Climate Adaptation Strategy

Ho Chi Minh City

moving towards the sea with climate change adaptation

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moving towards the sea with climate change adaptation

Executing Agencies:

City of Rotterdam

Ministry of Infrastructure and the Environment

VCAPS

Vietnam Climate Adaptation PartnerShip (VCAPS)-consortium:

Grontmij | bosch slabbers | Witteveen+Bos | ECORYS | IVM Institute for Environmental Studies | TRIPLE-A

PREFACE

The year is 2100 and Ho Chi Minh City has become a true metropolis. Its pleasant living environment has throughout the century attracted a multitude of multinationals, talented people and investments. This is a great achievement considering the huge competition that exists between cities in the region. Providing a safe and pleasant environment proved to be of key importance in the 21st century, as natural threats from climate change had an ever increasing impact on coastal and delta cities. Not the strongest cities of the 20th century have had most success in the 21st century. It were the cities best capable to adapt to changing circumstances that have become the most liveable with vibrant economies.

Focus on strategic action

This is only one possible future and less positive alternatives exist. To enable a city to adapt to the challenges of climate change requires persistent strategic action based on committed institutional and community support. The government of Vietnam acknowledges this and has solicited international expertise to give shape to a Climate Adaptation Strategy. Ho Chi Minh City and the City of Rotterdam agreed to cooperate on climate change adaptation and water management in 2009. Through the strategic partnership arrangement between Vietnam and the Netherlands, the Dutch Global Water Program provided funding that allowed the VCAPS consortium (see www.vcaps.org) to support Ho Chi Minh City in the development of this Climate Adaptation Strategy. From the Vietnamese side, the Department of Natural Resources and Environment is the leading organization.

The City of Rotterdam provided input for the Ho Chi Minh City Climate Adaptation Strategy based on the city's experiences with the Rotterdam Adaptation Strategy and the Water Management Plan Rotterdam. Through these plans, Rotterdam identified and implemented measures that prepare the city for climate change and at the same time contribute to the attractiveness and economical development of the city. The knowledge and experience developed in this process is applied in HCMC which is also a low lying port city focused on action.

Vietnam Ownership, Dutch Partnership

This strategy builds on the results of an intensive cooperation process. Much work has been invested in the development of the strategy, especially in the evaluation and coordination with existing sector development and master plans in HCMC. Discovering the right solutions for HCMC is a process best performed with all relevant available knowledge and resources. Developing the strategy therefore was a coordinated effort between the Department of Natural Resources and Environment, the Department of Agriculture and Rural Development, the Department of Construction, the Department of Transportation, the Department of Planning and Architecture and the Steering Centre for Flood Control. While these key city government institutions provided key commitment to preparing the strategy, many other relevant stakeholders and partners from outside institutions were consulted in the strategy building process.

To facilitate interaction between all relevant stakeholders, a series of Charrettes were organized. Charrettes are highly focused and interactive workshops aimed at finding connections between sectoral issues and interests, leading to integrated solutions and a joint agenda. In Charrettes stakeholders, experts and architects together discuss issues, solutions and designs using visualization as a tool. Visualization dissolves misunderstandings that arise in the use of text, words and differences in language, and thereby these tools can facilitate the process of joint problem solving and the discovery of solutions.

Integrated and innovative approach

New challenges require new approaches and new solutions. The development of a Climate Adaptation Strategy is a task that involves a wide perspective and a long planning horizon. The Adaptive Delta Management approach, also practiced in Rotterdam, offers a way of dealing with the uncertainties that are inherent to long term planning. Integrating climate solutions in the urban development process is one of the main challenges of climate proofing delta cities.

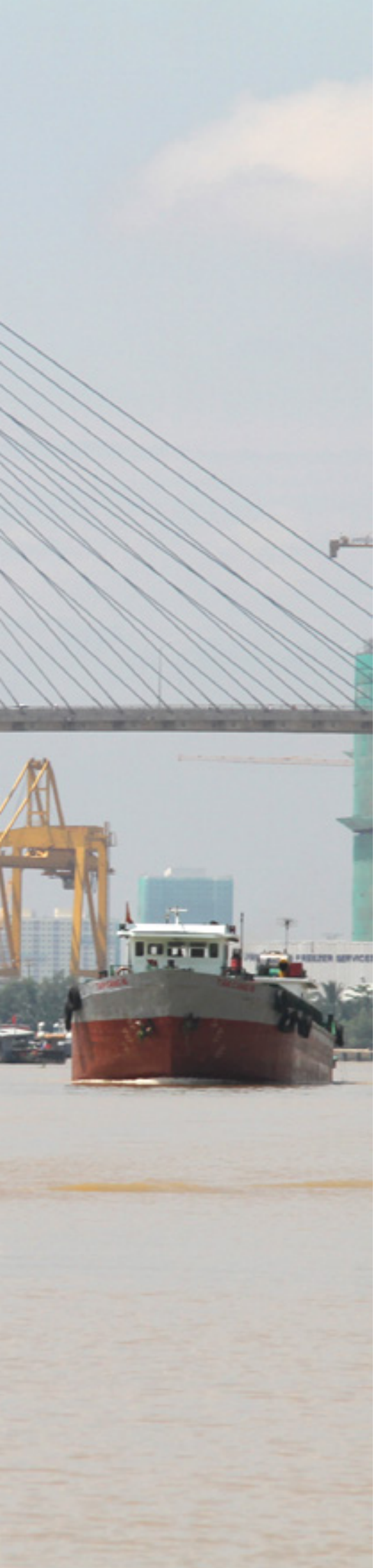
The authors of this strategy are convinced that the strategy provides an answer to the challenges that climate change poses to HCMC. In a short time, a lot of work has been done by the involved Vietnamese and Dutch organizations. Therefore we would like to thank all the people who have given their valuable contribution to this strategy. We also would like to give thanks for the hospitality of the involved organizations in Vietnam and the Netherlands and for their support in developing this strategy. Combining Vietnamese knowledge and expertise with a Dutch approach has lead to a strategy that we believe is capable of guiding Ho Chi Minh City s towards a **Unique Delta City.**

Mr. Nguyen Van Phuoc

Board Director HCMC project
Vice Director of DoNRE

Mr. Enrico Moens

Team leader HCMC project
Program Director Adapting Cities Grontmij



EXECUTIVE SUMMARY

A Climate Adaptation Strategy for Ho Chi Minh City

Ho Chi Minh City (HCMC) is a vibrant metropolis. The fast growing economy, increasing population and the existence of numerous social and cultural institutions characterize a city that has been expanding rapidly over the last decades. Most industry and harbours in southern Vietnam are located in HCMC or nearby provinces. The city serves as an international trade hub with its seaports lying at an intersection of strategic international maritime routes.

The city is expanding rapidly and the urban density is increasing. Increasing pressure on space has a drawback: available areas for urban green areas decreases, and build up areas can encroach on natural water systems. As natural vegetation and water systems are compromised through urban development, the result is that there are more frequent inundations caused by rainfall and high river flows. Besides these fast economy-driven developments, two slower and more subtle processes are becoming increasingly important for the city's future. The first is climate change which leads to rising sea levels, changing rain patterns and increasing average temperatures. The second is subsidence which occurs in parts of the city making these areas more vulnerable to flooding. Especially since the mid 1990's, the magnitude, frequencies and duration of floods are steadily increasing.

The rapid development of the city, combined with the slower processes of climate change and subsidence, will have a large impact on the economy of HCMC and the quality of life of its inhabitants: that is, if no immediate action is taken.

HCMC has much in common with the City of Rotterdam in the Netherlands as both cities are located in the delta of a large river system, have a large port and are an important factor in national GDP. The two cities have been cooperating since 2009 within the framework of the Connecting Delta Cities network which aims to exchange knowledge in the field of climate change adaptation. In 2008, The City of Rotterdam started a

climate change adaptation programme to prepare the city for climate change: the Rotterdam Climate Proof programme. The experiences and knowledge gained through this programme have been applied to the "Ho Chi Minh City, moving towards the sea with climate change adaptation" project that was started in 2011, funded by the Dutch Global Water Programme. In this project an Atlas, a Climate Adaptation Strategy (CAS) and an Action Plan (AP) have been developed, with the objective:

To enable and guide the long-term sustainable socio-economic development of HCMC towards the sea, taking into account the effects of climate change.

This report contains the CAS, which has been developed by a fruitful cooperation between the Departments of Natural Resources and Environment (DoNRE), Department of Agriculture and Rural Development (DARD), Department of Construction (DoC), Department of Transportation (DoT), Department of Planning and Architecture (DPA) and the Steering Centre for Flood Control. The executing agency on behalf of the Kingdom of the Netherlands is Agency NL under the Partners for Water (PfW) program. The VCAPS consortium was contracted by Agency NL for consultancy services.

Development ambition of HCMC

HCMC is located in the delta area formed by the Dong Nai and Saigon Rivers. The water system of the delta is still an important feature of the city. Because of its location, the city has an important commercial seaport (29th container port of the world). HCMC has an enormous attraction and is the largest and most populous city in Vietnam with 7.5 million inhabitants in 2012 and a forecasted 10 million inhabitants in 2025.

The challenge facing HCMC in the coming decade is to sustainably develop the growing city in relation to increased competitiveness in the regional and global market. Key ambitions are that HCMC becomes the centre of industry and multi-disciplinary services of the region and South-East Asia, and the central hub of international transportation. Ambitions for the socio-economic development are documented in the HCMC master plan of socio-economic development planning till 2020 and the draft Spatial master plan 2025. The general ambition that can be derived from these master plans is:

To develop HCMC into a modern industrial city in 2025 in which fast economic development is connected with sustainable development so that social progress and fairness are realised whilst protecting the environment.

The plans focus on modernizing the city and enhancing the city's liveability while maintaining its unique character. The city will offer its citizens a safe, healthy and pleasant environment in which to live and work. Safe meaning, amongst others, that the city is safe from catastrophic floods. Healthy meaning that the levels of air, water and soil pollution are controlled and reduced to internationally accepted norms for human health. Becoming a healthier, pleasant and safe city also has an economic pay-off: the city becomes more attractive, not only for tourists but also for international service oriented companies that want to provide their highly skilled employees with a pleasant living and working environment.

Climate change

Climate change will adversely affect HCMC in the coming decades. Precipitation is projected to decrease during the dry season and to increase during the wet season. Average temperatures are projected to rise by 1 degree towards 2050 and up to 2.6 degrees by 2100. The sea level is projected to rise 30 cm by 2050 and to continue to rise reaching 65 to 100 cm in 2100, as compared to the average sea levels from 1980-1999.

Climate change impacts that will threaten HCMC include:

- Rise in temperature, leading to higher temperatures in the city (heat island effect) and deterioration of air and water quality.
- Sea level rise, leading to increased flood risks and salt intrusion.
- Change in precipitation, leading to increased nuisance from extreme precipitation events
- Change in river runoff, leading to an increase in flooding frequency.

Besides the climate change impacts, also land subsidence resulting from over extraction of groundwater will lead to increased flood risks.

The draft Spatial master plan 2025, as well as other sector development plans of HCMC, do not explicitly take climate change into account. If no action is undertaken, the safety and livelihoods of HCMC residents is at stake. HCMC will be flooded more often, the air and water quality will become worse, nuisance associated with flooding from extreme precipitation events will increase, and the general living conditions will become uncomfortable as temperatures increase.

At the same time, HCMC has several important development potentials in relation to climate change adaptation. The rapid development of the city in itself is an opportunity for adapting to climate change as measures can be integrated into foreseen development plans and projects. Development on river banks for instance has a potential to make the city safer and at the same time contribute to the attractiveness of the city. Some of these areas are now not always visible, accessible, respected or utilized to full potential. Restoring the original water system will create natural water storage areas and will strengthen the hydraulic connectivity of the city with its delta environment thus improving water quality. An area with a high potential for development is the northwest part of the city. The soil in this area is structurally stable and has a high load carrying capacity.

Challenges

But there also constraints that have to be dealt with. The growth of the city puts pressure on providing appropriate living conditions to all inhabitants. Because of rapid growth, green space in the city is under pressure. Heavy traffic results in economic loss and high concentrations of air pollution. Many industries do not utilize required pollution control technologies. Groundwater is being increasingly used illegally as process and drinking water with over abstraction leading to subsidence. The current sanitation system also constrains future development; in most places waste water is discharged untreated. In the south of the city subsidence occurs and the subsoil is weak and moisture laden resulting in difficult conditions to build on. Due to high sedimentation, harbour locations need to be carefully chosen to avoid high dredging costs. Large parts of HCMC are currently affected by flooding causing a constraint for further city development as floods result in nuisance, danger and economic loss.

A major challenge when planning for climate change is to deal with uncertainties. The pace and magnitude of climate change and the future socio-economic development of the city cannot be predicted accurately. Uncertainties should however not cause delay in decision making. To deal with uncertainties, this adaptation strategy adopts the adaptive delta management approach also applied in the City of Rotterdam. This means that the strategy:

- links short-term actions and long-term developments and includes ways to deal with uncertainties;
- is flexible and uses a stepwise approach in order to take cost effective corrective actions depending on the future speed of climate change and urban development;
- is based on an integrated approach, using sectoral synergism to increase the attractiveness of the city. It contributes to the socio-economic development ambitions of HCMC and takes into account the potentials and constraints of city development;

- connects to or incorporates ongoing developments and plans to create synergy and connect to various investment schemes;
- uses the adaptive capacity of economic sectors to incorporate adaptive developments or systems through policy measures;
- applies the technique of the adaptation pathways to analyse possible sequences of measures.

Climate Adaptation Strategy

The CAS consists of six Strategic Directions that together constitute a guide towards a climate proof future for HCMC. Implementing the strategy will make HCMC a "Unique Delta City" in which the urgency to adapt to climate change provides the opportunity to make the city a safe and attractive place to work and live. The Strategic Directions are translated into Strategic Interventions and actions that decrease vulnerability and increase resilience against climate hazards.

Direction 1: Base development direction on soil and water conditions

Directing socio-economic growth in a sustainable manner is one of the main challenges towards 2025. The soil and water system in and around the city determine the conditions for development. Developments in areas with unfavourable soil or water conditions should be avoided to prevent large investment costs or future damages. Considering elevation, soil conditions and exposure to sea-level rise, urban development in the north-western direction is more climate-proof than in south-eastern direction. Increasing population density in the inner city decreases the need for expanding urban areas in unfavourable locations. When developing harbour locations towards the sea, with higher flood risks and bad soil conditions, an adaptive approach should be used to mitigate flood risks. Examples are building elevated roads and flood proof electricity networks, as well as land filling to raise foundations of structures. Infrastructure should be developed to connect residential neighbourhoods in the north and harbours in the south.

Direction 2: Use a stepwise approach for flood protection

Floods in HCMC are caused by high tides, high river discharges, excessive rainfall and combinations of these. Considering the complexity of the hydrological system, the diversity of the city and the uncertainty of future developments, no one-size-fits-all solution for flood control exists. Flood risks will increase due to climate change, but the pace and magnitude will differ from location to location. Solutions will most likely consist of a mix of large scale infrastructural measures combined with local community based measures tailored to fit local circumstances. Therefore, a stepwise and multi-scale approach is proposed to keep the city safe from flooding. An important basis for flood protection is the development of flood protection standards. To protect the existing city, a ring dike is required as well as the protection of the riparian zone along the river. Through reservoir management the discharge from the reservoirs can be optimized to reduce floods. In new urban developments, elevated and adaptive building can be considered. Non structural measures like strengthening of emergency response capacity and mechanisms reduce the severity of impacts in case of flooding.

Direction 3: Increase the water storage and drainage capacity

An enlargement of the capacity of the water system in HCMC is needed to cope with excessive rainfall. This includes enlargement of drainage systems which also creates additional water storage areas. The current drainage standards have to be revised and made climate proof. Redevelopment of urban areas offers an opportunity to create additional storage. To achieve a significant increase in water storage, appropriate land use regulations will have to be developed and enforced.

Direction 4: Prevent salinisation where possible, adapt where necessary

Salinisation will lead to shortages of fresh water and to changes in the river ecosystems, and should therefore be curtailed where possible. Salinisation of rivers and the urban water system will be reduced when structural flood protection measures, like tidal barriers, are implemented. These measures are too costly to be implemented solely for the reduction of salinisation. Other measures that can be applied are smart dredging or flushing of the city's water system. When salinisation can no longer be prevented, drinking water intakes should be relocated upstream and resistant vegetation in flood prone areas should be used.

Direction 5: Create alternatives for groundwater use

The current level of groundwater abstraction, estimated at 600,000m3/day, is well above the sustainable level. Ground water tables are falling 2 to 3 m/yr, leading to a current subsidence rate of 5 to 80 mm/yr, resulting in increasing flood risks. Immediate action is needed to avoid uncontrolled expansion of ground water abstraction and subsidence. A program is needed for sanitation and water surface water quality improvement, combined with regulation and enforcement on groundwater abstraction. Another source to provide fresh water is the Dau Tieng reservoir.

Direction 6: Strengthen the blue-green network and 'urban ventilation'

Due to the Heat Island Effect, the temperature in the city is significantly higher than the surrounding rural area (up to 10 degrees hotter). The increase in temperature affects human health, increases air pollution and lessens the liveability of the city. Interventions to reduce heat stress are strengthening the green-blue network in the city, the implementation of green building codes and taking natural ventilation into account in city planning.

Pilot districts

The effectiveness of applying these Strategic Directions was tested in HCMC at two pilot locations on a district scale involving stakeholders. In group workshop settings and using an interactive process of sketching and drawing, possible climate change adaptation designs have been tested to determine their applicability at the local scale. A further output of the pilot test is to explore opportunities in urban re-development for applying the Strategic Directions to make the city climate proof and at the same time more attractive.

Two pilot locations have been selected that are instrumental in the relocation of harbour locations towards the sea. The two locations are district 4 and Nha Be district. District 4 represents a dense inner-city area that will be undergoing redevelopment. The space that becomes available upon removal of the port facilities offers opportunities for climate adaptation measures contributing to urban improvement and attractiveness at city scale level. Nha Be is a location where new harbours, industries and residential neighbourhoods are being developed in a low lying area. Most of this location will be outside possible ring dikes and therefore will require adaptive solutions for development of infrastructure and housing.

From the pilot studies, it can be concluded that many climate adaptation measures will most likely have a positive cost-benefit ratio. Many adaptation measures can be included in autonomous urban developments. Examples are creation of water storage in urban reconstruction, or making embankments at harbour locations that will be restructured. The positive cost-benefit ratio is partly due to these combinations or synergisms, but foremost because implementation of the CAS solves major problems for many years to come. And above all that, the CAS creates many opportunities to develop the vibrant metropolis HCMC into a Unique Delta City.

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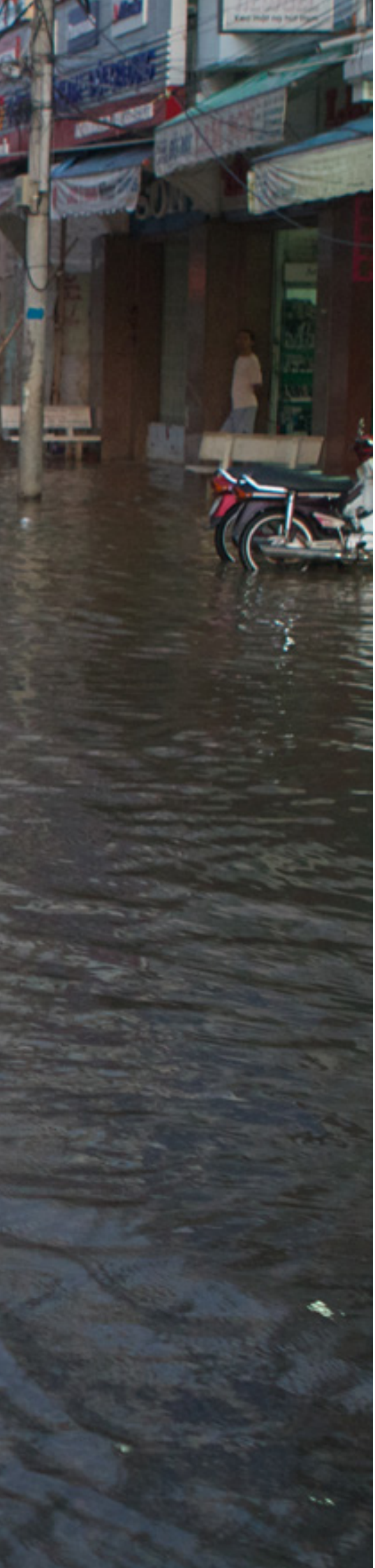


1 A CLIMATE ADAPTATION STRATEGY FOR HO CHI MINH CITY

1.1 Introduction to Ho Chi Minh City

Ho Chi Minh City (HCMC) is a vibrant metropolis. The fast growing economy, increasing population and the existence of numerous social and cultural institutions characterize a city that has been expanding rapidly over the last decades. Most industry and harbours in southern Vietnam are located in HCMC or surrounding provinces. The city serves as an international trade hub with its seaports lying at an intersection of Strategic International maritime routes.

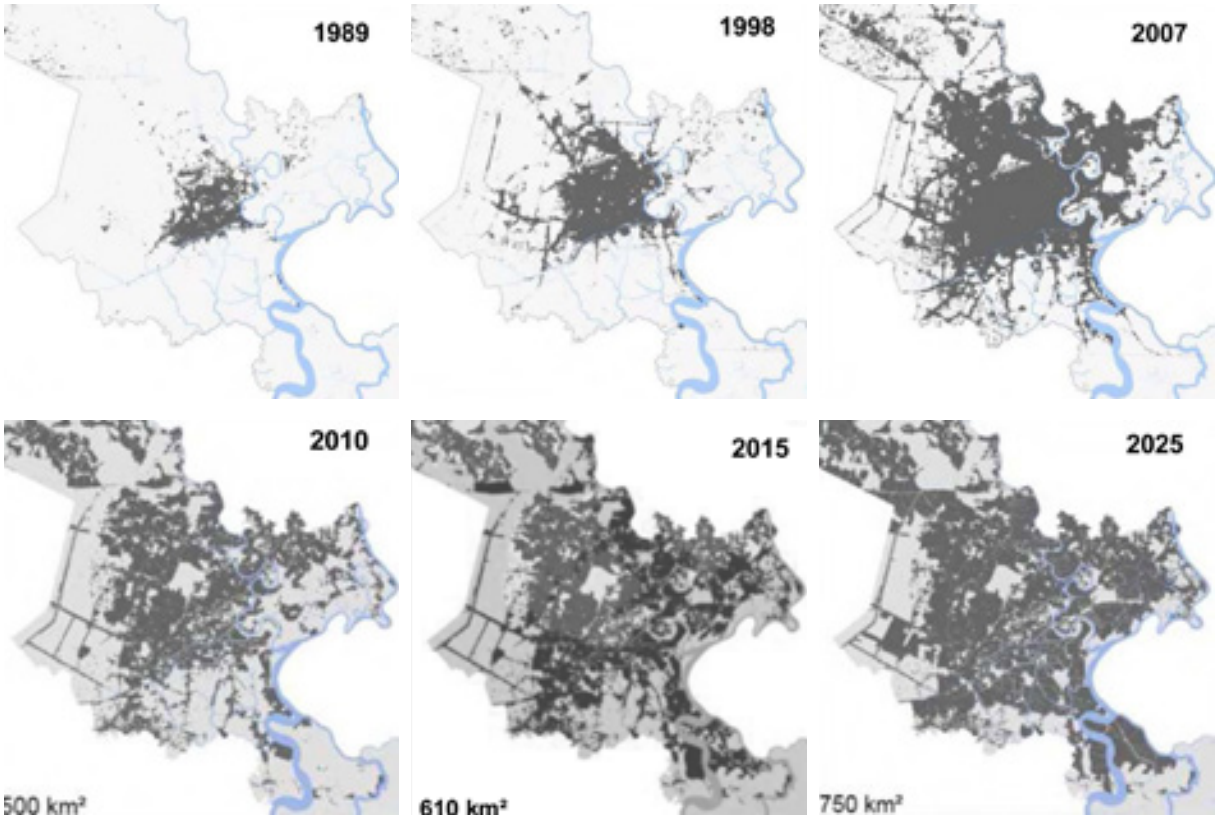
The city with its characteristic historic districts is continuously being changed by modern development and technological advancements. In the business centre high rise office and condominium buildings are increasingly common. Available space is getting scarcer and therefore the urban density is increasing. Infrastructure for energy, water and transportation provide the essential services on which the life of the city depends. These service networks are expanding and being refurbished to keep the city moving. In many places, the infrastructure network is a catalyst, driving urban development in an unplanned manner along roads, rivers and vulnerable low lying areas.

With increasing population densities, these networks are also under stress to provide adequate services. Urban development has resulted in a decrease in green space and encroachment on natural water systems. Consequently, there are frequent inundations caused by rainfall and high river flows. More cars, trucks and motorcycles lead to traffic jams and increased air pollution.

Besides these fast economy-driven developments, two slower and more subtle processes are becoming increasingly important for the city's future. Although the exact magnitude of change is unsure, the fact that the climate is changing is undeniable. Sea levels are rising, rain patterns are becoming more extreme and average temperatures are increasing. In addition, in certain parts of the city land subsidence is steadily occurring making these areas more vulnerable to flooding. Currently large parts of the city are built barely above sea level: 60% of the land is less than 2 metres above sea level. Low land elevations, combined with the increasing

urban density and loss of blue and green spaces, make the city extremely vulnerable to water logging and floods. Especially since the mid 1990's the magnitude, frequencies and duration of floods are steadily increasing.

The fast development of the city combined with the slower processes of climate change and subsidence will have a large impact on the economy of HCMC and the quality of life of its inhabitants: that is, if no immediate action is taken. Decisions taken in the coming decade on where and how the city expands and will be protected will determine the future of HCMC for a long time to come. It is therefore of key importance that plans, policies and projects in the city take into consideration climate change and subsidence. In addition, changing the approach of projects, developing specific knowledge and increasing the level of education and public awareness regarding climate change education will be necessary to shape climate proof future. To guide these developments there is a need for a Climate Adaptation Strategy and Action Plan.



Source: Presentation Spatial Planning as an Adaptation Strategy to Climate Change in Ho Chi Minh City, October 2010; atlas HCMC Towards the sea

1.2 Two Delta Cities

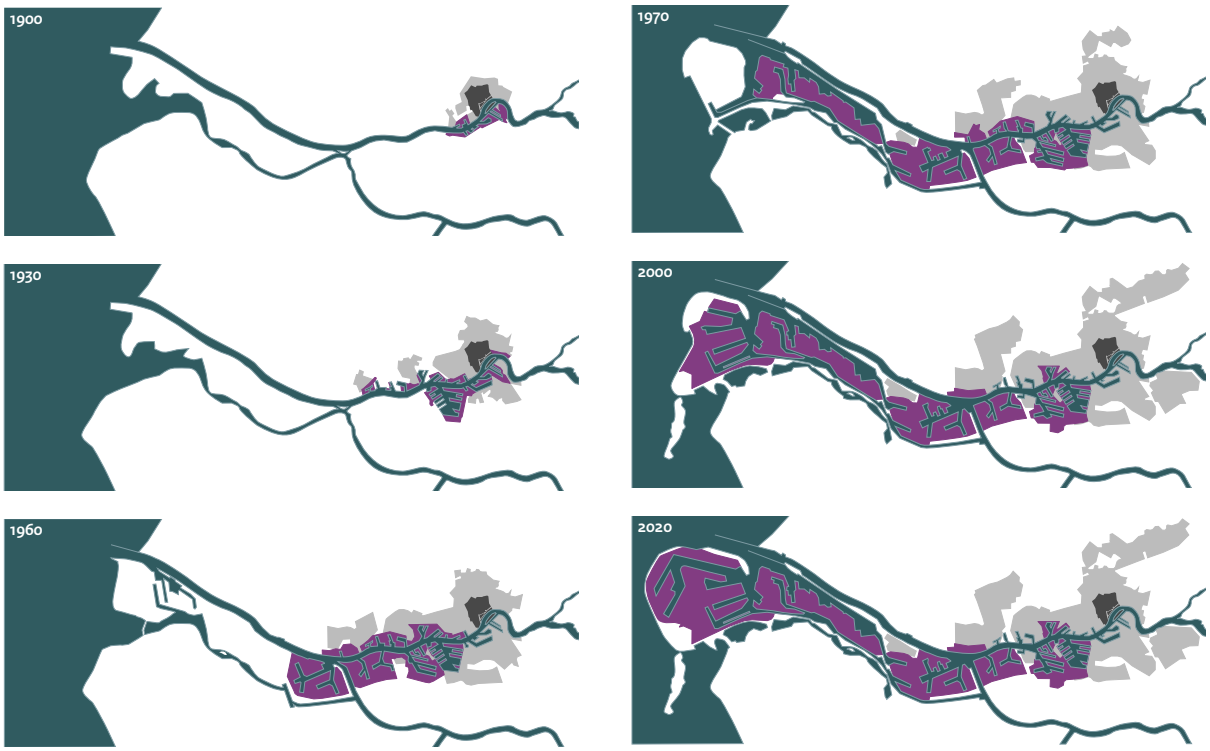
HCMC has much in common with the city of Rotterdam in the Netherlands as both cities are located in the deltas of large river systems. HCMC is located in the delta formed by the Saigon and Dong Nai rivers bordering the northern part of the Mekong Delta, and Rotterdam is situated at the mouth of the Rhine and Meuse rivers. Having large ports, both cities form the gateway to a large hinterland and contribute considerably to the national GDP. The cities and their respective harbours are main economic generators. An increase in global marine transport has resulted in a demand for deeper harbours in both cities. Subsequently, both harbours have had to be relocated more towards the sea. As a consequence, both cities are developing new harbours and are re-developing the inner cities areas formerly occupied by these harbours.

In addition both HCMC and the City of Rotterdam have acknowledged the challenges that the changing climate poses. To keep their cities economically prosperous, safe and a pleasant environment to work and live, both cities have to make strategic choices regarding long term development.

Although there are similarities, large differences between the cities exist. Rotterdam has over 600,000 inhabitants, while HCMC has a population of almost 7,5 million and is rapidly growing. Climatic conditions also differ greatly with an average rainfall of between 700 and 800 mm per year in Rotterdam, while HCMC averages more than twice this amount. Both cities have dealt differently with regards to their respective positions in their deltas and have historically made different choices regarding strategies to keep their cities safe. Rotterdam, as many cities in the Netherlands, has focussed investments on flood defence and is well protected against flooding through the construction of the Maeslant barrier. The water system in HCMC is more open and unrestrained; and the city is regularly flooded due to heavy rains, large river flows and high tides. In HCMC people are therefore used to adapting to and living with water, while in Rotterdam inhabitants rely on a structural system of dikes and levees and are not accustomed to even minor nuisance due to rainfall or high tides.

Being both low lying delta cities and facing similar challenges, cooperation between the cities creates advantages for both. Rotterdam is now implementing adaptation measures that are more commonly used in HCMC; and HCMC is looking at engineering structures to increase flood defence. Rotterdam can contribute to the cooperation with its extensive experience in developing and moving port activities towards the sea as port activities in HCMC will also be moved out of the city centre closer to the sea. To meet these challenges Rotterdam is implementing an approach in which the interrelated fields of water management, spatial planning, climate change adaptation and socio-economic development are connected. Therefore, the experiences from Rotterdam will be highly relevant and valuable to HCMC.

Redevelop old harbor areas into attractive residential and business areas



Rotterdam: Outplacement of harbours towards the sea

1.3 Connecting Delta Cities

Vietnam is a partner within the Netherlands Global Water Programme, and in 2010 the Prime Ministers of Vietnam and The Netherlands signed a Strategic Partnership Arrangement (SPA). Cooperation between Rotterdam and HCMC has taken shape through the Connecting Delta Cities network and focuses on the strategic choices regarding the long term development of the respective cities. Within the context of the Connecting Delta Cities network, a Letter of Intent (LOI) was signed on May 27th 2009 regarding cooperation on Climate Change Adaptation. Thereafter, a Memorandum of Understanding (MoU) was signed on 30 March 2011 to cooperate on this project entitled "HCMC moving towards the Sea with Climate Change Adaptation".

1.4 Project organisation

The implementing agency for the project on behalf of HCMC is the Department of Natural Resources and Environment (DoNRE). The executing agency on behalf of the Kingdom of the Netherlands is Agency NL under the Partners for Water (PfW) program. The VCAPS consortium was contracted by Agency NL for consultancy services with regards to the project. The VCAPS-consortium is formed by the organisations Grontmij (lead company), Witteveen+Bos, Bosch Slabbers, Institute for Environmental Studies (IVM), Ecorys and Triple A.

The government organisations contributing to the project through cooperation in four working groups are DoNRE, the Department of Agriculture and Rural Development (DARD), the Department of Construction (DoC), the Department of Transportation (DoT), the Department of Planning and Architecture (DPA) and the Steering Centre for Flood Control (SCFC). At various moments in the project, a wider range of stakeholders and experts has been consulted, like port authorities, knowledge institutes and consultancy companies that work in HCMC.

1.5 Scope of the Climate Adaptation Strategy

Because of the diversity of effects and impacts of climate change, HCMC will need to develop a sustainable, integral, long term approach to climate change to make sure the city is up to the challenges it will face in the future, while also addressing the challenges of today. The overall objective of the project is therefore:

To enable and guide the long-term sustainable socio-economic development of HCMC towards the sea, taking into account the effects of climate change.

To achieve this project objective, the project focuses on a process that leads to three main planning tools:

- an Atlas including all readily available relevant facts, trends and underlying factors for climate proof city planning. The Atlas forms the joint common reference for rational spatial planning;
- an Adaptation Strategy (CAS) describing the Strategic Direction that integrates technical interventions and additional measures for a climate proof HCMC;
- an Action Plan detailing the mechanisms of implementation of the strategy for the short, medium and long term, based on institutional commitment, multi stakeholder participation, secured investment and detailed implementation scheduling.

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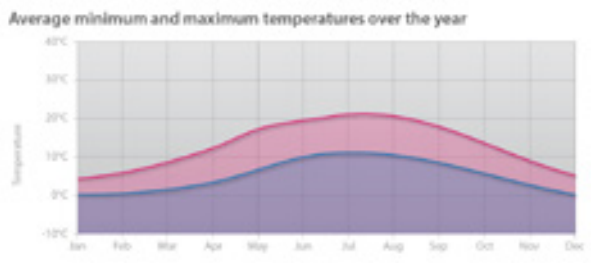
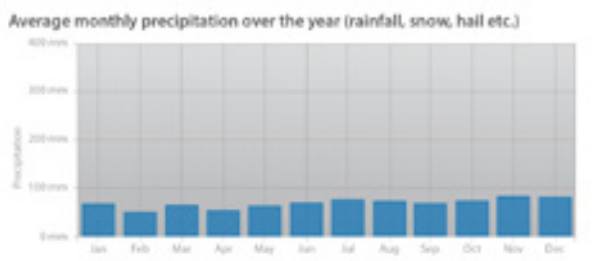
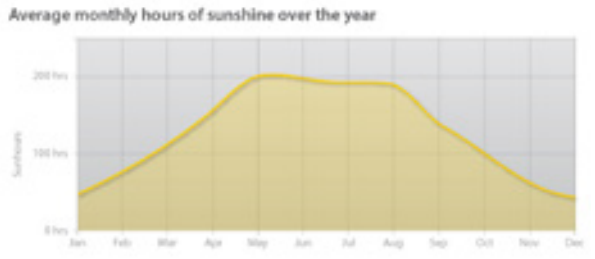
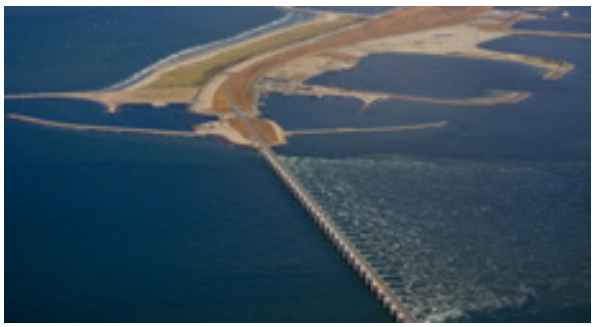


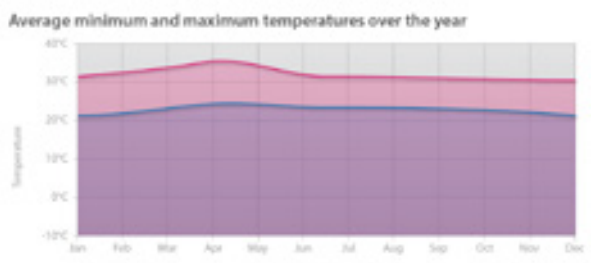


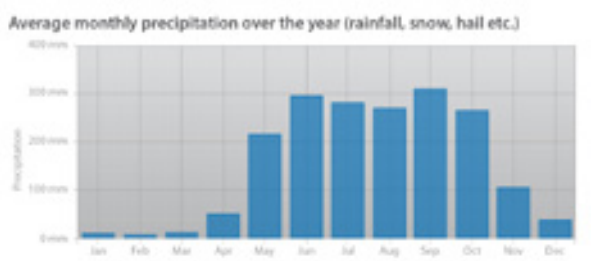


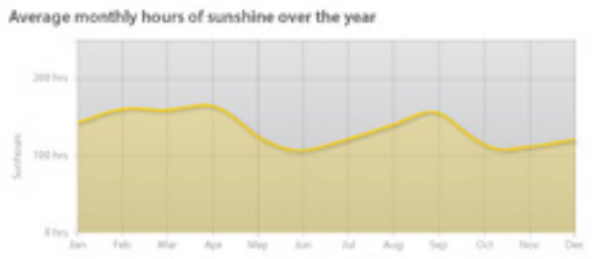


Advanced defense system versus...

HO CHI MINH CITY







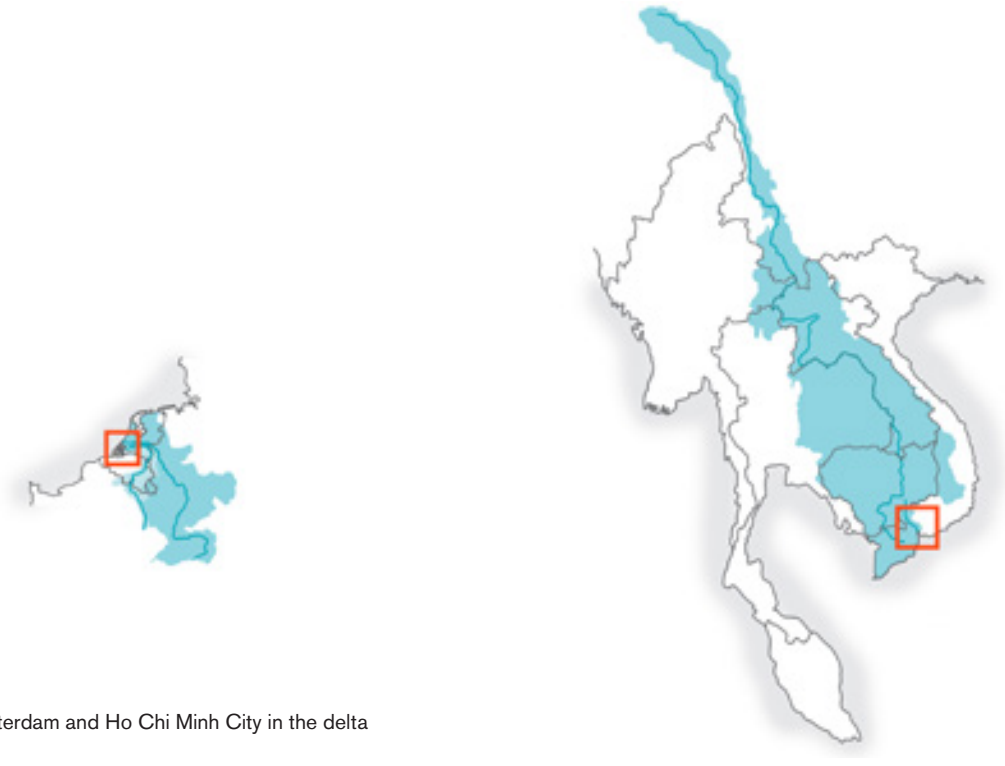
Defense system yet to be developed

This report contains the Climate Adaptation Strategy that has been prepared through close cooperation between Vietnamese working groups and Dutch experts. The Atlas and Action Plan are reported separately.

This Adaptation Strategy does not describe specific long term development profiles for HCMC. Exact future development realities are difficult to forecast as the future depends on all kinds of factors. Political policies can shift, the exact rate of climate change is uncertain and the development of global economy and demographic changes are hard to predict. The Climate Adaptation Strategy therefore explores a future range of development scenarios based on up-to-date knowledge. Robust adaptation strategies are developed using adaptive delta management (see chapter 5). The result is based on a consensus of opinions from Vietnamese stakeholders, capable to deal with uncertainties and utilizing the opportunities in spatial development that will occur.

1.6 Reading guide

In chapter two of this CAS, the ambition for the development of HCMC is outlined. This is the general development goal to which the CAS contributes. In chapter three the characteristics of the current city and the current sector development and master plans are described together with the development potentials and constraints that these characteristics encompass. In chapter four the impacts are described that the changing climate will and can have on HCMC. Dealing with these challenges is the main objective of the strategy. But climate change is not the only variable to which the city has to adapt and that has to be taken into account in the strategy. Chapter five explores the bandwidth of socio-economic development and presents the approach used to deal with uncertainty in this strategy. The strategy itself is presented in chapter six and consists of a set of Strategic Directions and Strategic Interventions. The strategy was tested in two pilot areas: District 4 (urban district) and Nha Be (rural district). The strategy is used to prepare possible urban develop designs for these districts, and these are described in chapter seven.



Location of Rotterdam and Ho Chi Minh City in the delta

2

AMBITION OF HCMC 2025-2100

2.1 Global circumstances

In the last 25 years, the economic structure of Vietnam has changed considerably by being transformed from an agro-based economy to a more modern economy dominated by a large industrial and construction sector, retail growth, export earnings, the services sector and tourism. This economic restructuring has led to continuous economic growth, with growth rates exceeding 10% in HCMC almost every year for over a decade. Economic growth in this period was heavily driven by increasing investment capital and high exploitation of natural resources but tempered by a low skilled labour force.

In the meantime, global competition is increasing and the world is changing quickly due to several major trends. The first trend is the rapid development of science and technology. Formation of knowledge based and clean technologies are major drivers of the restructuring global economy. Secondly, globalisation and economic connectivity become more and more important. Therefore, Vietnam including HCMC need to strengthen their position with respect to global commerce. Thirdly, the balance in the world economy is shifting as evidenced by the robust development in India and China. Offering further integration, the Association of Asian Nations (ASEAN) enables individual member countries to profit from their respective geo-strategic positions and roles in the region. HCMC, with its harbours and access to international marine trade routes, has the potential to develop as a strategic link in the international commerce chain.

2.2 A sustainable city

Ambitions for the socio-economic development are documented in the HCMC master plan of socio-economic development planning till 2020 and the draft Spatial master plan 2025. The general ambition that can be derived from these master plans is:

> To develop HCMC into a modern industrial city in 2025 in which fast economic development is connected with sustainable development so that social progress and fairness are realised whilst protecting the environment.

HCMC is the key economic driver and therefore has a leading role in modernising the economy of Vietnam. The challenge facing HCMC in the coming decade is to sustainably develop the growing city in relation to increased competitiveness in the regional and global market. In the draft Spatial master plan 2025 and Socio-economic strategy 2011 – 2020, key ambitions are that HCMC becomes the centre of industry and multi-disciplinary services of the region and South-East Asia, and the central hub of international transportation. Also, the plans focus on modernizing the city and enhancing the city's liveability while maintaining its unique character.

The city is already the scientific and technological centre of Vietnam. Future emphasis will be on developing high technology industries related to mechanics, ICT, pharmaceuticals, chemical industry and food processing. To support these industries, education will need to be improved to lead to a skilled labour force equipped to perform and create higher added value. As a consequence of the focus on education, overall wealth will increase in an equitable manner. The ambition is also to provide the growing population of HCMC with adequate housing.

The scope of the socio-economic ambition is broader than providing housing and jobs. The city will also offer its citizens a safe, healthy and pleasant environment in which to live and work. Safe meaning, amongst others, that the city is safe from catastrophic floods now and in the future. Healthy meaning that the levels of air, water and soil pollution are controlled and lowered to internationally accepted norms for human health. Becoming a healthier, pleasant and safe city also has an economic pay-off: the city becomes more attractive, not only for tourists but also for international service oriented companies that want to provide their highly skilled employees with a pleasant living environment.

A key goal is to significantly improve the water quality in the rivers, canals and natural drainage systems in the city. Cleaner waters will help to reinvigorate the development of the cities many waterways and waterfronts. It is the ambition that the waterfronts along the Saigon and Dong Nai rivers will become the hotspots for urban development. Old inner city harbour areas have the potential to become new, high quality residential areas overlooking the river. A pleasant living environment also means that the nuisance of water in the streets due to heavy rainfall is reduced to an acceptable level. The quality of public space makes for a stimulating environment with ample opportunities for recreation and the development of tourist potential.

The ambition is that the economy of the city in the course of the 21th century focuses more and more on a highly skilled labour force as the primary source of value added production. Services and technology are becoming a more dominant part of the economy. HCMC wants to strongly develop high-value-added services as tourism, transport, logistics and seaport services in order to take advantage of the country's strategic position in global commerce. To become the central hub of international transportation in the region, Prime Minister Dung has mentioned the development of a comprehensive infrastructural system as a precondition. Because of its geo-strategic position, current economic sectors, the relatively young and intelligent labour population, HCMC has the potential to further develop itself and become an attractive city for foreign investors.

3 CHARACTERIZATION OF HCMC

3.1 Characteristics of the city

HCMC is the largest and most populous city in Vietnam. The city is located in the delta area formed by the Dong Nai and Saigon Rivers that originate in the Lang Bian Plateau in the central highlands and in Cambodia, respectively. The city centre lies about 60 kilometres from the East Sea. Between the city and sea lies the rich Can Giao mangrove forest, a UNESCO world heritage site, and an agricultural area.

Because of its location, the city for centuries has functioned as an important commercial seaport. The city always had a strong connection to the delta, the Saigon River and the many canals linking the city with the Mekong Delta. Nowadays the water system is still an important feature of the city, although not always visible, respected or utilized to full potential.

The history of HCMC (formerly Saigon) extends back several centuries. Under French colonial rule (1859-1954) the city rapidly expanded and took advantage of its position in the delta. The city was turned into a metropolitan centre with a major port and a regional railway system. District 1 of HCMC still resembles this period with its grand shady boulevards and colonial architecture.

The city is located at the crossroads of international maritime routes. The city therefore provides an important maritime function, supporting manufacturing industries that to a large extent are export oriented. In 2011 HCMC was ranked as 29th container port of the world[1]. In 2010 about 45% of the GDP of HCMC was produced in industry and construction, and just over half of the GDP in the services sector[2]. Although much of the growth in production has been in light industrial manufacturing (textiles, wood processing, foodstuffs and beverages), in recent years, heavy industries such as chemical, plastics and steel production have increased in importance.

The industry sector has gone through a large period of growth, especially since the economic reforms of 1986 established the socialist oriented market economy and attracted foreign and domestic investors. In 2010 about 75% of the city's GDP[3] was produced by private companies and through foreign investments.

Due to migration and natural growth, the population of HCMC has steadily grown from over 2 million in the 1960's, 3.3 million in the 1970's to 5.5 million at the beginning of the 21st century. Since then the population has increased by over 200,000 a year up to 7.5 million in 2012. There is an increasing need for proper housing for this growing population. Apartment buildings and multi-storied row houses make up most of the housing in the city. Currently, part of the population is living in slums or temporary housing, especially along certain water ways and regularly flooded low lying areas. The density of the inner-city districts is increasing rapidly.

HCMC is the centre of the south of Vietnam and therefore is well linked to surrounding provinces by road and rail. Traffic in the city itself is dominated by motorcycles which currently represent 96% of all vehicles in the urban core and 89% in the suburban areas. A general increase in traffic and especially an increase in the amount of cars and container trucks are causing more and more congestion and air pollution.

An Atlas was developed in this project containing all readily available information from involved stakeholders and other sources. The Atlas provides a common perspective on the challenge of climate change for HCMC, as a starting point for further analysis. The Atlas categorizes information in four profiles:

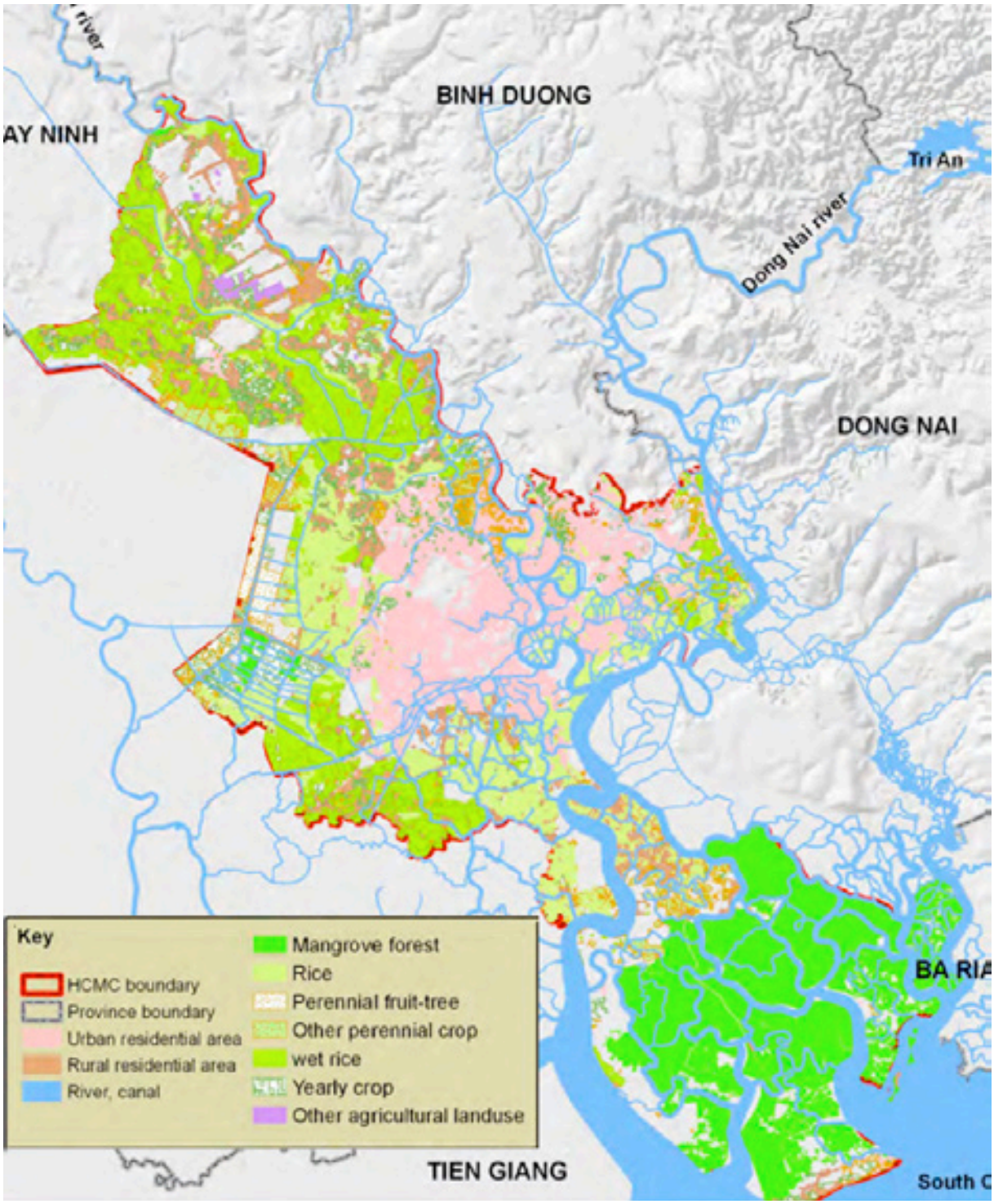
- Spatial profile
- Socio-economic profile
- Infrastructural profile
- Institutional profile

The characteristics of the city described in 3.1 are based on the findings that are collected in the Atlas. Maps and summaries from the sector development plans and draft Spatial master plan 2025 are included in the Atlas. The Atlas was the starting point for the SWOT analysis that resulted in the overview of potentials and constraints presented in 3.3.

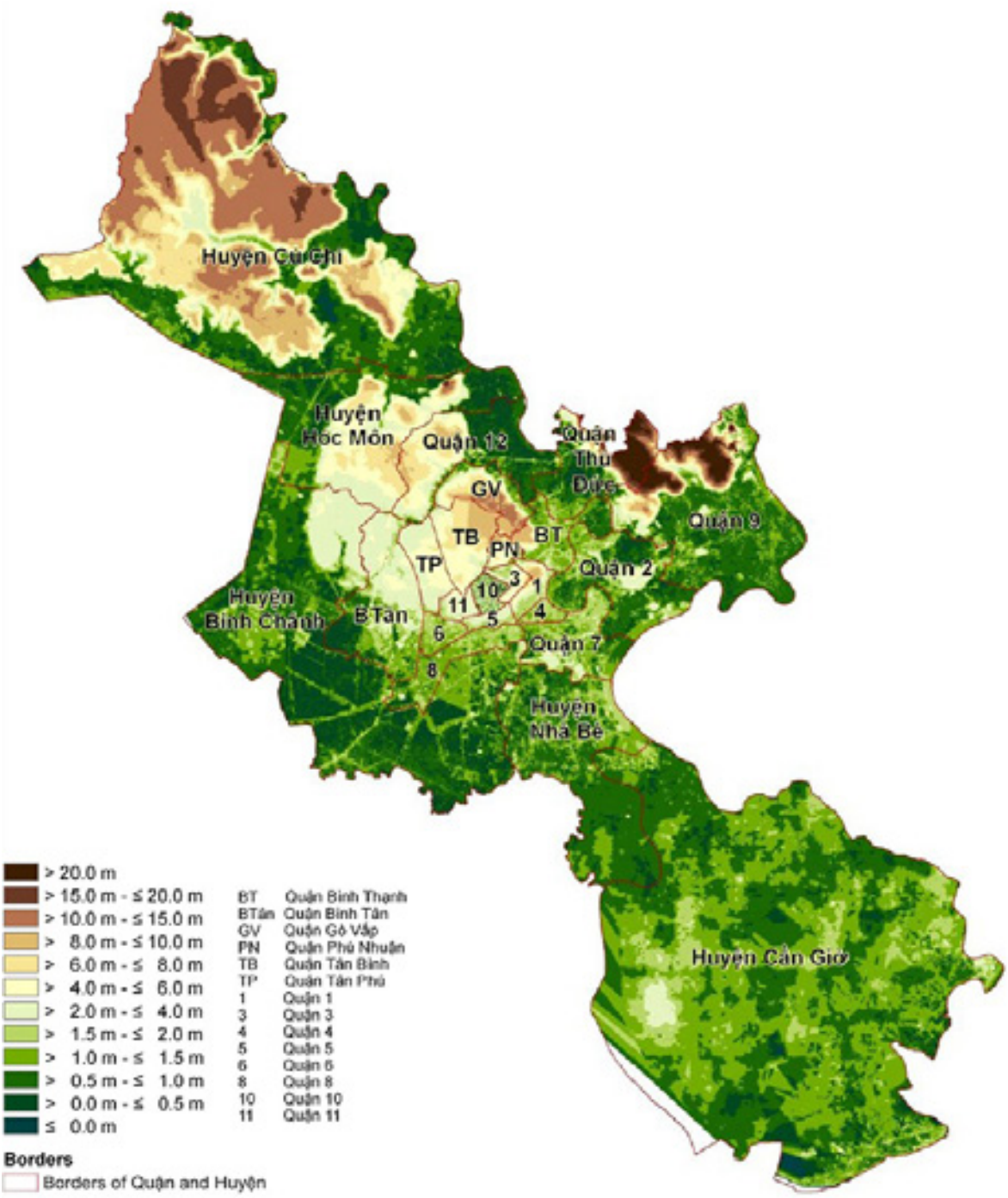
[1] www.worldshipping.org

[2] Statistical Office HCMC, 2010

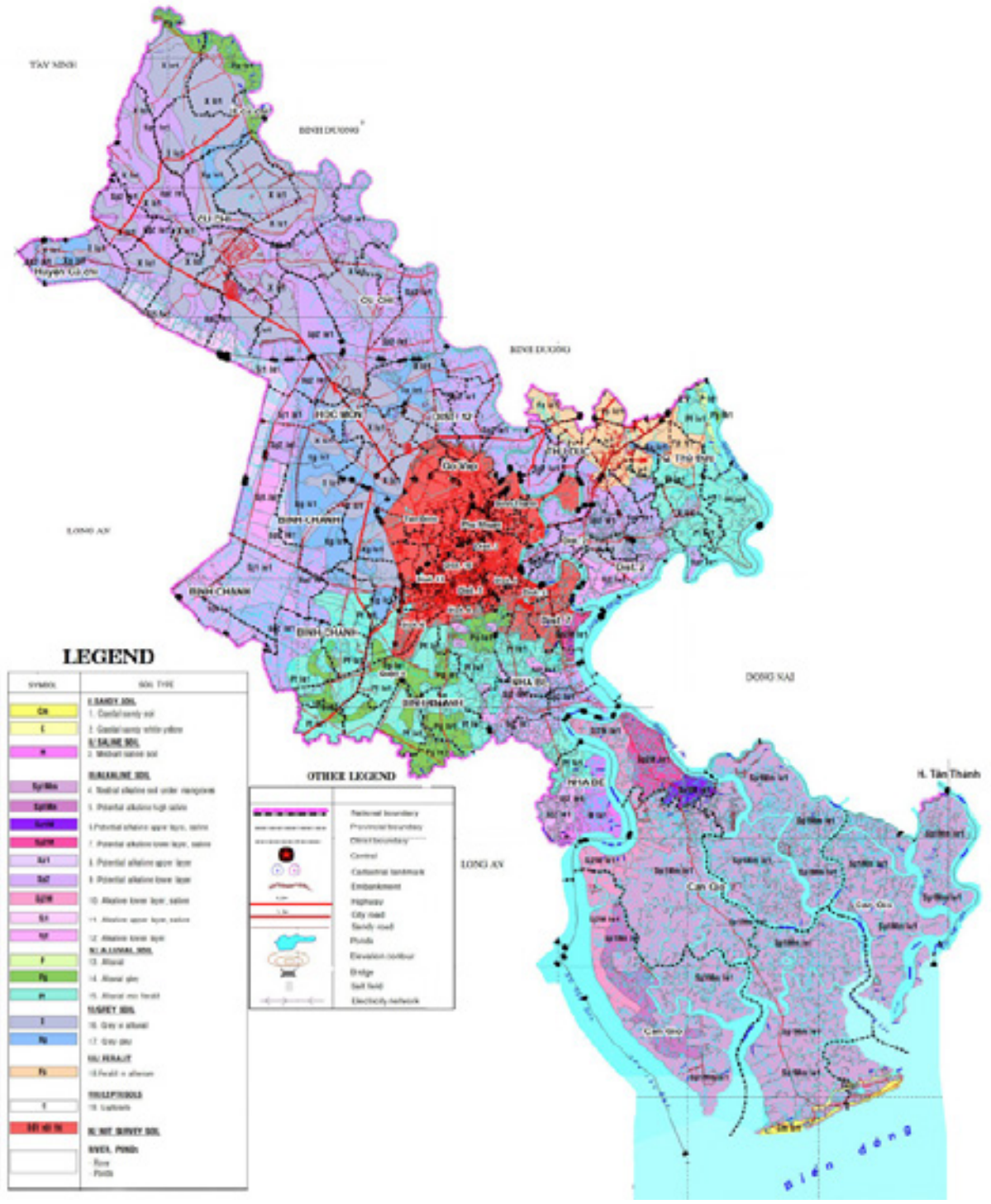
[3] Statistical Office HCMC, 2010



Land use map of Ho Chi Minh City in 2005. Source: HCMC Adaptation in Climate Change Study Report



Elevation map of Ho Chi Minh City



Soil map of Ho Chi Minh City. Source: Sub institute on agricultural planning

3.2 Draft Spatial master plan 2025

To guide the city's growth in the decades to come, the draft Spatial master plan 2025 was developed. This master plan envisions HCMC as a world class industrial, services oriented, scientific and technical node in the South-East Asia region, with a forecast population of 10 million and around 2.5 million visitors and temporary residents. The master plan aims to guide the city to harmoniously build new development areas, renovate existing urban areas, modernise the infrastructure system and the social infrastructure and protect the environment.

The goal is to modernize the city whilst preserving its unique character and enhancing the potential benefits of the water system whilst creating an appealing city, and enhancing the city's liveability. The master plan focuses on sustainable development, which has been defined by Vietnam as follows: "development that satisfies current needs without compromising those of future generations, ensuring the harmonious development of three aspects: economic, social, and environmental".

Urban development

The draft Spatial master plan 2025 aims to develop the city according to a multicentre model. The Central Business District will consist of the current inner city area, district 1, and the modern financial and commercial Thu Thiem district located on the opposite side of Saigon River. The administrative centre is located in districts 1, 3 and parts of district 4. City development focuses on two major and two minor development directions. The major directions are oriented east and south towards the sea and the minor directions towards the northeast and southwest. In each of these directions a new urban centre is developed and each centre has its specialized function, like training centres, scientific research, health centres, culture and sports.

In existing urban areas focus will be on rehabilitation, reorganization or conservation depending on its characteristics. New urban areas will mainly be developed as large scale developments balancing social and urban infrastructure.

Industry and ports

In the coming decade, polluting factories will be relocated out of the inner city and attention will be paid to attracting clean (knowledge-based) industry in the new industrial zones. New industrial zones are concentrated in Cu Chi and Hoc Mon in the northwest and Binh Chanh in the west and Nha Be in the southeast. In district 9, east of the city centre, a hi-tech zone is under development.

The current port systems along the Saigon River will not be developed further. Several ports will be relocated downstream from the city centre to the Cat Lai and Hiep Phuoc ports. These ports mainly focus on regional export and import while the Vung Tau port, located in the neighbouring Ba Ria–Vung Tau province, is a deep sea harbour equipped for international transport.

Infrastructure

The draft Spatial master plan 2025 foresees large investments in infrastructure to sustain the development of the city. A system of centripetal highways and ring-roads should prevent congestion. The existing ring road one will be upgraded and ring road two will be completed. In addition the construction of ring roads three and four is foreseen. Ring road three surrounds the main new urban developments, and ring road four connects the satellite cities.

To ease traffic congestion and make the city more accessible, a public transportation system is envisaged. This system will consist of six metro lines that to a large extent will be built on viaducts. In addition, existing railroads will be renovated and a light rail system will connect the city with the new international airport in Long Than, about 40 kilometres east of the city. A new railway is envisaged to connect Vung Tau, HCMC and Cambodia.

Green/blue

In the master plan, parks and 200 hectares of existing green zones in the inner city are to be preserved and protected. In addition the plan is to develop 250

hectares additional green zones using the vacated land from relocated factories. The zones along the rivers (Saigon River, Dong Nai River and Nha Be River) will be developed into green-blue waterfront zones for tourism and entertainment purposes. In the corridors adjacent to the rivers, restrictions on constructions will be put in place to protect the river systems.

Urban development in preservation and ecological protection areas will be prohibited. Preservation areas include the Can Gio mangrove forest and the special-use forest in Binh Chanh and Cu Chi province and also for nature conservation reserves located along the Saigon and Dong Nai rivers. A new boat station in the Can Giao mangrove forest will serve tourism operating from Vung Tau and HCMC.

3.3 Urban Development Potentials and Constraints

Potential

The greatest potential of HCMC is the people of the city. The dynamic and creative nature of the inhabitants provides the basis for the modern services and high tech oriented economy that is envisaged. To develop this potential, attention is required to education and training and a focus on improving working and living conditions to attract young and highly educated people. Being able to accommodate a young and skilled labour force is an important factor in attracting foreign investment.

The pace of economic development in the city has been very high over the last decade, fuelled by both international and domestic investment. The city is the economic engine driving the economic development and modernization of the whole region, and it is expected that this trend will continue into the future.

With its strategic location, HCMC has the potential to strengthen its role as a logistical hub on a local, national and worldwide scale. International trading and business competition however is fierce and development of logistical facilities and investment in infrastructure, multimodal facilities and waterways is necessary to further develop a competitive edge. A related threat to this development is sedimentation; harbour locations need to be carefully chosen in relation to sedimentation to avoid high dredging costs. Further, upstream land use practices need to be closely regulated and monitored to reduce soil erosion and subsequent downstream sedimentation.

The city's river banks have a potential to contribute to the attractiveness of the city. In many metropolitan cities river fronts are the most attractive public spaces offering recreational areas to stroll and enjoy river views. River panoramas also often include bridges which can serve as icons for the city. At some locations in HCMC today, river fronts already offer great views over the Saigon and Nha Be rivers but this potential largely remains undeveloped. The river system currently contributes very little to a positive image of the city. Public access to the river is often blocked due to private property and motorways, and in some areas slums and unofficial housing make waterfronts unattractive places to spend time. To transform high quality river front areas into accessible public spaces will require appropriate city planning and support from key stakeholders and local communities.

The subsoil stratum of the delta was formed by deposition from a complex, hierarchical network of streams and rivers. In the process of urbanization, many of the streams were filled up resulting in a dramatic alteration of the natural hydrological system. Only small sections of the original water system still exist. The original water system could be restored to a more natural spatial orientation. Bringing back the original water system will create natural water storage areas and will strengthen the hydraulic connectivity of the city with its delta environment thus improving water quality. The soil in the north-west part of the city is structurally stable and has a higher load carrying capacity. This area therefore has a high potential for city expansion and development in contrast with the subsoil in the south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east of the city which is weak and moisture laden, resulting in difficult conditions on which to build due to subsidence in this area.

Constraints

Because of increasing migration towards the city and general population growth, demand for housing and urban services is high. The rapid increase in demand for housing puts pressure on the urban planning system making it more challenging to provide appropriate living conditions to all. If urban planning and provision of urban services is not undertaken in a coordinated manner, then the result will be uncontrolled development and the creation of slums.

Large neighbourhoods are restructured over short periods of time and as a result the density of the city is increasing. Prices have gone up considerably and this puts pressure on keeping available space for water and parks. On the other side, the fact that the city is changing also offers opportunities to incorporate climate adaptation measures. Inside districts the available space for water storage is limited. Also the traditional structure of neighbourhoods is changing; small scale neighbourhoods and shop houses are replaced by large scale apartment buildings. This creates living space but eliminates an important original quality of the city, namely the street life. Tourists as well as local citizens appreciate the small scale businesses, markets and restaurants found everywhere in the city. This type of commerce makes the city a lively place and creates a unique atmosphere that might be lost through modernisation and increase in mega businesses.

At present, traffic in the city is dominated by motorbikes, and many roads are already heavily congested at peak hours. As the purchasing power of the population grows, more cars will appear on the road, resulting in even heavier traffic and congestion. Road congestion negatively impacts the sustainable development of the city due to economic loss and high concentrations of air pollution. Developing towards a sustainable megacity therefore requires emphasis on public transport.

The current socio-economic development in the industrial sector is not sustainable. Air and water quality in the city often do not comply with national standards since many industries do not utilized required pollution control technologies. Environmental protection enforcement and monitoring efforts currently are insufficient to remediate the situation. This results in wasteful use of natural resources and damage to the environment. One example is the demand for high quality process and drinking water. Because current surface water quality is poor, groundwater is being increasingly exploited as process and drinking water. Due to excessive extraction, groundwater levels fell 2-3 meters a year between 2001 and 2006[4]. Falling groundwater levels in turn lead to subsidence, with a rate up to 4 or 5 mm/year[5], which increases flood risk.

The current sanitation system also constrains future development. Separate sewerage collection and treatment systems are lacking in many places, leading to direct discharge of untreated wastewater to surface waters. This has a considerable negative impact on the environment and public health.

Large parts of HCMC are currently affected by flooding causing a barrier for further city development as floods result in nuisance, danger and economic loss. Floods occur due to high tides, high river discharges and intense rain storms, with compounding impacts when happening at the same time. Most of the drainage systems in the existing city are old, and drainage capacity decreased over time due to poor maintenance and blockage caused by improperly disposed solid waste. The dredge spoils and waste that accumulates in the canal systems further decrease drainage capacity.

[4] Atlas, chapter 1.2.3

[5] Ho Tong Minh Dinh et al., 2008

CLIMATE CHANGE 4

4.1 Climate change scenarios

Climate change will adversely affect HCMC in the coming decades. As the pace of climate change and the exact impact of these changes are uncertain, several projections can be used which together should cover all probable climatic futures. In this study the climate change projections of the Ministry of Natural Resources and Environment (MoNRE) are used (MoNRE, 2009). The table on page 46 shows the current climate and sea level parameter, and forecasts for these climate change parameters for 2050 and 2100. The table shows slight variations in values for 2050, and wider variations or bandwidth in 2100. These forecasts are relative to the average values for the period 1980-1999 and are calculated for the South of Vietnam where HCMC is located.

Precipitation is projected to decrease during the dry season and to increase during the wet season. Temperatures are projected to rise by 1 degree towards 2050 and up to 2.6 degrees by 2100. The sea level is projected to rise 30 cm by 2050 and to continue to rise reaching 65 to 100 cm in 2100, compared to the average sea level between 1980 and 1999.

Climate change projections for HCMC (MoNRE, 2009)

	Current	2050	2100
SRES scenarios[6]	n.a.	B1, B2, A2	B1, B2, A2
SLR (cm)	+1,3 to 1,58 at Phu An[(a)]	28 to 33	65 to 100
Temperature °C	26 to 27[(b)]	1	1,4 to 2,6
Precipitation (mm)			
Dec-Feb	84[(c)]	-7,4 to -8,1%	-10,1 to -19,6%
Mar-May	256[(c)]	-7,2 to -7,5%	-9,4 to -18,2%
June-Aug	911[(c)]	+0,8 to 0,9%	+1,1 to 2,1%
Sept- Nov	717[(c)]	+6,3 to 6,8%	+8,5 to 16,5%

(a) = FIM report, (b) = Atlas, (c) = /www.vietnamembassy.org.uk/climate.html

[6] These climate change scenarios give a bandwidth of climate change dependent on possible variations in various driving forces, including population growth and socio-economic development.

4.2 Climate change impacts

Climate change will have a major impact on the living conditions in HCMC. The main predicted effects of climate change on HCMC are described as follows:

Rise in temperature, leading to higher temperatures in the city and deterioration of air and water quality.
A rising temperature will increase the number of extreme hot days. Especially in the densest parts of the city, the rise in temperature will further exacerbate the urban heat island effect. This is the effect that causes cities to be warmer than their surroundings, which can be up to an 8 °C increase[7]. During warm months, living conditions will become worse, as the streets and the buildings will become more under heat stress. Higher temperatures will lead to deterioration of air quality (smog) and surface water quality, which is already poor and not in compliance with standards. These negative environmental conditions lead to reduced human productivity and an increase in illness.

Sea level rise, leading to increased flood risks and salt intrusion.
Low lying parts of HCMC are currently already flooded during high tides in October and November. In the future, flooding due to sea level rise will extend further to places that currently are typically dry. The flooding depth is projected to increase up to circa 30 cm in 2050, and aggravated by the local effect of land subsidence. Peoples' livelihoods are hampered if flooding depth is above 20 cm, which is the limit for motorcycles to pass. This depth is likely to be exceeded regularly at many places in the future. In the longer run, even personal safety will be at stake. Flooding is especially problematic in the districts in the North-West and District 2.

A second effect of rising sea levels is the intrusion of salt further upstream, which already reaches the intake point for the drinking water treatment plants at certain times in the year. In the dry season (December-April) this effect will have most impact especially since the dry season river flow also decreases as a result of climate change. Besides its effect on drinking water supply, increased salinity will also impact agriculture in the surroundings of the city.

[7] Dopp et al., 2012

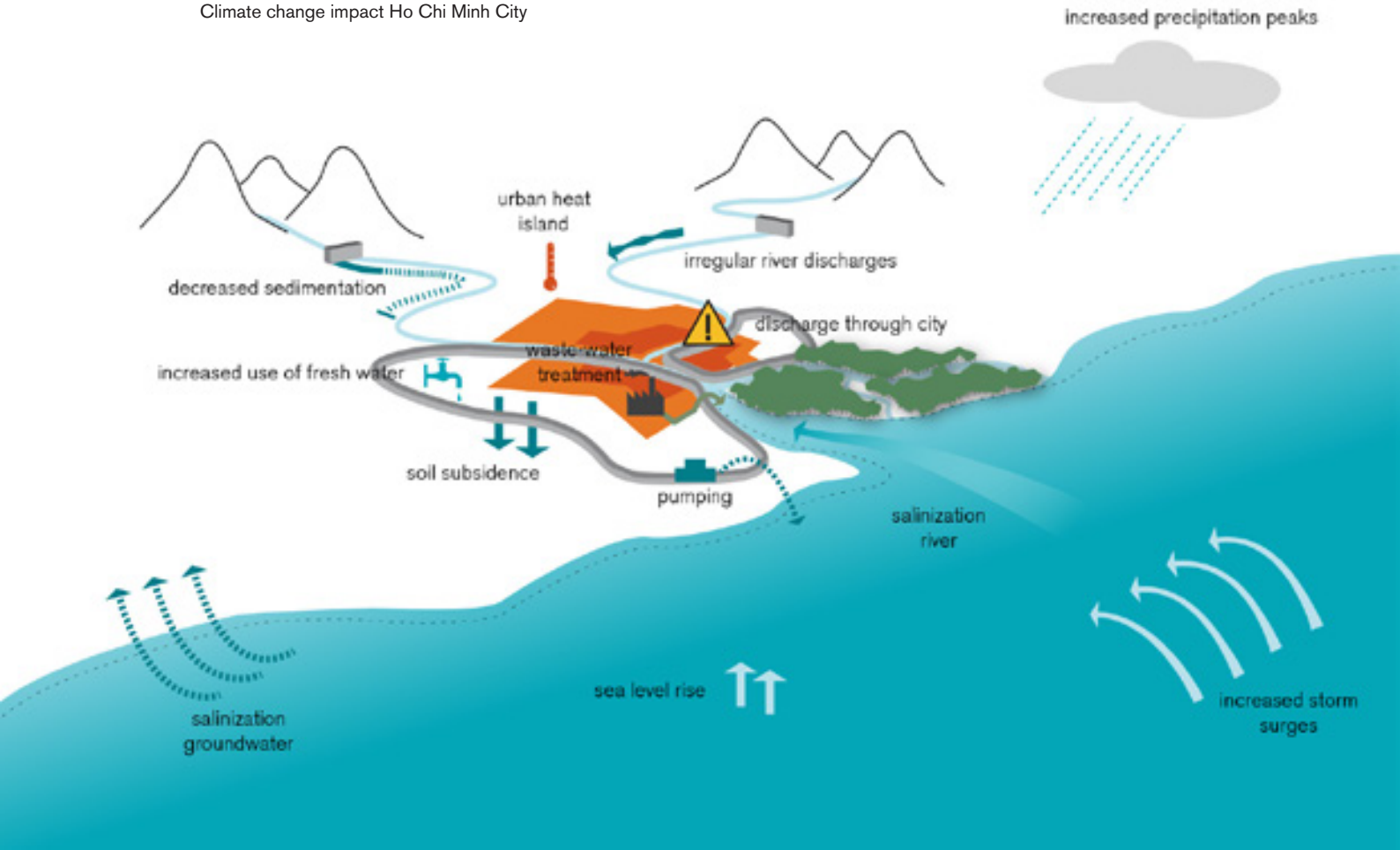
Change in precipitation, leading to increased nuisance from extreme precipitation events.
Precipitation is projected to increase up to 16.5% during the wettest periods from September to November. This will lead to an increase of flooding problems and economic damage. It is also expected that extreme precipitation events will occur more often. Currently, there are already problems managing the high volumes of excess rainwater in many parts of the city, as the capacity of the sewage system is insufficient. Also the limited room for water storage in the densely built urban areas contributes to flooding damage and nuisance.

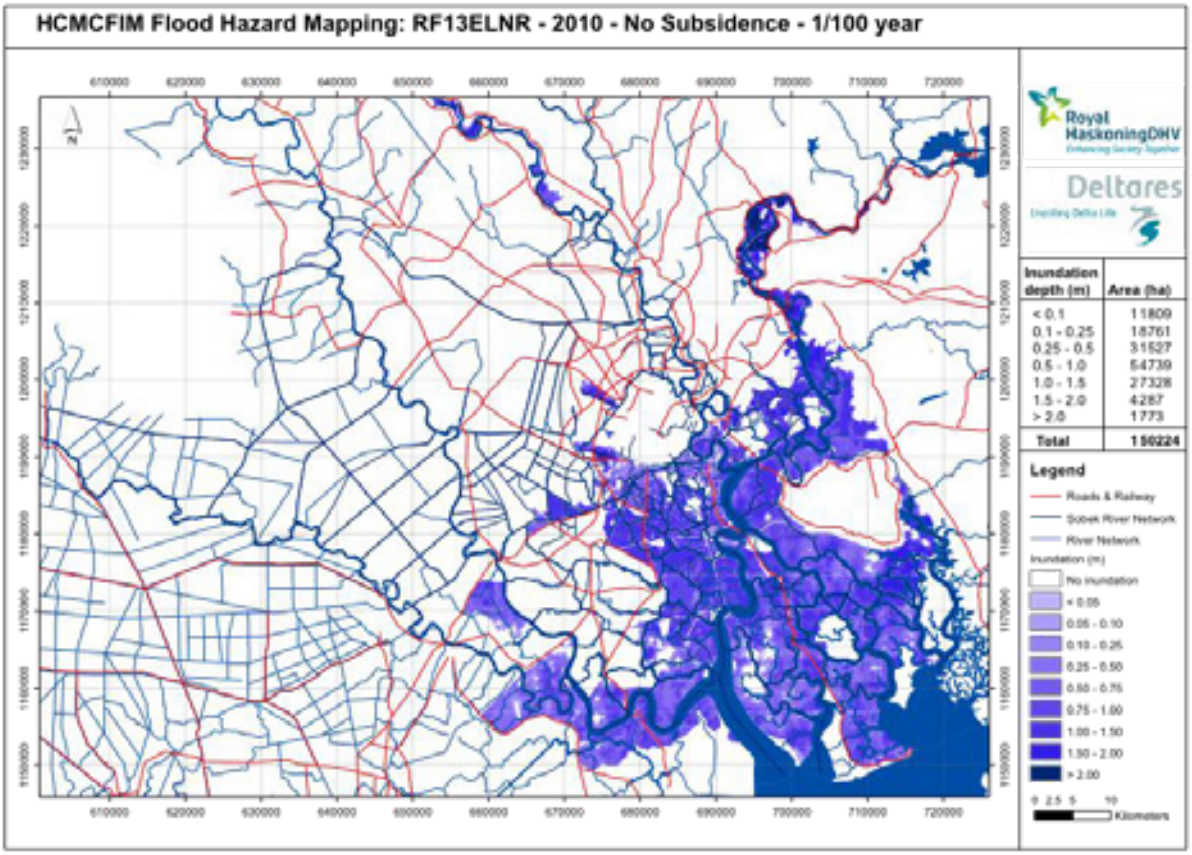
Change in river runoff, leading to an increase in flooding frequency.
Upstream watersheds are being over developed and these are expected to lead to increased downstream runoff and sedimentation. The effects of changes in precipitation and temperature due to climate change on river runoff are not known yet. This topic should receive attention in the near future.

Land subsidence.
Although this is not a climatic factor, it is included as it is an important factor influencing the flooding frequency and nuisance of extreme precipitation. Land subsidence is caused by groundwater extraction and decreased infiltration capacity. In low lying areas near the river or canals, this will lead to higher flood levels. Also subsidence areas that currently do not have flooding problems will become more vulnerable to flooding.

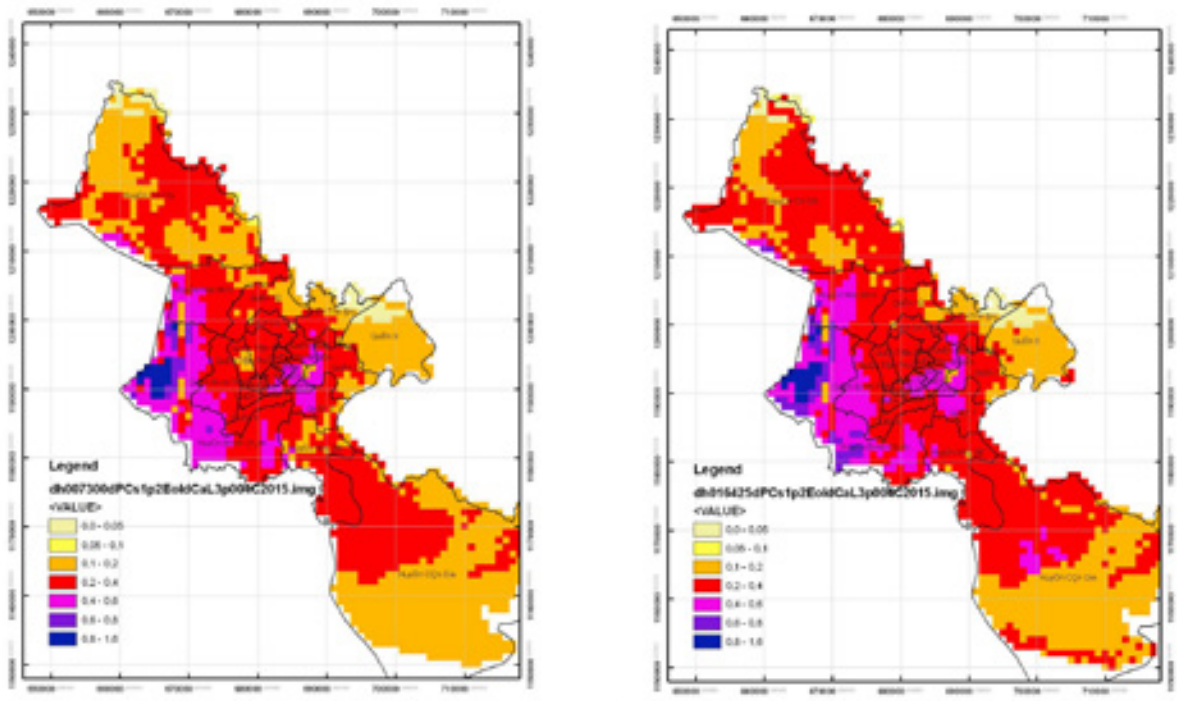
If no action is undertaken, the safety and livelihoods of HCMC residents is at stake. HCMC will be flooded more often, the air and water quality will become worse, nuisance associated with flooding from extreme precipitation will increase, and the general living conditions will become uncomfortable as temperatures increase.

Climate change impact Ho Chi Minh City





Flooded area at 1/100 year frequency



Land subsidence predictions for 2005-2025 (left) and 2005-2050 (right) with constant (2007 level) groundwater abstractions.

4.3 Review draft Spatial master plan 2025 with respect to the impacts of climate change

The draft Spatial master plan 2025 contains the vision and direction for urban development in the coming years. As the impacts of climate change can be potentially large, it is of paramount importance that the choices made in urban development will be climate proof. A Charrette workshop with all stakeholders has led to the analysis below.

Some elements of the draft Spatial master plan 2025 already are contributing to a climate proof city. The master plan acknowledges the need for water storage in new urban developments. The master plan calls for over 250 ha of additional green spaces to provide attractive leisure areas and at the same time provide shade during hot days. The master plan also envisions modern public transport systems, aimed at preventing traffic congestion and air pollution. Along the waterfronts of Saigon River, Dong Nai River and Nha Be River, water and green zones will be developed to create an attractive environment for tourism and entertainment, and at the same time providing the needed water storage and green areas. Also, space is reserved along the river to preserve natural storage capacity. For district 2, zoning is used to make a distinction between safety levels for various land uses.

There are also some deficiencies in the master plan with regard to climate change. The master plan does not specifically deal with flood protection. It is unclear which zones are protected to what level and what is expected of developers when building in specific zones. It does not explicitly state which measures can be taken to prevent flooding, and in which sequence these measures should be implemented. It would help the districts if such a step by step approach is available, because it enables them to make detailed planning regarding when these measures should be taken. A step by step plan will also enable the districts to determine which part of the district will be dedicated for flood protection. Measures like tidal gates and dikes require space, or even redevelopment. Adapting to climate change requires looking at impacts at a longer time scale (2050-2100) to make sure measures will be avoided that later will be regretted.

Some urban and industrial zones that are planned to be developed according to the master plan, are located in flood prone areas with low flood discharge capacity. Extra attention should be given to the climate adaptive development of these areas.

The master plan does not address how the water demand of the city, and new developed urban areas, will be met. The current practices of using river water and large amounts of groundwater appear to be unsustainable, as groundwater extraction is greater than the recharge rate of the aquifers. With a rising sea level, it is expected that salt will move up the Saigon River, even reaching the inlet of drinking water intakes. Additional attention should be given to this issue. Also planning of the sewerage system has to be reconsidered. Changes in extreme precipitation compounded by sea level rise require revised construction standards and an adjustment of the dimensions of the existing and new urban drainage systems.

High rise buildings will impact living conditions of the inner city. From several examples of other large cities, it is known that it is beneficial to maintain natural ventilation in these areas, and to include natural air flow corridors in the city landscape design.

Finally, some opportunities for synergism are can be exploited. Green zones can be combined with water storage. Redevelopment of the waterfronts to attractive leisure spots can be combined with flood protection measures.

4.4 Review of other master plans on the impacts of climate change

Besides the draft Spatial master plan 2025, the planning structure in HCMC consists of socio economic master plans and master plans per sector on the city scale. In each district there is a similar structure of district level plans to work out the goals set in the city master plans. Of these master plans, 26 have been reviewed to assess whether the developments envisaged in these plans are climate proof.

In the development of most of the 26 master plans, adaptation to climate change has not been an explicit issue. There are however proposed measures that will contribute to dealing with climate change. Implementation of the policies on water drainage will have a significant positive effect on the creation of extra drainage capacity. The creation of extra dikes and embankments will at least locally alleviate the pressure of flooding. Regarding subsidence, targets have been established for the reduction of groundwater use. In the master plan HCMC 2025 the creation of 12 waste water treatment plants is foreseen. Realization of these plants should lead to a significant improvement of water quality.

In the review many subjects surfaced that will become an issue as they will be impacted by climate change. On the macro scale, the master plan orients new major development directions of the city towards the south, which will run an increasing risk of flooding if no measures are taken. Climate change puts further pressure on the southern parts of the city as a result of increases in flood risWk and salinisation of surface water. Areas in Nha Be and Can Giao become less suitable for agriculture, residential zone development and industry development. In the plans attention is given to water storage, but these measures will not be effective considering the scenarios for sea level rise.

In the revision of several sector master plans, activities were identified that are already impacted by flooding and that will likely be more impacted in the future. Health care and education facilities are located in flood prone areas, mining areas and industrial areas in riparian zones will flood more often and agriculture will suffer losses. Sea level rise will also impact the infrastructure related to transportation by water as harbour infrastructure and the inland water ways will be affected.

Due to climate change, the design conditions for the drainage system change. Precipitation increases and river levels rise as a result of elevated sea levels. Also the operation of the drainage system itself will increase river water levels. These issues were not sufficiently taken into account in the drainage plans.

Also the increase in temperatures will have an impact not foreseen in the sector master plans and policies. Outside the city, in Cu Chi and Binh Chanh, higher temperatures increase the risk of forest fires and higher temperatures will impact the health of livestock and could increase the incidence and types of vector borne diseases. In the city, temperatures will rise even more due to the heath island effect. This especially has an impact on the health of the oldest and the youngest citizens.


TỔ CHỨC


AIA

4.5 Need for a climate adaptive approach

To cope with the foreseen impacts of climate change, to secure the realization of the vision for HCMC 2025 and to maintain or even improve the quality of the city, measures are needed. During several consultative sessions and meetings with key stakeholders, the most important issues were identified.

These issues include:

- reduce the occurrence and effect of flooding (e.g. protection, damage reduction);
- maintain good living conditions in the city (e.g. parks, open water, public transport system);
- secure sustainable provision of drinking water and industrial water;
- improve drainage and waste water treatment;
- improve living conditions in houses (e.g. heat adapted building, green roofs).

In addition, in most sector master plans ambitions for growth are formulated. However, the pressure on space in HCMC is further increasing due to climate change. E.g. in the northwest districts the soil is suitable for agriculture, but these are also the safest places for developing residential neighborhoods. This means that besides taking measures, strategic choices will need to be made to climate proof the city in concordance with socio economic development.

5 ADAPTIVE PLANNING APPROACH

5.1 Bandwidth of developments

How HCMC will develop as a city is to a large extent uncertain. Several main drivers of city development are outside of the span of control of city planners. Will the economic growth of HCMC in 2050 still be as high as it has been over the last decade? Will there live 9 million people, 20 million or 30 million people in HCMC in 2100? An accurate prediction for these planning horizons is impossible to make.

When planning climate change adaptation, these long term developments do matter: it is this future city itself that has to be climate proof when the impacts of climate change have revealed themselves. To better understand the possible long term development of the city, possible long term perspectives for the period 2050-2100 were explored in Charrettes. This resulted in an overview of possible urban and socio-economic developments which together form a bandwidth of the future development of HCMC. In the sections below, for the most important themes regarding spatial development, the extremes of the bandwidth are described. There is a high likelihood that the actual situation between 2050 and 2100 lies in between these extremes.

This analysis helps to make the climate strategy and climate change adaptation interventions more robust. By determining the effectiveness of interventions in various possible futures, no-regret measures and measures to avoid regrets on the long term can be identified.

Economic growth

Vietnam has enjoyed years of fast economic growth, sometimes reaching double digits. Economic growth slowed down in recent years as a result of global economic developments. If the global economy recovers of recent credit crunches and the Euro-crisis, HCMC in the future might enjoy relatively high growth rates. By policies to boost the national economy and by making use of the potentials of the city, an average yearly growth of 7% to 8% might be feasible in the long run. In this scenario all economic sectors show high growth rates, with services growing fastest (reaching a share of around 60% in the City's economy, including the fast growing tourism sector, followed by manufacturing (around 33%) and construction (7%).

Other, less inviting futures are also possible if the economic growth in the developed nations is stagnating. This could happen if the EU has not managed to solve the Euro-crisis and the Euro-zone has fallen apart at the cost of billions. This would immediately affect the US and the new economies like China, as a large part of their export market disappears. Foreign direct investments in HCMC almost come to a stop. As Vietnam had focussed on exports, these international developments would be a blow for the Vietnamese economy. In this future, growth in HCMC would drop to an average of less than 2-3% per year. At first it is the industry that feels the impact, but this later on trickles down to the construction sector and services.

Population and migration

In high growth scenarios HCMC offers work. Where unemployment in 2010 was around 5.5%, unemployment will be virtually non-existent as a result of growth in the future. Jobs and the growing income in the city will attract a high influx of low-educated people from the rural areas. Not only migration will lead to population growth, also the higher fertility rates lead to a population of almost 10 million in 2025 and growing. Some projections even forecast 30 million in 2100!

If economic growth is low, moving to the city will become less attractive as unemployment will slowly rise. At first the population still grows, as rural-urban migration reacts slowly to the developments. The size of the population peaks at 9 million in 2024, and after that slowly declines to the same level as 2011 (around 7 million). The decline is mainly due to out migration, as people are moving back to their former rural existence.

Urban development and infrastructure

In high growth scenarios the demand for development space is high. The long-term outlook of the city will depend largely on the extent to which the government will be able or willing to orchestrate the growth of the city. Growth can be dominated by market forces, leaving the people and companies with the highest purchasing power with the best locations, social housing along industrial corridors and slum areas in less favourable areas. If the government is able to coordinate development through a clear spatial vision, nodes and new centres will be the focus of development. Services will be centralised in such nodes and large investments in highways and public transportation will be done to connect the new centres. More space will be kept open for green and blue. When market forces dominate spatial development, there is a high risk that public needs for water storage and green zones will not be met.

If growth is low and migration towards the city will change into net outflow on the mid-term, this will result in a considerably lower pressure on available space. If the government directs urban growth in the coming decade, the predominantly low income immigrants will be housed concentrated in low cost residential areas around new nodes. When on the long term the population of the city decreases, old social housing projects and slums are vacated and demolished, thus creating green pockets in the city.


WAH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Port activities

A strong economic growth will stimulate the development of the Cat Lai and Hiep Phuoc industrial ports and the further development of the Vung Tau deep sea port. Development will lead to full outplacement of current harbour related activities in the city centre and space will become available for services and residential functions.

If the economic growth is moderate, currently planned industrial zones have over capacity and parts will not be developed. Not all industries currently located near the old harbour areas will have growth potential and will relocate to the planned new harbour areas, slowing down restructuring of the banks of the Saigon River.

Agriculture and rural

In the high growth scenarios agriculture has largely disappeared from HCMC. Agriculture moves further into the rural areas, and undergoes up scaling because of efficiency reasons. Small scale agriculture disappears altogether. The rural areas close to HCMC are attractive as garden communities, attracting high income elites. And as there is more time and money for recreational purposes, these rural areas turn from agricultural areas into residential and recreational areas. Remaining activities are specialized high value (industrial) agro-activities, although most of these activities are situated in the 'agro-valley' of the Mekong Delta, close to the source of production.

The small scale agriculture around HCMC remains dominant in terms of land use when economic growth continues to be low on the long term. There is some aquaculture at the southern border of the city. In general people are more inclined to do some agriculture 'on the side', as the perspectives on the formal labour market are not bright. Depending on the level of coordination the re-migration of people to the countryside after 2024 follows either a scattered pattern or is more organised and concentrated in villages.

Nature and ecology

Protecting nature and developing green structures in the city requires active coordination. Especially in high growth scenarios there is a lot of pressure on space. It will make all the difference between scattered green areas in the city or the development of green belts that connect the city's parks and have an ecological value. Without coordination, only natural areas with a very high value (e.g. Can Giao mangrove forest) will be preserved.

In case of lower pressure by man on the green environment the mangroves and swamps towards the sea will remain unchanged. If population declines on the long run, even extra space might become available for green areas.

Adaptation pathways

The method of adaptation pathways is a tool applied in adaptive delta managemernt to analyse the relationship between specific possible adaptation measures and the extent to which they are capable of dealing with changes. An adaptation pathway consists of sets of measures that are designed to respond to a specificand increasing impact of Climate Change (sea level rise, increased river discharge.).

The pathway describes consecutive measures, which can be implemented when a certain impact level is reached. It shows the options that exist. For instance, putting sand bags in front of the house is effective until a certain flooding depth. When the flooding depth becomes deeper due to sea level rise, other measures should be taken, e.g. the construction of a barrier to prevent flooding, or the elevation of the house to protect it from flooding.

5.2 Dealing with uncertainties: adaptive delta management

Dealing with uncertainties is one of the key-elements when planning for climate change. Uncertainties should not and do not need to cause delay in decision-making. To deal with uncertainties, this adaptation strategy adopts the adaptive delta management approach. This means that the strategy:

- links short-term actions and long term developments and includes ways to deal with uncertainties;
- is flexible and uses a stepwise approach in order to take cost effective corrective actions depending on the future speed of climate change and urban development;
- is based on an integrated approach, using sectoral synergism to increase the attractiveness of the city. It contributes to the socio-economic development ambitions of HCMC and takes into account the potentials and constraints of city development;
- connects to or incorporates ongoing developments and plans to create synergy and connect to various investment agendas;
- uses the adaptive capacity of economic sectors to incorporate adaptive developments or systems through policy measures;
- applies the technique of the adaptation pathways to analyze possible sequences of measures (see box).

Several options to deal with uncertainty exist and are applied in this strategy[8]. Which option can best be chosen is case-specific.

Develop low and no-regret adaptation options

No-regret measures are "adaptation options (or measures) that would be justified under all plausible future scenarios, including the absence of manmade climate change[9]". The analysis of the bandwidth of future developments (section 5.1) is used to determine which measures are no- or low-regret. Low regret measures are also these measures where costs are relatively low in comparison with the possible benefits.

Create win-win measures

These are the measures that have desired results regarding climate change adaptation, but also have benefits in other fields. E.g. they have a positive effect on spatial quality, or they have environmental or economic benefits. Tracking these types of measures is a key element in the Rotterdam Adaptation Strategy.

Increase flexibility

When the future cannot be accurately predicted, building flexibility is a good way to deal with uncertainty. Measures that are reversible or can later be adjusted keep the option open to adapt when necessary. The method of the adaptation pathways helps to determine to what extent a strategy is flexible (see textbox). The opposite of a flexible situation can also occur: becoming 'locked-in' into one specific option.

Include safety margins

The technical life span of infrastructure and buildings is long. It can therefore be wise to add safety margins in the design to be able to deal with a wider range of future situations. Incorporating best practices with regard to climate change adaptation now is in general more cost-effective than climate proofing in a later stage.

Delay action

Climate change is a relatively slow process. Especially in the case that there is no immediate advantage of taking measures right away, investments can be postponed and is usually more cost-effective. Uncertainties that exist now will decrease in the future and measures may become obsolete. Using time effectively to further investigate possible options increases the chance to make the right choices. The method of the adaptation pathways again is useful in this respect.

[8] http://climate-adapt.eea.europa.eu/uncertainty-guidance/topic2

[9] Eales et al., 2006

Reduce decision time

Anticipating taking decisions that might be necessary later increases the adaptability of a strategy. If studies that take time are already done, decisions can be taken quicker in a later stage.

5.3 Conditions for the strategy

The analysis of the bandwidth of development presented in 5.1 leads to the following general conditions for the strategy.

Until 2025 the scenarios indicate that there will be between 9 and 10 million inhabitants in HCMC. After 2025, the expected size of the population differs significantly between the upper and lower extreme of the bandwidth (7 to 30 million). This affects the size of the city and the area that needs to be protected. At the same time, the economic value that the city represents is an important factor in determining the level of protection that should be offered. In high growth scenarios the economic value, and therefore the potential damage will require higher water safety standards than in a low growth scenario.

The strategy that is chosen should be able to cope with these developments after 2025. This means that a stepwise approach for flood protection should be adopted that enables an increase in flood protection when population size or economic growth demand it. Flexibility regarding the levels of protection and the area to be protected is desirable.

Further improvement and climate proofing of the water system will require more space for water storage or water works. The pressure on available space varies significantly between low and high economic scenarios, but both scenarios pose enormous challenges for the development of an effective and robust water system.

Where in low economic scenarios the available financial means for improving the water system will be the biggest challenge, the scarcity of space will be a big challenge in high economic scenarios.

Especially when market forces dominate urban development in high economic growth scenarios, the claim on available space will be high, leaving little space for water storage or green, or making these functions relatively expensive.

Both in low and high economic scenarios the influx of low-educated people will continue in the coming years, threatening the capacity and quality of the water system through increasing slum development in waterways and in low lying areas.

Harbours are expected to relocate from the city centre towards Nha Be and Cat Lai. In high growth scenarios this is likely to happen as companies are looking for space to develop further. In low growth scenarios harbours might not move out, making it more difficult to integrate water safety measures along the river.

These kinds of developments require a strong coordination of the long term development of the water system in order to facilitate an active policy of keeping space for water and green, and finding opportunities for win-win situations.

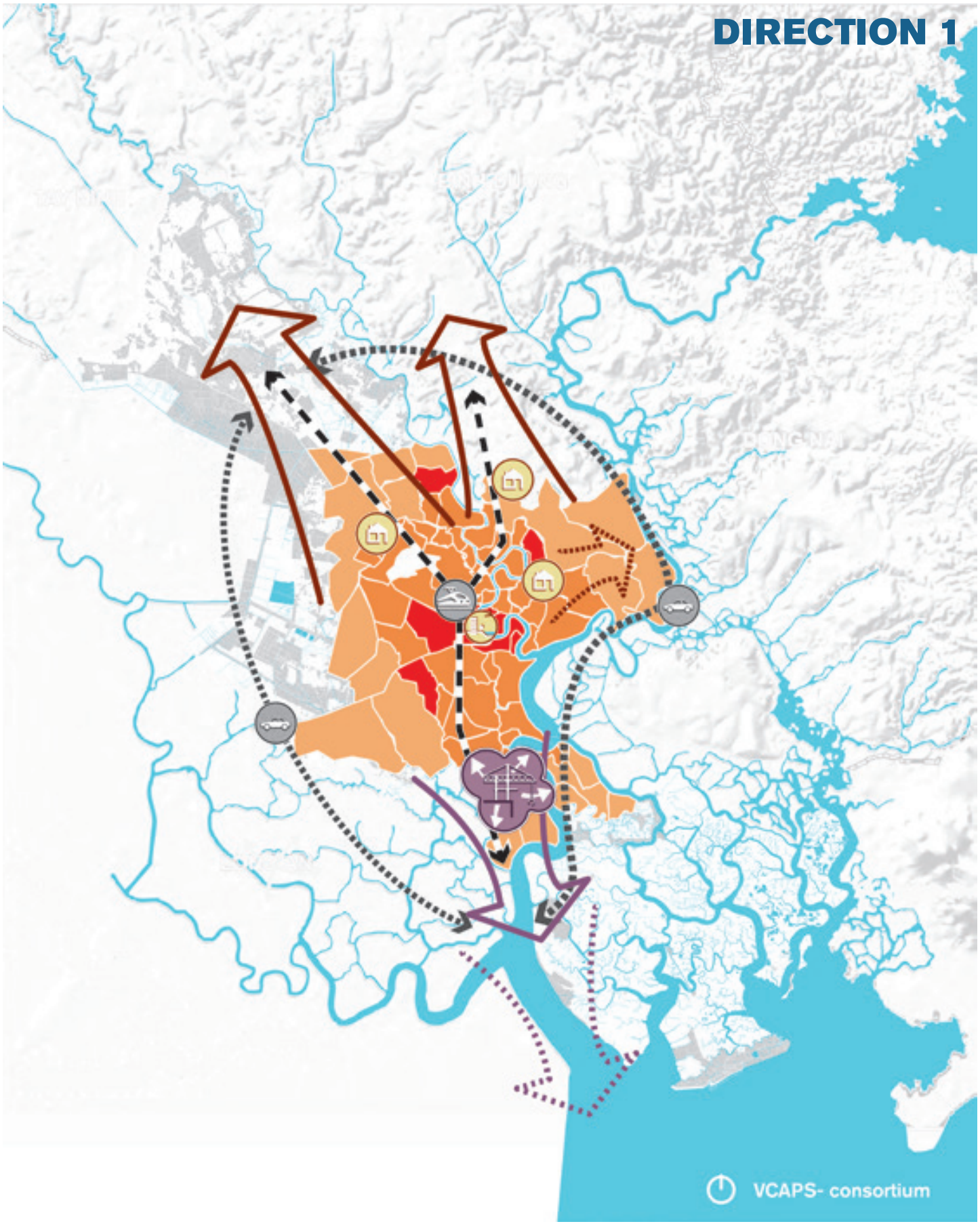
6 CLIMATE ADAPTATION STRATEGY

6.1 Six Strategic Directions

This CAS consists of six Strategic Directions that together constitute a guide towards a climate proof future for HCMC. By implementing these six directions, the urgency to adapt to climate change is used to add quality to the living and working environment of HCMC, turning HCMC into a "Unique Delta City". The Strategic Directions are translated into Strategic Interventions that decrease vulnerability and increase resilience against climate hazards.

The six Strategic Directions are formulated with regards to three planning horizons:

- Short term, until 2025: For the short term uncertainties are relatively limited. The short term strategy focuses on actions and measures that can be implemented within the timeframe of the draft Spatial master plan 2025. Many measures aim to also solve problems that have already manifested themselves. No-regret measures, regret measures to be avoided and win-win situations are identified.
- Mid-term, 2025-2050: For the mid-term the impacts of climate change and socio-economic developments are less certain. Trends in developments are relatively clear but the exact impacts cannot yet be foreseen. Measures necessary on the midterm should already be prepared or at least not be impossible on the short term (avoid regrets).
- Long term, 2050-2100: For the long-term measures are identified that considering the relatively slow progression of climate change don't need to be implemented before 2050. Their implementation might however already have consequences for land use in the shorter term.


DIRECTION 1
VCAPS- consortium

6.2 Direction 1: Base development direction on soil and water conditions

Over the last decade the built up area of HCMC has more than doubled in size. Also in the coming decades the demand for land to develop is expected to be considerable. Directing this growth in a sustainable manner is one of the main challenges towards 2025.

The soil and water system in and around the city determines the conditions for development. Strategic Interventions aim to base the future development of the city on this system as much as possible. In this way damages and unnecessarily high investments in protective infrastructure are avoided.

	Strategic Intervention	Term	Type	
1A	Develop new residential areas towards the northwest and east	Short term	No-regret	In all scenarios space is needed for urban expansion. From a climate adaptation point of view the northwest and east are the best locations. Developing towards the south will require large investments in water safety in the future.
1B	Develop harbours towards the south using adaptive measures	Short term, outplacement has already started.	Safety margin, include flexibility	Develop capital intensive harbour areas with a surplus height anticipating future sea level rise. Where possible, leave room for future adjustment. In case of lower economic growth, not all of the proposed locations may be necessary so don't develop too much land at once.
1C	Redevelop old harbours, combining flood protection with attractive water fronts	Short term, outplacement has already started.	Win-win	Developing a delta dike is in some inner-city locations a win-win situation as more space for development becomes available.
1D	Increase urban density in the inner-city	Short term	No-regret	In all scenarios the population of the city grows at least until 2025. Increasing density as a solution means that less new ground will be urbanized, a process that normally is irreversible.
1E	Develop north-south infrastructure	Short term	Robust	Build infrastructure robust, taking into account sea level rise. Measures are necessary for the success of the harbour and industrial areas in the south. The connections are clearly more profitable in high growth scenarios.
1F	Avoid encroachment on waterways	Short term	No-regret	In all scenarios there will be a need to avoid encroachment.

1A Direct new urban development towards the northwest and east

Building in less vulnerable areas considerably decreases the occurrence of floods. Considering elevation, soil conditions and exposure to sea-level rise, urban development in the direction is more climate-proof than in southeastern direction. The northwest areas are the safest northwestern locations because the soil is more suitable for urban development. An additional argument for avoiding development in the south-eastern direction is the presence of the valuable Can Gio mangrove forest (UNESCO status). This forest provides natural protection against coastal erosion and tidal surges resulting from typhoons[10].

Major development areas in the draft Spatial master plan 2025 are Cu Chi in the northwest and Nha Be in the south. From a climate adaptation point of view the south is unsuitable for large scale urban development. This area is vulnerable to sea level rise, and the soil conditions make this area prone to future land subsidence. Urban development in this area should be adaptive and climate proof, leaving room for natural hydrologic conditions. Therefore the scale and type of development towards the south should be re-evaluated.

Current plans include the development of an airport and sea harbour east of HCMC in Dong Nai province. These will likely attract urban development in this direction. As the average elevation in Dong Nai province is higher than HCMC, this can be considered a climate proof development.

1B Develop harbours towards the south using adaptive measures

The increasing size and draft of seagoing container vessels renders locations closer to the sea more favourable for harbours. In addition, industrial and harbour related activities are preferably located away from the city centre considering their potential negative impact on the urban environment and human health.

Existing harbours in or near the city centre will be relocated towards the sea. Harbour and port expansion is now foreseen especially for the Cat Lai and Hiep Phuoc port areas. The new locations for harbours should be developed taking into consideration sea level rise and land subsidence, and should be build high enough not to flood in the coming decades. The Ministry of Construction currently uses 1/100 years as a design level for urban land uses but these standards are under revision. As the area around these harbours will most likely be located outside a future ring dike, development of supporting functions and infrastructure should incorporate climate change into their design, e.g. by using elevated roads, flood proof buildings, flood proof electricity supply and building on mounds. Considerable dredging will be necessary for these ports to be able to receive bigger ships. Negative consequences of dredging can be an increase of salt intrusion and increase in inundations. A thorough analysis of environmental impacts is necessary before implementation.

[10] Asian Development Bank, HCMC, Adaptation to Climate Change, Summary report, Mandaluyong City, Philippines, 2010.

1C Redevelop old harbour locations, combining flood protection with attractive water fronts

The old harbour locations in the city centre have a considerable potential to be transformed into residential or commercial areas as they are situated near prime city centre and riverside locations. Redevelopment of these locations when harbours are moved out should combine raising these locations to ring dike level, following the principles of the delta dike, and renovate the water fronts to their full attractive potential. Stepped dikes can be introduced that combine a dike with preserving space for the river.

1D Increase urban density in the inner-city

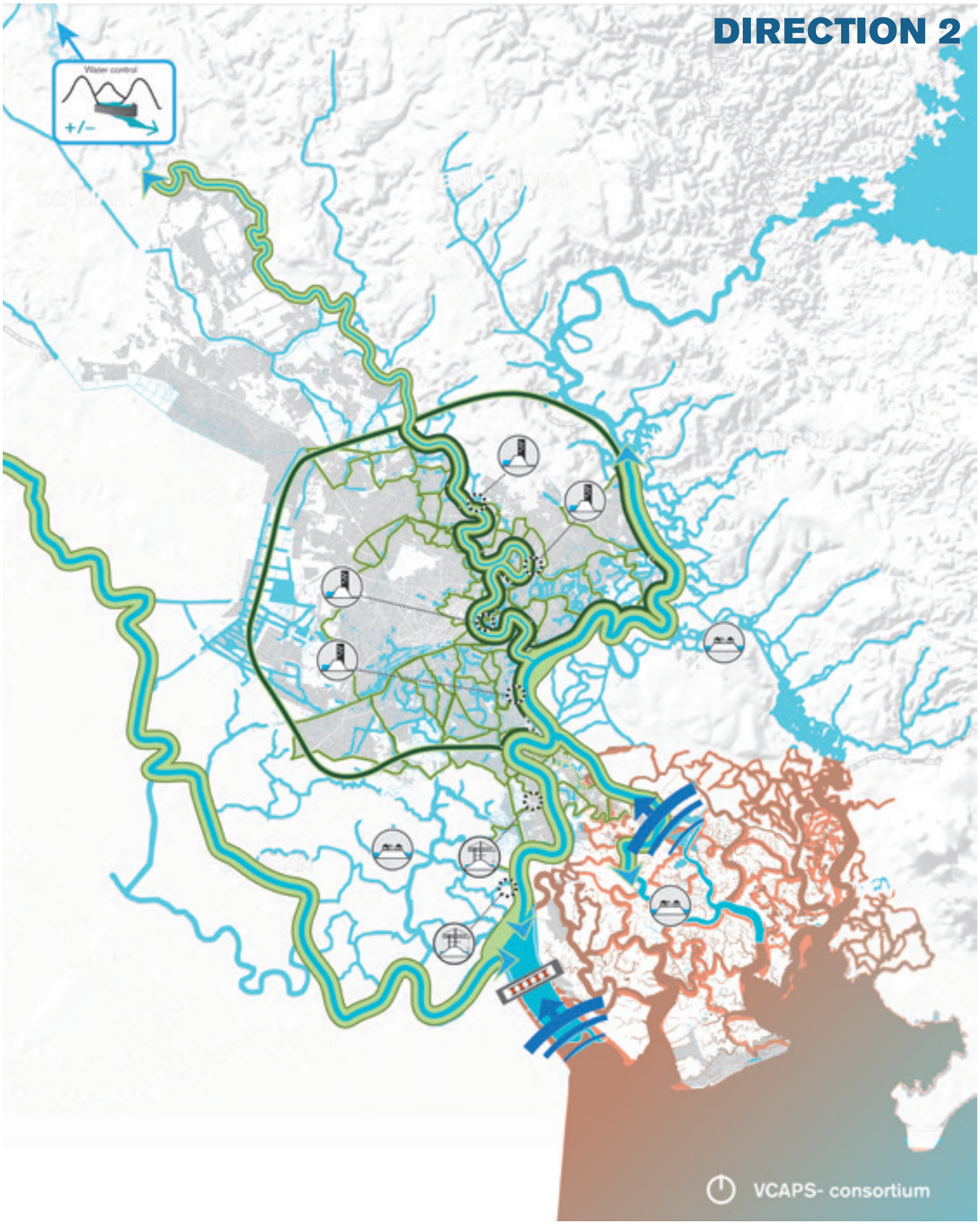
Before expanding into less favourable areas, increasing the urban density in existing inner city areas is favourable from an adaptation perspective. An important benefit of this solution is that it minimizes travel distances. The development of good public transport systems is key to supporting this action. By increasing urban density, there is less need to build in flood prone areas and investments in collective flood protection measures become more cost- effective. In the draft Spatial master plan 2025 inner-city development focuses on Thu Thiem and Cholon and four sub centres.

1E Develop north-south infrastructure

Other recommendations are to use infrastructure to drive development in the desired direction and connect residential neighbourhoods to industrial/ harbour zones near the sea. Further, establishing harbours and directly related industries near the sea and residential zones more inland requires multimodal infrastructure to get people to their work and to connect the harbours with the main transport routes. High quality public transportation is necessary to avoid congestions.

1F Avoid encroachment on waterways

Increasing spatial pressure and an influx of unskilled labour force from outside the immediate area leads to slum development along waterways and water storage areas. Establishing strict regulations, and enforcement of these regulations, will be necessary to keep the waterways open as these are vital in the functioning of the city water system.

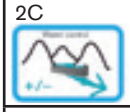

DIRECTION 2
Water control
+/-
VCAPS- consortium

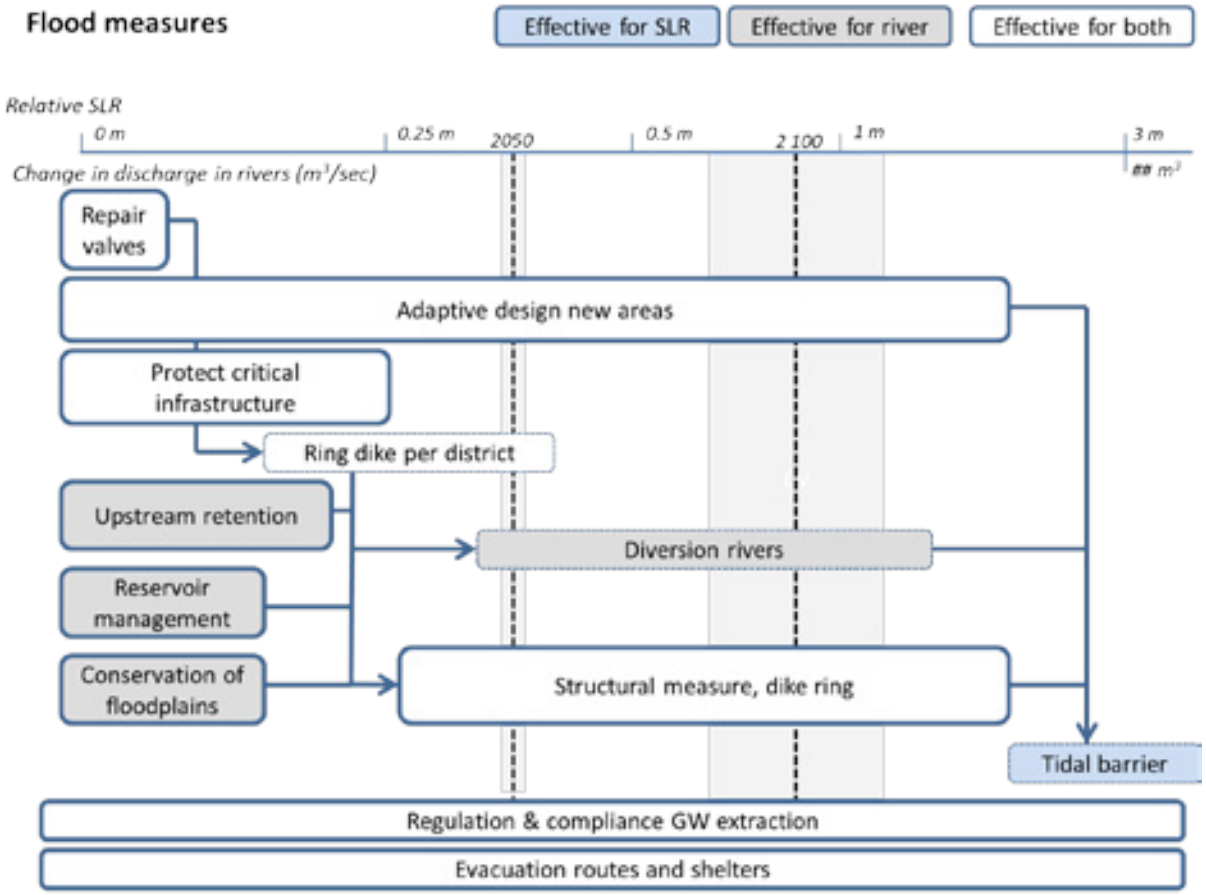
6.3 Direction 2: Use a stepwise approach for flood protection

Major floods in HCMC have several interrelated causes. Floods occur due to peak flows in the Dong Nai River, the Saigon River and the Vam Co River in combination with high tide, when the storage capacity in the river system and adjacent flood plains is insufficient. Floods can become worse when in addition excessive rainfall cannot naturally discharge into the river due to high water levels and insufficient storage of the urban water system .

If no measures are taken, problems will gradually increase as a result of sea level rise, land subsidence, and increases in rainfall extremes. As climate change is gradual and to a certain extent uncertain, and protection structures require large investments, a step-wise and multi scale approach is recommended in the implementation of flood protection measures in line with the adaptive delta management approach.

[11] Risks regarding the Vam Co River are strongly related to the distribution of water between the rivers in the Mekong delta and therefore considered beyond control. Changes in distribution on the Mekong could lead to considerable changes in flood risks in HCMC. This should be taken into account in the development of the Mekong Delta Plan.

	Strategic Intervention	Term	Type	
2A	Develop flood risk maps and flood risk standards	Short term		Flood risk maps form the basis for standards
2B 	Protect the inner city with ring dike	Short term	Win-win	Combination with the development of ring road 3 saves costs.
2C 	Optimize reservoir management for flood protection	Short term	No-regret	Optimizing reservoir operation from a floods perspective will reduce the risks of inundation north of HCMC.
2D 	Tidal barrier	Long term		Measure only necessary in case of extreme sea level rise.
2E 	Develop district adaptation pathways	Short term	No-regret	A bottom-up approach is expected to contribute to resilience at the district level.
2F 	Adaptive building towards the south	Short term	Flexible	Building in smaller quantities and on mounds leaving space for future adaptation makes it possible to grow with sea level rise.
2G	Identify and protect the vital and the vulnerable areas in HCMC	Short term	No-regret, robust	Create extra robust solutions for vital and vulnerable functions.
2H 	Protect the riparian zones along the rivers	Short term	No-regret	In all scenarios, safeguarding riparian zones leads to the reduction of flood risks.
2I	Strengthen emergency management	Short term	No-regret	Helps to reduce victims and economic damage also in the existing situation.



Adaptation measures to cope with relative sea level rise (SLR) and change in discharge in the rivers. Note: Measures in the closed boxes are part of the suggested adaptation pathway, dashed boxes are other measures that are applicable in the HCMC region.

Considering the complexity of the hydrological system and the diversity of the city, no one-size-fits-all solution exists. Solutions consist of a mix of large scale infrastructural measures combined with local and community based measures tailored to fit local circumstances. The pathway of consecutive measures to be taken differs per location. The figure on page 70 shows the measures that can be taken in the HCMC region, to cope with changes in flooding frequency and flood height.

2A Develop flood risk maps and flood risk standards
An important step in flood risk management is the preparation of flood standards or protection levels. Flood risk is a function of the probability of a flood and the impact that a flood will have on a certain location. Therefore flood risk maps should be made for the entire area of HCMC to increase insight into current and future flood risks and the lives and economic value that are at stake. Based on these flood risk maps, flood standards or protection levels per area should be developed. In addition, flood risk maps are a tool to inform citizens, companies and government institutions about flood risks, enabling them to adjust their behaviour. Knowing that higher flood risks exist in the south of the city will decrease investments in residential neighbourhoods in this area.

2B Protect the inner city with ring dike
A high level of flood protection is required for especially the centre of HCMC in order to enable the city to realise its socio-economic development ambitions. City residents are to a certain extent used to living with water and occasional flooding. However, damage to property and the disruption of daily lives caused by floods are increasingly curtailing the development of the city. The nuisance caused by flooding is less likely to be accepted when the population becomes wealthier.

With rising sea levels, protecting parts of the city with structural measures is becoming inevitable. Protecting a large part of the existing city with a ring dike is expected to be a cost-effective solution. Tidal gates should be integrated in the design of the ring dike at the entrances of the canals. When high water levels on the river occur, these tidal gates close off the protected area, thus maintaining the available storage capacity in the canals and waterways. The build up area within the ring dike should be build sufficiently elevated and part of the area inside the ring dike should remain low for water storage purposes.

When determining the exact location of the ring dike, leaving sufficient room for the river is essential. In addition, it is important to look for win-win situations in the planning phase of the development of the dike. Combining the development of the ring dike and the development of ring road three will reduce the development costs considerably. Furthermore, along the trajectory bordering the river, the design of the ring dike can be integrated into the design of boulevards and dense urban developments, improving spatial quality. Many of these locations are redeveloped due to the outplacement of harbours, leaving space for multifunctional solutions. This requires strong coordination to avoid unwanted developments in which for instance the dike closes the city off from the water. Specific design parameters for the dike need to be determined based on the flood risk standards.

2C Optimize reservoir management for flood protection

Improved regulation of upstream reservoirs in the Saigon River is a no-regret measure from a floods perspective as reservoir discharges have a considerable impact on flood risks in the upstream part of the basin. The reservoirs have functions for agricultural water supply, drinking water supply, energy generation and storage of rain fall peeks. Determining the best regime for the basins will require making choices between the interests of involved sectors.

Diversion of river discharge peaks around the city has been suggested as an option to reduce flood risks. However, according to the flood inundation model study[12], diverting part of the peak flow of the Saigon River towards the Vam Co Dong River does decrease flood hazards downstream of Rach Tra, but at the expense of an increase of flood hazards upstream and along the Vam Co River. In view of the planned urban expansion towards the northwest, this diversion is not advisable. Using the natural low of Rach Tra for managed retention is a possibility that deserves to be studied further.

2D Tidal barrier

If on the long term sea level rise is extreme, additional measures will need to be taken as dikes will not be sufficient to maintain the desired protection levels and land filled areas will still flood. In such an extreme case, large scale measures like a major tidal gate at the coast might be needed. Tidal gates in the Soai Rap or at Vung Tau have already been suggested and could be further investigated. Future studies need to consider impacts on amongst others: river morphology, water depth for navigation, water quality, changes in salinity and impacts on ecology.

2E Develop district adaptation pathways

The location of the ring dike and the timing of its completion determines the conditions of what additional measures are necessary at the district level. These can be fine tuned to the necessary level of protection for each urban function. The impacts of flooding on a local level can be reduced by for instance raising local embankments, raising land levels, and flood proofing buildings. Determining the measures to be taken in each district can be done using the technique of the adaptation pathways. The flood risks maps are an important input for developing these pathways.

Where urban development takes place outside the area protected by the ring dike, an approach implementing other adaptation measures should be used to decrease vulnerability to floods. Examples of measures include raising buildings (poles or mounds), wet-proofing, dry-proofing, zoning in spatial planning and smart development of critical infrastructure like the electricity or drinking water system.

For each city district a specific plan or adaptation analysis should be made incorporating the most feasible local measures. These analyses are the basis for revise and climate proof district scale master plans. Facilitation of the development of these plans from the city level will be required. This type of local planning should start with the districts that are most vulnerable and where the investment levels are highest.

[12] Royal HaskoningDHV, Ho Chi Minh City Flood Inundation Project, Final report, January 2013..

2F Adaptive building towards the south and the southwest

The south of the city is most vulnerable to sea level rise. Therefore it is advisable to reconsider the current plans for developments outside the ring dike. New urban development outside of the ring dike can be built on mounds high enough to counter the effects of subsidence and sea level rise. These mounds can serve as local safe centres during flooding.

Currently, small scale adaptive measures are widely applied in the south: elevated floors within buildings (up to 1 meter) and dry and wet-proofing of buildings can be seen in parts of the city. When these measures become insufficient, houses can be relocated to the new centres or rebuilt on mounds (already practiced).

Where larger clusters of new and existing houses are established, local ring dikes can provide another solution. According to a cost-benefit study in the flood inundation model study, local ring dikes become more cost effective than building on mounds when the size of the development exceeds 100 to 150 hectares. However, the advantage of applying adaptive building methods is that the floodplains of the river are preserved. Developing the southern areas in this way is more flexible with regards to adapting to various possible scenarios for urban development and climate change. Choosing dike options tends to be a lock-in decision: changing to other solutions in the future becomes increasingly difficult.

2G Identify and protect the vital and the vulnerable areas in HCMC

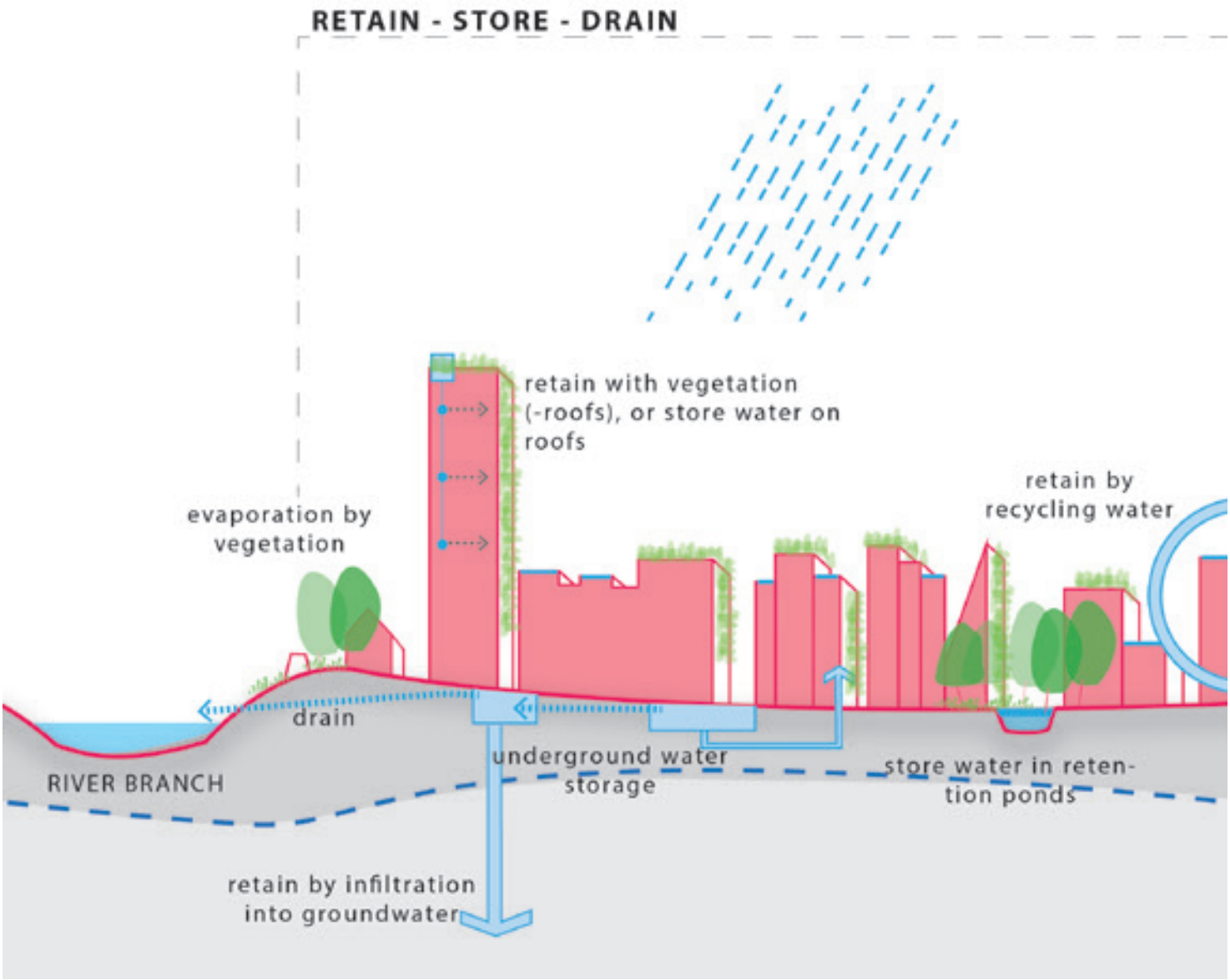
A dike never offers 100% protection. It is therefore advisable to identify and secure the most vulnerable and vital infrastructure in all parts of the city (e.g. hospitals, power plants, industries) by providing additional robust protection measures.

2H Protect the riparian zones along the rivers

Because of the increase in city density and construction in areas close to the river (for example Thu Thiem), the space for the river decreases. Sufficient storage capacity in the river system, especially upstream, is necessary to buffer high river discharges. Ring dikes should therefore be located leaving as much room for the river and its flood plains as possible.

2I Strengthen emergency management

Floods already occur regularly; and therefore increasing attention to emergency management is a no-regret measure. To implement emergency management there is a need for a reliable early warning system and a clear emergency response planning system should be in place to be able to effectively implement emergency measures. Also the development of flood shelters in the districts and raising awareness of the community on how to respond to a flood, are advisable.

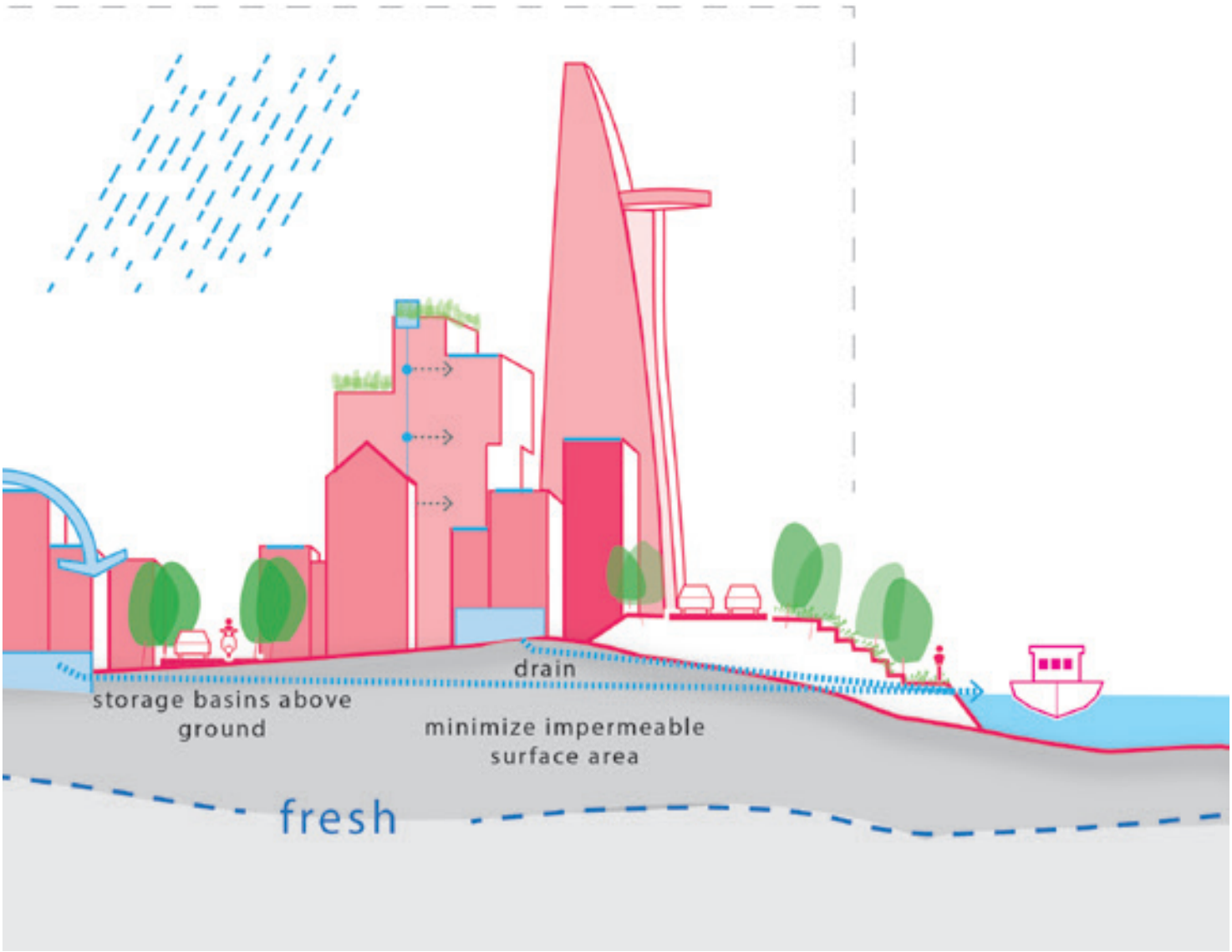


6.4 Direction 3: Increase the water storage and drainage capacity

Besides the larger floods mentioned in Strategic Direction 2, streets and houses in parts of the city are regularly flooded as a result of high tides or heavy rainfall. This causes nuisance, property damage and unhealthy living conditions. There are several causes:

- insufficient water storage capacity in the urban areas due to a lack of natural water systems and green spaces;
- low elevation, complicated by land subsidence in certain areas;
- insufficient capacity of the sewage or drainage system to discharge rainwater;
- insufficient maintenance of water ways (e.g. dredging, garbage removal) adversely affects flow capacity.

The situation is expected to deteriorate in the future if no measures are taken as increasing urban density results in less space to store water, the rainfall intensity increases caused by climate change and the rising sea level and land subsidence impact the drainage system. Many of the problems caused by rainfall are best dealt with on the local scale. On this scale a well planned mix of water retention and discharge capacity has to be designed to avoid problems. These measures need to be integrated into the planning of the existing urban area (especially spatial water/green areas).

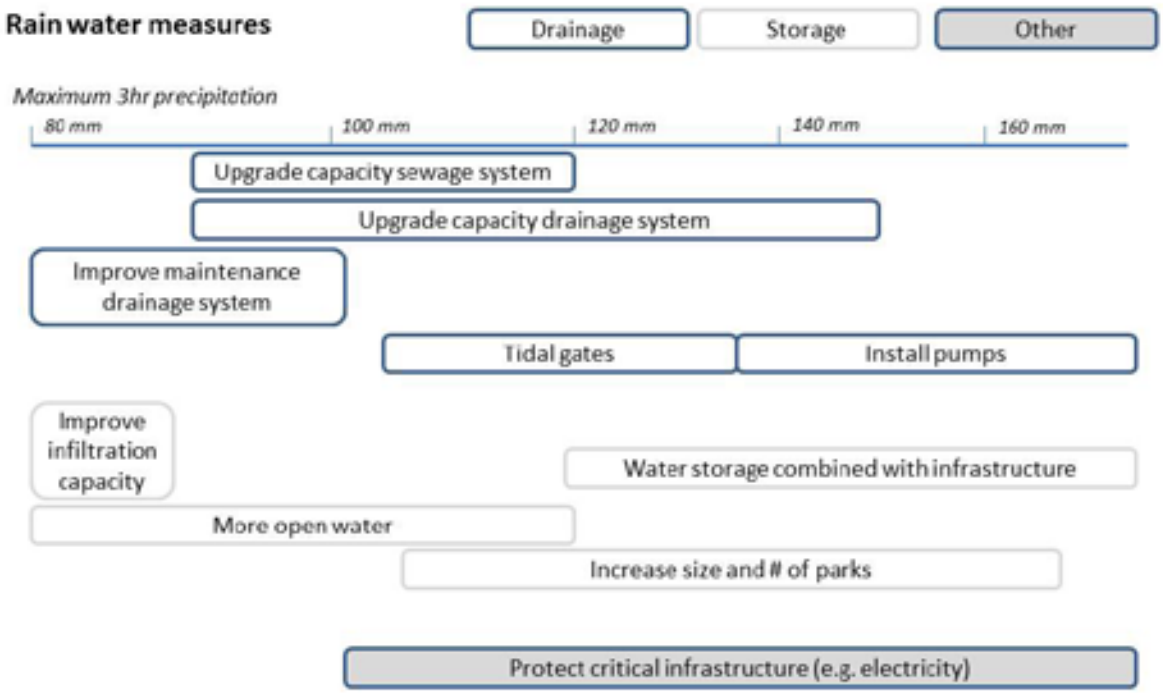


3A Review storage and drainage standards

As available space is limited, measures need to be taken on various scales: as well on the district, ward and building level. To determine the size of the required water storage and the discharge capacity, design standards for areas and buildings play an important role. Design standards should be reviewed regarding their capacity to cope with impacts of climate change and if necessary revised. Issues of concern include: when does flooding really become a problem? How much water can be tolerated on the streets and what frequency of flooding events can be tolerated and applied in urban design?

3B Develop and apply procedures to enforce storage and drainage standards

Climate change requires to give water a more important role in spatial planning. Compliance with existing regulations is generally weak. This leads to an unacceptable low water storage capacity which will result in future problems. The construction of new urban developments, re-development of areas and also maintenance works of inner city locations provide good and cost-effective opportunities to increase the infiltration and water storage capacity in the city, e.g. by including water areas in new development plans, using parks for water storage and integrating blue and green roofs in building design. In this way, water storage solutions can make the city more attractive.



Adaptation measures to cope with an increase in precipitation in HCMC. Note: no adaptation pathway is indicated as all mentioned measures need to be combined to deal with increased precipitation.

Enhancing the water awareness in spatial planning requires on the one hand better procedures regarding the role of water managers in spatial planning. Establishing an obligatory 'water assessment test' for spatial plans is a way to increase the role of water in spatial planning. On the other hand human resource development and capacity building will be necessary to increase the role of water in spatial developments. In addition, juridical procedures and economic instruments should be developed to enforce the application of the design standards (Strategic Intervention 3A) in (re-)developing areas or infrastructure projects.

3C Improve sewer and drainage system

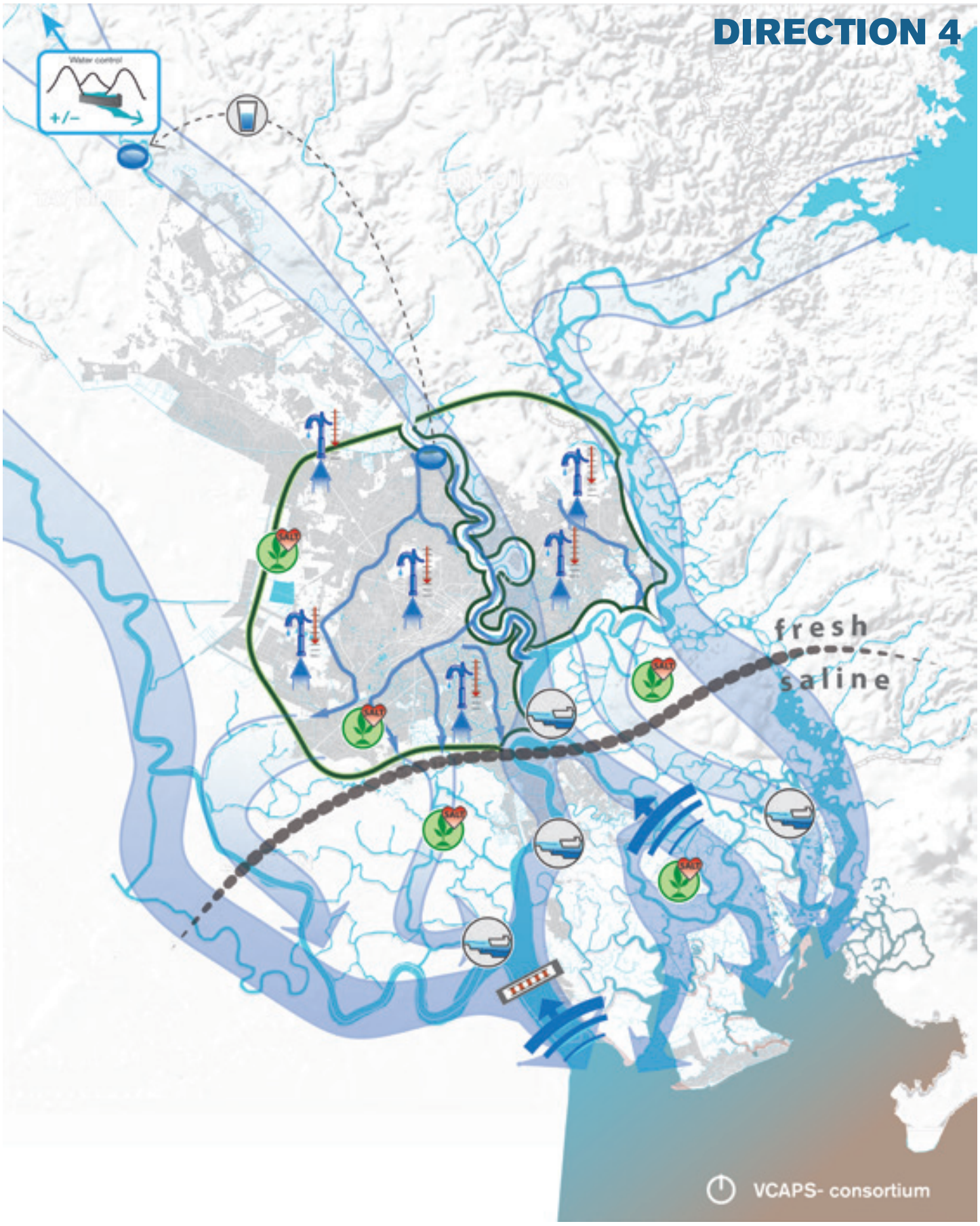
There is a strong relation between the options chosen for flood protection (Strategic Direction 2) and the functioning of the drainage system. Most of the rainwater in the city now drains to the rivers under gravity. Currently, malfunctioning in these systems, for instance due to non-functioning return valves, results in inundations. Dredging is required to increase the capacity of the city's drainage system. To make sure that improvements will remain effective, the operation and maintenance programs for the urban drainage infrastructure should be reviewed.

Due to sea level rise, natural discharge is becoming increasingly difficult during periods of high tide. In the period up to 2020 the drainage master plan is being implemented. The designs do not sufficiently take into account sea level rise and subsidence and the functioning of the design will therefore decrease with time.

If a ring dike is developed (Strategic Intervention 2B), the large investments in the drainage project are safeguarded through water level control within the ring dike area. The tidal gates will close at high tide, thereby creating water storage for rainwater within the ring dike area. The drainage master plan will need to be reviewed and revised with regard to the implementation of the ring dike.

In the future, when due to sea level rise water levels on the river have become too high to sufficiently drain the rivers at low tide; installing pumping facilities will become necessary. In figure ## the sequence of measures to decrease nuisance caused by rainwater is indicated.

	Strategic Intervention	Term	Type	
3A	Review storage and drainage standards	Short term	No-regret	This measure contributes to solving existing problems and is valuable in all scenarios.
3B	Develop and apply procedures to enforce storage and drainage standards in new developments	Short and mid term	No-regret	After development of standards and procedures, application is a continuous process. This measure contributes to solving existing problems and is valuable in all scenarios.
3C	Improve sewer and drainage system and review and revise drainage plan	Short term	No-regret	This measure contributes to solving existing problems and will contribute to the solution of flooding caused by rain in all scenarios.


DIRECTION 4
Water control
+/-
fresh
saline
VCAPS- consortium

6.5 Direction 4: Prevent salinisation where possible, adapt where necessary

Salt concentrations in the city's rivers are increasing due to sea level rise and a reduction of river flow during parts of the year. Salt water advances more upstream in the dry season (December - April) as the river discharge decreases in this period. Also in the groundwater system, the balance between salt water and fresh water is changing. As a result, increasing salinity will lead to a shortage of fresh water and to changes in the river ecosystems.

Agriculture is currently considered the most vulnerable sector to salinisation. However, agricultural land use in HCMC has decreased considerably in recent years and this trend continues. The impact of salinisation is therefore limited in comparison to surrounding provinces (e.g. Long An).

	Strategic Intervention	Term	Type	
4A	Large scale measures against flooding reduce salt intrusion	Mid-term	Win-win	A ring dike with tidal gates will also reduce the amount of brackish water entering the city's water system. If these measures are taken this will be justified from a floods perspective. Their effect on salt intrusion is a positive side-effect.
4B 	Smart dredging to reduce impact	Short term	Delaying action	Coupled to development of harbours. Smart dredging reduces the impact of dredging on salt intrusion compared to normal dredging.
4C 	Flush the city's water system	Short term		Measure to reduce impacts.
4D 	Evaluate relocation of drinking water intakes and wells	Mid term	No-regret	Locations for water supply station should be reserved on the short term to relocate intakes on the mid-term.
4E 	Decrease groundwater extraction to a sustainable level	Short term	No-regret	If groundwater extraction is not reduced to a sustainable level, groundwater resources will be depleted in all scenarios.
4F 	Use salt resistant vegetation in flood prone areas	Short term	No-regret	Take midterm changes in salt levels into account when designing public space.

4A Large scale measures against flooding reduce salt intrusion on the rivers

Salt levels in the rivers can be influenced considerably by large scale measures. The ring dike and the tidal barrier introduced under direction 2 will decrease salt intrusion in the city water system. The impacts of salt intrusion alone will however not justify the necessary investments in such large scale measures; it is a positive side effect if such a barrier is constructed from a floods perspective.

4B Smart dredging to reduce impact

Dredging river mouths to facilitate water transport will increase salt intrusion. Salt water intrudes further inland in a deeper waterway since saline water is denser than fresh water. To reduce this effect, it is recommended to dredge only to necessary depths and make sure that larger ships dock closer to the sea. The environmental and economic impacts of various dredging options should be further investigated.

4C Flush the city's water system

Salt levels in the city's water system can also be influenced by flushing the system with fresh water. River water and local fresh water storages can be used to flush saline water from specific canals. Since in the dry season not much water is available, further research should identify where this measure is effective and necessary.

4D Evaluate relocation of drinking water intakes and wells

Increase in salinity levels may force drinking water intakes in the rivers to be moved upstream. In addition, changes in salinity levels in groundwater, might lead to closure of wells in some areas. The planning of the relocation of wells should be preceded by a detailed study of trends and availability in surface and groundwater resources.

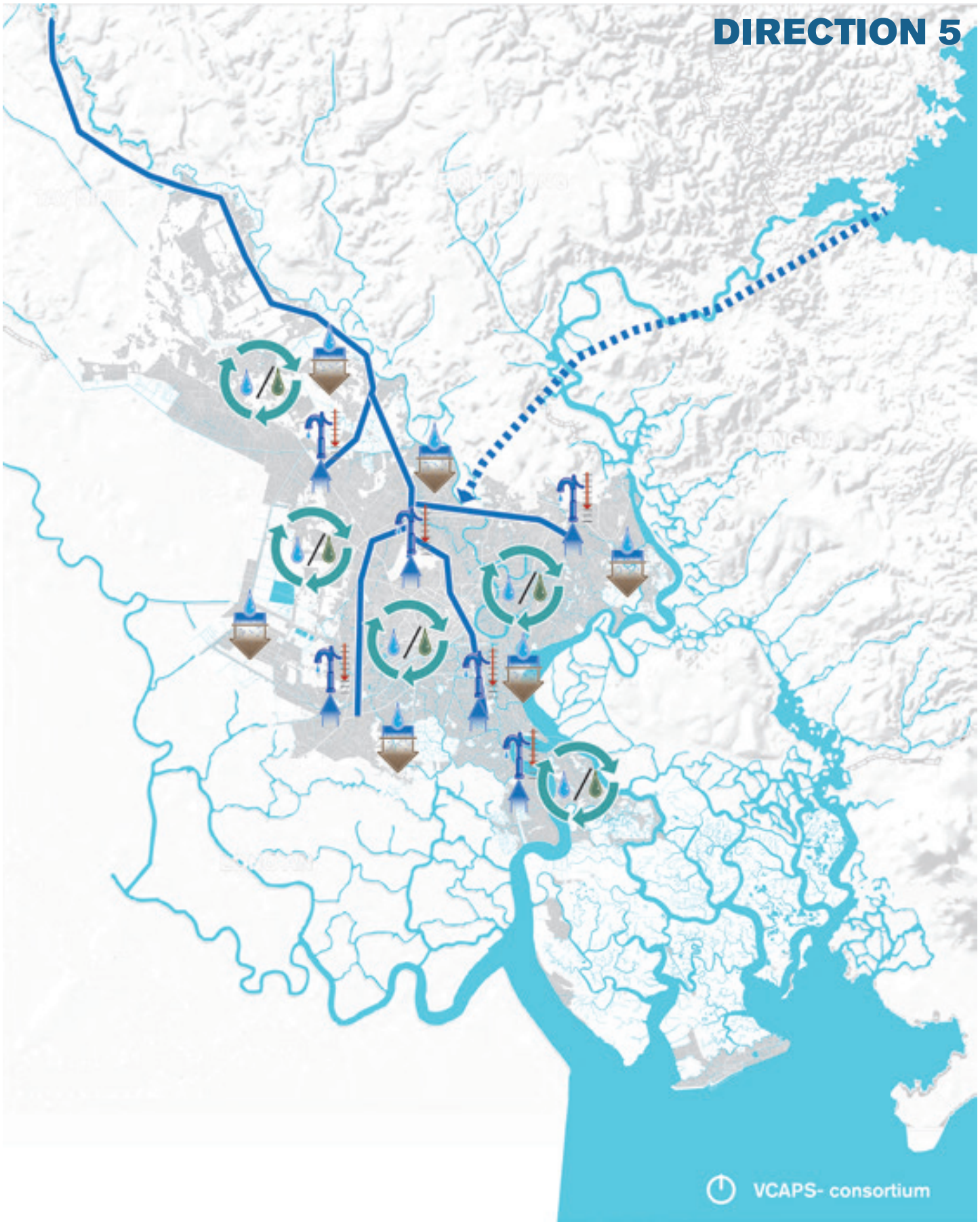
4E Decrease groundwater extraction to a sustainable level

Over extraction accelerates the increase in salinity levels in groundwater. Decrease of groundwater extraction through management measures (see also Direction 5) will therefore have positive effects on salinity levels.

4F Use salt resistant vegetation in flood prone areas

Generally, trees and green areas in city parks use superficial groundwater for irrigation and therefore are less affected by salinisation. When river water is used for watering plants and in areas that are regularly flooded, salt resistance plant species will need to be selected for urban green areas.


LG
HITACHI


DIRECTION 5
VCAPS- consortium

6.6 Direction 5: Create alternatives for groundwater use

Groundwater abstraction levels are currently well above sustainable levels. In 2005, daily groundwater extraction in HCMC was more than 600.000 m3. In addition, the paved area in HCMC is increasing, which decreases infiltration. As a consequence, deeper groundwater levels have been falling on average 2-3 meters per year[13]. Due to the drawdown of groundwater levels in the deeper aquifers, these aquifers become compacted resulting in land subsidence. Subsidence in its turn leads to flooding and water nuisance. Studies show that subsidence is most severe in the Holocene areas west and south of the city. Estimations of the subsidence rate range from 5 to 80 mm/year (Atlas, 2013 and FIM, 2013). To get a more accurate indication of land subsidence rates, more intensive research including monitoring is required.

Data on the current groundwater extraction amounts differ significantly (a rate of 86.000 m3 per day in official data, to 600.000m3 estimated in 2006) because the amount of unregistered extractions is not clear. To reduce subsidence, groundwater extractions need to be limited. Even after reducing groundwater use, the effects of subsidence will continue as long as the drawdown exists. Natural and artificial recharge may help to limit subsidence.

[13] Atlas, chapter 1.2.3

	Strategic Intervention	Term	Type	
5A 	Reducing demand and regulating use	Short term	No-regret	Measures are necessary in the current situation and in all scenarios.
5B 	Stimulation groundwater recharge	Short term	No-regret	Measures are necessary in the current situation and in all scenarios.
5C 	Upgrade water supply from Dau Tieng reservoir	Short term	No-regret	Measure is necessary to replace current groundwater use
5D 	Install and execute programme for sanitation and water quality improvement	Short term	No-regret, win-win	The current poor water quality has a high impact on ecological and living conditions in and around the city. In all scenarios investing in water quality will make using river water more economically attractive.
5E	Mitigate effects of subsidence on drainage system	Mid term		The possibility to invest in expensive mitigation measures will depend on the economic scenario. In LP3 and 4 such areas may be abandoned rather than upgraded.

5A Reducing demand and regulating use

In the short term, groundwater use should be strictly regulated in order to reach a sustainable level of abstraction. Lessons should be learned from e.g. Jakarta where uncontrolled groundwater extractions resulted in subsidence up to 20 cm/yr[14]. This means that:

- demand for groundwater should be reduced by stimulating water efficient techniques in industries to reduce their water footprint;
- groundwater use should be regulated so that it is only used for functions that require the highest water quality including consumption and high-grade industrial use;
- other users should switch to sources other than groundwater, e.g. surface water.

Implementing regulations on water use include introducing pricing mechanisms to cover maintenance and operation costs of the water supply system and to stimulate efficient water use. Introducing such a policy should take into account water supply for the poorest, as their means to pay for water are limited. To support efficient water use, the city should implement water conservation and reuse campaigns to raise public awareness regarding the necessity to reduce water consumption.

5B Stimulate groundwater recharge

As a high percentage of the inner-city of HCMC is paved area, the infiltration capacity is limited. Measures that are taken to increase water storage also result in an increase in groundwater recharge. In addition, possibilities for artificial recharge can be studied to increase the rate of recharge as natural recharge takes time.

5C Upgrade water supply from Dau Tieng reservoir

To meet the short term water supply needs for the city, the water supply infrastructure from Dau Tieng reservoir in the Saigon River should be upgraded. Water supply from local rivers would be more cost-effective due to shorter transport distances but the current water quality in the Saigon and Dong Nai Rivers is in many places very poor making conveyance of water from the reservoir necessary.

In the mid-term, salinity levels in local rivers will increase due to sea level rise (see Direction 4). The design of the water supply system should take these changes into account since several current water intake points are already threatened by salinity increases.

5D Install and execute programme for sanitation and water quality improvement

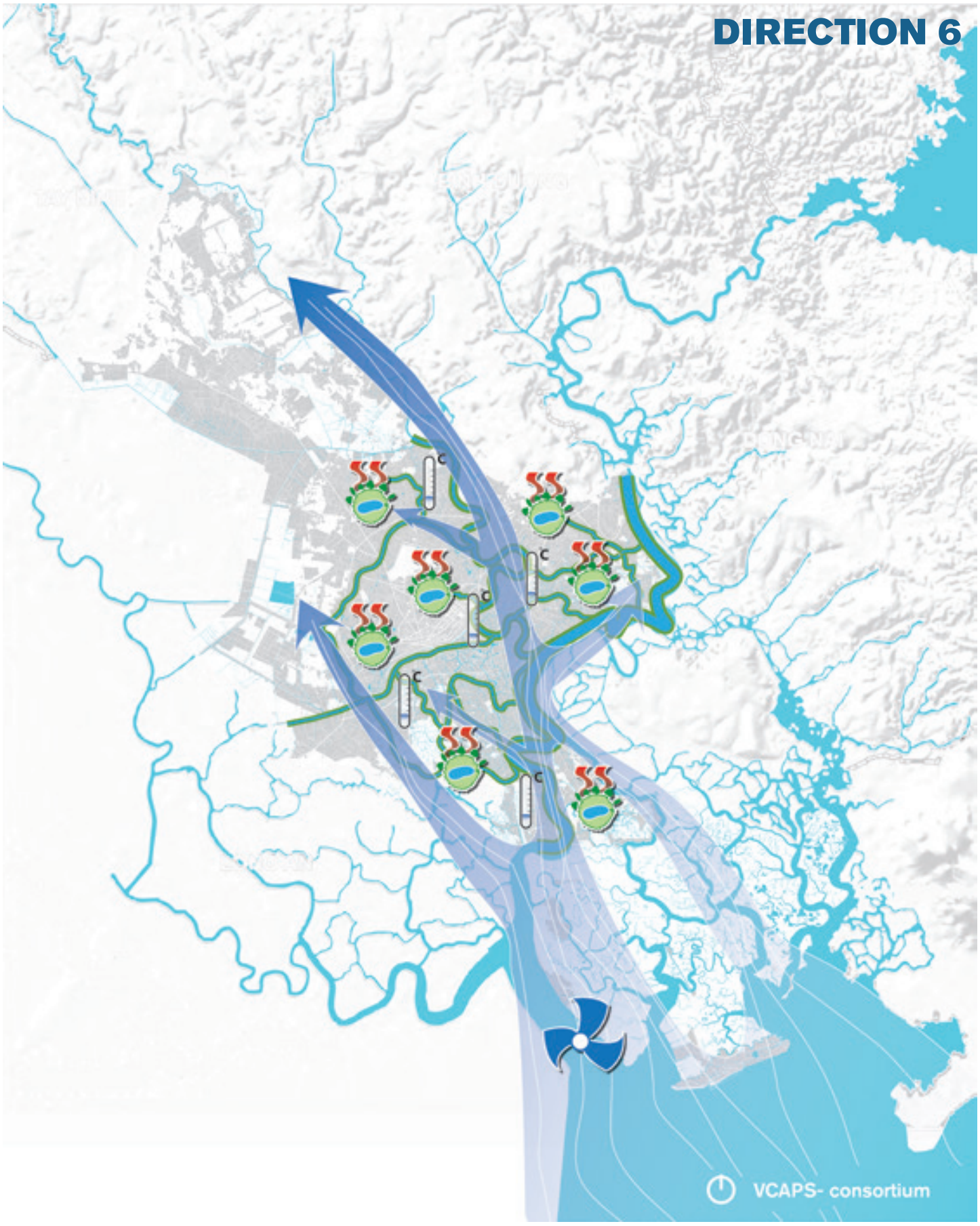
A fundamental problem regarding water supply is the poor surface water quality in the city. The quality is poor and does not meet current standards for water supply, and ecological and recreational purposes. Measures to improve water quality should be taken on the short and midterm.

Where feasible, relatively clean storm water should be separated from waste water. Separately collected waste water can be efficiently treated in treatment plants due to reduced volumes. As a result of separation, water quality in the rivers will gradually increase which has economic as well as ecologic benefits.

5E Mitigate effects of subsidence on drainage system

Even if through above mentioned interventions groundwater extraction is limited, subsidence will continue for years as a result of past over extraction. As a result of groundwater extraction, the drainage system will also subside and this will lead to depressions from which water is unable to drain naturally. Mitigation measures will be necessary on such locations to keep the city functioning, either by raising land in such location or by installing pumps to clear water.

[14] Atlas Jakarta Coastal Defence Strategy 2011, chapter 1.2.6


DIRECTION 6
VCAPS- consortium

6.7 Direction 6: Strengthen the blue-green network and 'urban ventilation'

Average HCMC temperatures are slightly increasing due to climate change (see table 4.1). Due to the "Heat Island Effect", the temperature in the city is significantly higher than the surrounding rural area (up to 10 degrees hotter[15]). The increase in temperature affects human health, increases air pollution and impacts the liveability of the city. In addition, the consumption of electricity for cooling increases significantly during high temperature. Energy demand is also soaring because air conditioning is becoming more affordable for a larger percentage of the people. For the above mentioned reasons, interventions are needed to reduce heat-stress in the city.

6A Use new urban development and re-development to strengthen the green-blue network

To improve the comfort for residents, measures should be taken to create cool microclimates in specific locations in the city. By employing shading and creating air flows, public spaces become more pleasant places. For instance, a shady boulevard along the river is a pleasant place to pass time on hot days. Creating a blue green network of parks, tree lined streets, boulevards, water fronts, fountains and water playgrounds can contribute to alleviating heat-stress. District and community parks also contribute to this network and can be combined with water storages.

6B Establish and implement green building codes

The design of buildings can help to provide a pleasant living environment as well. Green roofs, green facades and roof-top gardens provide natural cooling and also decrease the need for cooling inside buildings. White roofs help to reflect sunlight and therefore have a cooling effect and help to reduce the energy bill on cooling. Water storage on roofs (blue roofs) also has a cooling effect through evaporation and has the additional advantage in providing water storage.

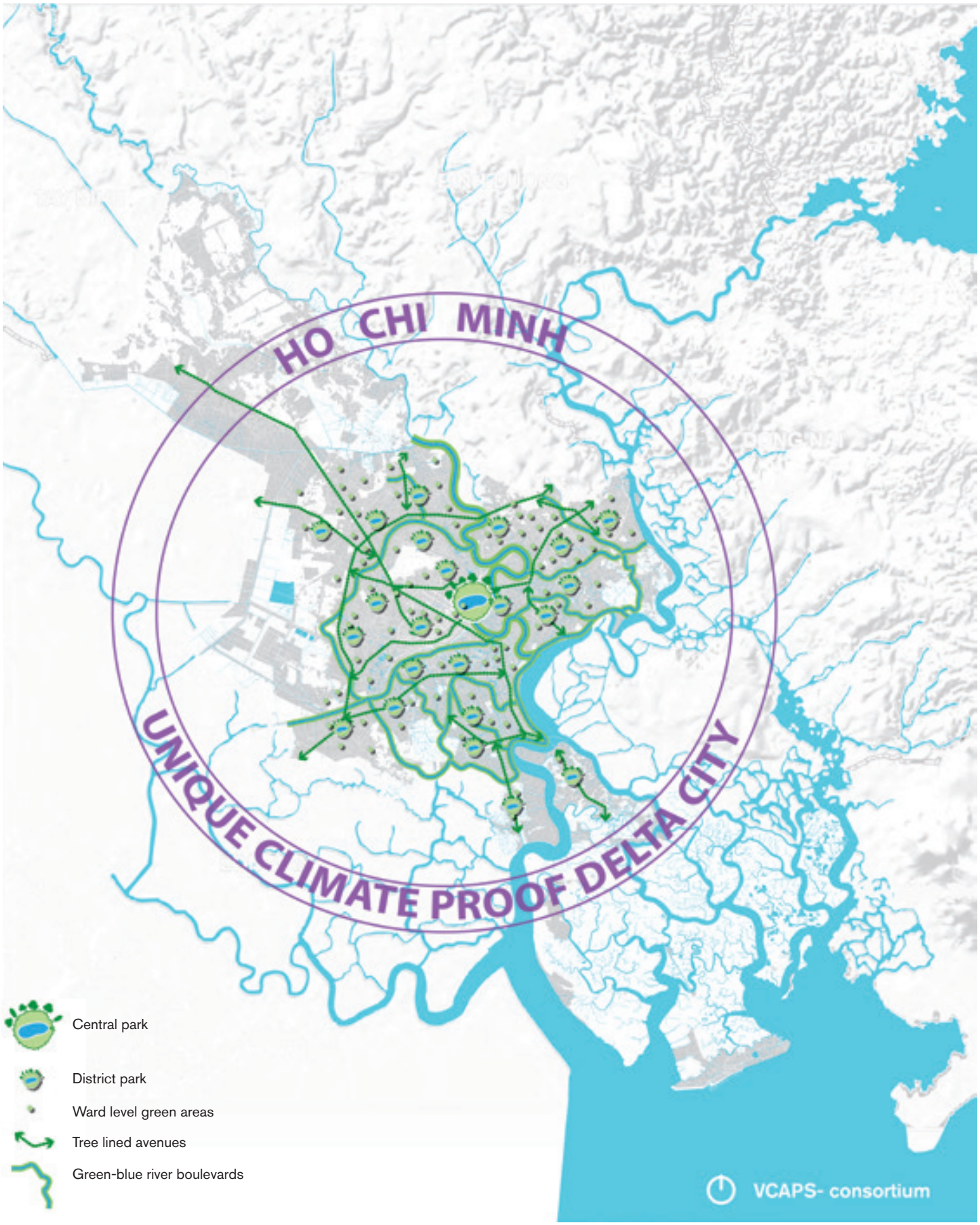
Heat proof architecture contributes as well. The thermal insulation properties of building materials and the promotion of natural ventilation in buildings can cool ambient temperatures. Government regulations to implement green building codes will be necessary.

6C Include measures for natural ventilation in master planning

On a larger scale, maintaining natural ventilation in the city is an important condition that should be included in city planning. High buildings can block natural air flows preventing the city from cooling. Planning of high rise building in relation to neighbouring structures should take into account the prevailing wind direction, and open spaces should be preserved to support ventilation.

[15] Atlas, chapter 1.2.3

	Strategic Intervention	Term	Type	
6A 	Use new urban development and re-development to strengthen the green-blue network	Short term	No-regret, win-win	In case of lower economic growth there is more space available for developing such measures. This measure is also a strong measure to add spatial quality.
6B	Establish and implement green building codes	Short term	No-regret, win-win	Many of buildings build today will still be there in 2050. The development stage offers the best opportunity to build climate proof. Adjustments in later stages are not always possible.
6C 	Include measures for natural ventilation in master planning	Short term	Avoid-regret	Once the urban structure is developed in a way that it blocks wind through the city it is difficult to change because of the large life span of buildings.


HO CHI MINH
UNIQUE CLIMATE PROOF DELTA CITY
Central park
District park
Ward level green areas
Tree lined avenues
Green-blue river boulevards
VCAPS- consortium

6.8 HCMC: becoming a Unique Delta City

The ambition of HCMC is to develop into a modern city in which the rapid economic development is managed in a sustainable manner by 2020. To realise sustainable development, it is essential to employ integrated action plans to adapt to climate change.

Climate adaptation however, should not be realised as an isolated goal. Far more interesting results are achieved when the HCMC also commits itself to the goal of adding quality to the already vibrant city. In each climate adaptation project, and during the implementation of each measure reaching both goals can be combined:

ADAPTATION MEASURES WILL MAKE HCMC A UNIQUE DELTA CITY.

Connecting Adaptation Measures and spatial development

Many districts will undergo considerable development changes in the coming decades. By incorporating climate change adaptation measures in urban (re-) development in an integrative manner, costs can be shared among sectors making implementation more feasible. In addition, newly developed buildings and infrastructural works that have a long life-span should already be climate proofed according to current best-practices. This is a no-regret measure as costly future refurbishing is avoided this way.

Multifunctional solutions often are win-win solutions. Integrating climate change through multifunctional measures makes implementation of these measures more accepted, affordable and more integrated into the future city.

Adding spatial quality

HCMC should use its position in the delta as a key element in its international image. To strengthen this image several water related icons can be developed including promenades along the rivers and waterways, iconic bridges and a central park.

Natural water systems should define the development of HCMC; let water be an integral part of its identity and visual qualities. Establish bridges as icons of a city blending with the water environment and develop shady promenades and boulevards along the main water courses. Especially where rivers and canals meet, opportunities exist to create attractive public spaces.

The Saigon River has the potential to become a key element in the image of HCMC. Parts of the city have not properly developed this natural heritage symbol and have instead made river areas more difficult to access and enjoy. Riverfronts in many other cities are popular locations for residents and tourist. As Thu Thiem develops in the coming years, the Saigon River will become more visible and a centre to city activities. It will become one of the city's most important public spaces.

In the development of a structure of green and blue spaces in the city, adding quality to the city and realising a climate proof urban environment go hand in hand. The city should develop based on a structure of green and blue spaces:

- A central park for the city as a whole;
- Additional green elements in the districts consisting of tree lined avenues;
- Each district has a multi-purpose park combining green areas with water storage
- Small green areas at the ward level

Delta dikes and water plazas

An example of a multifunctional measure is the creating of Delta dikes. Building is now often not allowed on dikes as this hampers future reinforcements. If extra robustness is added to the design of the dike, making it wider and higher, the dike will become climate proof. As a result it will not be necessary to raise the dike in the coming century. The space on top of the dike, usually including a river view, can be used for urban development.

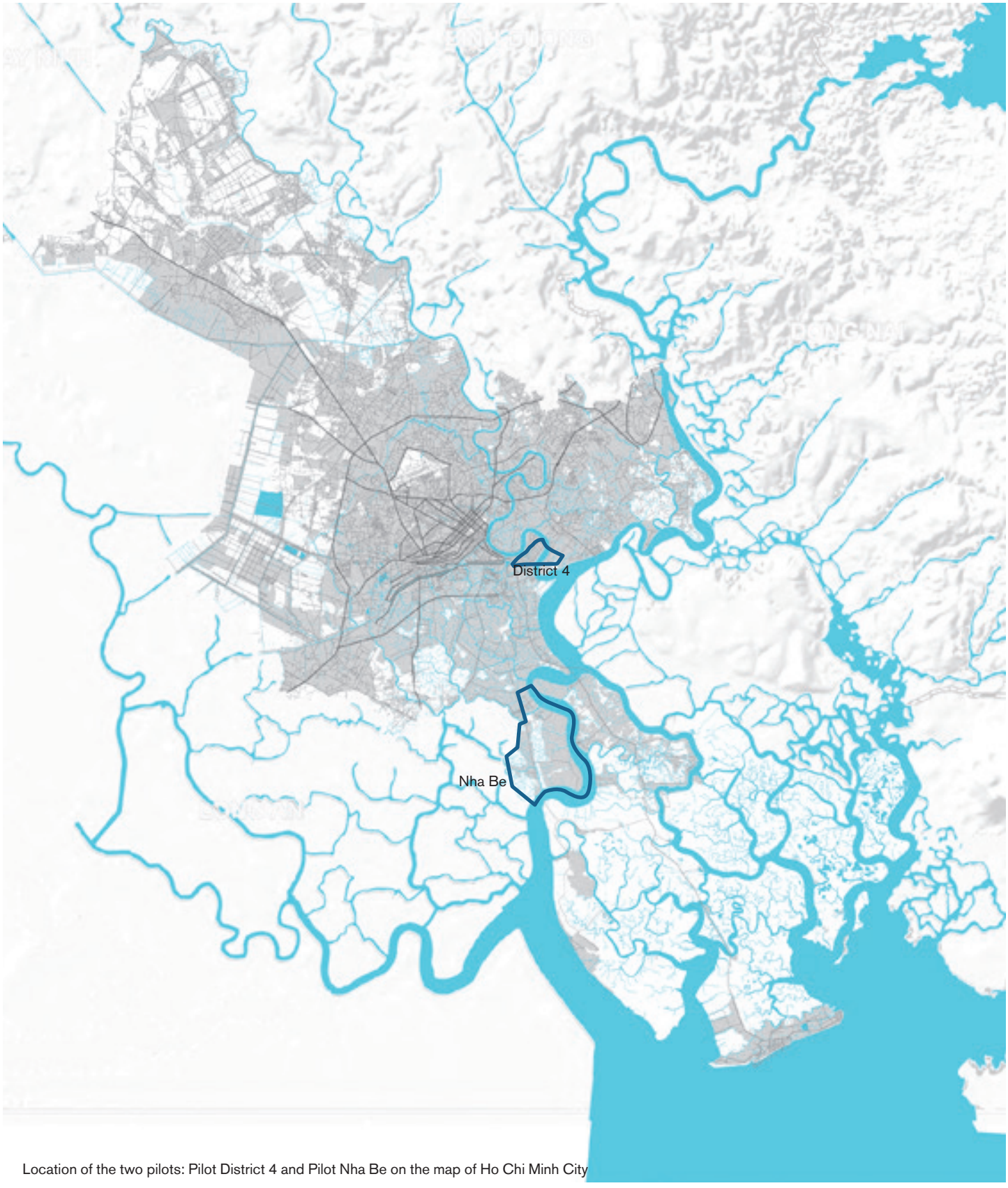
Another example is the development of water plazas. Goal is to add extra temporary water storage to urban areas by creating squares that can be temporarily inundated. This creates an interesting square, possibly even a water playground, that at the same time contributes to water storage in the city.

7 PILOT DISTRICTS

7.1 Approach

In the previous chapter, six Strategic Directions for climate change adaptation have been elaborated. The effectiveness of applying these Strategic Directions was tested in HCMC at two pilot locations on the district scale involving stakeholders from the districts. In group workshop settings and using an interactive process of sketching and drawing, possible climate proof designs have been tested to determine their applicability at the local scale. The basis for both pilot tests has been the draft Spatial master plan 2025 and its district level elaboration. A further output of the pilot test is to explore opportunities in urban re-development for applying the Strategic Directions to make the city climate proof and at the same time more attractive.

Two pilot locations have been selected that are instrumental in the relocation of harbours towards the sea: district 4 and Nha Be district. District 4 represents a dense inner-city area that will be undergoing redevelopment. The space that becomes available upon departure of the port facilities offers opportunities for climate adaptation measures contributing to urban improvement and attractiveness at city scale. Nha Be is located in a low lying area south of the city where new harbours, industries and residential neighbourhoods are being developed. Most of this location will be outside possible ring dikes and therefore will require adaptive solutions for development of infrastructure and housing.



Location of the two pilots: Pilot District 4 and Pilot Nha Be on the map of Ho Chi Minh City

7.2 District 4

Characteristics

District four is a densely populated inner-city district, separated from district 1 by the Ben Nghe canal. The district has several different physical features and is changing and redeveloping rapidly.

Bordering the Saigon River a harbour zone with many old, historical warehouses is located. The river front is sealed off from the rest of the district by harbour activity. Currently, the harbour is being relocated towards the sea to amongst others the Hiep Phuoc area in Nha Be district.

District 4 is characterized by its bustling and traditional street life. It is well appreciated by residents for its many markets and road side restaurants which give the area its distinct atmosphere. Many small streets dominate the western part of the district. Along the canals and in the south west part of the district, slum developments are present.

Because of its central location, heavy traffic is predominant in parts of the district and therefore adversely affecting the quality of the area. Even though the district is located along the Saigon River, the original waterways and water networks such as creeks and small canals are hardly recognisable anymore. Very little natural surface water remains in the district.

Spatial master plan district 4 2010-2020

Based on the draft Spatial master plan 2025 , a master plan for district 4 for the period 2010-2020 was drafted. District 4 is to be part of the city centre of HCMC together with districts 1 and 2. The plan indicates that residential and commercial functions as the main functions of the area. The north-south orientation of infrastructure is dominant in the area including a metro line and the upgrading of roads. In addition a new connection will be made with district 2.

The master plan divides the district into three clusters:

- The southwest: This part of the district is dominated by residential functions and public services. In this area a cultural and sports centre is developed.
- The northeast: Also this area is dominated by residential and commercial functions. In addition this area houses central administration functions and the administration of the province. Also healthcare services are provided in this area.
- The southeast: Besides commercial activities, public works and the provincial administration is housed here.

The outplacement of the harbours along the Saigon River is part of the master plan for district 4. In the vision of the master plan, the area between the river and Nguyen Tat Thanh road will be developed as the prime location for commercial services and office buildings. In addition space is reserved to develop a boat terminal to service local and international tourists. Along the river, open public space with trees will be created to offer the inhabitants of the district recreational options.
A large park will be developed in the district. In addition, 5 to10 percent of the surface of projects will be reserved for urban green.

Impacts of climate change

Floods caused by rainfall and tides occur regularly in this area. Due to malfunctioning of the drainage system, high tides cause floods when river water via the sewage system flows backwards into the streets. At exceptional high tides, river levels exceed the heights of the dikes surrounding district 4. This flooding leads to damage to properties and goods.

As indicated in chapter four, the sea level is expected to rise from 28 to 33 cm by 2050. As a result, the frequency and depth of floods will increase. Since

the economy and investments in district 4 are growing, the monetary damage caused by floods will increase.

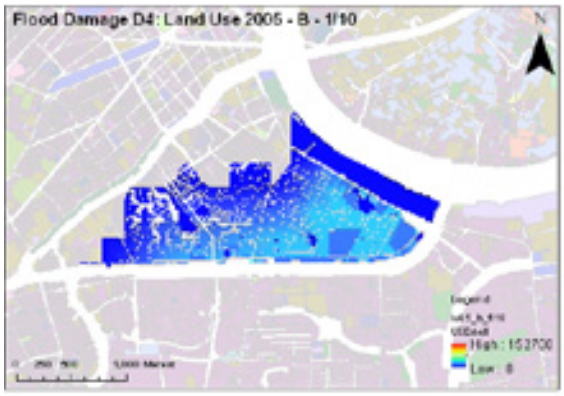
Current and projected future damage caused by river floods has been calculated for various flood return periods as indicated in the table below (Lasage et al., in prep). The calculations are based on the current situation, the land use map 2005, a 30 cm Sea Level Rise (SLR), and land use as forecasted in the master plan 2010-2025.

The calculations show that if no measures are taken, sea level rise will dramatically increase damage in district 4. The damage caused by floods with a return period of one in 10 years rises from 82 to 488 million USD; the damage for a flood with a return period of 50 years rises from 138 to 627 million USD. Currently, certain areas suffer little monetary flood damage (low invested capital and/or flood levels). However, almost all of district 4 will be heavily impacted by floods in 2050 if climate adaptation interventions are not implemented.

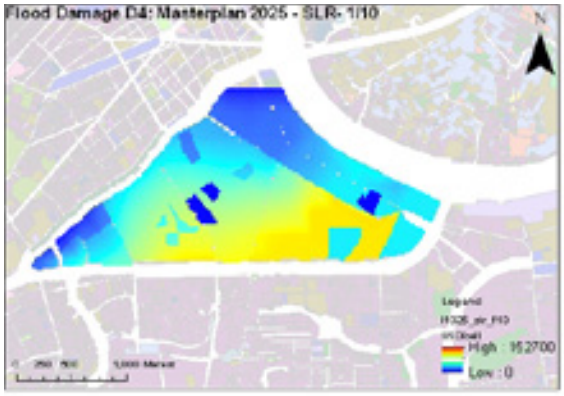
Current and projected future damage of flooding to District 4[16]

Return period	Land Use 2005, current sea level Damage cost (million USD)	Land use 2010-2025, Sea Level +30 cm Damage cost (million USD)
1/1000	$ 249,5	$ 706,5
1/100	$ 173,5	$ 626,7
1/50	$ 137,7	$ 564,3
1/25	$ 114,7	$ 537,8
1/10	$ 81,9	$ 487,8

[16] after: Lasage, R., Veldkamp, T.I.E., Van, T.C., Aerts, J.C.J.H., Phi, H.L., Vellinga, P., (in prep). Participatory development of adaptation strategies for HCMC, and their effectiveness.



Flood damage D4, landuse 2005, 1/10 return period



Flood damage D4, landuse masterplan 2025, 1/10 return period

Climate proof design

The river front

The areas along the Saigon River in district 4 are developing rapidly. The harbours and warehouses are being relocated towards the sea making prime river front locations available. With the development of Thu Thiem on the opposite site of the river and the close vicinity of district 1, the district 4 riverfront will become a key location for high rise buildings.

In the midterm planning horizon, however, this riverfront location will be required for the construction of the ring dike to protect the city. Integrating this ring dike in the climate adaptation design is considered a low regret measure. As part of the ring dike, building high rises on a multifunctional dike provides double safety for these large investment projects since sea level rise will directly endanger these locations.

The design of the river front offers many opportunities to strengthen the aesthetic identity of HCMC as an unique urban area along the Saigon River. The river front will become an accessible public space again. It is envisioned that the area will become a shady location to relax, while enjoying the view over the Saigon River with the high rises of Thu Thiem forming the background in the distance. On hot days the breeze that comes into the city over the river makes this place even more enjoyable.

The buildings constructed on the dike could be developed as partly low-rise and partly high rise; a mix between modern, iconic buildings and restored old warehouses bringing charm to the area. By leaving spaces open between the high rise buildings, natural ventilation corridors will be formed for cooling the remaining parts of the district. A new road and bridge will connect district 4 with Thu Thiem and will serve as a new icon for the city.

In 2025 many more vehicles will run through the city, and especially through district 4. It is proposed that an eight lane road will be integrated in the design of the multifunctional dike to alleviate the adverse impacts of increasing vehicular traffic. This leaves space for parks on top.

A ring dike for water safety

Protection against flooding in district 4 cannot wait for the ring dike to be finished. Already today considerable damage occurs, and with increasing investments short term action is necessary. Flood protection can be increased on the short term by creating a medium sized dike around district 4.

When the larger ring dike, including tidal gates, around the city is finished the smaller local dike will still have a function. By creating the small dikes, extra storage capacity is added to the canals along the district. Under water slopes stimulate the growth of natural vegetation. This results in a more attractive scenery and helps purifying the water.

Blue green spaces

Urban redevelopment can be planned to increase water storage areas in the district. A district park will be created in the western part of the district. Remnants of old creeks will be upgraded for storage of excess water. Each neighbourhood will have its own park with the dual function of water storage during rainy days and a place to cool down during hot climatic periods. In addition, green facades and blue or green roofs will be incorporated into the architecture of the area.

Market Street

Street life, markets and road side restaurants are the urban amenities that will be preserved in district 4. These amenities attract residents and tourists to district four. The market will be relocated to a new location to create space for dense urban redevelopment. A new market and market street will be integrated in the design. The market street will be multi functional; beneath the street level, large rainwater storage areas will be constructed to help manage flood waters.

Creating density, preserving character

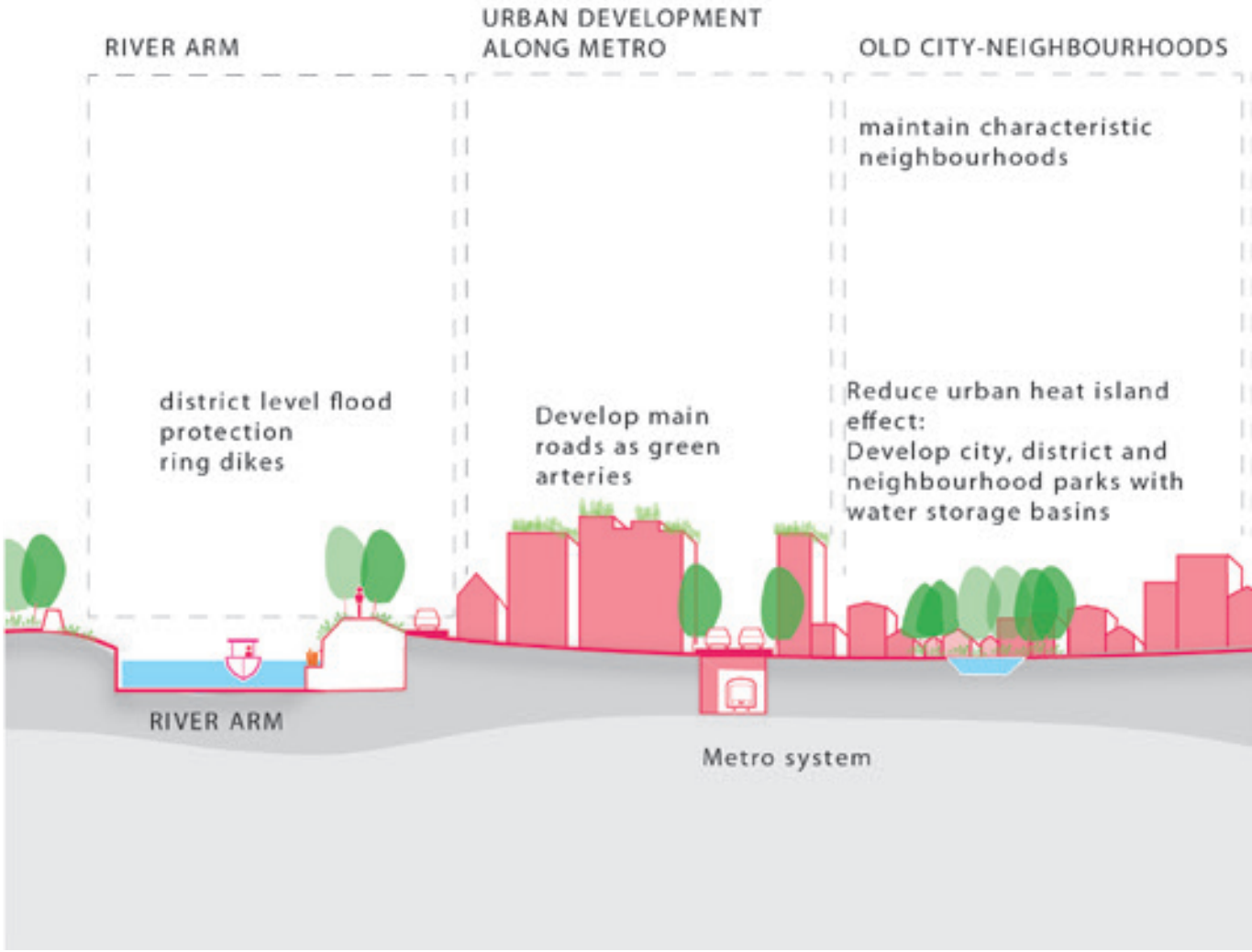
To accommodate the city's population growth, the density of the inner city will increase. As good building locations outside of the city are becoming scarce, restructuring the inner city is the most feasible solution. Important is preservation of historic and heritage areas.

High rise buildings will be situated in the west of the district between the river and the market street, surrounding the district park. The existing traditional streets will be preserved. Around the market, the original grid street pattern will be preserved.

Metro and green arteries

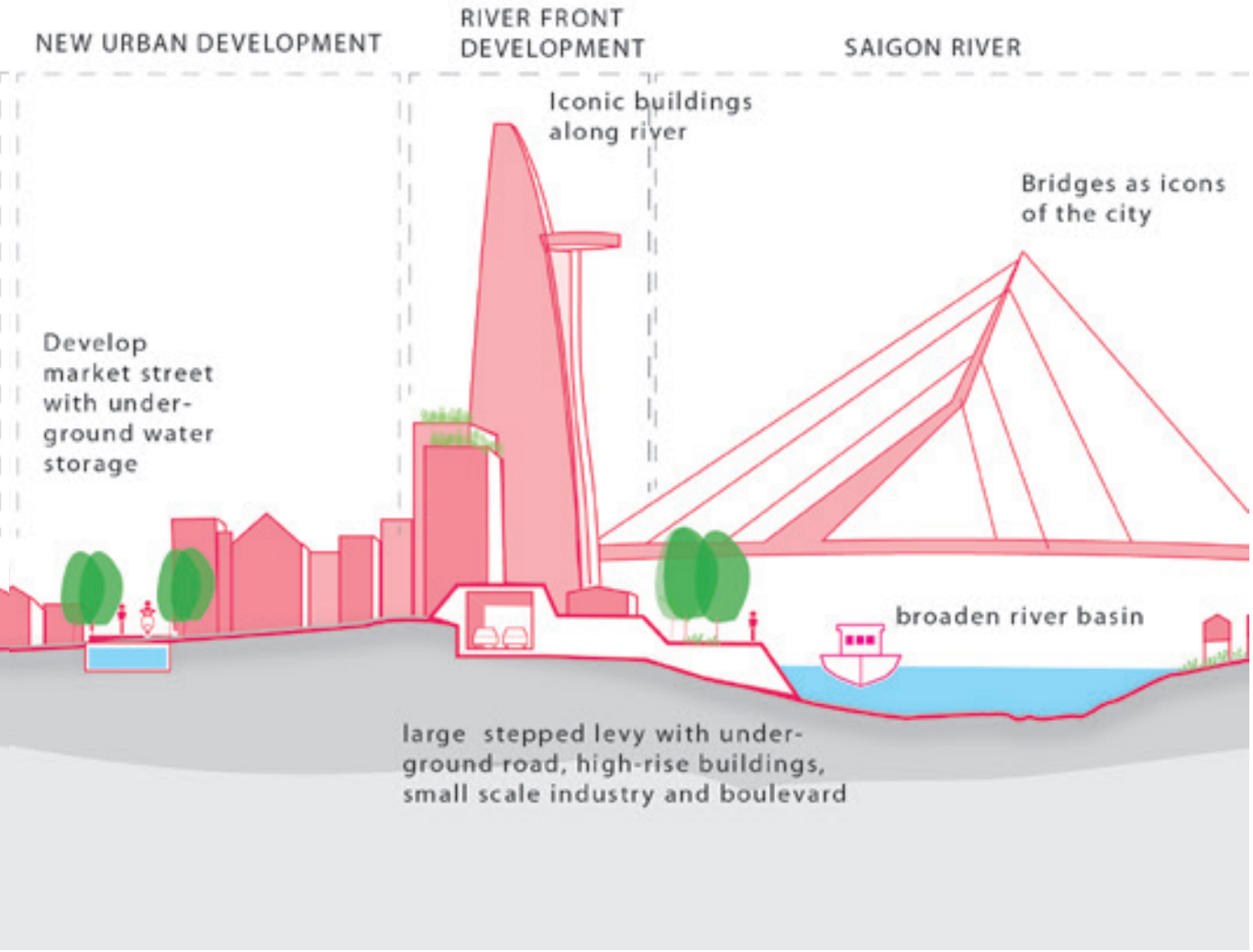
Increased urban density requires the support of a modern and multimodal public transportation system. Possibly, vehicles in the future could be restricted from parts of the city. A metro line will connect district 1, 4 and 7. Additional urban density will be created by high rise buildings located along these new transportation corridors. The roads in the district will be green arteries for transportation. Where possible, extra trees will be aligned along the main boulevards creating shade and a cool environment.

CLIMATE PROOF DESIGN DISTRICT 4



Cost benefits analysis

A first qualitative Social Cost-Benefit Analysis (SCBA) of climate proofing district 4 has been performed. The main question to ask in this context is how the benefits that adaptation measures will bring to society relate to the costs of their implementation and maintenance. The objective of a SCBA is to have insight into all costs and benefits for society as a whole, including external social and environmental costs and benefits. In the table below the main costs and benefits of the climate proofing the district that have been identified are summarized.



Costs are related to the following measures	Benefits of climate proofing
• Multifunctional stepped levy along Saigon River in combination with underground road • Embankments along canals (ring dike) • Water storage in parks • Water storage underneath market street • Trees along boulevards, parks, • Green roofs, blue roofs and green facades in buildings.	• Flood risk reduction. The benefits are determined by calculating the difference in expected flood damage with and without structural flood defense measures • Better living environment because of a reduction of water nuisance; the effects of inundation from precipitation • Better living environment because of a moderation of urban heat waves which have negative impacts from temperature rise on human health • Increased accessibility through improvement of transportation networks • Improved business and investment climate; improved living and working conditions attract businesses and increases land and property values

Accurate cost estimates of the measures are currently not available, but flood mitigation measures require significant investments. Based on secondary cost information the (discounted) costs could run as high as 110 - 130 million USD. For this study, the total discounted (investment and operation and maintenance) cost estimates from the flood inundation model study have been taken as a base[17], of which a proportionate share have been assigned to District 4.

Many of the mentioned measures taken in the urban environment would also be taken in the 'without CAS' situation. This means that the extra costs for climate proofing of the urban environment are relatively small. All flood damage that is prevented by the implementation of measures in district 4 can be considered benefits. The flood risk reduction is estimated at (discounted) 1.4 billion USD[18]. Also travel costs savings are a considerable and quantifiable benefit.

[17] See FIM-report for costs estimates for MARD variant, an indicative 5% of the costs has been assigned to District 4.

[18] Avoided flood damage for the period 2025 – 2100 discounted to 2013.

The benefits of the investments can be expected to outweigh the costs. The reason for this is that the CAS contributes to solving some major problems for the future of the area, namely flooding, heat waves and increasing congestion.

There is insufficient data however in this stadium to substantiate this conclusion with calculations of costs and benefits. It is recommended to gather more and better detailed information for the most important value components. Good quality data is needed for drawing robust conclusions regarding the economic efficiency of implementing CAS.

Conclusion

Combining city development and the Strategic Directions have led to an adjusted and climate proof design for district 4 with most likely a positive cost-benefit ratio. Urban redevelopment and restructuring are seized as opportunities to make the city climate proof and at the same time more attractive. The different options that are still under discussion for larger scale solutions will be compatible with the described approach for district 4.

7.3 District Nha Be

Characteristics

Nha Be district is a rural district in transition. The district is one of the lowest in the city and located close to the sea. The influence of the sea is very noticeable. Through many creeks high tides intrude deep into the land causing regular inundations. The area can be divided in two parts: the quickly urbanising northern part where residential neighbourhoods dominate and the southern part that focuses on harbour and commercial developments in Hiep Phuoc and related residential neighbourhoods. The pilot focuses on the southern part of the district.

Large parts of the pilot area are still in agricultural use at this moment. Fish and shrimp ponds and rice fields dominate the area. The communities that are present in Nha Be at this moment cope with the floods that regularly occur in this area. Houses are built a little higher above the ground surface, entrances are elevated, floors are raised and wet proof materials are used on the ground floor level. The main roads into the area have also been raised several times over the years.

In the north of Hiep Phuoc the development of harbours and commercial zones has already started. A modern container port has been constructed to replace harbours in district 4. A new road has been constructed connecting the commercial zones with the city. This road is being extended towards the south to connect to the future ring road four.

Downstream of Hiep Phuoc, the Saoi Rap River is not navigable for the larger ships at this moment. Ships enter to Hiep Phuoc port through the Can Giao mangrove forest. Plans exist to dredge the river downstream of Hiep Phuoc.

Spatial master plan 2010-2020 for Nha Be

In the spatial master plan 2010-2020 the southern part of Nha Be, which is the pilot area, consists of the Hiep Phuoc Industrial area along the Saoi Rap River and a residential neighbourhood west of this area. The industrial area consist of a 335 hectare port with an expected capacity of 130 million tons/ year, industries, warehouse areas and petroleum storage.

The current main road, Nguyen Van Tao, is upgraded and serves as the backbone of the area. This road is connected to ring road 3 in the north and to ring road 4 in the south. In addition plans exist to build a dedicated railroad to Nha Be area to ensure the transportation of large volumes of goods.

The largest creeks are preserved in the layout of the Spatial master plan 2010-2020. Hardly any space is reserved for agriculture, the complete area between the main road and the river is assigned as development area for the Hiep Phuoc industrial area.

Impacts of climate change

Nha Be has a strong relation with the sea. Tidal fluctuations impact daily lives, especially when tides reach peak highs from October till February. The area already is inundated regularly, especially when peak discharges on the river and high tides coincide. When sea level rises, the local measures that people have taken against flooding (wet-proofing, dry-proofing houses) will no longer be sufficient as floods are becoming more frequent and inundation depths increase. In addition the ground in the area is vulnerable for subsidence. Predictions made with a groundwater-subsidence model show 20 to 40 cm subsidence in the period up to 2050[19].

At this moment not sufficient data is available to predict current and future damages caused by flooding.

Location of a ring dike

Nha Be is very vulnerable for sea level rise, flooding from rivers and soil subsidence. Therefore, according to the first Strategic Direction of the strategy the main direction of urban development should be towards the north and east. Expansion towards the south should be limited as the impact of climate change here will be considerable. The development of Nha Be should not primarily be focused on large scale residential and industrial areas, but rather on facilitating supportive functions for Hiep Phuoc port.

An important choice will have to be made: how to realise the desired flood protection level in Nha Be? Nha Be could be enclosed in the city ring dike but this will stimulate further urbanisation and population growth. Another option is to leave this area outside the ring dike, requiring local and adaptive water safety solutions.

The decision on the location of the ring dike will have a considerable impact on Nha Be and the pilot area. Here we study two alternatives:

- Option 1: Pilot district is partly protected by the ring dike and within the protected area the city expands.
- Option 2: The ring dike follows ring road three, leaving the pilot area mostly outside of the dike. Protection from flooding is realised with adaptive measures, decreasing the vulnerability.

[19] Royal HaskoningDHV, Ho Chi Minh City Flood Inundation Project, Final report, January 2013

A climate proof design – option 1

Ring dike and shelter

The western part of the pilot area is protected by the ring dike system that protects HCMC. This dike will be located just behind the current settlements along the central road (Nguyen Van Tao). At places where the main creeks intersect with the dike, tidal gates will be installed, allowing rain water to drain from the area at low tide and protecting the land behind the dike at high tide. A high shelter is located in the town. In case the dike does breech in an extremely rare event, this is still a safe place to go and therefore will reduce casualties in such a case.

1A - Protection through ring dike and shelter

Elevated ports and industrial areas

Ports are constructed all along the river. These ports are built on elevated land. The height of these elevations take into account the rising sea and river water levels and, especially in the south of the pilot area, the effects of subsidence. Water related industries and harbours are located on the water's edge. Industrial parks are located behind, also on elevated land.

1 B - Elevated ports and industrial areas

Blue green area

The natural water system is preserved as much as possible. Along the waterways a green blue area is located that has several functions. This green-blue area is directly connected to the river and therefore provides room for the river. In addition this area alleviates heat stress and provides recreational opportunities.

The blue green network provides the framework for the indusial area: a blue green 'glass in lead' structure. This is also the system to which the industries and residential neighbourhoods drain rainwater. Behind the dikes the same structure provides rainwater storage capacity during high tides when the tidal gates are closed. The blue green structure is designed to provide for natural ventilation and to reduce heat stress. In the blue green zone, no buildings should be situated unless they are built on poles: no slum developments but interesting architecture is envisaged.

1 C - Multifunctional blue-green area

Smart dredging

The necessary dredging for the harbours in the pilot area should take into account the effects of salt intrusion. Dredging to different depths and creating underwater steps helps to reduce the effects of salt intrusion. One of the characteristics of salt water is that it is heavier than fresh water; salt water therefore stays at the bottom of the river or channel.

Water treatment

In the pilot area rainwater and waste water will be separately collected. Industrial wastewater will be treated in the treatment plant of the industrial park. Local waste water treatment facilities will be installed in the residential areas.

1 D - Smart dredging and water treatment

Residential neighbourhoods and recreation

In design option 1, a choice is made to develop a ring dike. This stimulates population growth in the area as the area becomes safer. Only with a large growth in population including this area in the ring dike will be cost-effective.

In all of the area, rainwater is mostly drained to the surface water. Extra temporary water storage is necessary in residential neighbourhoods to store water during high tides. These rain water storage facilities should be designed taking into account health requirements.

Nha Be district, close to the sea, close to the mangrove and with beautiful river views also has potential from a recreational and touristic point of view. This potential can be developed to further exploit the connection that the area has with the river.

CLIMATE PROOF DESIGN NHA BE - OPTION 1

1 E - Residential area and recreational opportunities

A Climate proof design – option 2

Development without a ring dike

In this option, the ring dike around the centre of HCMC and ring road three are partly integrated. The advantage of this option is that construction costs for the ring dike will be lower as it is shorter and as construction is combined with the ring road. As a consequence, the southern part of Nha Be district will find itself without protection from the ring dike. Industrial and harbour activities will be developed as in option 1. Improved public transportation facilitates workers to live further from to the factories they work in. The vulnerable residential and agricultural area will, in line with the first Strategic Direction 1, be developed less densely.

2 A - Adaptive development with a ringdike

Flexible growth

Current residential areas will be climate proofed by measures that increase resilience against flooding and conserving the current hydrological system and infiltration capacity as much as possible to limit further subsidence. Houses will be relocated on mounds or built on stilts. Dry proofing and wet proofing solutions can be chosen to provide additional security. Infrastructure is adapted to be able to withstand incidental inundation. A shelter provides additional safety for extreme events.

Housing is concentrated on a few specific locations. In between, with time, the influence of the sea will increase. Agriculture adapts to changing circumstances and increasingly focuses on brackish aquaculture.

2 B - build on small in various densities (max 5 stories)

If demand for land will remain high in the future, incremental growth in the south might become inevitable. Extra mounds can be created in an attractive blue green living environment. Between mounds aquaculture might be replaced with nature, parks and recreational functions that can cope with periodical inundation. In some areas mounds with touristic or recreational functions might become feasible.

A green blue network

The drainage system in the area will largely remain as it is today. Rainwater is drained to the creeks and rivers where it is transported to the sea by tidal movement. The connection of the area with the water will remain very strong as the movement of the tides is visible in all the area. As the area is not cut-off from the river by a ring dike, sedimentation still naturally takes place in the regularly inundated areas. Salt levels will rise and therefore vegetation with a high tolerance should be applied in public green.

Water supply solutions

Currently many illegal wells exist in rural areas resulting in subsidence. Households should be connected to the communal supply network to prevent subsidence. Rainwater should be used where possible to reduce demand. Rainwater can be infiltrated and stored in the mounds that will be developed. This infiltrated rainwater and can be reused for several domestic uses as an alternative for the use of tap water.

2 C - …..When necessary new mounds are added…….

CLIMATE PROOF DESIGN NHA BE - OPTION 2

2 D - Fresh water stored in mounds.


VCAPS- consortium

7.4 Conclusion

Testing the implementation of the Strategic Directions in district 4 and Nha Be has resulted in various examples for climate proof design.

In the table below the main observations regarding the implementation of the individual Strategic Directions are given.

Strategic Direction	Conclusion based on application in pilots
1. Base development direction on soil and water conditions	• District 4 offers many opportunities to further increase city density. In this way unnecessary expansion of the city can be prevented. • Following this Strategic Direction means adjustment of the current master plans of Nha Be where large scale residential developments are projected.
2. Use a step wise approach for flood protection	• Integration of the ring dike in the water front of district four is possible in a way that adds quality to this area. Multi functional use of the river front space seems necessary. • For Nha Be district the choice of the location of the ring dike is essential. The pilots have shown that development without a ring dike is very well possible here.
3. Increase the water storage and drainage capacity	• Integrating water storage in this dense inner-city area is challenging. With technical measures (underground rain water storage, blue/green roofs) and by integrating storage in parks and public greens extra rain water storage is created. • If Nha Be is included in the ring dike, more rainwater storage will be necessary. This is required to be able to store rainwater during high tides when the tidal gates are closed. As the city will rapidly develop within the new ring dike, pressure on these areas for water storage will be considerable. In option two there will be no need for storing rainwater to prevent inundation as the pilot area is connected to the sea and very much under influence of the tide. Water is stored in mounds to reduce the need for water supply from outside.
4. Prevent salinisation where possible, adapt where necessary	• No specific measures against salt intrusion were integrated in the design of district 4. • Salt concentrations in Nha Be will depend on whether or not large scale tidal barriers will be constructed. Agriculture and public green will have to adapt to higher salt concentrations.
5. Create alternatives for groundwater use	• Preventing river pollution is the largest contribution that the re-development of district 4 can make. For water supply the district is depending on the large scale choices made in this respect (see Strategic Intervention 5C). • In Nha Be the connection rate to the communal water supply should be increased as an alternative for illegal wells. Rainwater should be used where possible with regards to the quality of rain water.
6. Strengthen the blue-green network and 'urban ventilation'	• In district 4, extra green space can be created on roof tops and by integrating this in the design of the multi functional ring dike. Urban ventilation can be stimulated by taking into account the prevailing wind direction in the design of high rise areas. • In Nha Be the natural blue-green structure is still very present. Using this structure as a basis for urban development offers possibilities for climate proof development.

Based on the experiences in the pilots it is recommended to make a climate adaptation analysis for each districts in HCMC by using Charrettes. The Charrettes, or interactive design workshops, has proven to be an effective tool to develop integrated designs for climate proof districts involving knowledge and experience from stakeholders in the districts. The results of the climate adaptation analyses on the district levels provides input to climate proof district scale master planning.

Throughout the world, many innovative solutions have been developed to climate proof a city, district, ward or house. A useful tool to assist the districts of HCMC to climate proof their plans would be to develop a toolbox that districts can use to identify suitable measures for the challenges they face. A first model of such a toolbox has been developed in the project and can be elaborated to become a fully operational toolbox. The toolbox provides inspiration and new solutions that can be implemented through interactive design workshops.

The pilot elaborations have shown the advantage of working on the district scale, in a bottom-up process. This way local experiences can be integrated in master planning. Work on the district scale can start right away: by starting now, quick wins can be realised and the results can contribute to the master planning on the city scale. Therefore it is highly recommended that an organisation is made responsible for the coordination and implementation of the climate adaptation strategy on the different scale levels.


3

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COLOFON

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Dutch VCAPS consortium:

Mr. Enrico Moens	*Grontmij Netherlands*
Mr. Alex Hekman	*Grontmij Netherlands*
Mr. Martijn Steenstra	*Grontmij Netherlands*
Mr. Frank Vliegenthart	*Grontmij Netherlands*
Mr. Arno Kops	*Witteveen+Bos*
Mr. Steven Slabbers	*Bosch Slabbers Landscape + Urban Design*
Mr. Stijn Koole	*Bosch Slabbers Landscape + Urban Design*
Mr. Pier Vellinga	*Institute for Environmental Studies VU Amsterdam*
Mr. Jeroen Aerts	*Institute for Environmental Studies VU Amsterdam*
Mr. Ralph Lasage	*Institute for Environmental Studies VU Amsterdam*
Mr. Leo Beumer	*Ecorys*
Mr. Manfred Wienhoven	*Ecorys*
Mr. Atze Verkennis	*Ecorys*
Mr. Rik Frenkel	*Triple-A team*
Mr. Frank van Paassen	*Triple-A team*
Ms. Nguyen Thi Cam Tu	*Grontmij Vietnam*
Mr. Wayne Stone	*Grontmij Vietnam*
Ms. Giao Lan Phuong	*Grontmij Vietnam*
Mr. Pham Tan Ha	*Grontmij Vietnam*

With support from:

Mr. Martijn van de Groep	*Partners for Water*
Ms. Chantal Oudkerk Pool	*City of Rotterdam*
Mr. Arnoud Molenaar	*City of Rotterdam*
Mr. Peter van Veelen	*City of Rotterdam*
Ms. Jose Kooi	*Rotterdam University*
Mr. Frits Dirks	*Royal HaskoDHV*
Ms. Welmoed Visser	*Grontmij Netherlands*

Vietnamese team:

Mr. Nguyen Van Phuoc	*Department of Natural Resources and Environment (DoNRE)*
Mr. Nguyen Van Nga	*Department of Natural Resources and Environment (DoNRE)*
Mr. Ha Minh Chau	*Department of Natural Resources and Environment (DoNRE)*
Ms. Vu Thuy Linh	*Department of Natural Resources and Environment (DoNRE)*
Mr. Nguyen Huy Phuong	*Department of Natural Resources and Environment (DoNRE)*
Ms. Nguyen Thi Thu Hang	*Department of Natural Resources and Environment (DoNRE)*
Mr. Bui Nhat Truong	*Department of Natural Resources and Environment (DoNRE)*
Mr. Le Trung Tuan Anh	*Department of Natural Resources and Environment (DoNRE)*
Mr. Nguyen Xuan Hoang	*Department of Agriculture and Rural Development (DARD)*
Ms. Nguyen Thi Phuong Thao	*Department of Agriculture and Rural Development (DARD)*
Mr. Huynh Thanh Tu	*Department of Agriculture and Rural Development (DARD)*
Mr. Le Viet Bao	*Department of Agriculture and Rural Development (DARD)*
Ms. Vo Thi Mong Thu	*Department of Agriculture and Rural Development (DARD)*
Ms. Nguyen Minh Ly	*Department of Agriculture and Rural Development (DARD)*
Ms. Dinh Thi Huong Lan	*Department of Transportation (DoT)*
Mr. Pham Quoc Huy	*Department of Transportation (DoT)*
Mr. Nguyen Xuan Hien	*Department of Transportation (DoT)*
Mr. Le Phung Vinh An	*Department of Transportation (DoT)*
Mr. Dang Van Pho	*Department of Construction (DoC)*
Ms. Nguyen Thi Thanh Van	*Department of Zoning and Architecture*
Ms. Le Thi Phuong Truc	*Steering Centre for Flood Control (SCFC)*
Mr. Phan Anh Tuan	*Steering Centre for Flood Control (SCFC)*
Mr. Nguyen Phan Hong Viet	*Steering Centre for Flood Control (SCFC)*
Mr. Nguyen Phi Hung	*Steering Centre for Flood Control (SCFC)*
Ms. Hoang Thanh Thuy Nhien	*Department of Construction (DoC)*
Mr. Phan Truong Son	*Department of Construction (DoC)*
Ms. Do Thi Buoi	*Department of Construction (DoC)*

With support from:

Mr. Ho Long Phi	*Vietnam National University of Ho Chi Minh City*
Mr. Ly Khanh Tam Thao	*Department of Zoning and Architecture (DoA)*
Mr. Nguyen Trong Hoa	*Institute for Development Studies of HCMC (HIDS)*
Mr. Vo Cong Hoang	*HCMC University of Water Resources (WRU)*
Mr. Trinh Cong Van	*Institute for Water and Environment Research, (WRU)*
Mr. Nguyen Ngoc Anh	*Southern Institute for Water Resources Planning (SIWRP)*
Mr. Nguyen Xuan Hien	*Southern Institute for Water Resources Planning (SIWRP)*
Mr. Bao Thanh	*Sub-Institute of Hydro-Meteorology & Environment of South Vietnam*
Mr. Che Dinh Ly	*Institute for Environment and Natural Resources (IER), Vietnam National University of HCMC City*
Mr. Do Thanh Vu	*Saigon Premier Container Terminal (SPCT)*
Mr. Nguyen Chuong	*Saigon Water Corporation (Sawaco)*
Mr. Phan Dinh Cuong	*Hiep Phuoc Industrial Park JSC*
Mr. Nguyen Ngoc Xuan	*People's Committee of Hiep Phuoc Commune*
Mr. Nguyen Van Truong	*People's Committee of Nha Be District*
Ms. Nguyen Thi Hong Quyen	*People's Committee of Nha Be District*
Mr. Le Nguyen Ngoc Tai	*People's Committee of Nha Be District*
Mr. Bui Duc Long	*People's Committee of District 4*