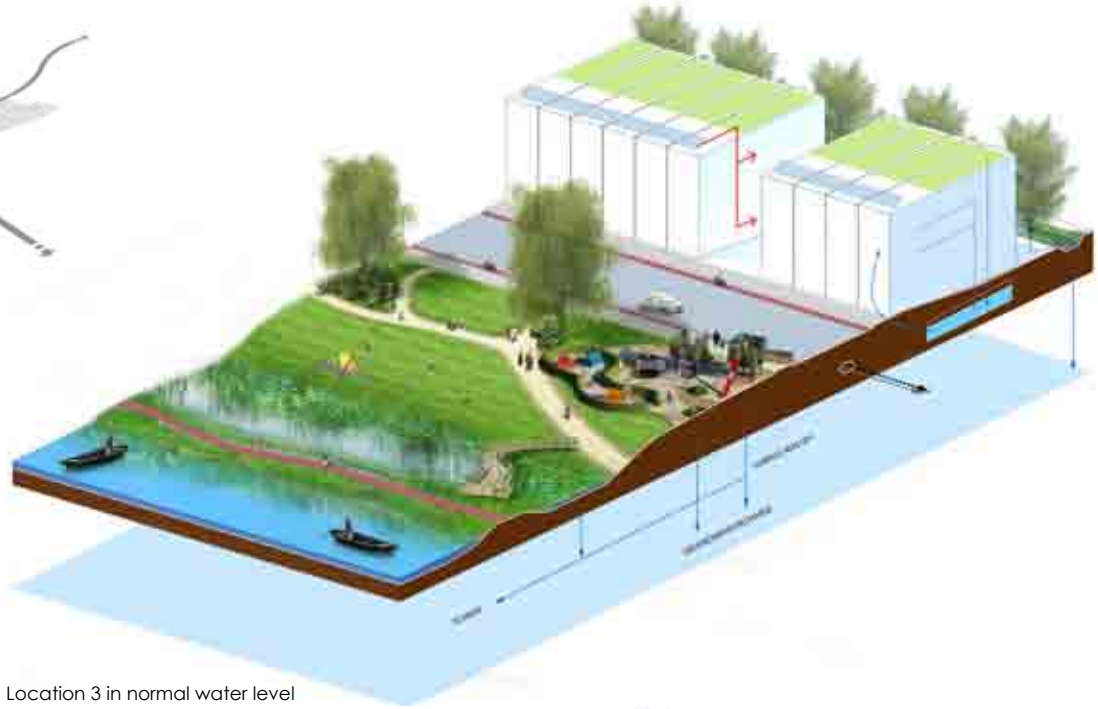
Map shown designed location



Location 2 in normal water level

Location 2 in extreme water level

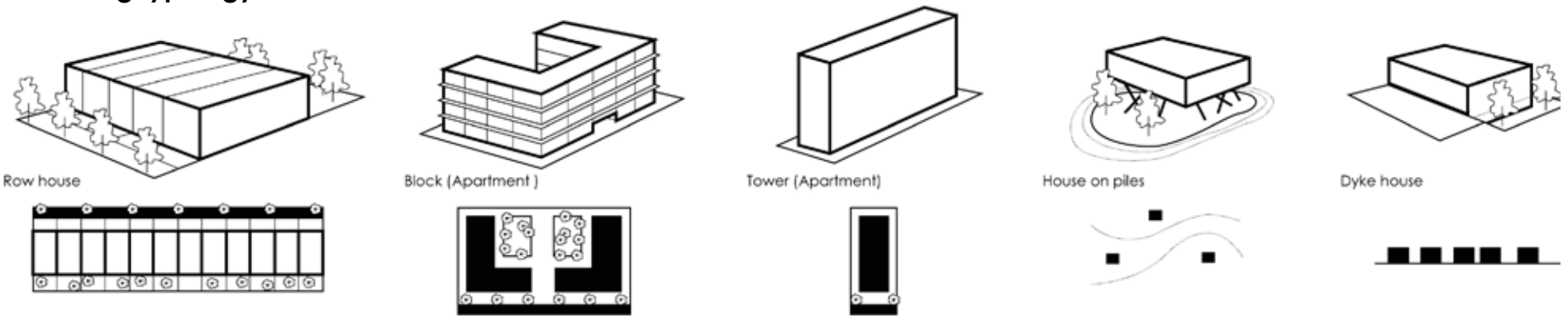
Map shown designed location



Location 3 in normal water level

Location 3 in extreme water level

5. Housing typology



House on piles
Source: Based on Oxbow Marina Style properties of Levee Urbanism
www.deltanationalpark.org


Cao Lanh City in 2020...

City Structure Plan

Cao Lanh City in 2050...


Cao Lanh City in 2080...2100...

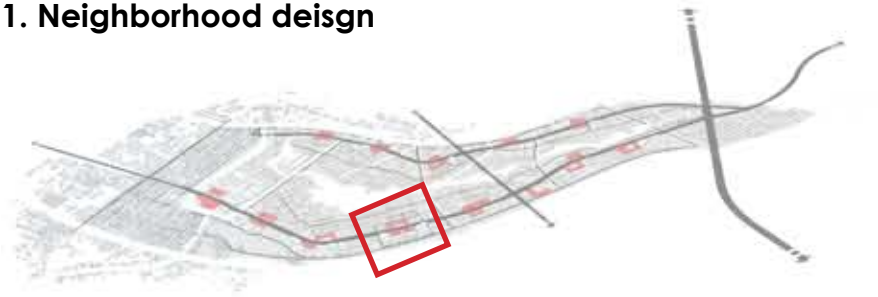
PHOTO BY TANNOBI

Chapter VIII. Urban design

Neighborhood design
Detailed design

Urban Design

1. Neighborhood deisgn



Map shown designed location

A chosen TOD neighborhood is designed with a transit station, surrounded by relatively high-density development with progressively lower-density development spreading outward from the center.

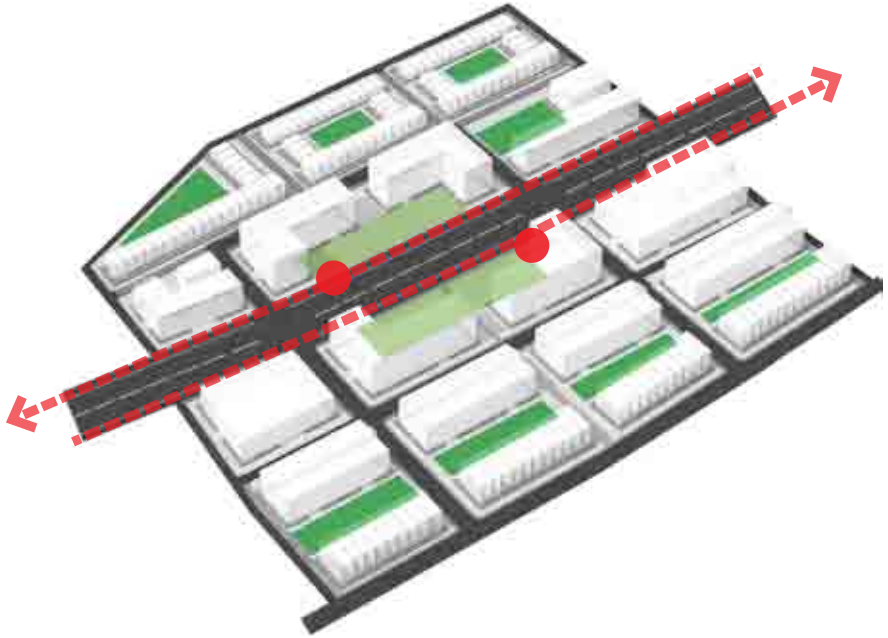
Statistic

Area: 570,000 m2 (5.7 ha)
Foot print area: 259,600 m2 (45.6%)
Open space area: 8,000 m2
Floodable area: 3,200 m2
Population: 2,100 inhabitants

Neighborhood master plan

Bird's eye view

Urban Design



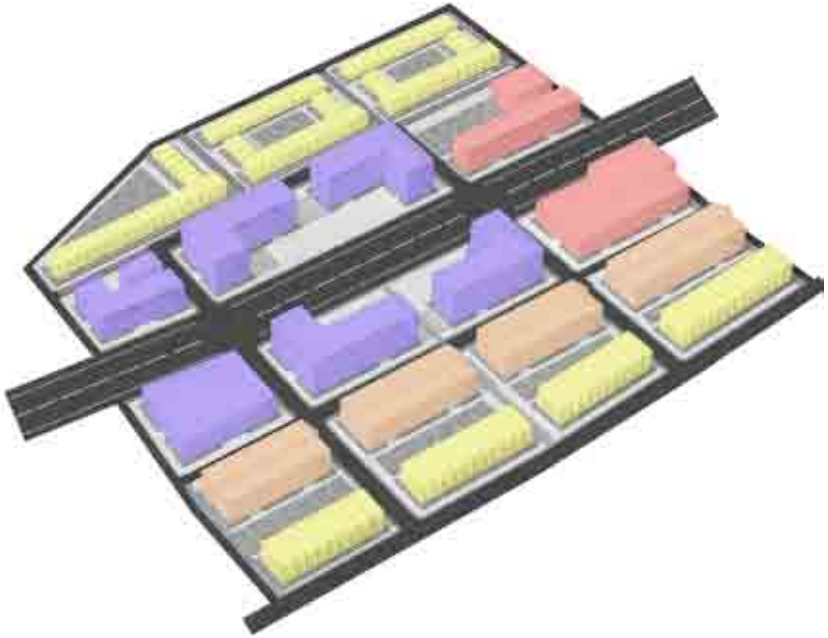
Green space and transit line

High quality bus stop

Park, kindergarten

Community garden

Market square



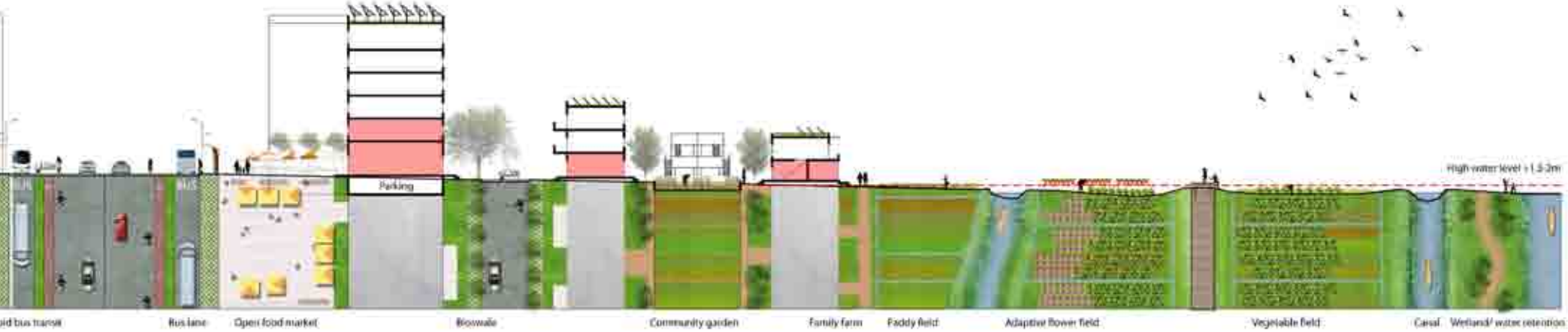
Program

Private houses
2-4 floors

Retails, offices
5-7 floors

Afforable apartments
5-7 floors

Schools and Culture
center
3-5 floor



Neighborhood section

Urban Design

Waterfront masterplan

2. Detailed design

This project proposes a new living philosophy toward water. Floodplains and floodable areas are returned to nature, therefore, people do not need to fight against flood. Conversely, people learn how to live with flood, appreciate its benefits and enjoy the landscape created by flexible floodwater level.

The designed area used to be polluted by informal settlements along Cao Lanh River. By removing these settlements, there are spaces for river improvement. The new waterfront is designed with continuous water's edge promenade and a series of public spaces and water activities. The existing concrete floodwall is replaced by a more habitat friendly riverbank that allows native species to grow. This area works as a flood protection buffer zone that creates more room for floodwater and accelerates storm water drainage in the rainy season. Moreover, the terrace design of this area alleviates the height difference between the city and the river, reconnecting people to the waterfront.

LEGEND

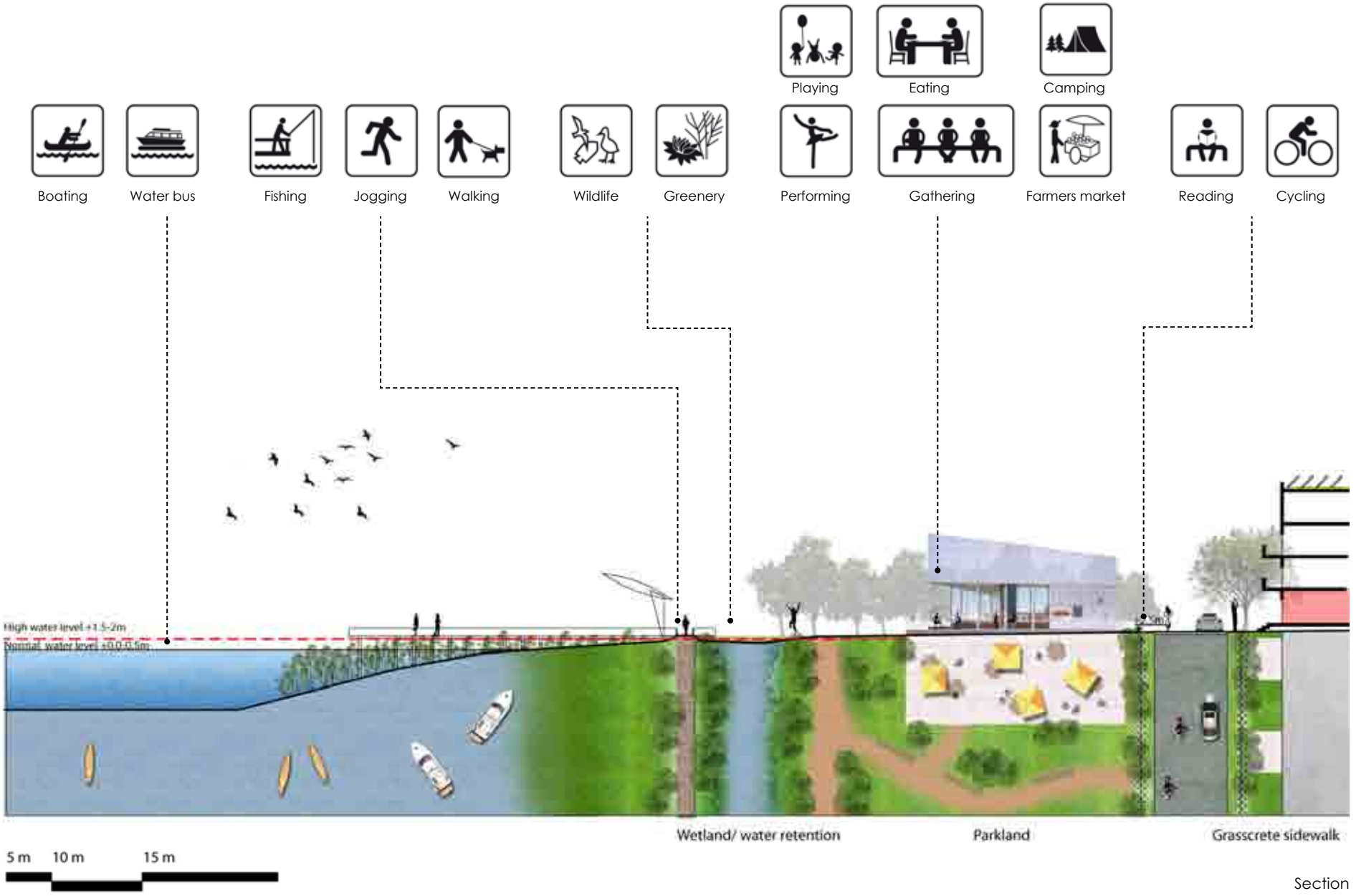
1 Waterfront restaurant
2 Water-bus stop
3 Designed staying area
4 Water retention
5 Wooden Platform

Bird's eye view

Normal water level +0.5m

High water level +1.5m

Extreme water level +2.0m


Playing
Eating
Camping
Boating
Water bus
Fishing
Jogging
Walking
Wildlife
Greenery
Performing
Gathering
Farmers market
Reading
Cycling
High water level +1.5-2m
Normal water level +0.0-0.5m
Wetland/ water retention
Parkland
Grasscrete sidewalk
5 m
10 m
15 m

Section

Room for water and water recreation

Promotion of cyclist and pedestrians

Conclusion and Reflection

Conclusion

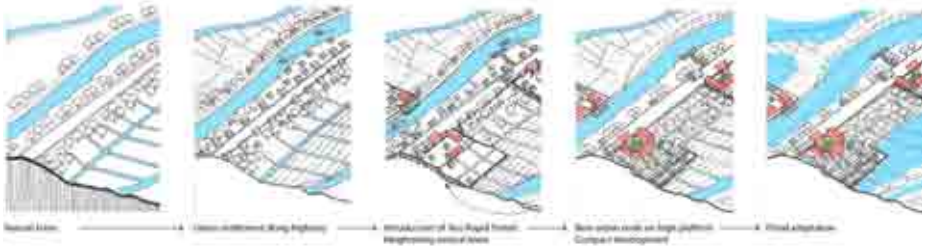
"Flood adaptive cities" is no longer a new topic for deltas in all over the world, especially in the perspective of extreme climate change. However, the integration of different approaches in water management, spatial planning and urban design seems to be new and provides researchers a wide range of opportunities to investigate its solutions in different contexts.

In this graduation project, the case study of Mekong Delta is chosen because of its complex system including nature system and urban system and its great challenges that are going to be experienced in the future. The projects aimed at answering a research question:
How a new form of urban development for the Mekong delta can provide a water safety condition, preserve environment, improve the spatial quality and meanwhile provide economic value for its inhabitants?

It is not a difficult question to answer if one can just copy the more or less successful approaches from the Dutch Delta, Mississippi Delta or other developed deltas. However, without understanding its context, the end results can be wrong or unfeasible. Therefore, as the first step, the project researched in the complex system of Mekong delta cities. Research question was step by step answered through triple 3 layer approach and different layer analysis through different scales. These researches provided a clear understanding in: how nature layer, infrastructure layer and urban layer proceeded and integrated throughout 300 year history of Mekong Delta; what current image of development in Mekong Delta is and why water should be maintained for future development. Equipped with this knowledge, it was possible to create a new strategy for Mekong Delta and explore new form of urban development in order to react flexible to uncertain future changes.

As defined in the chapter of "Problem statement", there are two main problems that Mekong Delta have to deal with nowadays, namely climate change and urbanization. In order to deal with these two problems in their extreme situations, the project proposed to apply the theory of Transit Oriented Development (TOD) in combination of water management. The result is compact urban areas in regional scale or compact neighbourhood in city scale that are protected on high levees, connected by public transports, surrounded by natural delta landscape and provided with diverse economic values. Again, TOD theory is not anything new. It has been used widely since 1990's in the North America and now is expanding to different continents. However, the innovative portion of this project is to integrate TOD with water management and then test this idea in different scenarios of Mekong Delta, a developing region in Vietnam.

Currently, much of the research on TOD has focused on the developed countries, particularly the United States. The opportunities and challenges for such policies in the developing countries were initially examined in metropolitan area in Mexico, China and India. Development in Mekong Delta seems to be difficult to compare with these metropolises' development because of its median growth rate, its natural threaten, its rural environment…etc. Nevertheless, TOD can be used as a form of urban development and an orientation towards sustainable development. In big cities, such as: Can Tho City, Vinh Long City, Cao Lanh City and Long Xuyen City, TOD strategy can solve the existing problems of over-populated areas, low living conditions and natural landscape loss. In suburban and rural areas, TOD strategy can stop unintended urban sprawl by adding compact urban nodes with commercial activities, agricultural services, affordable housing…etc.



Regional development strategy

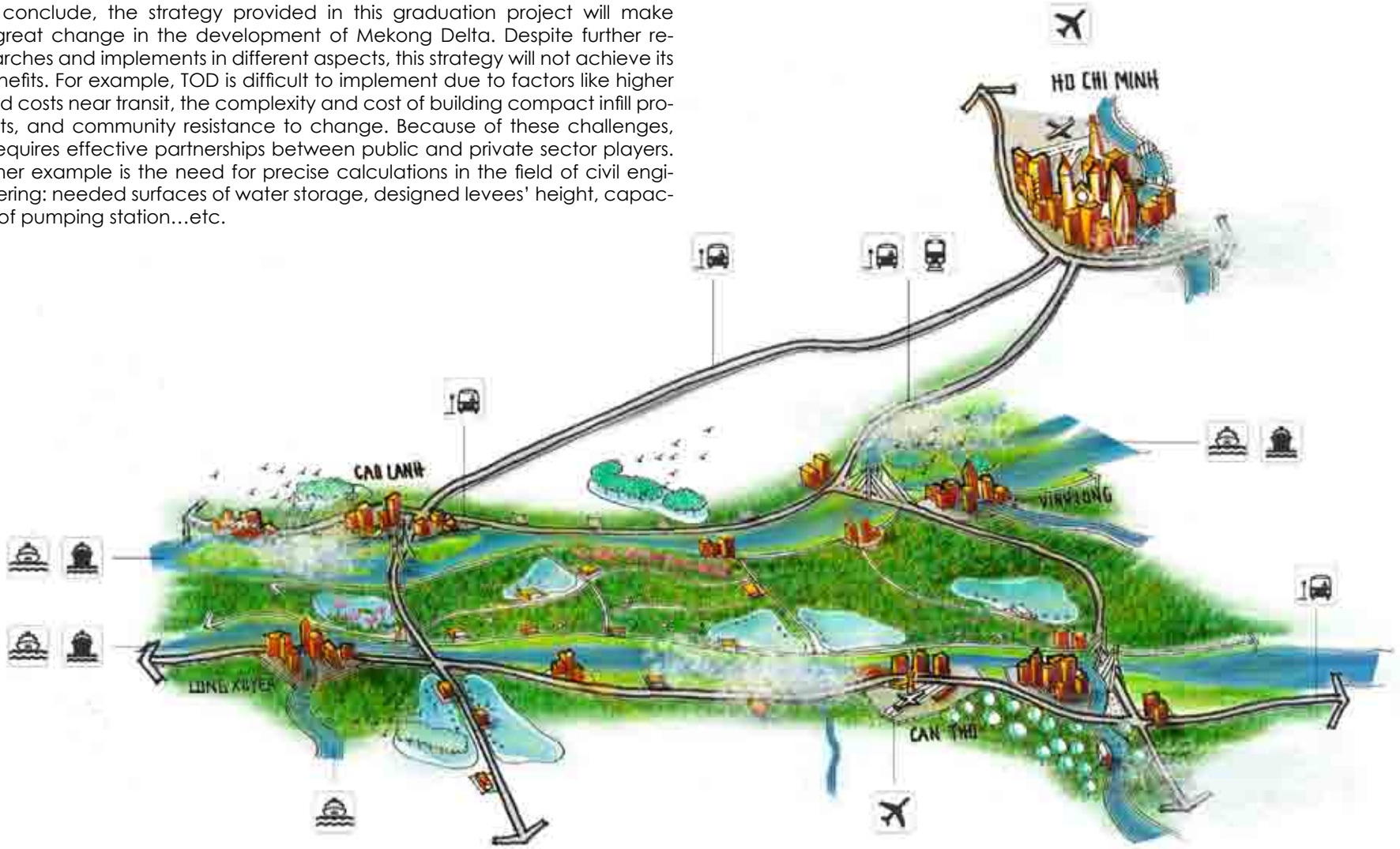
Although, Vietnamese government in recent years has built many residential clusters and encouraged people to migrate to safer locations in order to avoid flood damages, this strategy received little attentions of the farmers who do not want to leave their farms. The integration of TOD and water management is an alternative strategy, in which, people are attracted by these safe clusters because of their job offers and easy connections to their workplaces. Moreover, this strategy not only provides a new form of urban development, but also ensures that urban development is done in a way that both respects the unique delta landscape and works within the "living with flood" idea.

In the designing part, the project proposed a master plan of District 3 in Cao Lanh City and an example of one TOD neighborhood. Instead of removing all the rural parts of the area as the government's proposal, the project tried to preserve and strengthen its delta landscape with paddy fields, floodplains and waterways and create mixed urban-rural environment. As the result, this design provided an attractive living and working environment with safety, environmental quality, spatial quality and economic value.

It can be argued that this plan is too costly to implement in full but it helps to form the basis for future developments in both regional and city scale. Furthermore, investment in TOD is relatively inexpensive considering the alternative, sprawl. Sprawl drives up costs of development because it requires the expansion

of public infrastructure such as roads, water lines, electrical services and sewer lines. Water management costs also rise from increased protected areas that result from additional urban settlements. Therefore, the long-term benefits of this strategy far overshadow its initial costs. Main research question is answered.

To conclude, the strategy provided in this graduation project will make a great change in the development of Mekong Delta. Despite further researches and implements in different aspects, this strategy will not achieve its benefits. For example, TOD is difficult to implement due to factors like higher land costs near transit, the complexity and cost of building compact infill projects, and community resistance to change. Because of these challenges, it requires effective partnerships between public and private sector players. Other example is the need for precise calculations in the field of civil engineering: needed surfaces of water storage, designed levees' height, capacity of pumping station…etc.



Regional development in Mekong Delta and its public transport system until 2050

Conclusion and Reflection

Reflection

The relationship between research and design

Reviewing this project, it can be concluded that many researches had been done before the final strategy and design was proposed. These researches aimed at giving a clear understanding of the complex system of Mekong delta cities including nature system and urban system. As the result, they determined the precise assignment for design which is safety, environmental quality, spatial quality and economic value. Moreover, based on different theories and practices, such as Compact City, Transit Oriented Development, "Design with Nature" and "Room for the River", researches provided a wide range of possibilities for design.

In the design phase, a lot of interactions between research and design were implemented. Testing and evaluating design ideas was repeated several times in order to maximize the feasibility and quality of the outcome.

The theme of the studio and methods

This graduation project focuses on two main themes, namely: climate change and urban development in Mekong Delta region. These are also important themes in the Delta Intervention Studio:

'Due to a changing climate and changing insights concerning sustainable relations between cities and water-landscapes, new interventions will be needed to create a new urban delta-landscape'.
'Delta Interventions therefore is an inter-disciplinary studio which, on a wide variety of scales, deals with the necessary transformation of the delta'.
'Within this scope of the delta, students are free to follow their fascination and choose their own assignment which (due to their discipline) can vary from buildings, constructions, public works, to urban areas, landscapes and regions'.

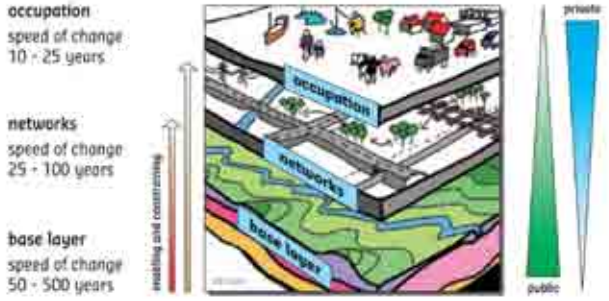
Delta Interventions Studio 2013

The research and design methods used in Delta Intervention Studio are:
- Triple layer analyses
- Case study analyses
- Research by design

The studio organized studio meeting every week during the first semester. As the starting point, the studio introduced the use of triple three layer analyses. This method gave students an insight of delta system formed by the interaction between three different layers: natural layer, infrastructure layer and occupation/ urban layers. Especially in the research of Mekong Delta, as the lack of understanding about this interaction, different disciplines such as architects, urban planner, urban designers, landscape designers and civil engineering are working separately and inefficiently. Therefore, the "triple layer analyses" was used intensively in this project. Later, researches from triple layer analyses and multiple case studies have provided generic knowledge for Research by Design. In this method, scenario study, mapping and modeling are techniques were used to reinforce the final design.

The other method of this project is working through scales, in a way that researches and designs in different scales interconnects. There are five main scales in this project, including: regional/ delta scale, city scale, district scale, neighborhood scale, waterfront scale. The researches on greater scales adds knowledge for designing in the smaller scales and designing in the smaller scales answers the research questions and reflects the outcome for greater scales.

Apart from the used methods, Delta Interventions Studio organized several lectures from different disciplines introducing their different techniques in dealing with climate change and changing relation between cities and water-landscapes. I was inspired by lectures given by Ties Rijcken on the Dutch Delta system, by Han Meyer on the development of settlements in relation to water safety structures, by Jan vd voort Attika architecten on building in/ with/ near water, by PHD student Dieu Pham about Mekong Delta,… etc. However, since the second semester, most of lectures were in Dutch. It was a pity that international students could not join in.



Layer approach for planning of delta development
Source: Delta Interventions Studio

The relationship between the project and wider social context

From a wider perspective, Mekong Delta is an attractive area with its unique natural resources that favors agricultural production and other agriculture-based economic sectors. The historical development of Mekong Delta is not

similar as any other regions in Vietnam, but nowadays is experiencing the same problems of rapid urbanization process. Adding threats from climate change, finding a solid development for this region becomes a crucial target for Vietnamese government. This development has to involve different disciplines such as architects, urban planner, urban designers, landscape designers and civil engineering.

Taking it into account, the project proposed a new form of urban development in order to deal with climate change and rapid urbanization by combining the theory of Transit Oriented Development (TOD) and Design with Nature. This new form aims at providing inhabitants a safe and attractive living, working environment and guiding urban development to a way that both respects the unique delta landscape and works within the "living with flood" idea.

The social relevance of this project is that it changes human behavior towards water, in the context of Mekong Delta, is bringing back traditional ways of living with flood. Moreover, the idea of Transit Oriented Development provides a new way of living and working: from individual to collective environment. Sprawling, social segregation and poor living conditions will be replaced by compact urban areas with numerous economic activities, adequate living conditions and affordable housing for different levels of income.

The relationship between the project and wider academic context

From the academic world, although there already exists a large body of knowledge on the characteristics and functioning of many deltas, most of this information is of a mono-disciplinary. There is relatively little knowledge that enables an overview of delta management in which different disciplines would be integrated. Studying at TU Delft gave me a chance to research intensely in this field and thus, final design can visible the interaction between climate change, water management and urban development of Mekong Delta.

Although the outcome of this project is still conceptual, it can be seen as a first step towards sustainable development in Mekong Delta. The project might contribute for on-going projects such as "Mekong Delta Plan" "Towards a Mekong Delta Portal"… which are being done by the Dutch and Vietnamese experts.

Moreover, the strategy of integrating Transit Oriented Development with water management seems to be promising not only in Mekong Delta, but also other developing delta areas in the world. There are couples of reasons that make this strategy feasible:
_ Transit Oriented Development is a major solution to the growing problems of rapid urbanization in many developing countries, such as China, India…etc.
_ In the threat of floods, Compact development is important. It is not just thinking about transit or dense urban centre, but also as a tool to help create more safe urban form.
_ Integration of Transit Oriented Development and water management aims at preserving natural delta landscape and maintaining water in the development of delta cities.

A question is asked: *Is it possible to apply this strategy in the Dutch Delta , the best protected delta in the world??*

In the Netherlands, the concept of Transit Oriented Development is now implemented in the South Wing of the Randstad Holland. Although there is no universally accepted definition of TOD, common elements refer to compact, mixed-use land use developments located within easy walking distance around a nearby public transport stop or railway station. Furthermore, the policy of "Room for the River" did introduce the idea of "living with water" by giving more spaces for the river (2005). This idea has continued to develop in the Delta Program (2008) which aims at protecting the Netherlands from the effects of flooding and high water level. Thus, these ideas are not anything new in the Netherlands.

However, the project has introduced a new paradigm which combines Transit Oriented Development and water management. Working through five scales, the project proposed a regional development strategy for the Mekong Delta: how cities and towns in this region interconnect; how each city adapts to flood events and how inhabitants benefit socially and economically from this strategy. It showed a possible future of Mekong Delta in time of climate change and rapid urban urbanization.

As Dutch Delta has experienced several changes in spatial configuration whenever delta interventions changed, Dutch experts are searching for an innovative spatial strategy in combination with the Delta Program. Therefore, the outcome of this project might be an ideal example to experiment.

I would encourage myself to research more in order to realize this idea of "Flood Adaptive Cities" not only in the context of Mekong Delta, but also in comparison with other deltas in the world.

Appendix

1. Literature review

Urbanizing delta areas
Towards Adaptive Delta Cities to Rapid Changing Environment

Abstract – Deltas are the magnetic areas to inhabit for half of the world's population and half of the world's urbanized areas because of rich natural resources and strong economic potentials for urban development (UN-Habitat, 2006). However, deltas are also some of the most highly stressed areas in the world. As floods become more frequent, as salt water intrudes more aggressively and as water becomes scarce, these dangers put larger numbers of people at risk.
In Mekong delta region, for thousands years, people in the delta consider these dangers to be normal phenomenon and have generally adapted their lives to their presence. Thus, countries such as China, Vietnam and Thailand are known as some of the world's biggest exporters of rice (USDA, 2011). As Meyer states 'the urbanized deltas can be considered as areas with a double complexity: the complexity of the deltas, as the meeting of rivers and sea, with the complexity of urban pattern, as result of economic, cultural and social life creates unique areas with a double complexity' (Meyer, 2009), delta cities in these regions are growing, undergoing continuous transformation and development to facilitate spaces for living, producing and recreation to meet the increasing needs of the population. However, rapid changing in climate, human interventions and the urbanization experienced throughout the last decades happens to highly pressure on the natural system and destabilize the availability of the natural resources. These consequences have led experts and policy makers to rethink their development strategies. At the same time, people all over the world are seeking practical, innovative, sustainable solutions to adapt to the impacts of climate change and facilitate sustainable development of delta cities.
The aim of this literature review is to investigate the 'double complexity' (Meyer, H. and Nijhuis, S., 2011) of the urban deltas in history and present situation. This is based upon the context of Mekong delta region in comparison with other deltas in the world. Therefore, the study will provide an answer for spatial planning and design on how the unique nature landscape of deltas can be repaired and combined with future urban pattern in respond to the rapid changing environment. The outcome of this paper will be applied as a theoretical framework for my master graduation project "Flood adaptive cities" in order to structure a sustainable solution for Mekong delta in Vietnam.

Key words – Urban deltas, urbanization, climate change, water management, interacting layers, sustainable strategies, Mekong delta region

1. Introduction

Deltas, where river flows into the sea, ocean, lake or reservoir, are the magnetic areas to inhabit for half of the world's population and also half of the world's urbanized areas (UN-Habitat, 2006) because of the most fertile land for agriculture and the most strategic locations for industrialization and urban development. Living close to the waterfront is now attracting a new stream of inhabitants, tourists, services and business to the cities. Since most of the large cities are located in delta region, an unintended side effect of the growth and the ensuing concentration of population is the increased challenge. The changing global climate recently puts additional pressure on this challenging situation.

How people deal with sea level rise, with erosion, with salinity intrusion, with subsidence and drought, and with the interactions between climate and urban areas?

Accommodating this question will involve the development of hydraulic infrastructure, such as: flood defenses, land reclamation, etc. In the Netherlands, answering this question is matter of survival. For a thousand year, the inhabitants built dikes to protect themselves and their properties against floods. After the devastating storm surge in 1953, Delta Works were created to keep the North Sea out of the estuaries and tidal inlets using dams, sluices and storm surge barriers (Delta program, 2012). The protection practices continue until the present day situation, however, the relation between Dutch people and water has changed: '*The main characteristics of the delta landscape in the past were the dynamic changes in water tables, the erratic and uncontrolled flooding and seepage and the vast, inaccessible stretches of low-lying land during winter inundations… This image has completely changed. Nowadays land is land, and water is water… Erratic changes in water tables are not allowed anymore*' (Nienhuis, 2008). Traditional approaches focus exclusively on the primary function: protection against flooding might not be efficient in the new challenge situation.

In the Mekong Delta region, people in the delta consider water dangers to be normal phenomenon and have generally adapted their lives to their presence. Thus, countries such as China, Vietnam and Thailand are known as some of the world's biggest exporters of rice (USDA, 2011). For hundred years, the water system including natural and manmade canals used for agriculture, irrigation, water transportation and military has been a foundation for other systems to be laid on (Shannon, 2009). However, in the last decades, as the rapid expansion of urban areas, road has replaced water to become the main economic, social and cultural life of the delta (Tayler, 2006). The canals are filled up and many flood plains are removed. Delta cities in this region are now separating from water and facing additional threats.

Therefore, sustainable development is crucial in deltas all over the world. This is not solely relying on technical solutions to fight against and control the delta environment, but a new approach that utilizes natural processes for water safety and sustainability for both the delta and its inhabitants. This approach is targeted at different disciplines: hydraulic engineering, urbanism and landscape architecture. Although there already exists a large body of knowledge on the characteristics and functioning of many deltas, most of this information is of a mono-disciplinary. There is relatively little knowledge that enables an overview of delta management in which these disciplines would be integrated. The aim of this literature review is to investigate the complexity of the urban deltas and from this systematic study, a relevant approach that can visible the interaction between climate change, water management and urban development of deltas will be tested.

Based upon the context of delta cities in Mekong delta region in comparison with other deltas in the world, the literature review paper first gives a brief overview of the transformation and development of urban deltas with their formative layers by applying "Layer model" analysis. The review continues with the section about drives of change and pressures in different layers of the urban delta nowadays including: climate change, technology development, demography trends and economic development. Thirdly, the paper provides a literature study on "Ecological method" and possibilities to apply this method in spatial planning and design for sustainable delta cities. The paper ends with conclusions and recommendation for my graduation project.

2 .Deltas: as complex ecological and social systems

Urbanized river deltas demonstrate different characteristics depending on their local climate, geographical condition, economic and political circumstances. Therefore not all deltas can easily be compared to other deltas. But many deltas have developed along the same patterns and have experienced the same problems as other deltas did at the same phase in their development. Delta cities all over the world, such as: New York, Rotterdam, Ho Chi Minh city, are the result of a long time interrelation between the nature and urban system. The natural complexity of the deltas, as the meeting of rivers and sea, with the complexity of urban pattern, as result of economic, cultural and social life creates unique areas with a double complexity (Meyer, 2009). Between these systems, infrastructure including waterways and roads play the key role in creating conditions for the development of the urban systems and influencing the nature system.

To provide insight in these complex systems, it is proposed to apply a simplified structure in the form of a "Layer model" that is a component of three layers: the natural landscape (bottom-layer), the infrastructural layer (middle-layer) and the urban layer (top-layer). This approach firstly was introduced by Ferdinand von Richthofen (1833-1905) to describe the chorological and topological relationships in the landscape. In the late sixties, Ian McHarg, a landscape architect, applied and developed it into 'layer cake model' for reasons of spatial analysis and planning in his seminal work: Design with Nature (McHarg, 1969). Recently, "Triple 3 layers approach", a more comprehensive planning and design oriented approach towards urban delta landscapes, was introduced by Meyer and Nijhuis (2010). This 'Layer model' presents a physical hierarchy in the sense that the layers enable and/ or constrain activities in another layer.

Figure 1: Layer model of planning of delta development. The picture shows the interrelationship between formative layers: occupation/ urban, networks/infrastructure and base layer/ natural landscape
Source: Meyer and Nijhuis (2010) http://homepage.tudelft.nl

2.1 Natural landscape

Use of the term "delta" began with the Greek historian Herodotus, who made the observation that the triangular shape of the Nile River's delta was somewhat similar to the shape of the Greek alphabet's fourth letter △.

Deltas are first formed from the deposition of the sediment carried by the river and over long periods of time, this deposition builds up the very typical nature systems of the deltas. They are existentially tied to occasional inundations. In the Netherlands, about 2000 years ago, before the human interventions, most of lands were covered by extensive peat swamps. The coast landscape was formed by nature dunes and embankments along the coast and Rhine and Meuse Rivers, which brought in sediments from the Alps. In South-East Asia, Mekong River as the hydrological backbone of its basin travels 4200 km from its headwaters in the Tibetan plateau to China, Myanmar, Thailand, Laos, Cambodia and to its delta in Vietnam. The complexity of Mekong delta is ecologically shaped by water of the Mekong River, monsoon climate and tide of the South China Sea (Hans Dieter, E. and Simom, B, 2009). There were a largely waterlogged territory which black mud, mangrove forest, and thick tropical forests dominated (Osborne, 2000).

When a delta does form, the soil of the delta itself is usually rich in nutrients since the sediment from which it is made arrived replete with organic matter and useful

minerals from upstream. The resulting fertility has made deltas, such as: Nile, Ganges and Mekong, very important to the development of agriculture civilizations throughout history. On the other hand, the natural process of sedimentation resulted in 'natural levees' of the river banks and other natural heights like river dunes, sandy ridges and barrier beaches that offered dry and safe land for the first urban settlements (Meyer, H.et al.2009).

2.2 Formation of infrastructure and urban layer

Urbanization is the second step forming delta landscapes. *'Building deltaic cities in a manner that accommodates seasonal flooding by primarily urbanizing higher natural levees, leaving low-lying swamps and marshes undeveloped to store water, and strategically perforating riverfront levees balances urban requirements with deltaic processes'* (Campanella, 2010). People started to settle on higher areas and learned to adapt with all the disadvantages of natural conditions. Measures have been taken to prevent flooding (through the construction of dikes, dams and delta works), to make shipping possible (by canalizing and/or damming rivers and constructing harbours), to enable farming (by cutting down woods and levelling and draining the land), and to allow the extraction of natural resources (sand, clay, peat) (Thampanya et al., 2006).

The process of urbanization in the Netherlands started from the 11th century that was based on agricultural exploitation of fertile soils. The Dutch landscape was soon transformed from a natural swamp of peat and clay into a number of "polders" surrounded by dikes and drained by a system of ditches, canals and locks (Meyer, H. and Nijhuis, S., 2011). Cities in these polders grew from the agricultural markets to the centres of regulation for the polder's water system (Burke, 1960).

The canalization process were introduced far later in the Mekong delta. Until the 19th century, canal systems were introduced and played a key role in the development of new urban form. Silt from digging these canals created high manmade levees for settlements. In these cities, waterways as rivers and canals were mainly transportation and goods exchanged routes. Moreover, they were also used for irrigation, drainage and fresh water supply purposes. Aware of the changing environment conditions, inhabitants in these cities developed adaptive strategies, often called "shaking hand with floods", that accepted rather than resist the potential catastrophic risk (Miller, 2006). These strategies resulted in a typical delta image with stilt houses, boat houses, floating markets, three sided canoes that are still visible in the current delta cities (See figure 2).

Figure 2: Floating market in Mekong delta, Vietnam.
Source:http://www.enjoytravelvietnam.com

Following the development of technology and the increasing needs for urban development, infrastructure became more powerful and strong with wind mills, dikes, dams, pumping station, water-control system, etc. Thanks to these interventions, urbanization in the delta areas grew dramatically as well as economy. In Mekong delta, starting from the sixties, the system of land-based infrastructure and flood-control became a national concern for economic development. Settlements and cities developed at the meeting points of motor roads and waterways that are high and dry places in times of flooding. In addition, the August flood control dyke systems and several excavated canals protected from 900,000 to 1,000,000 hectares of two crop rice fields and nearly 200,000 hectares of three crop fields during 1976-1987. As the result, Mekong delta became Vietnam's main productive agricultural region (Pham, 2011).
However, these interventions produced an essential change in the natural landscape (Meyer, H. and Nijhuis, S., 2011). The transformation from a natural dynamic water system in which people adapted to the forces of nature into an infrastructure system in which the forces of nature are attempted to be controlled, turns out to be problematic. Particularly in the urban area, where this transformation is most apparent, problems are bound to happen when weather events become more extreme due to climate change.

3. Drivers of change and pressures of delta cities in their new phase

Today, most delta areas in the world are dealing with the increasing complexity and changing dynamics, because of two reasons: first, the changes in the natural dynamics of the delta due to climate change and human interventions, and second, the changes in the dynamics of land-use, dominated by urbanization, industrialization, port-development, agriculture and leisure/tourism (Meyer, H. and Nijhuis, S., 2011). These changes have resulted in increased pressures on formative layers of urban deltas.

3.1 Climate change

The most important driver in the deltas studied is climate change, which is a global issue with diverse consequences throughout the world. Climate research has verified that the global temperature will be increase by a few degrees, resulting in the more extreme weather in many places, with more flood events, storm and changed river discharges (IPCC, 2001). The sea level also rises faster of 3mm a year and brings growing fluctuation in dry and wet seasons. These changes will have a serve impact on the natural system of the deltas and in the lives of those living in these areas. Moreover, the economic losses can be enormous. For instance, one serve storm in December 1999 caused a loss of 6 billion Euros in Western Europe (IPCC, 2001).

In Mekong delta, climate change adds to the already substantial sources of risk. The average temperature is predicted to rise by 2°C in 2050. Until 2100, the temperature is projected to rise and by 3°C in 2100. This will cause an increase of the discharge of the rivers. It is also one of the causes of the rising sea level. Furthermore approximately 20 per cent of the land will be flooded when sea level increase 1 meter in 2100 (Monre, 2003).

3.2 Human interventions

Living in the delta has always required human interventions. As the last section, it can be seen that infrastructure was and is developing to create more favorable conditions for living and working in the deltas. However, following the technological development of water management, human interventions as adaptive measures for the complexity of natural system have now led to continuous effects on the natural landscape within the deltas

Deltas are losing their natural flexibilities and no longer able to changing circumstances. The main effect of human interventions is a shortage of sediment in the delta. As the consequences, the relative of the sea increases, resulting in erosion and subsidence of the delta. It also means an increased risk of flood. People prevent this by building up their dikes, consequently, no longer benefiting from the nature resource due to the lack of sediment (Recker, J. et al. 2006). For example, the construction of dikes in the Dutch delta has resulted in large areas no longer being flooded and no more sediment being deposited. Consequently, large areas of the Netherlands now lie below sea level.

3.3 Demographic trends

Most of the deltas in the world are now densely populated, especially deltas in Asia, such as: Ganges, Yangtze and Mekong delta (See table 1). As human population increases in deltas, so does pressure on delta nature landscape through increased demand of natural resources (fresh water), land for construction and increased pollution. In developing deltas, rapid urban development has led to mega-cities and increasing urban development with a very high growing pace. The unplanned and uncoordinated urbanization cannot be supported basic infrastructure as water, sanitation and protection measures by weak government (Konings, 2011).

	Population (in million)	Density (inhabitants/km)	Growth rate (%)
Nile	35	1000	2,0
Incomati	2,5	44	0,4
Ganges	156-200	1200	1,3
Yantze	20-85	>1000	0,3-2,0
Cilwung	23	>1000	3,6
Mekong	17	425	0,6
Rhine-Meuse	6,5	500	minor
Danube	0,01	5	minor
California Bay	0,5-0,7	?	?
Mississippi	1,5	<100	minor

Table 1: Comparative overview of delta population (number, density) and growth rate.
Source: (Bucx, T., Marchand, M., Makaske, A., Van de Guchte, C., 2010)

3.4 Economic development

In delta cities, economic development is an important driver with medium to severe impacts. The deltas of the world are multi-functional landscapes that can support a multitude of economic activities, such as agriculture, industry, services, transport and energy production. While agriculture dominates Mekong delta and Ganges delta, industry, port and services are high national economic important with most people employed in Rhine-Meuse delta and Yangtze delta. Recently, tourism is beginning to merge in several deltas like Danube delta, Nile delta and Mekong delta (Bucx, T., M. Marchand, A. Makaske, C. van de Guchte, 2010). Despite the current financial crisis, economic development may be expected over longer periods of time, resulting in larger demands to be met, higher values to protect, more energy to be generated and more goods to be transported. However, in most deltas, intensive agriculture and industrial development strongly compromise water and soil pollution. Water and soil quality is affected by the overuse of fertilizers and pesticides and the waste disposal and sewage from industrial activities. For instant, every year, 25 billion tons of sewage and industrial waste is discharged into the Yangtze river representing 42 % of China's total sewage and 45 % of the industrial discharge. This pollution overcomes the self-purifying capacity of the river, and poses serious threats to human health and the environment (Bucx, T., Marchand, M., Makaske, A., Van de Guchte, C., 2010).

Large demands on spaces for agricultural, industrial and port development in recent years have also resulted in the loss of natural delta ecosystems. The loss of wetlands is a clear example for this point. In Thailand and Vietnam, mangrove forests have been transformed into shrimp farms, melaleuca forests have been reclaimed to cultivate. As the result, natural coastal protection from storm and salination, fisheries and biodiversity is being deteriorated (Thampanya et al., 2006).

4. "Ecologic method" for guiding spatial planning and design

Deltas on the world are complex systems with their formative layers: the natural landscape layer, the infrastructural layer and the urban layer. The change in one layer might result in significant impacts on other layers and the loss of their interrelationship. The knowledge provided from applying "Layer model" in the previous sections proved that traditional approaches "protecting against flooding" or "building in nature" have separated nature from human and their urban development. These approaches are not only damaging to the nature system but also human civilization. Therefore, these damage forces people to take a step back rethink about the problem, about their relationship with nature and understand intensely the natural landscape before impacting nature. '*Man and nature are indivisible, and our survival and health are contingent upon an understanding of nature and processes*' (McHarg, 1969, p.27).

In "Design with nature", Ian McHarg defined "ecological method" as a way of studying natural landscape and using this understanding to guide regional planning and design (McHarg, 1969). The method proposes to identify and evaluate the value of different aspects of the natural landscape, for example: surface water, floodplains and marshes. Each of these natural landscapes is best suited for different land uses, such as: agriculture, recreation and urbanization. This ecological method developed by Ian McHarg to apply "Design with nature" theory was seized upon and used throughout the world.

In the Netherlands, numerous long term planning studies and policies have been implemented. The new approach is no longer about "protecting against flooding" but instead respecting it and giving space for water and its natural landscape. Based on a clear understanding of the delta system, the Dutch attempt to plan their future with natural landscape, creating both healthy ecosystems and a safe country.

4.1 Rooms for the river: Spatial planning Key decision

Throughout a thousand years of protecting against flood, space for the rivers in the Netherlands has become only more limited. Drivers of change put greater threats on the development of the country. So to make the Netherlands a safe, comfortable and pleasant place to live, trend has to be reversed. The answer lies in the plan to make more room for the river. As the Spatial Planning Key Decision, "Rooms for the River" (Ruimte voor de Rivier 2007) policy was proved by Dutch government in 2007. The policy outlines numerous designs (See figure 3) to provide more space for the river and lower high water levels. These designs present an integrated spatial planning with the main objectives of flood protection, master landscaping and the improvement of overall environmental conditions.

Appendix

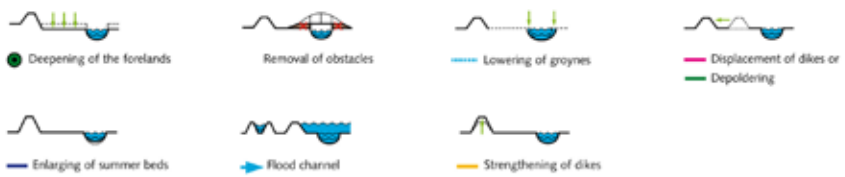


Figure 3: Measures in the Spatial Planning Key Decision "Room for the River". The picture shows the measures in the basic package-deepening forelands of the rivers, displacing dikes further inland, depoldering, and creating flood channels.
Source: Room for the River: Explanatory Memorandum, 2006

4.2 Building with nature: Sustainable hydraulic engineering solutions

The new concept "Building with nature" (De Vriend, H.J. and Van Koningsveld, M., 2012) aims to be proactive, utilizing natural processes and providing opportunities for nature as part of the infrastructure development process. In this concept, design infratructures such as: Sand engine, using coral reefs and mangrove forests to protect coastline, not only ensure water safety but also promote nature development and recreation.

5. Towards adaptive delta cities to rapid changing environments

Achievements from "Room for the river" and "Building with nature" in the Netherlands have marked a dramatic change in policy and thinking about nature and its natural landscape. To promote more resilience and sustainable development of deltas, "ecological method" has to be developed as the guiding for spatial planning and design. Especially in the context of developing deltas, such as: Ganges, Yangtze and Mekong delta, these tasks have become more crucial. Using the understanding of delta system from previous sections, several validity of the "Ecological method" in planning and design to cope with rapid changing environment are found in literature study.

Firstly, spatial planning can reduce the flood risks in deltas (Recker, J. et al. 2006). As Ian Mcharg argued each of the natural landscapes is best suited for different land uses, spatial planning can work in a way that flood resistance zone, buffer zones and flood hazards zones are identified. Flood resistance zones are suitable for urban development, while in the buffer zones, space for future defense measures is reserved, other economic and recreation activities such as: ports, beaches and national park might be possible. Urban expansion and human activities are restricted in flood hazard zone that are used to reduce floods and storm surges.

Figure 4: Schematic model of the delta. The picture shows on the left side interventions that have negative influences on the natural landscape within a delta and on the right side ecological measures.
Source: drawing by Jeroen Helmer

Secondly, infrastructure layer as the middle layer connecting nature and urban landscape has achieved a lot of successes in creating safe conditions for human activities and urban development. Innovative infrastructure can design with more than just one purpose, that is aligned with natural process rather than traditionally working against them and that is adaptive to cope with changing conditions, such as: climate change and sea level rise(De Vriend, H.J. and Van Koningsveld, M., 2012). Especially when used in combination with the traditional approach, the new infrastructure system can lead to cheaper, more economic potential and more aesthetically appealing solutions. For example, combining "Room for the River", Studio MarcoVermeulen proposes to create floodplains in a flood-resistant landscape. In this strategy, floodplains have been used for centuries as a growth of medium for biomass, building materials and food productions (Delta program, 2012).

Finally, 'Making city is putting Water to Smart Use in designing the City' (IABR, 2001). Indeed, water as the main element in nature landscape of the delta, have become an indispensable element in the development of urban delta. 'Putting water to smart use' requires a sustainable water management that can provide a sustainable use of floodwater, groundwater, surface water, waste water and drinking water. This water management combining with the green spaces, such as: parks and pedestrian paths functions as an attractive place for social interaction. Valencia's Green River in Spain is a successful example. In 1957, Valencia experienced a devastating flood that forever changed the city's relationship with the Turia River. The plan proposed by Ricard Bofill has changed the riverbed in to attractive parks with bike paths, event spaces, active recreation fields, fountains, and many notable structures (Phelps, 2012). Despite the apparent success of the plan in preventing flood, the new intervention could restore the river's natural landscape and connect it to the dense city.

6. Conclusions

Living in the delta is always living with challenges. Climate change, urban development, and other drivers have urged people to find better solutions to adapt to these changes. These solutions have to base on fundamental knowledge on the delta systems and the future driving forces. According to Meyer and Nijhus: *'The transforming process of landscape from the past and its changes in present situation helps to understand the particular 'driving forces' of the landscape involved and can serve as a base for future development'* (Meyer and Nijhuis, 2010).

Discussed here are several theories and methods that provide a way to preserve and utilize natural landscape in the urban delta for water safety and sustainability for both the delta and its inhabitants. The "Model layer" mentioned in this paper will be used as framework to understand the complexity and dynamic of urban deltas, while, "Deign with nature", "Rooms for the river" and "Building with nature" will give insight into "Ecologic method" as one of the most strategic method guiding spatial planning and design. The combination of these method and theories is answer for one question in my thesis on how the unique nature landscape of deltas can be repaired and combined with future urban pattern in respond to the rapid changing environment.

The knowledge from this literature review is applied as a theoretical framework for my graduation project about "Flood adaptive cities" in Mekong Delta. The Mekong delta today is a product of different engineering decisions throughout three hundred year history. On one hand, agricultural production has developed successfully, and economic growth and urbanization has been very rapid. On the other hand, intensifying agriculture and large scale water control structures have challenged the natural landscape and

social equity (Käkönen, 2008). This paper will ultimately provide the ability to address this specific region and its difficult challenges.

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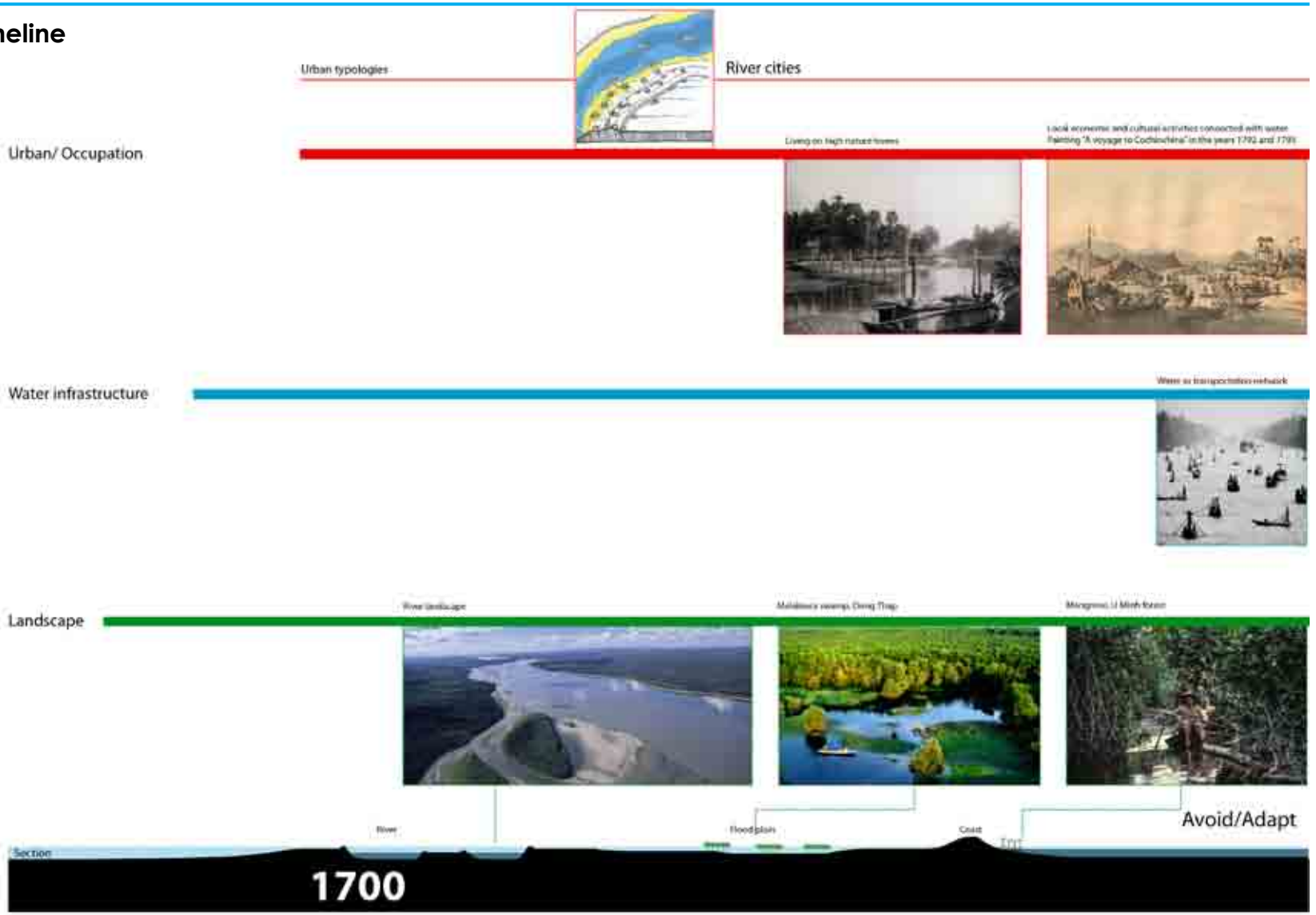
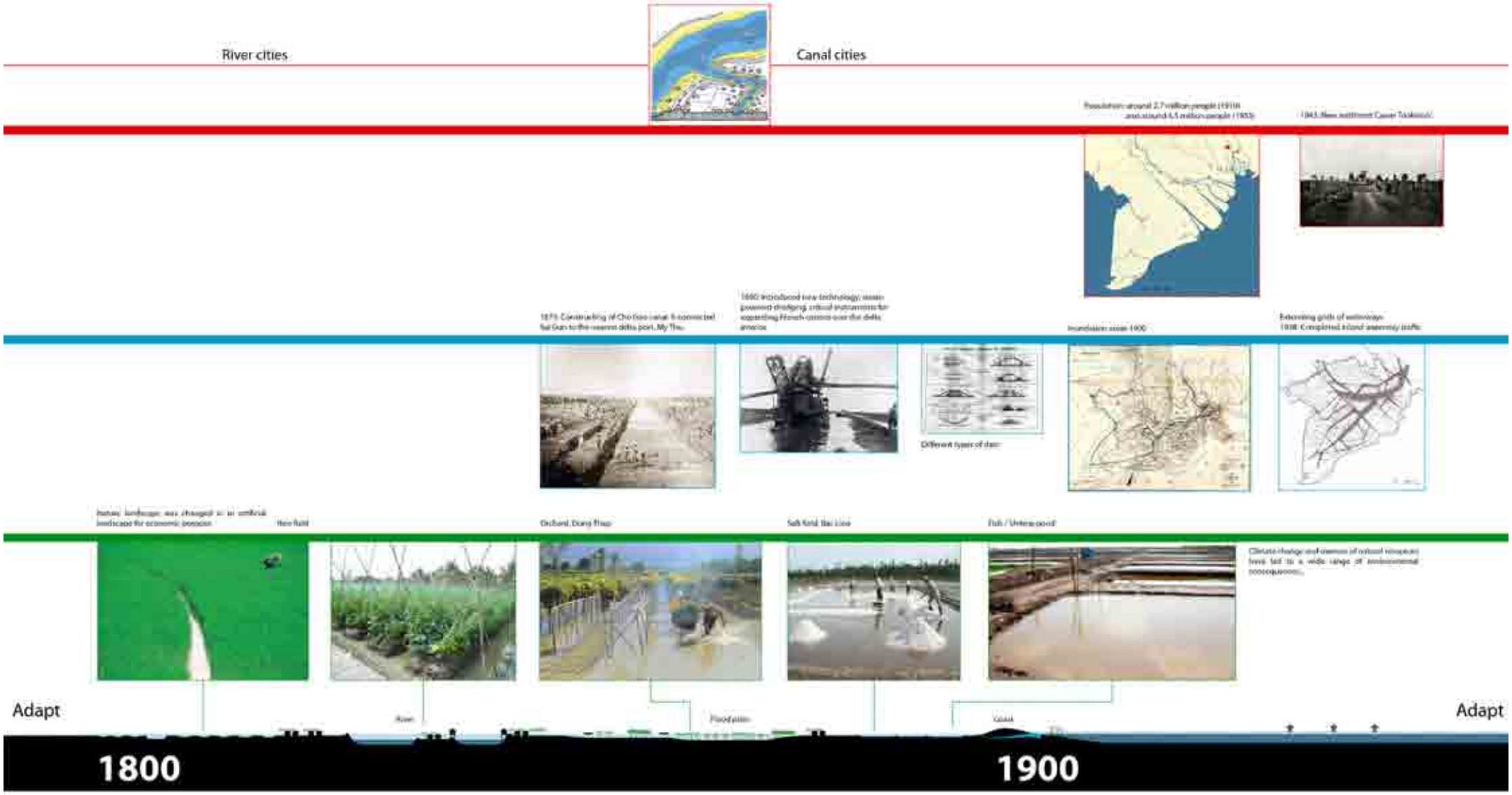
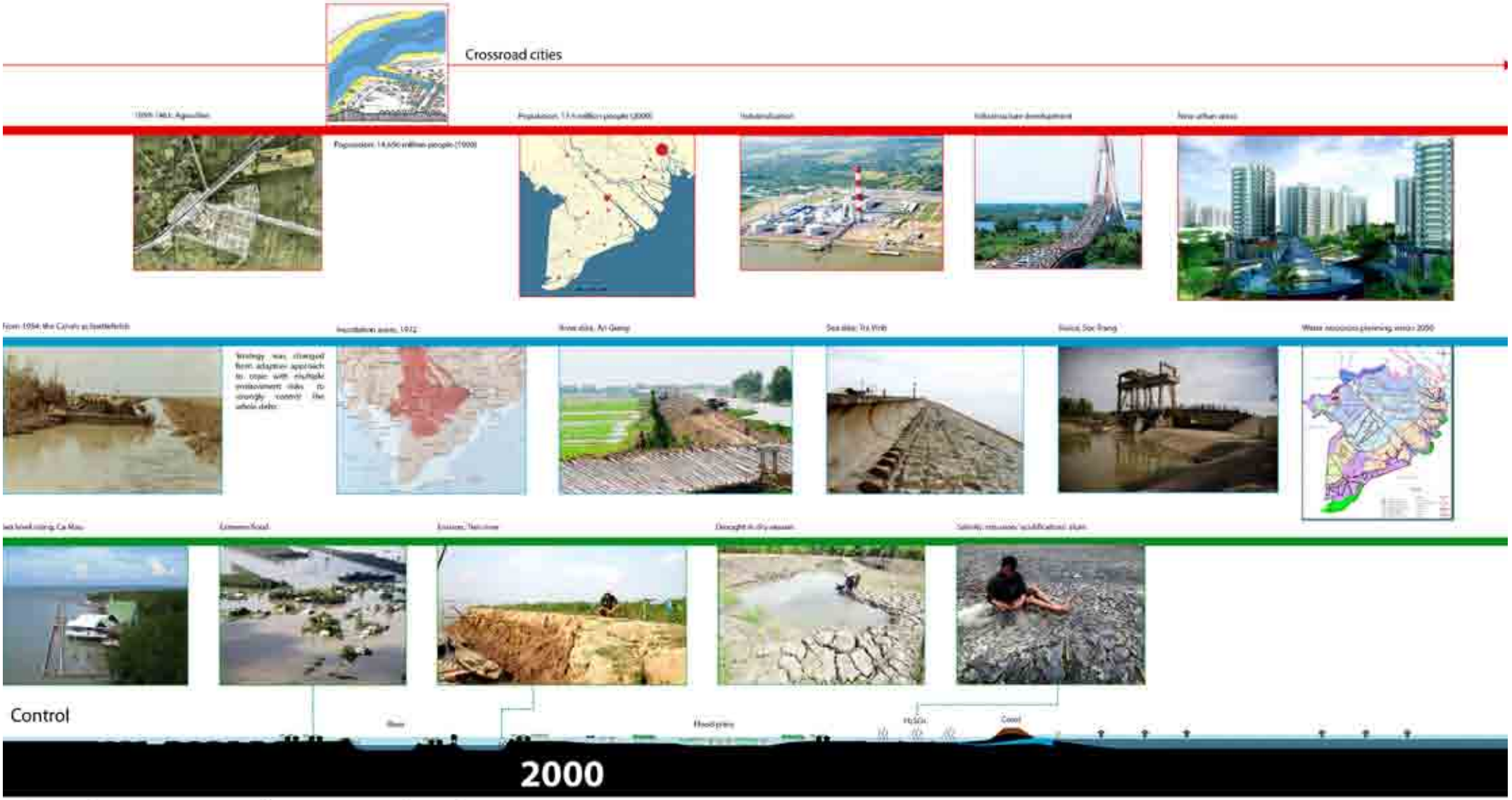
2. Mekong Delta Timeline

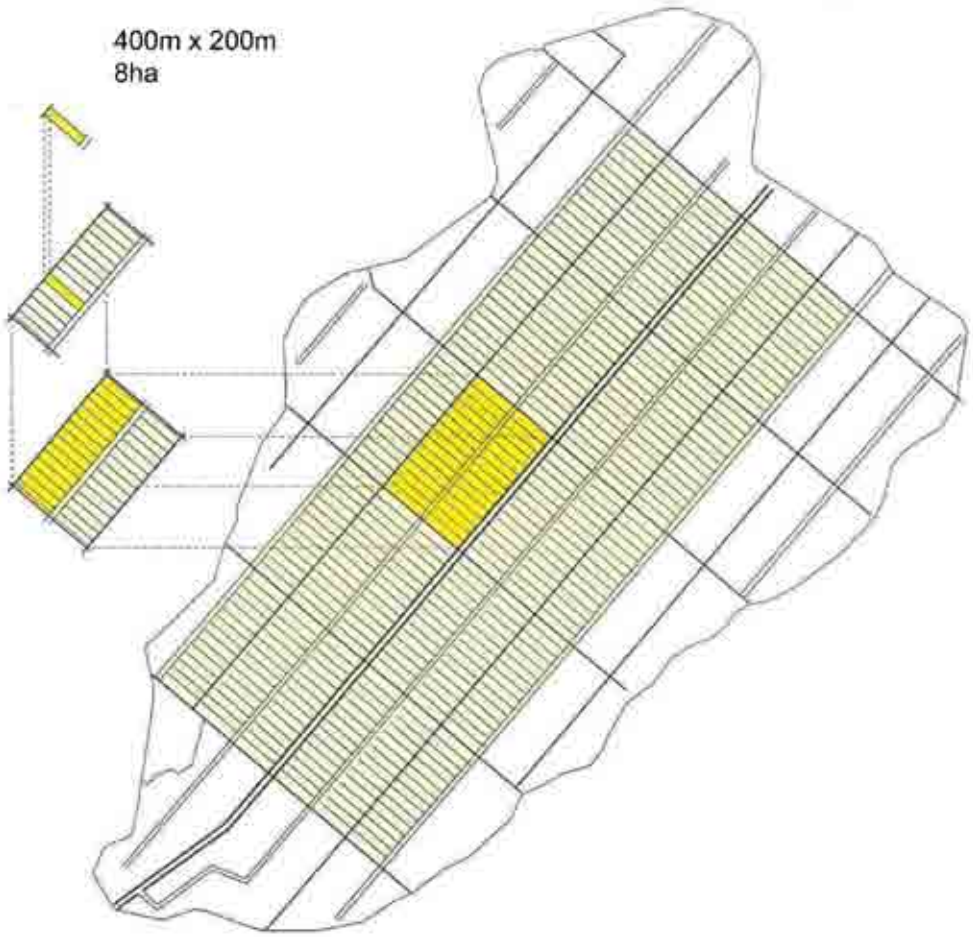


Appendix


River cities
Canal cities
Adapt
Adapt
1800
1900
1802: Nguyen dynasty
1859: French colonial rule in IndoChina bean
1875: New network of inland waterways
1890: Introduce steam powered dredges


Crossroad cities
Control
2000
1954: End of French colonial
1955: Vietnam war
1975: Fall of Saigon
Re-union of Vietnam
1986: "Doi moi" Policy
1990: "Open door"

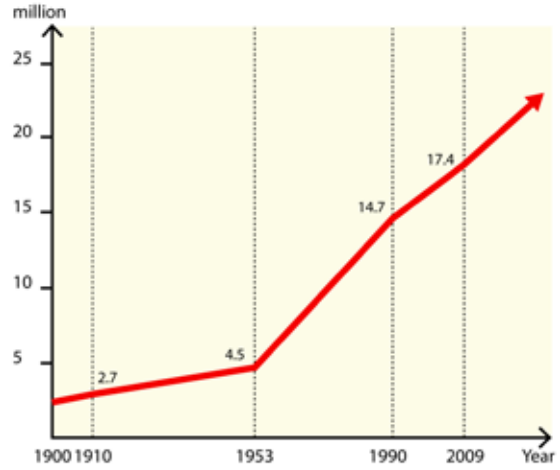
3. Comparison of the land parcels



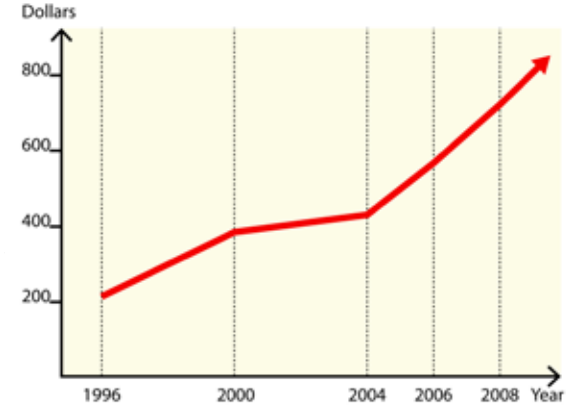
HAARLEMMERMEER, NETHERLANDS
S: 185 km2
Population: 138.392

CAO LANH, VIETNAM
S: 107 km2
Population: 131.021

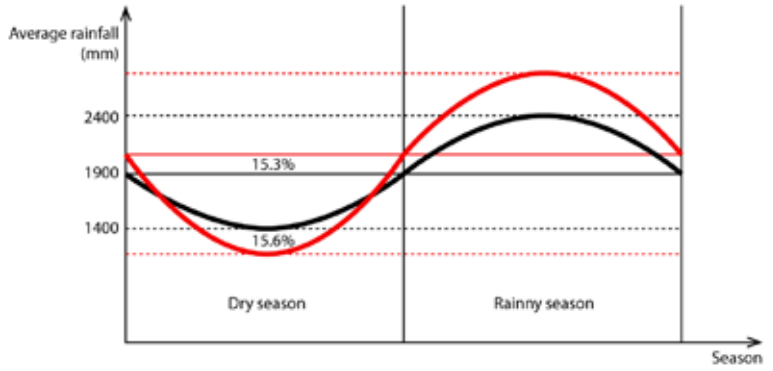
4. Tables



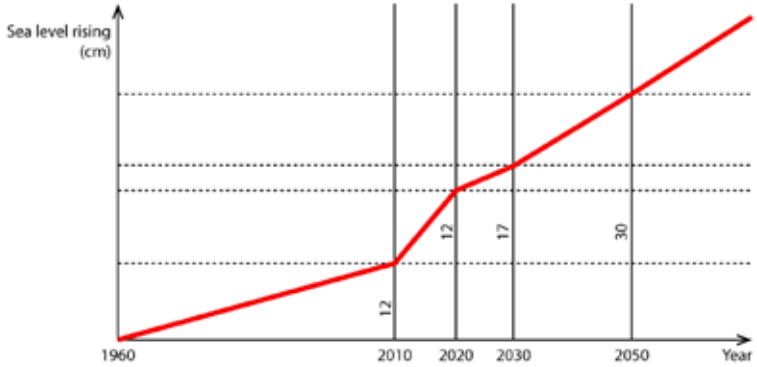
Population growth in Mekong delta
Source: based on World Bank 2010



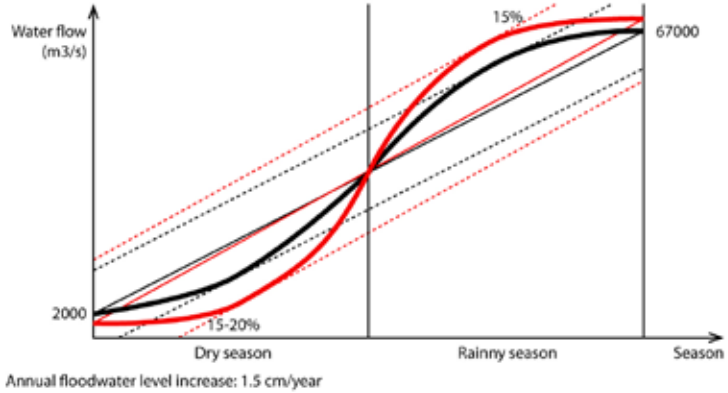
GDP growth in Mekong delta
Source: based on World Bank 2010



Average rainfall in dry season and rainy season in 2010 (black curve) and 2050 (red curve)
Source: based on Vietnam Academic for Water Resources
www.vawr.org.vn



Predicted sea level rising until 2050
Source: based on Vietnam Academic for Water Resources
www.vawr.org.vn



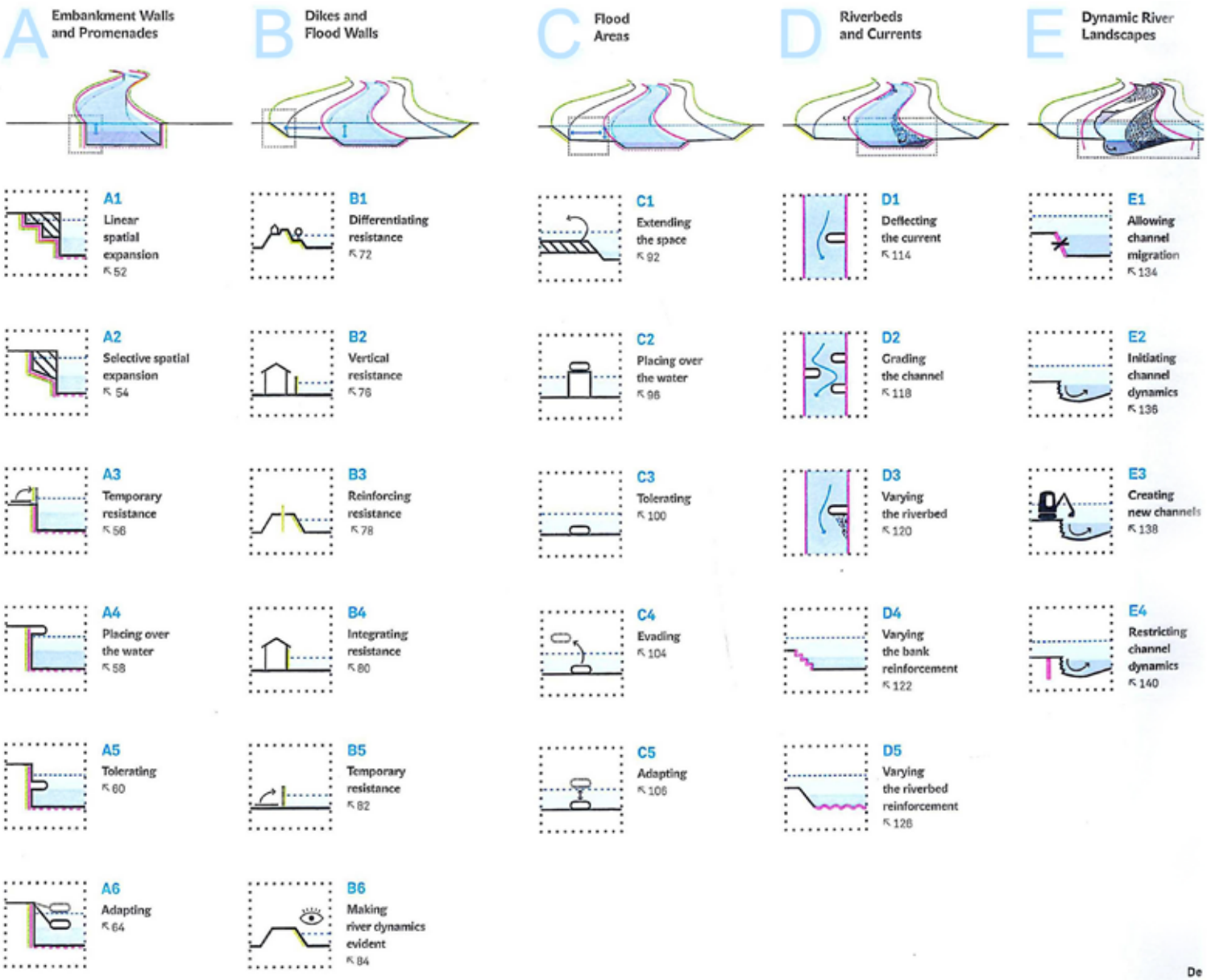
Annual floodwater level increase: 1.5 cm/year

Average waterflow in dry season and rainy season in 2010 (black curve) and 2050 (red curve)
Source: based on Vietnam Academic for Water Resources
www.vawr.org.vn

5. Toolbox

Space.River.Design

List of process spaces and design strategies



List of design tools and design measures

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6. Natural process and urbanized process in Mekong Delta

NATURAL PROCESS

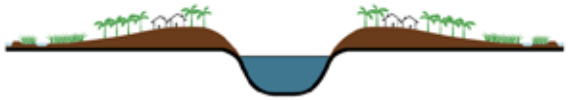
Before Flood

During Flood

After many Floods

URBANIZED PROCESS

First settlements



Cultivating

Fast Urbaniza-

More extreme

REFERENCE

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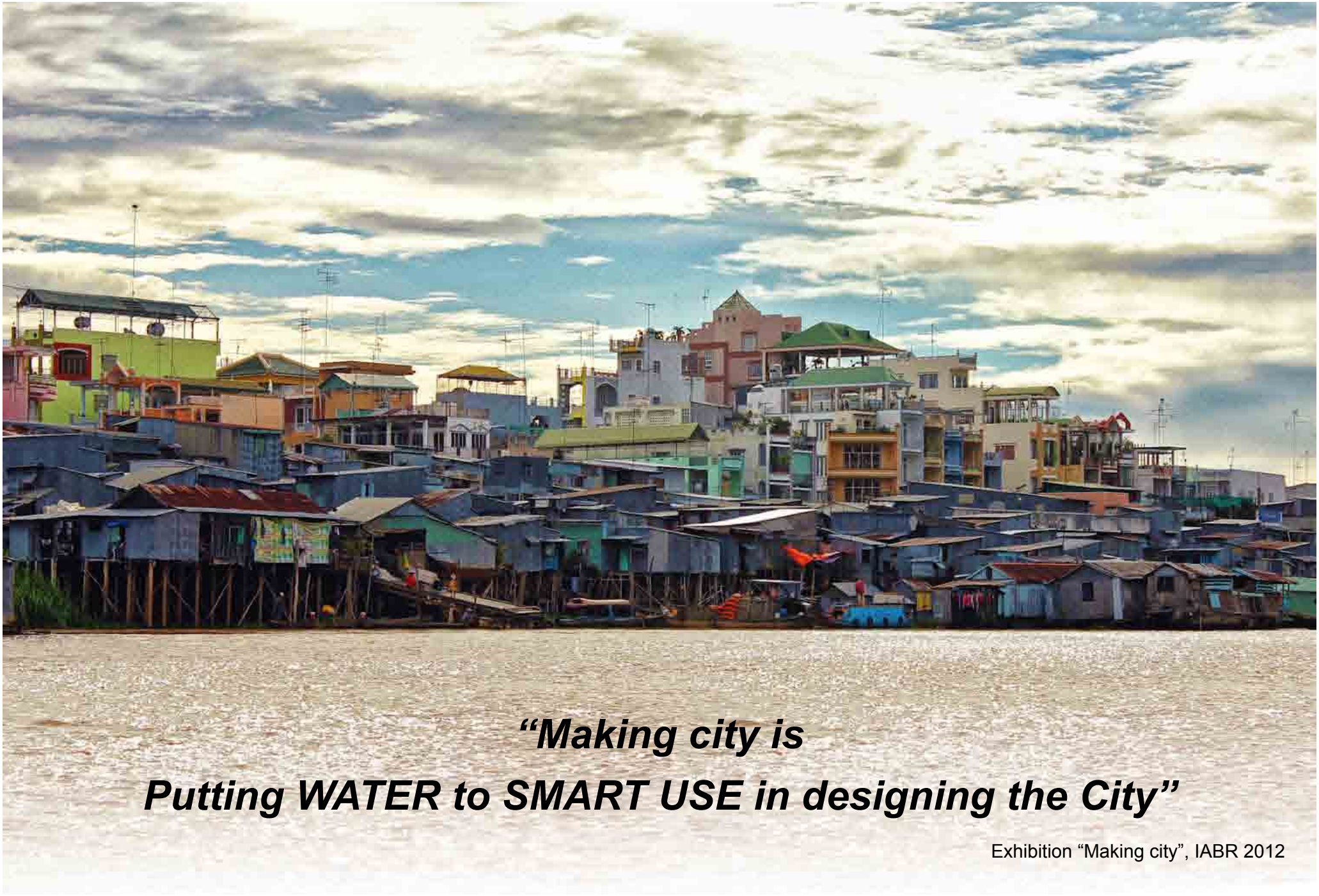

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