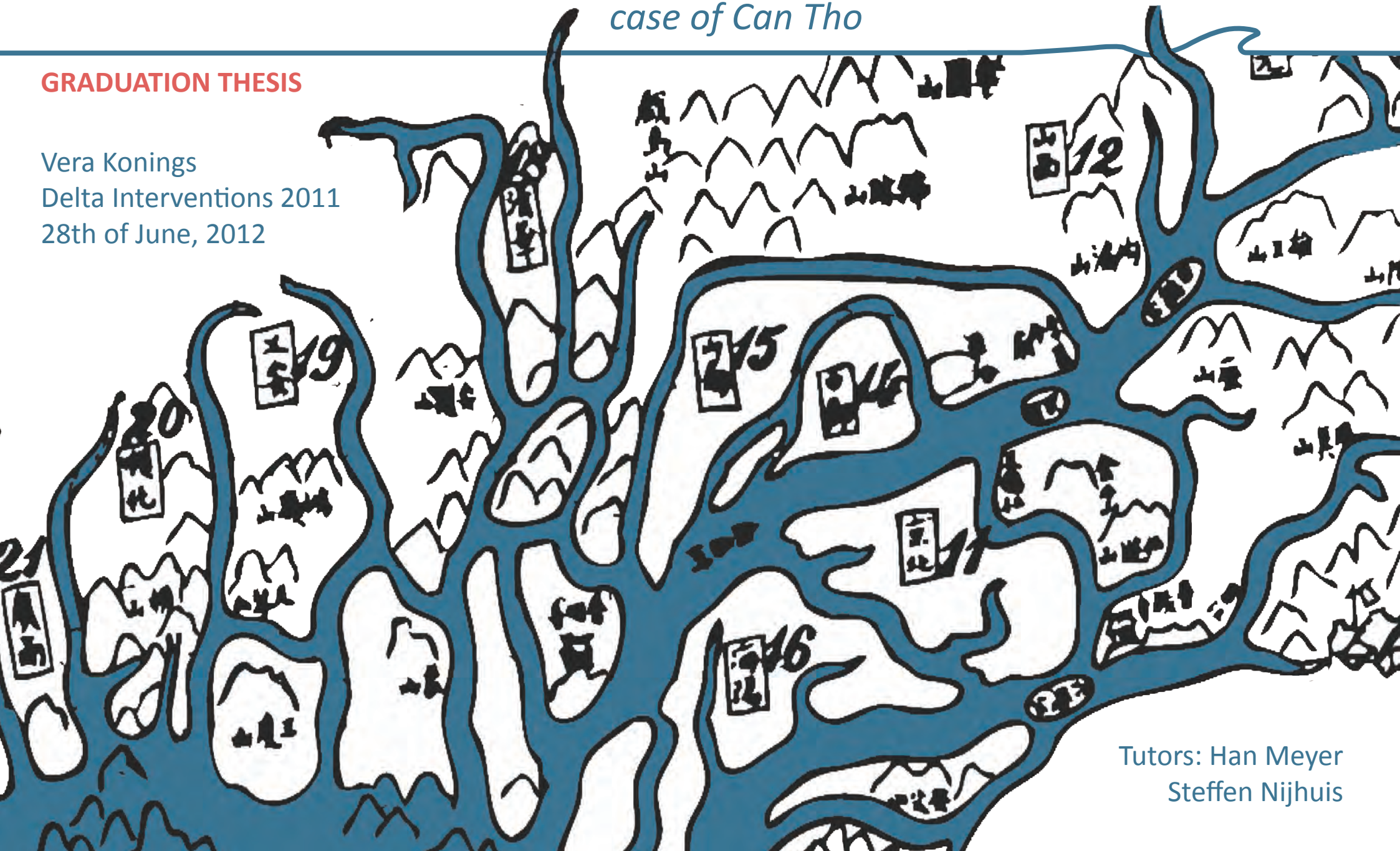
CAN THO, HOW TO GROW?

Flood proof expansion in rapidly urbanising delta cities in the Mekong delta - the case of Can Tho

GRADUATION THESIS

Vera Konings
Delta Interventions 2011
28th of June, 2012



Tutors: Han Meyer
Steffen Nijhuis

Colophon

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Master thesis

Vera Konings
Koornmarkt 81d
2611 ED Delft
The Netherlands
vera_konings@hotmail.com
+31(0)6 44 41 44 39
Student number: 1316737

Mentors
1st mentor: Prof. dr. ir. V.J. Meyer - Chair of Urban Design
2nd mentor: Ir. S. Nijhuis - Chair of Landscape Architecture
External committee member: Ir. M.C. Stellingwerff - Form & Modelling Studies
Studio mentor: Ir. A.L. Nillesen

TU Delft
Faculty of Architecture
Department of Urbanism
Graduation Studio Delta Interventions
Julianalaan 134
2628 BL Delft
The Netherlands

Date: 28/06/2012

Picture front page : 'Dat Nuoc' : *Earth and Water*; the Mekong delta from 1490.
Based on: Shannon, 2009. Studio, 2011

TU Delft URBANISM Delta Interventions

Preface

This thesis is made for my graduation year of the Master Urbanism educated at the Faculty of Architecture, TU Delft, The Netherlands. This document is the support for my P5 presentation presented at the 5th of July 2012, 10.30h, room A. This document and the P5 presentation show the final work of my graduation year started in September 2011.

The graduation project is accompanied by the Delta Interventions Studio, a design studio which has his main focus on urbanism and architectural design in delta areas in times of climate change.

Since long, deltas are favourble places for urbanisation because of their fertile soils and very good water transportation networks. Meanwhile, deltas have always had the side effect of being dangerous. They are often threatened by flooding from sea and high river discharges upstream which can cause severe economic and social damages. With a growing world population the tension between flooding and urbanisation will increase in delta areas.

The delta city in my graduation project is the city Can Tho in the heart of the Mekong delta in southern Vietnam. Can Tho is rapidly urbanising and faces a quick economic growth, but their flood protection is not yet suitable to secure this process.

Vera Konings

"The Mekong delta is at the crossroads. Today, the delta has to adapt once again to the new conditions of change, this time a rapid urbanisation and quick economic changes. Climate change in the future causes huge drastic changes in the water regime of the Mekong delta in the future. This asks for a new way of thinking in water engineering, management and design to let grow the Mekong delta cities safely and sustainable." (Käkönen, 2008)

Riverfront of Can Tho

TABLE OF CONTENT

SUMMARY

Can Tho, how to grow?

Flood proof expansion in rapidly urbanising delta cities in the Mekong delta - the case of Can Tho

Since 2008, for the first time in history, more than 50% of the world's population lives in cities. This development can be seen in the Mekong delta in Southern Vietnam, one of the world's most threatened delta areas related to climate change. This area is experiencing a quick process of urbanisation and economic growth. Meanwhile, large areas in the delta are affected by flooding during the rainy season and suffering from a lack of fresh water shortage in the dry season. This shows that the (Mekong) delta cities are facing a double complexity: Their location in a delta in context to flooding and climate change and secondly, the rapid growth of cities while they face a rapid transformation from a traditional to a modern and globalising society bringing huge social, cultural and economic changes. One characteristic city facing this process is Can Tho situated in the heart of the Mekong delta which will double its population to one million in the coming 20 years. In this graduation project is researched how to find a strategy for the expension of this Mekong delta city as a sustainable example for other Mekong delta cities.

To understand the social, spatial and hydraulic problematics of the delta - and more specific for the city Can Tho - several methods are used: the method of the layer approach demonstrates how human intervention transformed the delta landscape to an more urbanised area and how this resulted in problems for the Mekong delta. A spatial-, typological- and hydraulic analysis for Can Tho adresses other location specific issues of Can Tho in order to find the most suitable way of expanding.

The layer approach shows how the delta transformed from a water based network to a road based society. Furthermore we see urban sprawl around the large cities, mostly between Ho Chi Minh City and Can Tho, the two largest cities of the delta. This area is also the most fertile agricultural area. While the Mekong delta is one of world's largest rice producing areas, this urban sprawl could threaten the world food supply in the future. The second layer approach of the urban area of Can Tho shows the current city densification and how nowadays growth leads to the loss of creeks and green space, which results in more flooding by extreme rainfall because rain water can not run off anymore.

A spatial analysis of Can Tho makes clear that there is a lack of public space and public green in the city. This results in the fact that streets are the place for all daily activities as markets and terraces and that there is no place left for the pedestrian. The green spaces in the city, like a large university complex, are fenced private domains which are blocking the continuity of the city, showing the first signs of spatial segregation. A lot of riverfronts are blocked by poor housing, industries or resorts, loosing the strong Vietnamese traditional relation between the city and water.

The building typology research shows the former rice field allotment structure has a strong impact on the growing urbanisation around Can Tho; the dikes between rice fields are transforming towards roads, keeping the structure of the landscape intact. Furthermore, suburbs are not connected with piping for sanitation or fresh water supply, making rain water and pumped ground water their source of fresh water. The poorest people even use the Mekong water for their 'fresh' water supply. Meanwhile, rivers and creeks are used as sewage system and garbage bins in the poorer areas.

Hydraulic analysis learned that in the rainy season annual flooding of 50 cm is normal for Can Tho. This flooding occurs by rainfall and a high sea tide and a high discharge upstream from China. In the dry season saline sea water intrudes more and more in the delta. The absence of rain in the dry season increases ground water pumping causing soil subsidence resulting in more flooding. Climate change and urbanisation will result in more extreme hydraulic problems in the future.

The proposal to expand Can Tho on a sustainable and climate proof way is based on a new city structure that relates to the existing landscape and the water network. Green public spaces along rebuilt and existing creeks become a new network covering and connecting the whole city. Waterfront development along the Mekong river provides safety for flooding with a 'delta dike'. With its gentle slope this type of dike will not disturb the relation between water and city. The creeks inside the dikes are locked off from the natural water flow of the Mekong river, these creeks have an enormous potential. Firstly, they improve the drainage capacity to store rain water. Also public spaces along the creeks are designed to be temporally flooded in case of extreme rainfall. Secondly, this creeks are not connected with the polluted Mekong. Water treatment systems make this water suitable for grey water supply in housing making Can Tho, independent from ground water pumping. Thirdly, maintaining a natural water balance will avoid soil subsidence.

The already existing landscape rice field structures and a strong local policy will be used to guide the transformation from an agricultural to an urban area. Strategic road building and a proper division of ground lease contracts creates potential to urbanise the rice fields. This model of growth as a cooperation between landscape, urbanism and engineering could be used in more Mekong delta cities answering climate change, avoiding lurking segregation and the maintainance of the local food production.

This transformation from water as a threat towards water as an opportunity gives the basis to sustainably expand the Mekong delta cities!

Building a flood defence along Can Tho

INTRODUCTION

Starting with the graduation studio Delta Interventions in the beginning of September 2011 I became more and more fascinated about the way water is or should be threated in delta areas with the predicted future of climate change and socio economic changes worldwide. This fascination started nearby Delft, due to plans for a new housing project almost seven meter below sea level in the Zuidplaspolder, The Netherlands.

In the Dutch polders, pumping and building causes subsidence of the soil and if a dike breaks through, the damage in the polder could be enormous (imagine water level of seven meter in a housing district). Furthermore, in other places in the countryside, polder areas are seasonally too wet because the pumping is reduced to avoid further subsidence. These polders became unuseful for agriculture or cattle breeding and are sometimes unused.

While thinking about these complex, but interesting questions and how to make a project out of this for The Netherlands I spoke with mr. Stive, professor in hydraulic engineering from the faculty of civil engineering, TU Delft. He proposed me to change the project completely and work together with the faculty of engineering to contribute in a project guided by mr. Veerman in giving advice for the Mekong delta in southern Vietnam. Here, the need for intervention is currently much higher than in The Netherlands. How could we make a delta plan that implements the experience (positive and negative) that we have from the Dutch context?

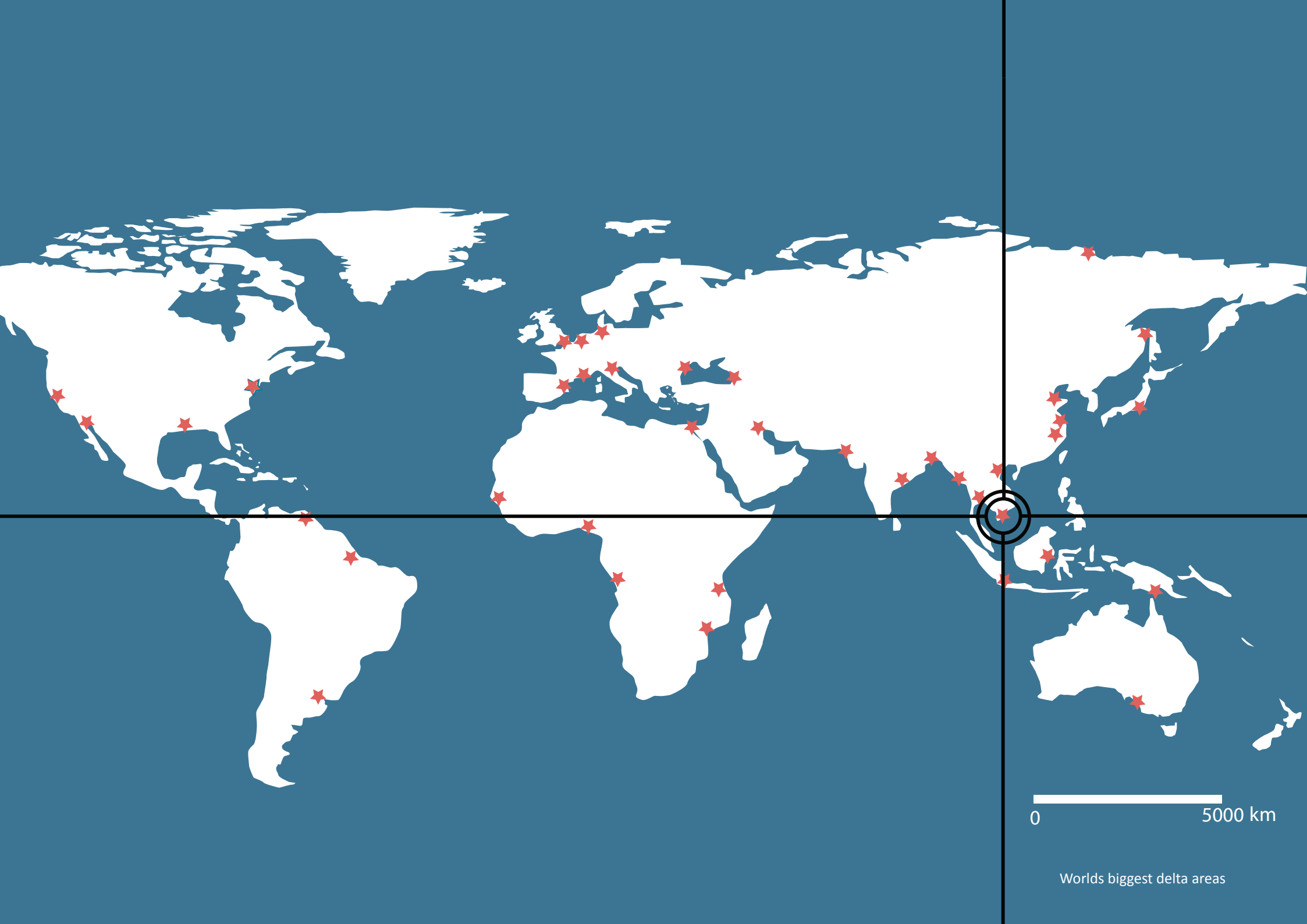
The Mekong delta could be seen as the Dutch delta, but than in a development stage of about a hundered years ago. Agriculture and the rural community are dominant and flood proof measurements exist of hand made dikes, irrigation canals and pole housing. Nowadays Vietnam is facing rapid urban and economic growth that makes flooding a growing social and economical problem.

This graduation project focusses on the Mekong delta from an urban perspective: city expansion in combination with water safety. The aim is to develop a sustainable expansion model for the explosive growth of these cities with the city Can Tho in the heart of the delta as case study. The strategy made for Can Tho could be used in other comparable Mekong delta cities such as Long Xuyen and Vinh Long.

This thesis starts with an introduction of the project in which the problems of delta areas worldwide are explained and later on zoomed in on the Mekong delta and a small introduction of Can Tho. In chapter 2 the problem statement, aim and relevance of the project and the used methodology will be explained.

Chapter 3 and 4 analyse and map the problems and will conclude with a diagnosis for the expansion of Can Tho city. This results in a vision for the city in chapter 5. How this vision could work on smaller scale is shown in chapter 6 in which the growth of the area behind the university complex shows how a flood proof expansion can work from spatial, hydraulic, and realisation point of view.

If there is no source is mentioned, the pictures and illustrations are made by the author.



Worlds biggest delta areas

Chapter 1
Content

DELTA'S OF THE WORLD

Half of the world's population live in delta areas. Meanwhile, delta areas are the most vulnerable cultivated areas for climate change while the urbanisation will increase coming century the most in these areas. Certainly cities in developing countries grow enormously due to industrialization, globalisation and an increase of population in general (Delta Alliance, 2010). Currently, 30 000 km2 of the 30 major river delta areas lay below sea level and another 100 000km2 lay below 2m elevation. These surfaces will double in size due to climate change the coming century (Kuenzer, 2011).

Delta areas are characterised by highly productive, flat land for agriculture and cultivation. The location near rivers and the sea provides good food sources and are often facilitated with a very good transportation hub (water transport is cheaper than road transport). That is why the largest harbours of the world are also situated in delta areas (Shanghai and Rotterdam). Furthermore, the regions often have a rich biodiversity and ecosystem what is attractive for tourists.

Meanwhile, growing urbanisation and growing industralisation in combination with climate change show growing tensions in delta areas. The current drivers of these ten are shortly explained:

Climate change: Climate change predicts more extreme seasons and sea level rise. Although this are all estimations, delta areas will feel the consequences.

Urbanisation: The flat lands provide good conditions for urban sprawl what has negative effects for ecosystems and agricultural lands (food production). This results in the fact that agricultural intensification is needed to feed the population leading to monoculture and overuse of fertilizer, antibiotics and pesticides.

Subsidence: Building skyscrapers on weak grounds, city growth, fresh water pumping and the drilling of off shore industries (oil and gas) give an enormous pressure on the soil causing subsidence what makes the area lower and more vulnerable for floods.

Coastal erosion: Construction of upstream dams depleting the supply of sediments to many deltas. Also the intensification of aquaculture near the coast leads to depletion of mangrove forests which break the waves and are a natural flood defence.

Salinisation: Due to dryer summers and upstream dams, river discharges decrease in dry season what leads the salt sea further inland. This decreases the fresh water supply and agriculture. (Kuenzer, 2011).

The World Bank (2008) states the delta areas in East Asia are probably the most affected by sea level rise due to climate change and the World Bank states Vietnam is on the top 5 most affected ones. (World Bank, 2008).

THE MEKONG RIVER

The Mekong river is with about 5000 km the 12th largest river in the world and the dominant river in South East Asia. It has his offspring high in the Himalaya Mountains, Tibet and after passing China, Myanmar, Laos, Thailand Cambodia and Vietnam the river ends in the South Chinese Sea. At the beginning of the river on a height of 5000m small streams find each other to form the Mekong river more downstream and southwards. Melting snow from these mountains fill the river. Before passing the Chinese border 200km above Louangphabang you can find huge Chinese dams to generate energy and to store which have great impact on the sedimentation and flow of the river downstream. After the border between China and Laos, the river basin becomes more green, but also more southwards new dams are planned. Vientiane is the capital of Laos and from here on to the south the river basin area becomes flat and more and more urbanized. Larger cities, rice fields and jungle areas appear and the river becomes wider. From the east small rivers from the Vietnamese Amman mountains flow to the Mekong river. The average width of the river is about 1.5 km when the river changes into an enormous delta covering an area comparable with the surface of The Netherlands. At the city Phnom Penh in Cambodia, 80 km before the Vietnamese border, the Mekong river divides itself and becomes the Mekong delta.

Fig. 1.2 (below) shows the discharge from several measure points in the Mekong river. The discharge in the river depends on the season, and can be 20 times higher in the wet season compared with the dry season with a maximum peak of almost 40 000 m3/s what is 10x larger than the Dutch Rhine/Meuse. Seasons, natural flood plains as the Tonle Sap lake in Cambodia and the Plain of Reeds in Vietnam (appendix D) and a growing amount of power plant dams influence the discharge of the river downstream. Besides generating energy this stored water behind dams are used for irrigation and drinking water upstream what decreases the discharge in dry season further downstream resulting in further saltwater intrusion in the delta and decrease of sedimentation.

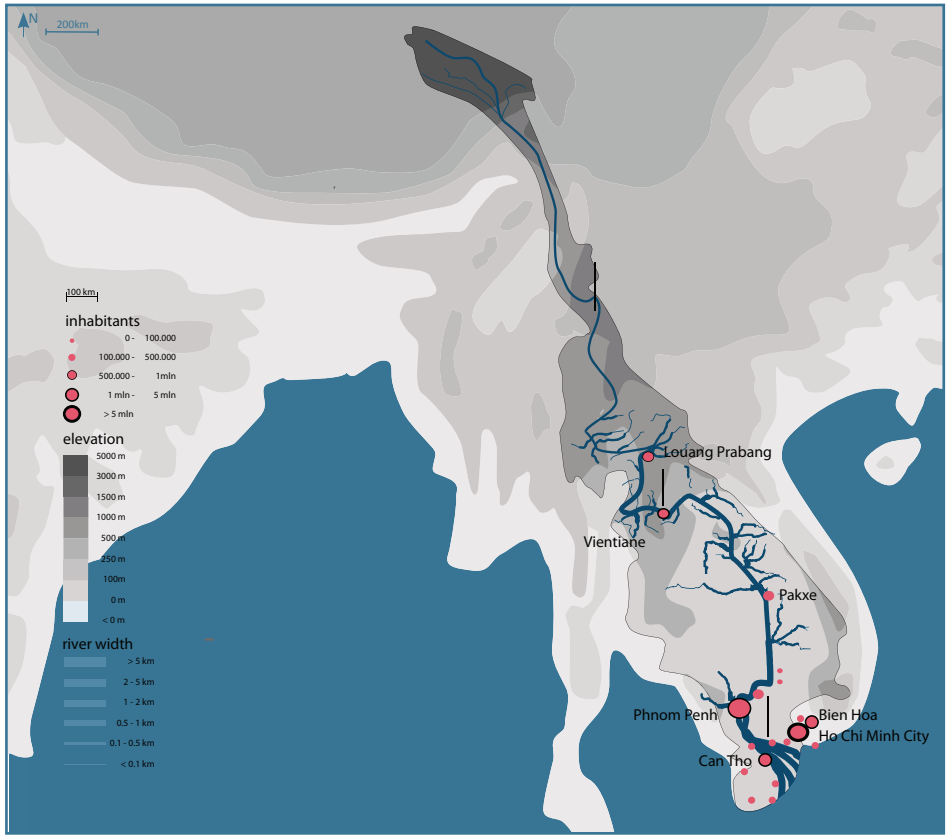


Fig. 1.1 Elevation map of the Mekong river basin with its main cities

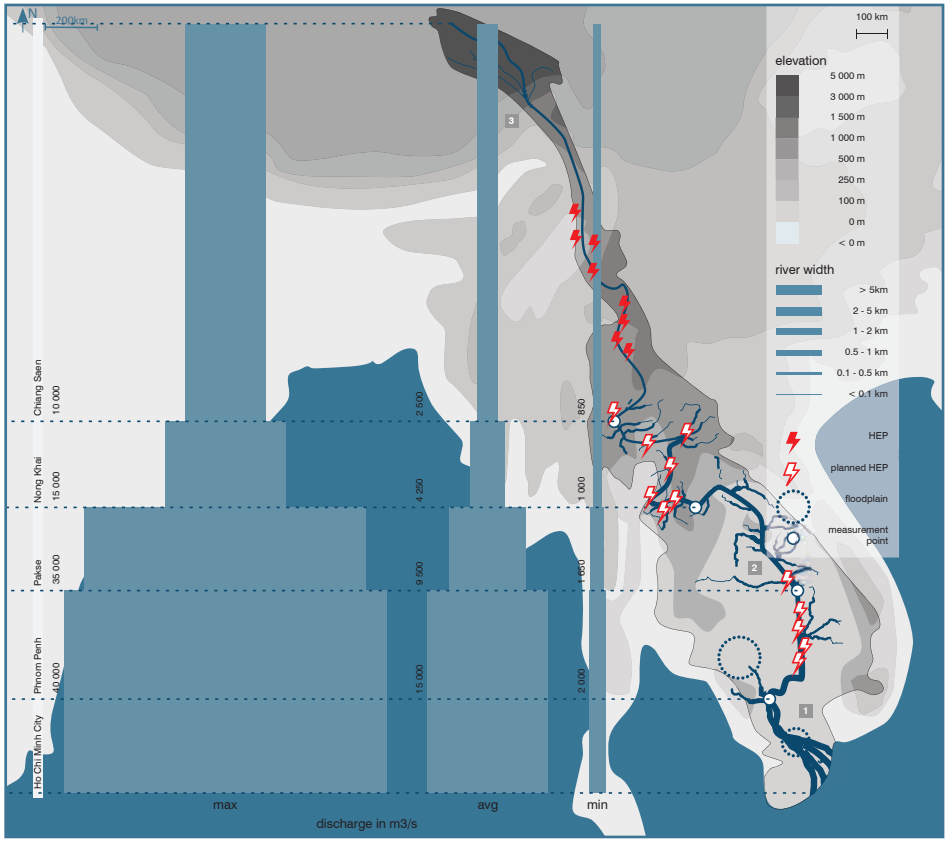


Fig. 1.2 Elevation map of the Mekong river basin with it's discharge and powerplants.

INTRODUCTION OF THE MEKONG DELTA

Cities and nine tails

From the capital of Cambodia Phnom Penh, the Mekong river divides itself in two seperate rivers; the Bassac river and the Mekong river. These two rivers stay interconnected through small rivers and canals. More towards the sea, these rivers divide themselves again in the '*Cửu Long*', the Vietnamese name for the Mekong meaning '*Dragon with nine tails*' what refers to the nine huge rivers which finally disburse into the sea. (Although if you count them you just come to eight, but nine is a lucky number). (Brocheux, 1997).

Actually, the Mekong delta is an aggregation of two deltas; the large Mekong delta in the south and the much smaller Saigon delta at the northern side of the delta in which Ho Chi Minh City is situated. They can be considered as one delta because they are interconnected through small rivers and dug canals in the nineteenth century, but this is a discussable subject. (Fig.1.3). On the next page characteristic photo's are shown to give a short impression of the Mekong delta.

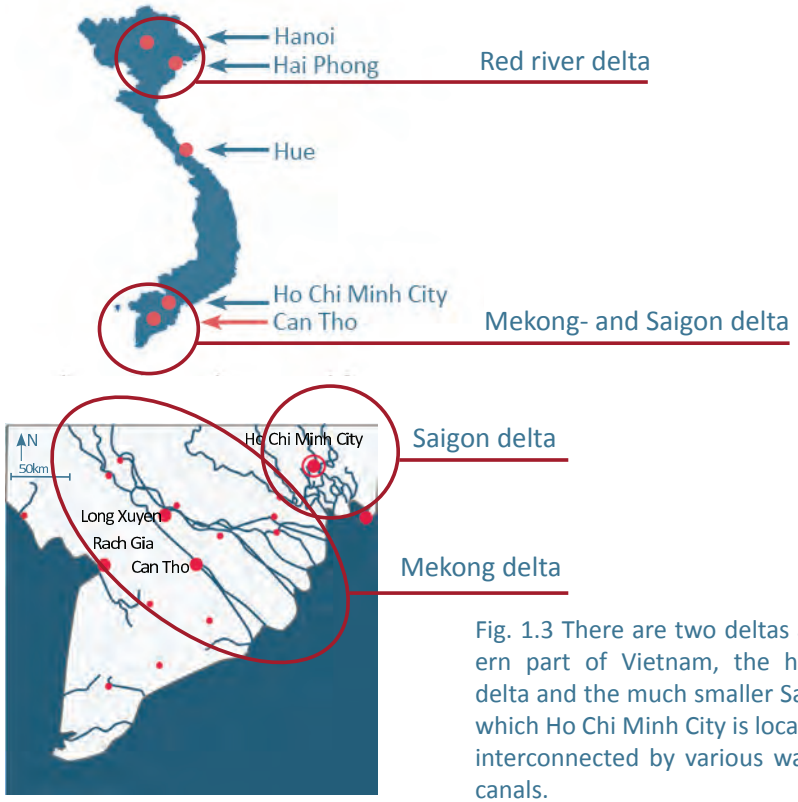


Fig. 1.3 There are two deltas at the southern part of Vietnam, the huge Mekong delta and the much smaller Saigon delta in which Ho Chi Minh City is located. They are interconnected by various waterways and canals.

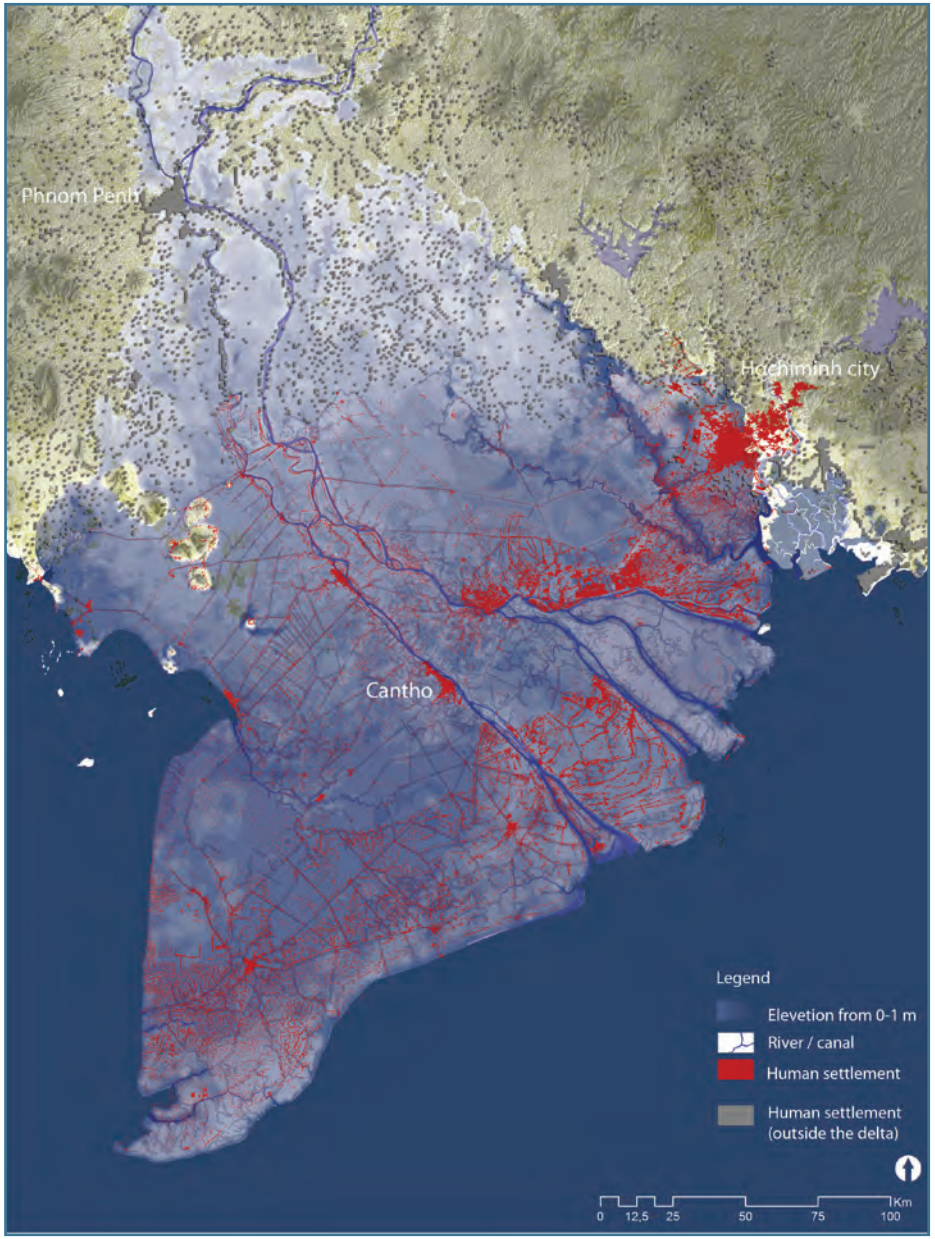


Fig. 1.4 Settlement pattern in the Mekong delta. Source : Pham, 2012

PHOTO IMPRESSION

Fig. 1.5 Large rivers which can have a width of 1.5 km. Source: Google, 2012

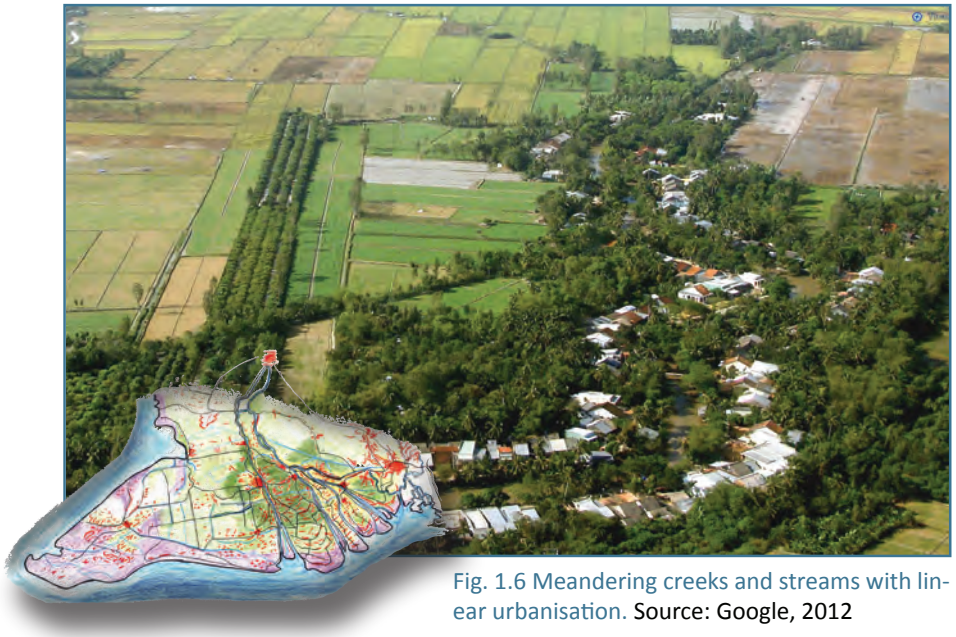


Fig. 1.6 Meandering creeks and streams with linear urbanisation. Source: Google, 2012

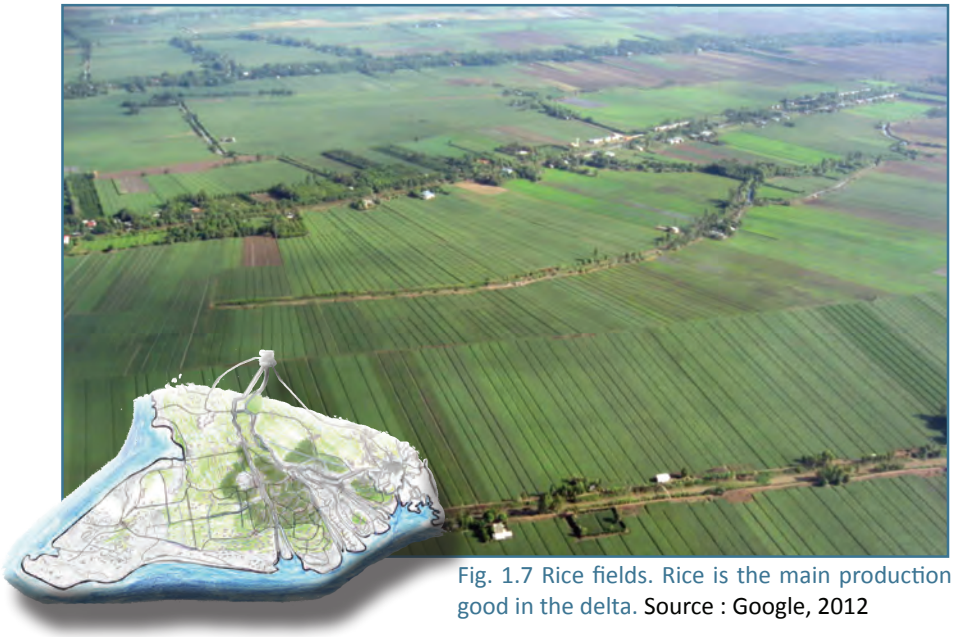


Fig. 1.7 Rice fields. Rice is the main production good in the delta. Source : Google, 2012

Fig. 1.8 Aquaculture producing fish, shells and shrimps along the shores. Source : Google, 2012

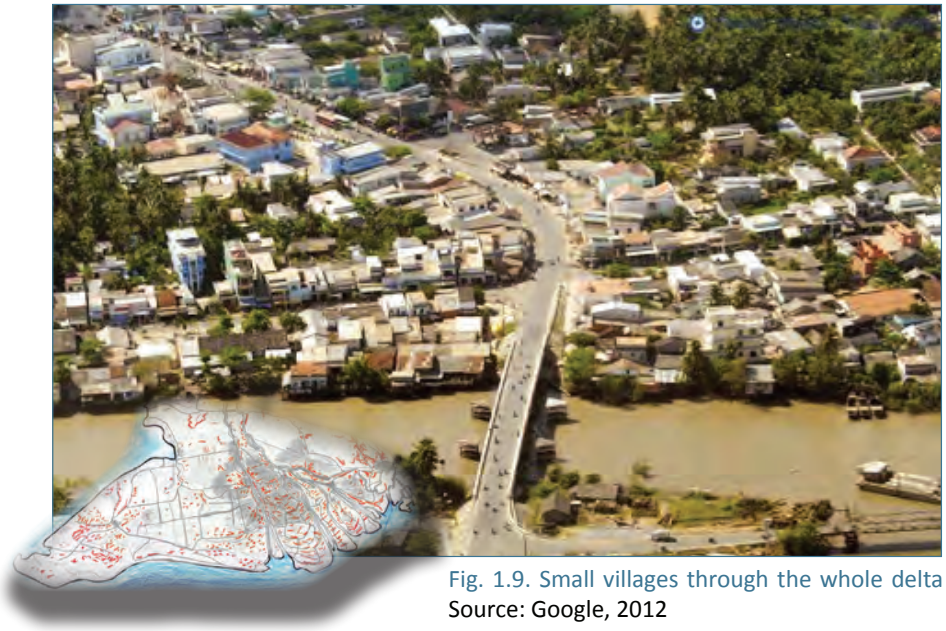


Fig. 1.9. Small villages through the whole delta
Source: Google, 2012

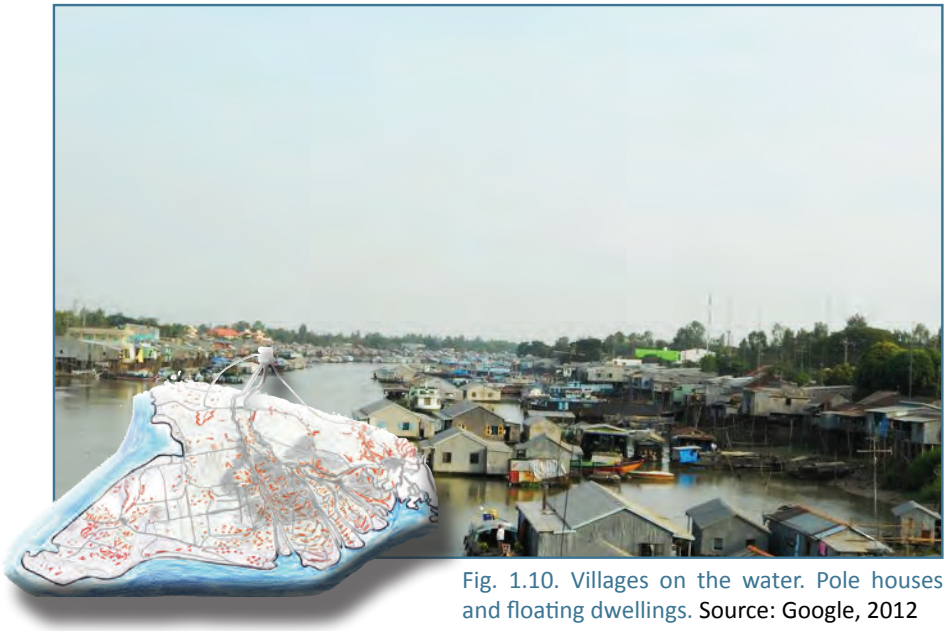


Fig. 1.10. Villages on the water. Pole houses and floating dwellings. Source: Google, 2012

Fig. 1.11 Big cities with high densities in the urban area.

Fig. 1.12 Big cities are growing through agricultural soils.

Geomorphological forming of the Mekong delta

15 000 Years ago, the Mekong delta was probably even larger than its current size. The main land of current Indochina was much larger, but when sea level rose around 7500 BP the peninsula became smaller. 1500 Years later, the current Mekong river delta was almost vanished due to the high sea level of that period. When the sea level lowered again, sedimentation from the Mekong river heightened the area around the river mouth. This takes place because the water speed decreases in the delta because rivers become broader resulting that sedimentation sinks quicker to the bottom.

Nowadays, the Indochine peninsula is growing towards the sea again at the location of the Mekong delta. Each year, about 160.000.000 ton of sediment from upstream is deposited in the Mekong delta. This has not changed significantally for the last 3000 years (Pham and Pham, 2011).

Delta type

The delta is very flat with height differences of max. 5m. The water fluctuations in the delta are mostly caused because of the tides, although the influence of the rivers and waves from the sea also have their impact as well. (Syvitski, 2009). The expanding shape of the rivers in the delta is also characteristic for a tide dominated delta.

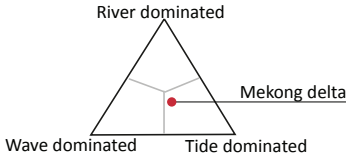


Fig. 1.13 Location Mekong in delta triangle. (Source: Syvitski, 2009)

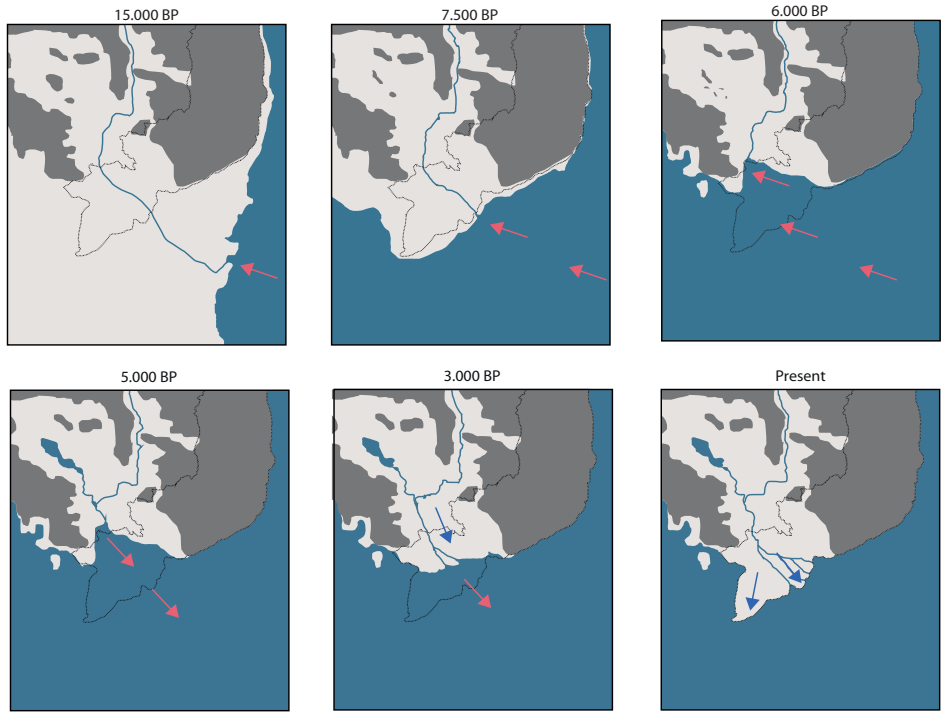


Fig. 1.16 Growth and shrinkage of the Indochinese peninsula through time. Source: Delta Interventions Studio, 2011

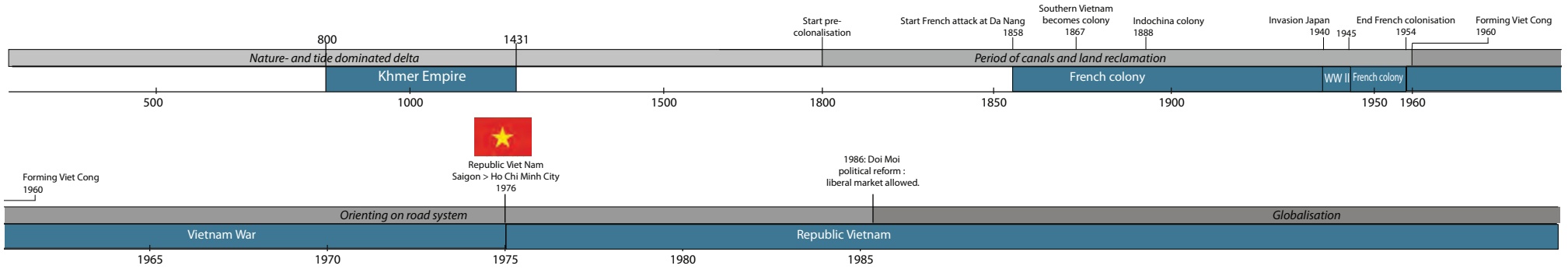


Fig. 1.14 Timeline with most relevant evenys in the history of the Mekong delta

History

The Mekong Delta was likely inhabited since prehistory; the empire of Funan and later Chenla lived in the Mekong Delta for centuries. Archaeological discoveries at the peat hills at Oc Eo near the border with Cambodia and other Funan sites show that the area was an important part of the Funan Kingdom, bustling with trading ports and canals made in the first century and the Funan settlements in the region may have gone back as far as the 4th century before Christ.

Later on, the delta region was known as the Khmer Empire, which probably has settlements for centuries before its rise in the 11th and 12th century. At the end of the 13th century the kingdom of Champa, though mainly based along the coast of the South Chinese Sea, expanded west from the sea into the Mekong Delta, seizing control of 'Prey Nokor,' the former Saigon or Ho Chi Minh City.
Beginning in the 1620s, Khmer king Chey Chettha II allowed the Vietnamese migrating from the north of the country to settle in the delta. The increasing amount of Vietnamese settlers who migrated overwhelmed the Khmer kingdom, weakened as it was due to war with Thailand, and the area became slowly Vietnamized. During the late 17th century, a general began to expand Vietnamese and Chinese settlements even deeper into Khmer lands and in 1691, Prey Nokor was occupied by the Vietnamese and its name transformed to Sai Gon.

In 1858 the French arrived in Vietnam at Da Nang, a city situated north of the Mekong delta, the start of a turbulent time in the delta started. During the French colonial period, the French patrolled and fought on the waterways of the Mekong Delta region in order to keep control over the region. The Mekong delta was a part of the huge French colony Indochine till 1954 (with a small break in the Second World War when the Japanese took over control in the region for a short period). The country was divided in the Communistic north guided by their leader Ho Chi Minh and a democratic south. Ho Chi Minh launched a guerilla campaign in South Vietnam, led by Viet Cong units, with the goal of uniting the country under communist rule. The United States, seeking to stop the spread of communism, trained the Army of the Republic of Vietnam (the democrats) and provided military advisors to help combat the guerillas and the much discussed Second Indochine War took place from 1959 - 1975. Disabled people and children affected by Agent Orange are the still visible consequences of this war.

Following independence in 1975, the Mekong Delta was part of the Communistic Republic of Vietnam, but in the 1970s, the Khmer regime from Cambodia attacked Vietnam in an attempt to reconquer the Delta but this lead to a complete downfall of the Khmer. (Timeline: See fig. 1.14)

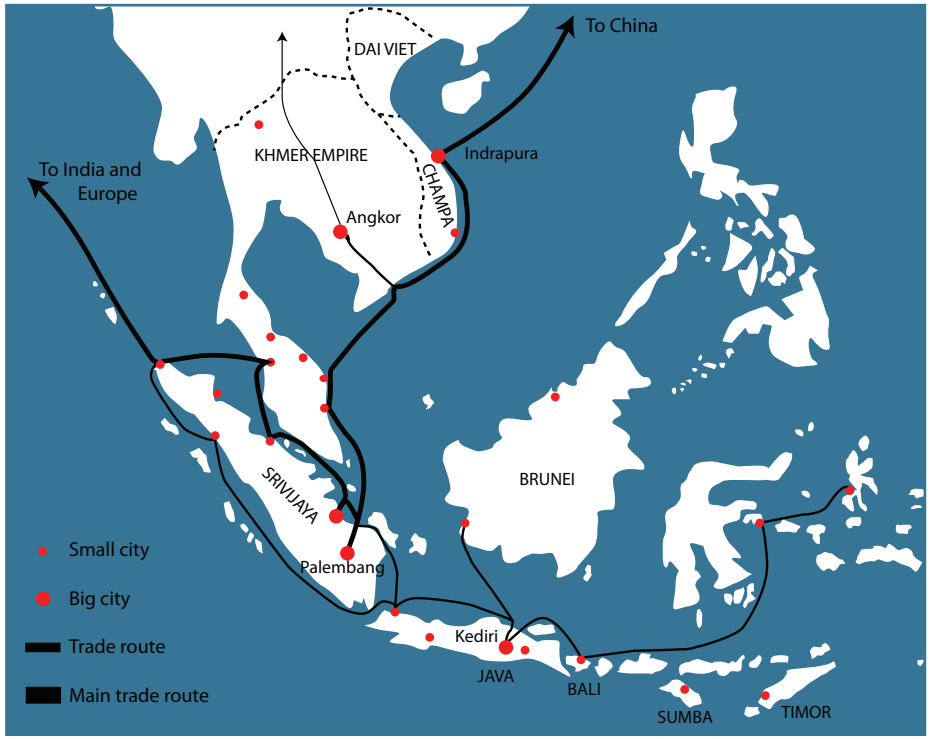


Fig. 1.17 Early trade routes in South East Asia

Fig. 1.18 American soldiers in the Mekong delta. Source: Google Images, 2011

CURRENT DEVELOPMENTS IN THE DELTA

(This chapter is based upon theory and the 3x3 analysis from chapter 3).

1. Urbanisation: growth of cities

17 Million people live in the river delta what is about 22% of Vietnamese population. Another seven million people live nearby the delta in the largest city of Vietnam, Ho Chi Minh City (or Saigon) in the Saigon delta. Currently almost 80% of the inhabitants of the delta lives in rural conditions. One of the trends in the Mekong region (and in Asia as a whole) is the rapid transformation from rural settlement into cities. Furthermore, in the South East Asian cities the economy, industry and service sectors are currently growing quickly. Nowadays, the population of Vietnam grows with 1,1% a year while the urban population grows with 3% a year (World Bank, 2009). Some Mekong delta cities are predicted to double their size in the coming 20 years and besides growing cities also more industralisation occupies more space of the delta landscape (World Bank, 2010). On the pictures on the right is shown the city Can Tho in the heart of the delta is the largest and quickest growing city of the last 10 years in the Mekong delta running up to million inhabitants followed by Long Xuyan and Rach Gia. (Ho Chi Minh City is not included).

Growth brings problems. These problems are familiar to all areas in the world. Overcrowding, not provided extra housing and the unplanned creation of slums in the cities. Extra housing can not be provided and the result is extra overcrowding and the creation of (new) slums in- and outside the city. (Hall, 1977). In relation to Mekong delta cities, this expansion is taking place in the low lying and flood prone areas because the higher places are already urbanized. This makes the poor also the most vulnerable for flooding. (Pham and Pham, 2011). Meanwhile, the uncontrolled urban sprawl grows towards (agricultural) landscapes and are a threat for the food production and environment. Densification of the cities lead to stinking rivers because they are used for sanitary. These sewage-rivers are finally disappearing leading to impermeable soils what makes rain water can not intrude in the soil what results in further flooding during a heavy rainfall. See fig. 1.20. (For more details see 3x3 analysis Mekong delta).

2. Social and economical challenges

This growth of cities goes together with a quick economic growth and industralisation of the country. The GDP of the country is growing with 6 - 8 % the last 10 years. (Fig. 1.21). This growth in economy started with the 'Doi Moi policy'; the reform of the Vietnamese economics from a communistic to a more liberal market in 1986. This reform had an enormous influence on the socioeconomic development of the Delta because it allowed the Vietnamese people to start their own business again. A growing economy does not only lead to more welfare but also to more difference between rich and poor.

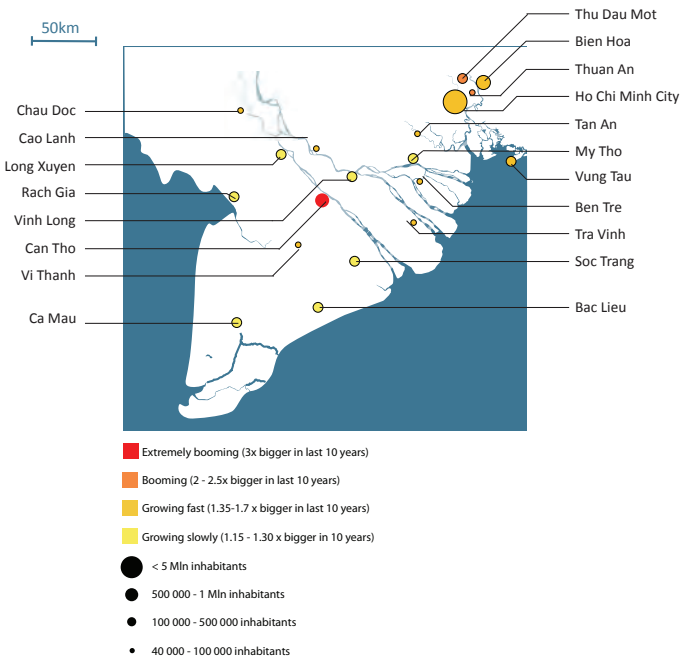


Fig. 1.19 Cities with their amount of inhabitants and speed of growth. (Source: Citypopulation, 2009)

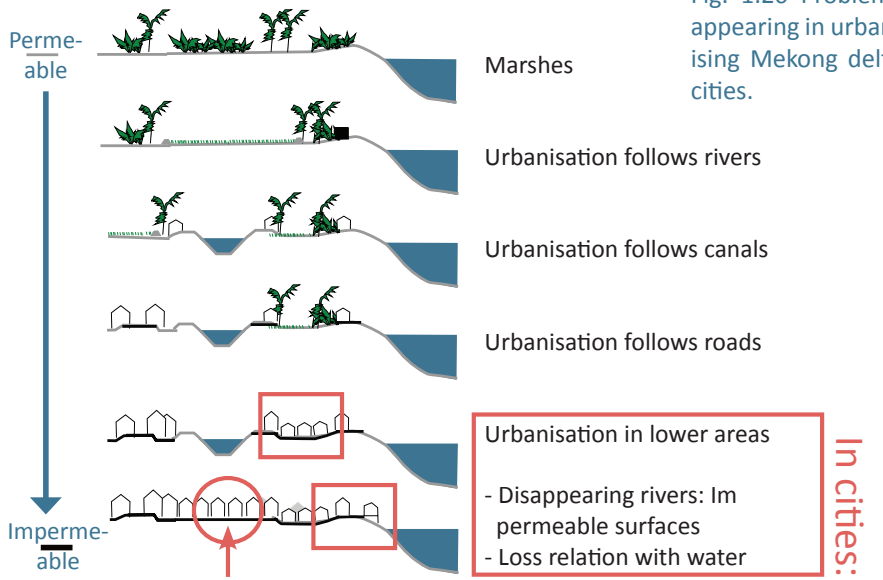


Fig. 1.20 Problems appearing in urbanising Mekong delta cities.

Production

The production of the delta is mostly agriculture. The Mekong delta is also called 'rice belt of South East Asia' what immediately tells the main agricultural product is rice. Vietnam is even second largest rice producing country in the world and the rice is mostly produced in the Mekong delta followed by the Red River delta. One of the most food production areas of the world should remain in order to keep the world food production as high as possible. Other agricultural products are shrimps, shellfish and (tropical) fruits. In figure 1.22 the productive areas in the delta are shown.

Socio spatial segregation

Research done by Ravallion (2002) for the World Bank indicates urban poverty will increase due to the growth of cities. Also Spencer (2010) argues the long term trend towards a growing social inequality is currently in its initial stages in the fast-developing countries of South East Asia. The research focussed on settlement patterns and the risk of the appearance of a permanent segregated urban underclass. This potential social inequality due to several reasons.

Firstly, the weak governments cannot take their responsibility in providing basic infrastructure as water, sanitation and infrastructure. (Spencer et. al, 2008). This is because the metropolitan growth outgrows investments in basic infrastructure. This stagnation affects the poorest people of the community which results in growing poverty, ill health, social tension and pollution of the environment.

Secondly, weak governments lead to unplanned and uncoordinated urbanisation outside the authority of the state, the so-called peri-urbanisation. The appearance of new settlements, slum areas are the first steps towards a more socially unequal world. The absence of basic infrastructure (sanitary and fresh drinking water) in the appearing slum areas actually are not the biggest problems. The long-term consequences threaten the society the most because this social and spatial segregation are hard to solve for the government in the future (Spencer, 2010).

Thirdly, the upcoming private market and political reforms without a strong government further increases the inequality. Globalisation creates polarised cities divided in a wealthy and professional class and an poorer service sector class (Friedmann, 1995 and Sassen, 1998). This causes unequal development resulting in the spatial form of the city, which is possible due to the weak governments (Marcuse, 1997). Gated communities are already appearing in Ha Noi. (Spencer, 2010). Finally, political inequality appears because urban politics becomes dominated by the people whom benefit from growth-oriented policies over the interests of neighbourhoods. (Logan and Molotch, 1987). Furthermore, globalisation creates competition between countries which makes

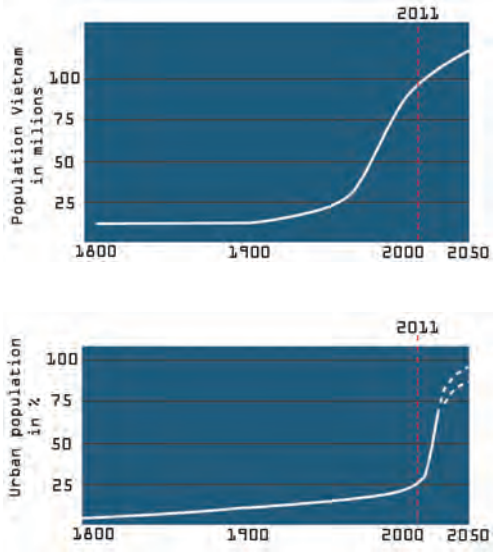


Fig. 1.21 Cities and their speed of growth. Based on: Citypopulation, 2009

Fig. 1.22 Land use in the Mekong delta.

the state, influenced by private investors, invest in an attractive business climate instead of providing basic infrastructure for the labour class.

Friedmann (2007) states that the basic needs of the people that live in a city should be the main asset for a city. Secure and adequate housing, access to healthcare and opportunities for education are the first fundamental rights of people and these points should be the aim of every development. In the perspective of the south east Asian delta cities, danger of flooding and rapid urbanisation are two points which threaten this. In the ideal city of Friedmann (2007), the wishes and needs of 80% of the city inhabitants should be the basic starting point for development. The 15% which need proper roads for their daily activities should not be the standard. If a wave of industrialisation or economic growth leaves the city, a strong basis will remain.

Furthermore, in growing cities the maintaining of a human scale is another social challenge. When cities grow in size, the inhabitants need to find a community or neighbourhood for their long-term stay. These things make the new urban landscapes more human scale and these identities fill the economic and social gaps appearing with the rapid urban development and changes which Friedmann and Martin also call 'place making'. (Friedmann, and Spencer.)

According to Spencer (2010), the ways in which housing, transportation, and environmental policy choices create physical spaces that either integrate or segregate cultural and economic communities in urban Vietnam are particularly important and the main challenge for urban landscape architects and planners.

3. Landscape challenges

The landscape of the delta is nowadays dominated by rice- and fruit farming, small ribbon shaped villages along rivers and the watersides. The mouth to the sea is recognisable by growing aquaculture (shrimps, fish and shells) and of its mangrove forests and large beaches. The most productive area is in the middle of the delta of which three crops of rice can be harvested each year while other regions produce one or two crops a year. (See fig. 1.5 - 1.12). Housing typologies and urban forms were shaped by the delta landscape what is still visible in the current delta cities. These naturally appeared patterns based on the landscape changed enormously in the French occupation in which a huge amount of kilometers canals are built between 1850 and 1950.

Last decades other huge changes took place because of two specific conditions: Firstly, the development of hydraulic works to protect human settlement areas like huge dikes and secondly, the development of a land-based infrastructural network instead of the existing water network. (Pham and Pham, 2011). This process of transformation from water cities into road cities started in the sixties and landscapes 'modernised' quickly.

Fig. 1.23 Poor housing in Can Tho

The traditional boat transport made place for upcoming motorised traffic (mostly scooters, which are able to drive to dry places in times of flooding). Fundamental changes in the landscape took and take place like heightening of dikes transforms the dikes into 'fences', preventing citizens from easily accessing open water. Along these dikes floating houses were removed and reoriented towards roads. (Pham, 2010).

Furthermore, an other kind of expansion than the urban sprawl in the previous chapter, the current modern urban expansion in the South Eastern delta regions often takes place on tabula rasa manner, starting with a blank, heightened up sheet of sand loosing relation with the place and landscape. Although, one of the most important functions in architecture is the expressing of one's own civilisation, stated with the word '*genius loci*' (Mumford, 1962) in order to keep the identity of a place. In the past our chances of survival had a close relation to the place and landscape in which one lived. They gave shape to architecture and urban form. Through time, when cultivating the land people took into account the flooding together with the structure of the landscape to form their built environment (Norberg-Schulz, 1979). Also today the landscape, soil and spatial conditions should give the rules how to built (Palmboom, 2010).

In order to define principles for urban extension in these harsh environments also Lusterio (2009) states that sustainable settlement development in coastal and river areas requires a high respect for the environment and the balance between man and nature. The landscape formed themselves the best on the conditions of the environment and will give solutions for city growth instead of starting again with tabula rasa expansion.

4. Climate and climate change : hydrological challenges

A year in the Mekong delta is divided in a clear rain- and dry season. In the delta the amount of rainfall is very depended from its region and changes between the 1200 - 3000 mm precipitation a year. (The Netherlands: about 700 - 900mm/year). This rain falls in the months May till November in short showers of maximum two hours a day. The temperature in the delta is very constant and fluctuates between the 27 and 30 degrees.

The location in delta areas makes the rapidly growing cities in the Mekong delta a special case. Higher population densities and new infrastructure makes citizens and their economy suffer more from inundation than those who live in the countryside in which flooding has great advantages for the agriculture (Tran and Nitivattanon, 2011). As mentioned before, the city expansions are taking place in the lowest and most flood prone areas because the higher places are already urbanised what makes the poorest people the most vulnerable for flooding (Pham). The areas that are affordable to the poor are typically on hazardous lands, in areas that are deemed undesirable for others. (World Bank, 2011). The already existing water related challenges in the Mekong delta will increase under pressure of climate change.

The climate change trends predict in many regions an increase of flood magnitude and frequency. It makes the weather more extreme, less predictable and heavy storms more uncertain and more often. (Huong and Pathirina, 2011).

You can separate the water challenges in the Mekong delta in four topics: Flooding from the river, flooding from the sea, rain water flooding and ground water level related to the availability of fresh drinking water.

Rain season: Water surplus

About two million hectares of the Mekong Delta is each year inundated by flooding of which one million hectares yearly is inundated by more than one meter while the total surface of the delta is about 3,9 million hectares (Lusterio, 2009). This means 50% if the delta is in danger for flooding each year. Being a low-lying coastal region, the Mekong Delta certainly is susceptible to climate change. This implements the flooded areas will increase in future. (Deltares, 2011)

Although flooding has great advantages for the local agriculture, citizens and their economy suffer more from inundation than those who live in less urbanized districts (Tran, 2011). In the Mekong delta, flooding is caused by high river discharges upstream, from storm and typhoons from the sea and from heavy rainfall described above. Mangroves,

Fig. 1.24 Canal network at the city Phung Hiep located southwards of Can Tho.
Source: GoogleE arth, 2011

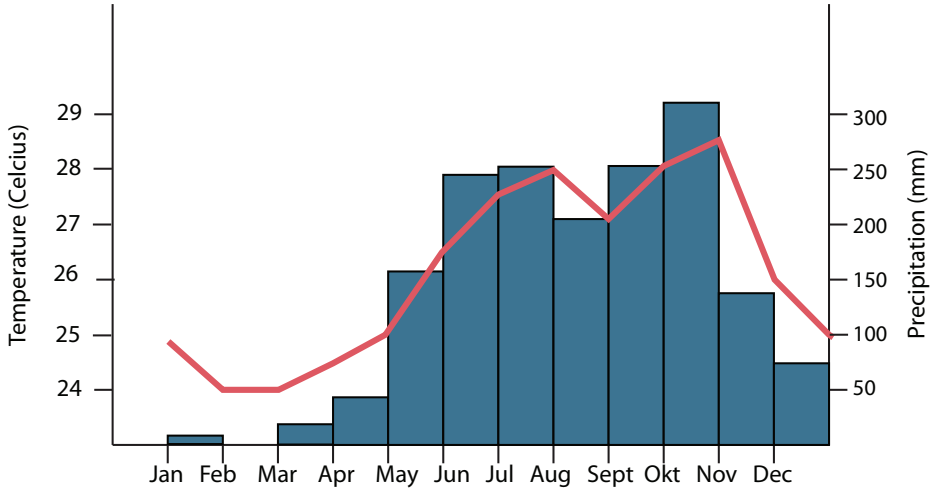


Fig. 1.25 Rainfall and temperature in the city Can Tho. Source: World Bank, 2009

functioning as natural storm surges along the shore, are decreasing due to human activities which increases the vulnerability of delta cities for typhoons and storms (Pham and Pham). Besides economical and social damage flooding can cause, the flooding of polluted rivers due to a growing amount of industries upstream causing more health problems.

- Flooding from the sea (sea level rise)
A global average sea level rise of 9–88 cm is expected over the next hundred years (UNFCCC, 2005). In Vietnam, sea level rose at the rate of about 3mm a year during the period of 1993–2008 (MONRE, 2009a). Based on this the mean sea level rise is predicted to increase for 30cm in 2050 and 100cm by the end of the 21st century as 'worst case scenario' (MONRE, 2009). This worst case scenario is the criteria for the design.
Flooding from the sea is tide depended what means it will only taking place due to high tide (short period).

- Flooding from rainfall and higher discharges upstream
More seasonal fluctuations predict wetter and dryer seasons. The annual rainfall will increase about 5% compared to that of the period 1980–1999 (MONRE, 2009). Between the river delta areas there are huge differences in rainfall patterns fluctuating between 1200mm/year to 3000mm/year. This rainfall falls in a few months and in short and extreme rainfalls of ca. 2 hours. Rainfall combined with high tide typically causes flooding in the Mekong delta.

Dry season: Water shortage: Groundwater, salinisation, acidification, fresh drinking water and subsidence.
Together with wetter monsoon seasons, the dry seasons will become dryer. This results in lower discharges in the delta dry season. Upstream power plant dam projects in China decreasing the discharge in dry season further. The pressure from the sea on rivers declines and saltwater intrudes nowadays already 40 to 50 km inlands. This salinates the delta currently affecting over 1,4 million hectares. (Lusterio, 2009). This results firstly in reduced lands for rice agriculture because of more salty grounds and shortage of fresh water in the rivers. The adaptations in agriculture are made to keep profit in the changing seasonal levels of salinisation. Shrimp aquaculture is growing and also mixed farms with a rice production in wet season and shrimps production in dry season appear already. (Deltares, 2011). Secondly, salt water intrusion in delta areas threatens the fresh water supply together with growing polluting industries. Fresh water shortages lead to the pumping of ground water in the Mekong delta. This ground water pumping results in subsidence of the soil what increases flooding. An other problem appearing in periods of water shortage are acid soils what is bad for agricultural lands. Having fresh water in an area prevents the acidification process.

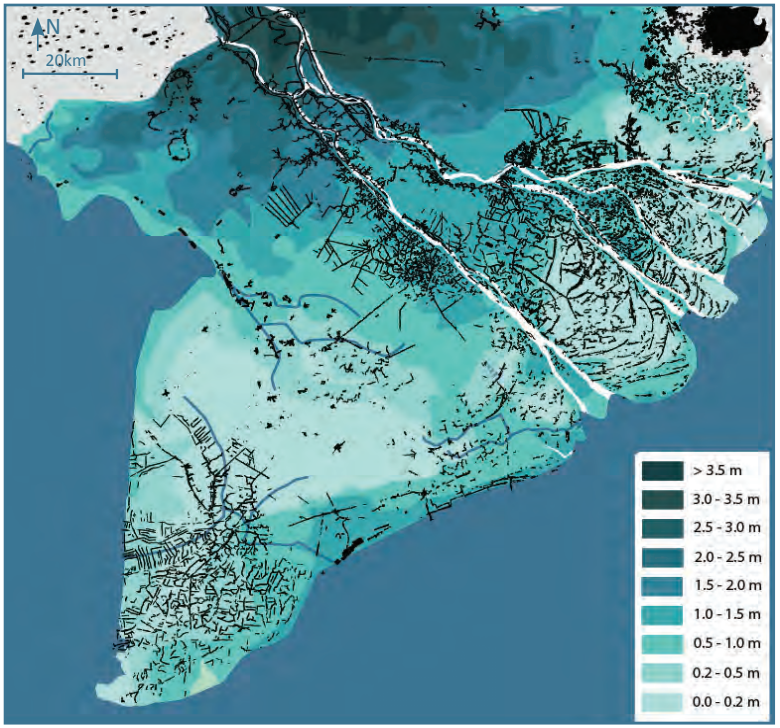
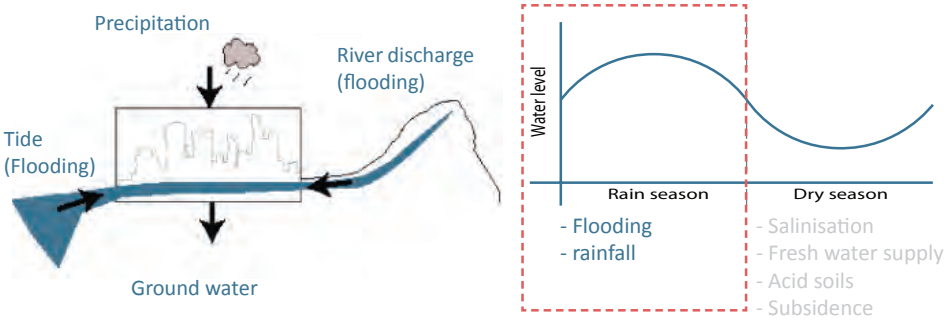


Fig. 1.26 Flooding map based on the year 2000.


Fig. 1.27 Fresh water shortage leads to ground water pumping. Source: Google Images, 2012

Fig. 1.28 Flooding in the Mekong delta. Source: Lansen, 2011

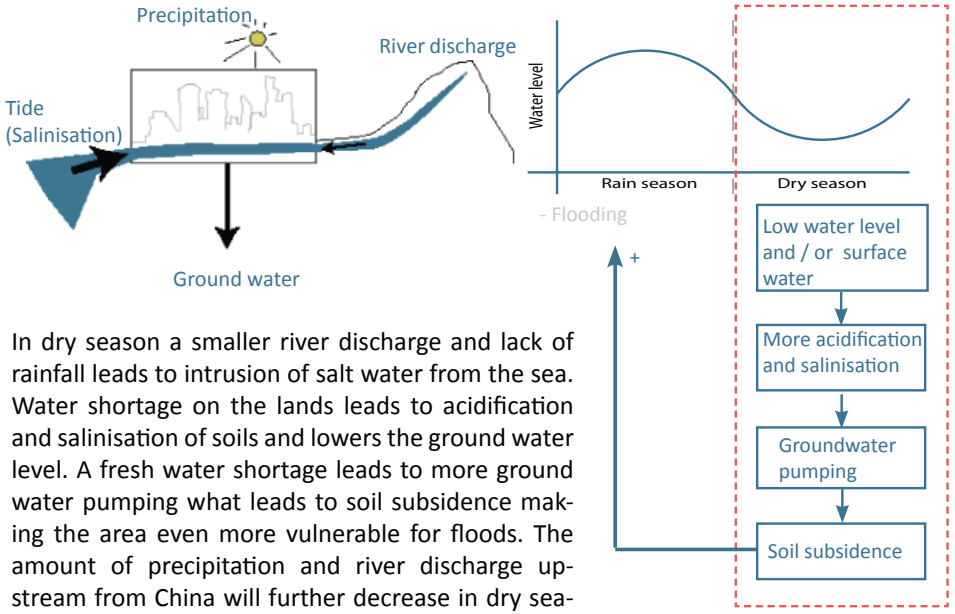
Conclusion the rainy season



In rain season the main problem related to water management are flooding caused by rainfall, discharge upstream and the tide of the sea. All these three influences will bring more water in the future: The amount of precipitation, the river discharge upstream from China and thirdly the sea level will rise in future.

(The ground water level is less threatened in rain season.)

Conclusion the dry season



In dry season a smaller river discharge and lack of rainfall leads to intrusion of salt water from the sea. Water shortage on the lands leads to acidification and salinisation of soils and lowers the ground water level. A fresh water shortage leads to more ground water pumping what leads to soil subsidence making the area even more vulnerable for floods. The amount of precipitation and river discharge upstream from China will further decrease in dry season, sea level will increase in future making salinisation and droughts a growing problem.

Fresh water supply

The saline intrusion and pollution of the Mekong river through growing polluted industries upstream threaten the fresh water supply in the Mekong delta. On the countryside and in sprawl around cities a proper sewer- and pipe system is lacking what forces people to use the Mekong water for cleaning, washing etc and even, if people are not able to buy clean water bottles, they even have to drink it. More and more people become sick of the water. In research done by the WWF, a sustainable management of freshwater ecosystems has provided to improve the poor, most significantly in an increase in income, well-being, and decreased vulnerability. (WWF, 2005). This makes the poor also less vulnerable for flooding. Also Marchant (2011) told the availability of fresh drinking water is the first asset to protect people for flooding.

INTRODUCTION CAN THO

The case study in this project is the city Can Tho which is facing all the landscape, hydrological and socio economic challenges described at the previous pages: a tension between urbanisation and climate change. Her old name is Cầm Thi Giang what means literally 'river of poems.' is the largest and fastest growing city in the Mekong delta. The city is situated in the heart of the delta along the southern benches of the Hau river, (also known as Bassac River) the southern arm of the Mekong delta. This is the river arm which is currently the most used water transportation route. Can Tho is built on a flat terrain with an average elevation of 0.8 - 1.0m with higher natural levees along the water ways. Can Tho has an enormous river - and canal network with a length of 3405 km. The city is a province as well and in size comparable with the Dutch province Flevoland in which about 1.2 million people live on an average density of 827 inhabitants/km2. (Including rural areas). (Source: World Bank, 2009).

The city appeared around 1750 as a strategic point in war in the armpit of two rivers along the higher river banks. iIn times of trade in the 18th and 19th century the city grew because it was located on the trade route to the north of Indochina. (See fig. 1.17) Nowadays, the city is known as the 'Boom Town of the Mekong delta': Prime minister Nguyen Tan Dun signed on June, 24, 2009 a document in what says Can Tho should be transformed from a second-class city to one of the 5 first-class cities in Vietnam (Hanoi, Hai Phong, Hue and Ho Chi Minh City are the other 4) functioning as the economic, cultural, education and medical center of the Mekong delta and also the main transport hub for (inter) national transportation.

The urban growth has resulted in the transformation from permeable land surfaces to large areas which are rain water impermeable. The results are many inner city areas face major problems with drainage. Although drainage systems has expanded, the areas without no storm drains at all quickly become small rivers after even modest rainfall. (Pham and Pham, 2012). (Further information about Can Tho, see chapter 3 and 4).

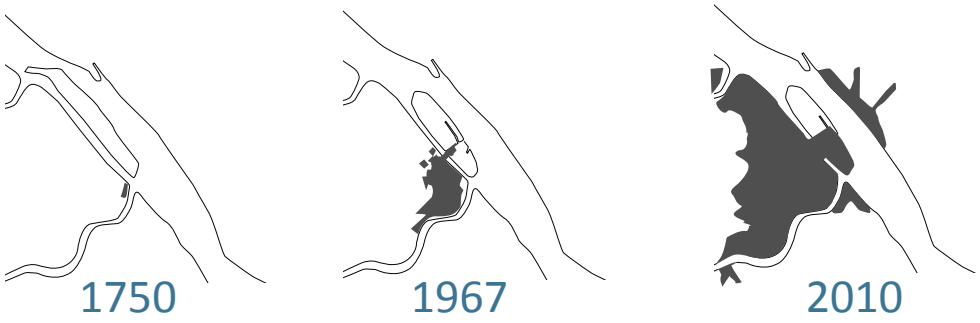


Fig. 1.29 Growth of the urban area of Can Tho

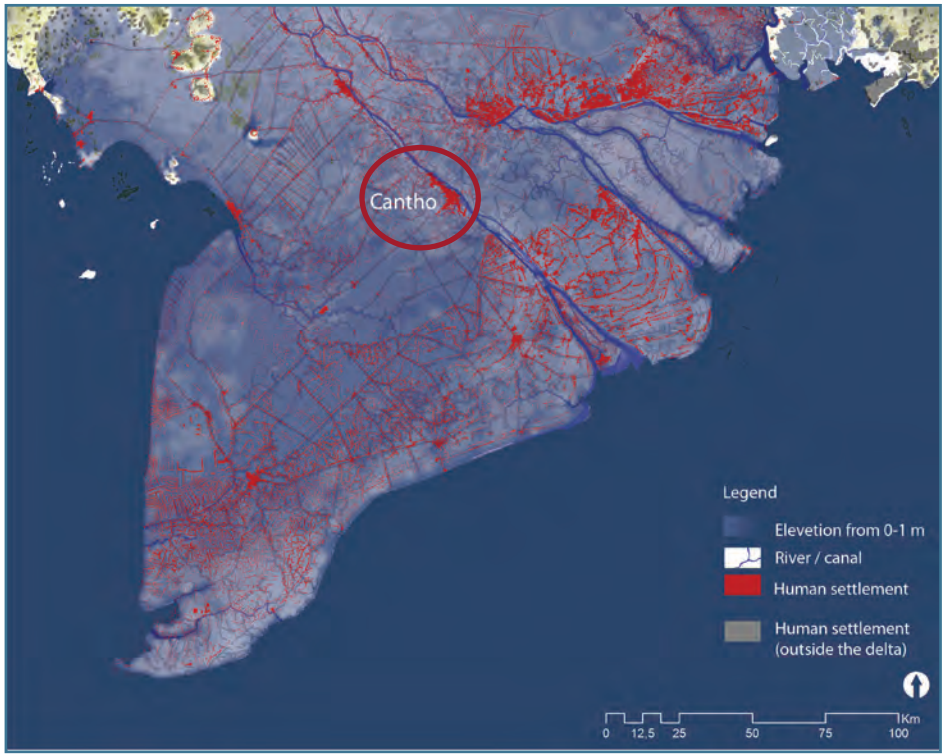
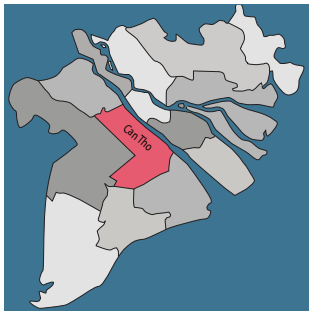


Fig. 1.30 Can Tho is situated in the heart of the Mekong delta along the Hau river.
Source: Pham, 2012



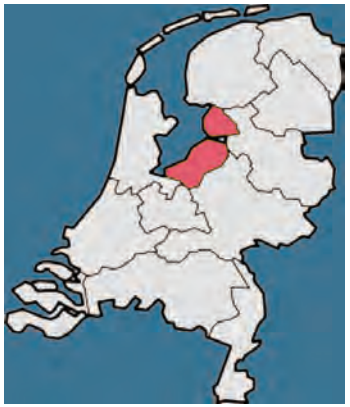


Fig. 1.31 Can Tho province is comparable with the size of Flevoland, The Netherlands

Fig. 1.32 Map Can Tho

This map shows the city and the surrounding allotment structure with their agricultural functions.

Around Can Tho rice fields, crops and fruit trees are harvested on fields which are formed by nature (mostly in the west) and more artificial landscapes (in the east across the river).

Irregular landscapes and along the waterfront harvest fruit trees and crops.

The gray surfaces show new developments.

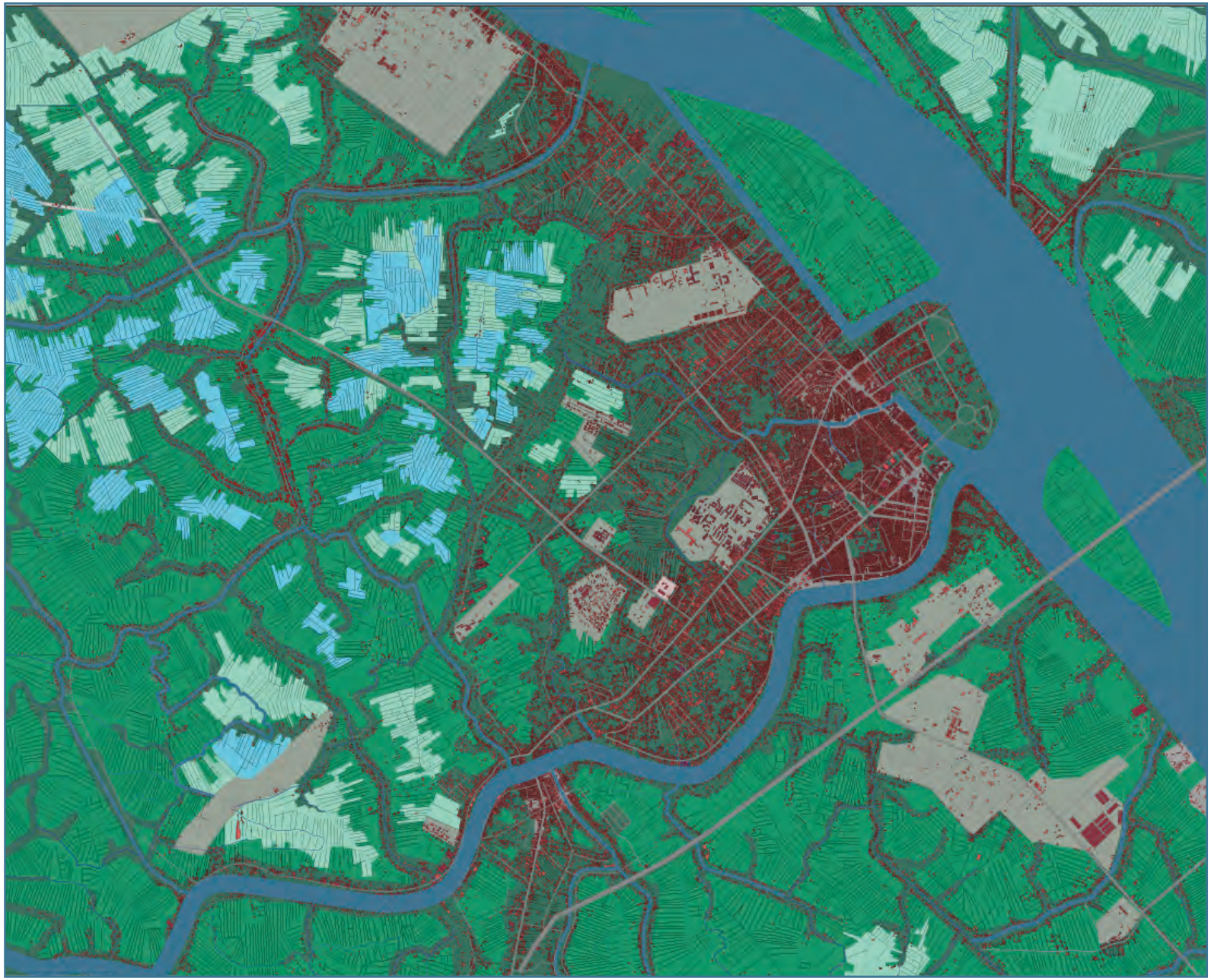


Fig. 1.33 The transformation from a traditional to a modernised society in Can Tho

Also Can Tho faces huge spatial and social transformations. last decades. An inhabitant told 5 years ago the streets were emty after 10.00h pm while today the youth scooters are still crossing along the boulevard after midnight. Traffic, shopping, building typology and work are quickly transforming in the city.

Traffic

from boats and bikes to scooters, but more and more the car makes its introduction in Vietnam.

Shopping

replaces y to shops for long shelf life products. Street markets are still for fruits, vegetables and fresh meat and fish. In the large cities also shopping malls appear.

Buildings

become higher, increasing the density of the cities. The material of concrete is more and more used.

Work

scaling of agriculture and bankruptcy on the countryside brings more people to the city where more and more factories like Nikon and The North Face and a growing service industry provide more jobs.

Fig. 1.34 Bird’s eye Can Tho

Fig. 1.34 Spatial impression Can Tho

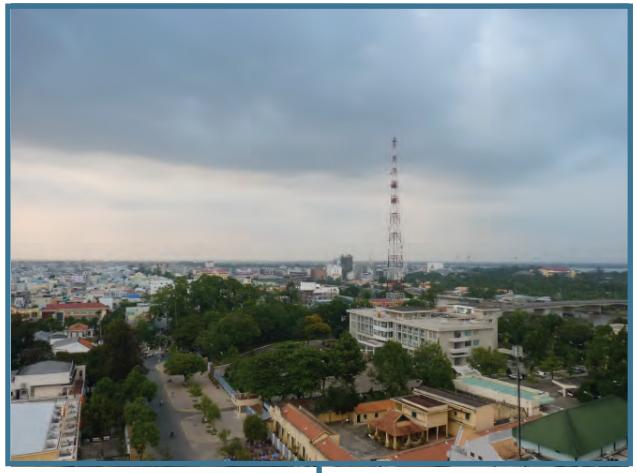


Fig. 2.1 Can Tho bridge finished in 2009

Chapter 2
Implementation

Problem statement
Research question
Aim
Sub research questions
Methodology
Relevance

PROBLEM STATEMENT

Since 2008, for the first time in history, more than 50% of the world's population lives in cities. This worldwide urbanisation process has not yet reached its final form, certainly in the developing world the current building stock has not yet reached its final form. Much of their urbanisation and investments in this building stock is to come in the next few decades. As each city has it's own unique context, there is no single solution for successful planning in response to expand these cities sustainable (Zevenbergen, 2011).

This urbanising development is also taking place in the Mekong delta in southern Vietnam. This area is experiencing a quick urbanisation process and economic growth. The Mekong delta is rapidly urbanising because of population growth and industralisation causing a migration of farmers to the city where there are more jobs in the growing service industry and factories. The delta is quickly transforming from an agricultural society to a globalised and industrialised part of Asia. Meanwhile, large areas in the delta are affected by flooding during the rainy season and suffering fresh water shortages in the dry season. This shows the double complexity in urbanising delta regions: Their location in a delta in context to flooding and climate change and secondly, the rapid growth of cities while they face a rapid transformation from a traditional to a modern and globalised society bringing huge social, cultural and economic changes. (Meyer, 2009).

History showed urbanisation in the Mekong delta took place along the higher grounds and the natural levees of the rivers. Later on, the digging of canals provided new higher grounds to live on. Some decades later, grounds were heightened up to build safe roads which gave also raised grounds next to the road to live safe for flooding.

Current city expansion of the Mekong delta cities results in an uncontrolled and rapid growth of the cities on fertile agricultural soils. Meanwhile, it is taking place in the low lying and flood prone areas because higher places are already urbanized. The lowest parts of the city have a higher risk of flooding and are often the places where the poorest people migrated from the countryside come to live.

Secondly, social and economical challenges are taking place: A growing economy asks for safer cities and while socio spatial segretation is already lurking in South East Asia the growth of slum areas or gated communities should be avoided. (Allowing of the free market in 1976 Free market leads to more income differences).

Thirdly there are the landscape challenges: Current developments show a loss of the relation between the people, landscape and water. Current flood defence developments show protection against water results in fightening against the water, (heightening dikes and plans for storm surges) a very non-Vietnamese approach in which the historically strong relation between water and the Vietnamese inhabitants seems to disappear. Shannon (2009) mentioned in the current economical liberalisation (Doi Moi policy) and transition from traditional to modernity, the water is often neglected in urbanisation and only seen as a technical engineering issue.

At last, climate change and hydrological challenges have a lot of impact of the delta future. Sea level rise and bigger differences between wet and dry season will increase flooding in rain season and drought and fresh water shortages in dry season.

In the city Can Tho (Fig. 2.1 and 2.2):
Current city growth results in disappearing rivers, disappearing permeable soils and a deficient rain water drainage system. These two developments together with climate change results in more flooding in the future..
Uncontrolled sprawl, a growing amount of private areas, no fresh water supply for all inhabitants and a lack of public space and green decreases the living circumstances for a lot of people making them even more vulnerable for floods.
In urbanising areas and in the cities people neglect or even disgust the rivers because of their use as sewage system and garbage bins. Some new city expansions take place on tabula rasa manner. This both results in a decrease in the relation between landscape, water and people. (Genius Loci).

If these developments show up in every Mekong delta city the effects on the delta will be (Fig. 2.3 and 2.4):
- More flooding because rain water can not find it's way into the soil in the impermeable cities and disappearling rivers decrease water storage of the river.
- Further salinisation in dry season and pollution affecting the fresh water supply
- An urban sprawl between the two main cities Ho Chi Minh City and Can Tho through-Vietnams most fertile soils.

That is why

Mekong delta cities are in need for a new way of urbanisation.

Current situation

Fig. 2.1 Current state of Can Tho

Future situation if no intervention takes place

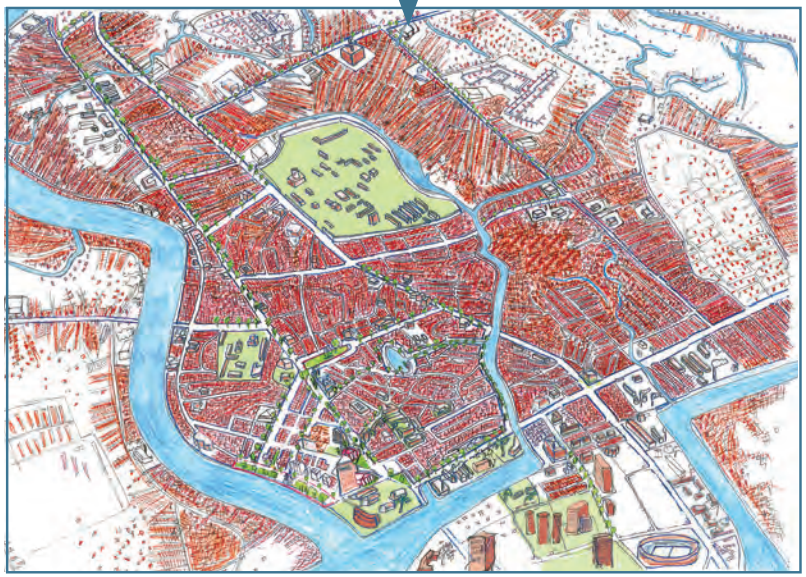
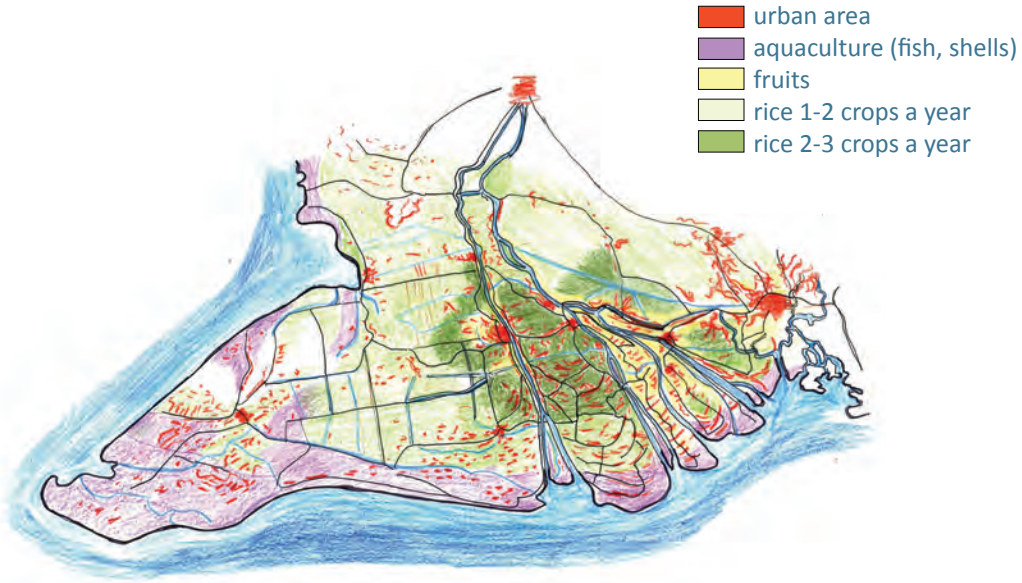


Fig. 2.2 Impermeable soils in cities lead to larger river discharges and increases flooding more downstream affecting the whole Mekong delta.



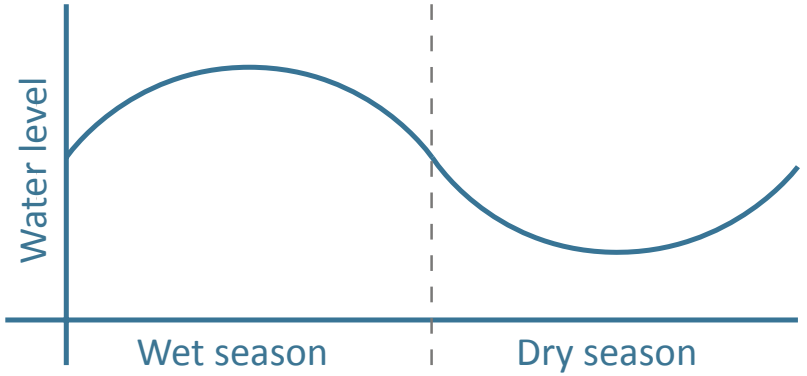
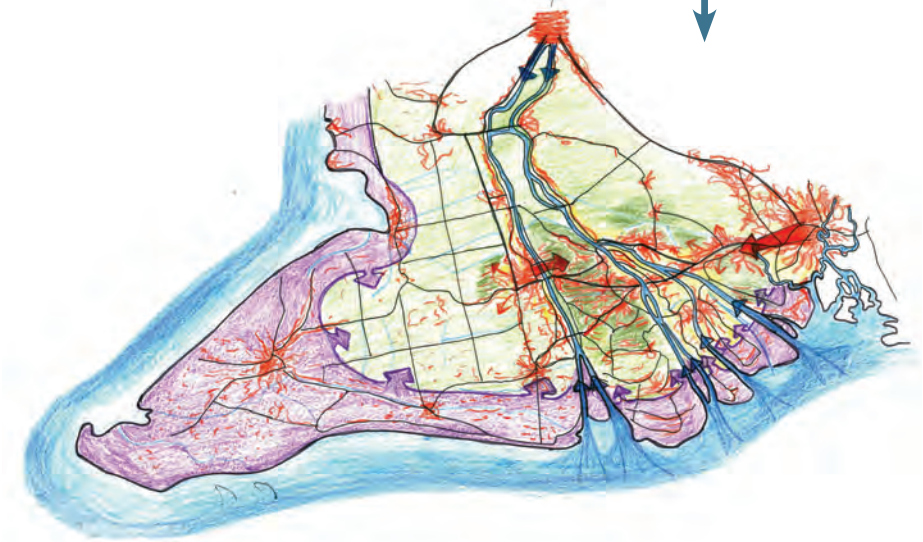


Fig. 2.3 Current state of the Mekong delta



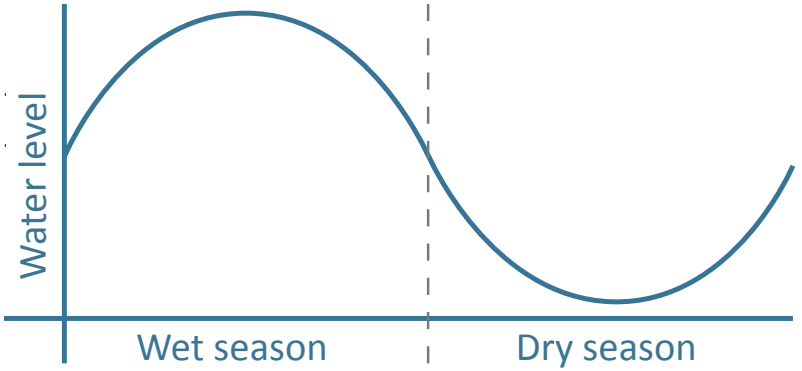
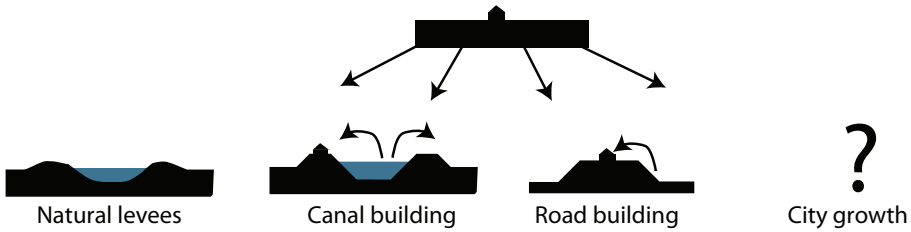


Fig. 2.4 If current way of urbanisation continues, the Mekong delta will urbanise through it's most fertile agricultural soil: The area between Ho Chi Minh City and Can Tho. This threats the Vietnamese food production. More extreme seasons will lead to more flooding in rain season and drought problems and salinisation in dry season.

RESEARCH QUESTION

How can a new spatial structure for the Mekong delta city Can Tho catch up with the city growth, provide water safety and meanwhile improve the living conditions for it's inhabitants?



AIM

Expansion of the Mekong delta cities should transform water as a threat towards an opportunity. Integrating urban design, water management and nature and furthermore using the existing landscape as starting point for design is the way to catch up with the city growth and built for a sustainable, climate proof way of urbanisation.

SUB RESEARCH QUESTIONS

In order to answer the main research question and to achieve the aim of the project the question is divided in several sub research questions which are answered in the following chapters of the thesis:

Chapter 3: 3x3 Analysis

1. What are the characteristics of the delta and how did the Mekong delta changed from a water based to a road based network?

2. How does this transformation take place in the city Can Tho?.

Chapter 4: Spatial, typology and hydraulic diagnosis Can Tho

3. What are the spatial, building typology and hydraulic characteristics of Can Tho and how does this result in problems and opportunities?

Chapter 5: Masterplan Can Tho

4. What can be the solution to solve the appeared problems in Can Tho and how does this reflect on city scale?

Chapter 5: Strategic project and design

5. How does this solution work hydraulically and spatially on the smaller scale?

Fig. 2.5 Inner city Can Tho

METHODOLOGY

The used methods are literature review, case studies, interviews, layer approach, site visit/observation, drawing, modelling and reading/television. They will be described shortly. Furthermore, for each methodology the most important materials / locations will be addressed.

1. Literature study

Through reading of different articles, books, conference proceedings, governmental reports and private institution reports theoretical questions can be answered.
authors:
- K. Shannon - Key author and designer about Vietnam, KU Leuven, Belgium.
- Q.D. Pham - PhD student about the Mekong delta, TU Delft, The Netherlands.
- D. Biggs - His book *Quagmire* describes the Mekong delta from detailed historical perspective.
- J.B. Spencer - Key reseacher about growing social inequality in Mekong delta cities.
- J. Friedmann - Growing social inequality in cities.

Institutes:
World Bank, United Nations, Delta Alliance, Deltares, Wisdom Project Germany, Can Tho University.

2. Case studies

Case studies are empirical inquiries that investigate a phenomenon or setting. (Groat and Wang, 2002). To focus on one or more specific parts in a plan, design or project you can investigate and discover why things are as they are. It is important to limit a case study clear on what you want to know because you can probably analyse a thousand things on one project. In the project two types of case study series are done.

The first case study series were done in order to understand the context of the Mekong delta as a whole better and to investigate how Vietnamese settlements protect themselves against flooding.
Soc Trang: Soc Trang is a good example on the effects of canal building and later on road construction on a city.
Long Xuyen: Long Xuyen is a city about 50 km upstream of Can Tho. Long Xuyen is much more affected by flooding because the city is on the border of the Plain of Reeds, a natural floodplain at the north west part of the delta.

The other case study series are already more towards solutions. These two case studies are examples of the two most appropriate flood defence systems for the future of Can Tho.
Super levee Tokyo: Since 1985 Tokyo is transforming its levees to super levees. Besides flood prevention the new dikes give a huge new urban quality to the city.
Adaptation in the traditional Southeast Asian settlements: Adaptation is the accepting of floods and the opposite of building dams and storm surges. Housing typologies and public spaces can reduce the negative effects of flooding. This case study shows traditional examples of adaptation from South East Asia.

3. Interviewing the experts

1. Marcel Marchand, Deltares, responsible for Mekong delta in the 'Delta Alliance' about the Mekong delta and it's problematics as a whole.
2. Dick Kevelam, Leading professional Coastal Development, DHV whom I met in Hanoi and is heavily involved in the Mekong advice. We spoke about scenario's in the Mekong delta, and water systems and future of the delta.
3. Dieu Quang Pham, PhD student at TUDelft on the urbanising Mekong delta.
4. Fransje Hooimeijer, teacher at faculty of Architecture, TUDelft, on urban water systems in relation to spatial quality and culture.
5. T. Baccini, teacher at faculty of Architecture, TUDelft about urban water systems.
6. Enrico Moens, Manager climate and sustainability at Grontmij, working on the project 'Ho Chi Minh City towards the sea.'
7. Sybrand Tjallingii, former ass. professor in Urban planning and Environment at TU Delft, Faculty of Architecture about urban water systems, water treatment systems.

4. Map making

There is a lack of proper maps and data of the delta and from Can Tho as well. Clear map making is important to understand and analyse the context. Nonetheless, not all information (like a detailed height map) is easily to get from a country as Vietnam.
Most important maps are: Flood map, soil map, height map, built surface, infrastructure, allotment of the agricultural fields.

5. The layer approach, 3x3 analysis

The layer approach is a very proper way to discover problems and relations in an area. The most known layers are occupation, infrastructure and landscape, but you can make layers to understand spatial relations in a city.

6. Site visit/observation and photograph analysis

The trip to Vietnam was for me the first Asia journey and was a very exiting experience for someone who has never been in a developing country. Observation of the site is the best way to understand the context and to gather information. This helped me very well in the project. The atmosphere of a place, culture and use of spaces is not understandable from maps or documents. Analysing photos and highlighting the most important elements give insight in the city.

7. Drawing and model building

Drawing helps to analyse and design and finding out new things and to discover more than just watching a map or photo while analysing. In the design project you can quickly investigate the relation between buildings and water through drawing sections, 3d's and maps. Through making your own maps you are able to understand the problems better and you are able to find more details than the copy - pasting images. Research by design is the method to reach the final design product through finding solutions through drawing. Furthermore, testing of the design on your starting points for design is a continuous process to stay focussed on your aim.

8. TV Series / movies / books

For me, the Mekong delta is a very unknown and exotic place. Besides pictures and descriptions from books or articles it is hard to imagine how the daily activities and problems in the delta take place. Watching documentaries like 'Als rivieren konden vertellen'(*If rivers could tell*), a serie about life in Mekong river at Nederland 2, movies about the Vietnamese war (Apocalypse Now, Deer Hunter) or reading a novel about Vietnam give useful information to get into the topic. These sources give impressions of culture and the daily way of life in the Mekong delta.

Methodology schedule

The project started with the understanding of the Mekong delta as a whole. Reading books, reports and papers and analysing the historical development, relation between soil, water and urban patterns showed several typologies in the delta. In order to understand the delta as a whole in practice, case studies, comparisons and a 3x3 layer analysis of the delta are done. The two cities Long Xuyen and Soc Trang showed the strong influence of the landscape on the built environment and how urbanisation changed through time. Comparisons between the Daugava delta (Latvia), Rhine Meuse delta and Ems delta (both The Netherlands) showed differences in delta type, cultural differences and (urban) landscape differences between delta's. An example is the cultural difference in the relation with water between The Netherlands and Vietnam; while flooding is more or less accepted in Vietnam, all the Dutch are complaining when their basement is flooded after a heavy rainfall.

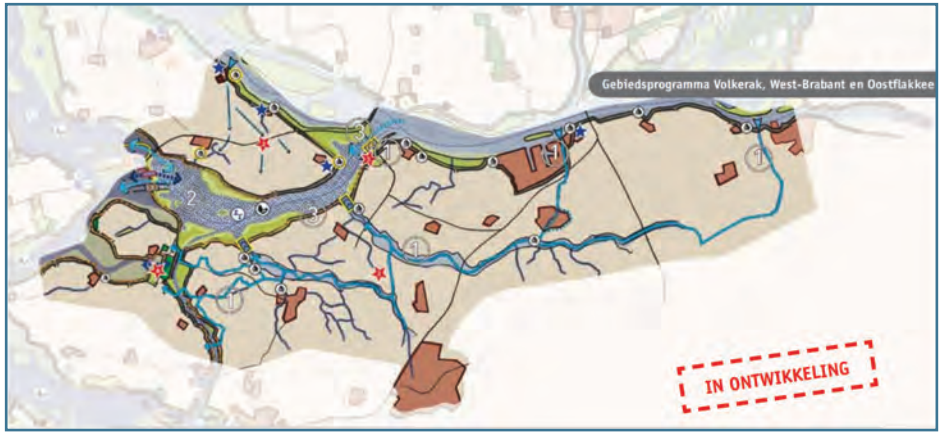
These first analysis and theory research lead to the first general problem statement and showed Can Tho is one of the key projects in the Mekong delta because all delta problems appear in this city. The next step is analysing and reading more about Can Tho. A field trip, spatial analysis, a typology research, hydraulic analysis in relation to climate change gave the design principles ('uitgangspunten') for the masterplan and a key project on smaller scale. (The next page shows the followed methods).

RELEVANCE

Soon, not only the Dutch delta, but also the Vietnamese Mekong delta will get a Delta Plan made with the aid of the Dutch. At 28 September 2011 Nguyen Tan Dung, the prime minister of Vietnam, visited The Netherlands to strengthen the economic trade between the two countries and to strengten the cooperation in the field of water management and climate change. Both the prime ministers of The Netherlands and Vietnam signed an agreement on the field of water and climate to work intensely together (Rijksoverheid, 2011). My project will contribute to this project from an urban perspective.

Comeback of the creek system

Current urbanisation and city expansion (see 'tabula rasa expansion' in the chapter 'building typology analysis') in the Mekong delta results in a loss of the creeks in cities because of pollution and urban pressure. The loss of the creek system results in further flood problems because rain water can not be drained off on a natural way. and fresh water can not be stored anymore. In the Dutch Rhine Meuse delta creek systems also disappeared the last centuries. In new delta plans in for example the Oostflakkee the comeback of the creeks is a key issue because the creek system will improve sweet water storage, ecology, rain water runoff and recreation. This shows the natural creeks have a very important function and they should be remained in the urbanisation of the Mekong delta cities instead of disappearing slowly. (Stuurgroep Zuidwestelijke Delta, 2011) My project contributes to the remaining of the Mekong delta creek structures.



Location of the old creeks

Fig. 2.6 Oostflakkee 'comeback of the creeks' development plan, The Netherlands.
Source: Stuurgroep Zuidwestelijke Delta, 2011

Methodology schedule: The project started with delta scale research in order to understand the Mekong delta complexity. This is done by reading theory, making comparisons with other delta areas, interviews and for an urban perspective view in the delta 3 case studies of the cities Long Xuyen, Soc Trang and Can Tho to. A 3x3 analysis gives insight in the development and possible future developments in the Mekong delta.

The definition of the general problem becomes the result of the first analysis and the case Can Tho seemed to be the best city to use as key project in the graduation because in this city the problems are the most relevant. In order to sharpen the general problem statement there is more insight needed in the city Can Tho itself. A 3x3 analysis, a socio-spatial, typology- and hydrology analysis made with maps, photos, reports and side visit made the problem statement more specific. The analysis also gave the principles for planning and design. This led to a city-scale solution for Can Tho and more and more, designing becomes more important than research. A key project in the masterplan shows how this plan works on smaller scale. New research to water treatment systems, physical environment and calculations are needed to find the most suitable solution. Information about policy and land use gives tools to understand how a project can also be realisable in Vietnam.

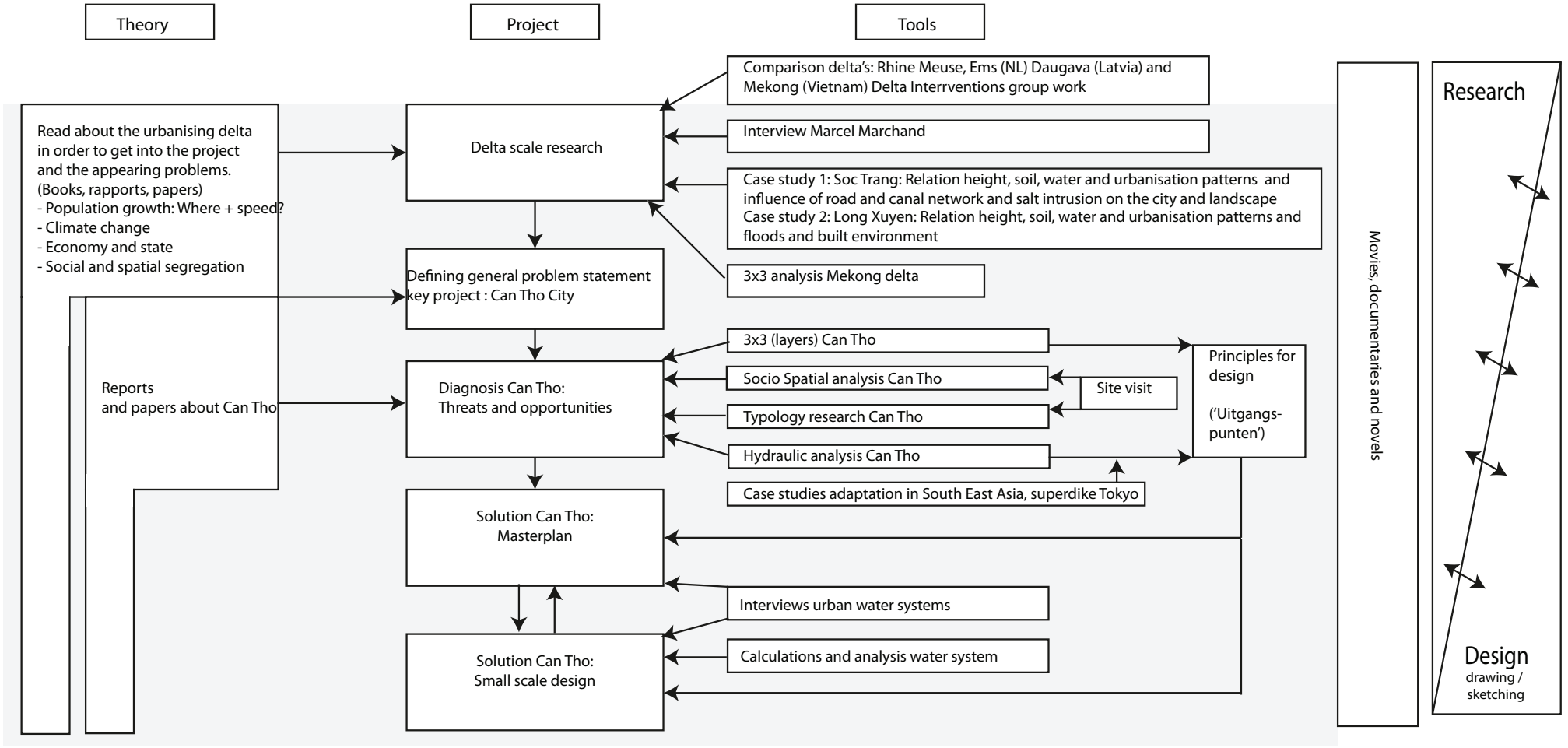


Fig. 2.6 Methodology schedule

Academic relevance

The interest of an integrated approach between urbanism, landscape and civil engineering gains a lot of attention nowadays. (Hooimeijer, 2011, Meyer, 2008, Shannon, 2009, Stalenberg and Vrijling, 2009). Although the problem is set on the agenda, the implementation is hard. This project will contribute to this issue and shows a solution working with several disciplines together. This will end with an integrated project what covers water safety, improving living conditions and landscape development.

Social relevance

In the period 1999-2009 about 4000 registered people are killed by floods in Vietnam. About 20% of the Vietnamese inhabitants were affected and almost 200 000 people became homeless due to these floods. The economical damage is estimated on US$2.758.525.000,00. (Pham, 2011b). With predicted climate change these numbers will only increase in future if no intervention takes place.

Secondly, growth brings problems. These problems are familiar to all people in the world. Overcrowding with not provided extra housing creates unplanned slums in- and outside the cities (Hall, 1977) creating social and spatial segregation. Spencer (2010) argues the long term trend towards a growing social inequality is currently in its initial stages in the fast-developing cities of South East Asia. Furthermore, In relation to delta cities, this expansion is taking place in the low lying and most flood prone areas because the higher places are already urbanized. This makes them also the most vulnerable for flooding (Pham, 2010).

While Can Tho is predicted to double in size in the coming 20 years (City population, 2009) it is important to react quickly to avoid these problems. Avoid it is better than cure. Also the fresh water supply and sanitation facilities are lacking resulting in poor living circumstances and will press down the economic growth of the country. These problems are predicted to occur in more big cities in Vietnam (and in South East Asia).

Furthermore, in order to maintain the economic growth in the country companies and factories which provide jobs, should be triggered to invest in the Mekong delta as well. If areas are often flooded, what causes enormous economic and social damages, investors will avoid the delta and will settle in surrounding countries.

Concluding: the quick urbanisation process should be designed properly in order to prevent unacceptable flooding and to avoid social and spatial segregation in future.

Fig. 1.20 Prince of Orange with Prime minister of Vietnam making appointments about further cooperation at 28 September, 2011
Source: Google Images, 2011

Fig. 1.21 Flooding in South East Asia in the press, October 2011
Source: www.nu.nl, 2011

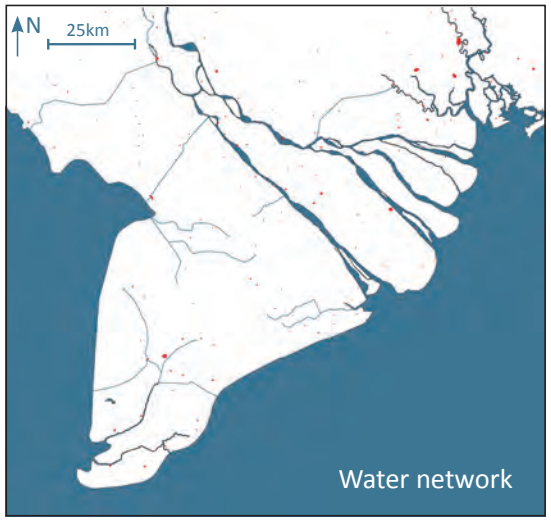

CARTE
DE
L'INDO-CHINE ORIENTALE
DRESSÉE PAR Mr. J.L. DUTREUIL DE RHINS
PUBLIÉE
Sous le Ministère de Mr. le Vice Amiral JAUREGUIBERRY
Au Dépôt des Cartes et Plans de la Marine
en 1881
Les travaux qui ont servi à dresser cette Carte sont ceux des Ingénieurs Hydrographes, des Officiers des diffé
corps de la Marine, des Missionnaires et des Voyageurs Français, Anglais, Américains, Allemands et Indigèn
Voir l'avertissement géographique et orthographique.
Cette Feuille est la réduction de la Carte à grande échelle.
Echelles Kilométriques moyennes.
MINISTÈRE DES COLONIES
SERVICE GÉOGRAPHIQUE
Map Division
3 - APR 19
Library of Cong
1:2.000.00
BASSE COCHINCHINE
PROVINCE DE BIGNE THOUAN
BOUCHES DU MÉKONG
Poulo condore
SAÏGON
CHOLON
BARIA
BIÊN HOA
MYTHO
VINH LONG
CHAU DOC
HA TIÊN
RACH GIA
SOC TRANG
TRA VINH
BEN TRÉ
TAY NINH
THOU DAU MOT
NGOARS
STIENGS
MER

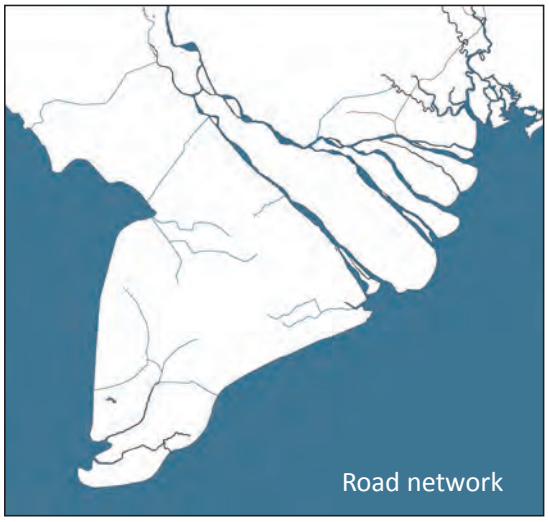
Chapter 3
3x3 Analyzes

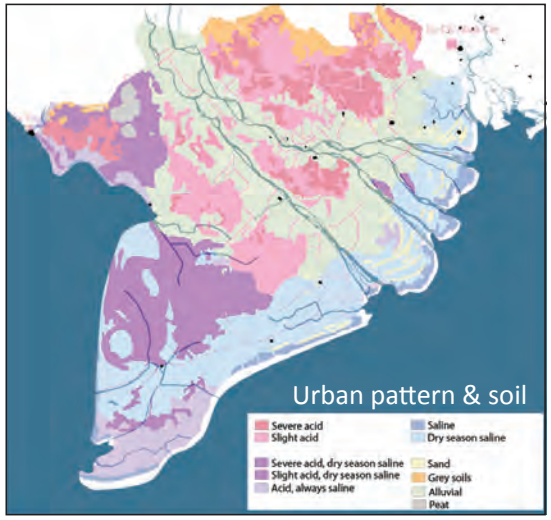
In this chapter the 3x3 analysis of the Mekong delta and the city Can Tho are shown in order to understand the development of these areas and to predict further development. The chapter starts with the 3x3 about the Mekong delta based upon old maps from the Indochine and the American period and current soil- and height maps. A summary shows the most important conclusions. Two cities (Soc Trang and Long Xuyen) and landscape types are zoomed in in order to show the strong influence from the landscape on the built environment.

The 3x3 analysis of Can Tho gives further insight in the appeared hydraulic and social problems of today. The chapter ends with the landscape component of Can Tho with the characteristic Vietnamese rice fields because landscape gives in my approach important starting points for design.

3x3 MEKONG DELTA : 1850







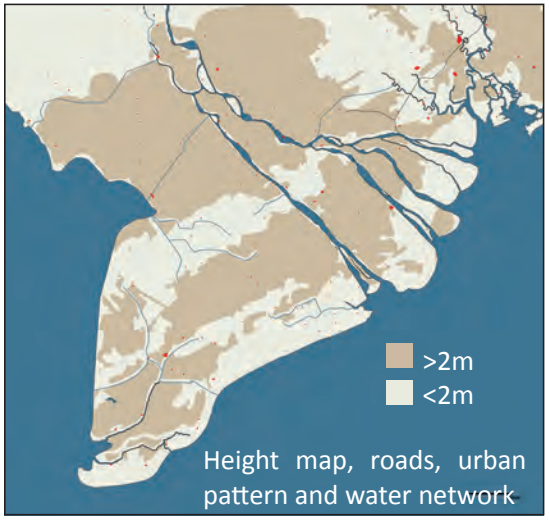


Fig. 3.3 Mekong delta 1850, current soil and height map

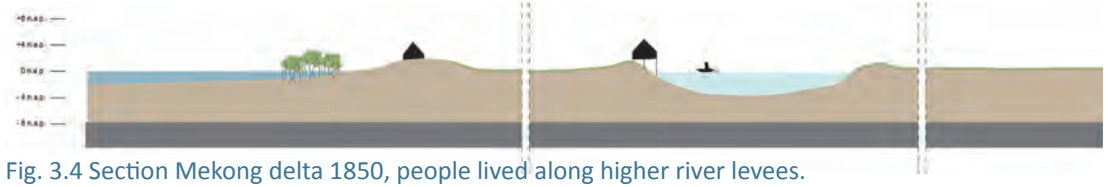


Fig. 3.4 Section Mekong delta 1850, people lived along higher river levees.

Fig. 3.3 - 3.5 The first known settlements of the delta were the Ankor empire in the North, Ca Mau area in the south and around Ho Chi Minh City. Later on, 1750 Can Tho was formed in 1739 as a strategic location in the delta and the cultivation to the west started. 1850 the delta was inhabited by several bigger clusters of urbanisation and scattered fisherman and farmers. The first road connected My Tho and Ho Chi Minh City to the north. Can Tho and Ho Chi Minh City became the main trade cities for transport between overseas countries and the hinterland of Indochina.

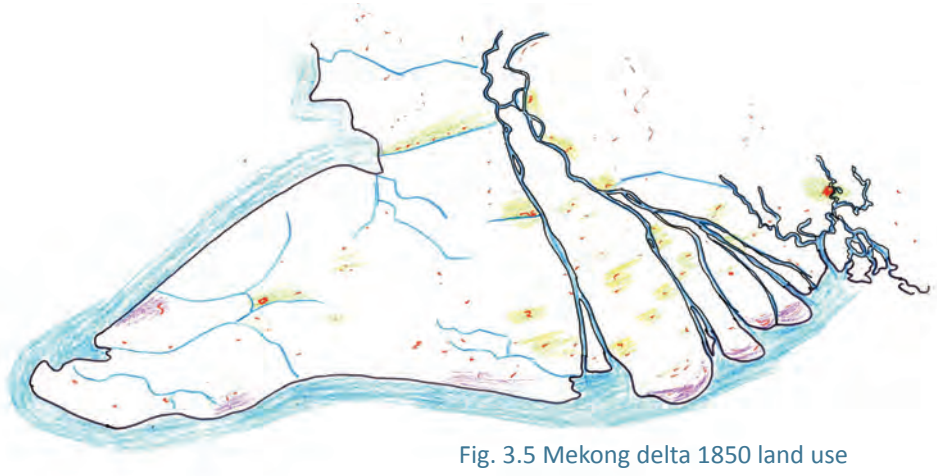
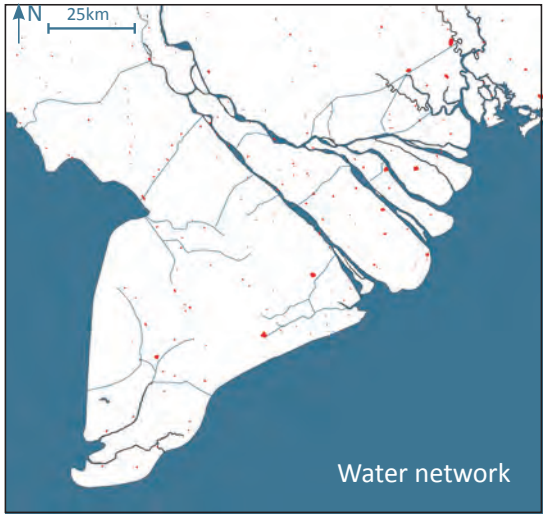
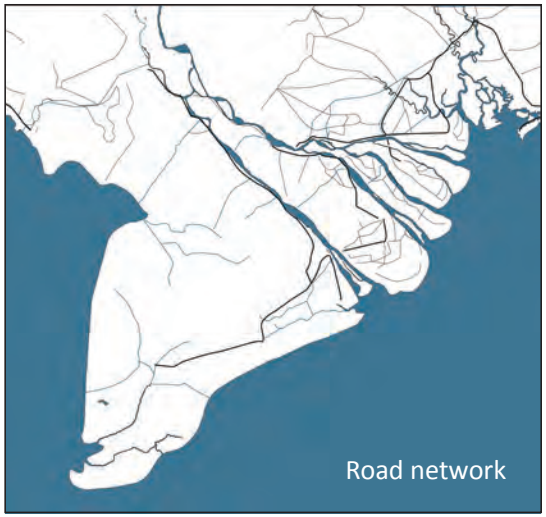


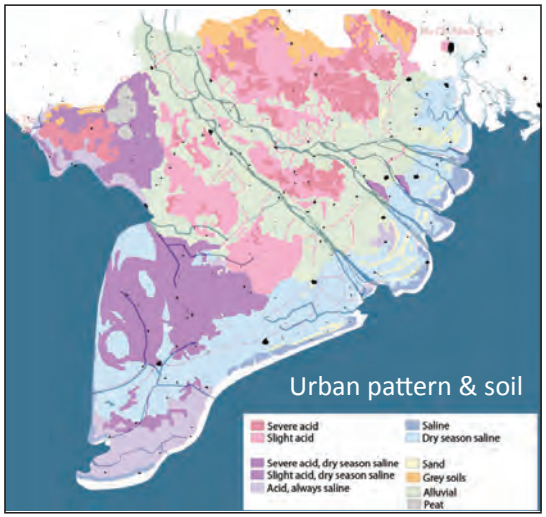
Fig. 3.5 Mekong delta 1850 land use

urban area
aquaculture (fish, shells)
fruits
rice 1-2 crops a year
rice 2-3 crops a year

3x3 MEKONG DELTA : 1900







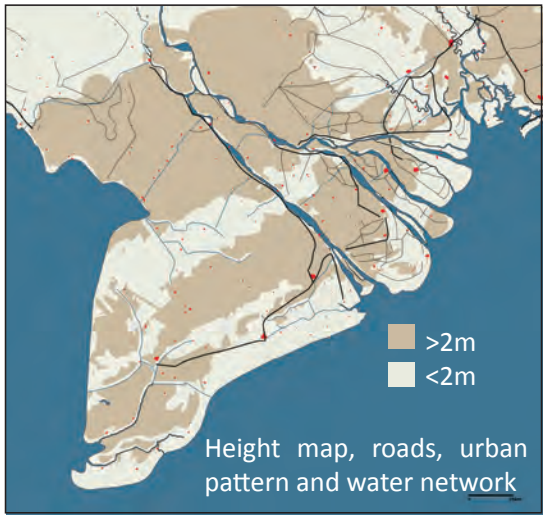


Fig. 3.6 Mekong delta 1900, current soil and height map

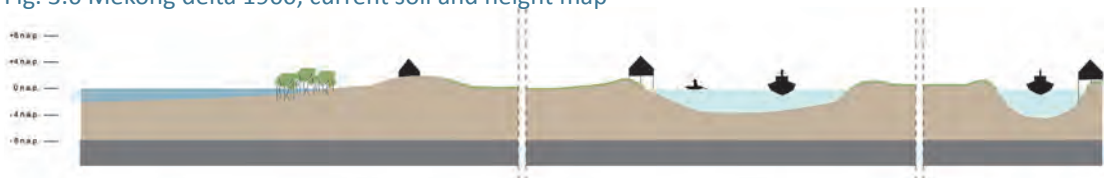


Fig. 3.7 Section Mekong delta 1900, people lived along higher river levees and new canal banks.

Fig. 3.6 - 3.8 Around 1900 the first canals were dug by the French which created the opportunity to cultivate and explore the inlands of the delta. Besides the river banks and higher grounds, the banks of canals became new strategic and safe places for urbanisation. The excavated grounds became the higher canal banks what prevented against flooding. The network of roads expanded, although these roads were more like muddy pathways.

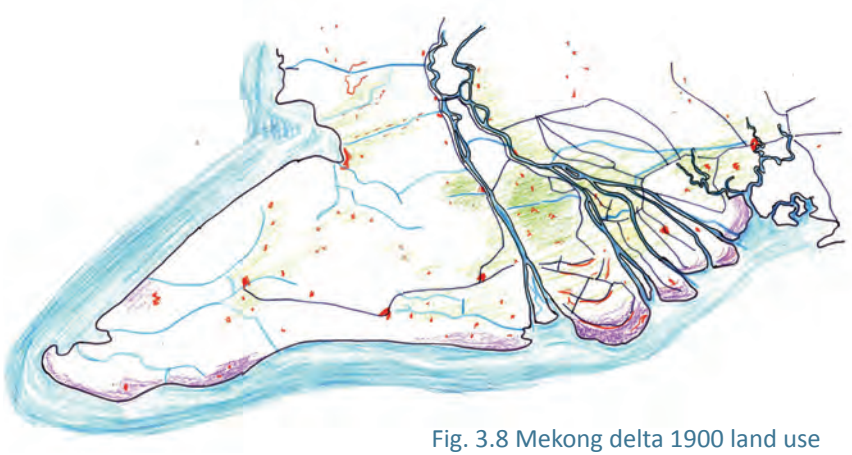
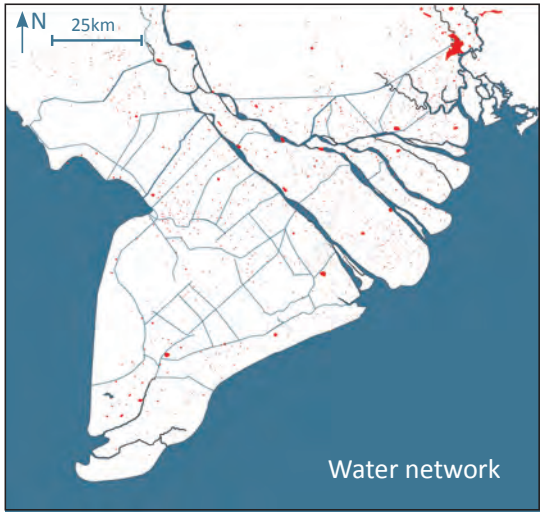
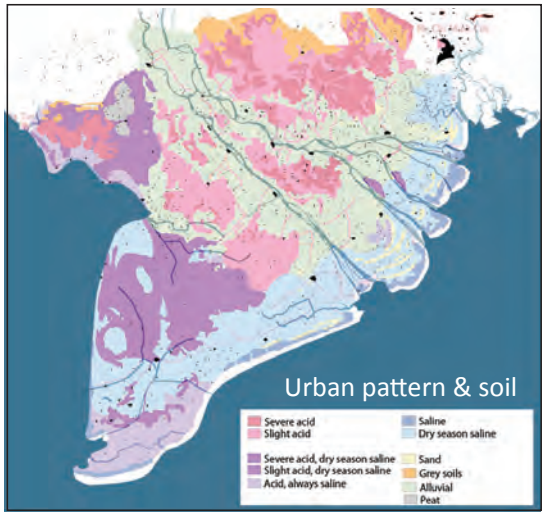


Fig. 3.8 Mekong delta 1900 land use

urban area
aquaculture (fish, shells)
fruits
rice 1-2 crops a year
rice 2-3 crops a year

3x3 MEKONG DELTA : 1960





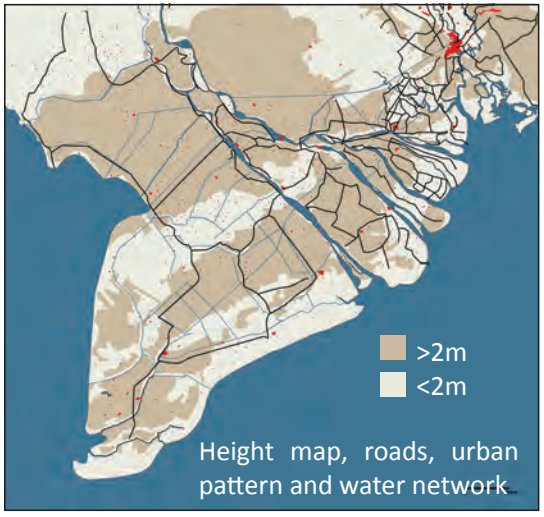


Fig. 3.9 Mekong delta 1960, current soil and height map

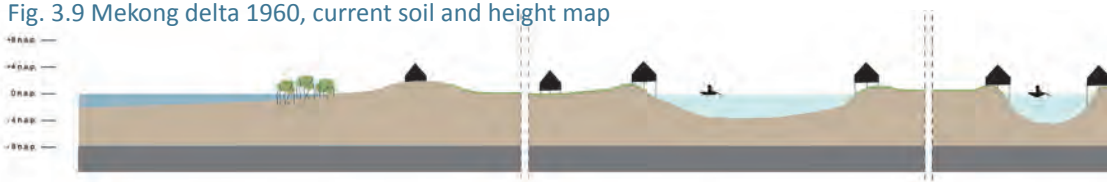


Fig. 3.10 Section Mekong delta 1960, implementation of the road system.

Fig. 3.9 - 3.11 The French expanded the canal network further and later on, the Americans built a road network suitable for motorized traffic to move their troops quickly through the delta in the Vietnamese War. The roads often follow the canals. People went living along these roads and motorized traffic introduced itself in the delta. Often, roads were built higher than the surroundings to prevent them against flooding. When floods occur, roads provide a strategic and safe place for human settlements.

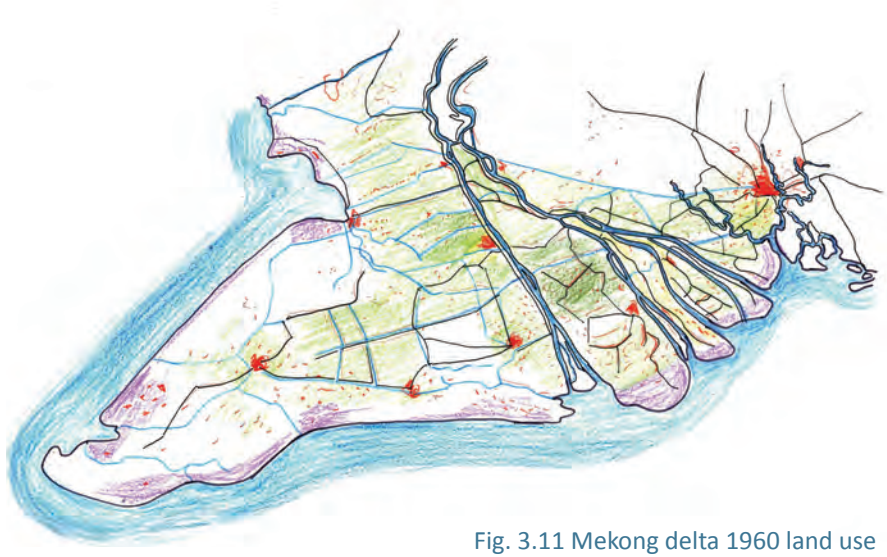
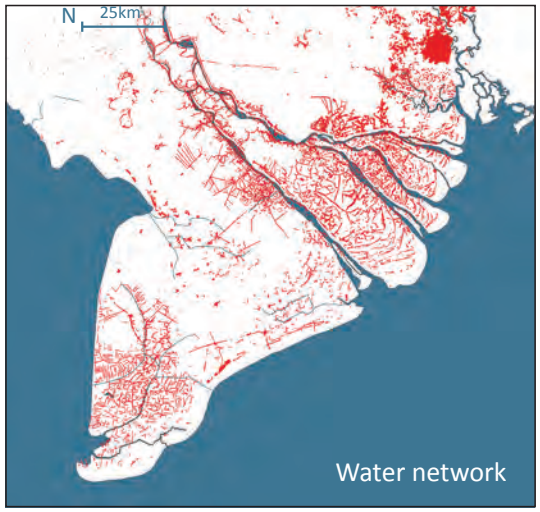
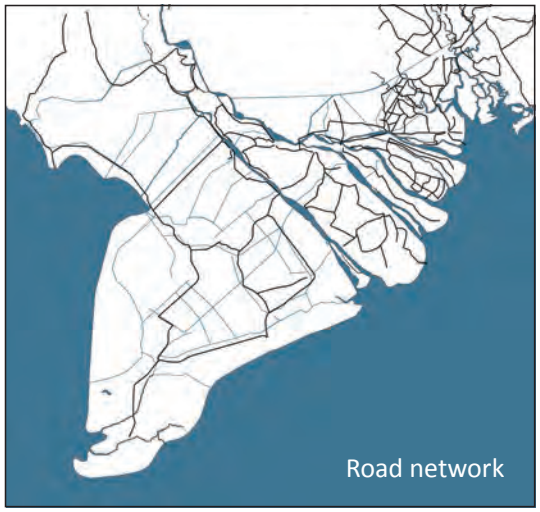


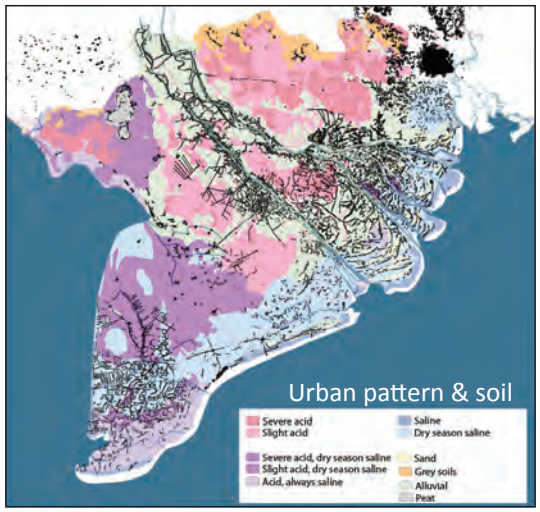
Fig. 3.11 Mekong delta 1960 land use

urban area
aquaculture (fish, shells)
fruits
rice 1-2 crops a year
rice 2-3 crops a year

3x3 MEKONG DELTA : 2000







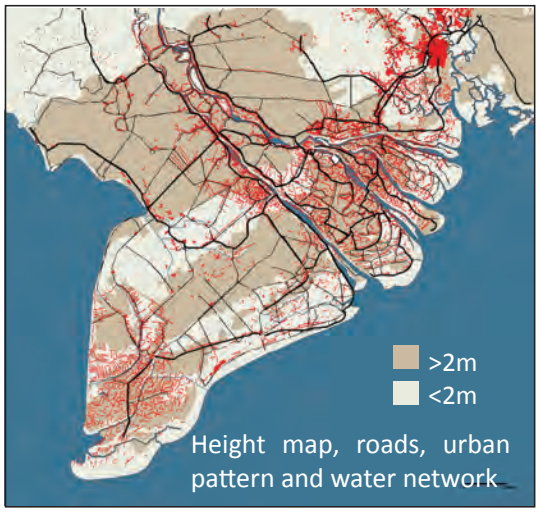


Fig. 3.12 Mekong delta 2000, current soil and height map

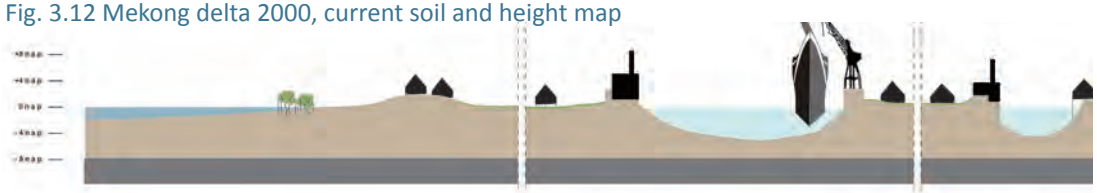


Fig. 3.13 Mekong delta 2000, blocking of riverfronts, urbanisation in low lying areas, mangrove loss.

Fig. 3.12 - 3.14 Nowadays, scooters and cars become much more popular than boat transport. Cities like Tan An grow along main traffic routes or crossings. The last decennia the population, the urbanisation and rice production of the delta grow enormously. This growth can be explained partially because of a reform in politics in 1986, the so called Doi Moi policy which allowed the free market in communistic Vietnam. Since a few years it is even possible to cross the delta from north to south without ferries because a lot of huge bridges are built..

Fig. 3.14 Mekong delta 2000 land use

urban area
aquaculture (fish, shells)
fruits
rice 1-2 crops a year
rice 2-3 crops a year

Thematic maps of the Mekong delta further explained

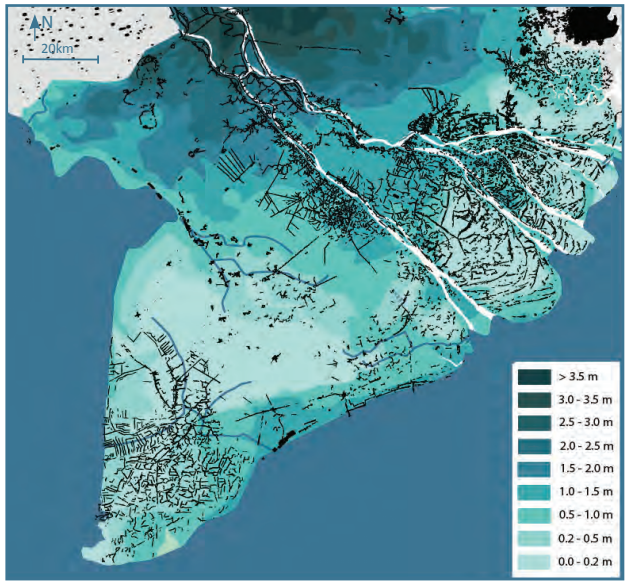


Fig. 3.15 Flooding map

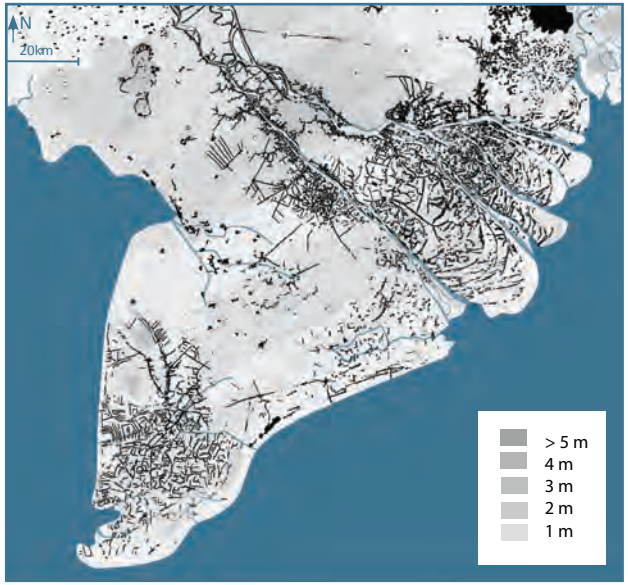


Fig. 3.16 Height map

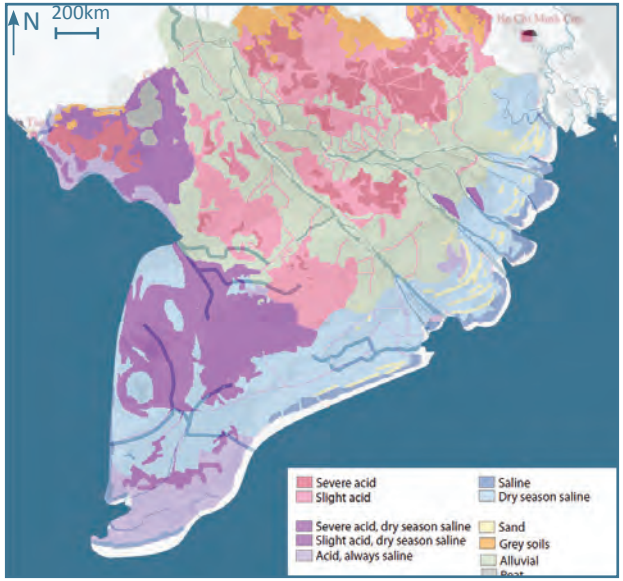


Fig. 3.17 Soil map (Acid / saline soils)

Flooding map

The biggest floods do not take place along the shores but upstream, near the border of Cambodia. The inundation depth can be more than two meters while shores hardly face flooding more than 1 meter. This seems not logical when taking a look at the height map, but upstream a natural storage lake is located called the Plain of Reeds. Due to the very small slope of the river (just 5m height difference from the Cambodian border to the shore) the water does not flow away from here as you would expect. The width of the rivers is also much smaller upstream causing larger water level differences than downstream what also results in more flooding upstream. The areas more affected by flooding are less cultivated.

Height map

The Mekong delta is very flat, height differences are just between 1m and 5m. The low lying areas used to be swamps but after irrigation canals, poldering and rice farming they became much dryer. The lands are heightened up by flooding of the rivers. Fertile deposits remain on the lands.

Soil map

The delta is dominated by acid and alluvial soils. The alluvial, fertile soil along the main rivers comes from the river deposits. Acid soils are less fertile and are a result of a natural chemical reaction in the ground what creates sulphate. The digging of canals expanded the sulphate to other areas. Higher sulphate concentrations in the surface water what has negative influences on the biodiversity and affects also other areas. Saline grounds are on low-lying areas and along the shores. Also here agriculture is not profitable. Aquafarming is rising. The acid and saline areas are much less cultivated than the fertile, alluvial soil.

Sandy ridges along the shore are very typical and show the growth of the peninsula. The peat hills in the north west were the places the first urbanisation took place in the delta. The soil is soft, costly for foundation, but suitable for digging.

Summary

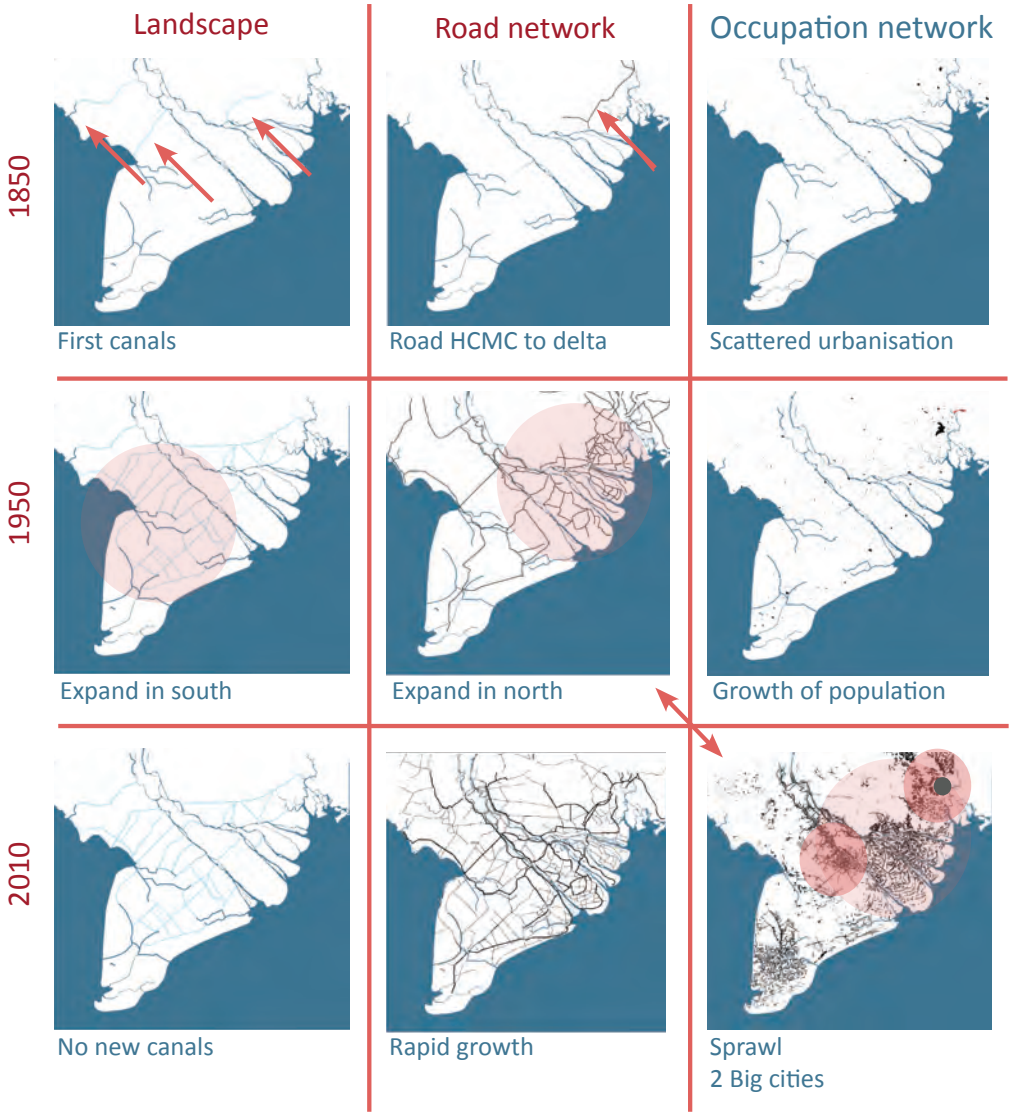


Fig. 3.18 3x3 analysis Mekong delta

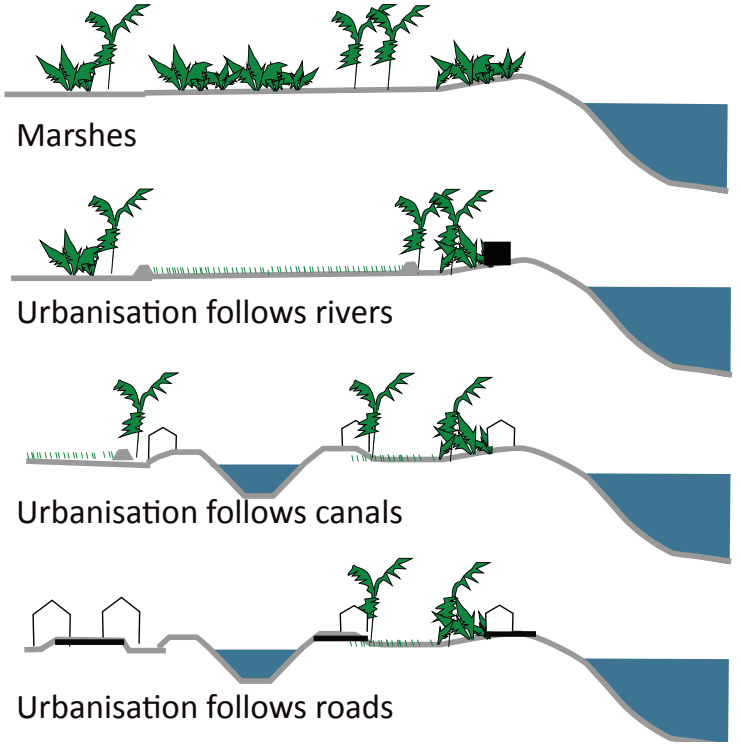


Fig. 3.18 Development of the delta in sections.

The cultivation of the delta

The first urbanisation took place along the higher levees. Around 1850 the first canals were dug by the French shaping new conditions to settle along which has economical profits because these routes were much used for quick transport. When the first roads were built the urbanisation followed these linear elements because roads took over the trade function from canals. Further urbanisation led to clustering more clustering of housing. Villages and cities grow in between river- and canal banks.

Since 1950 the road network expanded and the urbanisation is sprawling around cities.

Human intervention in the Mekong delta landscape

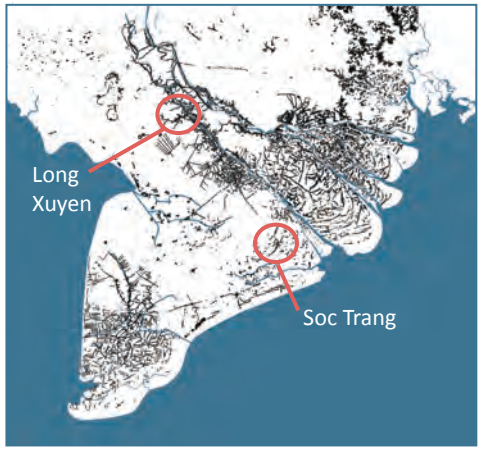


Fig. 3.18 There area several landscape patterns in the Mekong delta

Cities

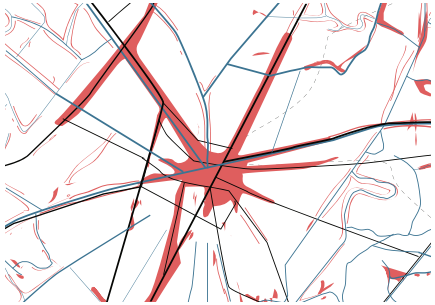


Fig. 3.20 Soc Trang. growth along canals, rowth along roads

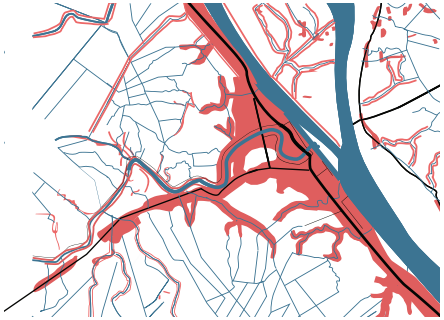


Fig. 3.19 Long Xuyen
- Growth along rivers and creeks

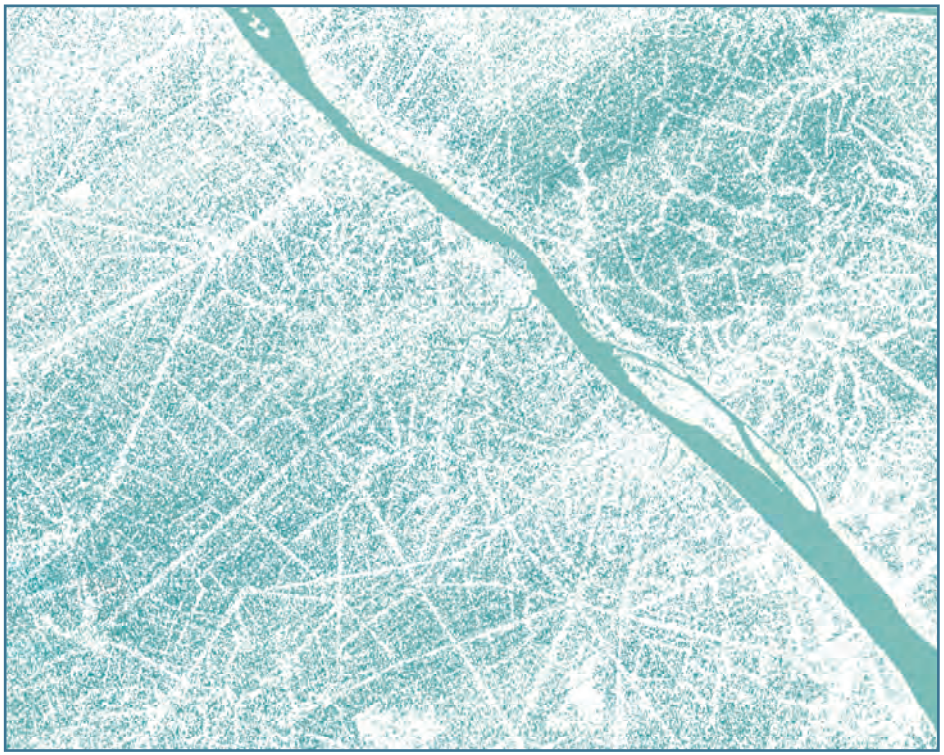


Fig.3.18 Water network in the delta: canals and creeks in the delta. Source:Nijhuis,2012

Rural urbanisation

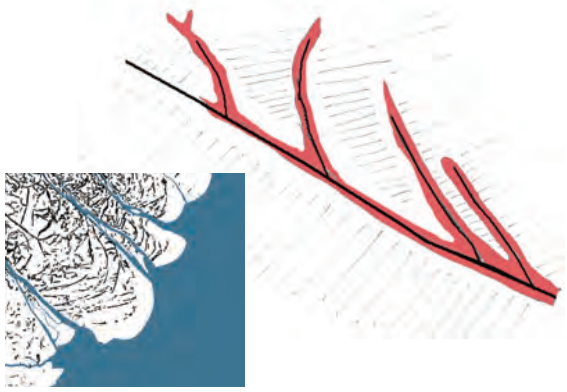


Fig. 3.21 Growth along sand banks near the shore

Fig. 3.22 Linear growth along creeks and rivers through the whole delta

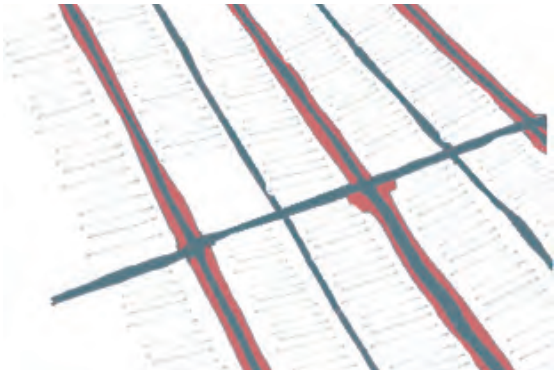


Fig. 3.23 Linear growth along the canal network

3X3 ANALYSIS CAN THO

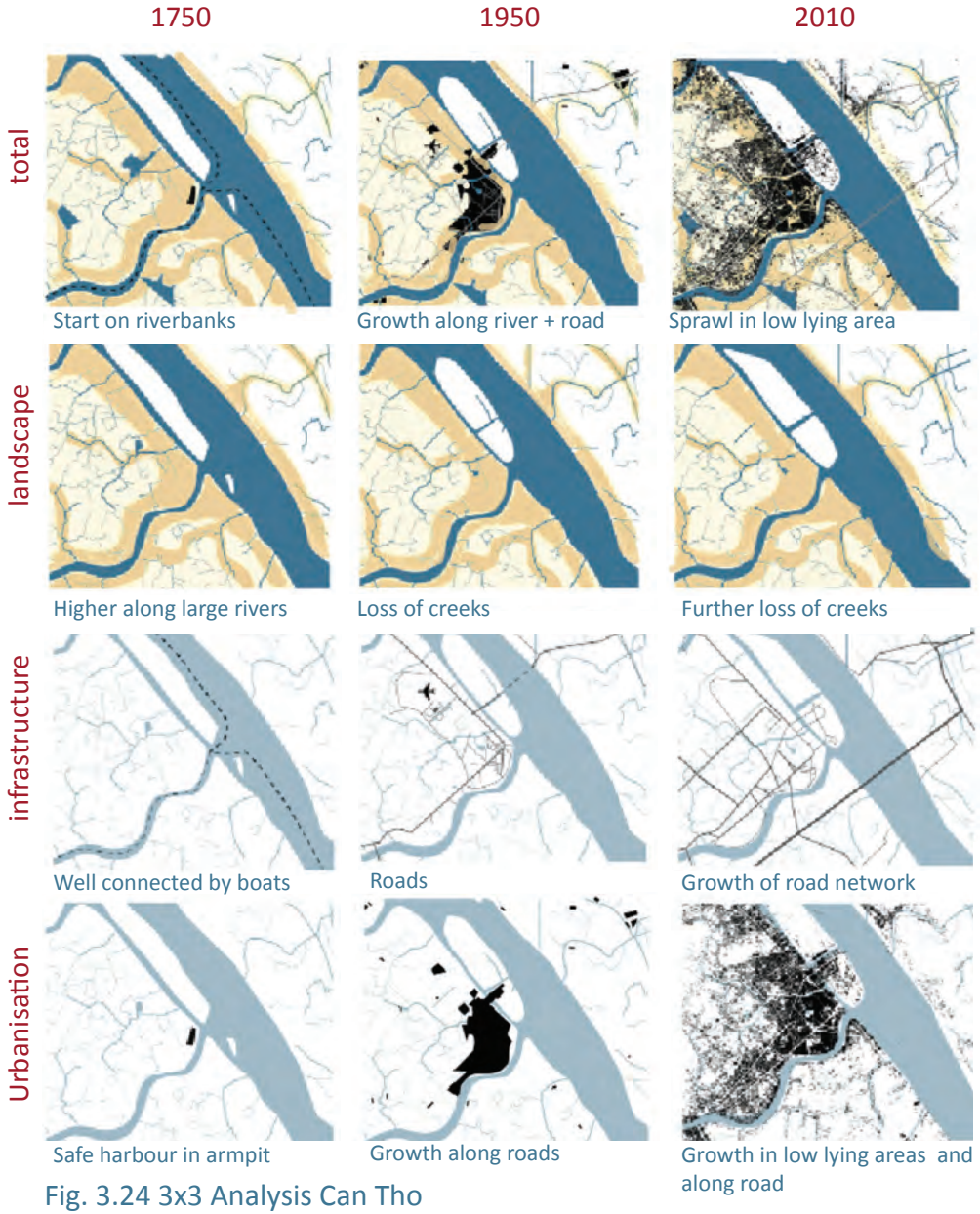


Fig. 3.24 3x3 Analysis Can Tho

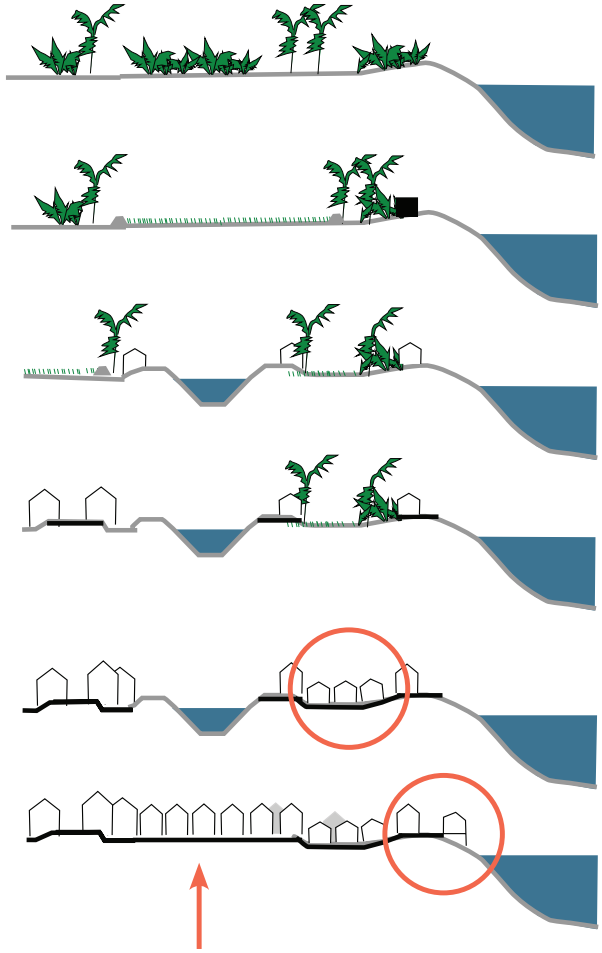
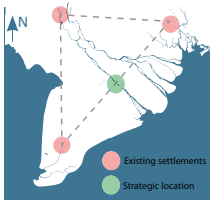


Fig. 3.25 *The urbanisation of Can Tho leads to a loss of creeks and rivers, blocked riverfronts and growth on the low lying areas.*

Growth of Can Tho

Can Tho City is a relatively new city founded along the banks of the Hau river around the year 1750. The location of Can Tho was strategic, in between the already existing cities of Ca Mau, Ho Chi Minh and Long Xuyen in the middle of the Mekong delta.



The location of the first settlements were at higher grounds in an armpit what gave place to a more safe harbour. The surrounding trees, also at the island, hided the place for enemies.

In the Vietnam War the city got an important military airport what is now replaced towards the north.

Infrastructure network

In the infrastructural network not only road transport, but also the traditional water transport plays an important role on local scale of the city. Can Tho is the main transport node in the Mekong delta. In 2010 the My Thuan bridge over the Hau river is finished and for the first time it was possible to cross the whole Mekong delta without a ferry. The southern part of Can Tho will grow due to this new connection. This new bridge will bring more traffic and commerce to Can Tho.

Water network: the boat transport is still in use by the traditional Vietnamese. In the city the youth crosses the street with scooters.

The water network: At the northern side of the Hau river artificial canals are the dominant water ways, around Can Tho natural rivers and creeks are dominant.

Towards Can Tho there is less and less surface water and the water routes are taken over by roads.

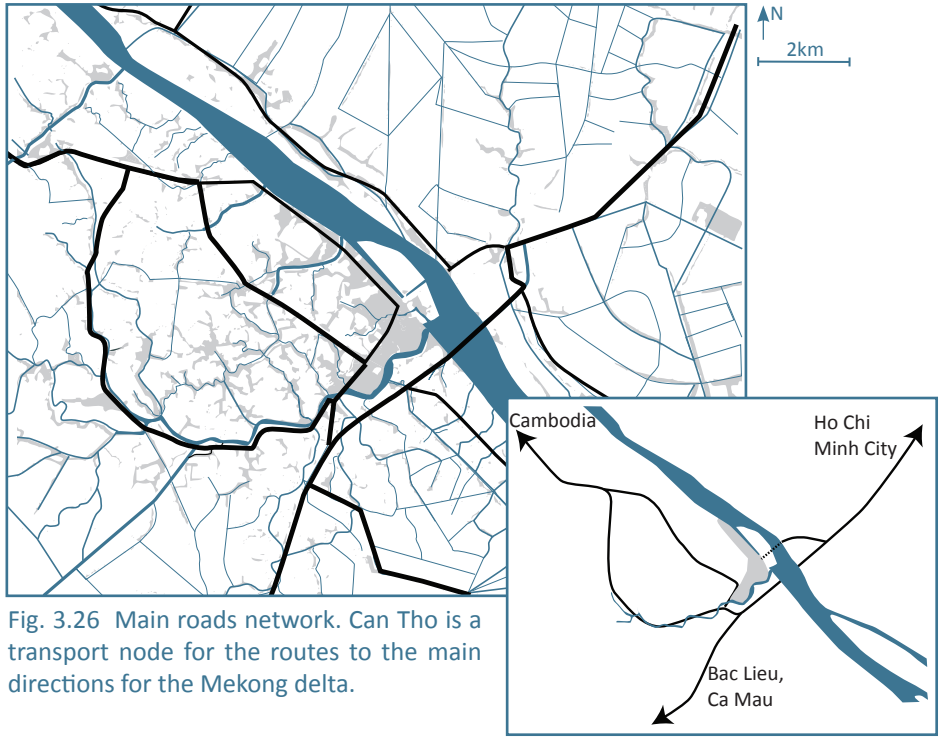


Fig. 3.26 Main roads network. Can Tho is a transport node for the routes to the main directions for the Mekong delta.

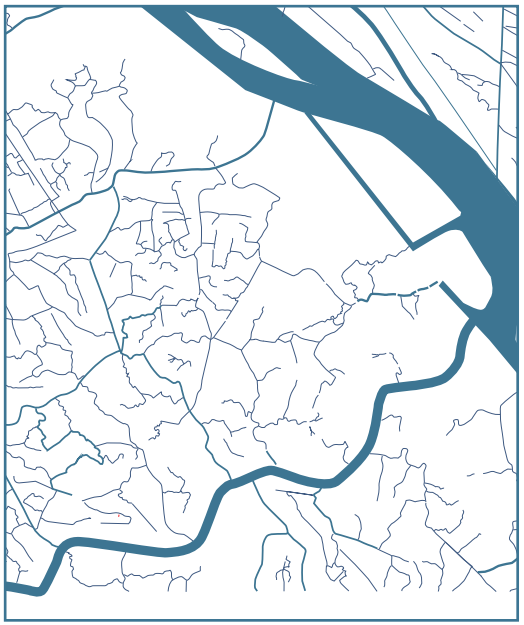
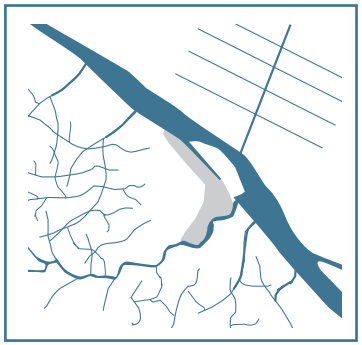


Fig. 3.27 Water network

2km N



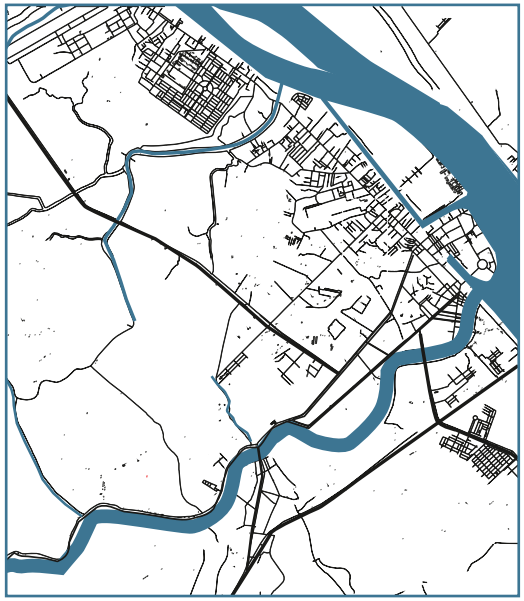


Fig. 3.28 Road network

2km N

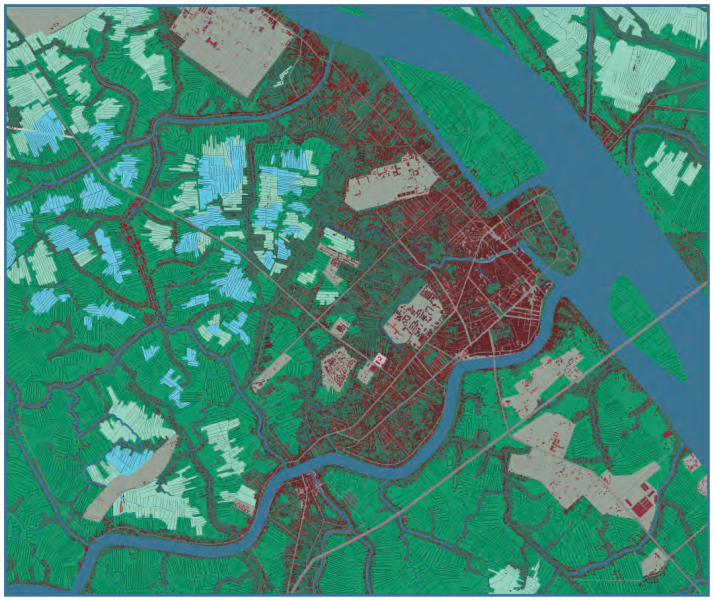


Fig. 3.29 Functions,flooding, artificial landscapes

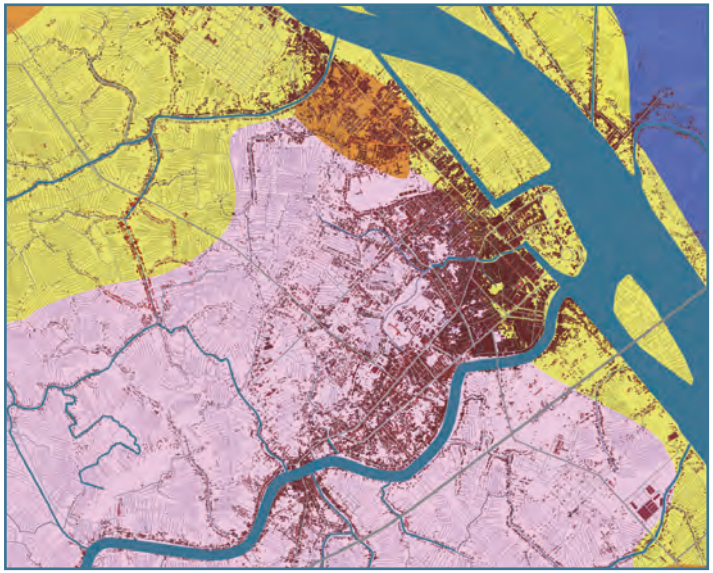


Fig. 3.30 Soil

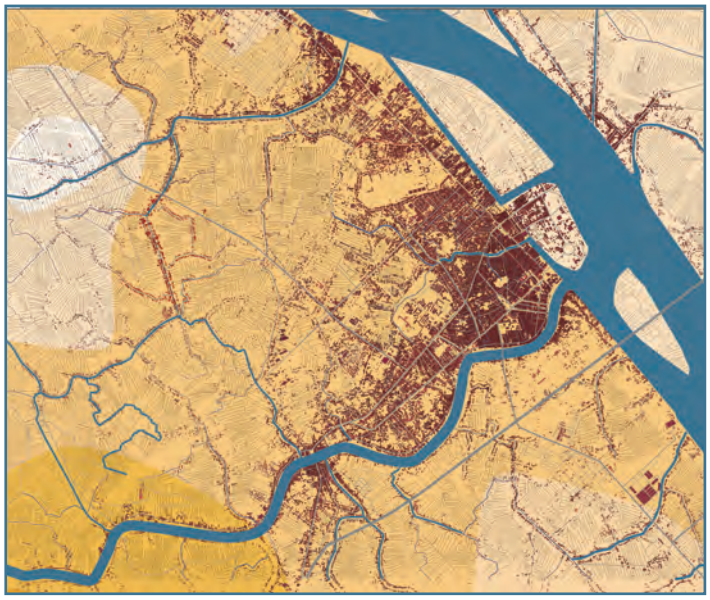


Fig. 3.31 Average height and allotment

Fig. 3.29 Flooding

The places which are flooded firstly lay outside the cities in the rice fields in between the large rivers.

Fig. 3.30 Soil and allotment

Can Tho area consists of several kinds of alluvial, fertile soils.

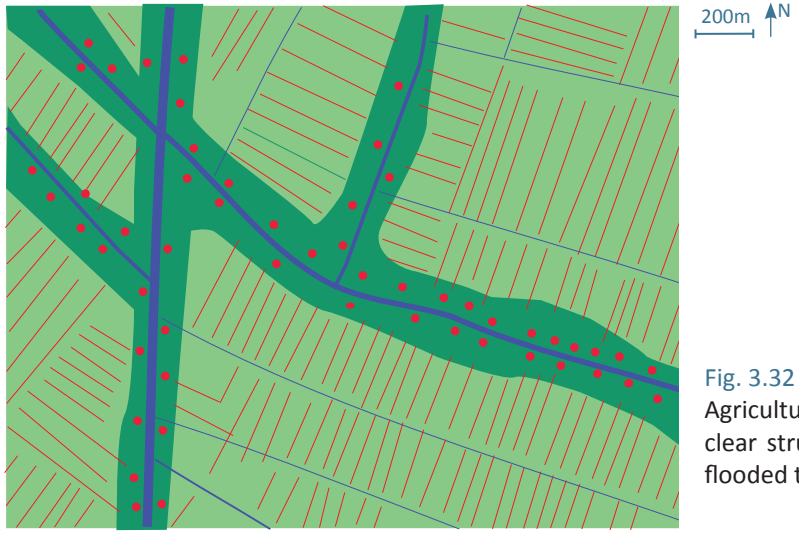
Fig. 3.31 Height and allotment

- Irragular patterns are on higher grounds.
- The city is situated on higher grounds.
- Lower rice grounds have longer and smaller lots.

On the next page, 4 landscape pieces are zoomed in.

4 Landscape typologies

When analysing the former maps there are 4 landscape types to distinguish :



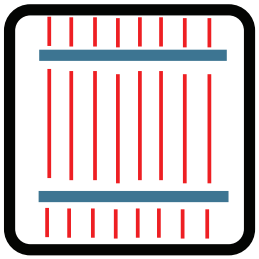


Fig. 3.32 Artificial irrigation landscape

Agriculture in the artificial made lands have a clear structure and produce rice. They are less flooded than the natural formed rice fields.

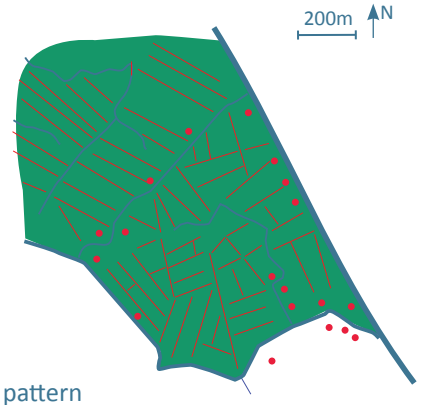
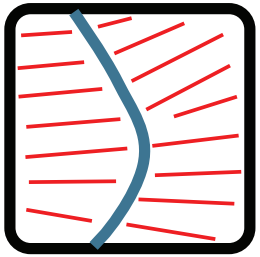


Fig.3.33 Irregular natural pattern

The areas in which fruit and crops are harvested are the most irregular and have short and broad lots. The irrigation is less important. These areas are higher than the surrounding and are not that much affected by floods.

Fig.3.34 Waterfront irrigation

The areas along the river have their own typology. The irrigation canals have a larger distance between each other and they make a right angle with the waterfront. Fruit- and cropfarming.



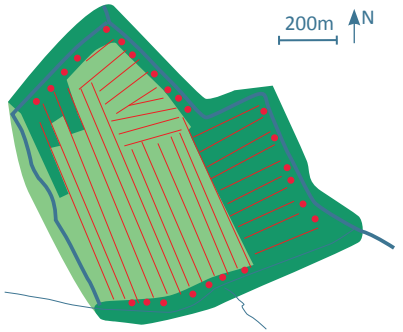
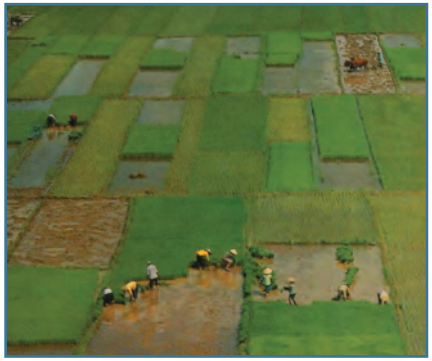


Fig. 3.35 Natural irrigation

In the landscape with the natural streams and rivers both rice and fruit and crops are harvested. The linear structure irrigates the grounds what is needed due to their lower location compared with the natural higher landscapes above.

Rice fields - opposite of the polder system

Where in the rice fields fields are seperated by small dikes. This is completely different than the Dutch polder system. In the Dutch polder system irrigation canals are used to seperate fields and to manage the hydraulics.

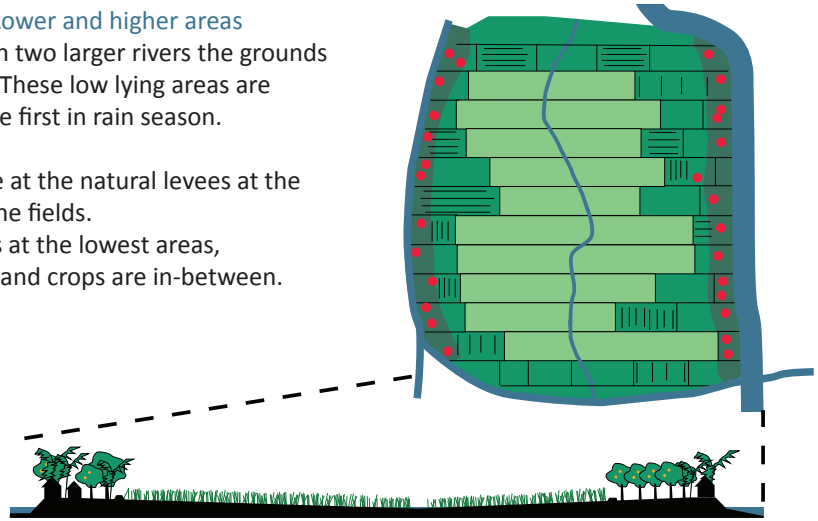


Rice fields: water storage
Source: Google images

Dutch polder system: water runoff
Source: Google images

Fig. 3.36 Lower and higher areas
In between two larger rivers the grounds are lower. These low lying areas are flooded the first in rain season.

People live at the natural levees at the heads of the fields.
Rice grows at the lowest areas,
fruit trees and crops are in-between.



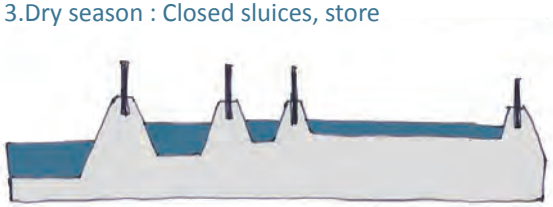
Working of the rice fields

The Mekong delta and around Can Tho the area is dominated by rice farming and some fruit farming. The growth of rice involves a complex water management system with sluices to keep the correct water level to grow rice in dry- and wet season.

1. After seeding : Sluices open, water in

2. Wet season : Closed sluices, protect

3.Dry season : Closed sluices, store



4. Harvest : water out, sluices open, water out, seed

Fig. 3.37 Picture of a sluice

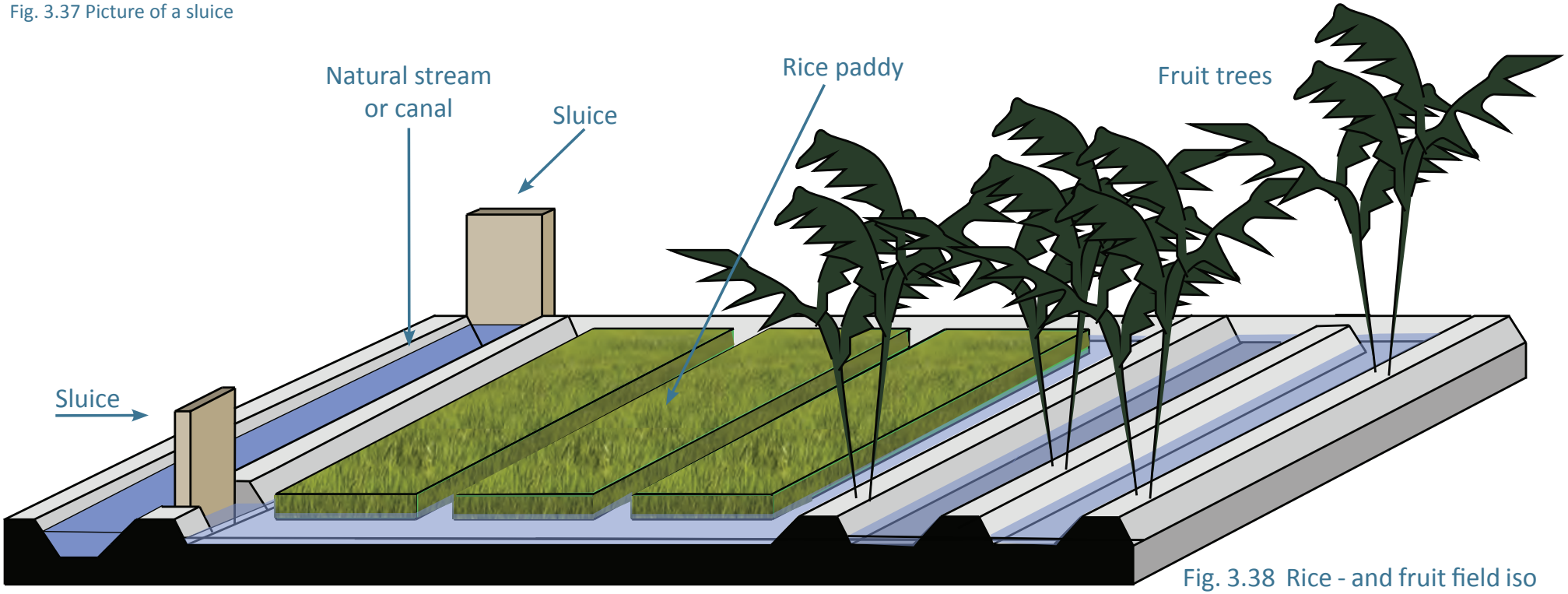


Fig. 3.38 Rice - and fruit field iso

Landscape

Fig. 4.19 Linear shape of rice fields

Fig. 4.20 Google Earth image of the ricefield structures. Source: Google Earth

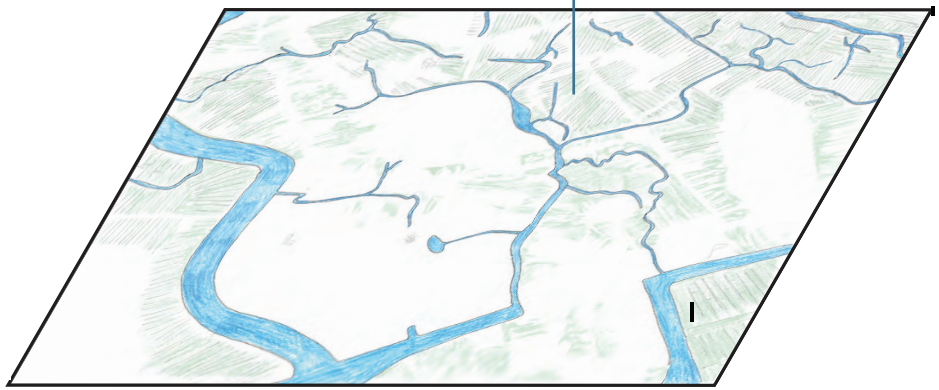


Fig. 4.19 Allotment around Can Tho

Spatial impression Can Tho

This chapter zooms in further in Can Tho. After defining the general problem statement there is a better insight needed for finding a specific solution for Can Tho. A spatial analysis shows the lack of public spaces and green in the city. With typology research new problems appear as lacking sanitation and tabula rasa expansions around the city. A specific hydraulic analysis shows gives a better insight what is needed to prevent flooding in Can Tho in the future. In the conclusion a diagnosis for the city is described.

Chapter 4
Spatial, typology and hydraulic diagnosis Can Tho

Built surface Can Tho

More information about the building typology is in the next paragraph ‘building typology analysis’

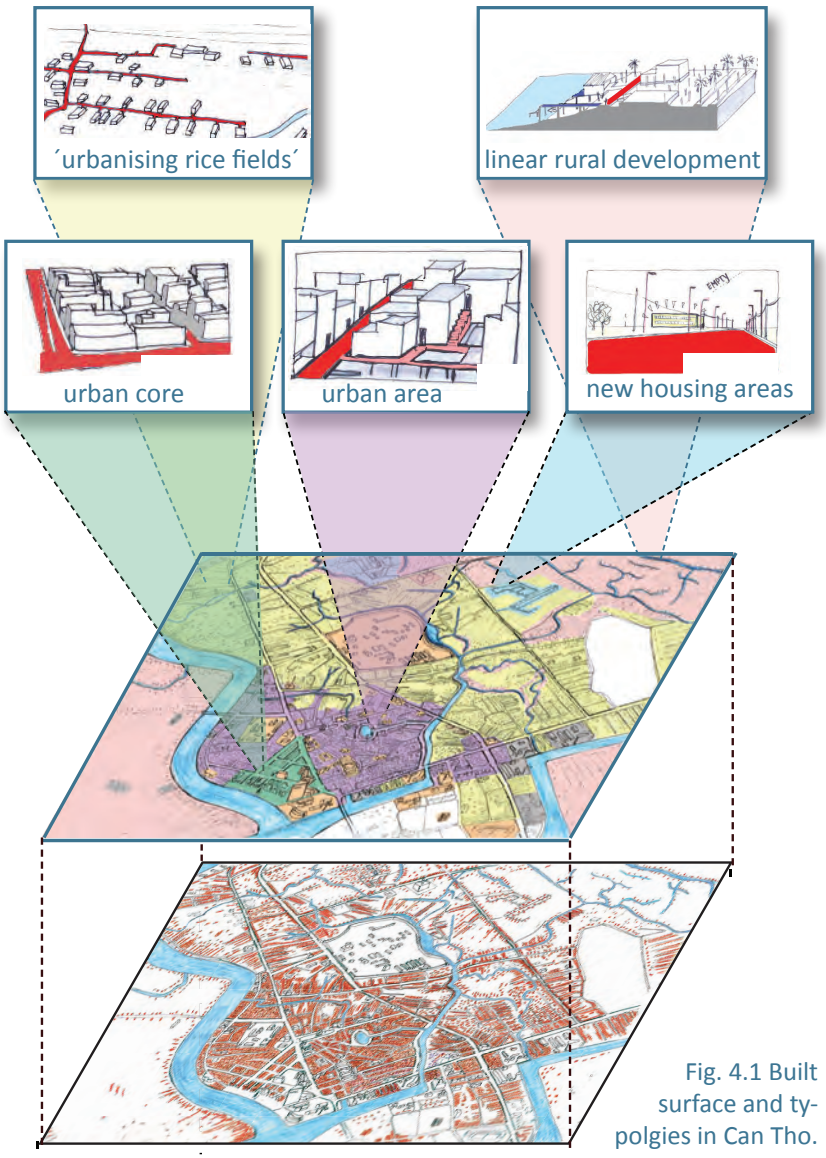


Fig. 4.1 Built surface and typolgies in Can Tho.

Green structure Can Tho

Fig. 4.2 Trees along the large roads

Fig. 4.3 Two small parks. Source: Google Images

Very few public green in urbanised areas

In Can Tho there are two small parks and along the large roads trees. This is a very small amount of green for a city of more than half a million inhabitants. Besides, a lack of green decreases the permeability of the soil for rain water runoff, increasing flooding.

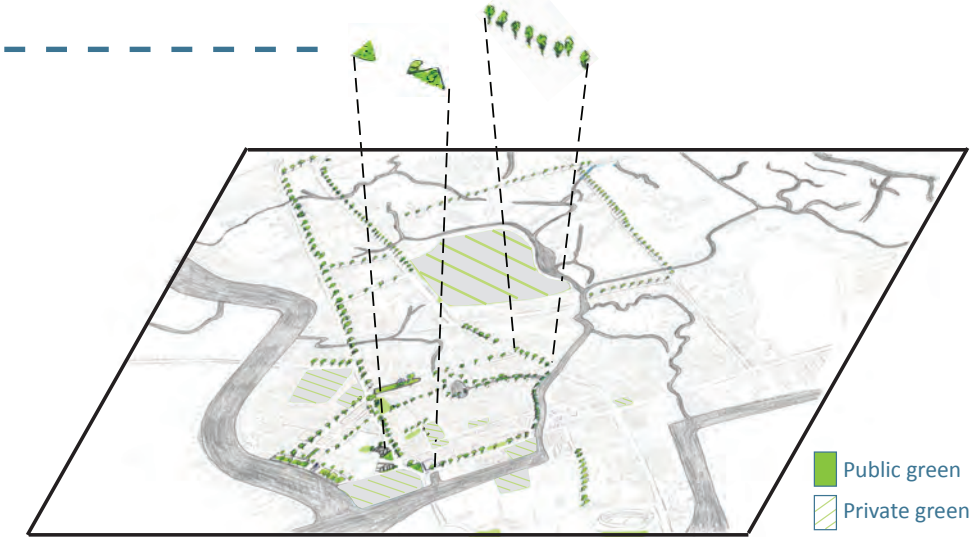


Fig. 4.4 Birds eye green structure Can Tho

Public private space Can Tho : Public spaces

Fig. 4.5 Boulevard of Ho Xang Thoi

Fig. 4.6 Ninh Kieu boulevard, the touristic area of the city.

Public spaces only in city center

Only in the city center are designed public spaces. They are situated along the waterfront where it can be cooler than in the rest of the city. Together with the few parks there is a lack of public space for recreation in the city.

Fig. 4.7

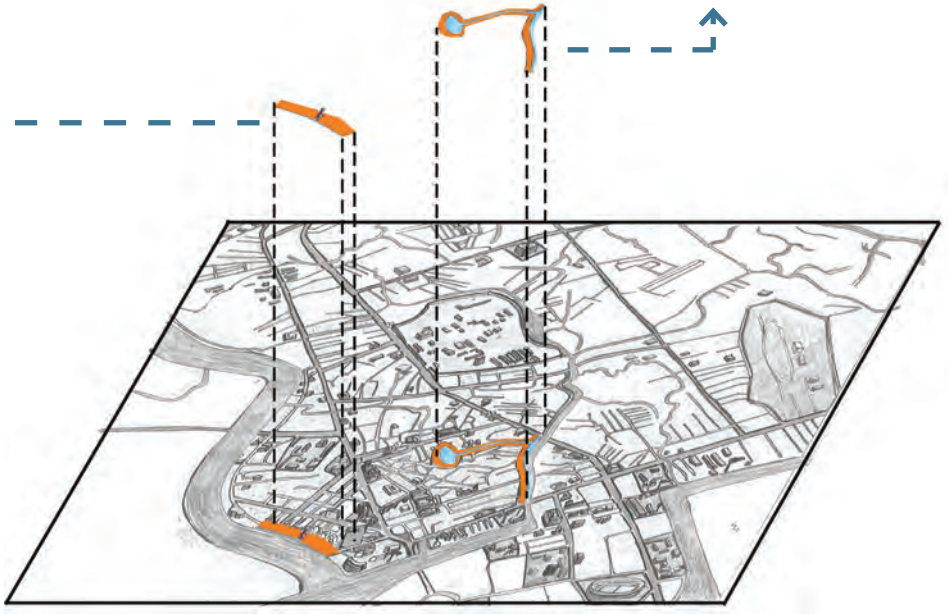


Fig. 4.8 Public spaces

Public private space Can Tho : Private spaces

Fig. 4.9 University and governmental buildings. Source: Google Images

4.10 Industries Source: Google Images

Private spaces in the city

A lot of open and green spaces are unaccessible places. These areas are blocking the continuity in the city and blocking the waterfronts.

4.11 Resorts

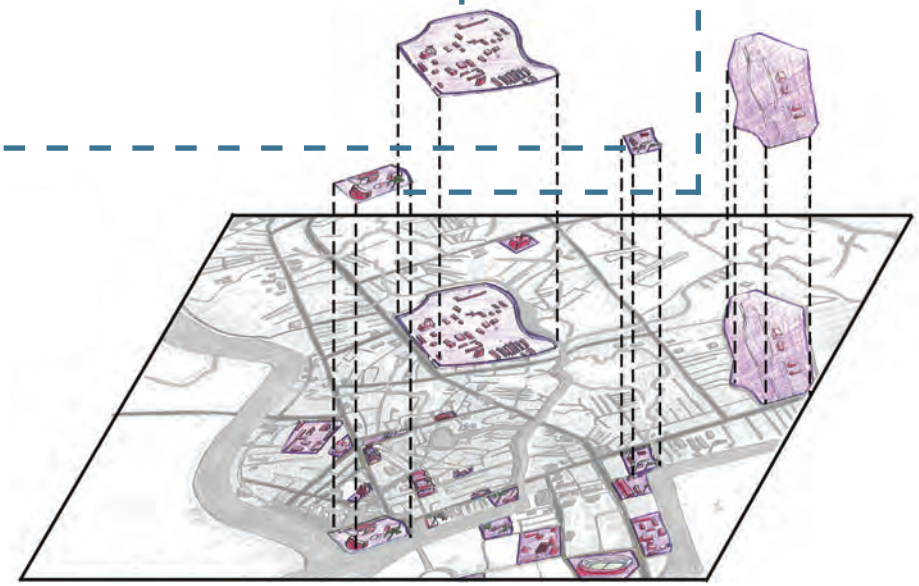


Fig. 4.12 Public spaces

Public private spaces Can Tho : Public space : streets

Fig. 4.13 Public spaces: markets

Fig. 4.14 Public spaces: dining

Streets

By lack of squares, public spaces and parking places the streets are used as public space for markets, terraces and parking places. This leads to a blockade of the sidewalk and a lot of people walk on the dangerous traffic roads. The main road pattern is a strong grid structure covering the city.

Fig. 4.15 Sidewalks are used for parking

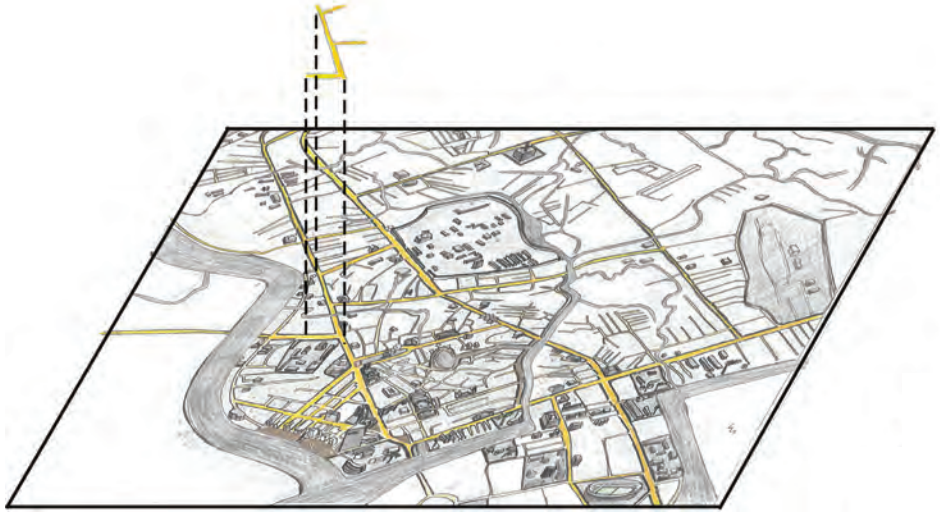


Fig. 4.16 Roads

In depth boulevard and road analysis

Analysis boulevards Can Tho

Unused boulevard | Used boulevard | Pleasant boulevard

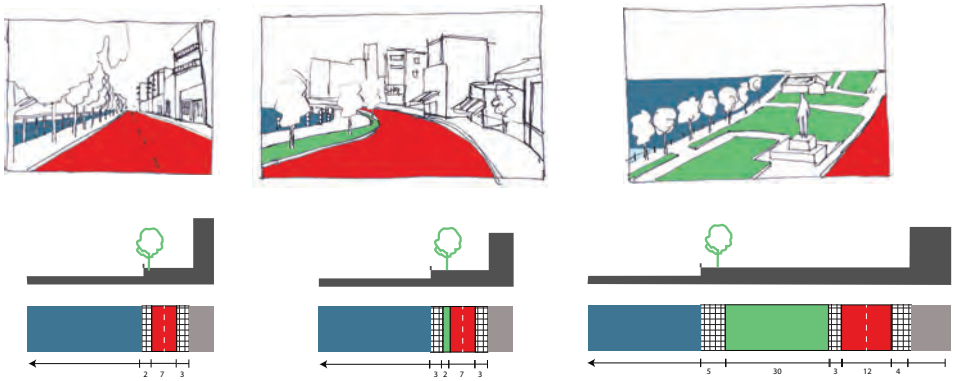


Fig. 4.17 Boulevards Can Tho

The three boulevards are all located in Can Tho. Between road and boulevard : green space for an attractive and safe boulevard. Trees provide shadow for the hot sun in southern Vietnam.

Analysis roads Can Tho

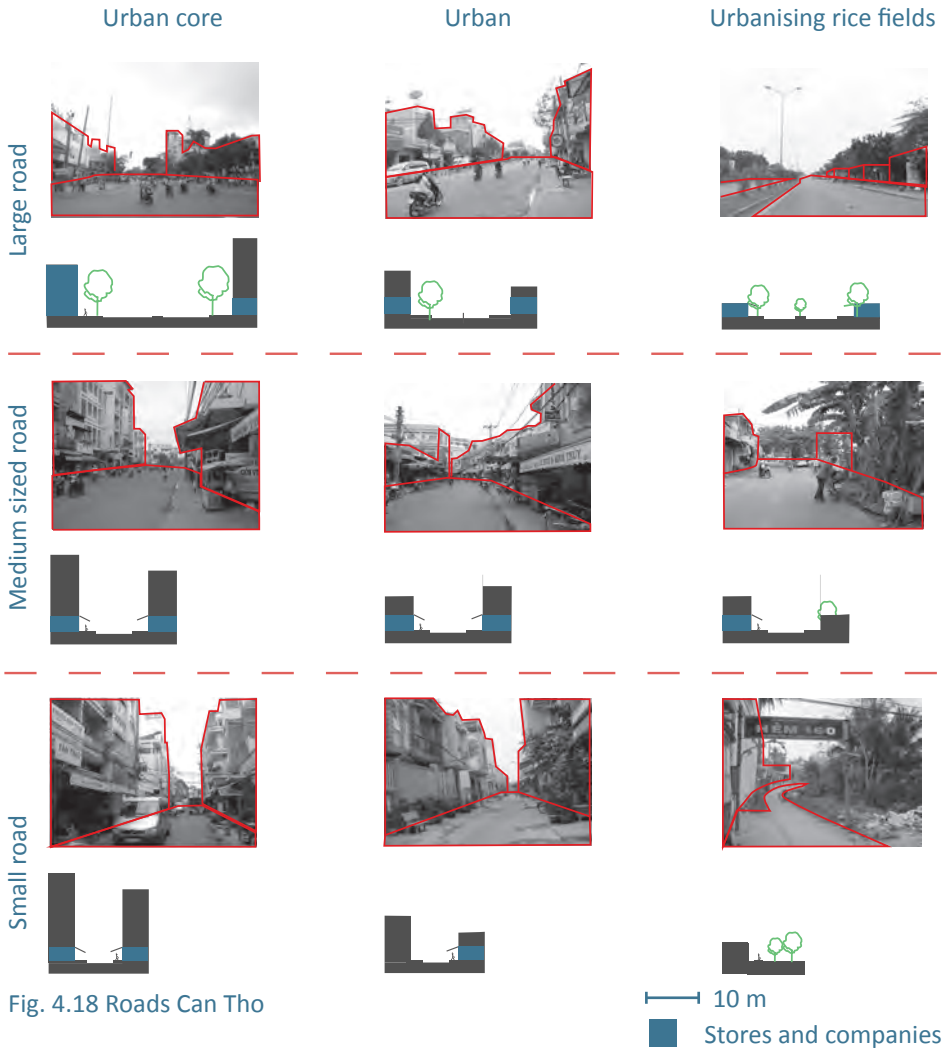


Fig. 4.18 Roads Can Tho

- How larger the streets, the more shops and people
- How larger/crowded the streets, the more traffic and more dangerous the roads are for pedestrians and bicycles.

Layers combined

Built surface
Dense inner city, sprawl around the city.

A lot of green is private

Public spaces are in inner city, streets are main public spaces in the rest of the city.

In the landscape around the city the rice- and fruitfield allotment is still visible. Towards the inner city the structures are disappearing.
(See chapter 3, landscape of Can Tho)

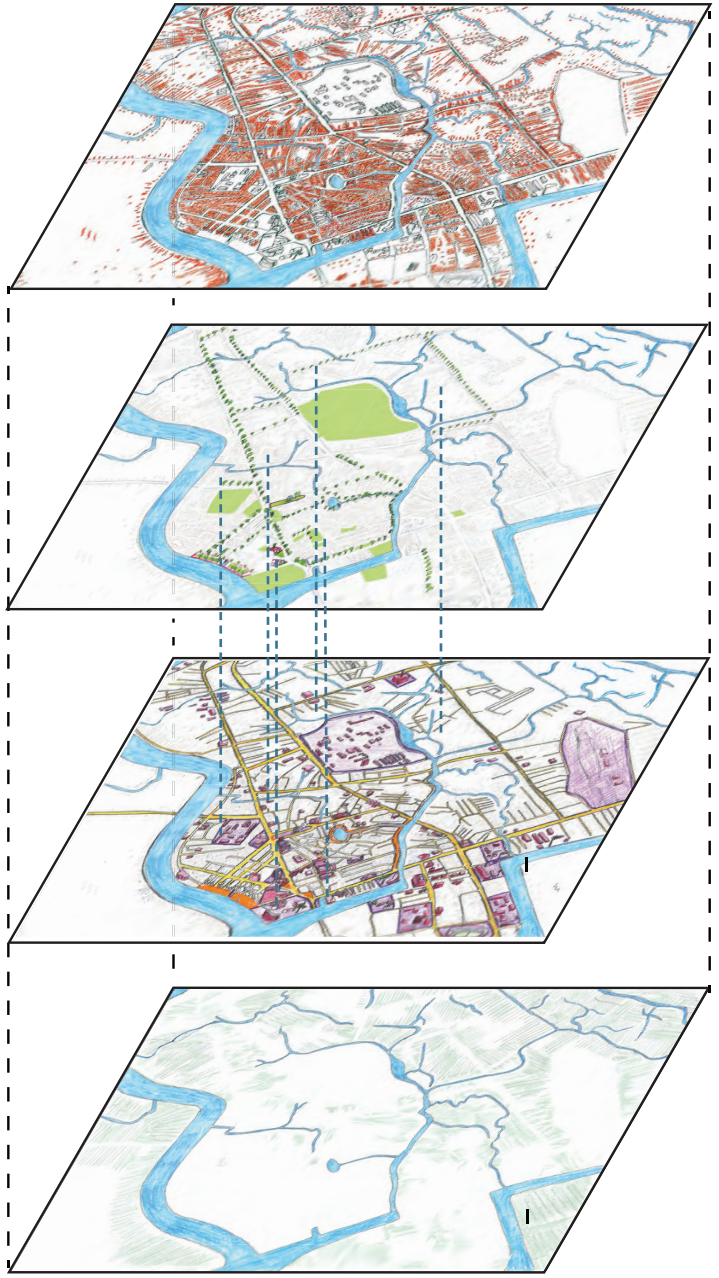


Fig. 4.18 Layers

Fold out larger version of the layers

Diagnosis spatial analysis : threats

These spatial threads together with climate change leads to more flooding. Segregation, densification, sprawl and aversion from the water leads to worsening living

Fig. 4.19 Further privatisation of the city

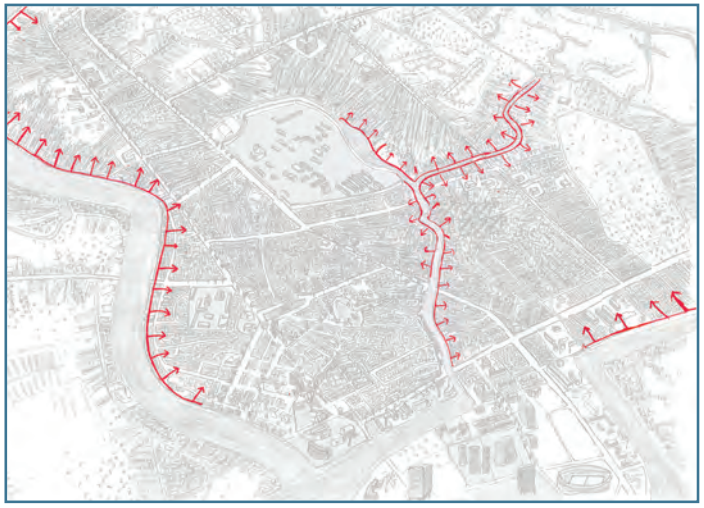


Fig. 4.20 Turning away from the water

Fig. 4.21 Upcoming car traffic in Vietnam: unsafe and traffic jams.
Source: Google Images

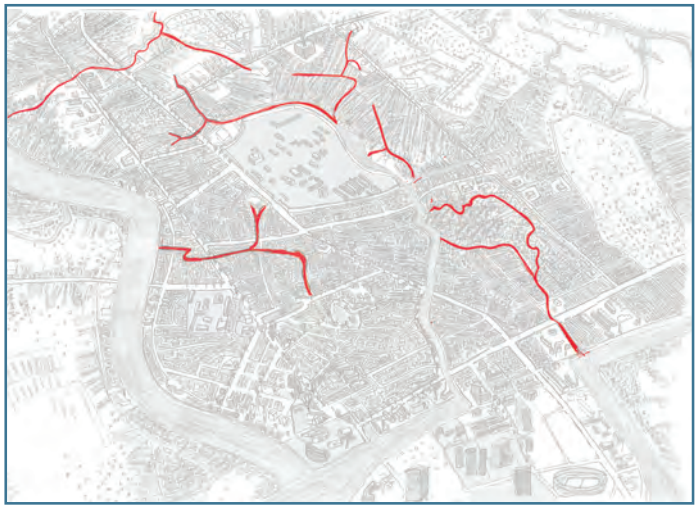


Fig. 4.22 Further loss of creeks

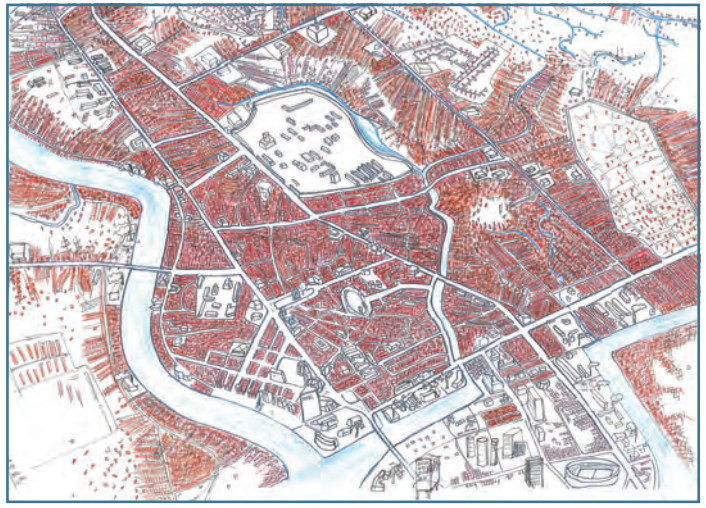


Fig. 4.23 Uncontrolled sprawl through fertile agricultural grounds
Further densification in inner city : urban heat effect and pollution

Diagnosis spatial analysis : chances

These spatial opportunities are an answer to challenge climate change, segregation and improve living conditions.

Fig. 4.24 Open up the green, private spaces and transform them to urban

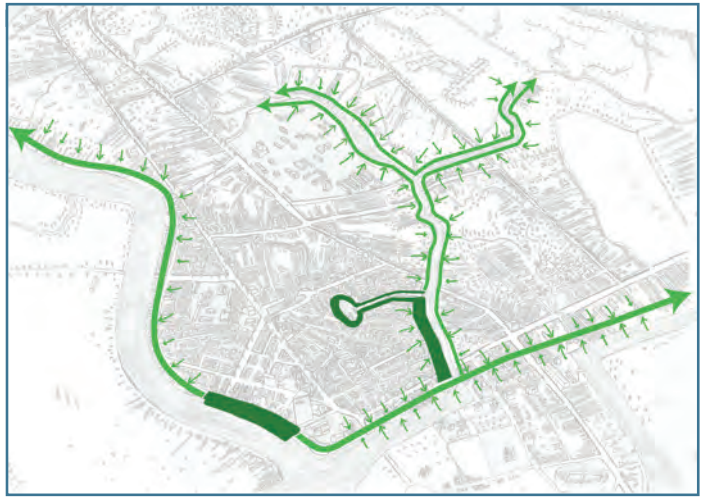


Fig. 4.25 Extend existing boulevards and focus on water again

Fig. 4.26 Make use of the existing landscape structures: ricefield principle and meandering creeks for water storage and drainage

Fig. 4.27 Continue strong road network

BUILDING TYPOLOGY DIAGNOSIS

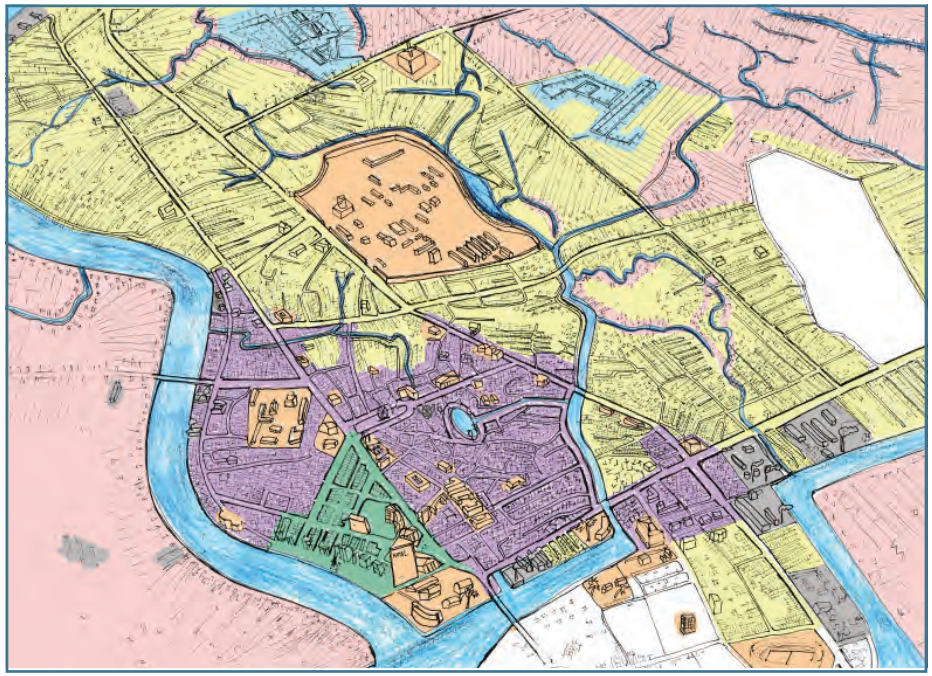


Fig. 4.28 Building typologies Can Tho

N

industry

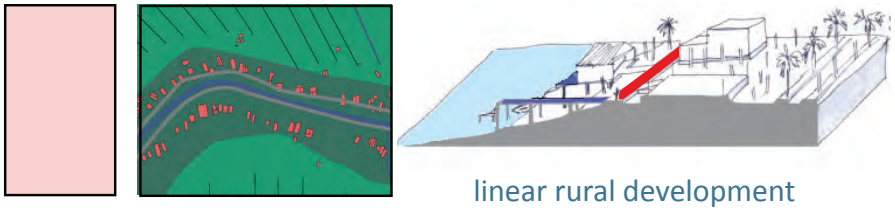
large building complex

other

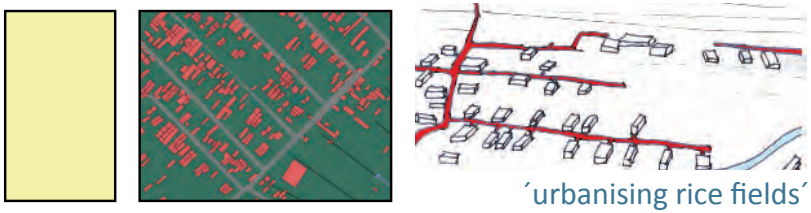
Overview of building typologies in Can Tho

In Can Tho you can find several building typologies. They are analysed on flood defence, relation with the water, their roads. This leads to a small diagnosis for each typology. This research finds out what is needed for the city and is important to understand for developing a masterplan for the city. The most interesting typologies are the linear rural development, urbanis-

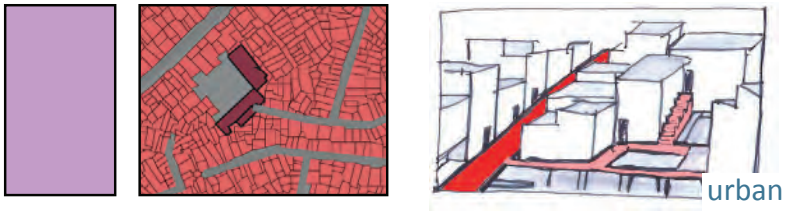
Typologies



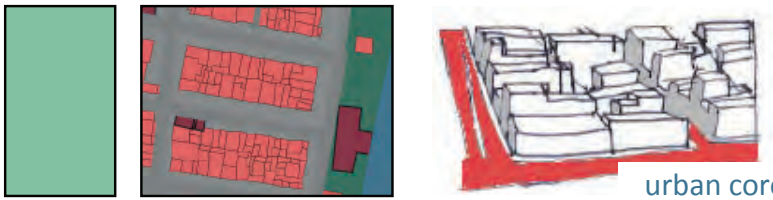
linear rural development



´urbanising rice fields´



urban



urban core

tabula rasa

1. Pink: Linear rural development

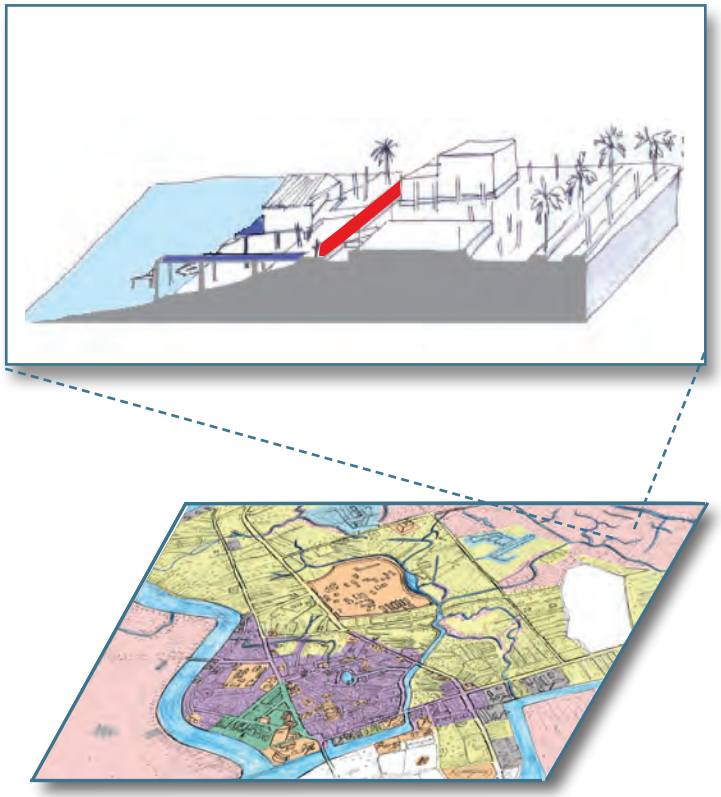
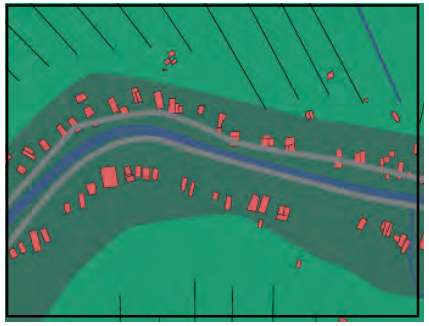
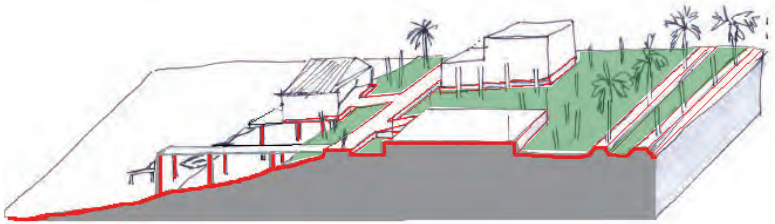
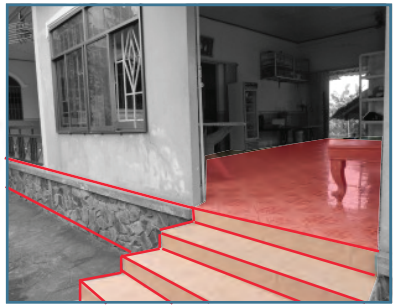


Fig. 4.29 Locations with linear rural development



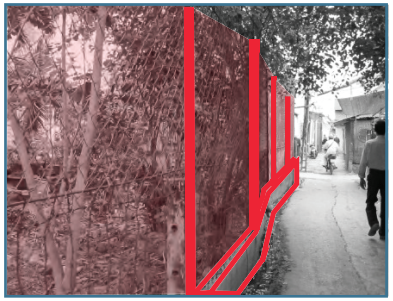
4.30 Map

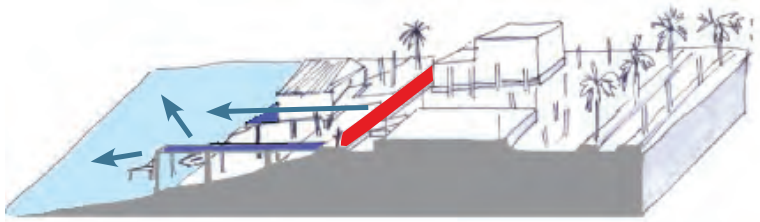




Flood defence

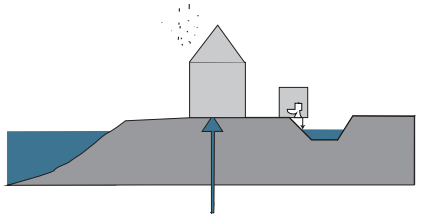
People protect themselves with heighten up their houses and roads. The ground floor is made of tiles what is easily to clean after a flood. Rain water can easily intrude in the soil because of the large surfaces of permeable soil.
Small dikes or concrete basements of fences can protect small flooding. In general the flood defence is poor and in case of extreme flooding the inhabitants can not go to higher floors or places.

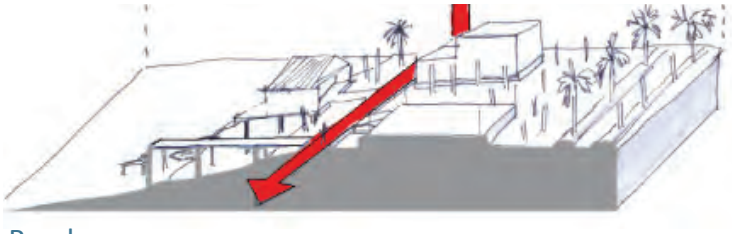




Relation with water

The river water is used for agriculture washing, cooking, cleaning and in sometimes even drinking. The river is also used for catching fish and for boat transportation. This shows the relation with the water is still very strong. . This pollution will get worse in the future. The river is meanwhile the garbage bin, with high tide the garbage will flow away. Fresh water comes from rainwater and ground water pumping and there is no sanitation system. From the roads and from dwellings the water is visible.





Roads

The roads are very narrow and are only accessible for scooters and bikes. The roads are parallel along the rivers and have very little exits. There is a bad connection with the rest of the city, just a very few routes lead to the city center.

Diagnosis

- Strong relation with the water
- No fresh water supply
- Poor flood defence
- Bad connection city

2. Yellow: Rice field urbanisation

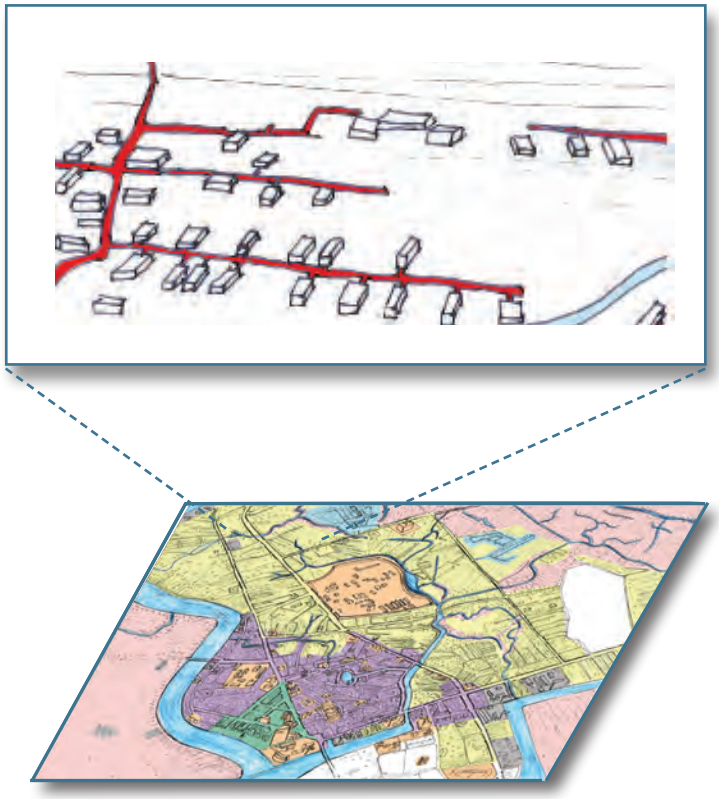
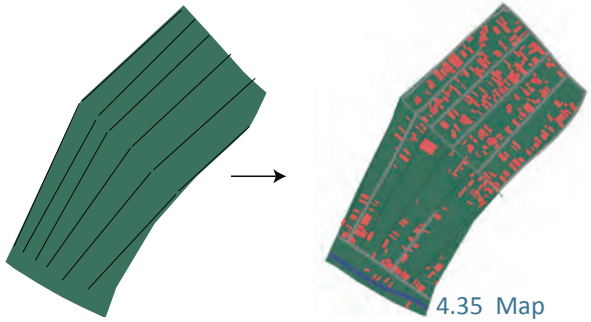
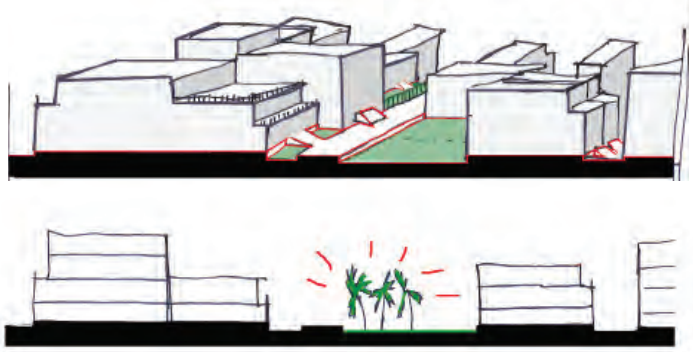


Fig. 4.34 Rice field urbanisation location



4.35 Map

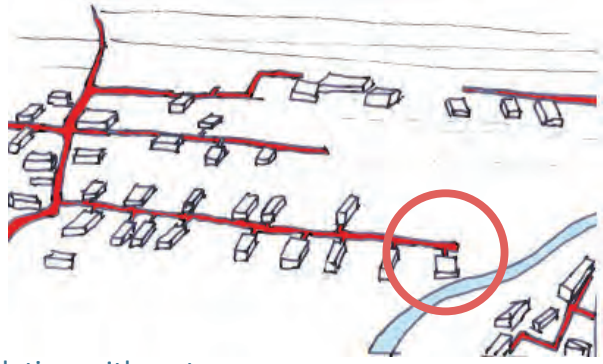


Flood defence

Houses are heightened up and are also provided with tiles. In the less urbanised 'urbanising rice fields' there is still a lot of green space in which water can penetrate. In the more urban districts this green space is disappeared in which rain water can not go anywhere, the urban heat effect increases by lack of green and there are no trees to provide any shadow.

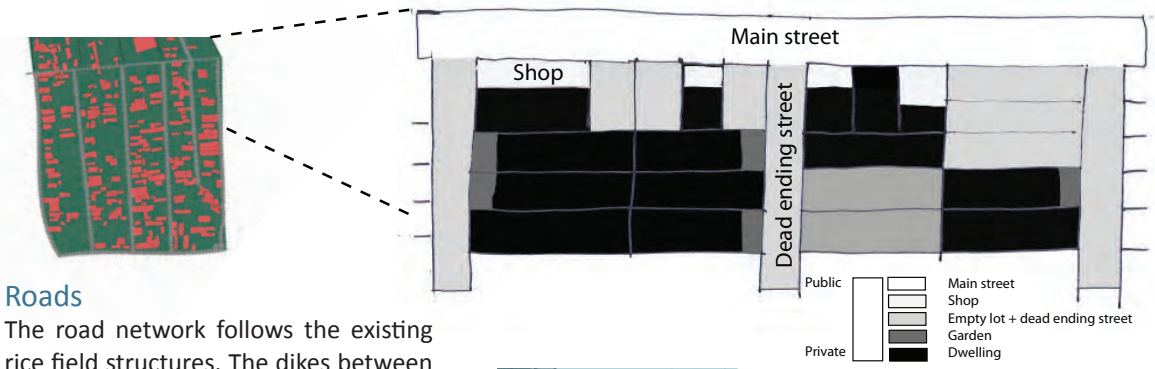
Rural 'rice field urbanisation'

Urbanised 'rice field urbanisation'



Relation with water

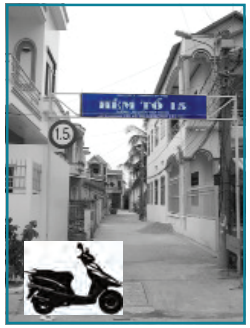
The urbanisation is facing it's back to the water and does not use the water anymore. The creeks are used a sewage system and garbage bin.



Roads

The road network follows the existing rice field structures. The dikes between the rice fields become the new roads.

A main road with shops connects dead ending streets in which the most houses are situated. The main roads are accessible by car, the most dead ending streets are only accessible by car or scooter.
The dead ending streets feels like semi-public space called 'Nem tó' and the



Diagnosis

- Based on existing landscape
- Loss of relation with the water
- Appropiate road system
- Densification of the 'urbanising rice fields' leads to loss of green

3. Purple: Urban area

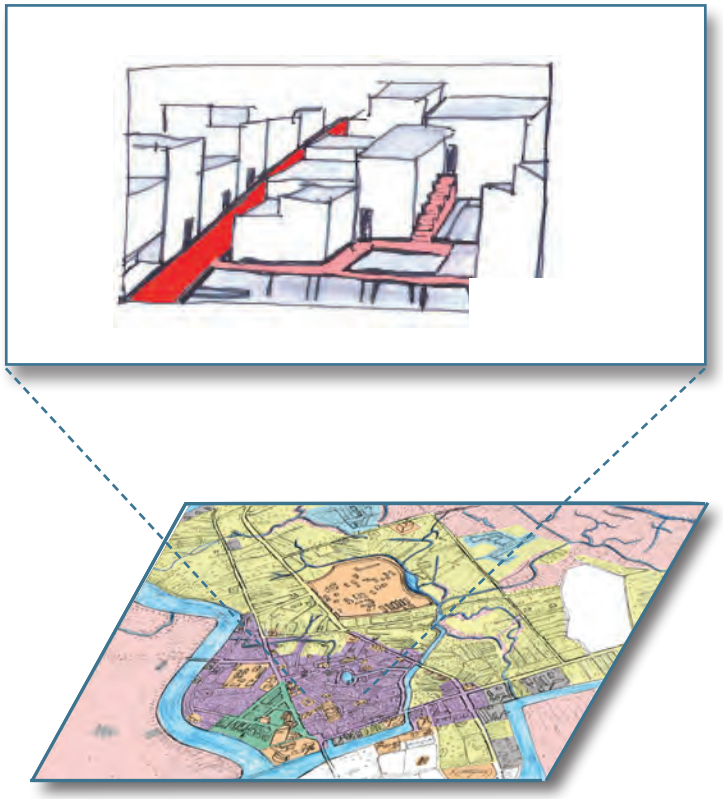
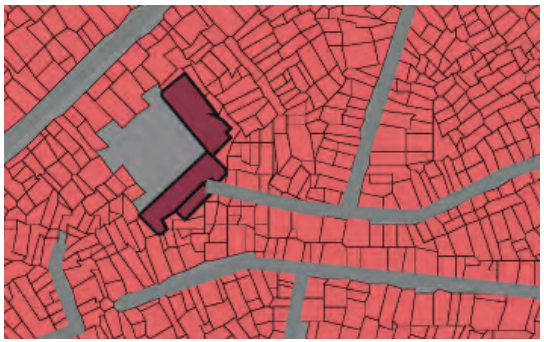


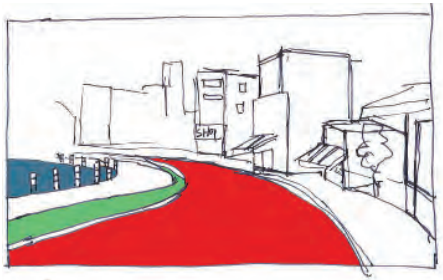
Fig. 4.40 Urban area location

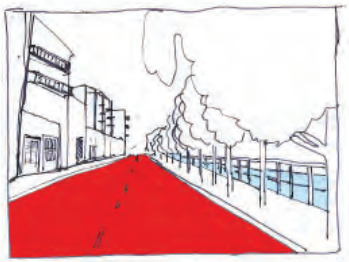


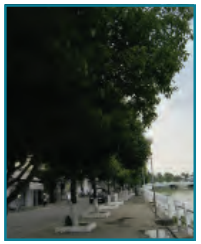
4.41 Map

4.42 Flood defence

Housing and shops are lifted up and also have tiles. The slopes are used to drive the scooters inside to keep them safe for flooding.



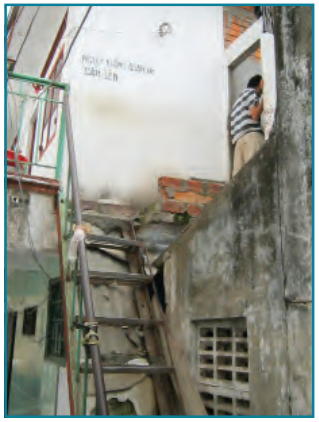


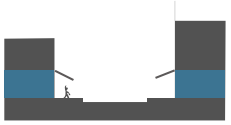


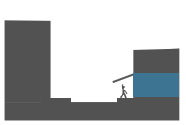
4.43 Relation with water

The urban area has small boulevards which also have fences.

Other rivers are dirty and unattractive, smelly places.







4.44 Roads

The roads have a few trees and have a lot of shops (blue). The roads are all accessible by car and there are no traffic problems. There are no parking places for cars or scooters, they park on the footpaths.

Diagnosis

- Some rivers have a well developed waterfront, others are dirty and unattractive places.
- Roads have no green
- High densities and no public space

4. Green: Urban core

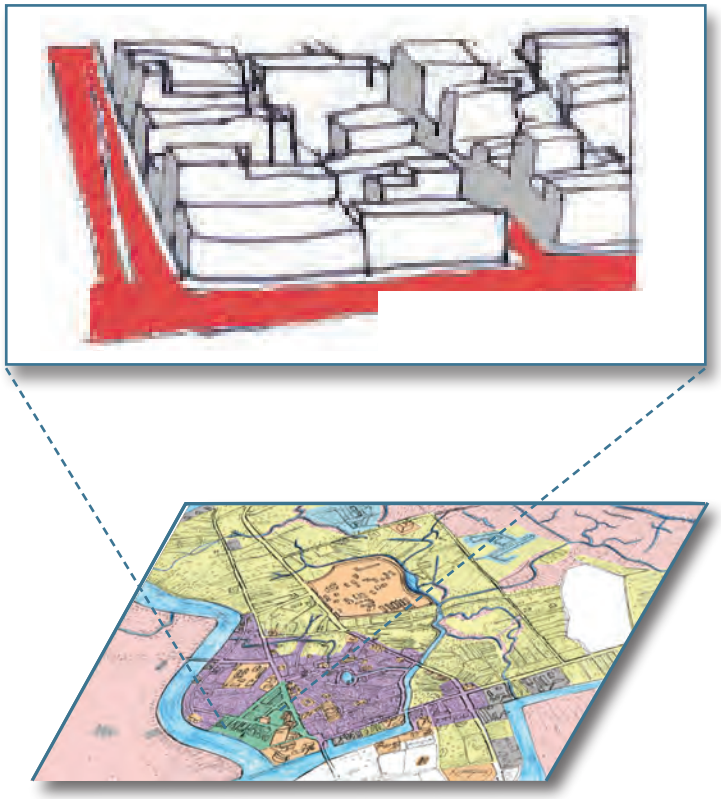


Fig. 4.45 Urban core location

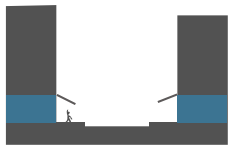
Fig. 4.46 Map

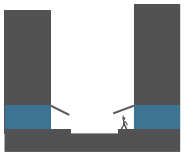
4.47 Flood defence

Housing and shops are lifted up and also have tiles. The slopes are used to drive the scooters inside to keep them safe for flooding.

4.48Relation with water

The urban core has a well developed, well used waterfront what is one of the few public spaces in the city. Along the waterfront it is less hot and there is space for recreation. Unfortunately the river and boulevard is separated by fences. The housing is all connected to sewage and fresh water system. Small restaurants along the boulevard use the Mekong river water for cleaning the dishes.





4.49 Roads

The large roads are provided with some green and trees and have very much lanes.
Smaller roads have lack of green.
Shops are everywhere and above the shops, people live in high densities.

Diagnosis

- Recreation and tourism along the waterfront. The waterfront provides a cooler place in town.
- Lack of green in smaller streets
- Lack of parking places if the use of cars grows in Vietnam.

5. Blue: New housing areas

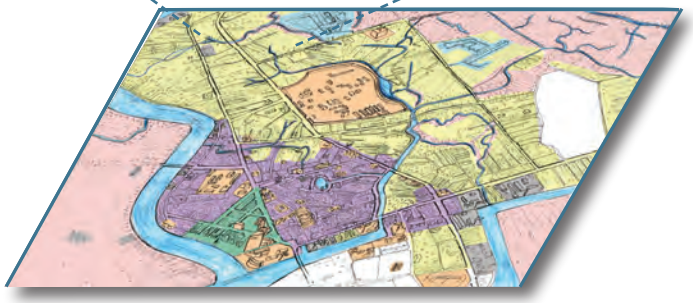
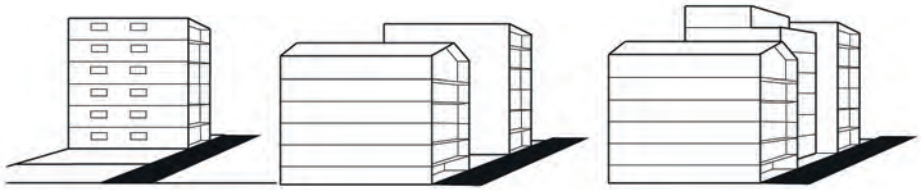


Fig. 4.50 New housing area locations

4.51 Map

Fig. 4.52 New expansion housing area. Source: Google images



Tabula rasa expansion is the other way of urbanisation. (The other one is urban sprawl in rice fields). Areas outside the cities are heightened up with a bulk of sand to protect the district for flooding. On this sand layer a new infrastructure network is placed. Along this infrastructural grid people can buy a plot to built on their house.

The new city district has no relation with the landscape anymore. (Genius Loci, Mumford, 1962). (See chapter 1 : Landscape Challenges)
The new area does not fit in the infrastructural network of the city; only the people will come there who can afford a dwelling here. Spencer (2010) argues already

'The long term trend towards a growing social inequality is currently in its initial stages in the fast-developing cities of Southeast Asia.'

Districts like this are the first examples of this. (See chapter 1 : Socio Economical Challenges).

Diagnosis typology analysis

Genius loci
- Rice field development is a useful natural way of city growth.

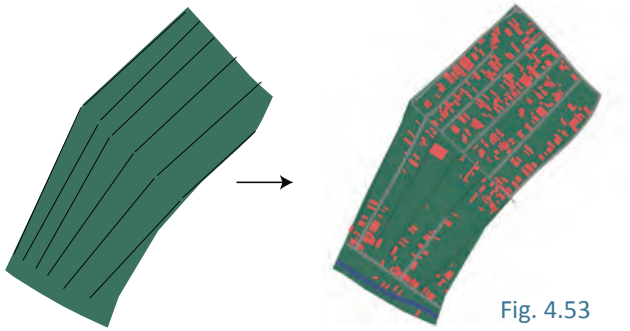


Fig. 4.53

- This in contrast to tabula rasa expansion resulting in loss of relation with the landscape and segregation in the city.

The relation with water

in urban core : Recreation
Relation with water in outer areas: Neglect of water
Relation with water in rural areas : Water is used in daily life, with pollution and salinisation of the river this leads to diseases and loss of nature.

Clean water will contribute to fresh water supply
will contribute to more attractive boulevards improving relation people - water

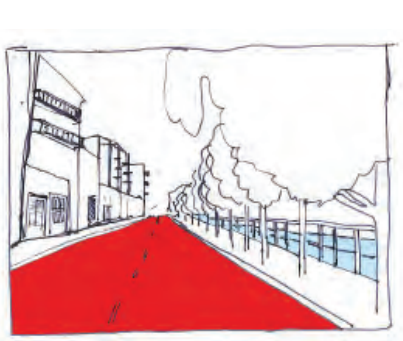
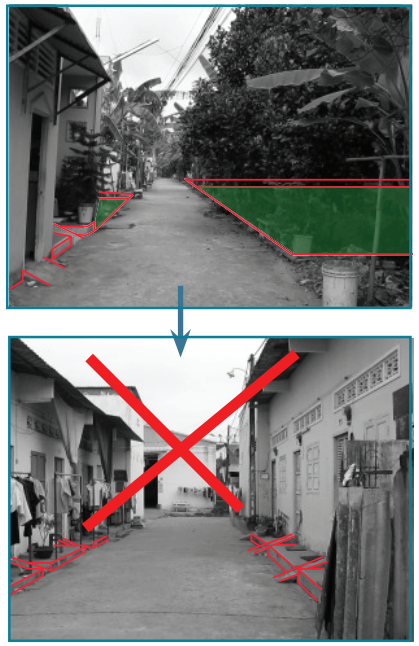


Fig. 4.54 Flooding:
Densification of the inner city leads to more flooding.
A further state of ricefield urbanisation leads to loss of permeable surfaces causing flooding by rainfall. This should be avoided.



Improving living circumstances:

More public space
Avoid segragation in the city
fresh water supply

HYDRAULIC DIAGNOSIS

In 2000 and 2009 two extreme floods took place in Can Tho. The flood in 2000 was even one of the biggest floods ever remembered in the Mekong delta, causing a river level of 1.9m. In the center of the city 25% of the main roads were inundated with more than 30cm due to high tide and 10 cm extra after a heavy rainfall on the same moment. In 2009 enormous rainfall caused flooding locally till one meter (Huong and Pathirina, 2011).

Besides the problem of flooding, according to Tuan, Wyseure and Vliet (2004) there are other quantitative and qualitative water problems in Can Tho:

Quantitative problems:
- Inundation
- Shortage of fresh water

Qualitative problems:
- Salt intrusion
- Acid sulphate soils
- Water pollution

For Can Tho, the largest problems are inundation and water pollution due to agrarian fertilizers, industrial chemicals and household waste (De Nijs and Derden). Furthermore, common poverty and high densities give high pressure on the fresh water supply in future and city expansions show poor areas in the most low lying city regions, which are the most vulnerable to flooding (Pham and Pham, 2011).

Inundation

Inundation has three main causes:
- Rainfall
- River level higher than 1.7m above sea level
- Tide from the Chinese sea, although, Can Tho City does not suffer much from storms, hurricanes or typhoons in comparison with other regions.

Fig. 4.55 Floods in Can Tho. Source: Google Images

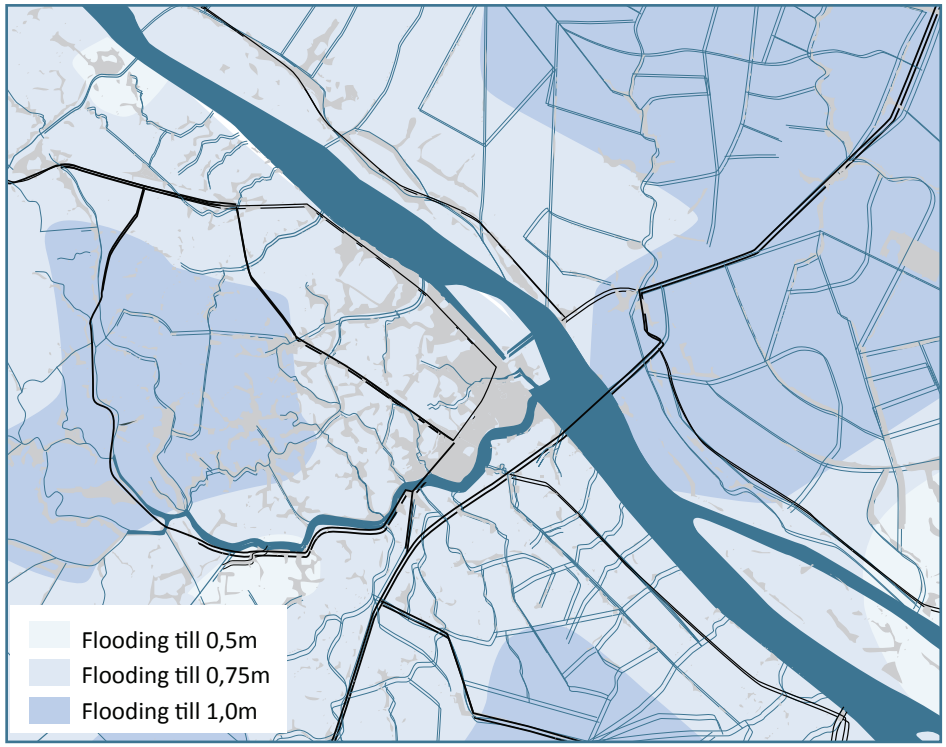


Fig. 4.56 Flooding in Can Tho province and Can Tho city region. At the northern side of Can Tho the city is more affected by flooding. Can Tho city is affected by flooding till 0.50m - 0.75m. Based on: World Bank, 2009

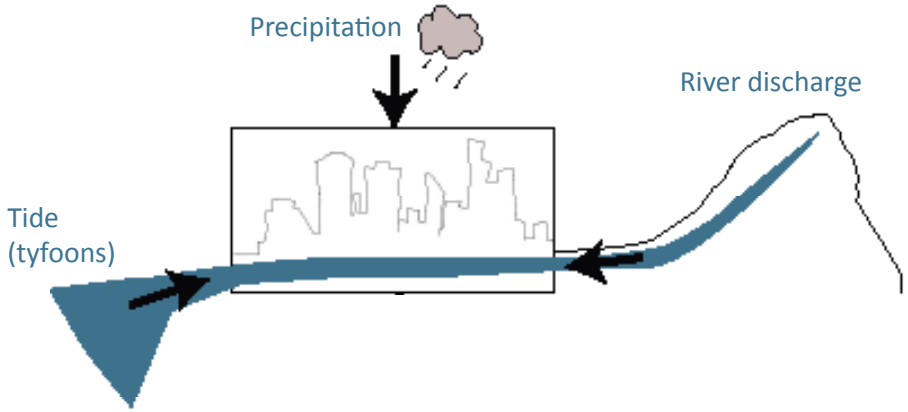


Fig. 4.57 Flooding The average rainfall in the city is 1640 mm a year. This rainfall falls in a few months and short and extreme rainfalls causes problems. Rainfall ranging from 50 to 100mm a day combined with high tide and a high river discharge typically cause flooding in Can Tho. The most extreme rain ever measured was 110 cm in 1,5 hour. The decreasing amount of m2 permeable surfaces in the city causes more problems in future. (rainfall The Netherlands: 700 - 900mm a year). When the tide is turning to ebb, the water surplus will go back to the river. (figures on the right).

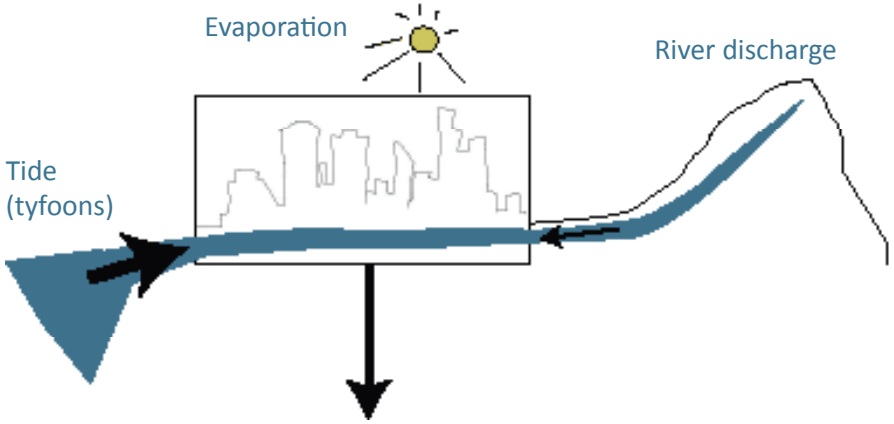


Fig. 4.58 Drought In dry season the influence of the tide is much larger in Can Tho than in rainy season what makes the salt sea water comes much further in the delta. The river discharge can be 10x smaller than rainy season and together with evaporation there is a fresh water shortage in urban areas resulting in large scale ground water pumping what causes land subsidence.

Water level fluctuations

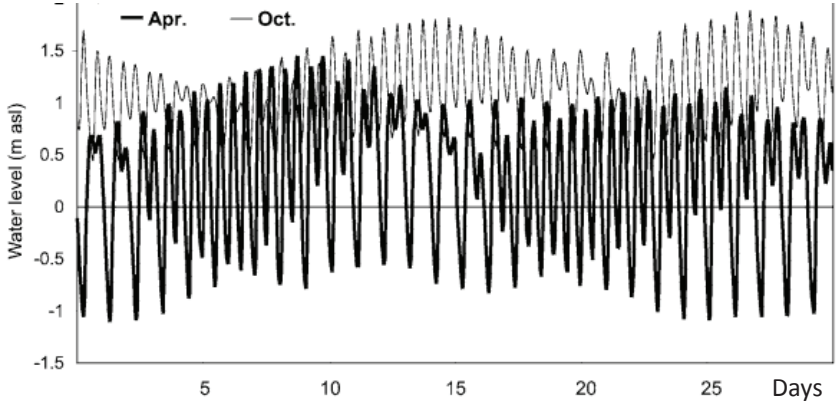


Fig. 4.59 Water level fluctuations in April 1993 (dry season) and October 1996 (wet season). Source: Wassmann et.al., 2003

Fig. 4.60 Dry season water level April 1993:
- Large fluctuations per month
- Fluctuations till 2.5m / month
- Water level max: 1.5m
- Water level min : -1m

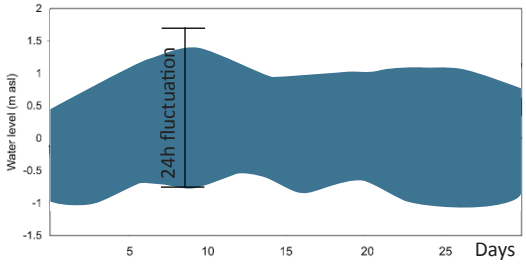
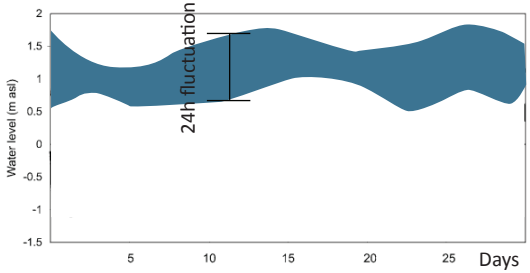


Fig. 4.61 Wet season water level October 1996
- Much smaller fluctuations per month
- Fluctuations till 1.25m / month
- Water level max : 1.8m
- Water level min : 0.5m



Fluctuation difference a year: ca. 2.8m

Differences wet and dry season:
- Dry season more fluctuation
- Min water level 1.5 m lower
- Max water level 0.5m higher in

Climate change

The climate change trends predict in many regions an increase of flood magnitude and frequency. THe climate change makes the weather less predictable and heavy storms more uncertain and more often. Huong and Pathirina, 2011).

Sea level rise

A global average sea level rise of 9–88 cm is expected over the next hundred years (UNFCCC, 2005). Although, this is a very vague basis to built the design on. In Vietnam, sea level rose at the rate of about 3mm a year during the period of 1993–2008 (MONRE, 2009a). Based on this the mean sea level rise is predicted to increase for 30cm in 2050 and 100cm by the end of the 21st century as the worst case scenario (MONRE, 2009). This worst case scenario is the criteria for the design.

Precipitation

The annual and rainy season's rainfall will increase about 5% compared to that of the period 1980–1999 (MONRE, 2009). Precipitation goes from 1640 to 1722mm a year with a maximum of 105mm rainfall a day (in extreme events).

Temperature

By the end of the 21st century, the temperature in Vietnam will increase by 2.3◦C based on the average of 1980–1999 (MONRE, 2009). This will improve urban heat effects.

Subsidence

Land subsidence probably also contribute to the increasing flooding situation in Can Tho due to ground water extraction and a larger pressure on the soil. However, there are no studies on the land subsidence rate in Can Tho.

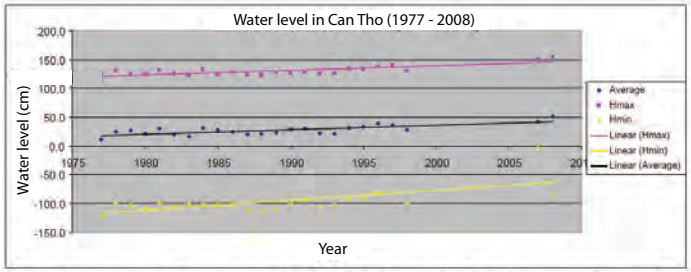


Fig. 4.62 Increasing water level at Can Tho. The difference between low and high tide is about 2m. Source: Statistical Office of Can Tho , 2008

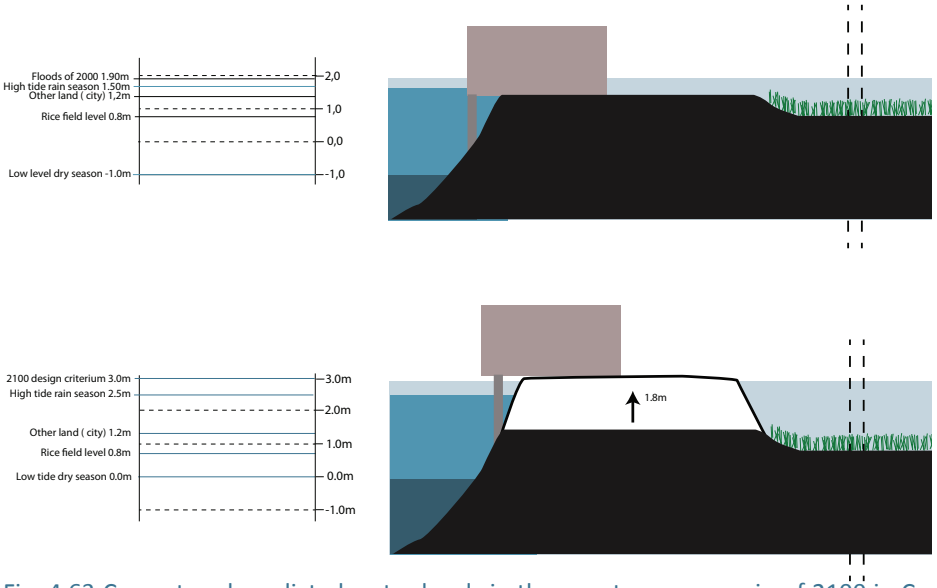


Fig. 4.63 Current and predicted water levels in the worst case scenario of 2100 in Can Tho. Source: Shannon , 2008

Diagnosis hydrological analysis Can Tho

Fig. 4.64 Today

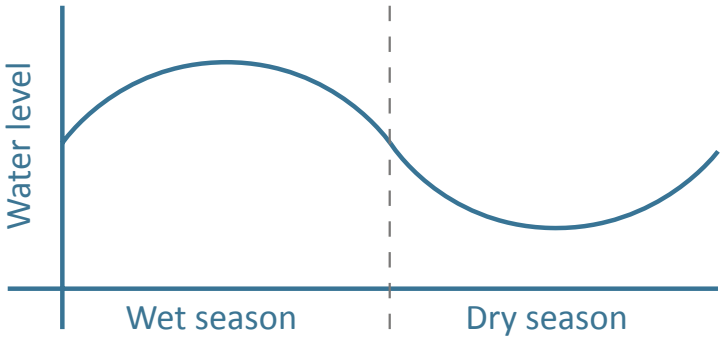
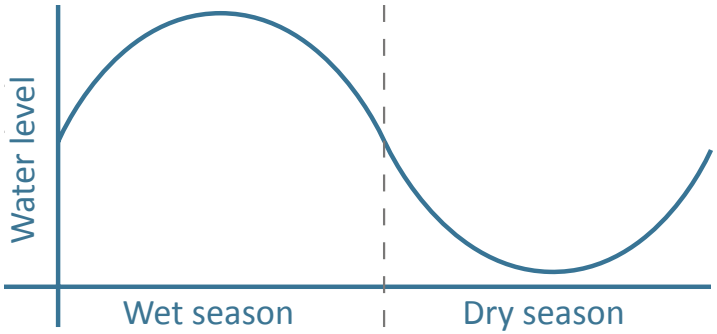


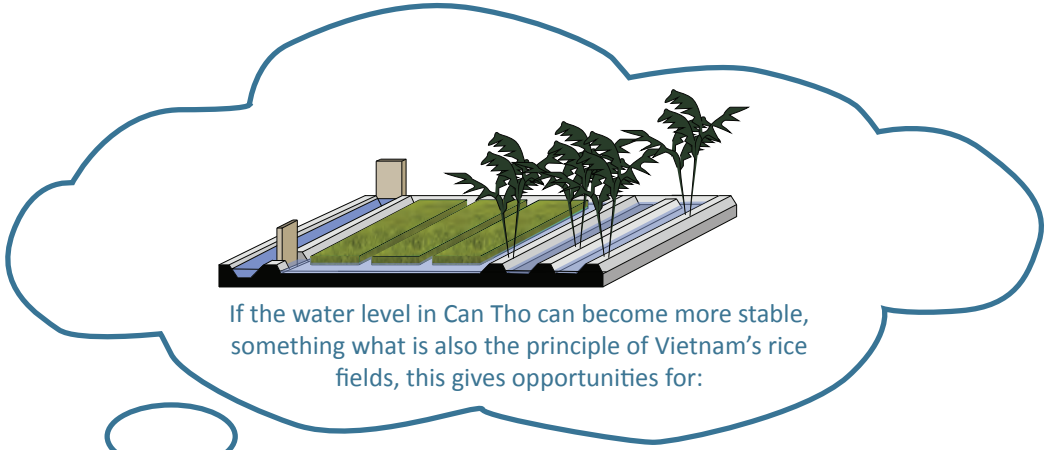
Fig. 4.65 Future : climate change



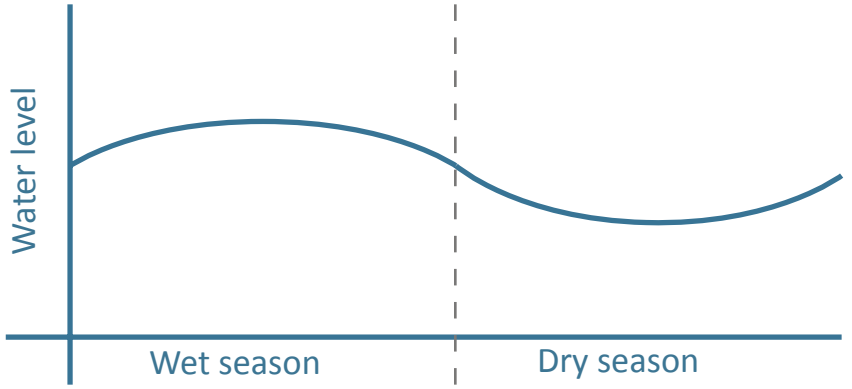
Unacceptable flooding

- Salinisation
- Fresh water shortage, increased by acidation and salinisation
  - Ground water extraction
  - Soil subsidence

Solution?



If the water level in Can Tho can become more stable, something what is also the principle of Vietnam's rice fields, this gives opportunities for:



Protect city for high water levels:

- Decrease flooding

Store water in dry season

- Decreasing acidation and salinisation
- Fresh water supply
- Decrease urban heat effect
- Better relation with the waterfront

CONCLUSION CHAPTER 4

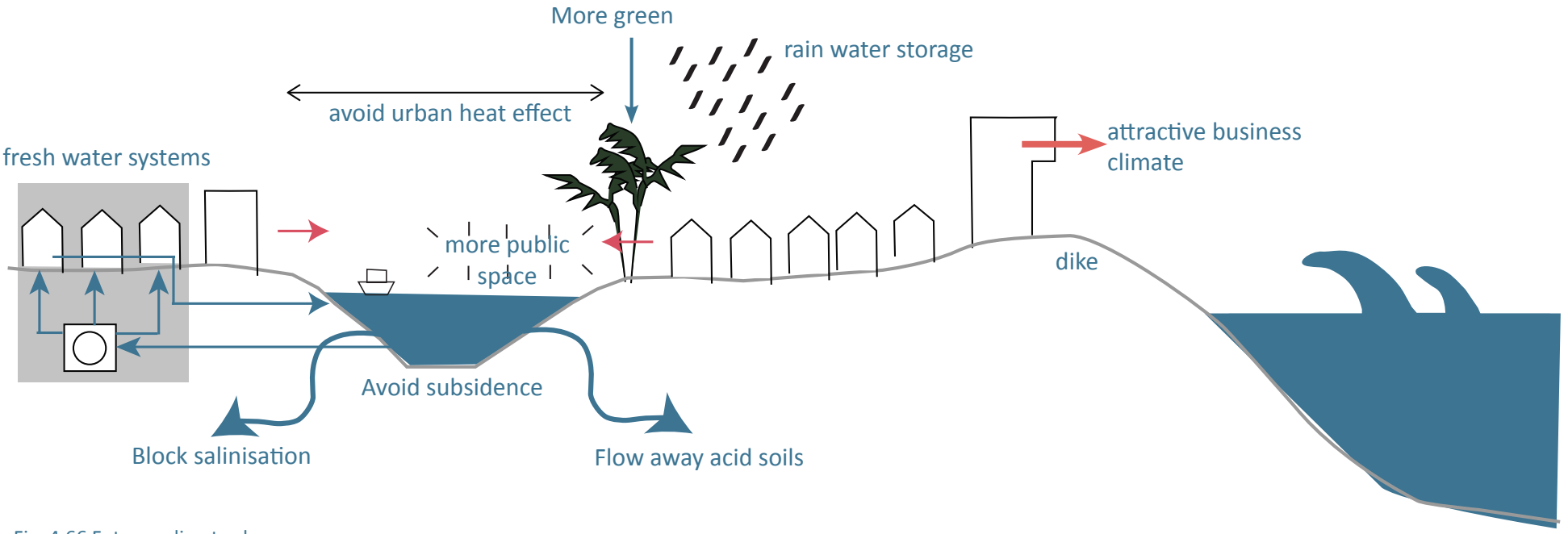


Fig. 4.66 Future : climate change

In order to answer the research question:

- Implement a dike to stay safe for high river discharges and keep clean water inside the dike ring
- Store this clean water to use in dry season avoiding subsidence and salinisation, use for maintaining a stable ground water level, fresh water supply, urban heat effect, improve relation water - city
- Increase permeable areas, green and water storage places to catch up heavy rainfall
- New city structure to connect whole city together avoiding segregation and give a public space network.


Long Tuyen
Thanh Loi
A5
BASSAC
Cai Van
My Thuan
Ap Binh Nhut
an Tho
Fy
Ap Dong Loi
CAN THO
Dong Thanh
14
Ap My Dong
Tan An
Cai Rang

In this chapter the diagnosis from chapter 4 will be transformed to a spatial vision for Can Tho on city scale; how should the city should develop in the future? The components of water, green and roads.

Chapter 5
Vision Can Tho

Water
Green and water safety
Drainage areas
Vision
Spatial transformations with the masterplan

1. WATER

Bring back the former creeks

The 3x3 analysis showed through time a lot of creeks are disappeared causing water problems in the city. (Fig. 5.1, 5.2 and chapter 3). If the former creeks will come back in the city the drainage, water storage capacity and ground water level of the city will improve. Focussing on water fronts gives opportunities for public spaces and paying attention to the water also increases the awareness of the importance of water.

The come back of surface water in the city will have direct effects on flooding. Current floods occur because rain water can not run off while the river tide is high. If this water could be stored this will decrease flooding.

After the implementation of a dike around the city the surface water has an important role as well. The balance of the ground water will be more constant and rain water can be collect and pumped away in low tide.

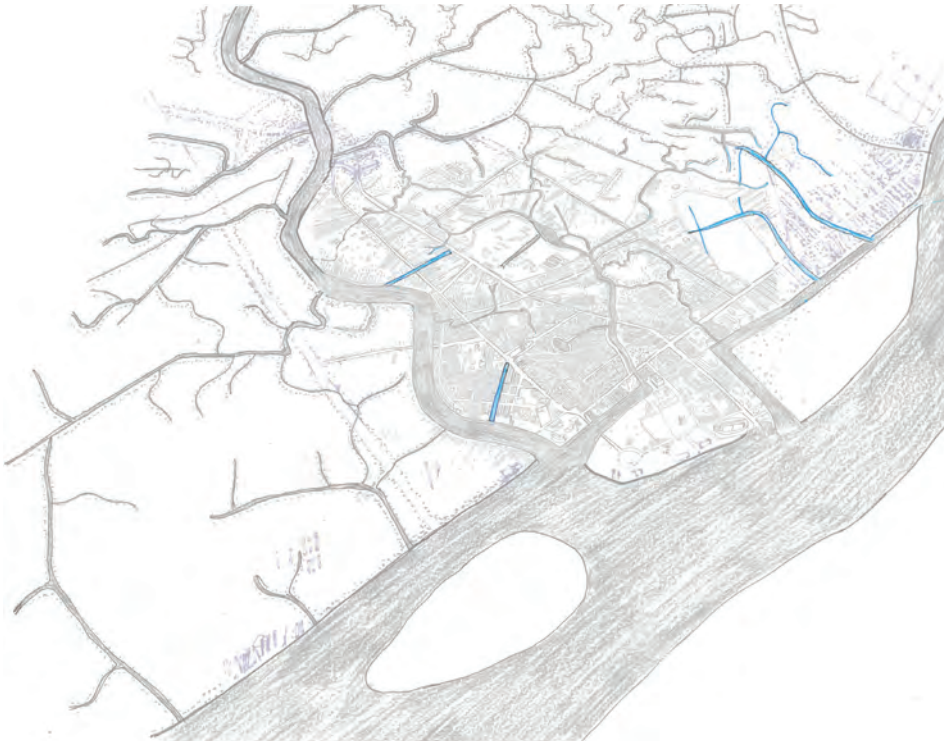


Fig. 5.3 Bring back former rivers

Fig. 5.1 Creeks and rivers 1900

Fig. 5.2 Creeks and rivers 2000

Fig. 5.4 Bring back former rivers - Current and new situation

2. GREEN STRUCTURES AND DIKE

A dike will protect the city and surrounding areas for flooding.

When the dike is implemented, water inside the dike is closed off from the main stream what gives the possibility to keep it clean and to remain a more constant water level.

The new structure of the city with green public spaces follows the rivers and becomes a network through the whole city. The poorer and richer neighbourhoods will meet each other along the boulevards because they are all connected by this network. Besides, public space along the riverfront makes people aware of the (clean) water and because of the water nearby these are the coolest places in the city. Along the dikes the green line can be integrated as a super levee boulevard, just like in Tokyo, Japan. (See Appendix B Case studies).

The dike can be slowly implemented by transforming the riverfront coming 30 years.

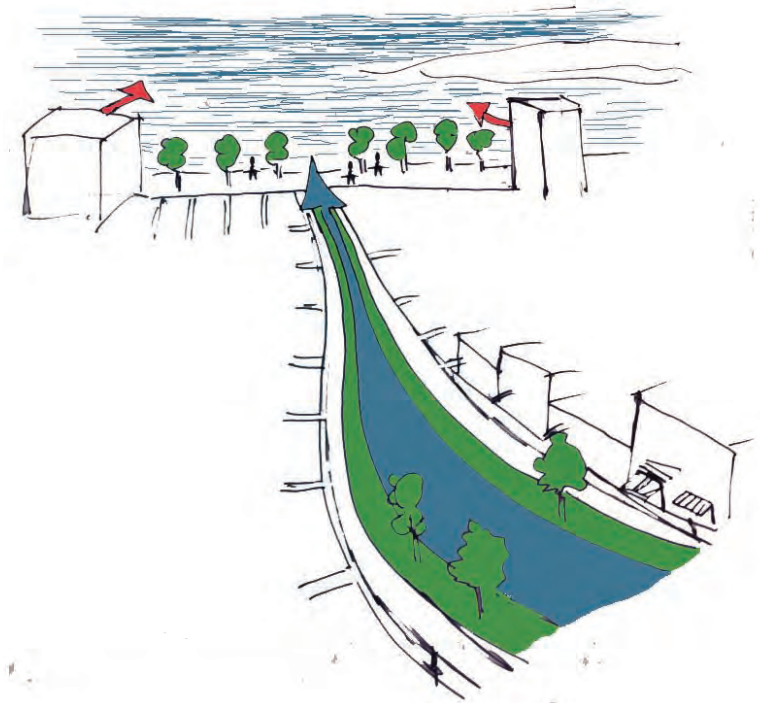


Fig. 5.5 Smaller green structures lead to larger green structures where rich and poor can meet along the boulevards.

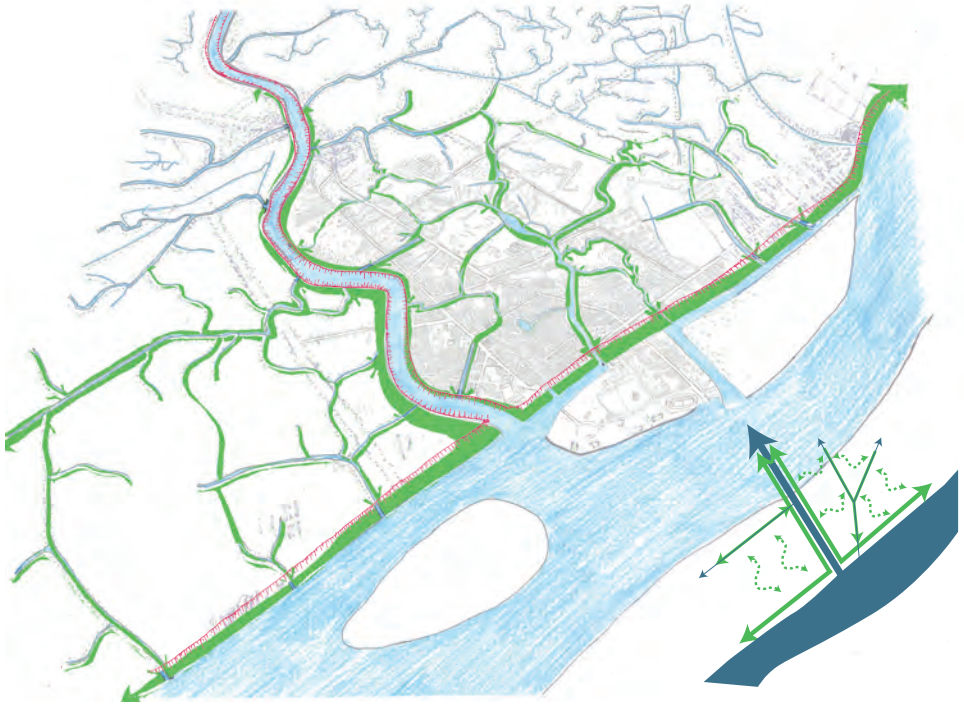


Fig. 5.6 New green structure for the city along the waterfront: Connecting all neighbourhoods.

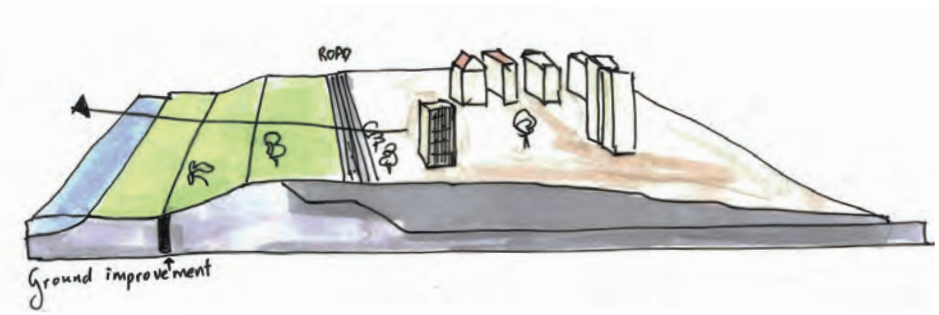


Fig. 5.7 Super levee Tokyo: Dike does not seperate city - river and an urban park is integrated with the dike.

Spatial transformations green network:

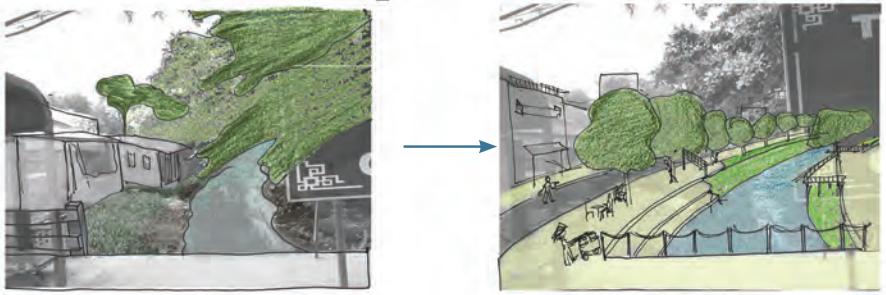


Fig. 5.8 Transform the forgotten rivers from a backside to a front

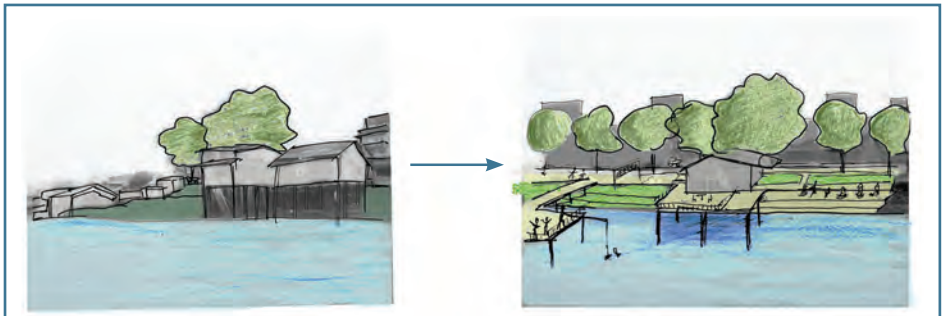


Fig. 5.9 Continue boulevards along the large rivers

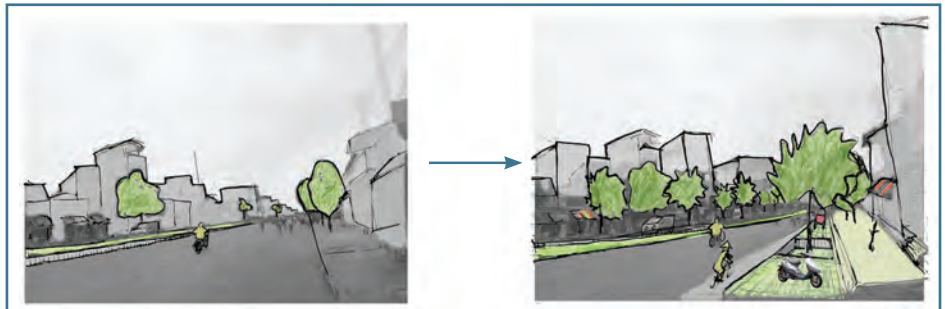


Fig. 5.10 More green and permeable surfaces along large roads

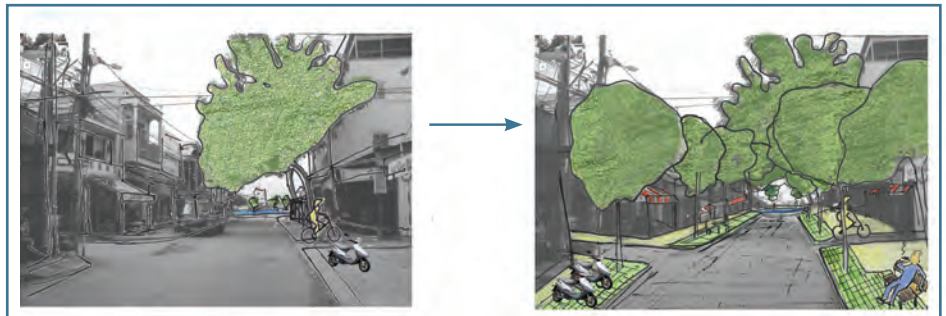


Fig. 5.11 More green and permeable surfaces along small roads

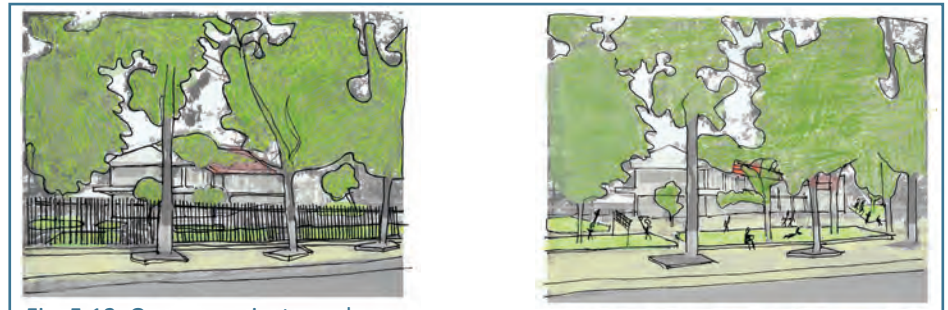


Fig. 5.12 Open up private parks

3. DRAINAGE AREAS

Naturally, rivers have their own natural drainage areas. In Can Tho the water network will be divided in several smaller water networks which are interconnected by sluices. (Drainage areas can help each other if there is a shortage in other areas). The drainage areas are also connected with the Hau river. A surplus of water can be pumped away in low tide of the river.

Each drainage area has the capacity to store fresh water. This water can be used as grey water supply in housing reducing the ground water pumping.
This is also done in Singapore West banks (Marina Bay) where 10% of the fresh water supply comes from natural storage lakes.

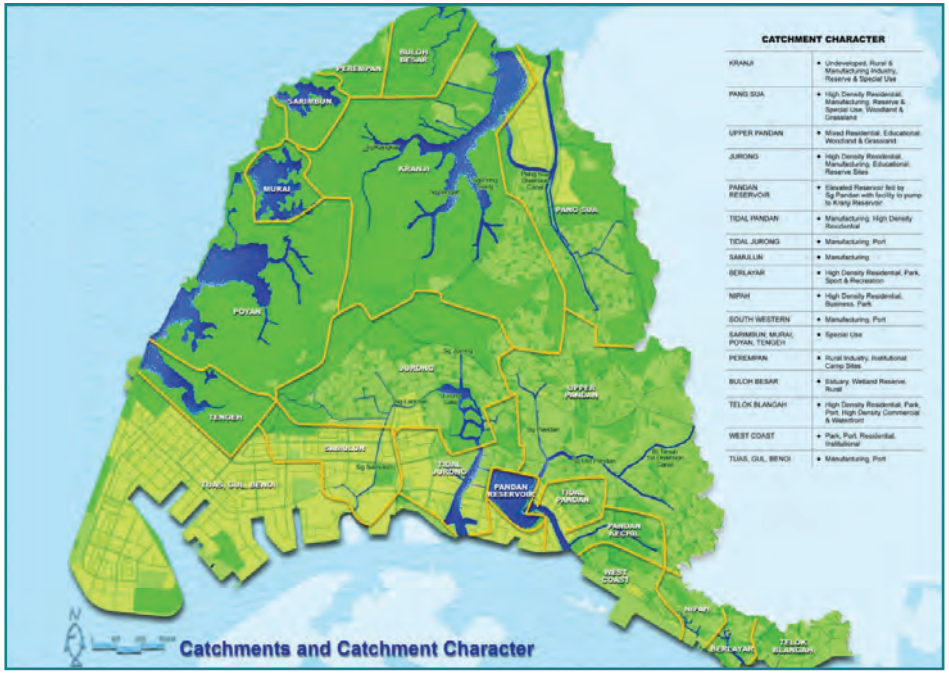


Fig. 5.13 Division of drainage areas of the Singapore Westbanks

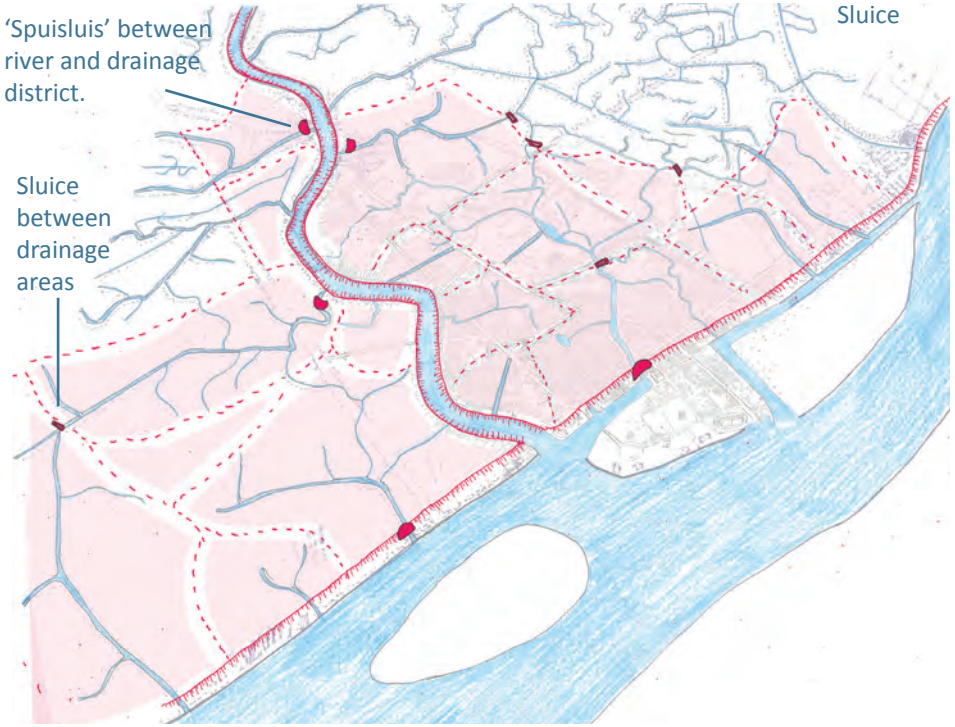


Fig. 5.14 Division of water systems in Can Tho based on drainage areas of river arms.

MASTERPLAN

Together with the continuation of the strong road grid what will avoid the green and water (Case study Tokyo) the vision of the city:

Fig. 5.15 Vision

Alternative solution

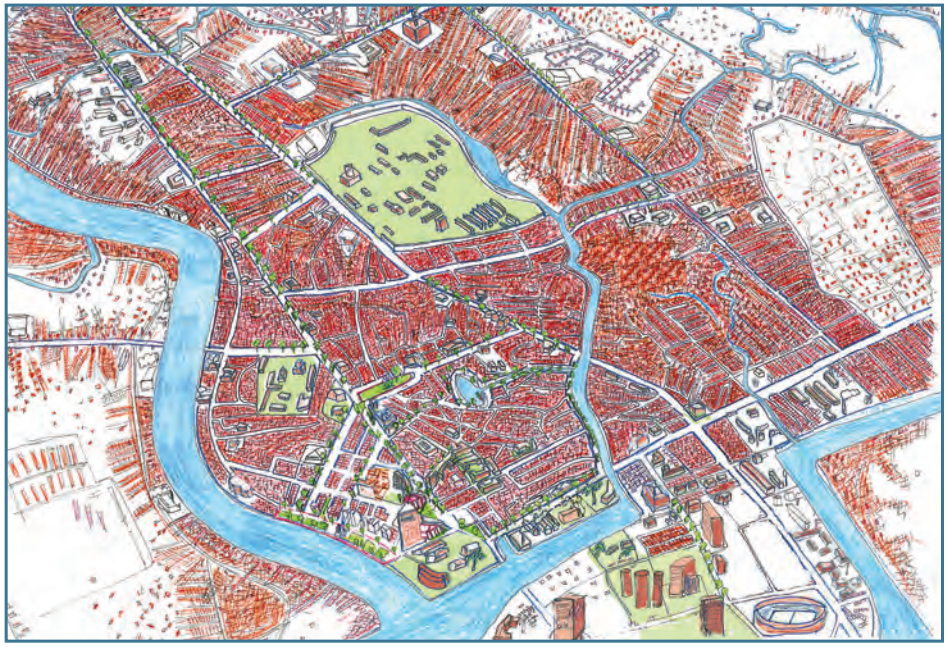


Fig. 5.16 Development of the city if no intervention takes place: Sprawl, further segregation, further loss of green and water.

Fig. 5.17 Alternative vision for the city :

Wetland area; Source: Google Images

Chapter 6
Strategic project:
'transformation of the rice fields'

Context: distict behind university
Layers of the University district
Water system concept
Calculations for needed water storage
Cleaning systems
Spatial concepts
Map
Details

TEST CASE: UNIVERSITY DISTRICT

One of the quickest growing areas in Can Tho is the area behind the (agricultural) university of Can Tho. The area is already surrounded by roads and in the growth of the city we see roads are popular places for settlement. This area is also one drainage area of a river arm. (See vision). This strategic project shows how the drainage areas work on smaller scale.

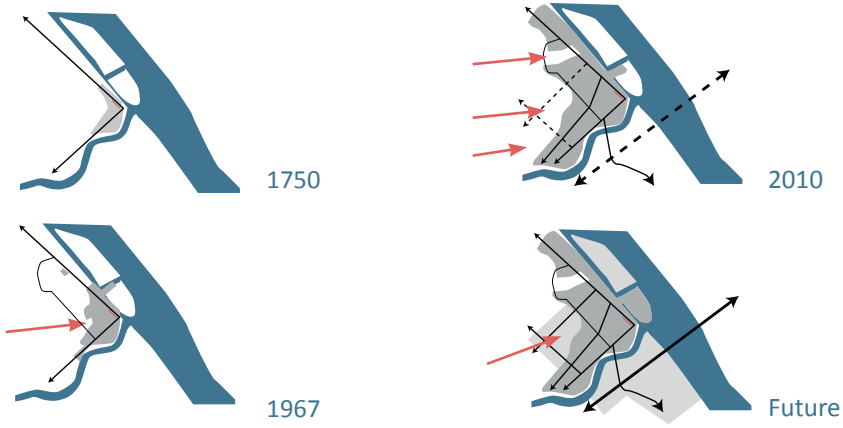


Fig. 6.1 Quick overview growth of Can Tho.

Fig. 6.2 Location of the strategic project: one drainage area

CONTEXT: DISTRICT BEHIND THE UNIVERSITY

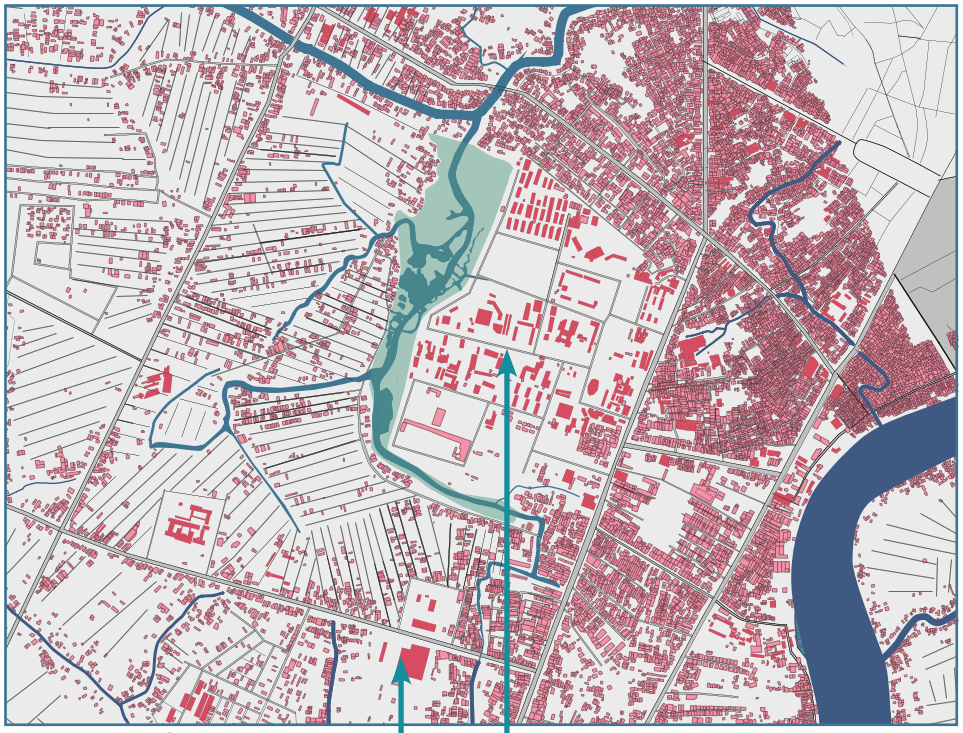


Fig. 6.3 Map of the area
Based on Wisdom, 2011.

Context

In the middle of the city a large university complex is situated. Besides faculty buildings the complex consists of dormitories, research institutes and areas for agricultural experiments. The wetland area in the middle is a water buffer area in rainy season.

Fig. 6.4 Wetland. Source: Google Images

Fig. 6.5 Can Tho university library.
Source: Google Images

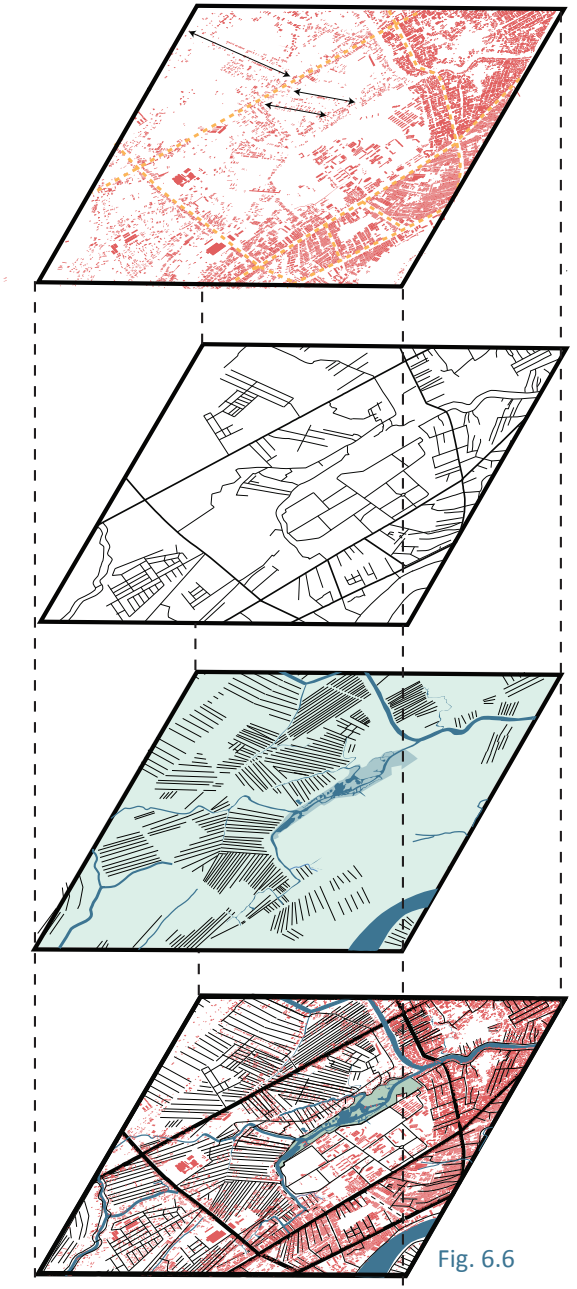


Fig. 6.6

Occupation

The area is dominated by landscape and the housing density is low. The rice field typology is the most common typology in this area. Also along the main roads linear urbanisation takes place.

Infrastructure

4 Main roads enclose the area. The university complex has his own road grid what is not accessible if you are not authorized to come there.
Small roads lead to the housing in the former rice fields.

Hydraulic system

The former rice field allotment structure is a dominant factor in the landscape. The river arm drains the area after rainfall and is connected with the former rice fields.

All layers

WATER SYSTEM

Masterplan

The masterplan showed the city will be surrounded by a dike in the future. This gives possibilities to lock off the rivers behind the dike from the large Hau river. The rivers behind the dikes are divided in their drainage areas. This division makes a proper water management possible in Vietnam.

In the area a natural storage lake is already situated. This lake can store the shortage of water in dry season for fresh water use and keep the ground water level in balance.

In rainy season

'Rainwater supply in the Mekong delta is plentiful and of good quality and it can be used for drinking water.'
(Mekong Delta Water Resources Assessment Study).

Rain what falls on roofs is stored in tanks below the dwellings will be used for fresh water supply for activities as cooking and washing. (3m3 per household in order to overlap dry days. This is an already proven concept and largely used in Asia, for example in Thailand, fig. 6.6). The overload of rainwater can be stored in the storage lake for use in the dry season. The waste water from these activities will go through a natural cleaning system to the storage lake. Water from the storage lake can be used as grey water for activities as the washing machine, cleaning and gardening. This water will be cleaned again and remains in the water system.

In dry season

In dry season (4 months) there is hardly any rain water for fresh water use. Extra water from outside the district will be needed. The rest of the system stays the same.

Toilet

Natural cleaning systems are not able to clean water from toilets. Human excrements will be picked up daily or a sewage system can be implemented and brought to artificial cleaning stations.

Overload

Not all the rain water is necessary to re-use. This makes we do not have to re-use the water what falls down on the most dirty places like the traffic roads and public spaces. This water is better to get rid off and let penetrate in the soil. Rain water that runs off from roofs, green areas and directly in surface water itself is the most clean. (Fig. 6.7) This water will be brought to the storage lake. Overload in the storage lake can be pumped to the large river in low tide. (Case Study: EVA Lanxmeer (Meijer, Dubbeling and Marcelis. 2010)). This water system paragraph will further explain :

- Water infiltration systems
- Natural cleaning systems
- Calculation for the needed storage water to 'survive' dry season

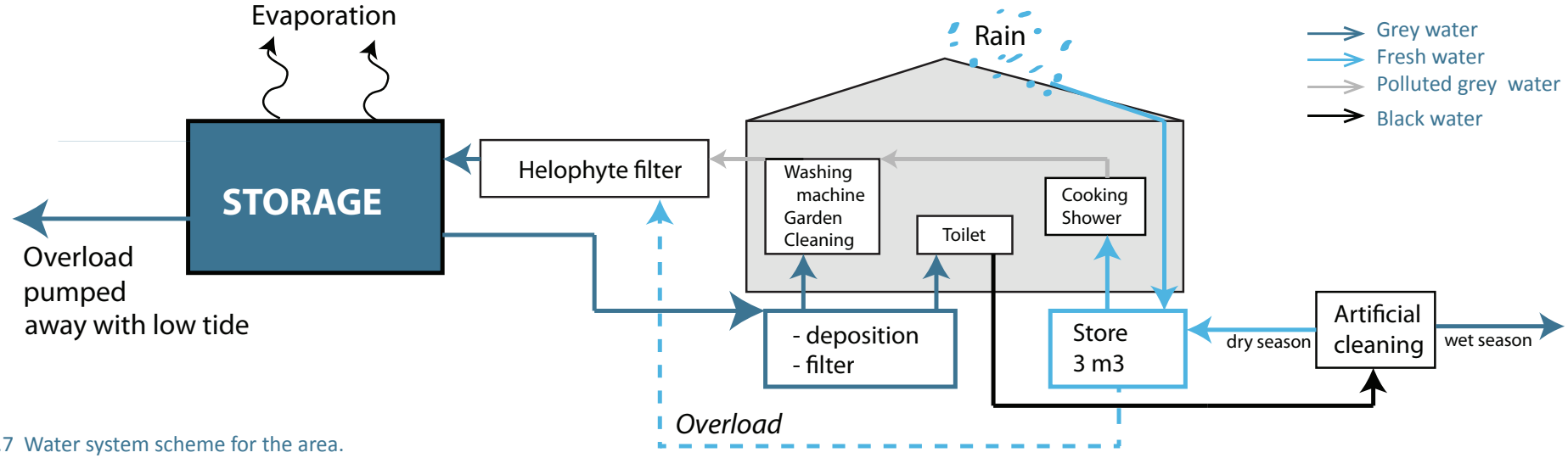


Fig. 6.7 Water system scheme for the area.

Cleaning system

Wetlands with helophyte filter plants fulfil an important function in improving the quality of surface water. These wetlands help in the elimination of phosphates, nitrates, solid substances and heavy metals. Urban wetlands can be used to maintain or improve the quality of the surface water. ((Ehrenfeld, 2000) (Polz and Bleuzé, 2012). An area of 2.5 m is suitable to clean the waste water of one person. (Polz and Bleuzé, 2012).

In an area with a housing density of 80 dwellings per ha. and an average of 4,6 persons per household this indicates:
(80 x 4,6 x 2,5) / (100 x 100) = 9,2 % of the urban surface needed for cleaning wetlands.

In order to keep a circulation system (avoiding mosquitoes and silent water) the horizontal helophyte filter is the most suitable for Vietnam. (Fig. 6.8). The Can Tho University is already working with large scale test projects with helophyte filters.

Suitable plants for the helophyte filters are : Reed, flowering rush (zwanebloem) , common club-rush (mattenbies), bulrush (lisdodde). In Vietnam the Phragmites reed species has proven itself the most.

From storage lake to housing

The water in the storage basin consists of rain water what is being exposed to the urban area. In order to make the water suitable to use in housing water needs to be treated once more to get rid of unavoidable pollution. Special tanks are available for this. (Polz and Bleuzé, 2012)

By focussing on the waterfronts with the proposed urban developments people get more in contact with the water. If they understand the importance of keeping it clean pollution and if they understand the water is re-used in their households pollution will decrease and people feel responsible for it.

A new city garbage system will further decrease the pollution of the water.

Fig. 6.6 The cleanest water will remain in the water system.

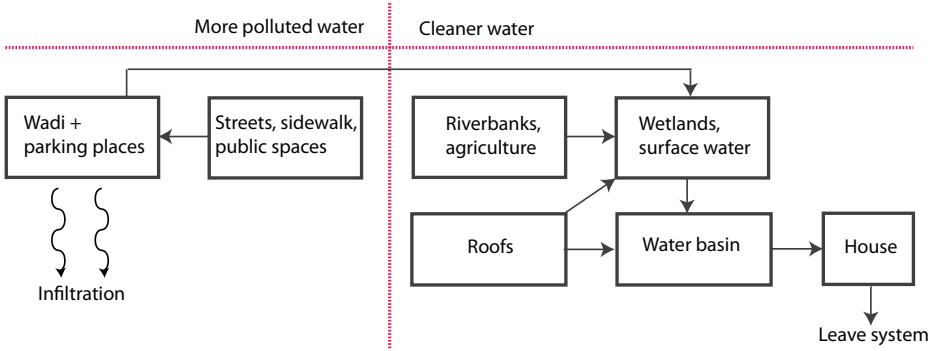


Fig. 6.7 The cleanest water will remain in the water system.

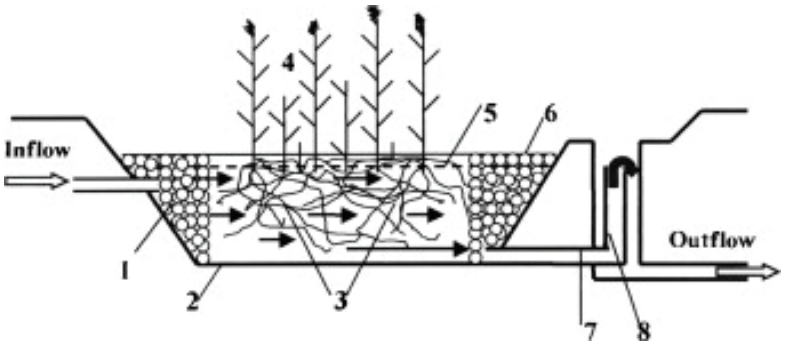


Fig. 6.8 Schematic representation of a constructed wetland with horizontal sub-surface flow. 1. Distribution zone filled with large stones; 2. Impermeable liner; 3. Medium (e.g., gravel, crushed stones); 4. Vegetation; 5. Water level in the bed; 6. Collection zone filled with large stones; 7. Collection drainage pipe; 8. Outlet structure for maintaining of water level in the bed. The arrows indicate only a general flow pattern. Source: Vymazal 2001.

Infiltration

The more polluted water what is unwished in the water system what is used as gray water in housing can leave the area as much as possible by infiltration in the soil. Parks, green parking places and wadi's or bioswales can help to infiltrate this water quickly. (Polz and Bleuzé, 2012). Plants like reed in the wadi can also clean the water before it infiltrates in the soil.

Methods to use are first the wadi: Wadi's are actually huge riverbanks in deserts which are only in use after a heavy rainfall. This concept is now a popular drainage system in urban areas for example in the Dutch city Enschede (Fig. 6.10 and 6.11). In the dry season the wadi functions as green space and recreation. In the rainy season water can be collected and infiltrate in the soil. If the wadi is overloaded an extra piping system can catch up the rain water.

An other principle are green parking places. This double use of space (parking and infiltration) is an interesting idea for Vietnam. Currently, cars are only affordable for the rich, but the amount of cars will quickly increase.
The future parking spaces can be used as agricultural soils or as parking places for the large amount of scooters. (Fig. 6.9 and 6.12)

Fig. 6.10 Swale or wadi in Enschede (Source: Polz and Bleuzé, 2012)

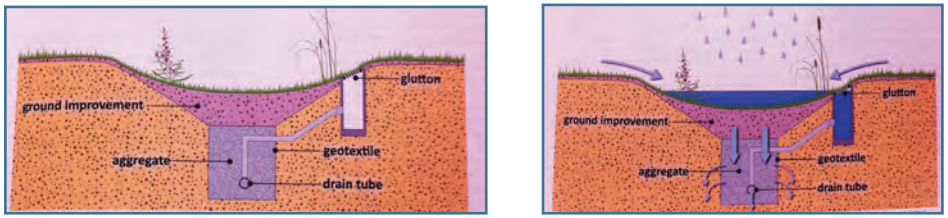


Fig. 6.11 Wadi in the dry and rainy season. Source : Polz and Bleuzé, 2012

Fig. 6.9 Small scale agriculture in between roads in northern Vietnam.

Fig. 6.12 Green parking places (Source: Google Images)

Calculations for water storage

The storage lake should store enough water to survive dry season. Water from the storage lake will get lost through the dry season due to
- Evaporation
- Loss of water in the system : watering the garden, lacking piping etc.: 25% of total water use

Evaporation:

In dry season there is a water shortage in the natural water balance. A larger evaporation than precipitation causes droughts and water shortages in the soil.
In wet season there is too much water what leaves the area. If you can store the water what is needed to keep the water balance proper in dry season less water needs to leave the system and the remaining water prevents drought problems in dry season. (127,5 mm)

Loss of water in the system:

Fresh water use per household per month:
Water use 1 Vietnamese person: 65 liter per day
(Mekong Delta Resources Assessment Studies, 2011).

Water use 1 Vietnamese person per month: 65 x 30 = 1950 liter per month.

Average amount of inhabitants in the Mekong delta: 4,6 persons (Mekong Delta Resources Assessment Studies).

Total needed water to store in the area:

Density: 80 dwellings/ha
Density: 80 x 4.6 = 368 inhabitants/ha
Housing area : 160 ha (university is left out of the calculation) (fig. 6.14).
160 x 368 = 58 880 inhabitants in the area.

58 880 x 1950 liter per month = 115 000 m3 water use per month.
= 115 million liter water use per month.

Per household 2 m3 water storage box for 2000 liter water storage.
58 880 x (2000 / 4,6 / 12) = 2,1 million liter water per household per month.
115 million - 2,1 million = 113 million fresh liter water use in the area per month.

	Precipitation in mm	Urban evaporation in mm	Water use in mm	evaporation - water use)
Jan	10	50	10,5	-50,5
Feb	0	55	10,5	-65,5
March	20	50	10,5	-40,5
April	45	47,5	10,5	-13
May	170	40	10,5	119,5
June	240	37,5	10,5	192
July	260	37,5	10,5	212
August	210	35	10,5	164,5
September	260	32,5	10,5	217
October	310	30	10,5	269,5
November	140	37,5	10,5	92
December	75	42,5	10,5	22
Total	1740	495	100,8	1119

Fig. 6.12 Graph precipitation, evaporation, fresh water loss in the system and total balance. Source evaporation and precipitation: Wds.worldbank.org

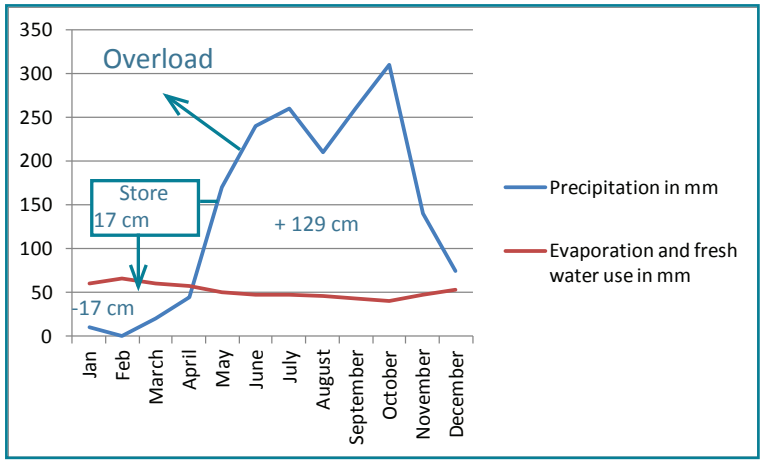


Fig. 6.13 Graph of the table of figure 6.12.

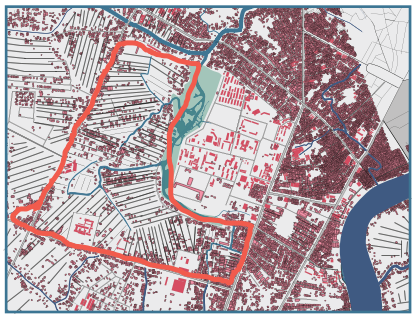


Fig. 6.14 Dwelling area 160 ha.

6.15 Total area 270 ha.

Area incl. university area = 270 ha. = 2,7 million m2 (fig. 6.15).

113 000 m3 water / 2,7 million m2 = 0,042 m/month = 42 mm

25% of 42 mm = 10,5 mm loss of water in the system per month if 100 % of the area is used for water storage.

Needed storage total:

In rain season there is a surplus of 129 cm what can be pumped in the Hau river in low tide..
The water shortage in dry season needs to be stored in the storage lake. (Fig. 6.13).
This is 169,5 mm (17 cm) if 100% of the area is used for water storage. If the height of the water level fluctuation between the rainy season and the dry season increases the water surface can decrease.

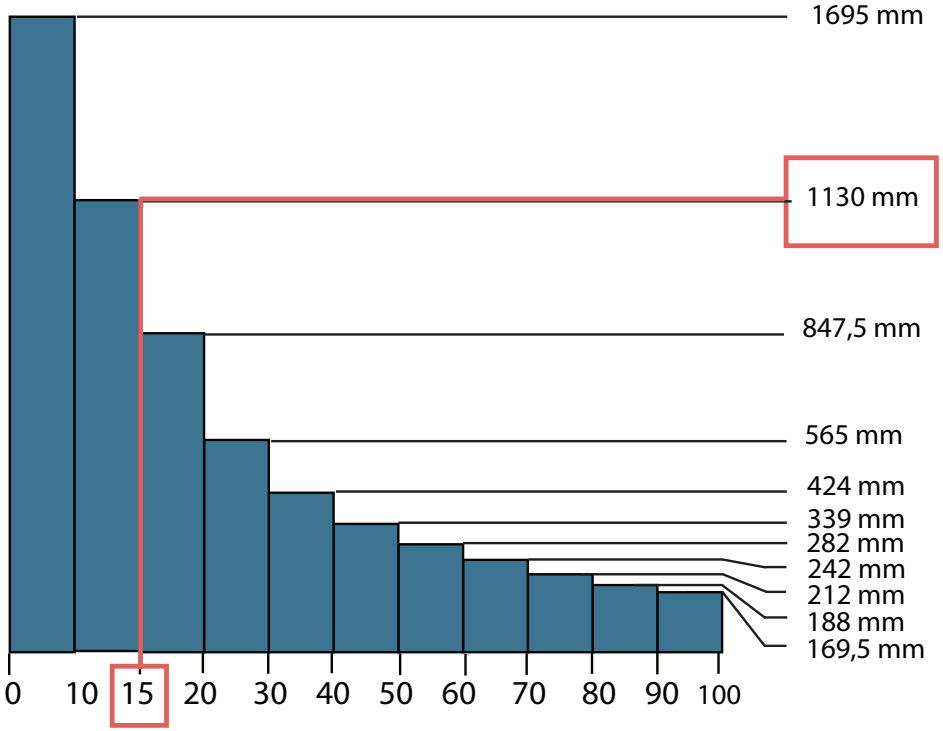


Fig. 6.16 If we use 15 % of the surface area for water storage the water fluctuations in the storage basin is 113 cm.

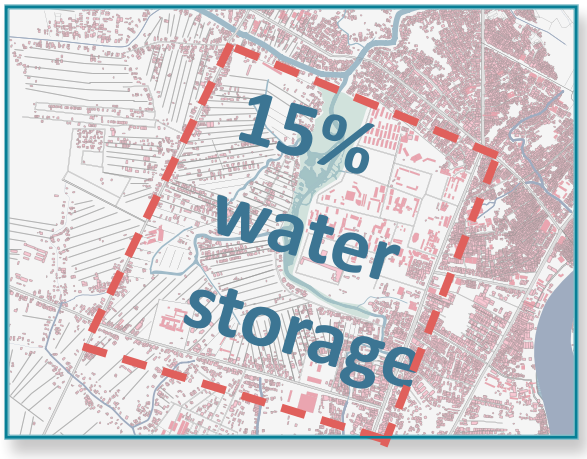
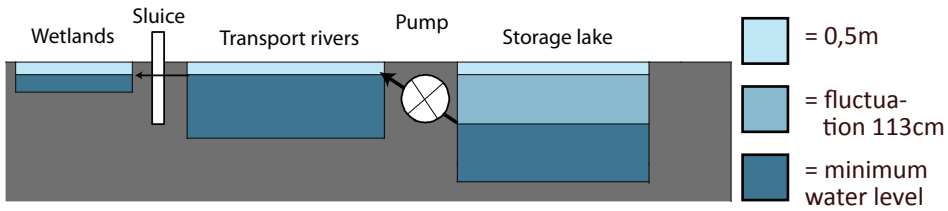


Fig. 6.17 Conclusion

Water system:

The water system is based on the existing water streams in the district. The wetland in the middle, the lowest part in the area becomes the storage reservoir. This storage lake is expanded and goes through the university where adaptive college buildings can be built.
A water circulation system brings water near houses to use them for fresh water supply. The water will be cleaned naturally before it will be used in houses.
The water system needs a circulation to avoid the breeding of mosquitoes.



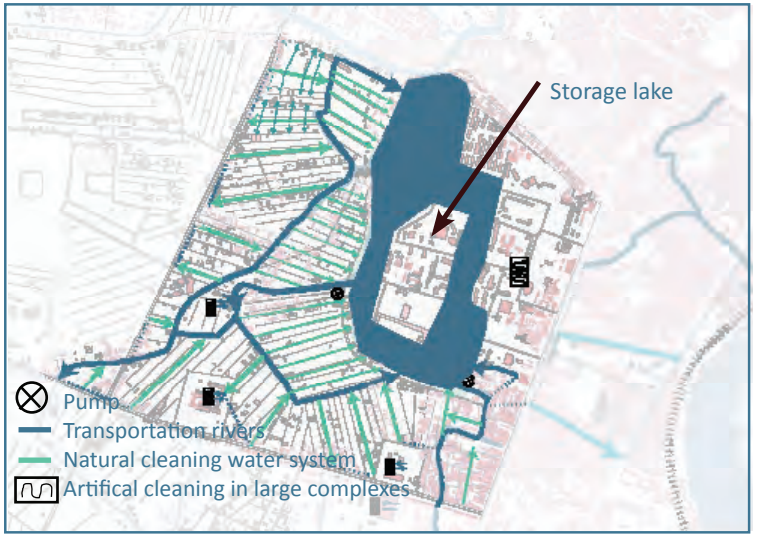
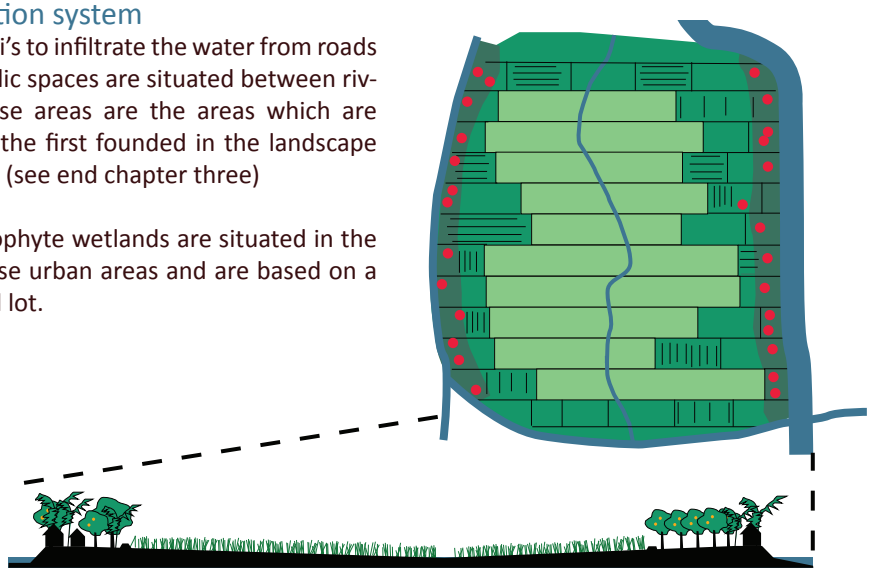


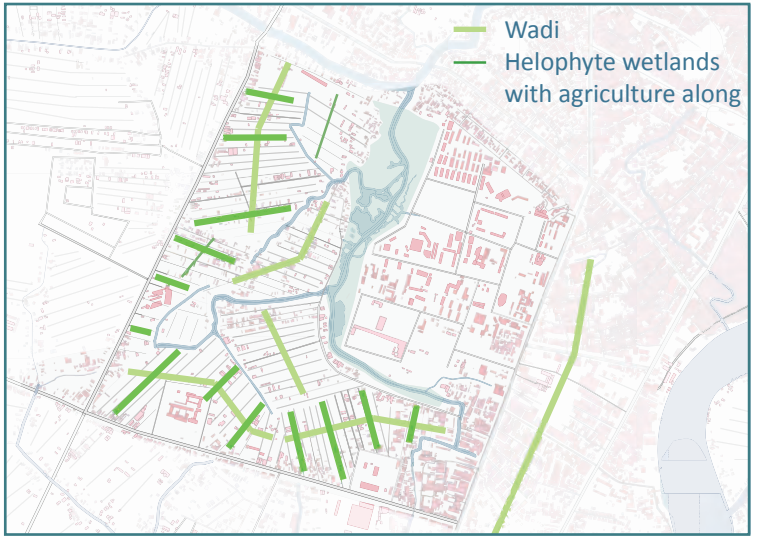
Fig. 6.19 Water system

Infiltration system

The wadi's to infiltrate the water from roads and public spaces are situated between rivers. These areas are the areas which are flooded the first founded in the landscape analysis. (see end chapter three)

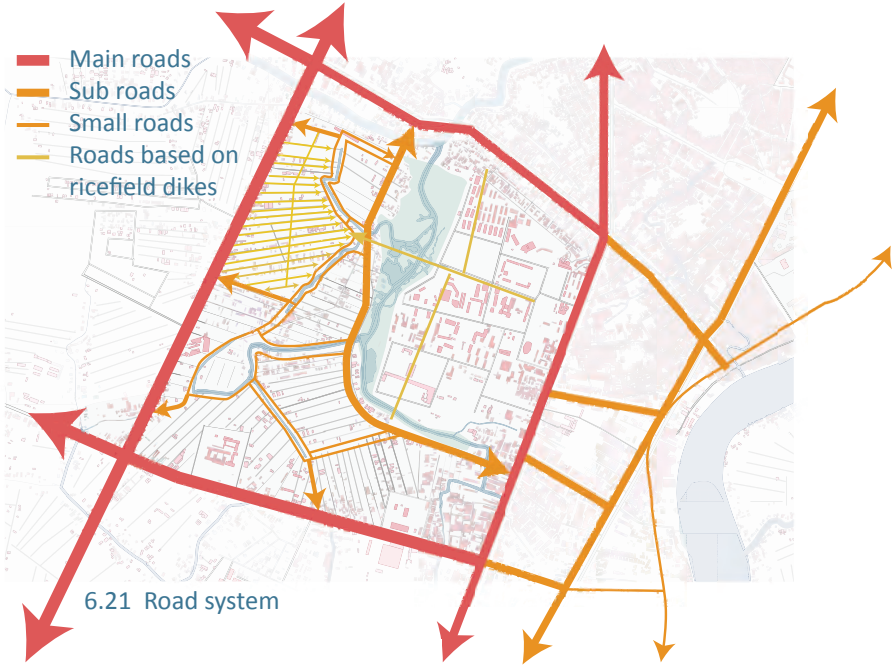
The helophyte wetlands are situated in the less dense urban areas and are based on a rice field lot.





6. 20 Wadi's and infiltration system

ROADS, MAIN GREEN STRUCTURE, DENSITY



6.21 Road system

Fig. 6.21 Road system

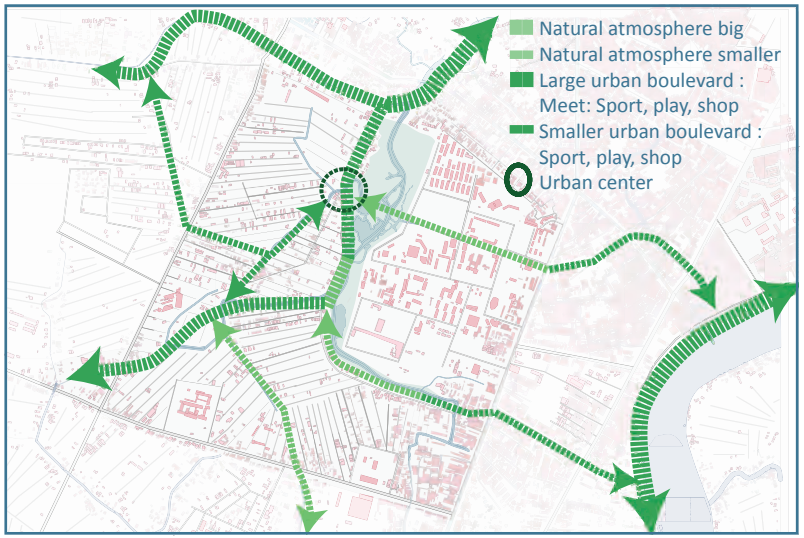
The four main roads are for the quick traffic. This traffic will not enter the district. Along the water the sub roads are the entrances to the area to decrease the amount of exits from the main roads. From the sub roads small roads on the former rice field dikes bring you to your house.

Fig. 6.22 Main green structure

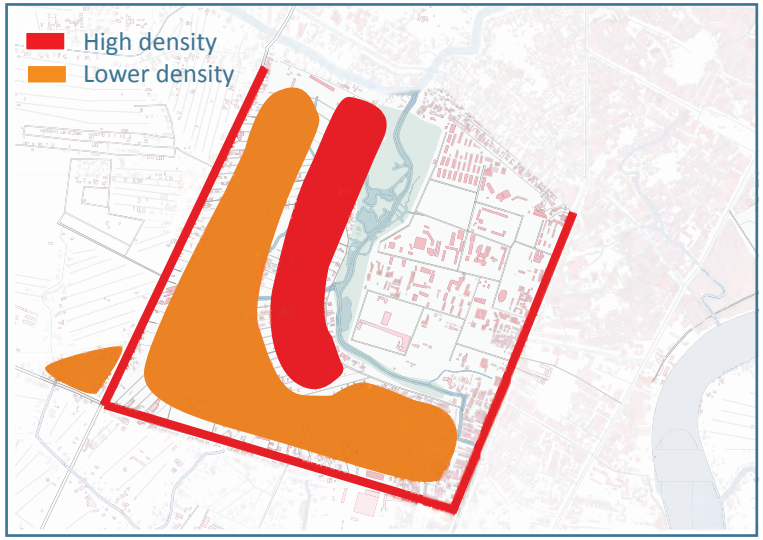
Lines from the vision (chapter 5) also pass this area.

Fig. 6.23 Density

The spot the most close to the current city center will have the highest density and business activity.



6.22 Green lines



6.23 Density

BUILDING BLOCKS

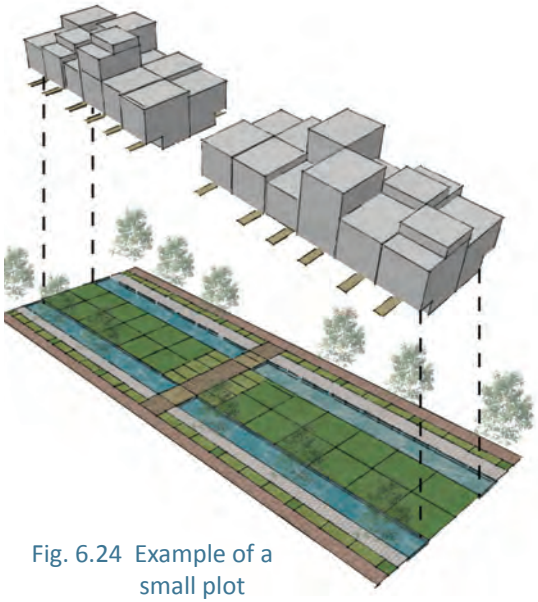


Fig. 6.24 Example of a small plot

The spaces between the roads are ment for urbanisation. The distance between roads through the area differ in size and gives plots between 20 - 80 m.

This paragraph gives solutions how these plots can be urbanised with simple rules for each plot. People can built their own house if they keep themselves on these building rules.

Puzzle pieces how to deal with light, parking solutions and water gives several examples of how these plots can be filled in.

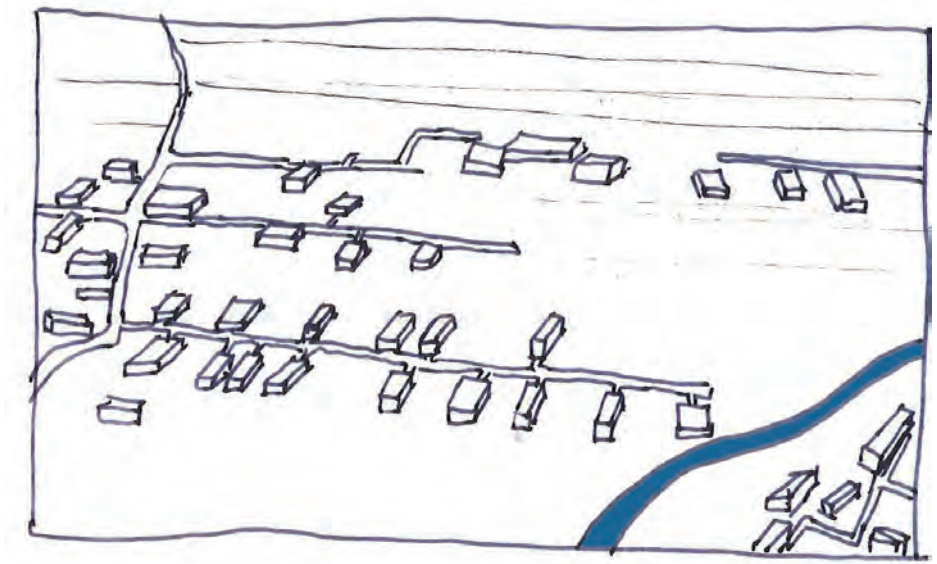
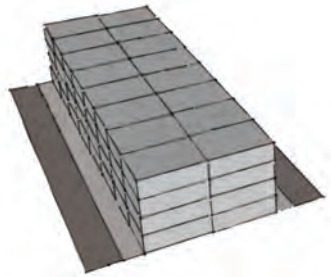
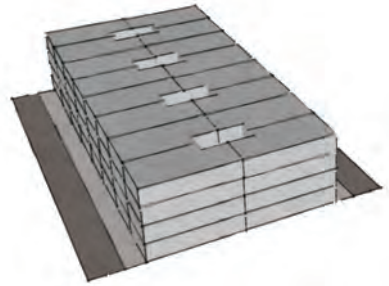


Fig. 6.24 Rice field typology

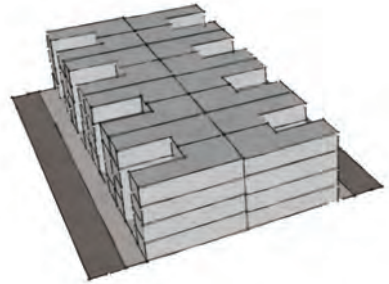
Fig. 6. 25 Light solutions



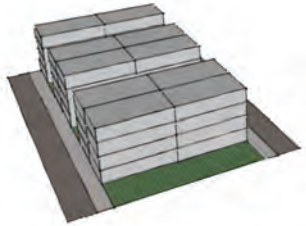
Short housing



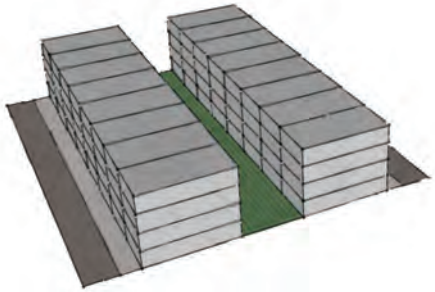
Patio's



Parking places in the dwelling

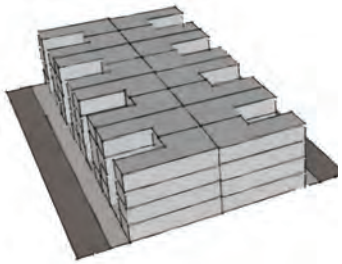


Keep some lots empty for garden/ agriculture

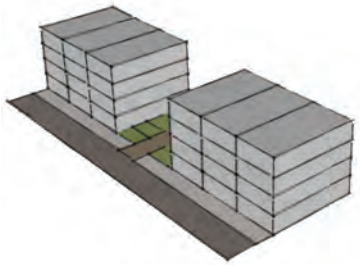


Gardens / agriculture

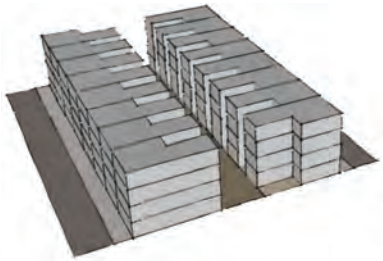
Fig. 6.26 Parking solutions



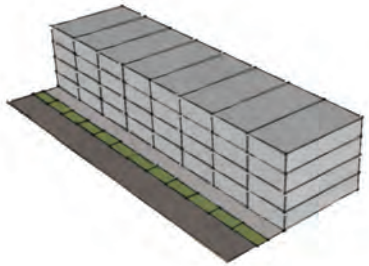
Inside housing



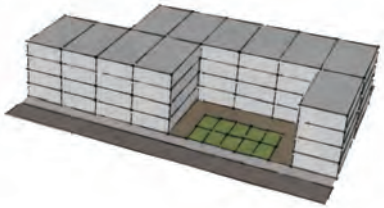
In between buildings



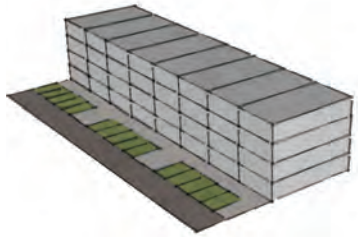
Backside inside housing



Parking in line in front

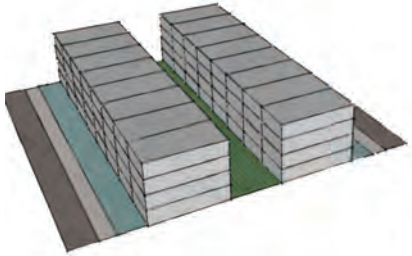


Keep lots left for parking

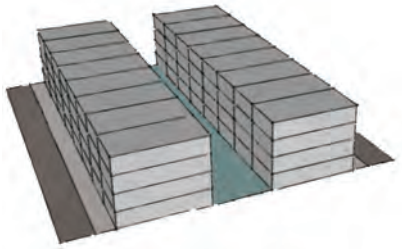


Parking in front

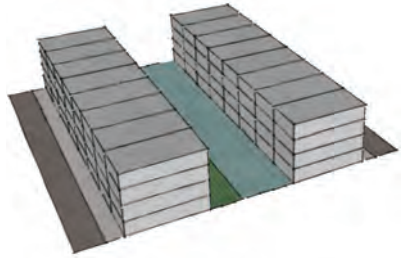
6.27 Water for helophyte solutions



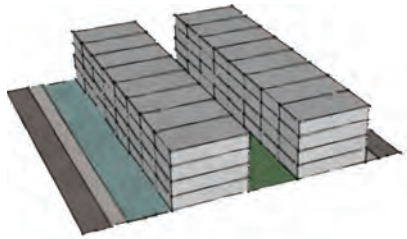
In front of housing, two sides



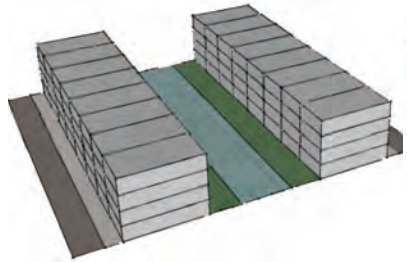
In between buildings



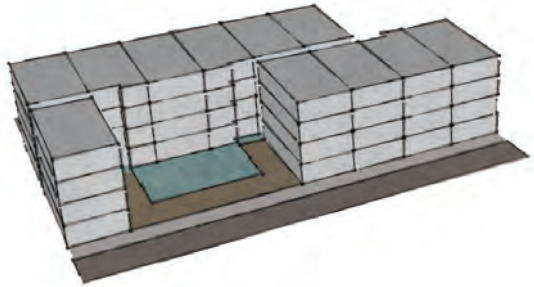
In between housing



In front of housing, one side



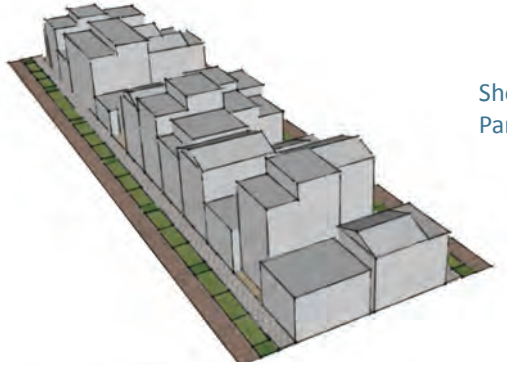
In between housing



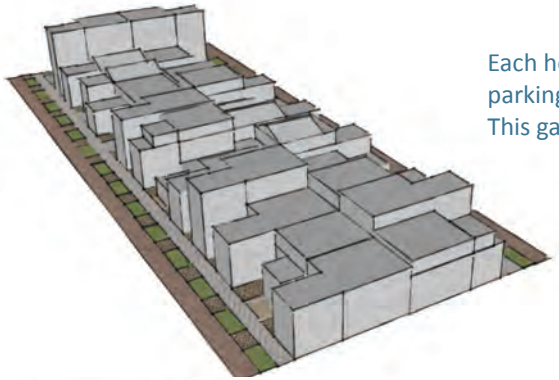
On several plots

Fig. 6.28 Fusion light, parking and water

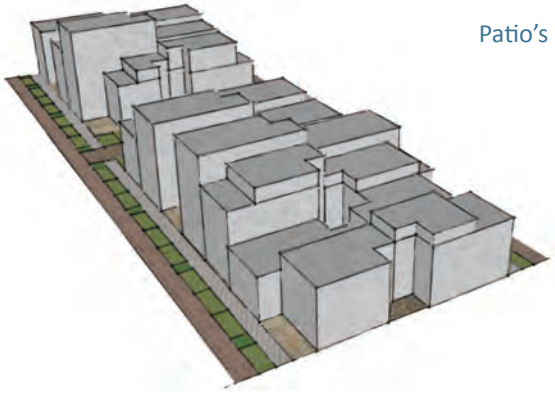
Narrow blocks



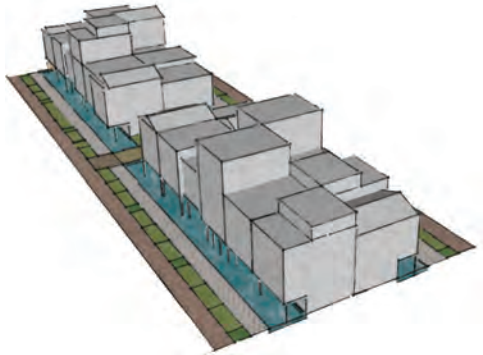
Short lots
Parking in line



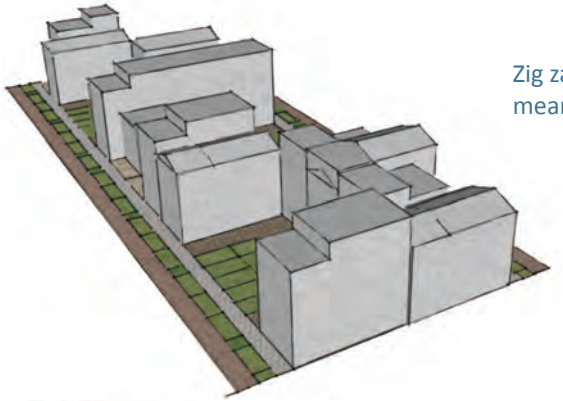
Each house has a drive and parking facilities inside the lot. This gap provides also light.



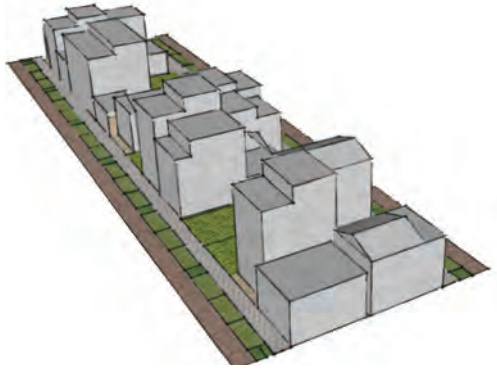
Patio’s



Housing above the water.

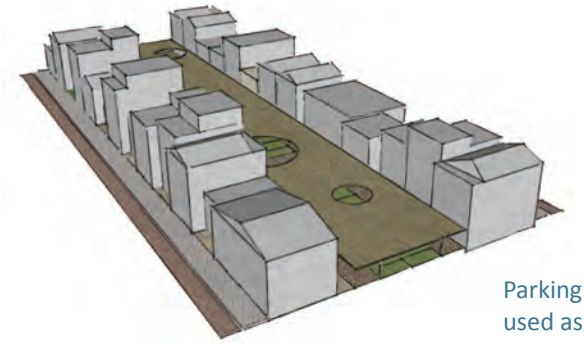


Zig zag parking places providing meanwhile sunlight in housing.

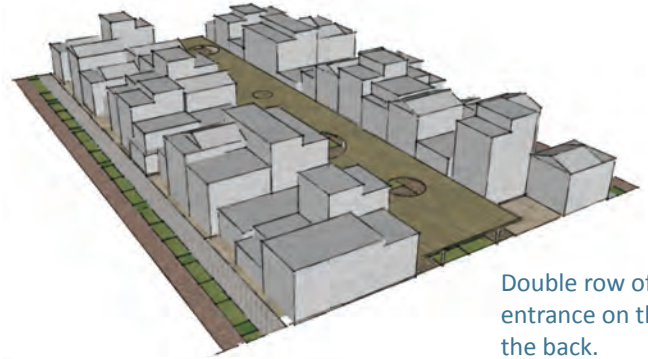


Urban agriculture in low densed blocks.

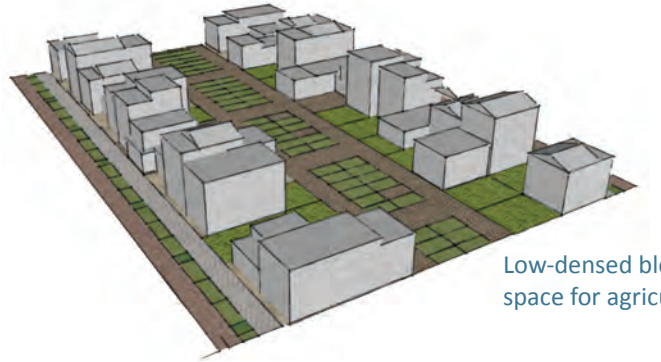
Broad blocks > width of 45 m



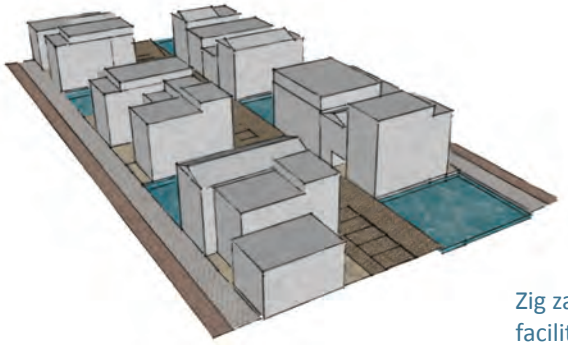
Parking in backyard, first floor is used as semi-public space



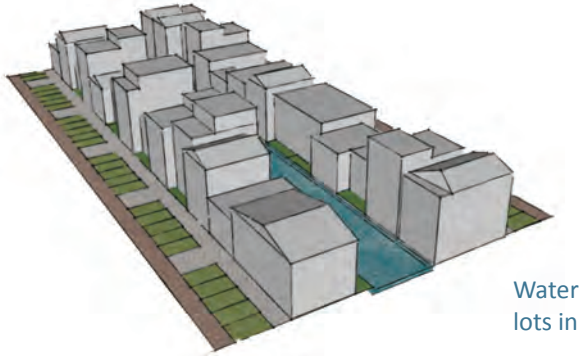
Double row of housing. one entrance on the front, one at the back.



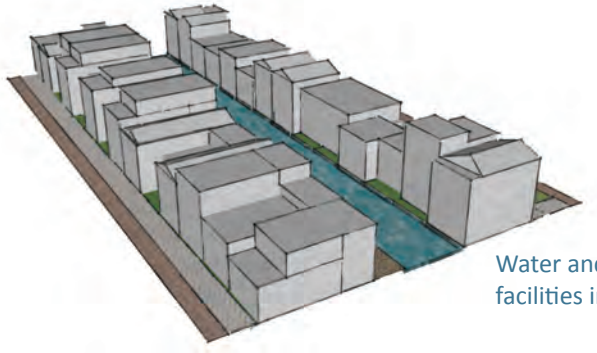
Low-densed block with a lot of space for agriculture.



Zig zag water, road with parking facilities.



Water inside the block, parking lots in front.



Water and a road with parking facilities inside the block.

BUILD THE PROJECT!

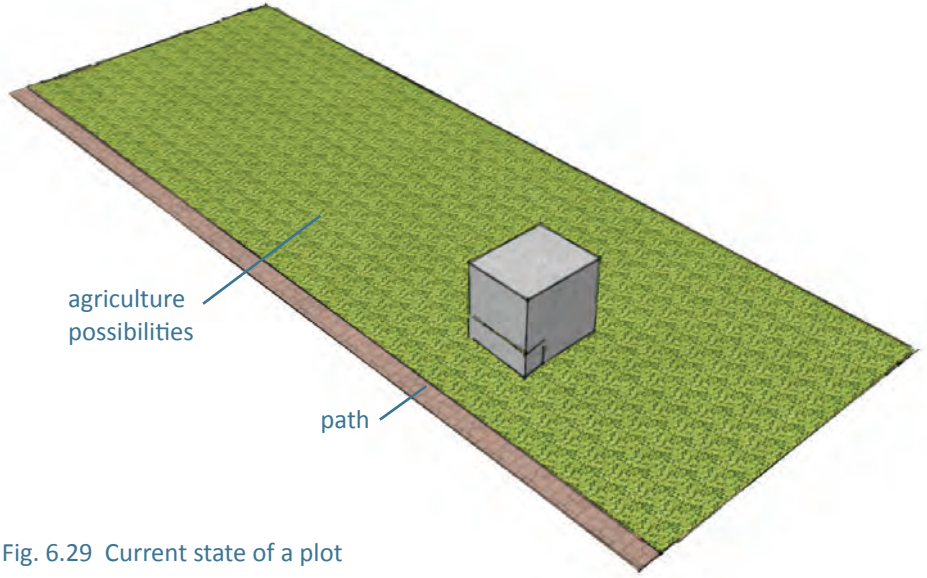


Fig. 6.29 Current state of a plot

Fig. 6.30 Small scale agriculture

1. Current state

Nowadays, the area has a low density and along paths (which are only accessible for scooters and cars) the amount of housing is slowly rising. The empty areas can be used for small scale agriculture.

2. Leasehold and realisation

In Vietnam people lease land from the government to build on their house, which they mostly built by themselves. The government is also responsible for the construction of roads. These things can give hold to let guide the rapid urbanisation by a well lease management, division of grounds and road management (where to build roads? People follow the roads).

- Each lease lot will obtain building rules on which the leaser has to comply. (See former paragraph for examples).

- Road building will guide which areas will be urbanised first.

- You may not build outside the borders of your lease lot.

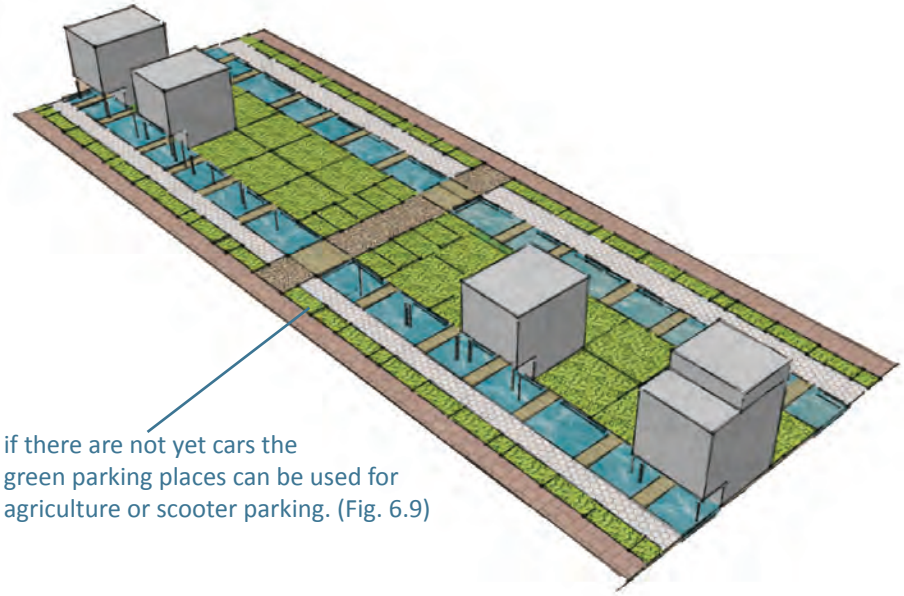
- From the money obtained from the lease contracts public spaces, roads and the water system can be build and maintained.

- Empty lots and parking places which are not yet in use should be used for small scale agriculture.

A proper management of roads and lease lots by the city's council is essential to let realise this project and to avoid uncontrolled urban sprawl in the area and to to realise a sustainable growth of the city.

Fig. 6.31 (right) Map of the area in stage 1


Storage lake
Transport water routes
Helophyte wetlands
Wadi's
Urban park
Natural waterfront
Public space
Street
Sidewalk
Urban agriculture
N
100m



if there are not yet cars the green parking places can be used for agriculture or scooter parking. (Fig. 6.9)

Fig. 6.32 Phase 1: Division of lots by the city council, some are already built.

Fig. 6.33 Implementation of the road system

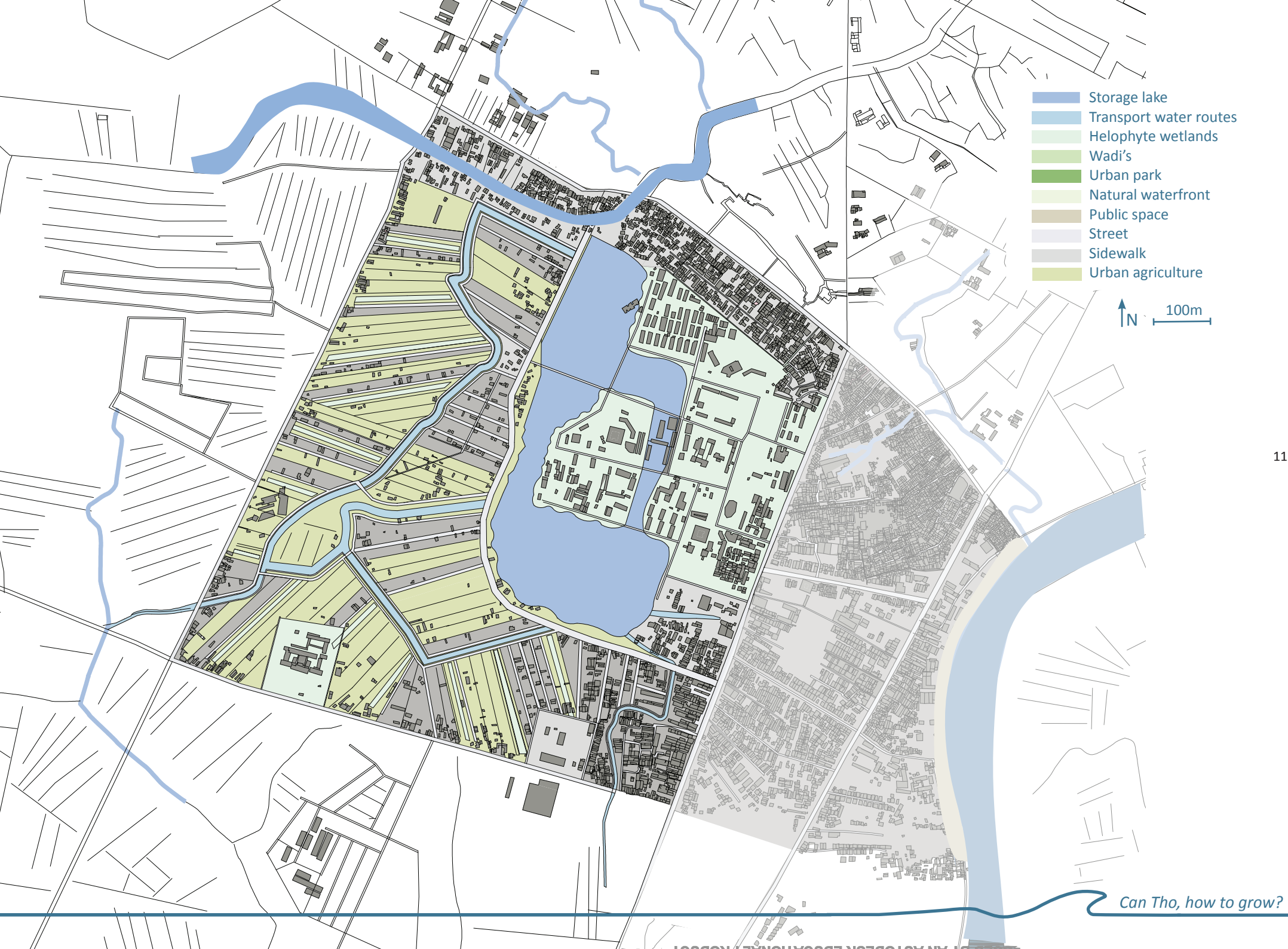
Stage 1

In the first phase the water system will be implemented. The water inside the area will become a closed off water circle with the needed pumping stations and broader river beds and also the university district will start to transform to a 'water campus' to give the storage lake the size it needs.
The helophyte filter water basins will be constructed to give the helophyte filters the chance to grow for future use.

In phase one the government will increase the amount of roads along the helophyte filters. These places will be divided in lease lots firstly and are urbanised first because the inhabitants can watch over helophyte filters (social control) and use the helophyte filter banks for agriculture.

Fig. 6.35 (right) Map stage 1

Fig. 6.34 Areas which will be steered to urbanise first (gray).


Storage lake
Transport water routes
Helophyte wetlands
Wadi's
Urban park
Natural waterfront
Public space
Street
Sidewalk
Urban agriculture
N
100m

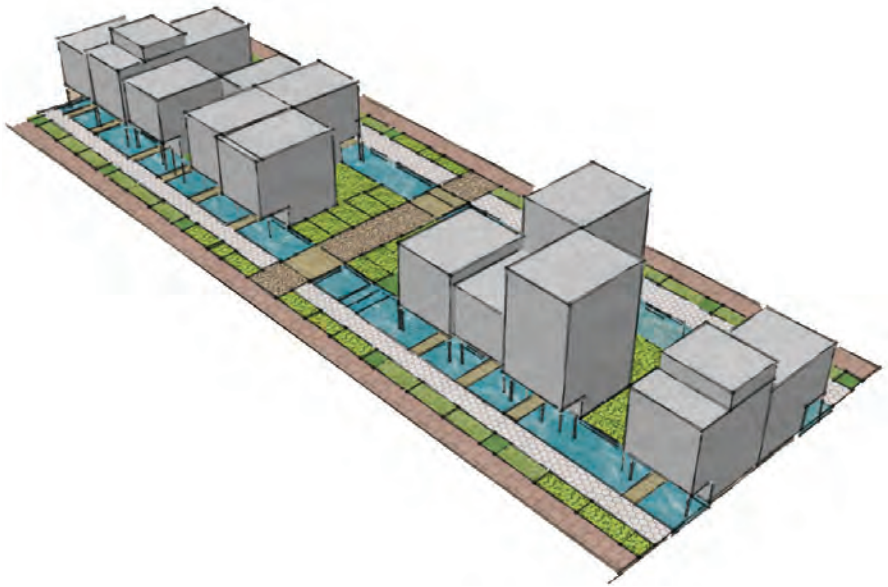


Fig. 6.36 State 2 : The plot becomes more dense, less space for agriculture.

Fig. 6.37 Implementation of the wadi's

Stage 2

Later on, the plots which are already started to urbanise in stage 1 will densify further. Strategic road building and strategic lease lot division give access to new plots to catch up the migration from the countryside.

Because of the growing amount of housing the green spaces will reduce. The wadi infiltration system will be implemented on the lower parts of the area in order to guarantee enough infiltration in the soil.

When enough lots are rented there is money for riverfront and public space development.

Fig. 6.39 (right) Map stage 2

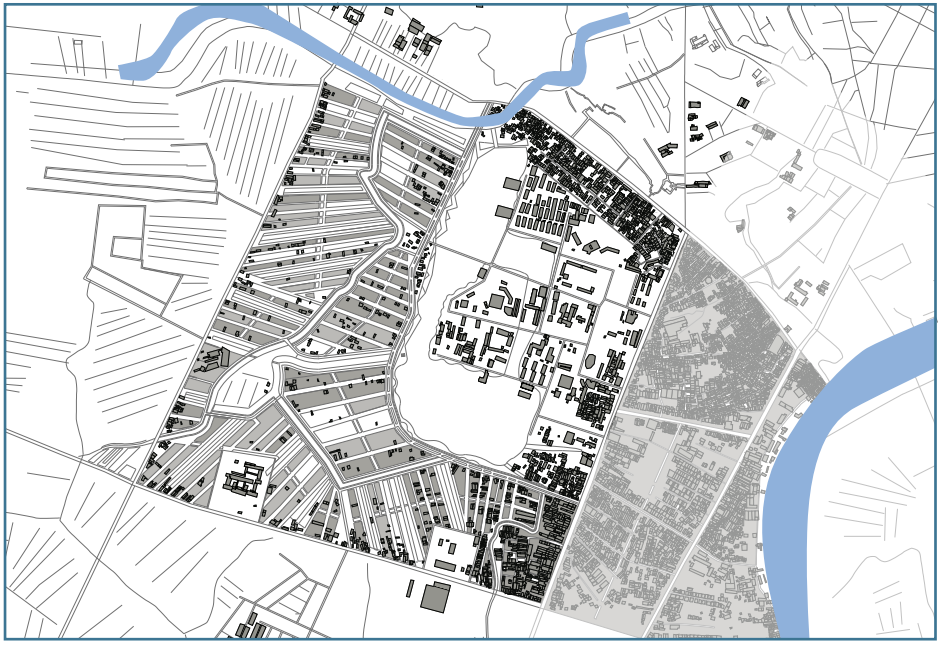


Fig. 6.38 Areas which will be urbanised later (gray).

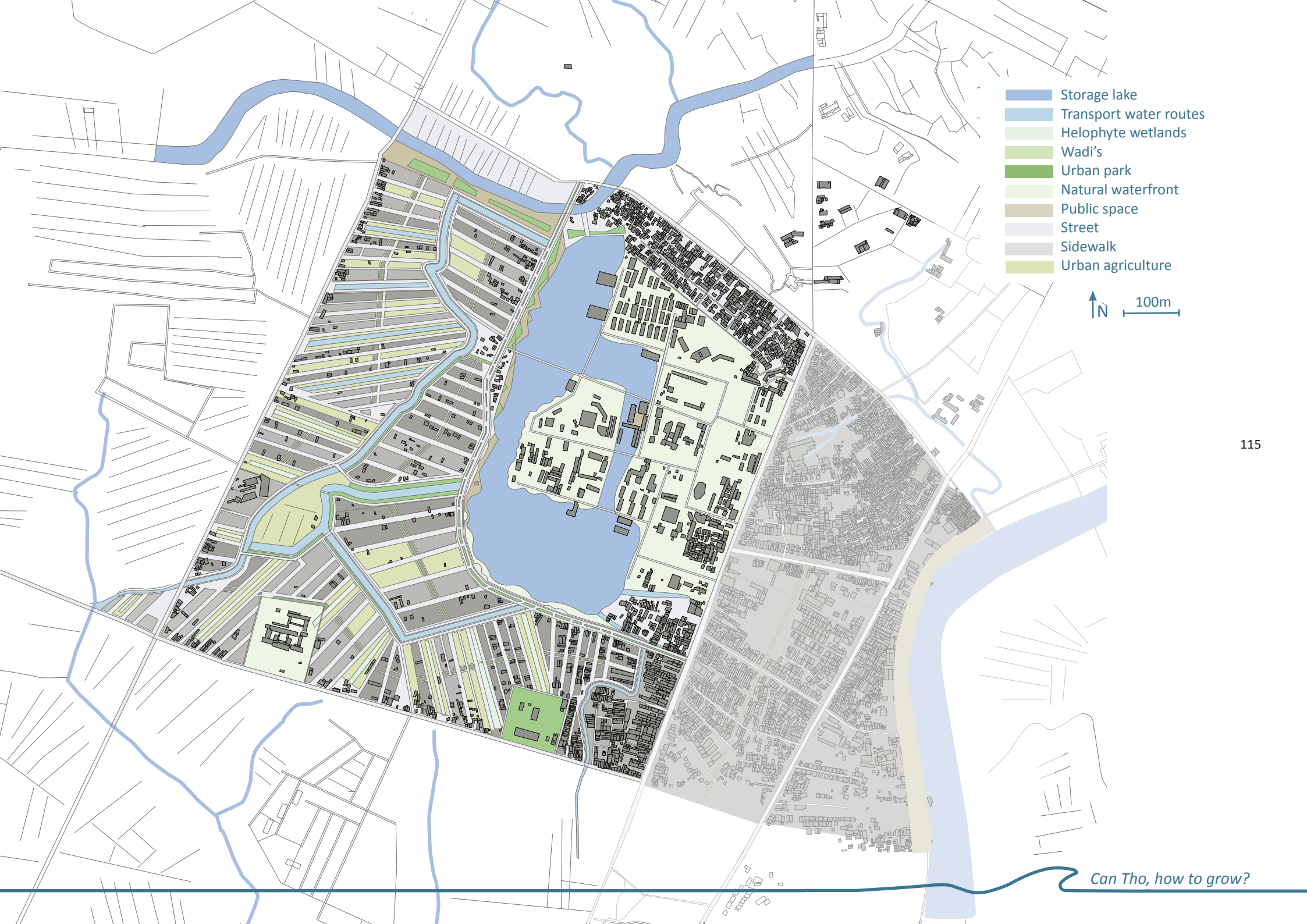

Storage lake
Transport water routes
Helophyte wetlands
Wadi's
Urban park
Natural waterfront
Public space
Street
Sidewalk
Urban agriculture
N
100m

Fig. 6.40 State 3 : Fully urbanised plot.

Stage 3

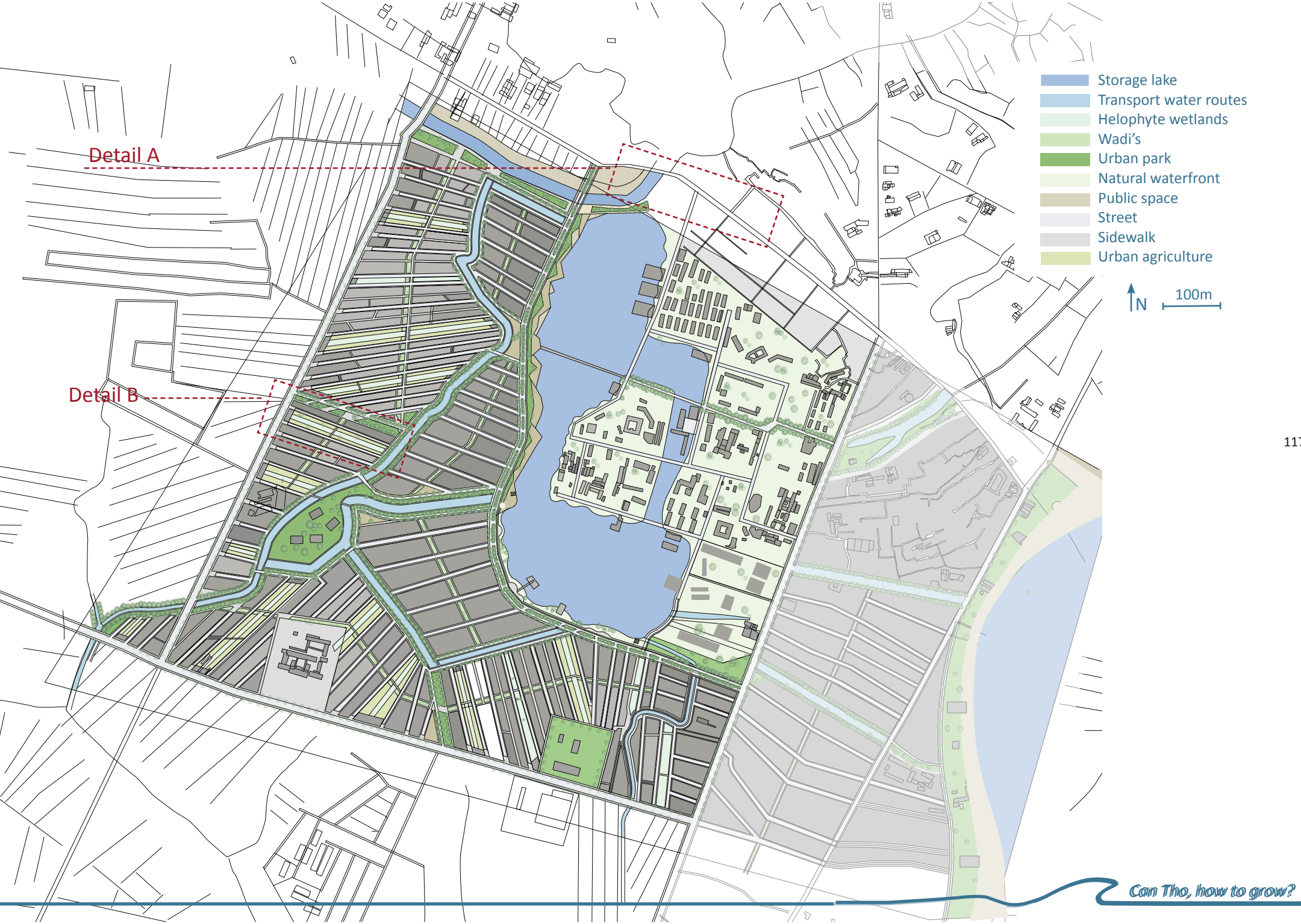
Stage 3 is an example how it could become in the coming 10 - 20 years if the area will urbanise completely. This does not have to be the case; if the urbanisation growth decreases coming years more plots can stay empty for food production.

In the coming pages two details of the area explain the proposal on smaller scale.

Detail A is the dense waterfront along the storage lake which has a water level fluctuation of 113 cm between the dry and the rainy season. The helophyte filters are included in the building blocks to reach higher densities than the areas which are less dense.

Detail B is a less dense area with a helophyte filter stroke and urban agriculture along. The waterfront of a transportation river as public space is also included.

Fig. 6.41 (right) Map stage 3


Detail A
Detail B
Storage lake
Transport water routes
Helophyte wetlands
Wadi's
Urban park
Natural waterfront
Public space
Street
Sidewalk
Urban agriculture
N
100m

DETAIL A:
WATERFRONT ALONG STORAGE LAKE

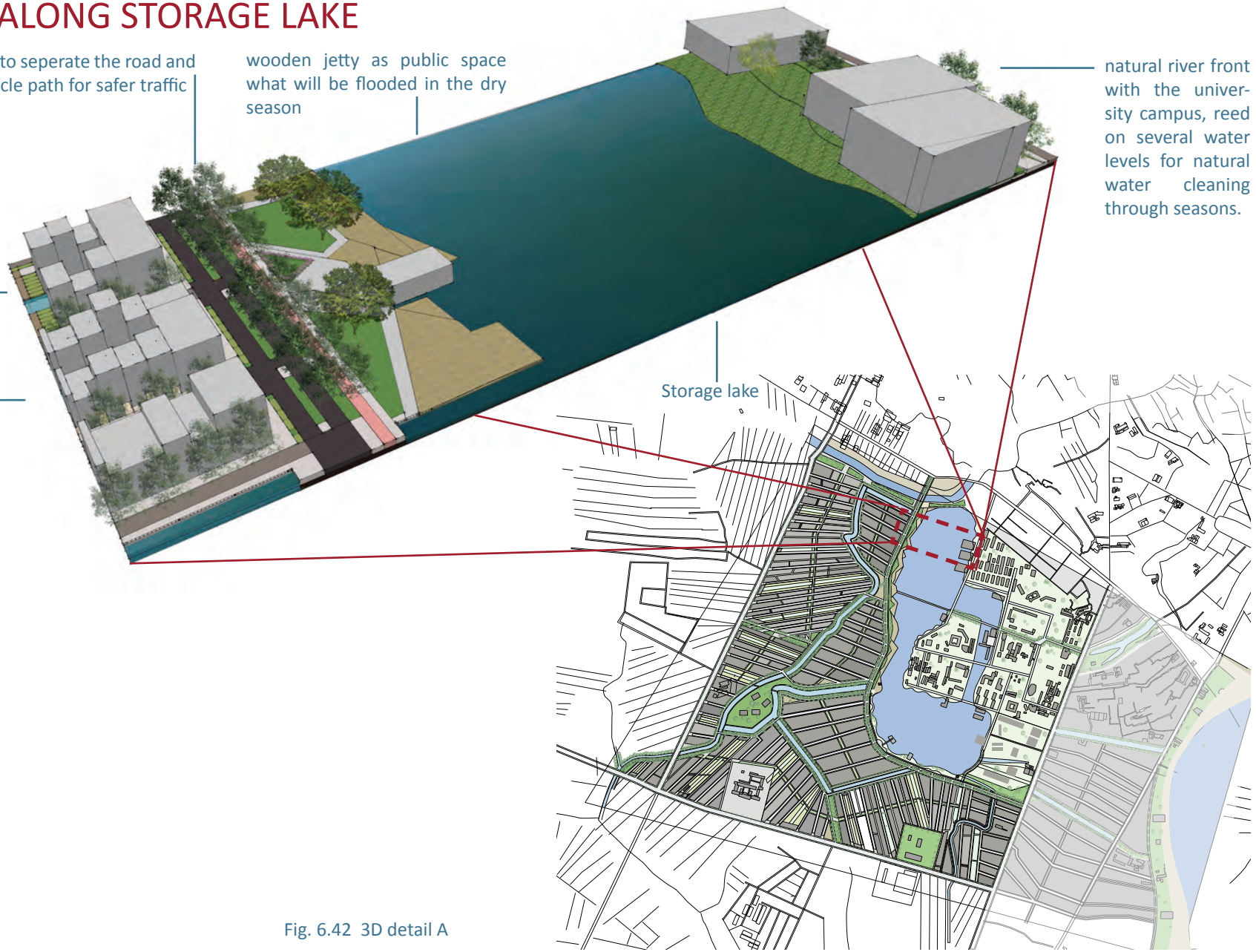
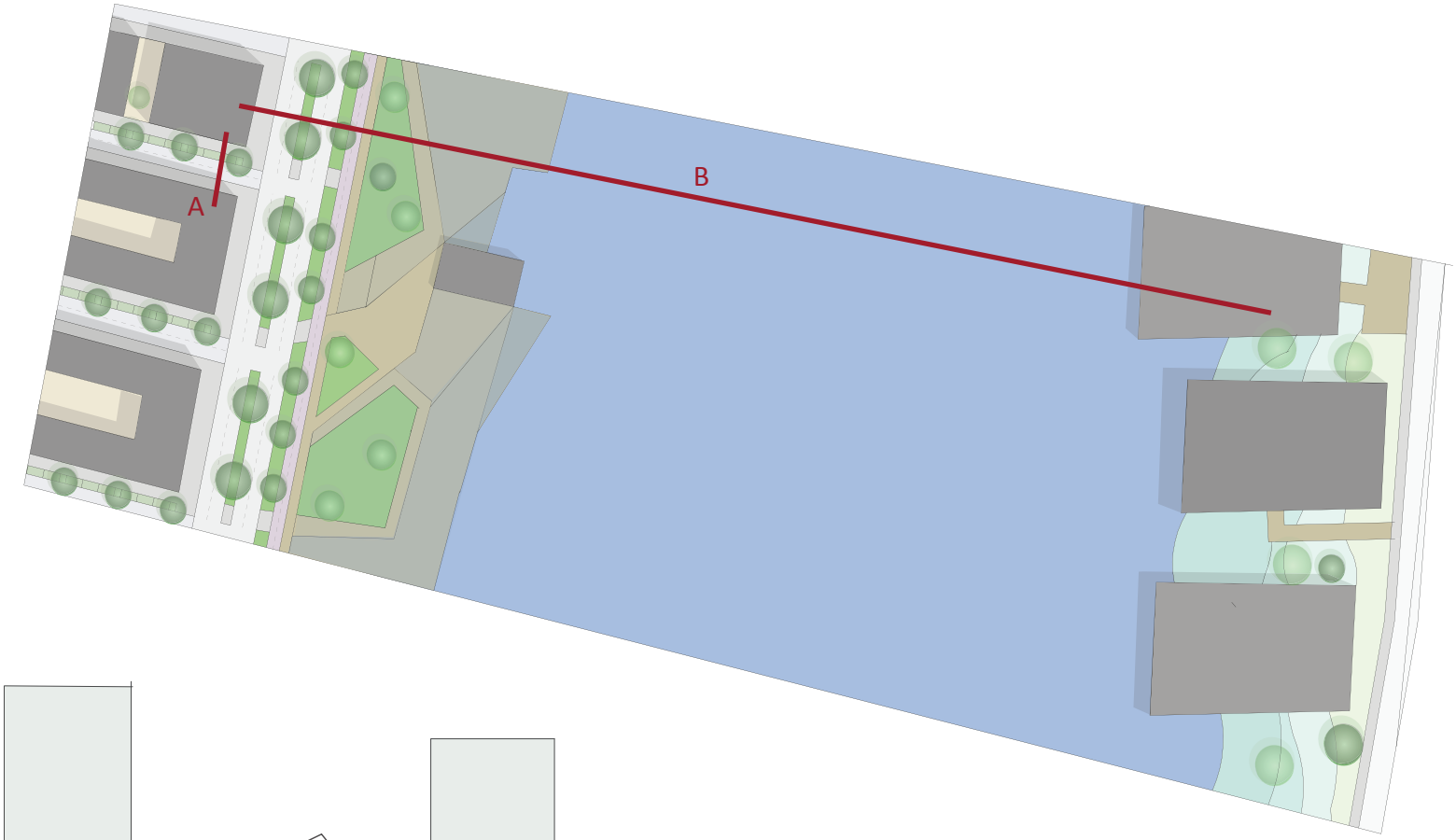
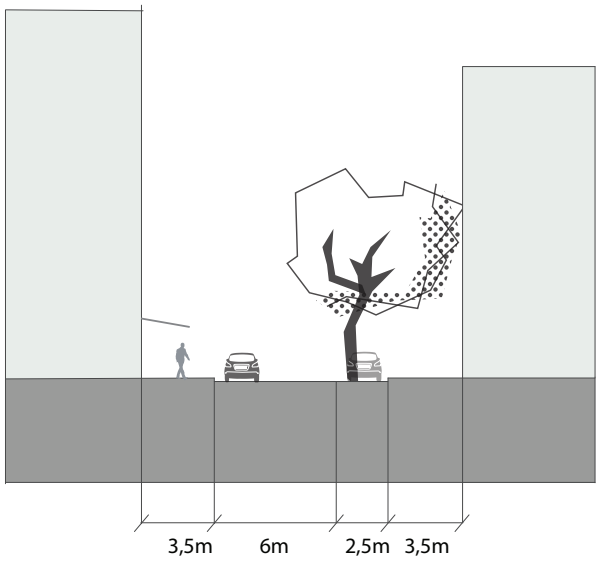


Fig. 6.42 3D detail A





Storage lake
Transport water routes
Helophyte wetlands
Wadi's
Urban park
Natural waterfront
Public space
Street
Sidewalk
Urban agriculture

Fig. 6.43 Map detail A

N

15m

Fig. 6.43 Section A: High dense urban street
Section B: See figure 6.46 and 6.47

10m

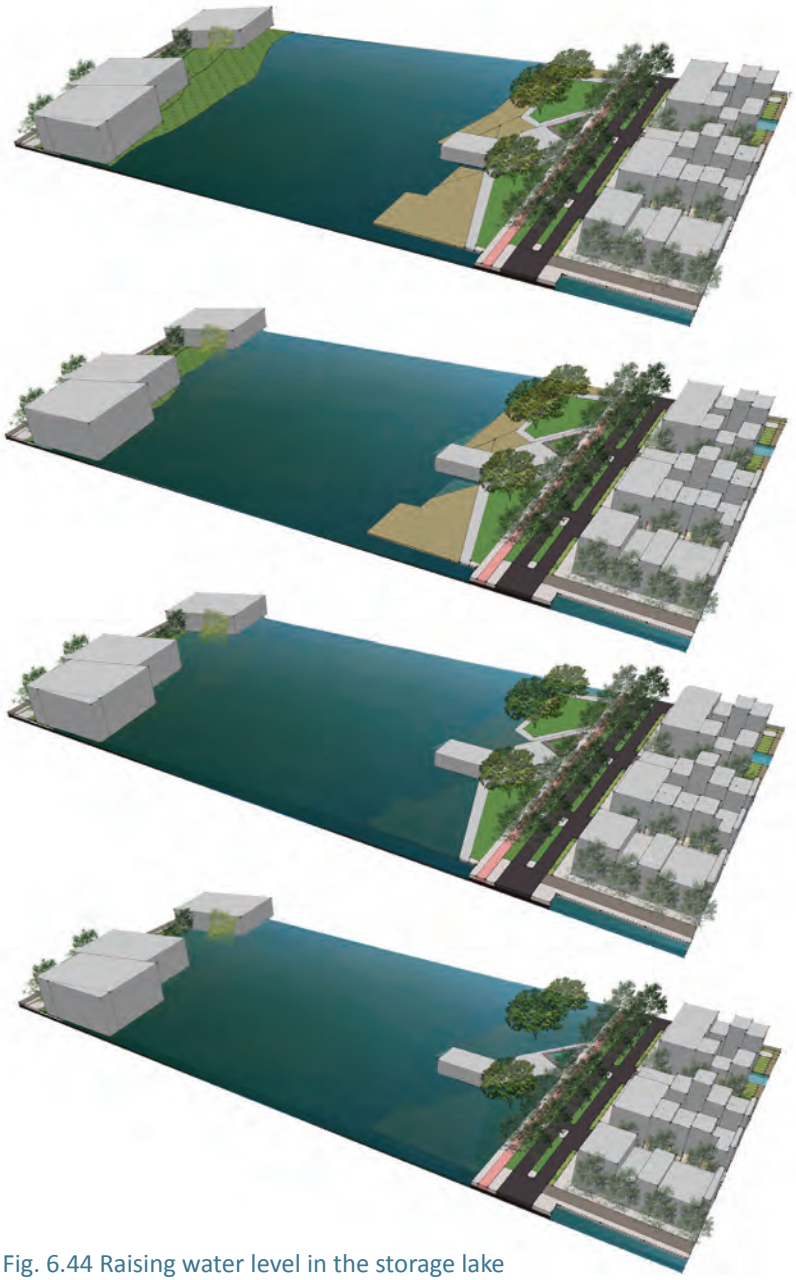
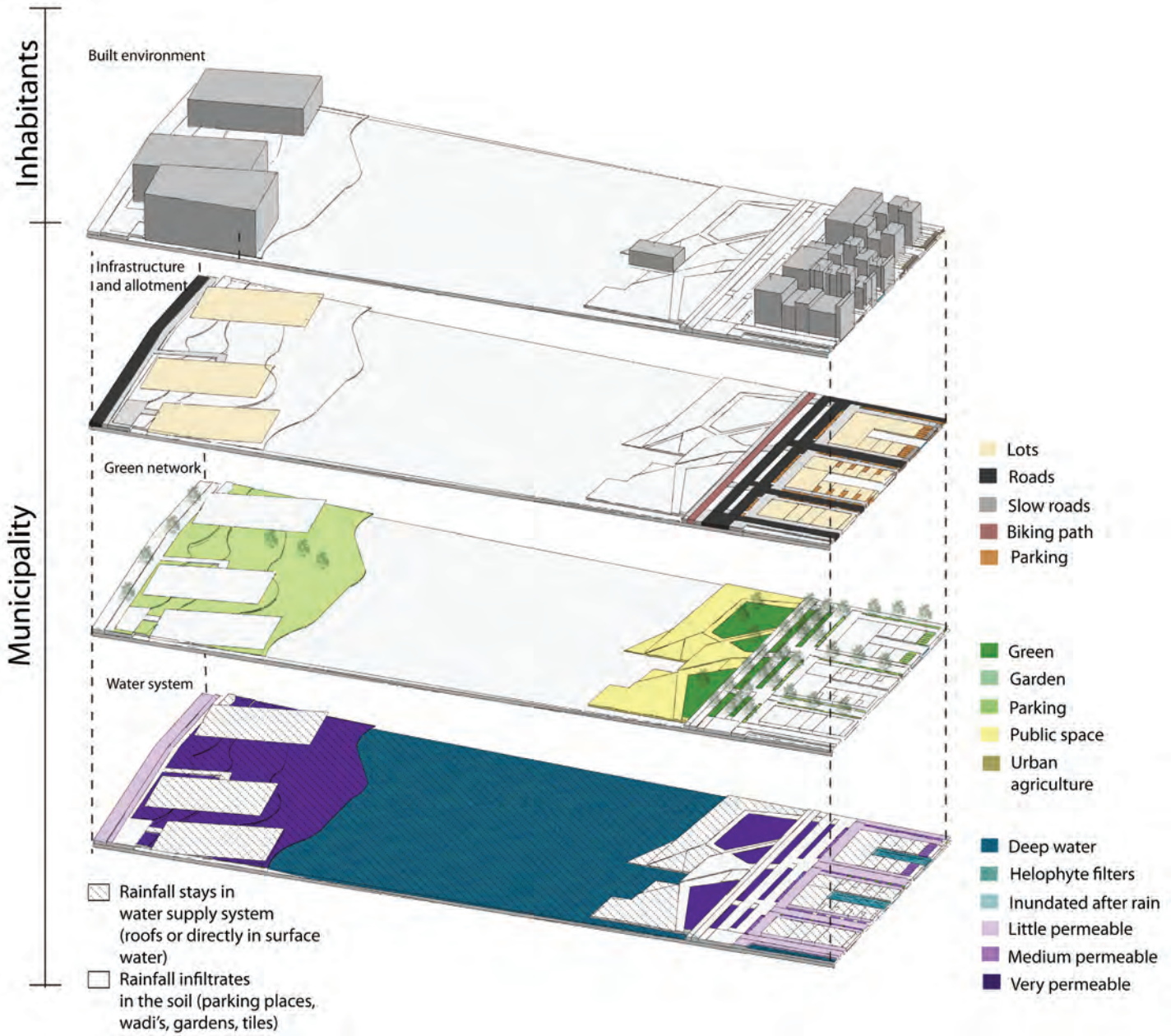


Fig. 6.44 Raising water level in the storage lake

Fold out larger version of the exploded view

Fig. 6.45 Exploded view
detail A
- Built environment
- Infrastructure and allotment
- Green network
- Permeable soils



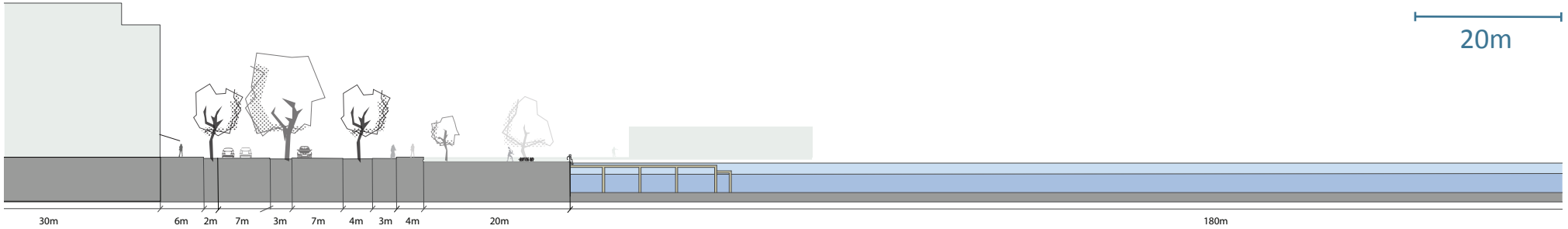
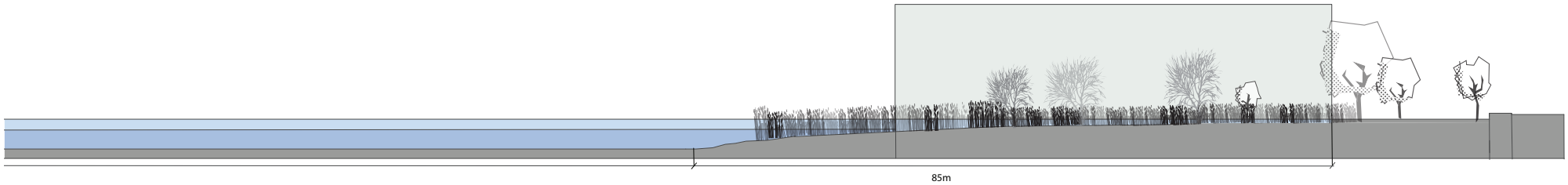
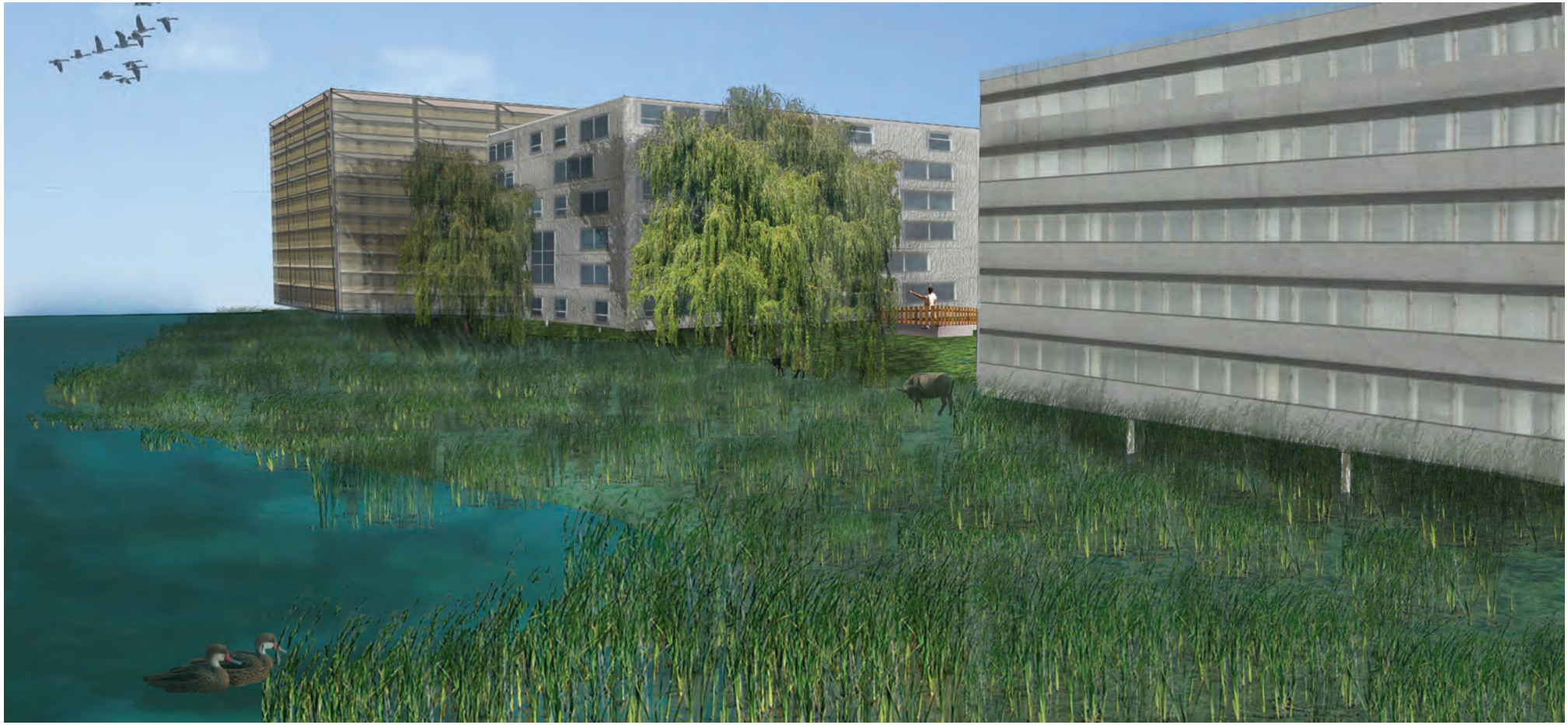


Fig. 6.46 Urban river front and natural river front section B and spatial impressions


85m



DETAIL B :
WADI, HELOPHYTES AND WATERFRONT

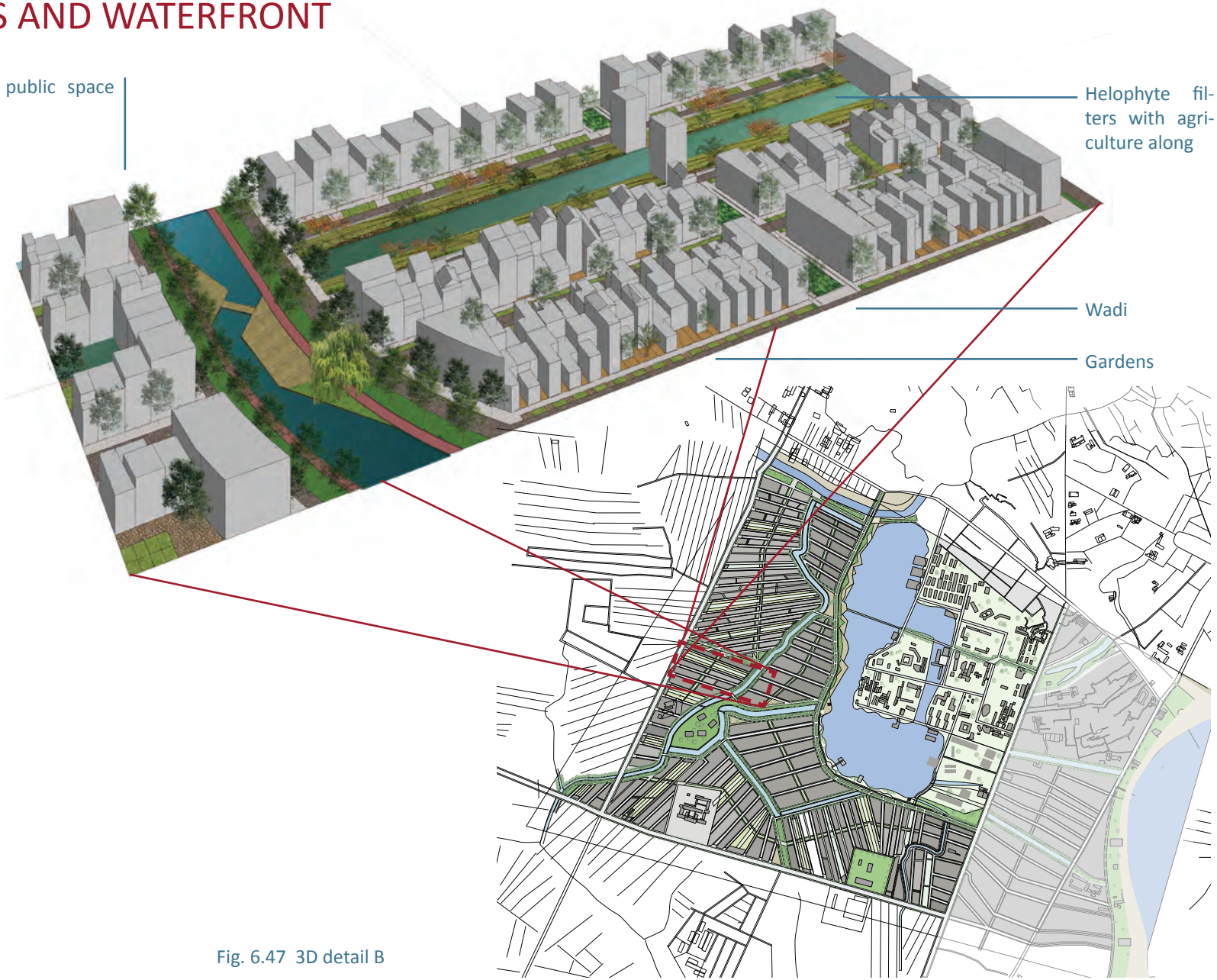


Fig. 6.47 3D detail B

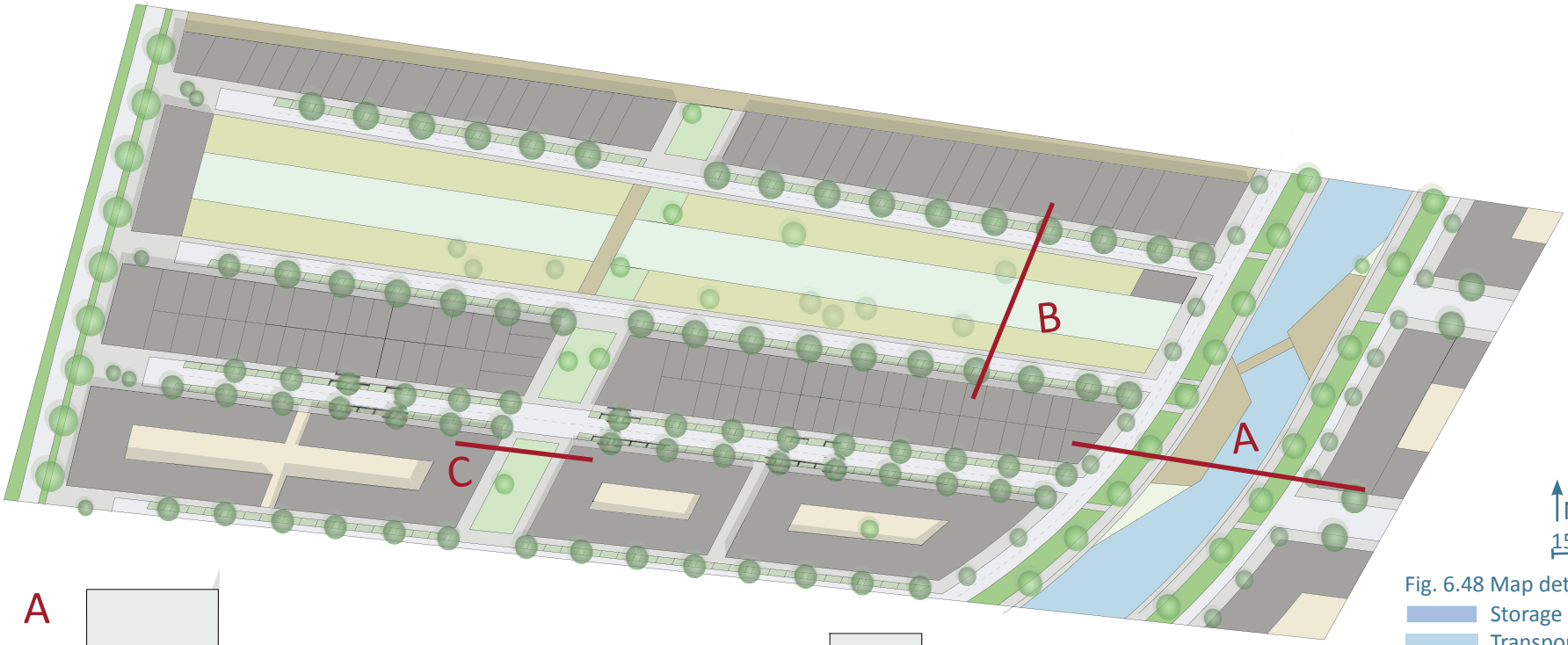
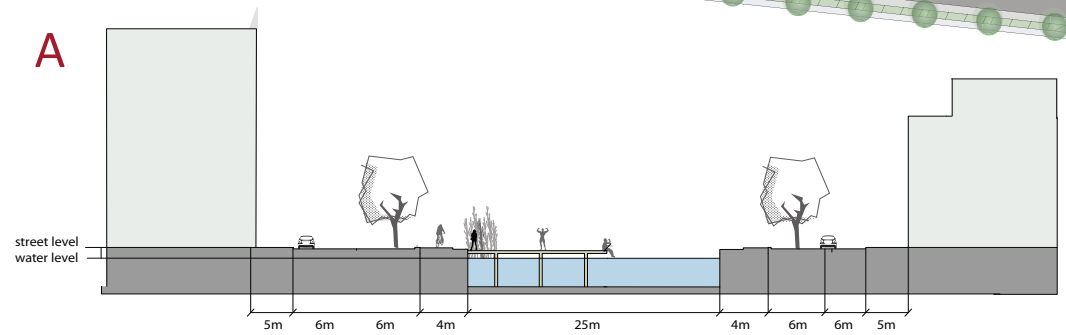
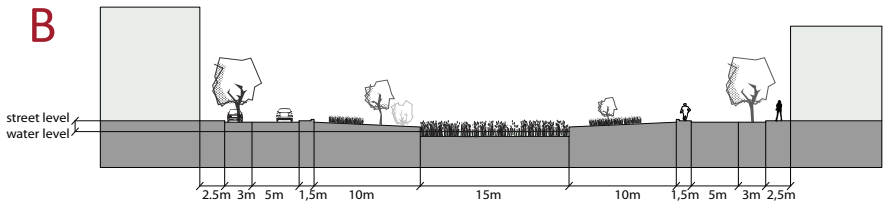


Fig. 6.48 Map detail B

- Storage lake
- Transport water routes
- Helophyte wetlands
- Wadi's
- Urban park
- Natural waterfront
- Public space
- Street
- Sidewalk
- Urban agriculture





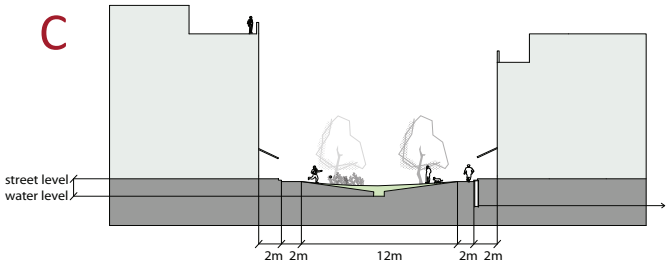


Fig. 6.49
Section A: Water front
Section B: Helophyte filters and agriculture
Section C: Wadi

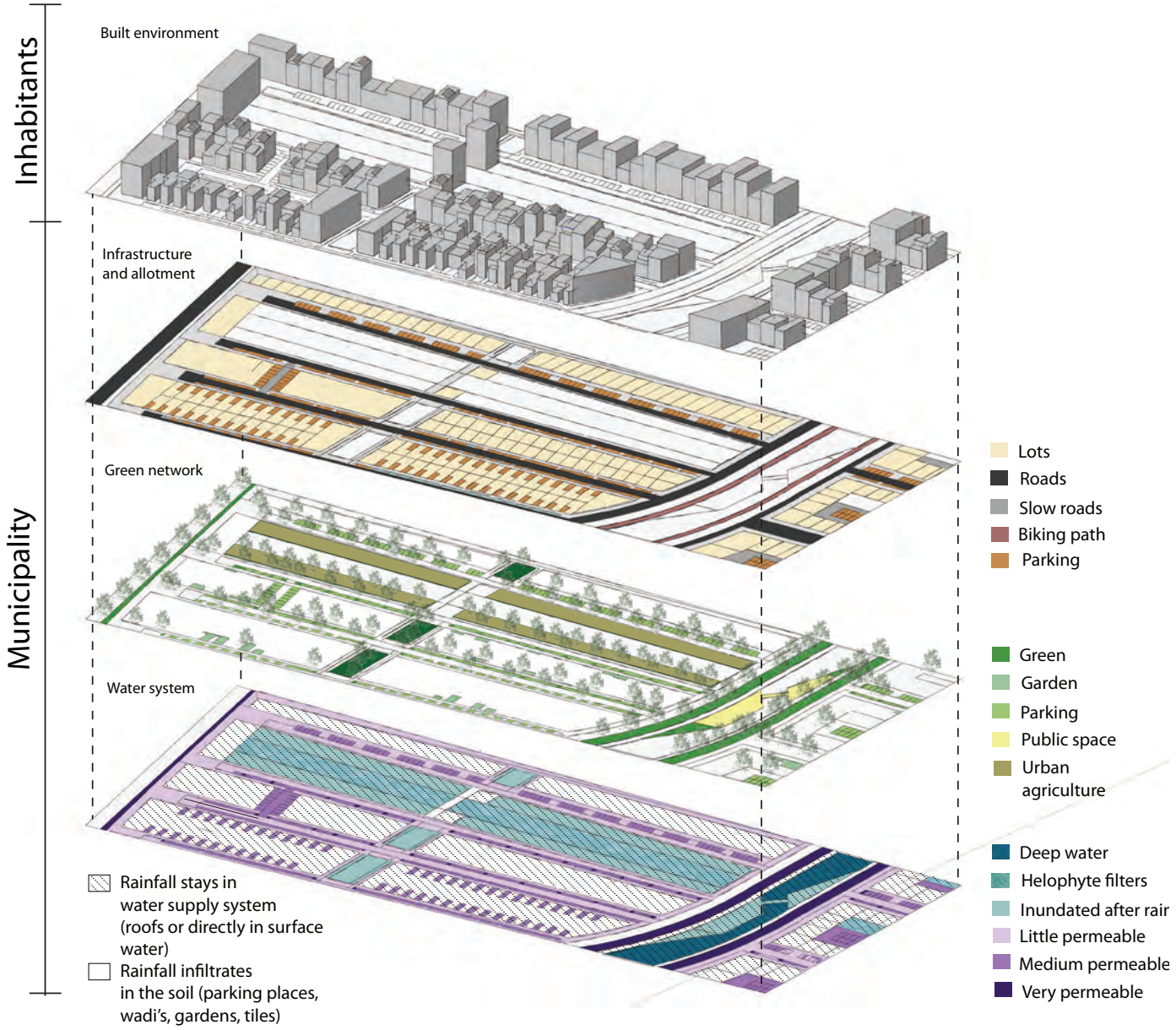
← Normal situation

← Situation after heavy rainfall

Fig. 6.50 Wadi's, public space along the waterfront and agriculutral areas can be flooded.

Fold out larger version of the exploded view

Fig. 6.51 Exploded view
detail B
- Built environment
- Infrastructure and allotment
- Green network
- Permeable soils



6.52 Impression section helophyte wetland and agriculture in the dry season.

6.53 Impression after a extreme case rainfall. Rain water can be temporally stored in the backup system of the water system.

Helophyte wetland with agriculture on both sides after extreme case rainfall

Floating market of Cai Rang near Can Tho.

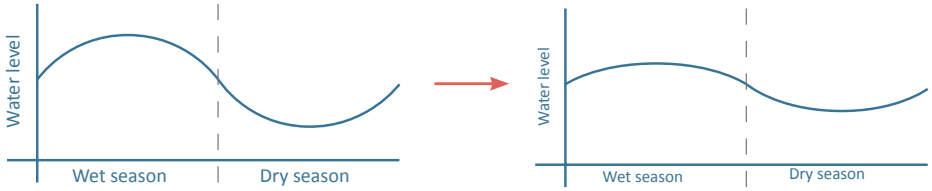
Conclusion and recommendations

CONCLUSION

The result of this project is a growth strategy for the city of Can Tho to steer the urbanisation process, to provide water safety and improve the living conditions for its citizens.

Provide water safety

The implementation of a dike around the city will provide water safety for high water levels in the future. This dike enables water safety for all inhabitants: the rich and the poor are both protected. Outside the dike ring the annual floods are desired for the rice field agriculture. The surface water as creeks and rivers inside the dike ring and also green in the city should be increased because they have an important function in rain water drainage in the rainy season in order to diminish the flooding due to rainfall inside the dikes. In urban areas a drainage system of wadi's, urban agriculture and green parking lots increase the permeability of the soil. In the dry season the rice field principle is used to store water in order to maintain a stable ground water level to decreasing salinisation, acidification and soil subsidence.



Improving living conditions: invest in public space

Besides water safety for all social classes the living conditions will improve in other ways as well. Inside the dikes the existing rivers and creeks form a new spatial structure based on the landscape for Can Tho. This will become the main axes through Can Tho making the water network the leading structure to urbanise instead of the road system. Firstly, this water-green network becomes the new public space- and green structure for recreation what is currently lacking in the city. The curving structure connects the poor and richer areas in order to avoid social and spatial segregation what is already lurking in South East Asia. The landscape based approach contributes to Mumford´s ideas in keeping the identity of a place. Secondly, the living conditions will be improved by the investment in fresh water supply. Rain water collection systems and space for natural waste water threatment systems by helophyte filters are taken into account in the urbanisation around the city and will replace ground water pumping or Mekong river water as fresh water source.

Guide the growth

The rice fields around Can Tho will and are getting urbanised nowadays. This transformation from agricultural to urban area should be steered wisely by the city council and NGO's by taking into account this new water- green- and threatment structures. Analysis showed urbanisation follows roads. Strategic road building together with a proper division of ground lease contracts for lots to built on gives means to control the urbanisation process and to avoid uncontrolled sprawl and to stimulate the growth of compact cities. By offering water safety, public space and fresh water supply on strategic locations in several ground price ranges (size of the lot) people will be attracted to the wished places.

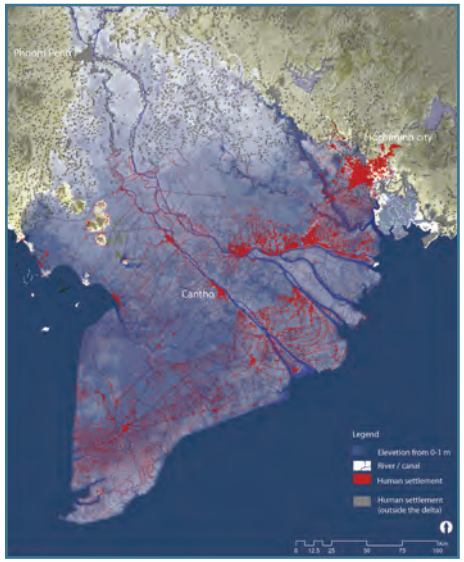
This way of growth as a cooperation between landscape, urbanism and water management could be used in more Mekong delta cities, you can find the rice field structures and creeks on which this strategy is based on through the whole delta. In this way the Mekong delta cities can give an answer to the question of climate change and rapid urban growth while the food producing function of the delta stays intact.

RECOMMENDATIONS

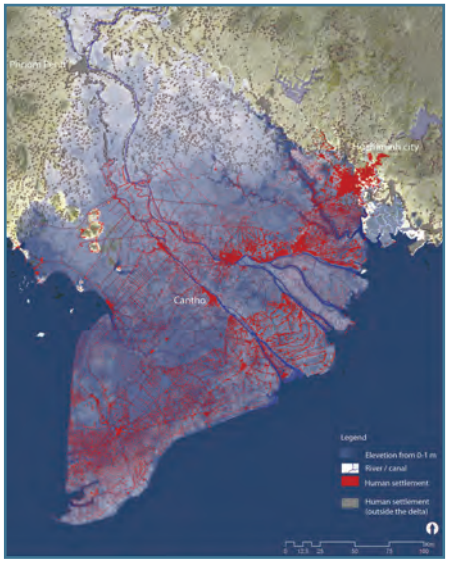
I would recommend the city council of Can Tho to invest as quick as possible in increasing the storage- and infiltration capacity of the city, certainly in the most dense city areas. This will have the quickest effect in order to decrease flooding in the city. Furthermore, this proposal should be checked by civil engineerers and biologists who can make better estimations in for example needed surfaces for water storage, helophyte filter systems, a realisable water circulation pump system and dike structures.

Further research can be done on the following topics:

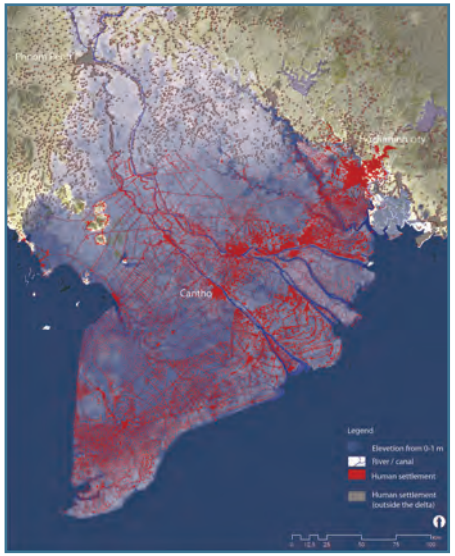
- the implementation of a garbage system
- the possibilities for more adaptive dwellings and floating districts on the water
- further investigation for the use of large scale waste water threatment systems
- better insight in the policy of Vietnam and how to realise this project in a communistic country
- connect energy systems like solar cells and biomass



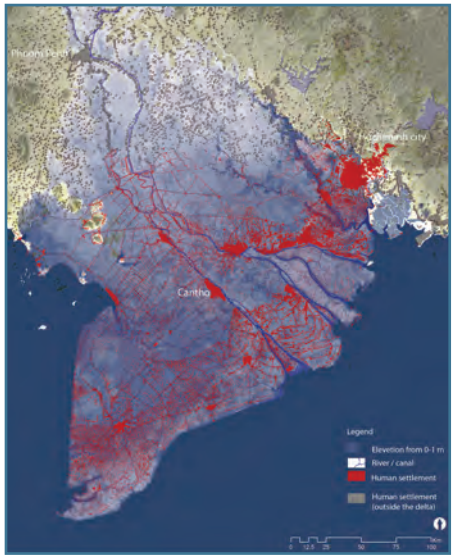
Current situation. Source: Pham, 2012



Future. Based on Pham, 2012



Future if no intervention takes place. Based on Pham, 2012



Future vision: building compact cities. Based on Pham, 2012

Delta Urbanism The Netherlands. Source: Meyer et.al. 2010
Delta Urbanism New Orleans. Source: Campanella, 2010

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Phung Hiep in the past. Source: Google Images

Appendix

A. Essay '*Benefit from flooding in Southeast Asian delta cities.*'
B. Case studies
    1. Typologies in Mekong delta : Soc Trang and Long Xuyen
    2. Defence vs Adaption: - Superlevee Tokyo and adaptation in South East Asia
C. Overview complexity in the Mekong delta
D. Tonle Sap lake
E. Geological forming of the Mekong delta

ESSAY

Benefit from flooding in Southeast Asian delta cities

Combining water safety structures with better living conditions

Abstract – Cities in Southeast Asia are facing rapid urban changes. With an annual urban population growth of 3%, cities will almost double in population in the coming 20 years (World Bank, 2010). These expanding cities are located in fertile, but flood prone river deltas. Flooding has great advantages for the local agriculture, but becomes increasingly harmful when areas get more urbanised (Tran and Nitivattanon, 2011).

The region is currently experiencing a rapid shift towards a liberalised economy and from a traditional society to a modernised one, resulting in a migration towards the cities. Traditionally, Southeast Asian delta cities were established on the high levees along rivers, as these were the safest places against flooding. Current city expansions show poor, high dense areas in low lying city regions which are the most vulnerable to flooding (Pham and Pham, 2011). An average annual sea level rise of 3mm and larger fluctuations in wet- and dry seasons will cause even more extreme inundation for the future of Southeast Asia (Deltares, 2011).

The aim of this review is to explore the possibilities of water defences as an environmental and urban quality in expanding areas to prevent flooding and improve living conditions. This is presented in the context of the expansion of Southeast Asian delta cities where the need to develop flood protection and suitable city expansion is high. The study answers the question on how water can be used as a structuring element to improve the living environment in the expanding regions of Southeast Asian delta cities. The results of this study contribute to my graduation project on the development of a concept for expansion areas of Can Tho, a rapidly urbanising city in the Mekong delta, Vietnam.

Firstly, this review elaborates on the way how water shaped the urban structure of cities in the past. This is followed by descriptions of the social, hydrological and landscape challenges occurring in this region reviewing among others Friedmann (2007), Spencer (2010), Pham and Pham (2011) and Norberg-Schulz (1979). Later on, several integrated solutions are shown. Spatial flood defence structures have the potential to play an important role to structure urban growth and improve the living quality. This paper promotes the relevance of this topic, stimulate interdisciplinary thinking and increase the awareness for climate change in developing countries.

Key words – Delta cities; Southeast Asia, urban expansion; water defence structures; socio-spatial segregation; multidisciplinar approach.

1 Tension between climate change and urbanisation

Southeast Asia is experiencing a rapid urbanisation and population growth. Annually, cities grow with 3%, implying that some cities will almost double in size in the coming two decades

(World Bank, 2010). Worldwide, the urbanisation rate is the highest in Southeast Asia and China, with Indonesia as the big leader (United Nations, 2005). The delta cities in this region are threatened by climate change and rapid urban growth. Climate change predicts an extra average sea level rise of 3mm a year and brings growing fluctuations in dry and wet seasons. As currently half of the world's population live in densely populated delta city regions (Unesco-IHE, 2010) and this amount will keep increasing, it is one of the main challenges for the future to plan and design sustainable expansions of these flood-threatened delta cities. These developments will take place in the tension field of climate change and urban growth.

Meyer (2009) explains this challenge shortly: "The urbanized deltas can be considered as areas with a double complexity: the complexity of the delta, as the meeting of rivers and sea, and with the complexity of urban pattern, as a condition and result of economic, cultural and social life." Pham and Pham (2011) add rapid urban growth to the list and asks for new ways in which we can design our cities to maintain the standards of living and avoid future natural disasters. In order to do this, several authors (Shannon, 2009; Stalenberg and Vrijling, 2009; Wilson and Piper, 2010) plead for better integration between disciplines of urbanism, landscape- and civil engineering in order to find solutions for the future as the problem tackles all these fields.

However, there is a lack of knowledge on how these issues can be combined in integrated solutions which cover both water safety and improve urban living conditions. The World Delta Summit 2011 (2011) urges world leaders and policy makers to seek practical, innovative and sustainable solutions to adapt to the impacts of climate change in urban and rural areas. The aim of this review is to explore the possibilities of environmental and structural solutions in expanding Southeast Asian cities, which can be used both as hydrological and as urban elements in order to provide water safety with good living conditions.

This paper is based on literature review. First, the paper shortly describes the development history of Southeast Asian delta cities and continues with the fundamental problem of how and why cities grow, reviewing Hall. The review continues with the three topics covering the problem: 1. Social problems appearing in growing cities according to Friedmann; 2. Water safety 3. The presence and importance of the landscape in delta areas. In the end, these three topics come together on how water structures can be used in order to combine water safety with good living conditions. The paper ends with conclusions and recommendations for future city development in expanding Southeast Asian delta cities. This review is the theoretical underpinning of my graduation project on the Vietnamese city Can Tho which is threatened by flooding and rapid urban growth. This paper promotes the relevance of this topic, stimulates interdisciplinary thinking and increases the awareness for climate change in developing countries.

2 From working to fighting against the water

Through the years, delta areas have always been very favourable places for urbanisation due to their fertile soils, fishing possibilities and good trade opportunities. The backside of living in these areas is the danger of flooding from the sea and rivers (World Delta Summit, 2011). The people living in the delta areas were used to live with a dynamic and unpredictable delta and the advantages of living in these areas outweighed the threats. That is why adaptation to the environment has always been a key way to survive in deltas areas.
In Southeast Asia, people first settled along slightly higher terraces and sandy ridges. Later on, naturally formed levees along rivers also became favourable places due to their higher grounds and strategic transportation possibilities at the waterside. Housing typologies and urban forms were shaped by the delta landscape, this is still visible in the current delta cities. This pattern is changing dramatically during recent decades because of two specific conditions. Firstly, the development of hydraulic works for agriculture and to protect human settlement areas and secondly, the development of a land-based infrastructural network. (Pham and Pham, 2011). The development of hydraulic works changed the landscape of the Red River Delta and Bangkok into polder landscapes. The French built a huge amount of canals in the Mekong delta which completely changed the hydraulics and landscape of the delta. In Dhaka irrigation to reclaim lands for agriculture changed the hydraulics of the landscape.

In the sixties the process of transformation from water cities into road cities started and landscapes transformed further. The traditional boat transport made place for upcoming motorised traffic, mostly scooters, which are able to move to dry places in times of flooding. Since then, fundamental changes in the urban landscape take place. Firstly, heightening of dikes transforms the dikes into 'fences', preventing citizens from easily accessing open water. Along these dikes floating houses were removed and reoriented towards the road (Pham, 2010). Also current city expansions show changes in the urban landscape. In Bangkok, Dhaka and Ho Chi Minh City some new expanding areas are constructed on heightened up land constructed with deposited sand loosing the structure of the landscape. (Tabula rasa). These examples show that the relationship between water and the city is disappearing. The old adaptive way of 'living with water' is slowly changing into 'fightening against the water.' Water safety is currently seen as a purely technical engineering issue (Shannon, 2009).

3 Social challenges

Research done by Ravallion (2002) for the World Bank indicates urban poverty will increase due to the growth of cities. Spencer (2010) argues the long term trend towards a growing social inequality is currently in its initial stages in the fast-developing cities of Southeast Asia. His research focussed on settlement patterns and the risk of the appearance of a permanent segregated urban underclass. This potential social inequality is lurking due to several reasons.

Firstly, the weak governments cannot take their responsibility in providing basic infrastructure as water, sanitation and infrastructure. (Spencer and Meng, 2008). This is because the metropolitan growth outgrows investments in basic infrastructure. This stagnation affects the poorest people of the community which results in growing poverty, ill health, social tension and pollution of the environment.

Furthermore, weak governments lead to unplanned and uncoordinated urbanisation outside the authority of the state, the so-called peri-urbanisation. The appearance of new settlements, slum areas and new towns are the first steps towards a more socially unequal world. Actually, the absence of basic infrastructure (sanitary and fresh drinking water) in the appearing slum areas are not the biggest problems. The long-term consequences threaten the

society the most because this social and spatial segregation is harder to solve for governments in the future (Spencer, 2010).
Thirdly, the upcoming private market and political reforms without a strong government further increases the inequality. Shatkin (2007) describes how the growing private market gives countries a stronger global position which makes scholars increasingly concerned about the growing inequality in Southeast Asia. As globalisation creates polarised cities divided in a wealthy and professional class and an poorer service sector class (Friedmann, 1995 and Sassen, 1998). This causes unequal development resulting in the spatial form of the city, which is possible due to the weak governments (Marcuse, 1997). Gated communities are already appearing in among others Ha Noi, Bangkok and Jakarta. Even whole new communities appear around companies on cheaper grounds outside cities (Spencer, 2010). Finally, political inequality appears because urban politics becomes dominated by the people whom benefit from growth-oriented policies over the interests of neighbourhoods. (Logan and Molotch, 1987). Furthermore, globalisation creates competition between countries which makes the state, influenced by private investors, invest in an attractive business climate instead of providing basic infrastructure for the labour class.

Friedmann (2007) states that the basic needs of the people that live in a city should be its main asset. Secure and adequate housing, access to healthcare and opportunities for education are the first fundamental rights of people and these points should be the aim of every development. In the perspective of the Southeast Asian delta cities, danger of flooding and rapid urbanisation are two points which threaten this. In the ideal city of Friedmann (2007), the wishes and needs of 80% of the city inhabitants should be the basic starting point for development. The 15% which need proper roads for their daily activities should not be the standard. If a wave of industrialisation or economic growth leaves the city, a strong basis will remain. This all show the presence of a strong government, guiding the private market well, can decrease social and spatial inequality.

Furthermore, in growing cities the maintaining of a human scale is another social challenge. When cities grow in size, the inhabitants need to find a community or neighbourhood for their long-term stay. These things make the new urban landscapes more human scale and these identities fill the economic and social gaps appearing with the rapid urban development and changes which Friedmann also calls ‘place making’. (Friedmann, 1995).

4 Hydrological challenges

The location in delta areas makes the rapidly growing cities in Southeast Asia a special case. Higher population densities and new infrastructure makes citizens and their economy suffer more from inundation than those who live in less urbanized districts or the countryside in which flooding has great advantages for the agriculture (Tran and Nitivattanon, 2011). As mentioned in the introduction, the city expansion is taking place in the lowest and most flood prone areas because the higher places are already urbanised which makes the poorest people the most vulnerable for flooding (Pham and Pham, 2011). The areas that are affordable to the poor are typically on hazardous lands, in areas that are deemed undesirable for others. (World Bank, 2011). Climate change predicts a sea level rise of 3mm a year and brings growing fluctuations in dry and wet season. Water related challenges in Southeast Asia distinguish in three effects: Flooding, rain water monsoons and the availability of fresh drinking water.

4.1 Rain water

More seasonal fluctuations predict wetter monsoon seasons. The urban growth has resulted in the transformation from permeable land surfaces to large areas which are rain water impermeable. The results are that many inner city areas face major problems with drainage. Although the sewage system has expanded, the areas with no storm drains at all quickly become small rivers after even modest rainfall. (Pham and Pham, 2011). More green in cities, water storage areas and well working sewage systems provide solutions, although the last one would be hard to implement.

4.2 Fresh drinking water

Together with wetter monsoon seasons, the dry seasons will become dryer. With lower discharges in dry season due to climate change, but also due to upstream power plant dam projects in China, salt water intrusion in delta areas threatens the fresh water supply. Furthermore, growing urbanisation and factories along the rivers also gives pollution. In the delta areas, ground water extraction is also no option because ground water extraction results in soil subsidence what increases flooding further.

4.3 Flooding

Flooding has great advantages for the local agriculture, but citizens and their economy suffer more from inundation than those who live in less urbanized districts (Tran and Nitivattanon, 2011). In Southeast Asia, flooding is caused by high river discharges upstream, from storm and typhoons from the sea and from heavy rainfall described above. Mangroves, functioning as natural storm surges along the shore, are decreasing due to human activities which increases the vulnerability of delta cities for typhoons and storms (Pham and Pham, 2011). Besides economical and social damage flooding can cause, the flooding of polluted rivers causes more health problems. With an eye on the future, urban areas have to protect themselves against flooding, whilst agricultural still need (controlled) flooding.

5 Landscape challenges

As mentioned before, the last decennia urban expansion in the South eastern delta regions often takes place on tabula rasa manner, starting with a blank sandy sheet. Although, one of the most important functions in architecture is the expressing of one’s own civilisation, stated with the word ‘genius loci’ (Mumford, 1962) in order to keep the identity of a place. In the past our chances of survival had a close relation to the place and landscape in which one lived. They gave shape to architecture and urban form. Through time, when cultivating the land (described at the beginning of the review) people took into account the flooding together with the structure of the landscape to form their built environment (Norberg-Schulz, 1979). Also today the landscape, soil and spatial conditions give the rules how to built (Palmboom, 2010).

In order to define principles for urban extension in these harsh environments also Lusterio (2009) states that sustainable settlement development in coastal and river areas requires a high respect for the environment and the balance between man and nature is very important. That is why analysis and understanding of the landscape is very important. The landscape

formed themselves the best to the conditions of the environment and can give solutions for building the city.

6 Structural elements

In the developing world the current building stock has not yet reached its final form and much of their urbanisation and investments in this building stock is to come in the next few decades. It is a huge task to do this properly. As each city has an unique context, there is no single solution for successful planning in response to sustainability, climate change and flood risk (Zevenbergen, 2011). Although, there are solutions which have the potential to combine flood defences and at the same time improve living conditions. After discussing the three challenges of social inequality, landscape and hydrology in Southeast Asia several of elements which can combine them are found in literature study.

Firstly, the development of waterway developments like boulevards along coasts and rivers are able to strengthen the public domain (Shannon, 2008). Through this urban element, different areas are interconnected. Waterway developments can be easily combined with hydraulic structures like a dike or the unbreakable, more broader super levees. The interconnection and interaction between areas can prevent or decrease social and spatial segregation. The design can allow places for trade along the waterside to re-strengthen the traditional relation with the water for the lower class people and provide space for the middle- and upper class people to enjoy the cultural water side. Although you can probably write a whole book about multifunctional dikes, examples are a viewpoint, (public) transport, terraces and recreation to bring citizens together.

Secondly, rainwater, fresh drinking water and social cohesion can be combined. Rainwater is cleaner compared to water from rivers and collected rainwater in basins in the wet season can be used in dry season. Flooding due to rainfall in impermeable cities can be reduced if the rain water can be drained well. In Bangladesh and India very old ‘water squares’ were already in use. People gathered around these places for daily activities like washing, fishing, drinking and trade. (Shannon, 2009). This way of urban drainage can also be implemented in urban (landscape) parks which functions as a place for interaction. Besides, with the current knowledge of helophyte filter plants, water can be cleaned in a natural manner. Open (water) places in the city also counters urban heat effects.

In cities along shores, the use of a pier can provide wave breaking and can also be an icon or characteristic of a the city. The pier of Scheveningen, The Netherlands is the main characteristic for the seaside and decreases the force of waves entering the shore (Vermeulen, 1999). Such a structure can strengthen the identity of the place what is important reviewing Mumford (1962).

A last point to mention is that the landscape should form a starting point when developing flood defences. It does not only give identity to a place, but also provides natural guidance to a suitable solution.

7 Conclusion

The tension between climate change and urbanisation is growing in the expanding cities in Southeast Asia, giving huge hydrological and social challenges for the future. Engineers, designers and planners ask for a better integrated design process in order to make plans for flood prone areas (Shannon, 2009; Stalenberg and Vrijling, 2009; Wilson and Piper, 2010). The plans should not just provide water safety, but should also be used in a multifunctional way to improve living conditions. The aim of this paper is to turn this wish into practice and give urban structures which have the potential to play an important role in providing water safety and also improve the future living quality.

The social challenge for the future is the lurking social and spatial segregation in Southeast Asian cities. This is lurking due to current globalisation and industrialisation without the guidance of a strong government (Spencer, 2010). Future hydrological challenges are the protection against floods due to the rise of sea levels, increased monsoon rainfall and a growing shortage of fresh water supply.

Several solutions show that water defence structures, besides flood defence, are able to be used in multiple ways. Boulevards can give interaction between different layers of the population. Rainwater storage can ensure the availability of drinking water and gives opportunities for recreation and as gathering point. Big hydraulic structures can function as an image or icon for a city. These multidisciplinary solutions provide ways to guide the urbanisation in the cities of Southeast Asia, while keeping the importance of a place (Mumford, 1962) and let landscape, soil and spatial conditions give rules how to built (Palmboom, 2010).

This literature review contributes to my graduation project about the rapidly growing city Can Tho in the Mekong delta, Vietnam. The city expansion needs an approach to protect the city against floods in the future and to strengthen social cohesion in order to prevent lurking social and spatial segregation, based on the logics of the landscape. This paper maps the future challenges of the area and explores possibilities to challenge them.

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APPENDIX B : CASE STUDIES

1a. TYPOLOGIES IN MEKONG DELTA : SOC TRANG AND LONG XUYEN

Case study Soc Trang

The case Soc Trang is interesting firstly because the implemented road and canal system have had a lot of influences on the shape of the city. Secondly, the area is located at the border of sweet and salt grounds. With the upcoming salt gradient the transformation to salt land use is well noticable in this area. If the sea level rises salt water intrusion will not be unthinkable in Can Tho.

Soc Trang is a city located 50 km southeast from Can Tho. The city and area have approximately 135 000 inhabitants and is in the top 10 largest cities of the delta. The city is not largely affected by flooding.

Fig. 9.2 Soc Trang 1966

Fig. 9.3 Soc Trang 2009

Fig. 9.3 Location Soc Trang

Fig. 9.4 Development Soc Trang area

Soc Trang appeared around 1650 as a Khmer settlement at a place of a few sandy ridges surrounded by fertile alluvial soils. The ground where the city appeared is higher compared with the area. (See soil map next page). These sandy ridges provided strong soils to built on. The location is in an area with a lot of sources: Nearby the large Mekong river and mangrove forests which were reachable due to the countless streams and smaller rivers and nearby mangrove forests. Mangrove forests provided wood and other materials, the rivers provided fish and possibilities for trade.

Around 1900 the first transportation roads were built in the delta. At Soc Trang the roads from Can Tho and from the north came together to continue as the main road to the south. This provided chances to grow.

When the French took over power over the Mekong delta the canal building reached Soc Trang. The French Haussmann plans made for Paris in the nineteenth century were copied to the delta in order to keep the area under control. Several canals crossed at Soc Trang what gave Soc Trang its star shaped form and strategic centrum. Also the city in the north, Phung Hiep, appeared on lower grounds. The city became a road and canal crossing place. The dirt which came up when the canals were digged provided higher canal banks along the canals. The higher banks and the trade opportunities made urbanisation grow along these canals.

Fig. 9.4 Development Soc Trang area

Maps Soc Trang area

Nowadays, the region of Soc Trang is dominated by salty grounds in the south dominated by shrimps aquaculture and alluvial soils in the north used for rice agriculture. The slightly salty grounds are still in use for agriculture, although the amount of crops a year is less than at the alluvial grounds in the riverbed area. In the northeast acid grounds are found where the grounds are less fertile for agriculture.

The salt water gradient goes further and further inlands. Rivers are buffer zones to stop this process for a while. (See fig. 9.6).

Fig. 9.5 Development Soc Trang area

Legenda fig. 9.5

Inundation

13 m

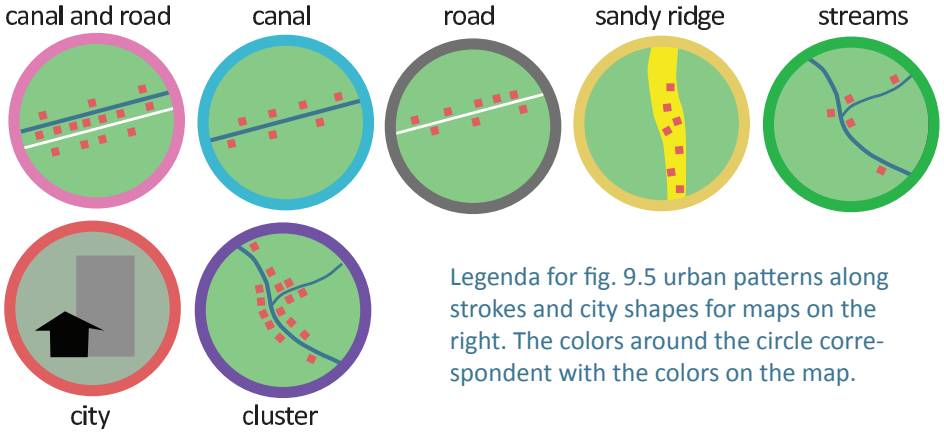
0 m

Height in meter

- > 2,5
- 2,0 - 2,5
- 1,5 - 2,0
- 1,0 - 1,5
- 0.5 - 1,0
- < 0,5 m

Soil map

- Sandy riches
- Alluvial soils with yellow-red mottles
- Deposited alluvial soils
- Cleyic alluvial soils
- Undeposited alluvial soils
- Saline mangrove forest
- Slightly saline soils
- Moderately saline siols
- Strongly saline soils
- Actual acid sulphate soils> 50 cm
- Saline - Potential acid sulphate soils - sulfidic material 0 - 50 cm
- Potential acid sulfine soils sulfetic material 0 - 50 cm
- Saline - acid sulphate soils - sulfuric horizon : 0 - 50 cm



Legenda for fig. 9.5 urban patterns along strokes and city shapes for maps on the right. The colors around the circle correspondent with the colors on the map.

Fig. 9.6 Shrimp and rice field border. The river is a natural salt water border, but also on the northern side of the river the shrimp farming is growing. (Source: Google Earth).

Fig. 9.7 Urban pattern, roads, canals, rivers, creeks of Soc Trang

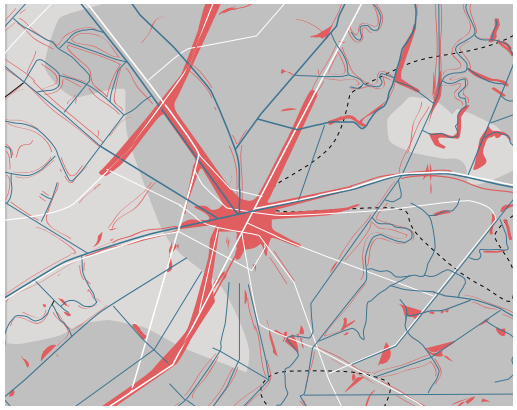


Fig. 9.8 Urban pattern types in relation to height

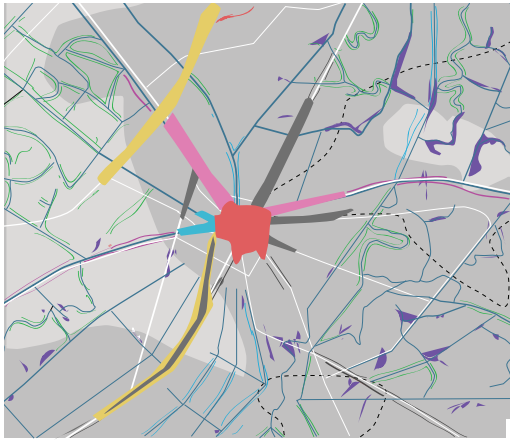
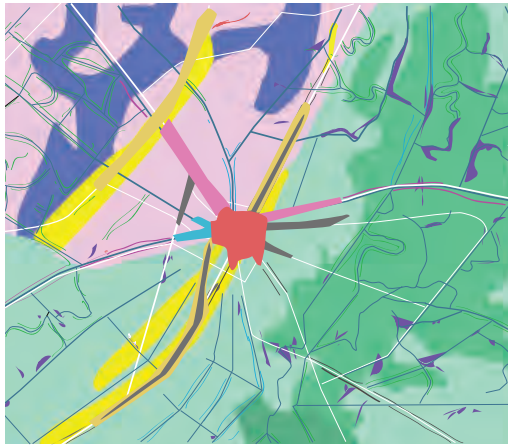


Fig. 9.9 Urban pattern types in relation to soil



Flooding

Fig. 9.10 The city and roads follow the higher grounds

Fig. 9.11 Due to pressure on space, waterfronts are urbanised. Living above the water is possible due to pole houses protect against flooding.

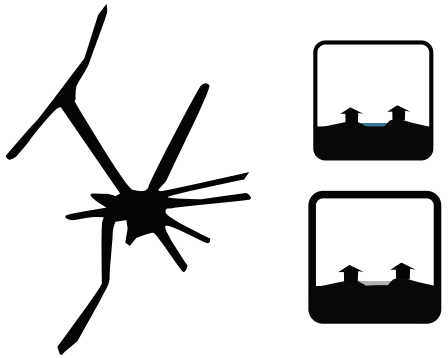


Fig. 9.12 Building canals and roads and existing streams and rivers have higher grounds where the urbanisation takes place what gives Soc Trang his starshaped form.

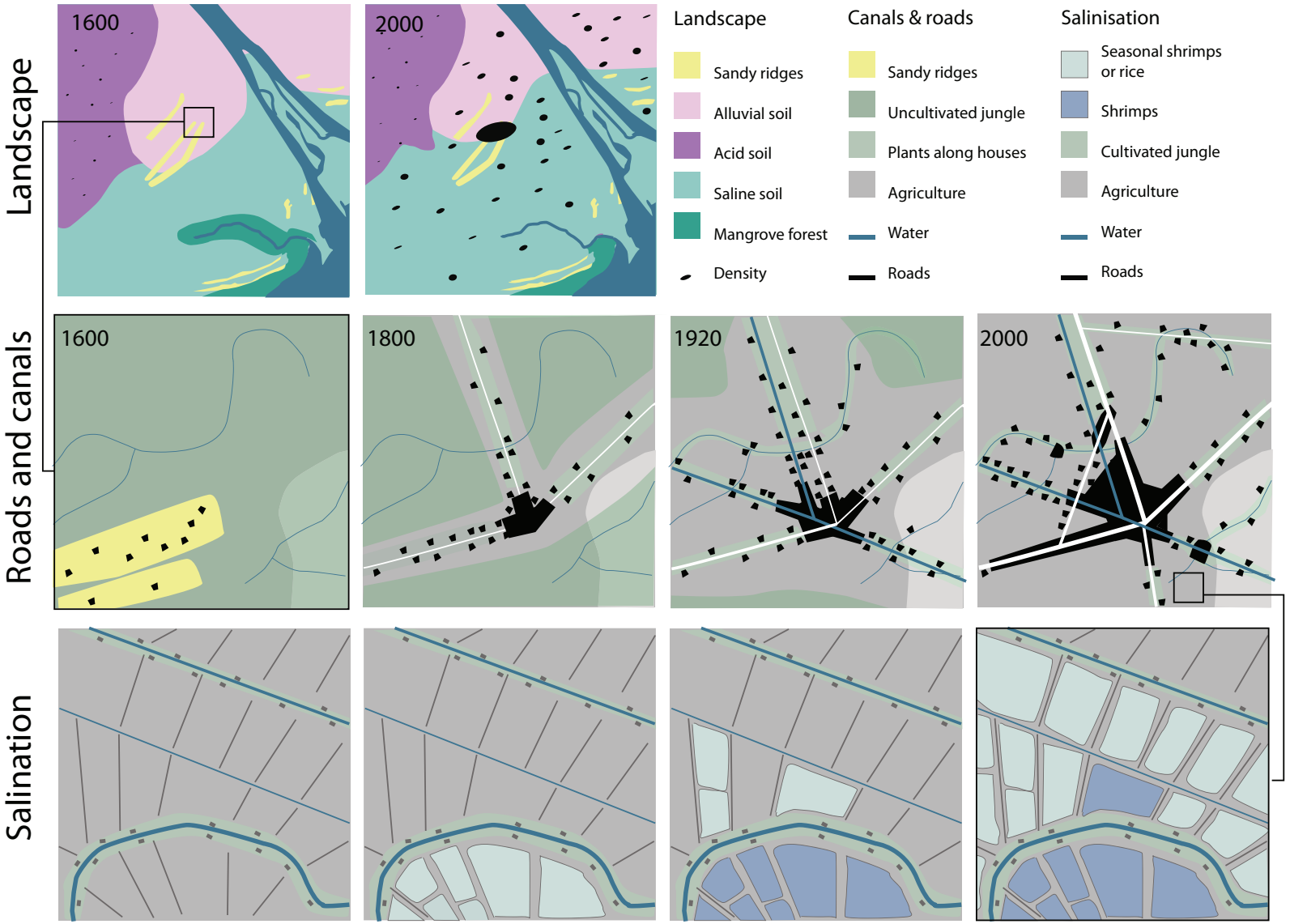


Fig. 9.13 Conclusions Soc Trang

Landscape

- Soc Trang is appeared along sandy ridges, this was good soil to built on.
- When the city grew due to roads and canals the cultivation spreaded in all directions.
- Acid soils which is bad for agri- and aquaculture in the west are less urbanised than the eastern grounds
- On fertile soils clusters of housing appear.

Roads and canals

- The first roads or muddy paths were made around 1800. Urbanisation followed these directions and the area became more cultivated.
- When canals are built, they were the most popular part for urbanisation because trade moved from the small roads to canals.
- Nowadays, roads become more important again.
- In the city, roads are most popular for development, in the countryside creeks and rivers stay dominant.
- At crossings of waterways on fertile soils do clusters appear.

Salination

- Salty grouds are also lower grounds
- Canals and streams are temporary salt-intrusion blocks
- Where grounds become too salty, shrimp farming replaces agriculture. First only in dry season, later on, all year round shrimp farming.

1b. TYPOLOGIES IN MEKONG DELTA : SOC TRANG AND LONG XUYEN

Case study Long Xuyen

Long Xuyen is the second city in order to understand the dynamics of the Mekong delta better and is an interesting case study because the city appeared likewise as Can Tho and has a lot of similarities in infrastructure and location. Only, Long Xuyen is much more affected by flooding due to the location of the Plain of Reads nearby. Because the future of Can Tho is an increase in floods, this case study shows how Long Xuyen, a similar city as Can Tho, adapted to floods already. The case study will focus on existing areas and expansion areas. The city and surrounding area have about 250 000 inhabitants.

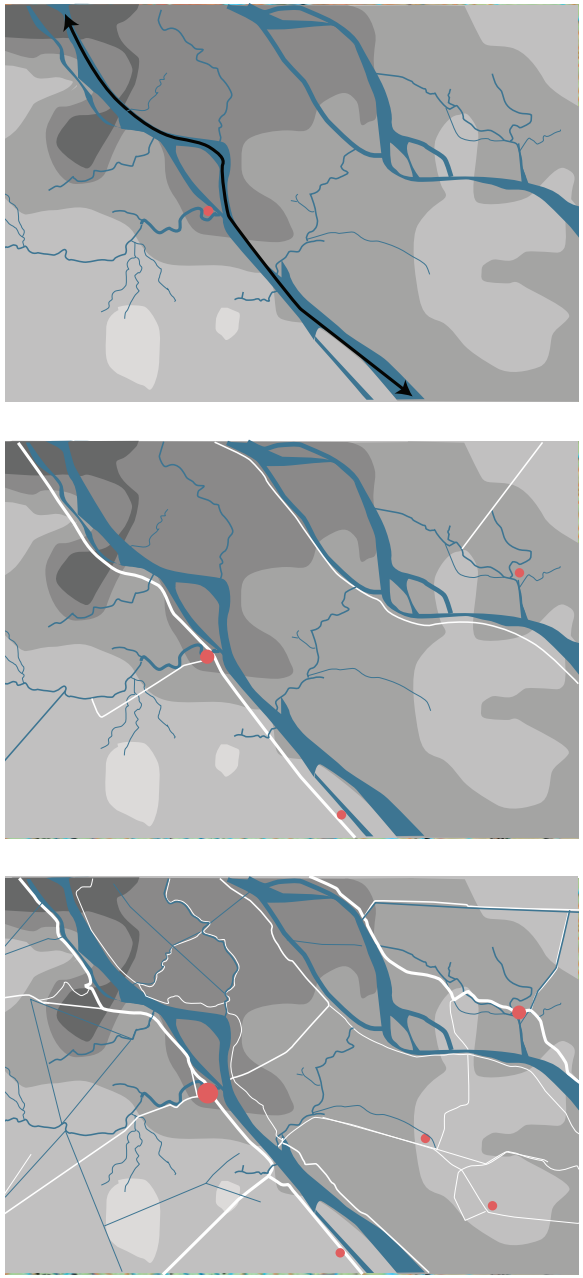


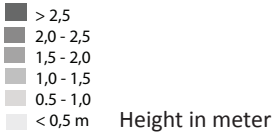
Fig. 9.14 Long Xuyen appeared in the armpit of the Hau river and a smaller river on higher grounds .

The armpit provided a safe place for an harbour and the island in front made the village invisible from the other side of the river due to the former jungles what gave the place a strategic, invisible position.

Other cities appeared because of new roads and population growth. Also a canal to Rach Gia in the south west gave Long Xuyen a good trade position.

In 2010 the road- and canal routes are a network and more cities appear.

Roads follow the rivers and canals because these areas were already more cultivated what made it more easy to built roads.



City structure

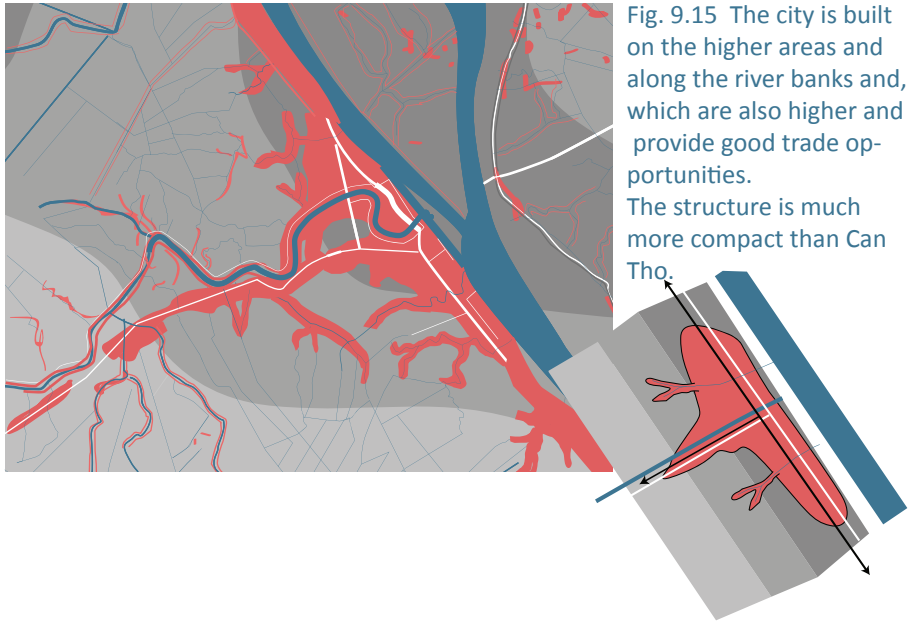
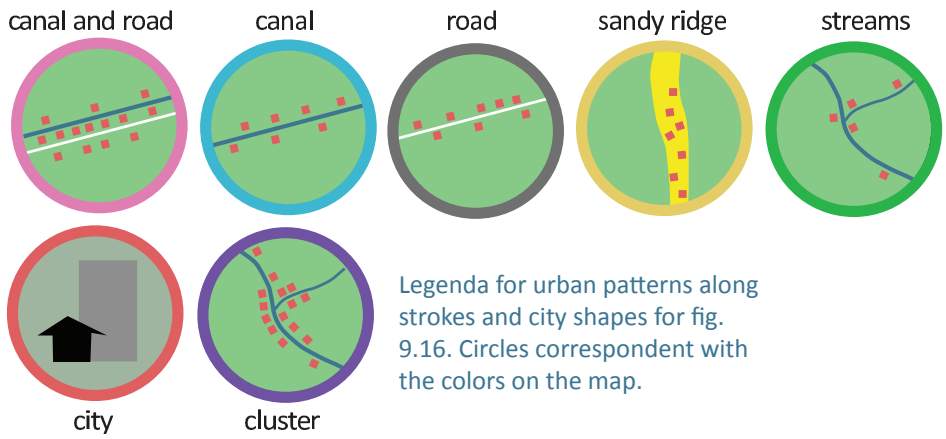


Fig. 9.15 The city is built on the higher areas and along the river banks and, which are also higher and provide good trade opportunities.
The structure is much more compact than Can Tho.

Fig. 9.16 The main typologies on the edges of Long Xuyen are linear developments. They are much more dense than in Soc Trang so you can also interpretate them as clusters. This happends because the higher grounds are really full what densifies the higher areas further.

Flooding in Long Xuyen

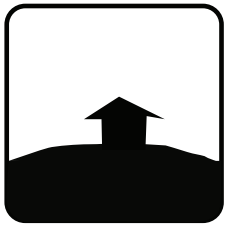
Fig. 9.17 Long Xuyen is much more affected by flooding than Can Tho.
(Source: Google Earth, 2007)



Legenda for urban patterns along strokes and city shapes for fig. 9.16. Circles correspondent with the colors on the map.

Protection against flooding

Fig.9.18 Floating communities.
(Source: Google Images)



Building on higher grounds and densify these grounds.

Building canals and roads and existing streams and rivers have higher grounds where the urbanisation takes place.

Fig. 9.19 Dike building to protect crops.
(Source: Google Earth 2007)

Expansion

In order to expand the city, new higher grounds are made with sand supply inside the low lying areas. The existing development along the roads are maintained.

Fig. 9.20 Expansion area in Long Xuyen. Source: Google Earth, 2007

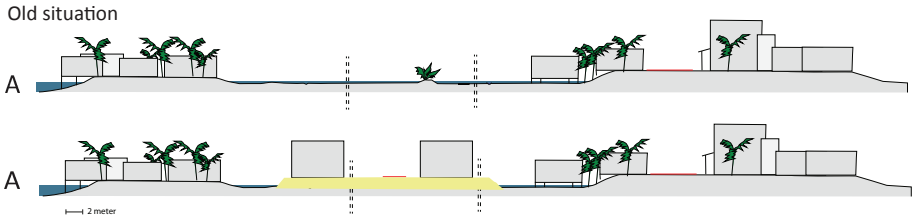
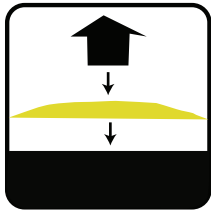


Fig.9.21 Sections figure 6.23



- Rain water is able to be stored in the remaining low lands
- The new area is isolated from the city

2a. DEFENCE VS ADAPTATION : SUPERLEVEE TOKYO AND ADAPTATION IN SOUTH EAST ASIA

Superlevees Tokyo

This case study is about the new implemented super levees in Tokyo. Tokyo is the capital of Japan and is often threatened by flooding and earthquakes. Since 1985 about 50 km of normal dikes are replaced by super dikes. The large amount of rivers in the city are slowly transformed to large green spaces when the super levees are implemente. This spatial transformation made the waterfront a valuable public and open space in the dense urban structure of Tokyo with its 12 million inhabitants one of the densed cities of the world.

Target case study:

1. Hydraulic advantages
2. Spatial impact on the city (size)
3. Urban advantages and possible functions
4. Infrastructure along the dike - how to solve?

Geographically, Tokyo is located in the delta of three large rivers: the Sumidagawa river, the Arakawa river and the Edogawa river. large parts of Tokyo are below the flood level of these main rivers. Flooding is caused due to heavy rainfall, typhoons and flooding from the rivers due to high discharges upstream.

Tokyo has three defences against floods:

1. Flood retaining structures like the super levee
2. Decreasing discharge upstreams due to diversion channals and detention areas
3. Damage migitation measures with signs through the city

Source: Stalenberg and Vrijling, 2009

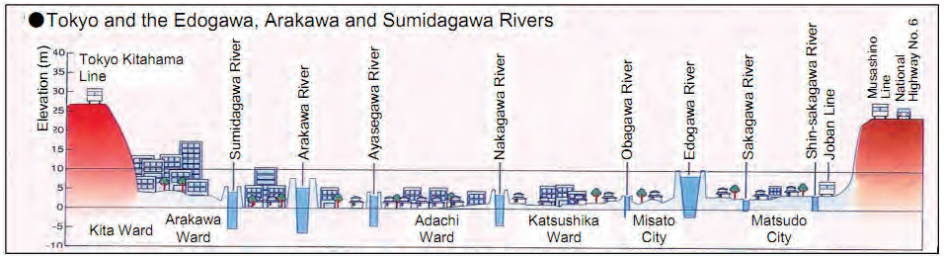


Fig. 9.22 Heights of the dikes in Tokyo. Source: Atsum, 2009

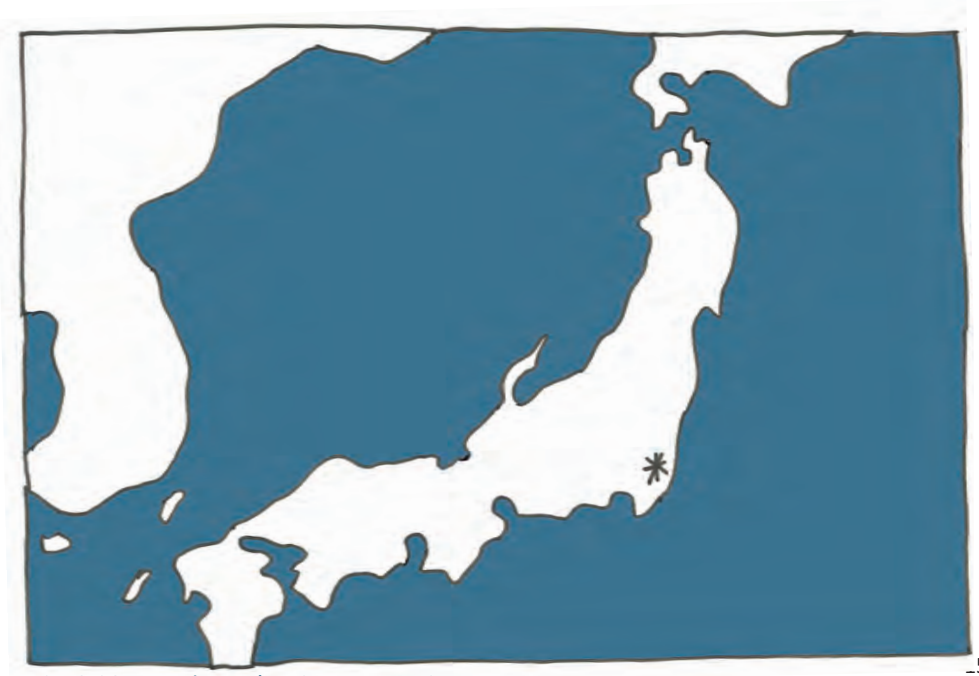


Fig. 9.23 Location Tokyo in Japan, Asia

Fig. 9.24 Tokyo. Source: Stalenberg and Vrijling, 2009

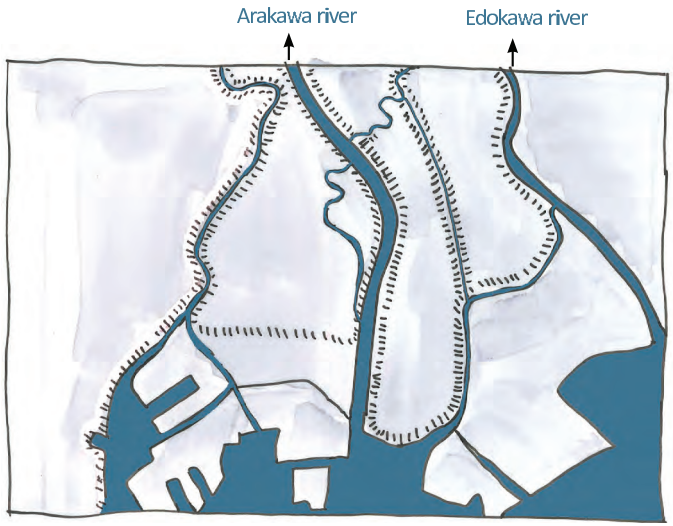


Fig. 9.25 Urban Tokyo city with the (planned) super levees.

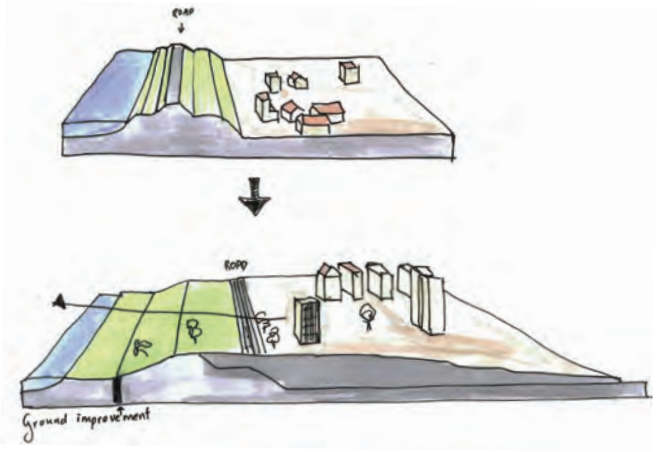


Fig. 9.26 From dike to delta dike

Urban advantages

The super-levee offers advantages besides being structural. The stabilized and strengthened sides can be developed, extending the urban fabric right up to the top of the levee and allows a much better visual and physical access to the water. In Japan, these developments are made together with parks along the waterfront as green lungs in the city. Because of the sight location and the parks nearby, the areas are popular for business. (Fig. 9.26)

Fig. 9.27 Hydrological advantages

According to the pictures on the right:

1. During an unexpected high flood, water overtops and may break the normal levee. The superlevee does not break and overtopping water flows slowly over the levee.

2. During an unexpected long and high flood, water seeps and may break a normal levee. The super levee does not break due to its wideness.

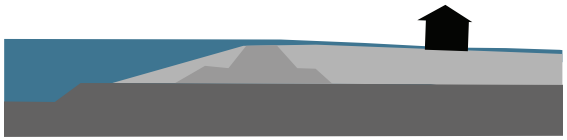
3. During a earthquake, soft grounds may liquefy, causing damage to the dike and the city. The super levee can be made strong against liquefaction when necessary.

The rule of thumb for the calculation of the broadness of the levee (what also has large effect on the spatial impact) is three times the needed height of the levee (height:width = 1 : 30).

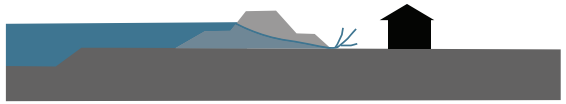
Super levees have to be reinforced with concrete slabs and a steel sheet pile.

(Source: Stalenberg and Kikumori, 2008)

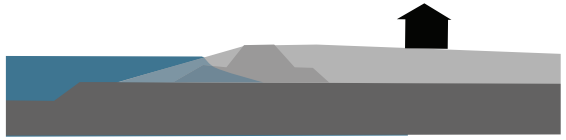
1. Stability for water pressure - normal levee



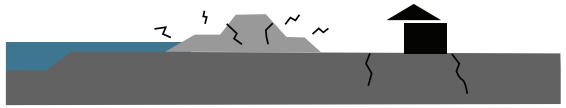
1. Stability for water pressure - superlevee



2. Stability while seeping - normal dike



2. Stability while seeping - superlevee

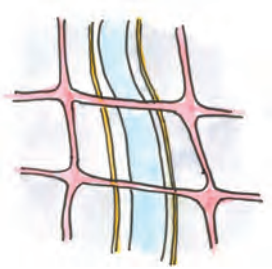


3. Stability with earthquakes - stronger soil - normal levee

3. Stability with earthquakes - stronger soil - superlevee

Infrastructure on the super levee

The dikes in Tokyo were almost everywhere used by road transport what decreased the relation between the city and the waterfront. The implementation of super levees gave the possibility for urban regeneration projects and to recover the relation between city and waterfront.



The road network in Tokyo is not placed along the water front anymore. The waterfront has sub roads. Plenty of bridges cross the rivers.

Still the small roads and also the large amount of bridges are a border between the city and the waterfront. This is solved with several concepts:

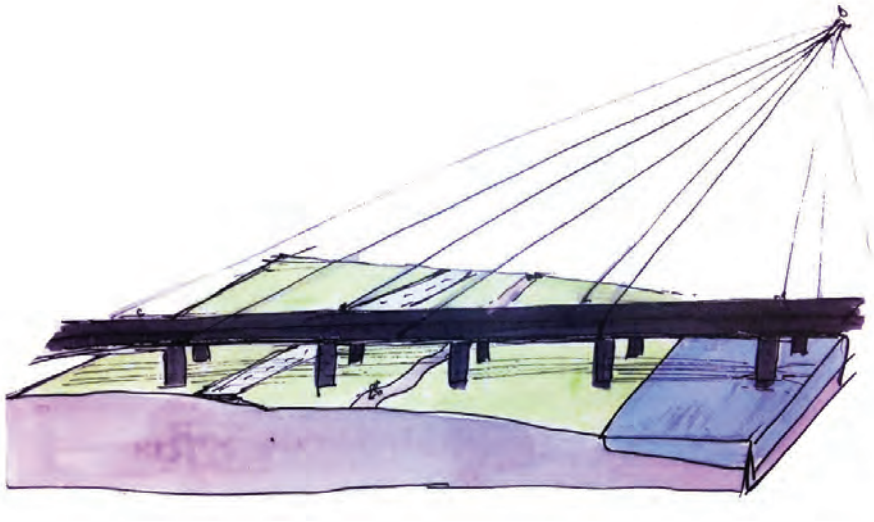


Fig. 9.28 The subroads and walking paths go underneath the bridges. The crowded roads do not have to be passed. The bridges have architectonical value.

Fig. 9.29 Pedestrian crossings provide a safe crossing of street on the super dike.

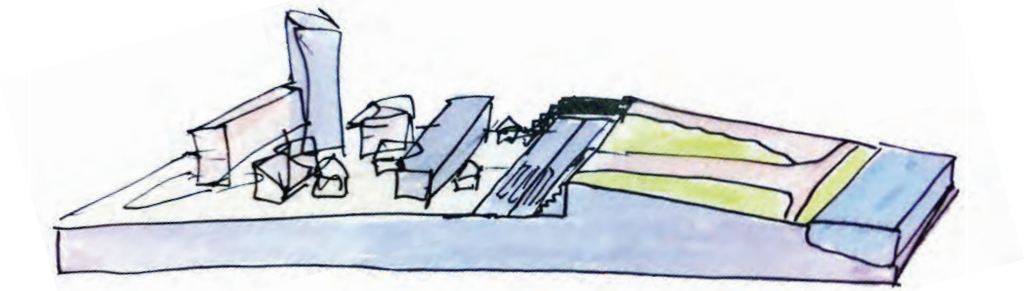


Fig. 9.30 This is a semi super dike in which the roads are really behind the dike. With stairs and bridges the waterfront is reachable.

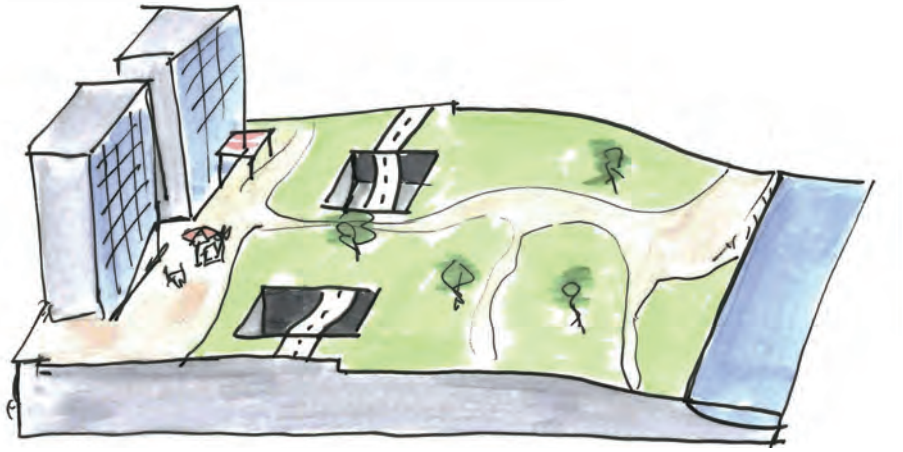
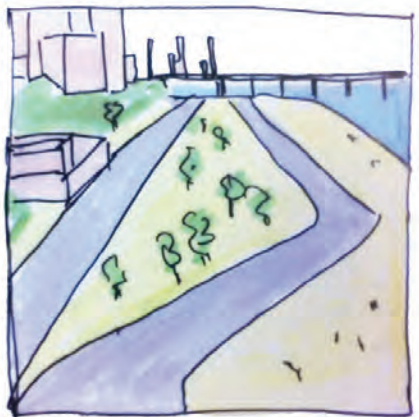


Fig. 9.31 Small tunnels keep the relation with the waterfront. Although this is an expensive solution, it has an larger urban quality than the pedestrian crossings.

Multifunctionality on super levees in Tokyo



The green open spaces which appear due to the implementation of the super levee are in Tokyo used for several activities:slow traffic, sports and playing, nature and as boulevard.

Buildings, parking and roads are also part of the dike.

Other imaginable functions are trade and some catering what is missing in Tokyo.

Fig. 9.32 Slow traffic - bikes and pedestrians

Fig. 9.33 Sports and playgrounds

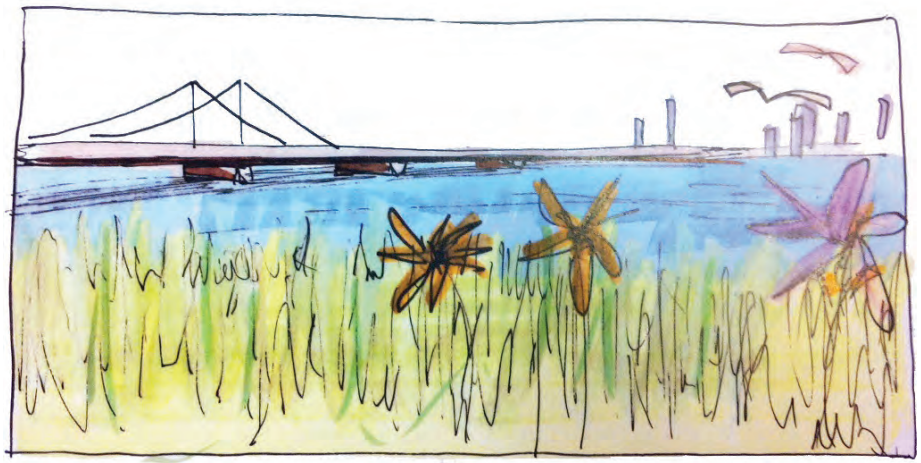


Fig. 9.34 Nature and green in the city

Fig. 9.35 Boulevard along the water side

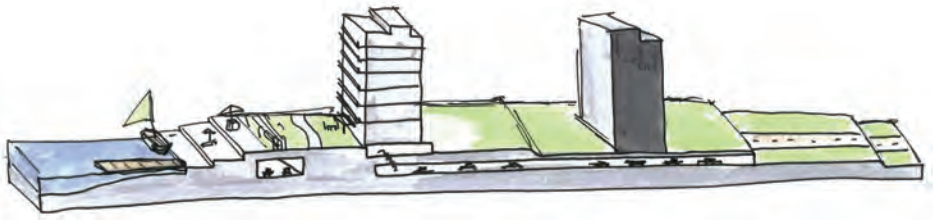
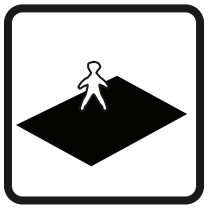


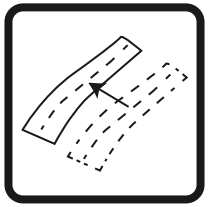
Fig. 9.36 Other possible functions for superlevee: Traffic in tunnel, parking lots, building as part of the dike, quay with trade,terraces, harbour

Problems for implementing the superlevee in Tokyo:

- Expensive

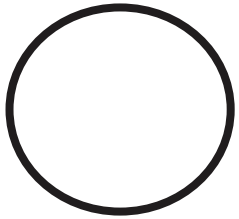


- Land ownership over the needed lands



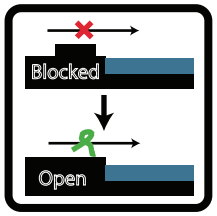
- Replacing infrastructure in a city with a dense traffic network

Approach:

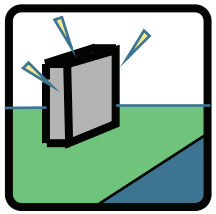


Total flood defence - city scale solution

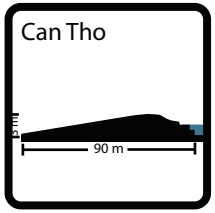
Design principles for for Can Tho



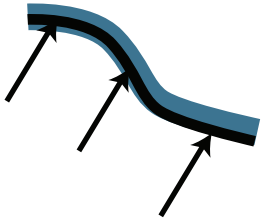
- Opening the riverfront and restrengten the relation city - waterfront for the inhabitants due
- View over the water
- Public transport along water side
- Functions along the water side



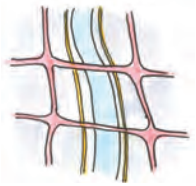
- Safe, attractive business climate along the (park) water side



- A super levee in Can Tho should be about 3 meters high. The levee in Can Tho has to be 3 x 30 = 90 m inlands.



- Place for public and social interaction. Sports, recreation, trade and public transport and connecting neighbourhoods



- Main transport routes not directly along the waterfront in the inner city.

2b. DEFENCE VS ADAPTATION : SUPERLEVEE TOKYO AND ADAPTATION IN SOUTH EAST ASIA
Adaptation in South East Asia

In this case study the traditional form of adaptation in South East Asia is researched.

Traditonal adaptation in South East Asia

1. Floating dwellings

Fig. 9.37 Floating dwellings are constructed with an pontoon constructed of bamboo or oil drums.

They are kept in place with large stilts which are embedded in the grounds. Transport is done by boat.

In the Tonle Sap lake in Cambodia live thousends of people on these houses. Also the former Bangkok was a floating community of ca 350 000 floating dwellings (Jumsai, 2009).

2. Partially floating dwellings

Fig. 9.38 This dwelling typology is found in Tha Khanon in Thailand. With the monsoons, the Khiriarat river overflows several times during the season what causes a flooding of 10 - 20 m height what can last for a few days till weeks. The whole community , including community center, is set afloat. The houses are placed on a bamboo construction and are constructed to stilts on the corners of each house (Jumsai, 2009).

3. Pole dwelling

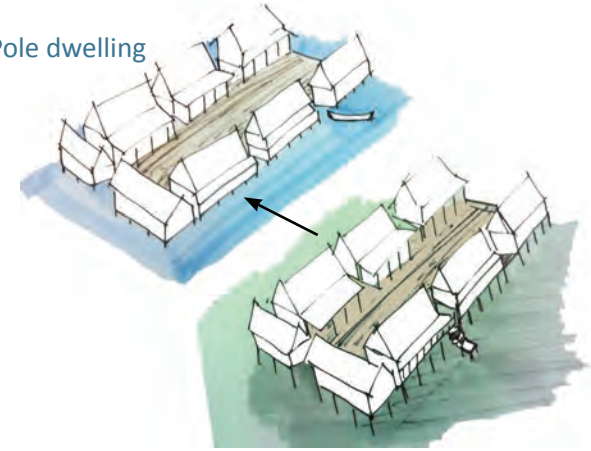
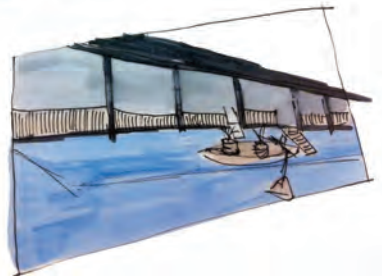
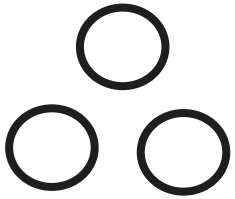


Fig. 9.39 The pole dwelling is a principle used worldwide. The shown building typology at the dwawing is found at the south east of Bangkok. The typology is well functioning in dry- and wet season and is constructed in groups of dwellings or as single dwellings.

Fig. 9.40 An other type of pole dwelling is found in Bang Li, also in Thailand. The dwellings have two levels. Wooden shops and markets all had upper malls which were linked together as a long strip. When flood season appears, all market stuff moves to the second floor and in boats. Even the pumping station is moved to the second floor in which boats are in the queue instead of cars. Unfortunately, this is something of the past and the town is heightened with soil Jumsai, 2009).





More individual or smalll group solutions

Adaptive vs defence

Adaptive

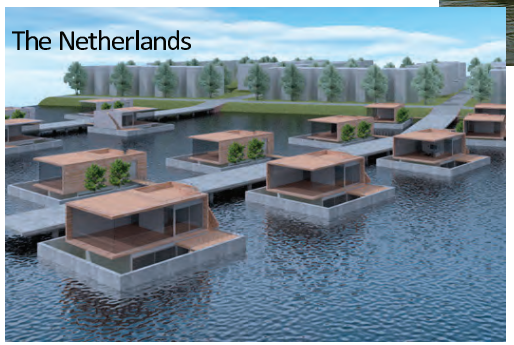
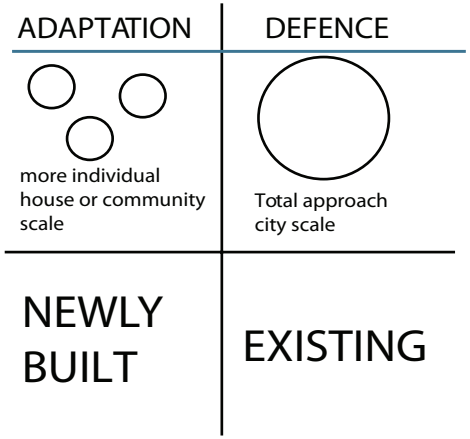


Fig. 9.41 Examples of adaptive built environment. Source: Google Images



Scheme differences between adaptation and defence

Adaptive plans are mostly on building scale or on small community scale. In developing countries you see this adaptation for centuries while in the Western world adaptive plans are used in newly developing districts.

Defence plans like dikes and storm surges provide a much larger area safety against flooding. If a city needs extra flood defence this mostly result in a defence wall, implementation of an adaptive method in existing dense built environment is very hard.

Defence plans

Fig. 9.42 Examples of defence built environment. Source: Google Images

Consequences of implementing a (super)levee or adaptation in Can Tho: critics and solutions

1. Build for which scenario ? For 2100 a very expensive and perhaps useless investment. (economical and climate scenario)

Heighten up when needed - in steps
keep always space left on land side (higher dikes are broader)
because building towards the river makes river smaller

2. Limited growth inside a dike ring

Higher densities causing
- urban heat islands
- soil subsidence quicker
- pollution and diseases

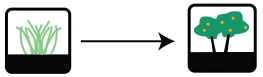
1.

Growing dike rings
Outer rings can be better adapted to the climate change trend

2.

Make very large dike ring

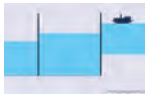
3. Rice
(No flooding anymore)



Fruit trees and other crops
which grow without floods

4. No water ways connected with large rivers while waterways are a very durable way of transportation

Sluice system



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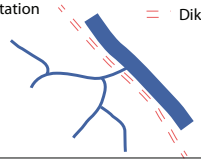


5. Constant maintainance in weak government

Responsibility of local government (province or city scale)

6. Relocate people

New housing

1. Existing buildings in city: they can not be transformed anymore?

Building stock renews itself. Every new building can be adapted. What is left of the current building stock in 2100?

2. Diseases (malaria, dengue), stank and pollution : Water is an easy garbage bin and sewage system

Avoiding silent surface water
Keep infrastructure network, and housing dry

3. Rice gets too much flooding in future.

Fish production can replace it.
Besides, the main economics of the area will be service instead of agriculture.

4. Heightening up land is also scenario based? It is hard to re-heighten up again?

New building stock can be adapted to this.

4.1 The poor cannot afford this.

Find bottum up solution
(In Bangladesh they sell water bottles in square form. If they are empty you can built your own pontoon of it).
Use of sedimentation after dredging canals and rivers?

APPENDIX C : OVERVIEW COMPLEXITY IN THE MEKONG DELTA

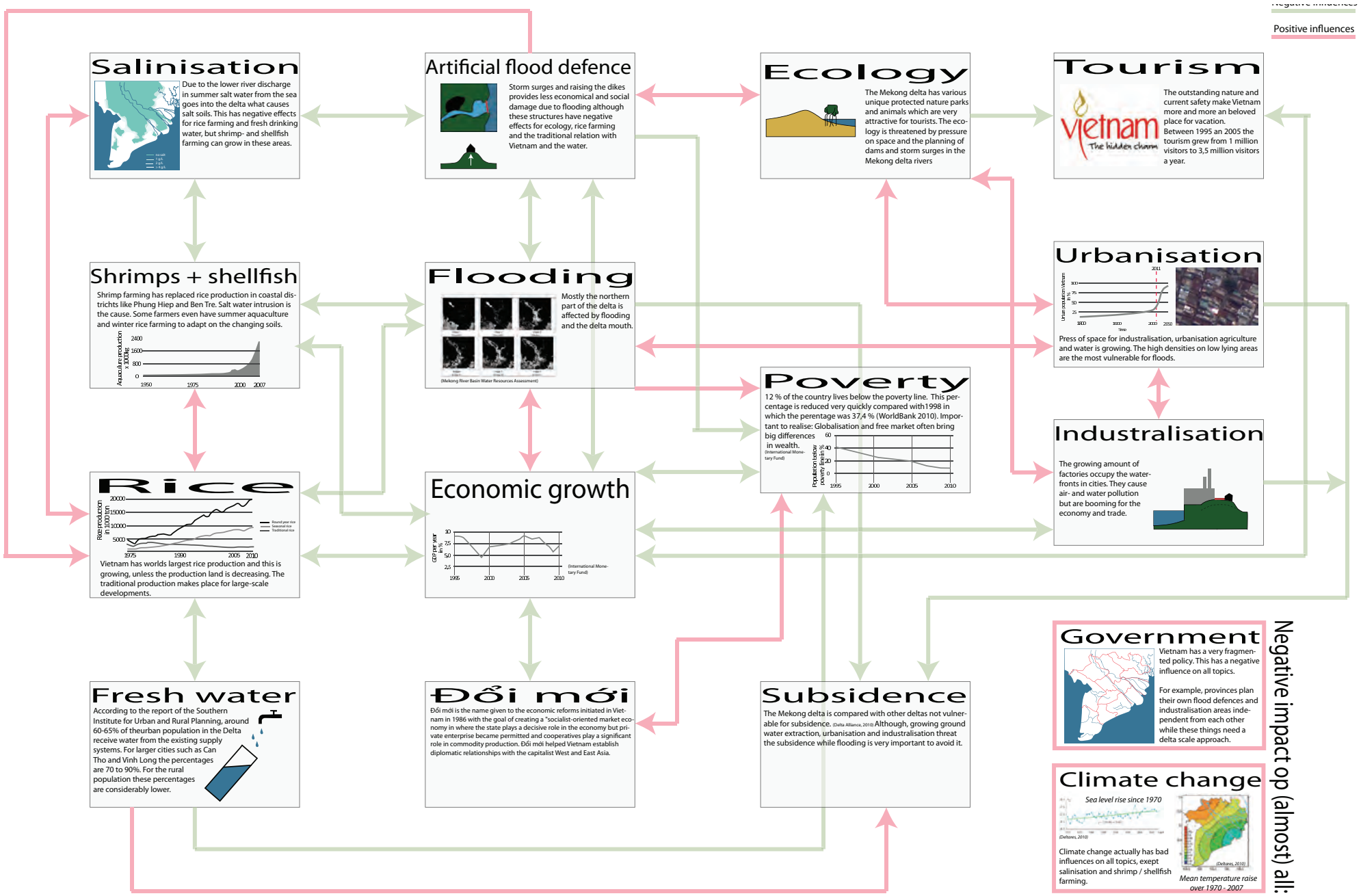
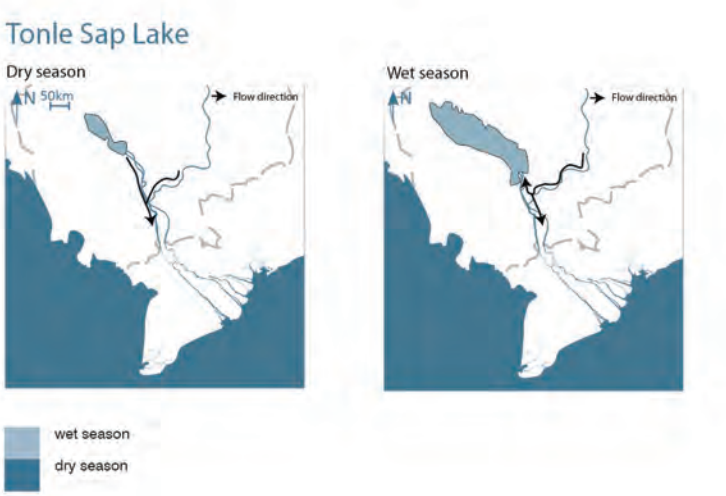


Fig. 9.43

APPENDIX D TONLE SAP LAKE

During wet season the Mekong discharges the water into the Tonle Sap lake and it expands to 16 000 m2 and 10m depth. (See picture on the right). Going to dry season the Tonle Sap changes his flow direction and the lake discharges his water into the Mekong and shrinks to the minimum size of 2700 m2 and 1m depth.



APPENDIX E GEOLOGICAL FORMING OF THE MEKONG DELTA