# THE BLUE PEARL OF ASIA

Flooding as an urban asset - a beautiful and resilient future Phnom Penh

Final thesis in landscape planning 30+30 hp

By: Gunilla Englund and Sara Ryttar
Supervisors: Per G Berg and Tomas Eriksson
Examiner: Kristina Nilsson
Department of Urban and Rural Development, SLU

SLU
Swedish University of Agricultural Sciences

# PREFACE

This is a final thesis at D-level in Landscape Planning.

Our supervisors are Professor Per G Berg and University Lecturer Tomas Eriksson. Examiner is Assistant Professor Kristina Nilsson and external examiner is Storm Water Consultant Kristina Hedlund at SWECO Environment.

Through our work on this thesis we had the possibility to make a fantastic journey, thanks to financial support from SIDA and the NL faculty at SLU. We got to know and love a new country and met many wonderful people and made new friends.

We focused our work on the environmental problems arising around the fast urbanization process in Phnom Penh City, also vulnerable to flooding, and the challenge to incorporate ecological storm water management and design in new construction projects. Our study ended up in two design proposals for two new development areas in Phnom Penh City.

We think our subject is very current, since the climate changes are affecting the general hydrological situation in the world and may cause great damage, especially to countries in extreme climate regions, like Cambodia. The ongoing fast development and urbanization of countries in the third world are also putting the environment under extreme pressure. Long term city planning and alternative ecological solutions to environmental problems are issues that will help us form our future in a sustainable way.

We want to thank our supervisors who have guided us through our work with good advice, discussions and their aspects on the subject. We are also extremely grateful to our Cambodian field supervisor Mr Sothea Kok and our guides/interpreters in Phnom Penh, Mr. Socheat and Mr. Weng who spent their weekends helping us in our work. Thank you Marianne Kjellén at Stockholm Environmental Institute for letting us be a part of your project and for introducing us to Phnom Penh City. We also want to send a million thanks to all the people who voluntarily took their time and spoke to us during our interviews in Cambodia and during our field studies in Sweden.

Uppsala, November 2008.
Sara Ryttar and Gunilla Englund

# ABSTRACT

Surface water drainage is together with water supply and wastewater management key parts of infrastructure in urban areas. As landscape architects we aim to find solutions that envisage aesthetical, social and ecological perspectives as well as technical. These aspects often go hand in hand and together they are part of the sustainability concept.

Phnom Penh was in the sixties known as “the Pearl of Asia”. The capital of Cambodia incorporated many green areas and water features and the architecture was blooming. After many troublesome years of cruel regimes and war the city is now degraded and the infrastructure is badly maintained. Corruption is widely spread and private construction companies are ruling the construction market and the urban planning.

The city is located on wetland by the conjunction of four great rivers. There are two dominating seasons, wet and dry and they shape the prerequisites for the city planning. Precipitation is a huge problem in the rainy season and most of the urban storm water is together with the city wastewater lead through open canals or drainage pipes to the surrounding wetlands. The wetlands biologically clean the contaminated water before it enters the rivers. The wetlands also possess great water storage capacity. Phnom Penh is protected from flooding by embankments (dikes). The urban storm water reaches the wetlands through sluiceways in the dry seasons. The sluiceways are closed during the rainy season to prevent the city from flooding and the storm water has to be pumped over the dikes.

Due to poor urban planning, corruption and increased land prices, the public green and blue areas in and around the city are rapidly disappearing and inundation of the city has become an enormous problem. New satellite cities have popped up in the wetlands and there is a shortage of public parks and spaces in the city centre. The water storage capacity of the wetlands has diminished due to constructions and polluted water reaches the rivers without cleaning and many sensitive ecosystems are lost.

Urbanisation is a fast ongoing process in Phnom Penh. The city needs to expand to cope with its increasing number of inhabitants. Development and expansion put a huge strain on the urban ecological and social structures. To protect and keep the sensitive ecosystems of the urban wetlands and lakes, a future city expansion must be well considered and the development should occur in phases.

An ecological storm water management tries to imitate nature as far as possible and use the prerequisites of the site. As much as possible of the storm water is therefore taken care of locally in an ecological storm water design. Urban environments generally consist of a majority of impermeable surfaces, which prevent water to infiltrate.

New development in Phnom Penh would benefit from ecological storm water design. The pressure on the under dimensioned drainage system of the city would lessen and problems with inundation be reduced. If polluted water was taken care of locally, emissions in the sensitive rivers would diminish. Urban infiltration areas and storage ponds could be incorporated in future urban design.

Since flooding is an unavoidable occurring event in Phnom Penh, the city would benefit from adjusting to the rising water levels instead of fighting against them. Floodable areas incorporated in the urban design are efficient in dealing with the problem of inundation in the streets as well as a beautiful variable design feature.

We have chosen two sites in Phnom Penh that soon are about to be developed for construction Boeng Cheung Ek and Boeng Kak Lake. These two areas are both hydrologically interesting. They are located on low points in the city and today they serve as natural water storage features. Our thesis resulted in two design proposals that incorporate an ecological storm water perspective as well as a sustainable city perspective.

# SAMMANFATTNING

Dagvattenhantering är liksom dricksvattenförsörjning och avloppshantering viktiga delar av stadens infrastruktur. Landskapsarkitektens uppgift i sammanhanget är att skapa lösningar som tar hänsyn till estetiska, sociala och ekologiska värden, liksom tekniska lösningar. Dessa värden är alla viktiga och tillsammans utgör de grunden för ett uthålligt samhälle.

Phnom Penh gick under sextiotalet även under namnet ”the Pearl of Asia”. Kambodjas huvudstad innefattade många grönytor och inslag av vatten och arkitekturen blomstrade. Efter många år av krig och en grym regim har staden förfallit och infrastrukturen är dåligt underhållen. Utbredd korruption är ett stort problem och privata byggföretag styr byggsektorn och stadsplaneringen.

Staden är belägen på våtmarker där fyra stora floder flyter samman. Två årstider dominerar, regnperioden och torrperioden, och de skapar förutsättningarna för Phnom Penhs stadsplanering. Nederbörden utgör ett stort problem under regnperioden och en stor del av stadens dagvatten flyter tillsammans med avloppsvattnet i öppna kanaler eller dräneringsledningar ut i de omkringliggande våtmarkerna. Våtmarkerna har förmågan att rena det förorenade vattnet innan det släpps ut i floderna. Våtmarkerna har också en enorm kapacitet att lagra vatten. Höga vallar skyddar Phnom Penh från att översvämmas. Dagvattnet från staden rinner ut i våtmarkerna genom slusskanaler under torrperioden. Slussarna stängs under regnsäsongen för att förhindra att vatten från våtmarkerna översvämmar staden. Vattnet måste då istället pumpas ut från staden över vallarna.

På grund av dålig stadsplanering, korruption och ökade markpriser har gröna och blå ytor i staden minskat kraftigt. Detta har medfört att staden oftare och lättare översvämmas. Nya satellitstäder har vuxit fram i våtmarkerna och staden lider brist på gröna offentliga utrymmen. Våtmarkernas vattenlagrande kapacitet har minskat på grund av den nya bebyggelsen och förorenat vatten släpps ut i de känsliga floderna utan rening. Många av stadens känsliga ekosystem har redan gått förlorade.

Urbanisering är en snabb pågående process. Staden måste växa för att klara av att försörja den växade befolkningen. Den häftiga expansionen påverkar stadens ekologiska och sociala strukturer. En försiktig och välplanerad stegvis stadsutveckling är nödvändig för att skydda och bevara stadens känsliga våtmarker och sjöar.

Ekologisk dagvattenhantering försöker så långt som möjligt efterlikna naturens naturliga förlopp och dra fördel av platsens unika förutsättningar. Så mycket som möjligt av dagvattnet bör tas om hand lokalt i en gestaltning som tar hänsyn till ekologiska dagvattenaspekter. Stadsmiljöer består vanligtvis av mycket hårdgjorda ytor, vilket försvårar infiltration i mark.

Nybyggnation i Phnom Penh skulle gynnas av en ekologisk dagvattendesign. Trycket på stadens överbelastade dagvattennät skulle minska och översvämningarnas omfattning skulle reduceras. Lokalt omhändertagande av förorenat dagvatten skulle även medföra mindre utsläpp i de känsliga floderna. Infiltrationsytor och dagvattendammar är ett viktigt inslag i en ekologisk dagvattengestaltning.

Eftersom översvämningar är ett oundvikligt och återkommande inslag i Phnom Penh, skulle staden dra fördel av att anpassa sig efter de sjunkande och stigande vattennivåerna istället för att kämpa emot dem. Att integrera översvämningsytor i gestaltningen är både vackert och ett effektivt sätt att bekämpa översvämningar av stadens gator och torg.

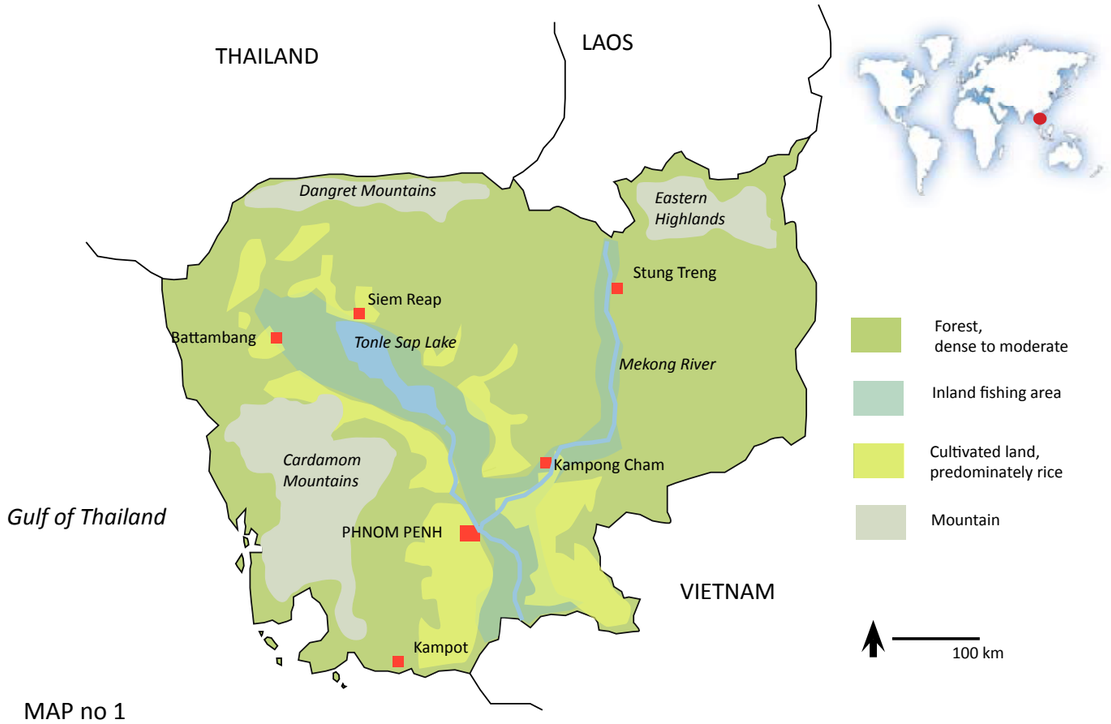
Vi har intresserat oss för två platser i staden som inom en snar framtid kommer att bebyggas – Boeng Cheung Ek och Boeng Kak Lake. Dessa två platser är särskilt intressanta ur ett hydrologiskt perspektiv. De är belägna på lågpunkter i staden och tjänar idag som viktiga vattenmagasin. Vårt examensarbete mynnade ut i två gestaltningsförslag som tar hänsyn till ekologisk dagvattenhantering så väl som uthållig samhällsbyggnad.

A storm water canal in the proposal ”Boeng Cheung Ek”.
(Photomontage: Sara Ryttar)

A Rain Park and a canal leading through the proposal ”Boeng Kak Lake”.
(Photomontage: Gunilla Englund)

# TABLE OF CONTENTS

# INTRODUCTION




MAP no 1

Phnom Penh is located on the floodplains of the Mekong River. View from the river walk overlooking the water landscape. (Photo: Sara Ryttar)

The streets inundate even after a minor rainfall. Traffic congestions cause problems. (Photo: Sara Ryttar)

## Background

Because every city is different, it requires understanding of its characteristics to make a suitable development proposal. This is an important component in the work towards sustainable urban development. With this in mind we left for Phnom Penh, the capital of Cambodia. Our mission was to come forth with a proposal for storm water management in city districts affected by flooding. During our study we made an effort to get to know and understand Phnom Penh.

We soon found out that there were a lot of aspects included in the problems of flooding and storm water. To understand this we had to make a journey that was passing questions about the country's political situation, the cultural heritage, the history of war and insecurity, climate change, poverty and slum settlements, just to mention a few.

Phnom Penh, the capital of Cambodia, is situated in the middle of the country by the floodplains of the Mekong River (see map no 1). It is a city built on wetlands and consequently, it doesn't raise much above sea level. In the Master Plan of Phnom Penh, the necessity of a careful and sustainable storm water management is defined. However, this policy is not followed in practice when the city is now experiencing a construction boom and an economical upswing. Wetlands that earlier functioned as effective detention areas and buffer zones for large water flows are now being filled and used for constructions.

Flooding is today a returning event on the streets of Phnom Penh. In the near future the climate changes will bring heavier rains that threaten to worsen this situation[1]. For Phnom Penh, like for many other cities around the world, it is necessary to plan for a sustainable storm water management. This is crucial for the attractiveness of the city to the inhabitants, investors, and tourists.

1 IPCC 2001
2 The Department of Urban and Rural Development at the Swedish University of Agricultural Sciences (SLU)
3 Modin, M, 2008
4 Ebeling, E, 2008

We would like to offer the ruling politicians and the planners of Phnom Penh a document with visions and thoughts. Phnom Penh can develop towards a modern, attractive city with a growing economy and yet be a sustainable city. In fact, we would like to state that a transformation towards sustainability is even crucial for the city's future existence.

We will start by putting Phnom Penh and Cambodia in its overall context in the world. Then we will zoom in to the scale of the city and explain how and why it looks like it does. To our help we have maps, figures and pictures. Finally we take a closer look at two specific areas of the city, which are interesting from a storm water point of view.

Why should we, as landscape architects, worry about storm water? For cities to be able to cope with future challenges it requires that we today introduce sustainable solutions in our urban areas. As landscape architects we have a responsibility to develop knowledge about the consequences that urban designs and landscapes have on the environment. We also have a responsibility to make the most out of these urban landscapes so the city can be a place for living even in the future. Storm water is one of the concrete aspects for a sustainable design.

The question of storm water management has interested some of our fellow students at SLU[2]. For example the inter related questions of storm water, climate change and urban sustainability are discussed in the two master thesis "Urban Climate Security – Climate Change, Urban Planning and Flooding"[3] and "The danger of lying low – planning cities for rising water levels"[4]. The management of sustainable solutions with relation to climate change in present and future urban areas have also been discussed in principal articles in Arkitekten[5] and Sveriges Natur[6].

Why is it important for landscape architects to take an interest in the urbanisation of developing countries? As landscape architects we are trained in looking at the city with a holistic view

5 Hallemar and Lauri (2008)
6 Temanummer Stad

Inundated street in a slum quarter in Phnom Penh City. The urbanisation process is fast and puts a strain on the existing infrastructure which leads to environmental degradation and health hazards. (Photo: Gunilla Englund)

and therefore we should be able to contribute to sustainable solutions in cities suffering from complex problems. We have a role to play, not only in the aesthetical finish of developed modern cities but also in the cities of the third world where knowledge about green and blue values in city centres are extremely low[7]. According to Perspectives on Poverty[8] a sustainable use and management of the environment plays an important role in poverty reduction. Management of natural environments inside and close to cities call for the knowledge possessed by, amongst others, landscape architects.

The majority of today's urbanisation is taking place in developing countries[9]. Since fast urbanization has a massive impact on the environment, it is of high relevance that the issue is taken seriously by decision makers both locally and internationally. In many developing countries, there is a lack of knowledge, time and money that make the development close to chaotic. Massive construction projects are carried out without the support of proper or correctly scaled infrastructure, such as roads, drainage systems, sewage and water treatment facilities, electricity and sufficient schools and hospitals. This is clearly being a problem locally but climate change and environmental destruction may be reasons for the rest of the world to get engaged.

# Problem Formulation

Why is storm water a problem in Phnom Penh? How can new urban districts in Phnom Penh be designed without interfering with the city's capacity to handle threats from storm water and floods?

# Objectives

**1** To come forth with two individually designed planning proposals in two specific areas in Phnom Penh. Both areas will deal with sustainable solutions regarding storm water.

**2** To describe and understand the context of Phnom Penh City with its surrounding areas, thus being able to propose changes adapted to this specific city.

**3** To describe and understand sustainable techniques for handling storm water in the work as a landscape architect.

## Outputs

- Two deepened designed proposals for physical environments that promotes a sustainable and ecologically sound storm water management. These proposals should be based on our research and experience of the city.

- Contribution to the project, *Water, Socioeconomic and Ecological Relations in Phnom Penh*, at the Swedish Environmental Institute, SEI.

# Methods and definitions

The main type of method used during the work on this thesis is case studies. According to Yin[10] a case study is an empirical study that investigates a contemporary phenomenon in its real context. Yin also states that the case study is based on different sources of information and that the data collection and analysis are directed by theoretical premises. We have been studying the specific question of storm water in the context of Phnom Penh City. We used data from multiple sources and four different types of methods for gathering information: literature studies, field studies, study visits and semi structured interviews. The information from these methods has been weighed against one another and we have been able to make an analysis of the city. This way of working is called "method triangulation" and is an important part of the case study method.

During our work, we used the three following methods for analysing places:

7 Berg, P.G and Florman, C, 2005
8 SIDA, 2002
9 www.sida.se/sida/jsp/sida.jsp?d=835&a=14363&searchWords=urbanisering
10 Yin, R, 1994

| Table 1 FIELD STUDIES AND STUDY VISITS | | |
|---|---|---|
| | Sweden | Cambodia |
| City Districts | Bo01 Västra Hamnen, Malmö<br>Augustenborg, Malmö<br>Hammarby Sjöstad, Stockholm | International City<br>CamKo City |
| Wetlands, Lakes and Canals | | Cheung Ek wetland<br>Boeng Kak lake<br>Trabek canal<br>Salang canal |
| Companies, Organisations and Municipal Departments | Veg Tech<br>WRS<br>Ramböll<br>WSP<br>SWECO Environment | Archetype<br>Bureau of Urban Affairs, BAU<br>Department of Public Works<br>Institute of Technology in Cambodia, ITC<br>Japan International Cooperation Agency, JICA<br>Land Cultural and Environmental Preservation Association, CEPA<br>Royal University of Fine Arts<br>Seucher Entwicklungsdienst, DED<br>Samakum Theang Tuot, STT<br>UN Habitat |
| Cities | Fagerås<br>Malmö<br>Stockholm | Kampot<br>Siem Reap<br>Sihanoukville<br>Takhmau |

During our field studies we met many nice people and we got to know how people live their lives in different parts of Phnom Penh. (Photo: Sara Ryttar)



• Site and situation analysis. We studied Phnom Penh City and its context and described what we saw.

• SWOT analysis. We identified and discussed Strengths, Weaknesses, Opportunities and Threats related to Phnom Penh.

• The framework of Sustainable Development with the seven criteria formulated on the Habitat II meeting in Istanbul. We analysed Phnom Penh from how well it follows the seven dimensions of sustainability: the Physical resources, the Economical values, the Biological diversity, the Organisation of human habitats, the Social interactions between inhabitants, the Cultural settings and Esthetical values[11].

In our meetings with people we used semi-structured interview. This form of interviewing was suitable for our study because we talked to people that represented different actors in Phnom Penh. A semi-structured interview is a conversation where the questions and the discussion subjects to a certain extent are determined in advance. We wanted to receive as genuine answers as possible and allow the interviewees to talk about the subject in their own free way. With this type of interview we also had the opportunity to ask improvised questions.

The general questions outlined to understand the urban context of Phnom Penh was as follows: How is Phnom Penh structured regarding first of all green and blue patterns but also regarding city districts, city centres, and social links? What are the problems and possibilities regarding storm water management in Phnom Penh and to what areas are they connected? Which parts of the city are most exposed to flooding? What are the limitations for making sustainable storm water solutions (physical, economical, etc.)? Which urban design solutions for storm water management are most suitable for the specific location?

## Collaborative and individual work

We have been collaborating during field studies, study visits, semi-structured interviews and discussions related to the literature. During the phase of writing and designing we have divided the work between us and have had frequent meetings where we have discussed and worked with each other's texts and figures. The two design proposals are individual parts based on the analysis that we made together. This way of working both separately and individually has functioned well. We see great benefits from being two, during fieldwork as well as during analysing and writing since discussions between us have made us reach further in our work.

## Definition of the term Ecological Storm Water Management

When we use the expression Ecological Storm Water Management we refer to a storm water management that aims to limit the flow of polluted water to watercourses, prevent negative effects on vegetation and ground water and reduce the risk of floods. An ecological storm water management tries to imitate the nature as far as possible and use the prerequisites of the site. As much as possible of the storm water is therefore taken care of locally in an ecological storm water design.

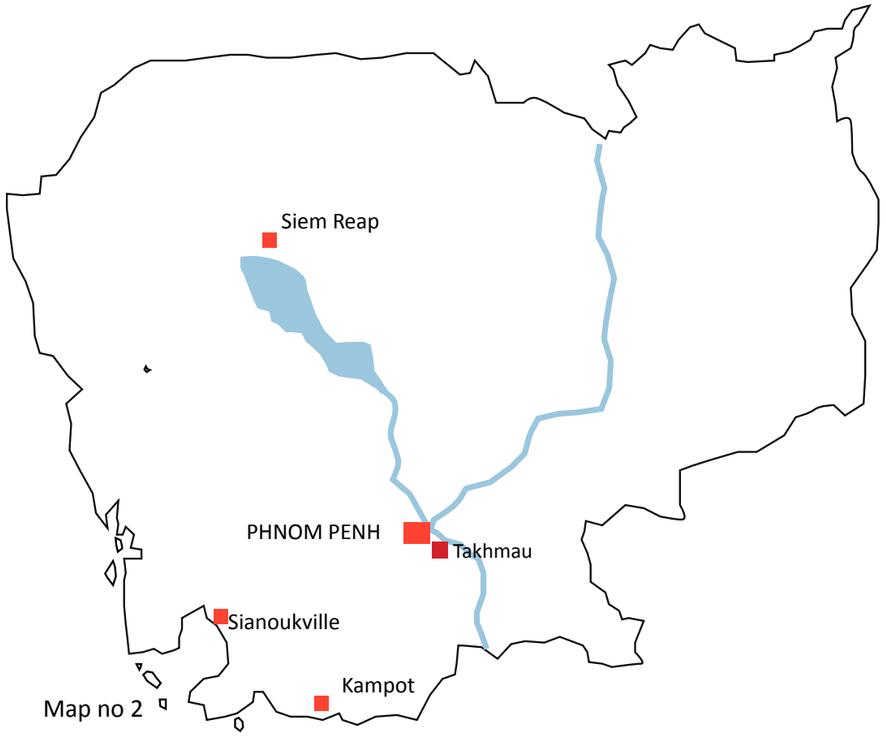
## Field Studies, interviews and literature studies

To gain inspiration we visited three residential areas in Sweden where storm water management has played an important role in the design (see table no 1). During these study visits we looked at examples of how storm water can be managed locally in residential areas. Even though these places are located in Sweden we believe some solutions can be implemented in Phnom Penh.

For further inspiration we contacted a few Swedish companies with projects related to urban storm water management (see table no 1). Our questions were: How do companies today work with storm water? Which solutions do they use? What is their approach regarding storm water?

11 The Habitat Agenda, Istanbul Declaration on Human Settlements, 2006

FIELD STUDIES TO OTHER CITIES IN CAMBODIA




Map no 2

A Tuk-Tuk on the streets of Phnom Penh.
(Photo: Gunilla Englund)

Left: Interview with locals at Boeng Kak Lake.
Right: Interview with the village chief in Cheung Ek wetland.
(Photos: Sara Ryttar and Gunilla Englund)

During our field studies in Phnom Penh we usually travelled by tuk-tuk (a motorbike with a passenger coach behind it) and sometimes by motorbike or bicycle-taxi. Joining us during most field studies were our assisting guides and translators Mr. Socheat and Mr. Weng, students in environmental science year three at the Royal University of Phnom Penh. At all our field studies we documented the places through photos and notes.

In Phnom Penh we visited two wetland areas with ongoing development for new city districts (see table no 1). In these places we looked at how the new constructions related to the surrounding wetlands and if there were any signs of local treatment of storm water in the parts already constructed. We tried to get a view of the areas around the development as well as the actual construction site. We also visited the showrooms on place to look for sustainable storm water solutions in the proposed plans.

We also visited a wetland and a lake where new development areas soon will be constructed (see table no 1). We tried to get an overall view of the areas to be able to understand their importance for the city environment. We also made field studies to storm water canals in Phnom Penh centre. The character of the surrounding areas and the state of the canals were of special interest. We tried to understand what qualities the canals gave the area and what part they played in the storm water management of Phnom Penh.

When we visited parks in Phnom Penh we looked at how they were designed and their ability to handle storm water locally. We also looked at how well the parks met the needs of the inhabitants in Phnom Penh.

We visited informal settlements in Phnom Penh to get an idea of how those people live who suffer the most from inadequate storm water management. We looked at how these areas are composed and where they are located. We tried to understand how these people would be affected by the development projects in Phnom Penh. We talked to some of the inhabitants that we met about the future for their homes.

Except Phnom Penh we visited four other cities in Cambodia (see map no 2 and table no 1). Takhmau is located near Phnom Penh and is therefore of interest as a future part of the expanding capital. The other three cities are further away from Phnom Penh and served as additional inputs of how Cambodian cities have developed. We looked at the green and blue structures of the cities and also tried to get an idea of the social life and the general ambience.

We had meetings with Municipality Departments and subdivisions, local and international NGOs, private companies and inhabitants in Phnom Penh (see table no 1). To have a meeting for an interview with the Departments at the Municipality of Phnom Penh and with the NGO´s we had to make a formal reservation in advance. The interviews were carried out both with and without interpreter thus most interviewees spoke good English. At the majority of the interviews we were alone with our interviewee. At a few occasions there were other persons present and if this person happened to be an employee at a higher position his presence limited the frankness in the answers of the interviewee and the amount of information we received. During the field visits we interviewed randomly selected inhabitants. When needed the students, Mr. Weng and Mr. Socheat, acted as our translators.

During our literature studies we looked for books and articles that deal with the subjects: ecological storm water management, sustainable city planning, urbanisation in developing countries, and city planning in Cambodia and Phnom Penh. We looked for maps over the entire country of Cambodia with information on the geography, nature and demographic variations. We also searched for maps of Phnom Penh that show an up-to-date view of the city, the altitude, the patterns of green and blue parts, the drainage areas, the city development and so on.

View overlooking the river and mountains. Field study visit to Kampot.
(Photo: Sara Ryttar)

View over the sea and archepelago. Field study visit to Sihanoukville.
(Photo: Sara Ryttar)

Park promenade. Field study visit to Siem Reap.
(Photo: Sara Ryttar)

We searched for different scaled maps, both overviews and closer views of specific areas of interest. The maps were found on the Internet, through the interviewees' databases, at the local bookshop, and in books. Documents about the city development and situation in Phnom Penh and general information about Cambodia were obtained through the interviewees and the Internet. For inspiration we found pictures and photographs of Cambodia and Phnom Penh on the Internet.

# Limitations of the study

### Physical

We focused our study on the city of Phnom Penh. The city is widespread and we did not have the possibility to visit all parts. We aimed to visit places related to the storm water management of the city. The access to these places was sometimes limited due to fences and non-walkable areas.

### Contextual

We have worked with the subject of ecological storm water solutions in city development. The economical, technical, social, chemical and biological issues related to this subject is only mentioned briefly. We
focused on the impact that ecological storm water management has for the sustainability of the city as a human habitat.

### Time

The field study, the analysing and the writing of the report took place within the limits of the time period devoted to a master thesis in landscape architecture. Presently this period is 20 weeks. The field study in Cambodia lasted for 7 weeks.

# PHNOM PENH
# - THE CITY AND ITS SURROUNDINGS

| Table 2 DEVELOPMENT STATISTICS FOR CAMBODIA | |
|---|---|
| GDP per capita | 2 727 US dollar in 2005 |
| GDP growth | 6% in 2004 |
| Literacy rate | 73,6% |
| Life expectancy | Men: 59<br>Women: 65 |
| Child mortality | Highest in Asia |
| HDI (Human Development Index) Using three variables: life expectancy, education level and income. | 131 of 177 countries |
| Percentage attending school of population aged 7-24 years | Men: 62,8%<br>Women: 55,3% |
| Rate of population under 15 years | 39% |
| Households with safe drinking water | 44% |
| Households with electricity | 17% |
| Households with toilet facility | 22% |
| Percentage of population living in urban areas | 20% |
| Percentage of urban population living in slum | 72% |
| Percentage of population living below national poverty line | 35% |
| Annual population growth | 2,28% |
| Corruption<br>2006 Transparency International Corruption Perceptions Index | 163 of 180 countries<br>2.0 out of 10.0 |

# Cambodia

Cambodia is one of three countries in the former French Indochina and a member country of the Association of Southeast Asian Nations (ASEAN). The country has adopted the Millennium Development Goals[12].

In 1954 the French colonised the country and stayed until 1969 when they returned the power. This period is still very present, as in most former colonised countries. Not least in the architecture and in the present political situation.

Cambodia is, together with the Lao PDR, the poorest country in Southeast Asia and is showing bad numbers in practically every statistical mean for measuring the development of a country (see table no 2). The country is still recovering from the terror regime of the Khmer Rouge (1975-1979) and the wars that followed. Benefits from economical development have been unevenly distributed over the country, favouring the urban areas. Poverty declines faster in Phnom Penh and in other urban areas than in the rural areas[13].

The population of Cambodia in 2005 was 14,8 million of which 20% lived in urban areas. 72% of the urban population lived in slum 2001. Cambodia is still in the early phases of urbanisation and is dependant on agriculture. Industry only employs 8% of the labour force while agriculture employs 70%. 35% of the population lived below the national poverty line in 2004. Of these poor, 90% live in rural areas. Urban areas will probably grow rapidly in the future due to natural growth and migration from rural areas. The annual population growth rate is 2,28% (2005-2010)[14].

During the Khmer Rouge rule, 3 million people, nearly 25% of the population, were killed. The urban centres of Cambodia were depopulated when the people were forced to live as farmers in rural areas. Today, the Khmer Rouge destruction of urban infrastructure, institutions and human capital is still visible and is hindering the country to develop[15]. The population is today very young, because of the many deaths during the war.

Being amongst the poorest people in the world with a long history of violence, Cambodians are eager to emphasize their rich cultural heritage. During the time this report was written, a dispute about the nationality of a temple close to the Thai-border almost caused a war. The country has one of the world's most important cultural remainings - Angkor Wat, the impressive Khmer temple from the 13th century. In fact, northern Cambodia is full of interesting temples, some as old as 1200 years.

Cambodia is officially a democracy but after taking a closer look at the political situation the word democracy feels quite unsuitable. Elections where held in July this year, just soon after our departure from the country. The result was hardly surprising when Cambodian Peoples Party (CPP), the dominant party in Cambodia, once again received the majority of the votes. CPP is a reorganisation of the communistic Kampuchean People Revolutionary Party, which broke out from the Khmer Rough. Hun Sen, the leader of CPP, staged a coup and took over power in the nineties. Dozens of members from the opposition party were executed. Hun Sen took over as Prime Minister and he is today still the leader of the CPP, which has kept the power ever since the coup.

During our stay we viewed the massive election campaign of CPP that were spread over the country. The message from CPP was written on almost every crossing when travelling through the countryside. The CPP has strict rules to prevent the opposition party to reach out with their messages. Posters and information signs are taken down, and TV-commercials are stopped.

12 Asian Development Bank, 2006
13 Asian Development Bank, 2006
14 Asian Development Bank, 2006
15 National Institute of Statistics, Cambodia

The ancient temples of Angkor Wat situated in the djungle outside Siem Reap is a UNESCO World Heritage. Cambodia has a magnificent cultural history and Cambodians are proud of their roots. The powerful Khmer culture was for centuries ruling this part of Asia and the impressive temples at Angkor Wat are still standing guard in the jungle. (Photo: Gunilla Englund)

| Table 3 THE CAMBODIAN CLIMATE | |
|---|---|
| Rain season | May - October |
| Dry season | November - March |
| Average annual rainfall | 1 400 mm – 5000 mm |
| Annual average temperature | 28 C |
| Maximum average temperature | 38 C in April |
| Minimum average temperature | 17 C in January |

| Table 4 EFFECTS FROM CLIMATE CHANGE IN CAMBODIA | |
|---|---|
| Temperature | + 1,3 - 2,5 C by 2100 |
| Rainfall | + 3 – 35% by 2100 |
| Flooding | More frequent and intense |
| Drought | More frequent and intense |
| Human Health | More cases of Malaria and Dengue fever |

| Table 5 COMPARISION - CARBON DIOXIDE EMISSIONS | |
|---|---|
| **Country** | **Million tons per year (2004)** |
| Cambodia | 0,5 |
| China | 5 007 |
| Laos | 9,8 |
| Indonesia | 378 |
| United States | 6 045 |
| Sweden | 75 (1994) |

Corruption is widely spread in the Cambodian legal system and is hindering the country's development. The organisation "Global witnesses" was thrown out because of it´s critique against the prevalent system of bribes in Cambodia. The corruption affects the urban development since people in key positions to permit new development and construction accept bribes. There is a risk that money leads the development and not the actualisation of a wise and long term planning.

## Geography

Cambodia is a beautiful country. Its different landscapes shape its prerequisites. There are massive mountain areas surrounding Cambodia in the west, north and east (see map no 1). In the middle of the country the enormous Tonle Sap Lake and its cultivated riverbanks unfolds. These flat central parts of the country are mainly used for rice production. In the south there are vast wetlands with no ending in site. Further south there are sandy and rocky beaches to the Gulf of Thailand and a beautiful archipelago follows you out to the open sea. These amazing sceneries are scattered with bombes and landmines. Due to Cambodian tragic history, the country is very inaccessible. Cambodia is a country full of contradictions.

The powerful Mekong River, the longest river in Asia, crosses the country from north to south and parts the country into two. The Mekong River is together with the Tonle Sap and Bassac rivers one of the dominant features in the Cambodian landscape.

## Climate and climate change and the relation to Cambodia's development

Cambodia is situated just north of the equator. The climate is tropical and governed by the monsoon with seasonal rains, which is prevalent in all of the country (see table 3). The climate is characterized by two major seasons: the rain season when strong prevailing winds from southwest bring heavy rains and high humidity, and the dry season when winds and humidity are low. Between these two seasons the weather is transitional.

Typhoons and severe storms are not common in Cambodia as the country is protected by the surrounding mountain ranges[16]. The most serious climate events in Cambodia are floods, droughts and windstorms[17]. Storms are most frequent during the last part of the rain period, from August to November. The highest frequency is in October[18].

Both serious floods and droughts occur now and then and are quite common in Cambodia. The high water levels result from heavy rainfall upstream in the Mekong Basin during the rain period form May to October. These extreme climate events cause a lot of damage to the country as they lead to severe economic, social and environmental losses[19]. Floods and droughts have in fact been stated as the main contributors to poverty in the country[20].

There are two types of floods in Cambodia: floods resulting from an overflow of the Mekong and Tonle Sap Rivers, and floods resulting from extreme local rainfall[21]. Cambodia has experienced more frequent and severe floods and droughts during the recent years and it is believed to be a result from climate change[22]. An IPCC study on emission scenarios, which suggests that the prevalence of extreme climate events in Cambodia may increase, supports this expectation[23]. There is also a study made by the Ministry of Environment, which shows that the risk of flood and drought in Cambodia might increase due to global warming[24]. Another report predicts a decreased river flow during dry season and an increased river flow during rain season[25] (see table no 4).

16 Vanna, P, 2000
17 Environment, M.o, 2005
18 Vanna, P, 2000
19 Vanna, P, 2000
20 The Royal Government of Cambodia, 2001
21 Environment, M.o, 2005
22 Environment, M.o, 2006
23 IPCC, 2000
24 Environment, M.o, 2002
25 EVS Environment Consultants, 1996

| Table 6 EXTRACTS FROM LAWS REGARDING SUSTAINABLE DEVELOPMENT<br>Laws and Regulations of Environmental Protection and Natural Resources Management (LEPNRM)<br>Law on Land Use Planning, Urbanization and Construction (LLUPUC) | |
|---|---|
| LEPNRM | "The natural resources of the Kingdom of Cambodia, which includes land, water, airspace, air, geology, ecological systems, mines, energy, petroleum and gas, rocks and sand, precious stone, forests and forest products, wildlife, fish, and aquatic resources, have to be conserved, developed and used in a rational and sustainable manner. Natural resources in protected areas, which include national parks, wildlife sanctuaries, protected landscape areas, and multiple use areas, have to be determined by royal decree."<br><br>"An EIA have to be done in every project and activity, private or public, and have to be reviewed and evaluated by the Ministry of Environment before submitting to Royal Government of Cambodia for decision. The procedures of EIA process have to be determined by sub-decree of the MoE."<br><br>"The disposal of solid waste or any garbage or hazardous substances into public water areas or into public drainage system shall be strictly prohibited."<br><br>"Even if it is found that any public water areas are suffering of pollution which could threaten human life or bio-diversity, the Ministry of Environment shall immediately notify the public about this danger and shall take measure to prevent the water pollution and to restore the water quality of such public water areas." |
| LLUPUC | "The objectives of LLUPUC were: (1) Respecting both common and individual interests, private rights, observing laws and regulations, and overseeing on the construction matters. (2) Assuring the value of natural and cultural wealth, ensuring the development of the economic and tourist sectors and maintaining the quality of environment"<br><br>"All individuals and private institutions as well as public authority were banned from conducting any constructions on the public yard-field or land such as: (i) water reservoir and water dams, (ii) the reserve mining field and the forest zones, (iii) the archaeological and historical resort sites, (iv) the gardens and public parks and development zones, (v) reserve land for the road or roadsides constructions, and the reserved land for the construction of rail-roads and airports, (iv) rivers, seas, streams including banks." |
| Other Cambodian environmental laws | "Law of the Convention on Wetlands of International Importance (Especially as Waterfowl Habitat)"<br><br>"Law of the United Nations Framework Convention on Climate Change"<br><br>" Land Law"<br>Water bodies, lakes, rivers etc are considered to be public state property. It is forbidden to sell state public land and leasing of public state property must: 1) not exceed 15 years, and 2) must not damage the property or change its function in providing public services. Any person who has lived peacefully on state private land for five years prior to the law's passing (2001) has the right to claim private titles to the land (Article 30) (The NGO Forum Cambodia). |

Cambodia is especially vulnerable to climate change and climate variability because of its situation as a developing country depending largely on agriculture. The ability to adapt to climate change is low[26]. Compared with other countries, Cambodia has a relatively low rate of Green House Gas Emissions[27] (see table no 5). Cambodia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995. As a developing country Cambodia has no obligations to reduce the green house gas emissions[28].

Many reports have been written and strategies have been formulated about how to meet the climate changes in Cambodia. In the report "Analysis of Policies to Address Climate Change Impacts in Cambodia"[29] it is said that the current policies are not dealing with the issues arising from global warming in a sufficient way. The report mentions poor management as one major obstacle for creating a well functioning way of working towards sustainable development. Further on the report states that there is a lack of understanding of climate change amongst important stakeholders and policy makers and that sustainable development only can be achieved if poverty, environmental and socio-economical development is dealt with at the same time.

## Laws and regulations regarding sustainable development

The lakes and wetlands of Phnom Penh are well protected in the law. They are described as important and valuable areas in need of protection and preservation. The wetlands, water reservoirs and the urban nature are however under a constant threat of distinction and pollution, despite of what the legal documents state, since the legal system in Cambodia is weak.

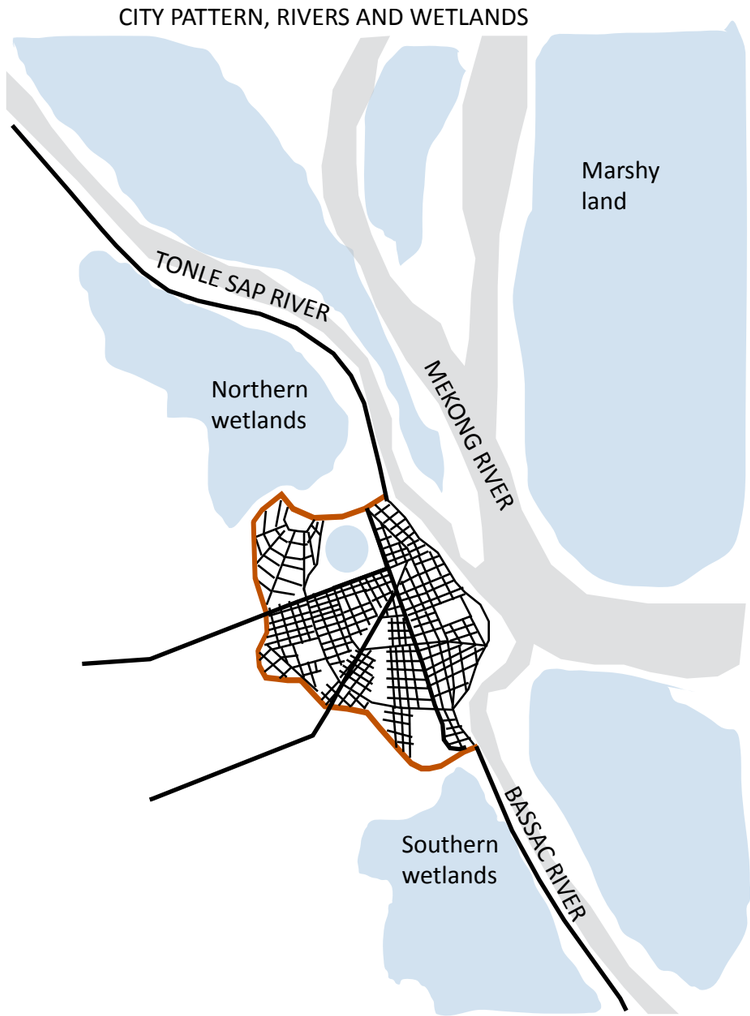
There are two legal documents that take extra notice of vulnerable city environments and describe them as important natural resources for the city and the country (see table no 6):

**"Laws and Regulations of Environmental Protection and Natural Resources Management (LEPNRM)"**. The law regulates the national and regional action planning, the natural resource management, the environmental protection, pollution control and the importance of Environmental Impact Assessments. An EIA is however hardly ever made, despite the law[30]. Penalties for violation of the law are clearly stated and regulated within the legal document.

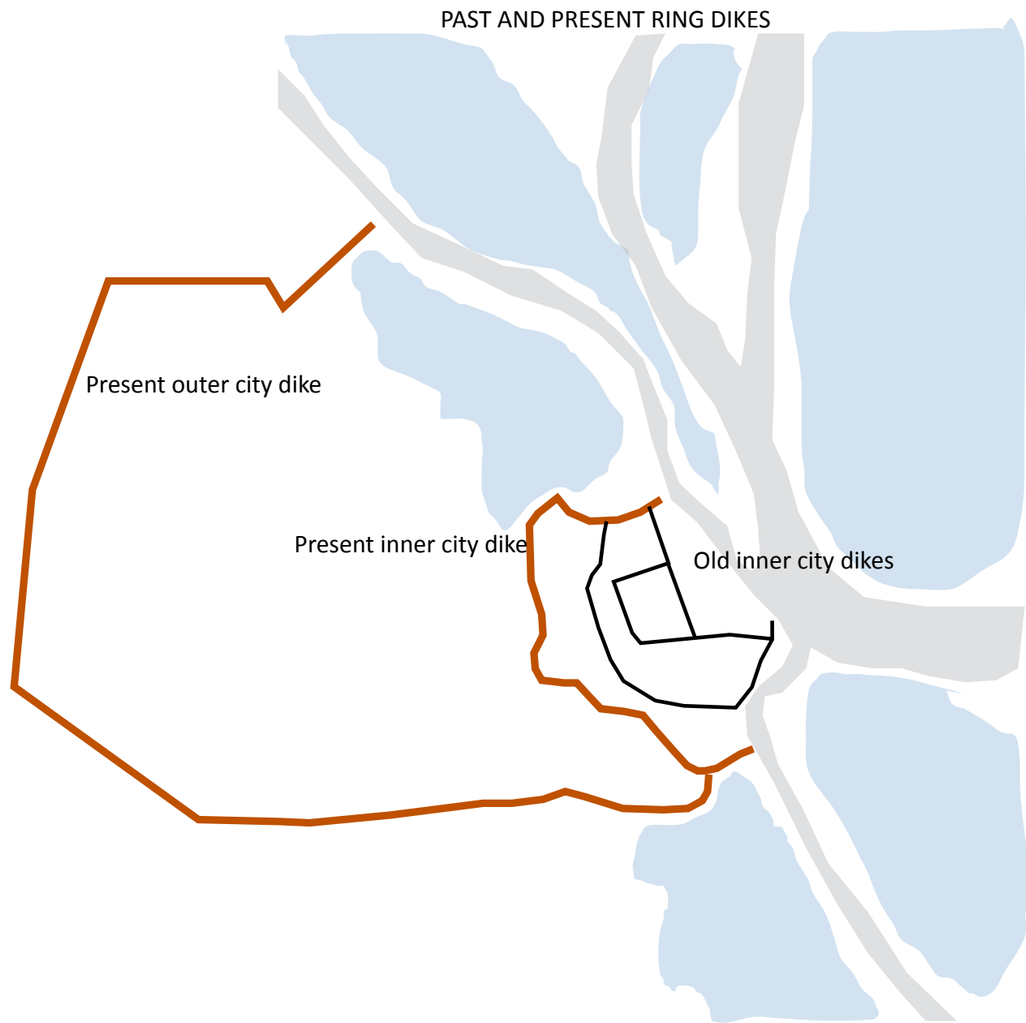
The Ministry of environment was created in order to implement the law and to protect the natural resources and prevent environmental degradation[31].

**"Law on Land Use Planning, Urbanisation and Construction (LLUPUC)".** This law is the key to city land use planning, harmonious urbanisation and effective control of construction. The concept is focused on establishing a committee for land-use planning and designing. Decisions should be based on site-specific conditions, protection of the patrimony and the certain environmental conditions. There is a prohibition of construction on public yard-field, such as water reservoirs, public gardens/parks and development zones. There are also rules regarding procedures of how to build houses or other construction works[32].

26 Environment, M. o, 2006
27 Human development report 2007/2008 – country fact sheets, Cambodia
28 Environment, M. o, 2002
29 Environment, M. o, 2005
30 Int. Goad, H, 2008
31 Environment, M. o.
32 Yin, M, 2006




Map no 3. Phnom Penh is situated on the western shore of the Mekong River. The city is surrounded by marshy lands and wetlands.




Map no 4. The ring dikes function as embankments and protect Phnom Penh from flooding. New dikes have been constructed as the city has grown.

# Urban structure

Phnom Penh is built on a flat alluvial flood plain on the western bank of the great Mekong River (see map no 3). The location is exceptional and imply many risks as well as benefits. The city has from the beginning been fighting the swampy wetland areas with dikes and land fillings. Located on the flat wetland of the rivers, Phnom Penh should easily be flooded during the rain season if it wasn't for a dike surrounding the city.

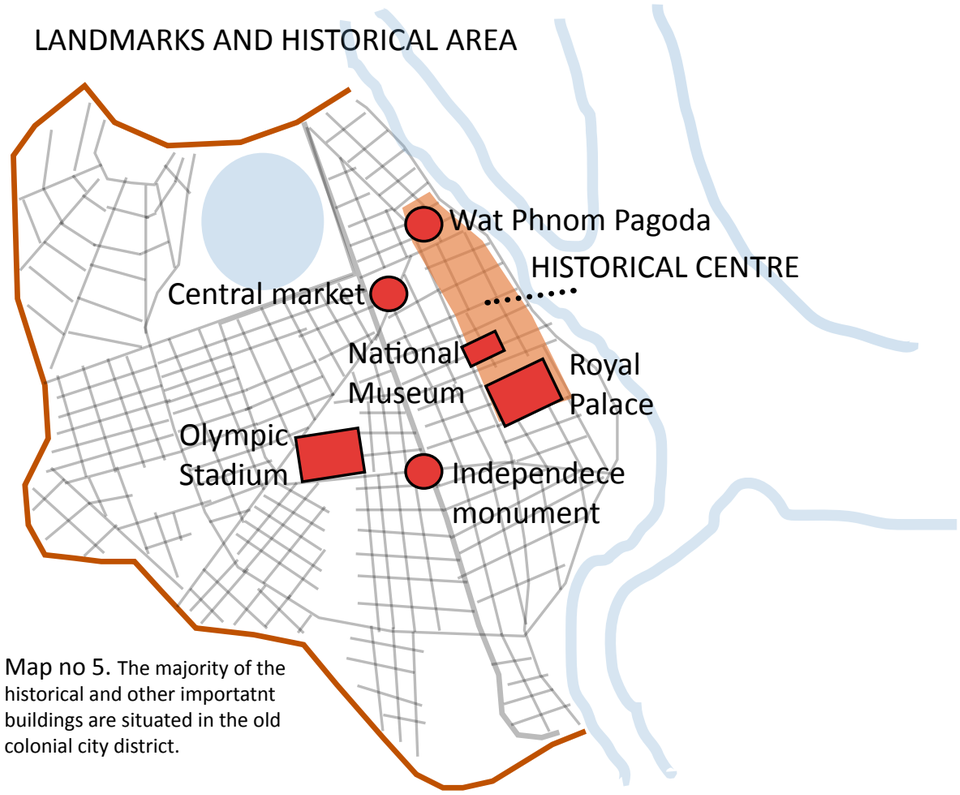
To the north, west and south the city limits of Phnom Penh are defined by a ring road. The road is built on a dike that protects the city from seasonal floods. To the east the river constitutes a distinct limit of the city. The city pattern inside the ring road is dominated by a grid road net defined during the colonial period. During the years Phnom Penh has grown outside its ring road many times. New ring roads have therefore been constructed, creating growth rings visible in the city pattern[33] (see map no 4).

The historical old town of Phnom Penh is located by the riverfront in the centre of the city (see map no 5). Grandiose buildings like the Royal Palace and the National Museum are located here and imposing parks with monuments are common features in the cityscape. Majestic trees border many streets and the colonial architecture is very visible in the historical part. In the areas outside the historical centre a type of Chinese tube houses is common and parks and other green areas are very scarce or nonexistent.

Today, the city is expanding in an uncontrolled manner outside the ring dike along major roads. Behind these roadside constructions there are areas of unused land[34]. To the west the land is higher and much of the uncontrolled development has occurred there (see map no 6). The wetlands around Phnom Penh are exposed to unplanned exploitation by private companies constructing new city districts. Development without planning also occurs inside

33 Int. Symann, R, 2008
34 Molyvann, V, 2003 p.118

LANDMARKS AND HISTORICAL AREA



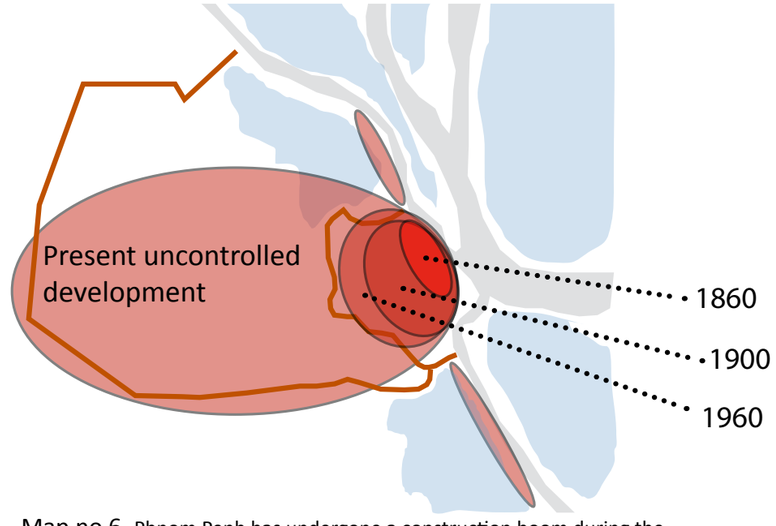

Map no 5. The majority of the historical and other importatnt buildings are situated in the old colonial city district.

National Museum
(Photo: Sara Ryttar)

Independence Monument.
(Photo: Gunilla Englund)

Wat Phnom.
(Photo: Joakim Englund)

APPROXIMATE HISTORICAL GROWTH OF PHNOM PENH




Map no 6. Phnom Penh has undergone a construction boom during the recent years. Unplanned settlements are today scatteder around the city.

| Table 7 PHNOM PENH URBAN HISTORY | |
|---|---|
| Pre-colonial period<br>1432-1863 | Establishments on the Mekong riverbanks<br>Land was formed on the floodplains behind the riverbanks<br>The riverbank was improved with sand<br>Canals, reservoirs and banks were made to manage floods in the city<br>Houses were built on stilts<br>The city had one inner city road, Preah Sisowath Quay |
| Colonial period<br>1863-1954 | The city expanded to the west and the south until Bassac River<br>The roads Norodom and Monivong were borders for the city<br>Outside the city was slum settlements and lakes<br>Lakes inside the city were filled<br>Railway station was built<br>The markets were constructed<br>The roads Blvd. J. Nerhu and Ave. Preah Sihanouk were constructed |
| Independence<br>1954-1975 | The Vietnam War lasted from 1959-1975<br>Olympic Stadium, the Theatre and the International Airport were constructed<br>The city blooms under the name "Pearl of Asia"<br>People fled from the war in to the city. The population doubled in just a couple of years. |
| Khmer Rouge<br>1975-1979 | A total abandonment of the city for 3 years and 8 months<br>Neglect and destruction of all components in the city |
| Vietnamese Occupation<br>1979-1989 | Major flow of people to the city after the war<br>Areas with slum settlements developed |
| Peace and Rehabilitation<br>1989-1995 | Rebuilding of infrastructure<br>House constructions increased the density of the city<br>Slum settlements continued to develop |
| 1995-today | Foreign investors become common in Phnom Penh<br>Public land are sold to private investors<br>Water bodies inside and outside the city are filled<br>Slum settlements continue to develop |



the ring road, which eliminates valuable green, blue and public structures.

## Urban development – past, present and future

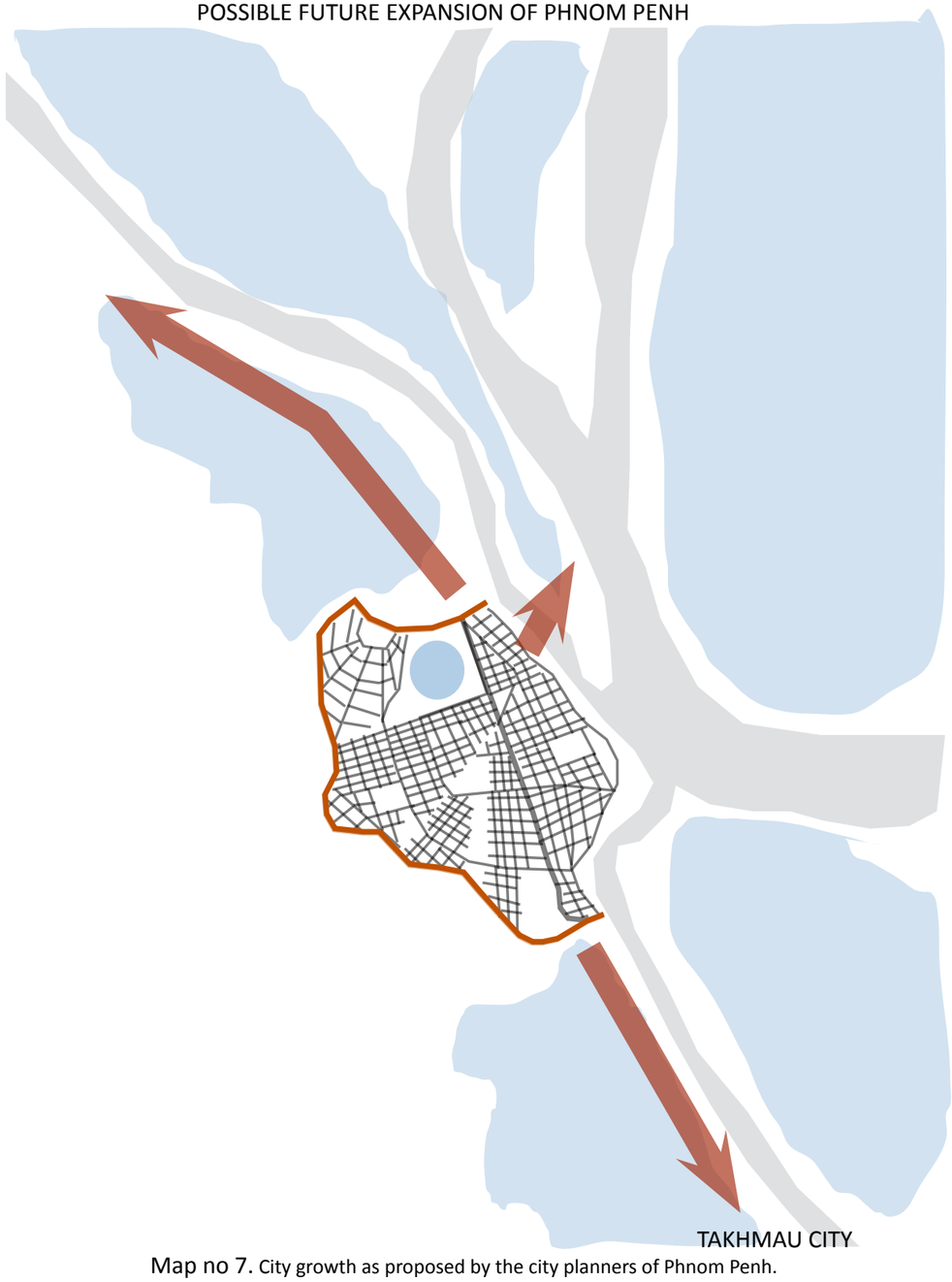
The western shore of the Mekong River at the site of Phnom Penh is protected from the floods by the naturally formed riverbank. Here the first human establishments occurred. It is believed they chose the location because of its convenient transportation possibilities along the rivers. The settlement spread to the more easily flooded area behind the bank where boengs and preks (lakes and ponds) were scattered[35]. To manage the seasonal floods the houses were standing on stilts. Canals and embankments were constructed and formed a hydraulic system for the city that protected it from flooding[36].

In 1863 the French colonisers established in Phnom Penh (see map no 6). During this time structures like the grid road net, houses, roads and bridges were built which are still important features in the city[37] (see table no 7). The colonisers did not adapt to the traditional way of building houses on stilts and were therefore eager to combat the floods. Sand was pumped from the Tonle Sap River to fill lakes and canals in the city[38]. It was the French who developed the system of filling and embankments that today characterize the city. Many of the names of different city parts relate to words for pond or lake. This is a sign of the common lakes and watersheds in the city during the old days.

During the years after independence Phnom Penh was a blooming city with green streets and gardens. Interesting architecture, such as the Olympic stadium, was constructed. Phnom Penh was the "Pearl Of Asia". A drastic change came at the end of the Vietnam War when one million refugees from provincial towns and cities fled to Phnom Penh. Temporary shelters occupied all free spaces around the city. The population of Phnom Penh rose dramatically from under one million to two millions only within a couple of years [39]. This was the first assault

35 Bureau des Affaires urbaines , 2007
36 UN Habitat, Phnom Penh History
37 Bureau des Affaires urbaines , 2007
38 UN Habitat, Phnom Penh History
39 UN Habitat, Phnom Penh History

POSSIBLE FUTURE EXPANSION OF PHNOM PENH




Map no 7. City growth as proposed by the city planners of Phnom Penh.

Degradation of drainage pipes due to neglect during the Khmer Rouge period.
(Photo: Sara Ryttar)

Decay of apartment blocks in the centre of Phnom Penh. The apartments were modern and popular in the sixties. Today the houses are homes to middle and low income families.
(Photo: Sara Ryttar)

against the Pearl of Asia. Next was the abandonment of the city during the Khmer Rouge period. During this time the inhabitants of Phnom Penh were forced to leave the city and move to rural areas. Phnom Penh was abandoned with only a few Khmer Rouge soldiers remaining. The destruction of trees, water reservoirs and storm water pipes were severe during this time. The city floodgates were not closed during rain seasons, causing the underground water pipes and open canals to fill with sediment. The destruction due to these years of total neglect is still visible and is causing problems.

The process of rehabilitating Phnom Penh started already after the fall of Khmer Rough in 1979 when people started to return to the city. Many of the roads and bridges were repaired and so were schools, pagodas and hospitals. New buildings were constructed everywhere in the city but were not sufficient. People continued to arrive to Phnom Penh and settled in illegal housings in and around the city[40]. Almost all possible and impossible areas in the centre of Phnom Penh became occupied by slum settlements.

Today the city is still struggling with some of the basic functions of organisation and urban services. Yet it is a growing capital where international investors are creating great constructions. The pressure to produce apartments is increacing. Young people from the growing middle class want their own living. As a result, Chinese tube houses are popping up everywhere creating areas with a uniform style and very few public spaces.

The Cambodian architect and city planner Vann Molyvann advises a development of the city along the rivers in a north-south direction (see map no 7). He wants to see a future fusion with Takhmau city in the south that forms a Greater Phnom Penh, rather than today's expansion to the west[41]. The new, yet not approved Master Plan follows this advice and marks a future growth of the city along the rivers[42].

40 UN Habitat, Phnom Penh History
41 Molyvann, V, 2003 p. 168
42 Bureau des Affaires urbaines, 2007

Traditional fishing boats by the river shore in Phnom Penh. (Photo: Gunilla Englund)

Erosion in Takhmau along the river. (Photo: Gunilla Englund)

The conjunction of the rivers “The four faces” and the popular river promenade in Phnom Penh. (Photo: Sara Ryttar)

Embankments made of concrete protect Phnom Penh from rising water levels in the river. Erosion is a big problem at other locations along the shore line. (Photo: Sara Ryttar)

## Green and blue patterns

*“The city cannot live without its green space”*[43]

Phnom Penh is located at the conjunction of four great rivers: the Mekong River, the lower Mekong River, the Tonle Bassac River and the Tonle Sap River[44] (see map no 3). This site is traditionally called “the Four Faces”. The northern part of the city borders to the Tonle Sap River and the southern part to the Tonle Bassac River. The rivers are important for transportation and as a food and water resource. Tourist boats with colourful lamps cruises the shore every night. Fishing boats of the traditional long narrow style harbour on the opposite side of the river and cross it in the early morning to bring their catch to the markets.

It is here, by the riverfront, that the old colonial quarters are located. As a matter of fact, most of the important buildings in Phnom Penh are situated along the rivers. High population densities are found along the riverbanks[45]. Today, Phnom Penh is also growing to the east and the west, with constructions popping up in an uncontrolled manner along the roads to the city. Two peninsulas, one small island and the eastern riverbank are land close to the city, little urbanised because of its marshy character.

Sedimentation and erosion are fast processes due to large amounts of water passing the conjunction. Therefore, the area is constantly changing. The city core of Phnom Penh city is protected from the river by concrete embankments. Other parts of the city are not protected towards the water and erosion is a major problem. The location of the city complicates urban planning, since the ground water level is normally about one meter below surface and during the rainy season one meter above surface[46].

**The Mekong River** is a very powerful and fast flowing river. It has an average flow of 15 000 m3/s which can increase to 60 000 m3/s in the rainy periods. The water level fluctuates in amplitude over the year, from two to ten meters above sea level[47]. The highest water levels occur in

43 Int. Seng, K, 2008
44 Molyvann, V, 2003
45 Molyvann, V, 2003
46 Int. Hultén, 2008
47 Bureau des Affaires urbaines, 2007

Traditional houses on stilts in the southern wetland. (Photo: Gunilla Englund)

Many poor people have settled in the wetlands surrounding Phnom Penh. They have adjusted their way of living to the fluctuating water levels. (Photo: Sara Ryttar)

The families living in the wetlands fish and cultivate water crops. They sell their products on the markets in Phnom Penh. (Photo: Sara Ryttar)

mid September to mid October and the lowest in early May[48]. The highest floods ever recorded in Phnom Penh reached a level at 11.78 meters above sea level. The embankments protecting Phnom Penh against the Mekong River stand at a height of 12 meters. Severe floods, when water levels exceed 11 meters seem to occur in average once every ten years[49]. Continuous sedimentation at the inlet of the Bassac River has caused a rapid growth of the peninsula Chrui Changvar, as well as the growth of a new island south of the peninsula. During the past fifty years alone, the tip of the peninsula has moved one hundred meters southward. This geological phenomenon affects the appearance of the urban landscape of Phnom Penh[50].

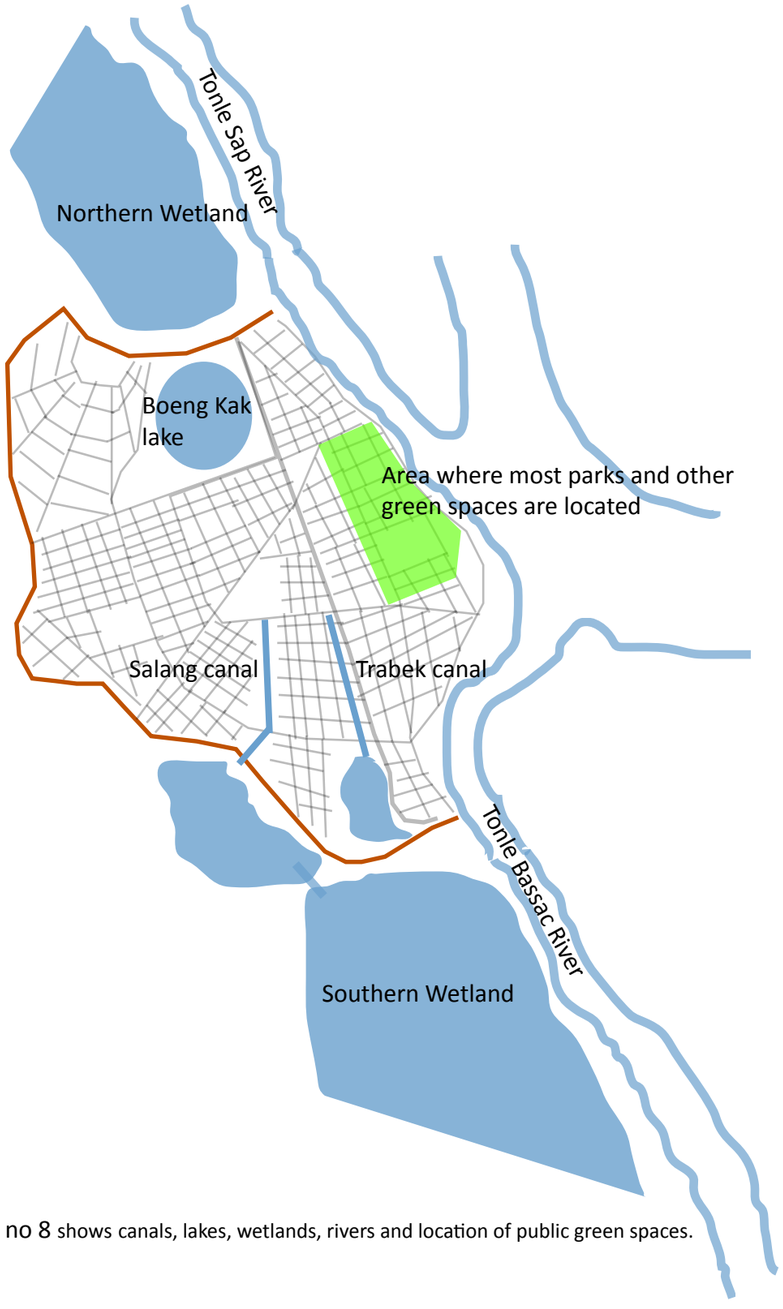
**The Tonle Sap River** is smaller than the Mekong River. It has a very unusual annual rhythm. It changes directions twice every year. In the dry season it flows from the south to the great Tonle Sap Lake in the north. In the wet season it flows from north to the sea in the south. When the change of current takes place, the river stands completely still for a couple of days. At this occasion, emissions of pollutants can become very concentrated in limited areas. This is a critical time for the river that affects the lives of animals and plants living and breeding here[51].

**The Bassac River** flows south to the sea. The Bassac River is undergoing a gradual displacement towards the east in the Four Faces region. The western bank is expanding, while the eastern is eroding. Very fertile land is found along the rivers. Nutrients in the soils are renewed every year, due to the floodwaters and the silt that the water brings[52].

Phnom Penh is surrounded by wetlands and their appearance change over the seasons. The water levels increase dramatically during the rainy period of the year and large parts of the outskirts of Phnom Penh flood. Since the water level in the wetlands fluctuates when seasons change, the water is both an enemy and a friend to the people living here. Many people live by the wetlands both in common houses and in

48 Molyvann, V, 2003
49 Molyvann, V, 2003
50 Molyvann, V, 2003
51 Molyvann, V, 2003 p. 146,
52 Molyvann, V, 2003 p. 143

MAJOR GREEN AND BLUE PATTERNS IN PHNOM PENH




Map no 8 shows canals, lakes, wetlands, rivers and location of public green spaces.

Trabek Canal has recently been upgraded. It stretches through the city before it ends in the southern wetlands. (Photo: Gunilla Englund)

Boeng Kak Lake is situated in the middle of the city. It is a popular spot for backpackers and many guesthouses are situated on the eastern shore of the lake. (Photo: Gunilla Englund)

informal settlements. The houses are located close to or in the middle of the wetlands. In the rainy months, the roads are flooded and the inhabitants have to transport themselves by boat. Most houses are constructed on stilts. This makes the houses less vulnerable to flooding.

A few dacades ago, Phnom Penh was famous for its many parks, gardens, canals and boulevards. The city was also known as "**the pearl of Asi**a"[53]. In the 1950´s and 1960´s, the famous Cambodian architect Vann Molyvann was at the peak of his career. He propagated for a well-planned, sustainable Phnom Penh with special consideration to the water systems and greenery inside and outside the city[54].

Most existing parks are situated at the very heart of Phnom Penh, in the most touristic areas around the Royal Palace (see map no 8). They resemble the classical baroque parade gardens with decorative and symmetrical plantings and very few trees. Some of the parks are situated in large roundabouts and in traffic refuges, which make them inaccessible. Very few parks are equipped with park benches and sofas which make them a place to look at rather than a place to visit and integrate with.

Few people use the parks in the daytime. The heat and strong sunlight can become somewhat unbearable without the shade of trees. It is at the hour of sunset that the people return to the parks to play games and sit on the ground or the grass. According to Mr Ratanak, people in Phnom Penh do not want trees, but they want open spaces to play and do sports. He also says that trees may block important monuments[55]. Mr Tiev Vinno believes that Phnom Penh would benefit from more trees though, for example by the riverfront walk where people now sit in the shadow of the flag stilts[56].

53 Int,. Symann, R, 2008
54 Molyvann, V, 2003
55 Int. Ratanak, T, 2008
56 Int. Vinno, T, 2008

The parks are in first hand intended to be decorative. The benches are situated around the baroque inspired plantations. Trees are scarce.
(Photo: Joakim Englund)

The river front walk. (Photo: Sara Ryttar)

Because of the lack of shade providing trees, people only use the parks in the evenings. (Photo: Sara Ryttar)

Most parks are situated close to important cultural buildings. (Photo: Sara Ryttar)

Many people we interviewed expressed their worry about the large areas of Phnom Penh completely missing out on green public spaces. A network of green corridors does not exist in Phnom Penh[57]. “The city is too dense”, says Mr Ratanak. “Most of the green parks are in the eastern part of the city and there are no parks at all in the western part “. The goal is to increase the number of parks in the city. Now the city has 70 ha of park area and there is a need of more open public spaces. It is very difficult to get hold on land in the city because of the high prices on land. Most of the land is occupied by the private sector[58].

The city planners acknowledge the importance of green space for public health, well-being and city sustainability. Mr Teav Ratanak thinks it is important to recognise how green areas improve the city health. Many Cambodians do gymnastics and Thai Chi in the early mornings before the sun heats the air. Today the riverfront walk and some parks are popular places for these group activities. During our trips in the centre we sometimes saw people playing racket and other social sports in traffic islands where grass and trees were planted.

Today the central green spots are rapidly diminishing due to fast urbanisation and land prices increasing in value. The municipality is selling public land to eager local and international developing companies. The city of gardens, so famous 50 years ago has transformed into a city with hardly any green areas left[59]. According to Tiev Vinno, it will be a lack of green areas in the city in the future. Mr Frederic Mauret doesn´t believe it is possible to restore Phnom Penh to the green city it once was, but he thinks there is still a chance to have a green city network between the satellite cities in the future expansion of the city.

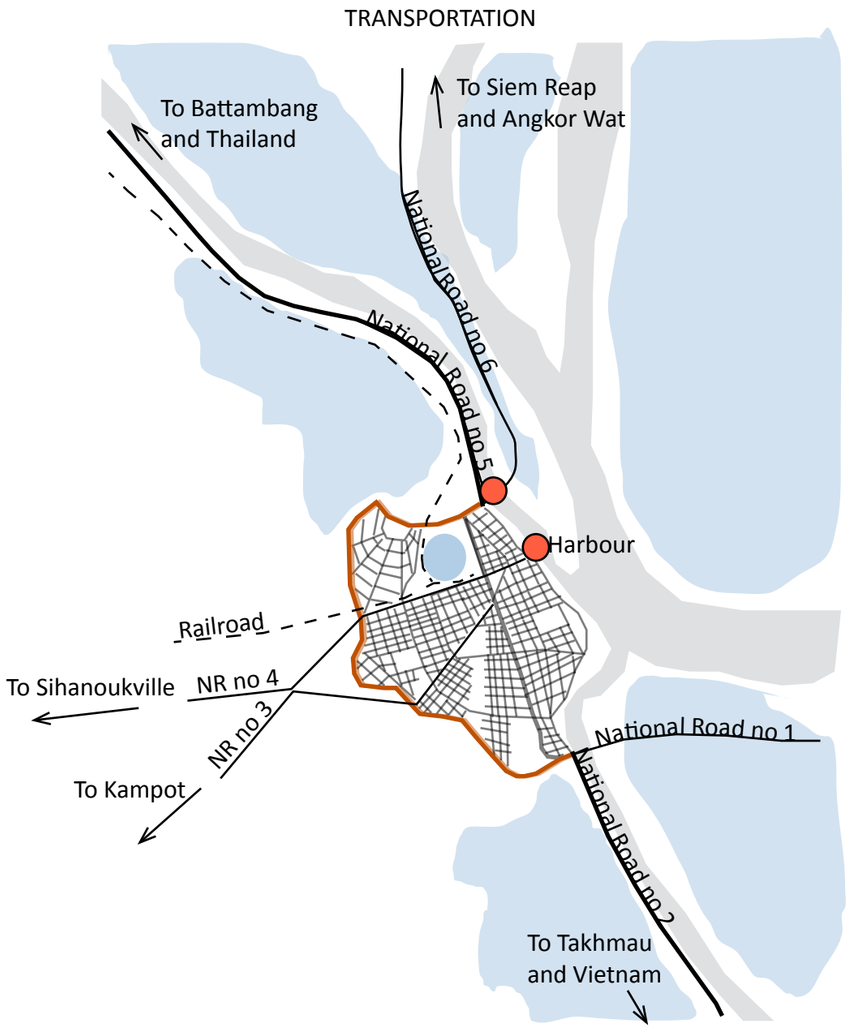
Today there is an alarming situation with violent evictions and unsanitary slum settlements that take focus off the environmental problems, such as the loss of public green and blue space. Most NGO´s are working with social questions nowadays, evictions mostly. Even if the destruction of environment has many negative impacts on social welfare it is not one of the most urgent things to fight for. “It is more dangerous to fight for ecological questions. No one wants to put themselves in that situation”, Mr Hallam Goad at the NGO STT tells us.

Mr Din Somearith at UN Habitat tells us that the organisation has a low profile in environmental issues. They are working more concentrated on upgrading and social questions, even though environmental questions are closely related to social problems[60].

Another factor leading to the diminishing of green areas in Phnom Penh is the inhabitants themselves. They are unfortunately not particularly protective of their green environment. Economical values are often put in front of the ecological. Shop and restaurant owners that believe the trees are hiding their business cut them down. This problem is everywhere in the city, but especially in the business areas[61]. Many trees and plantations are also destroyed because off careless driving across roundabouts and refugees.

During three days in September each year, there is a water festival. 2-3 million people gather in Phnom Penh to celebrate. All parks in Phnom Penh are crowded with people and all plant material is destroyed as a result of the extreme pressure. As a result, the plantations have to be replanted every year and it is extremely costly[62].

57 Int. Cheam, P, 2008
58 Int. Ratanak, T, 2008
59 Int. Mauret, F, 2008
60 Int. Din, S, 2008
61 Int. Ratanak, T, 2008
62 Int. Ratanak, T, 2008




Map no 9

Traffic is chaotic and no driving rules exist. The lack of public transportation makes the streets extremely busy since everyone needs to drive their own vehicle. This affects the city air quality and the soundscape of every street. Especially in peak traffic hours the streets are clogged, the air gets much polluted and the noise is alarming. The problem of the increasing congestion of the traffic inside the town, where the car park doubled in ten years obliges to set up a system of public transports. The need for improvement seems urgent. (Photo: Gunilla Englund)

Travelling by bicycle taxi is a common means of transportation. (Photo: Sara Ryttar)

## Life of the city

Phnom Penh is strategically situated and practically every major national road connects to the city. Phnom Penh is traffic wise the hub of Cambodia (see map no 9).

Phnom Penh is a busy city with a lot of traffic. Motorbikes and tuk-tuks (a motor-bike with a small coach for passengers) dominate the traffic. There are also cars, bicycles and bicycle taxis. Public transport does not exist but there is a big business with private drivers that offer rides in tuk-tuks, bicycle taxis and on mopeds. Private persons carrying passengers on homemade long coaches behind motorbikes solve the need of public transportation between the nearby city Takhmau and Phnom Penh today.

There was a trial period for about a year with public buses, but since nobody seemed to be using them, they were eventually taken out of traffic[63]. Maybe a public transportation system would work better now, because Phnom Penh hosts a bigger population with an increased need of transportation[64].

The history of Cambodia is common knowledge to the population of Phnom Penh. In many restaurants in the capital there are pictures showing the impressive Angkor temples. Cambodia's recent history is also on display. Museums in and outside the city are showing the terror of the Khmer regime.

Khmer food resembles Thai food. Many restaurants in the city serve traditional Khmer dishes. The dishes consist of locally harvested food. Each region has their specialty depending on the local food production. Tourists enjoy the Cambodian cuisine and it is a great way to experience the culture.

63 Int. Symann, R, 2008
64 Int. Vannara, T, 2008

We think of the Cambodian people as friendly and kind. They were eager to help, sociable and polite. (Photo: Gunilla Englund)

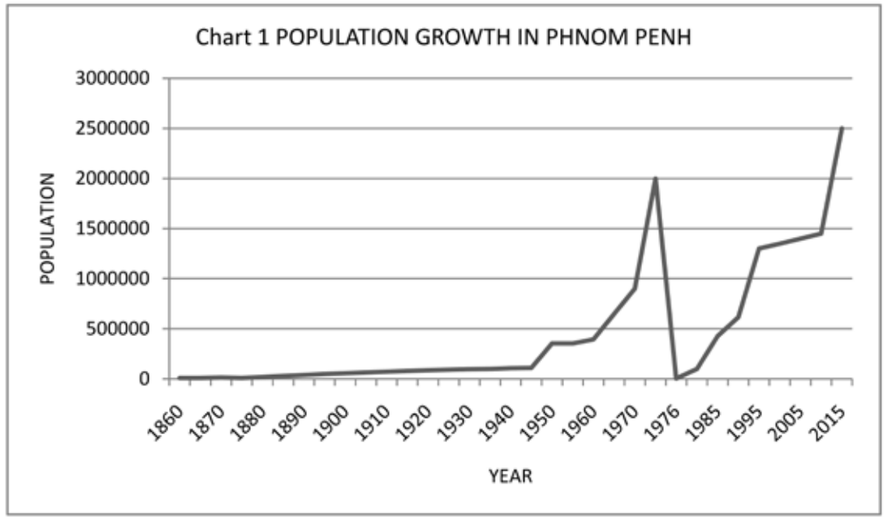
A lot of Buddha statues and other religious symbols are scattered all over the city of Phnom Penh, outside restaurants, in the hotel receptions, in the street trees, or close to fancy clothes shops. The religion and its symbols are a part of everyday life. Young Buddhist monks dressed in orange are seen all over the city. They live and pray at the many Pagodas (temples). The Pagodas and monks are characteristics of Phnom Penh City that contributes to the unique atmosphere.

Food stands border the streets and enrich the city atmosphere. People meet and interact while they eat on the streets. (Photo: Gunilla Englund)

Many young Cambodian men are monks for a period of their lives. Their orange clothing creates a characteristical feature in Phnom Penh. (Photo: Gunilla Englund)

Religious symbols can be found everywhere in the city. These bananas bring good prosperity to a newly upgraded canal. (Photo: Sara Ryttar)

Busy street life in Phom Penh. (Photo: Gunilla Englund)




SOME OF THE MAJOR SLUM SETTLEMENTS IN PHNOM PENH


Map no 10

Upgraded slum settlement area. The dirt road has been replaced and the street is more accessible. (Photo: Sara Ryttar)

# Urbanisation

Phnom Penh has had a fast urbanisation during the period after independence 1954 and since 1990 (see chart no 1). During the Khmer Rouge (1975-1979), urbanization experienced a big backlash. People were forced to the countryside and Phnom Penh was left as a ghost city. In 1975, Phnom Penh housed nearly 2 million people but in 1976 after the Khmer Rouge take over, that number was only 4000[65].

Today, Phnom Penh is a capital with few inhabitants (1,3 million) compared to its Asian neighbours. But the urbanisation process is strong again and the city is growing fast. The total urban population of Cambodia is predicted to grow from 20% in 2005 to 35% in 2030[66]. This will more than double the urban population in the country.

## Informal settlements

In Phnom Penh there are slum settlements on a variety of places around the city (see map no 10). Simple houses of concrete, bamboo, plywood, leaves and wood are built along the railroad, along the canals, on the embankment to the river, by lakes and wetlands and along roadsides. There are also people living on boats on the river and wetlands[67].

The rapid migration to Phnom Penh after the fall of Khmer Rouge is one of the major reasons to the problems with slum settlements. It was not possible to create adequate infrastructure and housing because the leadership of the country was unsure and organisation for dealing with urban planning non-existing. Human, technical and financial resources were very limited. Another reason to the increasing slum settlements is natural growth and migration from the countryside. As a result, about 34% of the population in Phnom Penh live in slum settlements[68] without proper hygienically and sanitary solutions. The rapid urbanization is causing problems with solid waste, air pollution, congestion and urban sprawl. In turn, these problems cause environmental degradation.

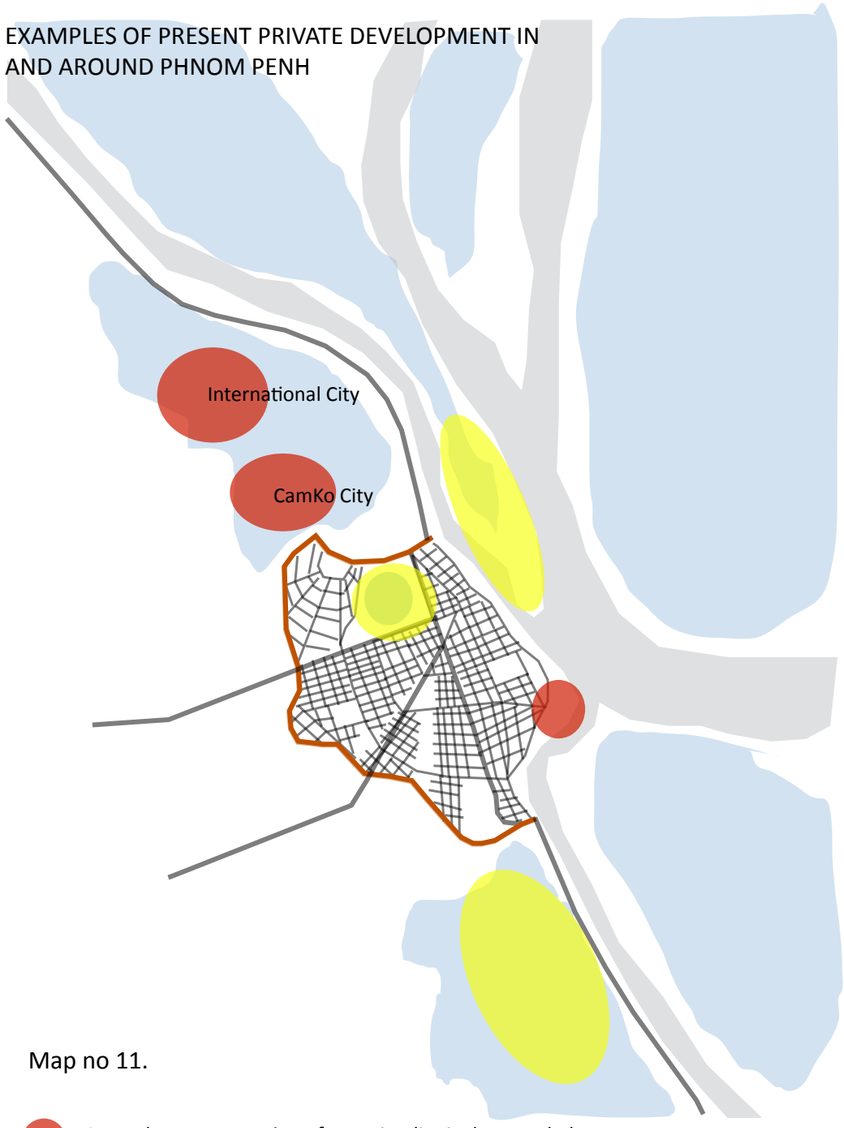
Because of poor urban planning many people from the middle-income class live in slum despite a stable economy. Most of the future construction plans are made for enclosed upper class areas and does not answer to the need of more middle-class homes. This will lead to an increased slum problem situation[69].

A large number of the slum settlements are located on low land, unattractive to others because of the recurrent flooding and stagnant wastewater. In the rainy season the water level can rise several meters. Many people have to move every time it rains or have their homes submerged[70]. Those who can afford it are building their houses on stilts and construct walkways and bridges of wood so they can access the house during floods. People living in the middle of the wetlands can only move to and from their houses with boats during half of the year when the roads are flooded[71].

The policy of the Government is to relocate slum settlers to places outside the city[72]. The land that the slum settlers occupy are many times claimed to be the property of the state and needed for the development of the city. Violence and insufficient compensations are common during these evictions. In a few cases the Municipality has offered to upgrade the slum areas on site. The people then get housing and proper infrastructure to their living areas. In 2003 the Prime Minister promised to upgrade 100 slum settlements per year during the next five years[73]. This promise has not been fulfilled. Today, only local NGO´s like STT are working to improve the situation in the slum areas[74]. The upgrading actions made by NGO´s have improved the situation for many inhabitants formerly

65 Asian Development Bank, 2006
66 Asian Development Bank, 2006
67 Field studies 2008-05-08, 2008-05-09, 2008-05-16, 2008-05-17
68 Seshimo, K. Chen, M, 2004
69 Int. Hultén, S, 2008
70 Seshimo, K. Chen, M, 2004
71 Field study 2008-05-11
72 Int. Din, S, 2008
73 UN Habitat, Phnom Penh Urban Poverty Reduction Project, 2008
74 Int. Seng, K, 2008 and Int. Hultén, S, 2008

EXAMPLES OF PRESENT PRIVATE DEVELOPMENT IN AND AROUND PHNOM PENH




Map no 11.

Area where construction of new city district has starded

Area where new city district is planned

High class residential area in the new city district “International City” situated in the northern wetland. (Photo: Sara Ryttar)

The “International City” is located on former wetland. Landfillings are reducing the water storage capacity of the wetland and are transforming the wetlands into sandy deserts. (Photo: Sara Ryttar)

living in degraded slum areas. But the inhabitants have no legal papers stating their ownership to the land and can be evicted any moment by the Municipality. All papers on ownership of properties and land were destroyed during the Khmer Rouge regime[75].

## Privatisation as a major force for urban development

*“Cambodia is expanding as Europe did after World War Two. Maybe some buildings have to be teared down in the future in order to build schools and green spaces again”* [76]

*“Public spaces in Phnom Penh are under extreme pressure. Private companies now occupy every free space in the city centre”* [77]

The fast increase in land prices is affecting the urban landscape. Land that till recently was saved for common purposes like parks, schools, theatres or retention areas for storm water and flooding, are now being sold and built on (see map no 11). Land management plans like The Master Plan of Phnom Penh 2020 are not followed or even legally binding.

Matt Rendall, a lawyer at local firm Sciaroni & Associates, said that despite recent growth, Cambodia’s real estate sector is still in its infancy and have yet to develop the planning regulations that guide urban construction in developed countries. *”There’s a lot to be done in terms of providing the country with a legal framework. Property just isn’t a priority.”* [78]

The Government of Cambodia has a policy to encourage the private sector to engage in the development. According to the National Strategic Development Plan 2006-2010, Cambodia still needs more investments from the private sector for its development. The National Strategic Development Plan clearly states that the Royal Government is determined to ”strictly adhere to competitive public bidding and transparency in all contracts, leases or disposal of state assets”[79]. At the moment, the future of Phnom Penh seems to lie in the hands of private investors. The municipality saves few areas when they sell out the common land. Strategic plans are being overseen and they are becoming more and more out of date for each new development. Some areas are noted as important in the strategic documents and regarded as areas that need special protection against development because of their values. Even these areas are now disappearing.

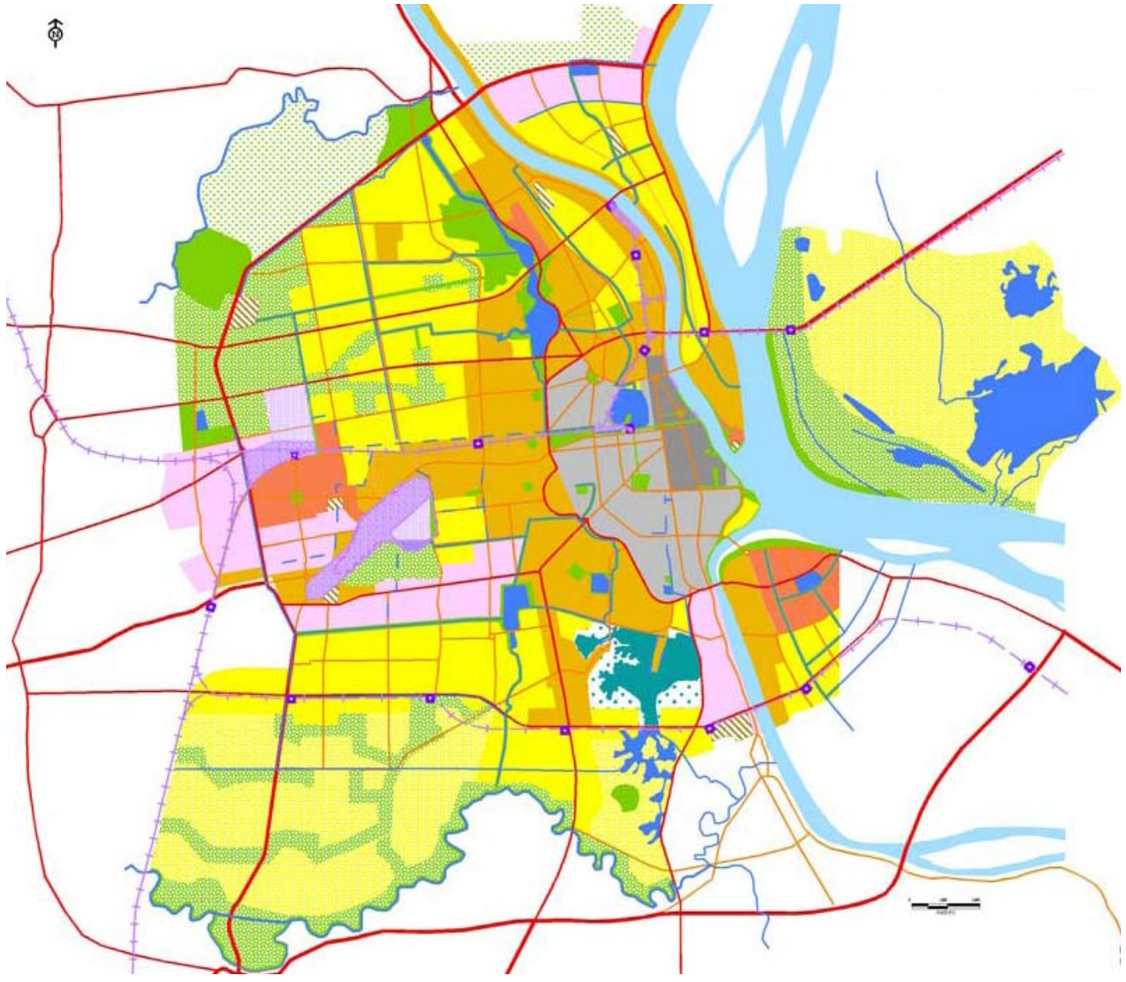
Sara Hultén at Archetype tells us about a planned public park that was converted into a construction site for private companies. A public park was planned along the river and also partly constructed. The law allows expropriation of land for building public parks and many people were relocated. Shortly after, the area was fenced in and sold to a private company that is now building shopping malls, apartments, casinos and hotels on the site. The whole riverfront that was planned as a park is now inaccessible for the majority of people[80]. The development was neither competitive nor transparent.

Private interests also threaten some culturally important buildings. The public theatre and the School of Performing Arts were two cultural heritages that have been demolished in order to sell the land to investors. The centrally located school of fine Arts is not yet sold, but there is a strong interest and a pressure to do so, since its location is on valuable central land[81].

Many satellite cities are developing around Phnom Penh (see map no 11). Projects financed and initiated by private investors are shaping and creating the city districts. These new development areas are isolated islands, some of them far away from the city. The districts are far from linking with the identity and culture of the rest of Phnom Penh.

75 Int. Symann, R, 2008
76 Int. Vinno, T, 2008
77 Int. Symann, R, 2008
78 Rattana, V, 2008
79 The Royal Government of Cambodia, 2006
80 Int. Hultén, S, 2008
81 Int. Symann, R, 2008

GENERAL PLAN FOR PHNOM PENH BY THE YEAR 2020



Map no 12. Map from Livre Blanc.

## Public planning and acting

*"We have to get the Master Plan accepted so the municipality are aware of the goals for Phnom Penh 2020"* [82]

*"We should learn from Sweden and China and not make the same mistakes. We should make a better Master Plan and plan BEFORE. Not fill it all, keep some"* [83]

*"We have to make a priority list of what is important to save and follow it. Otherwise we will loose everything"* [84]

BAU (Bureau of Urban Affairs) is, with help from France, working with urban planning in the Municipality of Phnom Penh. There are a few documents regulating the urban development (see table 8). From 2003 till 2005 the BAU office at the Municipality worked to create the new Master Plan for Phnom Penh (see map no 12). Yet, the prime minister has not approved it. The reason for not yet approving the Master Plan is because it changes the administrative boundaries of Phnom Penh to make the city bigger. The real reason, says Mr Symann from the German NGO DED, is that no one wants to stop the chaos. Now there are no rules or guide lines. Only Korean and Chinese companies are interested in making investments due to the insecure situation[85]. This situation gains certain economical interests. The fact that the Master Plan is not yet approved puts strains to the work of many people. An approval would mean that the Master Plan becomes a legal document, which prevents exploitation of some areas.

The not yet approved Master Plan is becoming more and more out of date with every unplanned new landfill and exploitation. The Department of Land Management is updating of the Master Plan. The Master Plan has a 30% strategy, which means to save at least 30% of wetlands in new development areas[86].

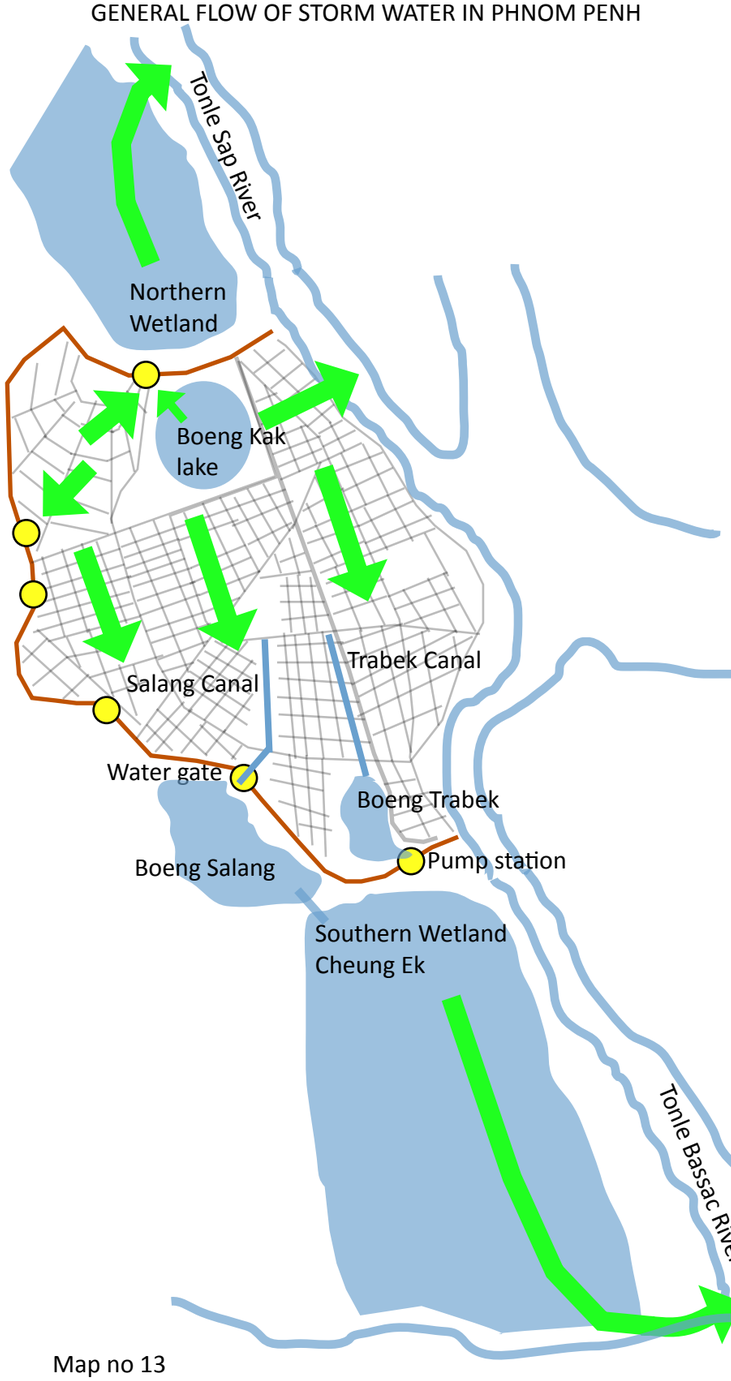
There is a large group of qualified, professional and engaged people working to direct Phnom Penh towards a sustainable development. Despite this fact, city planning in Phnom Penh is very focused on private incitements and lack a bigger perspective. Many small projects are going on and no global reflection is added.

Frederic Mauret at BAU would like to see more work on a district level so that solutions for schools, roads, drainage and so on could be carried through on a local level. He also thinks that the problems need to be discussed and understood[87].

| Table 8 DOCUMENTS REGULATING URBAN DEVELOPMENT IN PHNOM PENH | |
|---|---|
| Master Plan of Phnom Penh | The plan was made by Vann Molyvann and dealt with an area slightly broader than the four central Khans of today. Unfortunately the document does not exist in a digital version and the original seems to have been destroyed during the Khmer Rouge regime in the 1970´s. Only fragments of the document remains. |
| JICA drainage master plan | The Japanese development agency JICA completed a master plan for improvement of storm water management. |
| Livre Blanc, Master Plan of Phnom Penh by 2020 | Aim to replace the plan from 1950 but are not yet accepted by the Government. Development and management of Phnom Penh, economic, social and environmental diagnosis, tendencies, futurology and orientations, plan of town planning for Phnom Penh till 2020. |
| City development Strategy 2005-2015 | Presents the development objectives, strategies and policies of the Government strategies. |

82 Int. Mauret, F, 2008
83 Int. Vannara, T, 2008
84 Int. Mauret, F, 2008
85 Int. Symann, R, 2008
86 Int. Sophan, M, 2008
87 Int. Mauret, F, 2008

GENERAL FLOW OF STORM WATER IN PHNOM PENH




Map no 13

# Storm water in Phnom Penh

*"As anyone can see when landing at Phnom Penh airport in the rainy season, the city is like an island built in the middle of a complex wetland"* [88]

Although located on a wetland area on the border to four great rivers, the flooding in Phnom Penh is not due to overflow of rivers but due to excessive runoff during rains. During the history, landfills have elevated the city from the surrounding areas in order to lead the rainwater out of the city (see map no 13).

Some low points in form of smaller ponds and lakes have been left inside the city up until recently. Now these water reservoirs are being filled and the same development is occurring in the surrounding landscape of wetlands. It has been found that the rate and volume of storm water flows in Phnom Penh has increased due to urbanisation. Areas with infiltration capacity are being replaced by constructions of hard impermeable surfaces[89].

In Phnom Penh, the storm water is not separated from the wastewater. The water from the city is led through underground pipes of different sizes and open canals and thereafter it is discharged in four larger wetlands surrounding the city. Only the biological processes in these wetlands handle the treatment of the water.

Dikes that are also functioning as roads surround the city. These dikes protect the city from flooding in the rainy season, when water levels are higher in the wetlands outside the dike than in the city. On some places water gates lead the water out of the city, in other locations the water from the city is transported over the dike with pumps. The gates to the floodplains have to be closed during the rainy season otherwise the water would be pushed back to the city (see map 13).

The network of storm water pipes is not big enough and floods are recurrent[90]. The flow capacities of the underground pipes are remarkably restricted. The choke rate is reported at 50-90% of original pipe flow capacity[91]. One of the reasons is the neglect during the years of Khmer Rouge. The city was then lacking maintenance and flooded several times. Sediment filled the pipes and is still there. Another reason is that the network of drainage pipes is mostly built in the 1960´s and is today under dimensioned. JICA (Japan International Cooperation Agency) was at the time of our study working on restoring and making the pipes wider to increase the capacity of the drainage network[92].

The main drain system of canals and pumps in Phnom Penh are designed after 10-year rains and the rest of the pipes after 5 and 2 year rains[93]. This might have been a reasonable decision at time being but now circumstances have changed and the climate changes are making the climate events more unpredictable. In the new Master Plan from 2005 a 10 year rain perspective is used.

The Municipal department of public works and transport (DPWT) is the implementing agency for drainage improvement and flood protection. The drainage and sewage division in DPWT has a direct responsibility for drainage improvement but there is no division with direct responsibility for flood protection[94].

88 Rattana, V, 2008 (Helen Grant Ross, co-author of Building Cambodia: New Khmer Architecture, 1953-1970)
89 Yin, M, 2006
90 Int. Sothea Kok, S, 2008
91 JICA, 1999
92 Int. Vibol, C, 2008
93 Int. Sophan, M, 2008
94 JICA, 1999

The part of Salang canal that is not yet upgraded is very different from the upgraded part. Families living in slum settlements occupy the area close to the watercourse. The water and the slopes are full of rubbish and the smell is appalling. Outhouses are built on the slopes and cause an even more unhygienic environment. The sides also have some erosion that threatens the housing. (Photo: Gunilla Englund)

The restoration of the Salang Canal is partly finished. The part that is finished has sides of concrete and green areas where grass is established. New roads with sidewalks stretching along the canal are making it accessible for both private persons and garbage collectors. Before, slum settlers were living on the slopes, but they are now relocated. (Photo: Sara Ryttar)

## Dikes, Canals and Wetlands

A lot of the city waste and storm water fall out into open canals after running in underground pipes (see map no 13). The canals are draining water from the city to the southern wetlands.

The canals are often clogged with refuse and sediments. Most inhabitants of Phnom Penh dislike the open canals. They argue that they smell bad and are unhygienic. There have been ideas within the municipality to cover the canals with green gardens, a new technique developed in Japan. Unfortunately this would be too costly and difficult to implement according to the Municipality[95].

The Japanese aid agency JICA has made efforts to upgrade the two canals. The results have been successful and improved the environment along the canals. Both of the canals end at the southern dike. The water of Salang canal is flowing through a floodgate and continues in a watercourse towards the southern wetland (see map no 12). The Trabek canal ends at a pumping station, where the water is pumped to the southern wetland. The water is not cleaned or treated before it enters the wetlands.

Phnom Penh has natural treatment facilities in form of wetlands close to the city. The city is practically surrounded by water. There are wetlands to the south and the north of the city where the topographic features are lower in elevation than the surrounding landscape. The water flow is slowed down when it enters the wetlands and particles are able to sediment. Plants are absorbing heavy metals and nutrients. It is an efficient system and Phnom Penh has no other mechanical or chemical cleaning. The water finally enters the rivers and is then cleaned from the majority of pollutants[96].

The northern wetlands receive wastewater from about 25% of the city (see map no 12). The wetland has up until recently served as a natural treatment area, by biologically cleaning the water before it enters the Tonle Sap River. Today almost all the wetland is being filled in because

95 Int. Cheam, P, 2008
96 Dany, V, Eliyan, C

Trabek Canal has concreted sides to prevent erosion and flooding.
(Photo: Gunilla Englund)

Sediments block the Trabek canal and reduce the water flow severely. (Photo: Gunilla Englund)

Trabek pumping station. Poor people live in informal settlements near by the pumping station. It is a dangerous, smelly and unhygienic living environment. Children are playing in and near the contaminated water. In the rainy season the water level rise and inundates the ground floor of the houses. (Photo: Sara Ryttar)

Trabek pumping station. Only a fence of bamboo bars prevents big pieces of garbage to flow into the pumps. The floating garbage is being collected and gathered by the workers every day. Close to the pumping station there is a dumpsite for the collected garbage. The municipality collects the garbage when the dumpsite is full, in average every four months. (Photo: Gunilla Englund)

At the Trabek pumping station the water from Trabek Canal is being pumped over one of the road dikes (road 271) to the southern wetland. After the water has been pumped over the road it enters into the southern wetlands. It receives the majority of the city waste- and storm water. A couple of meters from where the untreated water is flushed out, vegetables are grown in aquatic cultivations and later sold on the central markets. (Photo: Sara Ryttar)

of the construction of new city districts[97]. A new wide canal is under construction that will bring the waste and storm water from the new satellite cities directly to the Tonle Sap River. There are no plans for a natural or artificial cleaning process of the water before it enters the river. Without natural treatment in the wetlands, the wastewater will cause great environmental damage to the sensitive Tonle Sap River[98].

The southern wetland, Cheung Ek, receives water from the majority of Phnom Penh centre (see map no 12). The wetland is vast and stretches all the way to the city of Takhmau where the water is discharged in the river Prek Thnot before it finally enters the Bassac River. The amount of water discharged in the south wetland varies with season but a mean value is 1 040 942 cubic m/day. Of this water, 95% is storm water and the rest is wastewater[99]. Because of the variations in precipitation the water volume managed by the wetland is varying a lot. The Cheung Ek wetland has the capacity to detain large volumes of water and protect the city from flooding. Unfortunately, Cheung Ek wetland is likely to follow in the same footsteps as the northern wetland. The wetland is under threat of being filled in and transformed into a construction site. Large parts have already been sold to a group of private companies. The future for the southern wetland is uncertain.

97 Field Study, 11-05-2008
98 Mauret, F, 2008
99 Muong, S, 2004

Dysfunctional waste collection is one of many factors causing problems to the storm water management. (Photo: Gunilla Englund)

| Table 9 FACTORS CAUSING PROBLEMS TO STORM WATER MANAGEMENT IN PHNOM PENH | |
|---|---|
| Neglect | Storm water pipes are clogged with sediment from the rivers |
| Climate change | More intense and frequent rainfalls have occurred in the region during recent years |
| New constructions | More hard surfaces in the city increase the runoff<br>Constructions often lead to destruction of lakes, green areas and wetlands |
| Dysfunctional waste collection | Waste end up in pipes and canals, blocking the water flow |

New drainage pipes replace the old and degraded ones. The work is ongoing in the most central parts of the city. (Photo: Sara Ryttar)

# Analysis

## Problems

Inundation on the streets of Phnom Penh is a common event during rain. This is a clear sign that the storm water management is not functioning well. During our study we found a number of factors causing problems to the storm water management in the city (see table 9).

**Neglect** - During the Khmer Rouge regime no one closed the gates during the rain seasons and the canals and pipes were filled with sediment when the rivers flooded. Today the sediment is still there and this is a problem that causes flooding[100].

**Climate change** - Southeast Asia is one of the regions where climate changes will bring heavier storms with more frequent and intense rainfall (see page 15). This will put higher demands on the capacity to manage storm water in Phnom Penh. The drainage system of Phnom Penh is already much stressed and inundations during rainfalls are already today common events in Phnom Penh. The pipes do not have the capacity to handle the increasing amount of water.
Phnom Penh is also affected by the consequences from climate change in neighbouring countries. As Mr Tek Vannara[101], argues: "What will happen if the dams in China and Vietnam break? If the water reservoirs (wetlands) around the city are filled, the city will have no protection and be completely flooded by such an event. The city of Phnom Penh has to think in long term development"[102]. This is a realistic fear in the future of climate changes.

**Land fills** - Only one decennium ago, Phnom Penh had several central lakes in low point areas[103]. They functioned as storm water collectors and detention ponds and were important as flood control. Because of landfills there are very few lakes left and as they have decreased in numbers, flooding in the city has increased dramatically. There are also extensive fillings of wetlands going on in the north of the city where new housing areas are being built.

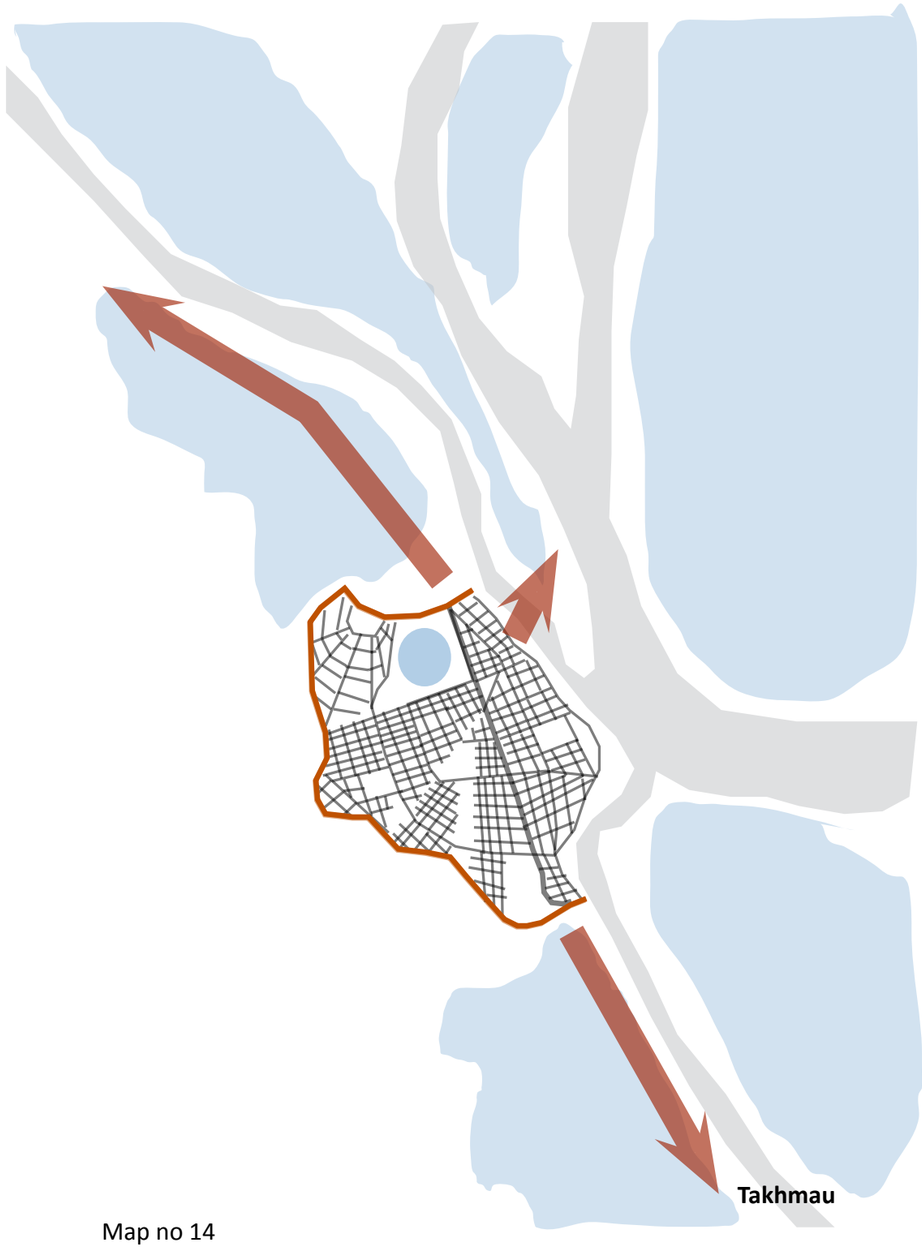
Mr Symann at the German development agency DED, tells us about the former green area with water basins and infiltration around the Olympic stadium. Recently it has been sold to a Taiwanese company that filled the land and constructed a shopping mall. As a result, there are now problems with flooding around the Olympic stadium[104].

Filling of the wetlands in the north were going on during the time of our study. A development project which demands filling is also planned for the south wetland. The function of these wetlands as detention ponds will be greatly diminished by the fillings. Mr Sophan[105] believes it will be problems with flooding when they build in the north. He also thinks there will be problems with flooding if the planned filling of the south wetland is carried through[106]. His thoughts are shared with Mr Sothea Kokh at the Royal University of Phnom Penh[107]. Ann Vannak and Ly Sarann at ITC (Institute of Technology of Cambodia) think that the only solution to the problems of flooding is to keep the lakes and wetlands and to rearrange the drainage system[108]

**Dysfunctional waste collection** - There is a problem of insufficient waste management in all parts of Phnom Penh. Waste is being dumped in watercourses, along roads and on abandoned land everywhere in and around the city. Because of the lack of garbage bins and because of habitude, people throw rubbish in the canals and along the roads where the rain finally washes the rubbish into the canals[109]. Wetlands, rivers and lakes outside Phnom Penh then become polluted.

100 Int. Symann, R, 2008
101 Int. Vannara, T, 2008
102 Int. Vannara, T, 2008
103 Int. Hultén, S, 2008
104 Int. Symann, R, 2008
105 Int. Sophan, M, 2008
106 Int. Sophan, M, 2008
107 Int. Kok, S, 2008
108 Int. Sarann, L and Vannak, 2008
109 Int. Hultén, S, 2008

POSSIBLE FUTURE EXPANSION OF PHNOM PENH




Map no 14

An example is the situation along Trabek Canal where waste disposal is a problem. People throw their rubbish in and beside the canal. This habit causes bad smell and an unhygienic living environment[110]. Signs along the canal urge people to throw their rubbish in the bins but no bins are at sight[111].

A good example is the Salang canal where physical restoration has helped improve the situation. The improvement helped the garbage collectors to do their job. This in turn has reduced the disposal of garbage into the canal[112]. Finally this means less polluted water to the wetlands, rivers and lakes outside Phnom Penh.

## Where to expand?

Phnom Penh is growing fast and needs to expand. Development and growth is necessary but it is of outmost importance that the expansion is well planned and controlled. The question is if there is a sustainable solution to the future expansion of Phnom Penh that considers ecological, economical, social, and cultural values.

Phnom Penh has very interesting and complicated prerequisites, since the city was established on wetlands. During our interview with Sara Hultén, she stated that she couldn't imagine a worse location for a multimillion-city. Nevertheless, Phnom Penh is growing and its´ development is in the hands of the selected government and city planners. During our study we found documents and persons stating a number of alternatives for a sustainable growth of Phnom Penh (see map no 14). Molyvann suggests an expansion in a north-south direction linking together Phnom Penh and Takhmao[113]. The architect and lecturer Mr Teav Vinno[114], advises an expansion to the east on the other side of the river. He believes the peninsula is important to preserve and make accessible with bridges from the city.

The expansion north and south along the rivers is natural since the rivers are important for water supply. Could an intrusion into the important wetlands be avoided in such a development? The answer is probably no. Land filling and construction works are already occurring in the northern wetlands and the area has more or less lost its wetland capacities, such as its ability to clean and store storm water and wastewater. Since the northern wetlands already are being developed and exploited it might be a successful strategy to continue expanding in the north to link the new development areas with the city. Though, this should be done with careful consideration to the ecological values and protection of important natural resources.

The southern wetlands on the other hand, are still more or less intact. No large scaled construction has yet been conducted. A restrictive approach, regarding city expansion, should be suggested for the southern wetlands.

A dense and space efficient city core is also a possible future scenario. Today Phnom Penh is dense, but the denseness is inefficient. There are a lot of one-family city villas and low raised buildings, one to three floors. Slum settlements are also an inefficient city structure and the settlements usually pop up in green or other open spaces and make public places unavailable. In a dense city it is especially important to save contrasting environments like parks and waterways. It improves the city's economic and environmental situation and people are proud of their city nature. Pieces of nature within the city are important for people to relax and for the citizens that are unable to get out to the countryside. It is important to determine and evaluate which environments in Phnom Penh are worth saving as open public spaces.

## Analyses of Phnom Penh after sustainability criteria

According to the Habitat Agenda there are seven dimensions of sustainability; Physical, Economical, Biological, Organisational, Social, Cultural and Aesthetical. We have analysed Phnom Penh from without these seven resources. We used the swot-analyse method and have categorised the resources in; strength, weakness, threat and opportunity (see table no10).

110 Int. Kok, S, 2008
111 Field Study, 2008-04-27
112 Field Study, 2008-05-11
113 Molyvann, V, 2003
114 Vinno, T, 2008

| SWOT ANALYSES OF PHNOM PENH AFTER SUSTAINABILITY CRITERIAS | | | | |
|---|---|---|---|---|
| | Strength | Weakness | Opportunity | Threat |
| Physical | Phnom Penh is situated in the very heart of Cambodia and is strategically placed right in the middle of the action where roads and rivers are crossing. There are waterways to Laos, China and Vietnam and the roads from Bangkok and Ho Chi Min City are straight and well maintained.<br><br>As in many big cities in developing countries, most people in Phnom Penh drive a motorbike. The car is not yet the possession of every person, and this can be seen as a strength when it comes to develop and implement public transportation.<br><br>The rivers create an impressive character of the city and the human settlements follow the river. The water is an extremely important resource and many people earn their living from it. | The location of Phnom Penh on easily flooded wetlands is an obvious weakness. The city often suffers from severe floods and expansion is difficult.<br><br>Phnom Penh is not dimensioned for its many people. Its population has boomed the recent years. The city is crowded and the roads are constantly jammed. The air and the water are polluted and garbage is thrown directly onto the streets.<br><br>The system of dikes and embankments offer a weak protection because it fights the fluctuating water instead of adapting to it.<br><br>The city is degraded since the Khmer Rouge war. For example the drainage pipes are still filled with waste, which causes reoccurring flooding. | The remaining wetlands north and south of the city, and Boeung Kak Lake are unusual and valuable environments close to a capital city. If well managed, these areas can offer recreation, biodiversity, ecotourism, food resources, wastewater treatment and flood prevention. | Phnom Penh is situated on a low laying floodplain and wetland area and the city is constantly threatened by water from the rivers, wetlands and rainfalls. The margins are not big and a minor catastrophe up streams or very heavy rain could put the entire city of Phnom Penh under water.<br><br>The city is built on the sandy wet banks of the meandering rivers. The landscape is constantly changing around the river due to erosion and new sedimentation. Its power is strong enough to move and create new bits of land. Erosion protection has been built to protect parts of the city from falling into the river when the water levels rise during heavy rains.<br><br>Climate changes threaten to worsen the floods and droughts in Phnom Penh. |
| Economical | The recent fast urbanization has made a huge impact on the economy. It is improving and a lot of people want to move in to the city to be a part of the economic boost.<br><br>Cambodia is becoming a popular tourist attraction. The unique site around Angkor Wat is attracting tourists and investors also to Phnom Penh.<br><br>Many markets are spread out over the city. People from the countryside sell their captive produced products. The majority of people live close to a market, many can earn a living form selling their surplus and few in between hands are needed.<br><br>The people of Phnom Penh are eager to work and contribute to the economy. The competition is hard though. There are a lot of unqualified workers looking for job opportunities in the streets. | The economic growth is not evenly distributed. Cities receive more than rural areas but even within Phnom Penh the growing wealth is unevenly spread.<br><br>The market system and corruption has made it possible to buy anything for the right sum of money at the expense of the people, the nature and sustainable solutions. | The fact that Phnom Penh still is a fairly small capital is probably positive. What other capitals in Asia (and the rest of the world) already have built, Phnom Penh can build even better and learn from others mistakes. There is a possibility to develop in a sustainable fashion, which is a winning strategy in the long term. The fight of attracting investors, companies, work force and tourists can thus be won by Phnom Penh.<br><br>Foreign investors are prepared to venture in the Cambodian market. There is construction works going on in and around Phnom Penh and the city is expanding in every direction.<br><br>Tourism is a lucrative business and is growing bigger in Cambodia each year. With the tourists come new job opportunities. University studies in tourism and history attract many students who see a future in the tourism business. It is important for Cambodia as a country to get on the map again and compete with its neighbouring countries for the tourists. | The privatization of land is rocketing and public land is diminishing. If the qualities of Phnom Penh are destroyed in today's hasty development it might lead to less tourists and investors in the future.<br><br>People are investing a great percentage of their monthly salary in private vehicles since there is no functioning public transportation system in Phnom Penh. Oil prizes are very high at the moment and it is an economical unsustainable situation for many people in Phnom Penh. |
| Biological | There is a variety of species and biotopes within Phnom Penh. Plants grow rapidly and can become very large. Thanks to the strong plastic force it is easy to establish new planting areas in a successful way.<br><br>Phnom Penh is a tropical city in the eyes of the tourists. The plant material is impressive and the street trees are unfamiliar and exiting.<br><br>Phnom Penh has many green streets and parks with trees and plants. The city trees and vegetation soothes the negative effects from the heavy traffic. The trees take up air pollutants and noise is reduced.<br><br>There seems to be an ambition of integrating green areas in the new developed city districts.<br><br>A great percentage of the inhabitants of Phnom Penh earn their living from fishing and cultivating rivers and wetlands close to the city. A positive side effect of the cultivated plants is their ability to biologically clean the city storm and wastewater. The vegetation capture pollutants and heavy metals before the water enter the rivers. | Many wetlands and lakes around and inside the city are being filled in. There is therefore a degradation of large areas with exceptional biodiversity.<br><br>The aquatic ecosystems of the rivers, lakes and wetlands in and around Phnom Penh are very disturbed by repeated dumping of polluted waste<br><br>There is a low and diminishing frequency of green and blue areas inside the city that makes up for a low rate of urban biodiversity. | There are still areas with biological diversity remaining close to the city. These areas can be secured and the biodiversity in the city can with the help from these areas be enlarged.<br><br>The natural cleaning processes in wetlands and lakes can also in the future be used to treat the wastewater and storm water from Phnom Penh. | The city flora and fauna are under a lot of pressure and affected by the traffic environment and the pollution in the city. The hot climate can harm them in the dry season and the heavy rains affect them negatively in the wet season. During the rain season many trees, especially palm trees, fall down because of heavy storms.<br><br>City vegetation is threatened in various ways by careless actions by the inhabitants. For example some shop owners in Phnom Penh are trying to make the city trees die by cutting and harming them. They believe that the trees are hiding their business signs. 2-3 million visitors are invading the city during a water festival each year, destroying the total plant material in park and green areas.<br><br>Future plans of city expansion are threatening the remaining wetlands and lakes to be filled in. This will lead to a loss of natural cleaning of polluted water form the city and the rivers will be exposed to the dirty water. The loss of wetlands and lakes around the city will also lead to the loss of important biotopes. |

| | Strength | Weakness | Opportunity | Threat |
|---|---|---|---|---|
| Organizational | Phnom Penh is the hub of the country and people constantly pass through the city, either to stay there for a while or to change means of transportation on their way to other parts of the country or the world. Transports on the roads to Bangkok and Ho Chi Min City work well and the roads are in good standard.<br><br>The relative smallness of Phnom Penh can be seen as a strength. What other capitals in Asia (and the rest of the world) already have built, Phnom Penh can build even better. There is a possibility to develop in a sustainable fashion, which is a winning strategy in the long term. The fight of attracting investors, companies, work force and tourists can be won by Phnom Penh.<br><br>Locally produced food on wetlands and land around Phnom Penh makes up the majority of the products sold on the city markets. This is an old and well-established system. It means that long transportation or import is unnecessary. It also brings the countryside in to the city and gives people job opportunities and a chance to continue to farm their land even though they technically live in the city.<br><br>There are many laws and regulations protecting the sensitive biological systems around Phnom Penh.<br><br>A new Master Plan for Phnom Penh is compiled. It is a competent work that deals with the variety of issues in Phnom Penh. This means that the city has a well carried out plan to accept and use as guidance in the future development. | After the war, many hasty decisions regarding land ownership were made and no proper documentation was established. It is in many cases unclear to whom the land belongs. People claim it is theirs, but the state argues that it is state land.<br><br>A lack of public transport and traffic rules result in many vehicles on the streets that are causing traffic jams every day. During public holidays the roads to and from Phnom Penh are completely blocked. Many traffic accidents occur during these periods of rush. The traffic situation may hinder ambulances and fire trucks to get in time to rescue.<br><br>A weakness in the strategic plans for the city is the missing of public transport. None of the current plans make space for a tramway or similar future investments.<br>The physical plans made by planners and architects are not included in the political decisions.<br><br>The Municipality of Phnom Penh is divided into many different departments and subdivisions. It is a complicated system and the divisions and the departments don't necessarily work closely together, even though they work in the same field area. The employees at the Municipality seem very competent, but they face a difficult task to plan for the new expanding Phnom Penh.<br><br>The Master Plan is still waiting to be accepted and approved by the Government. Meanwhile the city expands uncontrolled and the Master Plan is getting out of date.<br><br>The laws and regulations protecting the natural resources of Phnom Penh are not followed and many environments are destroyed without legal consequences.<br><br>The lack of a fair legal system in Cambodia is a big problem. A well working legal system is the base of a good society. Corruption is widely spread and paying bribes is a part of every day life. The people are feeling insecure, which make them less interested in opposition the political decisions etc. | Since there is no public transportation system, there is no need to compromise with an old inefficient one. Phnom Penh has the opportunity to invest money in a new sustainable, ecological and well-planned public transportation system.<br><br>With all the new constructions going on in the city, Phnom Penh has an opportunity to jump on the sustainability-train and compete with other new constructions in cities all over the world and specifically in Asia. Phnom Penh can become one of the world leading examples of sustainable city development.<br><br>There are many skilled, professional Cambodians and foreigners working in the Municipality, the Universities, NGO´s and companies in Phnom Penh. This is an asset to use in the building of a sustainable Phnom Penh. There is a will from many of these professional people to contribute to a greener Phnom Penh. | There is a one sided focus on economical gain and the market forces are very strong. This makes it difficult for experienced and skilled city planners at the municipality to get their voices heard. The possibility to make Phnom Penh a sustainable city, pleasant and habitable for its people seems low. There is a risk that economical forces alone will form the future city.<br><br>The urbanization is rapid and Phnom Penh is expecting an enormous increase in population the next few years, which puts a massive pressure on the city infrastructure, the economy, water supply, electricity, drainage, garbage collection and deposits etc. There is also a worry that there won't be enough public schools and hospitals. The fast urbanization is threatening a sustainable long-term development.<br><br>The public institutions have no strength to protect values that are not directly economically profitable such as biodiversity, wetland areas and public space.<br><br>New city districts developed in and outside Phnom Penh are not adapted to the local prerequisites of seasonal flooding. |
| Social | The inhabitants of Phnom Penh are in general very friendly and open-minded people. They smile a lot and are eager to help foreigners feel at home.<br><br>People in Phnom Penh spend a lot of their time outdoors, due to the hot climate, crowded apartments and the busy street life. Many people even bring their kitchen outside and cook for people passing by. When people are outside a lot they intermingle and get to know each other. "Everyone knows everyone" in the block and helps taking care of each other.<br><br>Family seems to be important and there are a lot of children. You see very young children playing in the streets without their parents. The fact that parents let their children run around without surveillance is a sign that they feel safe. They probably trust their neighbours to look out for their children as well.<br><br>If there is a problem with for example public transport, people solve it together by starting businesses around it as done on the line between Takhmau and Phnom Penh. | Almost all Cambodians have close family or friends that were killed during the war and Khmer Rouge regime. People now over the age of 35 experienced the regime themselves. This must affect people's psychological health very negatively. It has also affected their possibility to obtain an education and receive lucrative jobs to support their families and live a pleasant life.<br><br>Phnom Penh is a segregated city. A small group of privileged people is better off than the rest.<br><br>Poverty is causing a lot of social negative consequences. Many people are homeless and unemployed and have to live on the streets. Few children attend school, many people die of diseases, living standards are low, unemployment is high and prostitution is spread. Phnom Penh has low rates in life expectancy and high for illiteracy. Due to the poverty, violence and infestation is common.<br><br>A lot of poor people in Phnom Penh are feeling anxious since they are illegal settlers. They don't know whether or not they can stay in their homes or if they have to relocate. The problem of land tenure result in lack of caring among the inhabitants. They find no need in improving or caring about their city or community because they know that what they consider their own could be taken away from them anytime. | There was a baby boom after the war and these children have now grown up and started to work. They differentiate themselves from former generations through not having experienced the hard times themselves. They are also more eager to travel the world and move. Access to the internet has made the world more accessible. Many students study abroad and then return with their new knowledge. This new generation is going to form the future of Cambodia and hopefully they will use their knowledge to develop their country in a good way.<br><br>It seems important for most Cambodians to be able to improve their lives. They have a lot of lost time to make up for and most people are working extremely hard to make a difference to their and their families´ lives. | There is a risk of a growing segregation in Phnom Penh with the newly built gated communities and city districts. Segregation may increase the violence and the crimes.<br><br>The expected future lack of schools, public areas and hospitals will hit the poor communities the worst.<br><br>The possible future risk scenario of insufficient schools and hospitals may lead to even shorter life expectancy and less literacy than today's low numbers.<br><br>The present and planned relocations of people living in slum settlements to areas far away from the city will diminish the human capital of the city. People that can contribute to the social variety and skills in different areas will be placed too far away to have access to the city centre and job opportunities. |

| | Strength | Weakness | Opportunity | Threat |
|---|---|---|---|---|
| Cultural | Phnom Penh was once known as "the Pearl of Asia" and it has a reputation of being a green garden city.<br><br>Cambodia has a World Heritage in the temple site around Angkor Wat. The Cambodian people are very open about their history and display both their glorious Angkor era and their sad recent history.<br><br>Phnom Penh is a vivid city, full of life, movement and activity, 24 hours a day. Food is an important ingredient in everyday life. Spontaneous food courts on the streets of Phnom Penh contribute to make the street life pleasant and vivid.<br><br>Many different religions coexist in Cambodia and there is a genuine acceptance of different cultural and religious background. Religious symbols and buildings are characteristic and pretty elements in the urban environment.<br><br>The architecture is a very visual part of the cultural heritage. Each epoch has left its mark in the city and that is what characterises Phnom Penh -a mix of everything. Important cultural buildings are the Olympic Stadium, the central market, the National museum, the theatre and the many colonial buildings. | The Municipality wants to keep the label of "The Pearl of Asia", but it is harder and harder to integrate fast urbanization and expansion with a beautiful and green city.<br><br>The cultural heritage in Phnom Penh is not attended in the fast urbanization. For example the area around Olympic Stadium has been destroyed as well as the theatre.<br><br>The economical boom makes it difficult for decision makers to see the value of preserving traditional shapes in architecture and city patterns. | Phnom Penh has the opportunity to enhance culture in the many developments going on in the city. The new constructions can be influenced by traditional architecture. Phnom Penh can also profit from the traditional way of managing water flows. The relatively new way of building embankments can be transformed to the traditional way of adapting houses and city patterns to fluctuating water.<br><br>Phnom Penh can be "the Pearl of Asia" by enhancing and using its beautiful cultural symbols and habits. | The outstanding Khmer culture could fade away and disappear in the search to attract tourists and investors. There is a risk that Cambodia may adapt to western styles and become mainstream.<br><br>Today green and blue areas in the city are being destroyed which threatens the identity of Phnom Penh as the Pearl of Asia.<br><br>New satellite cities and city districts are planned with no connection to the traditional Cambodian culture. The traditional techniques of constructing houses are changing into new standard procedures. This may lead to a loss for the cultural identity, but also for the sustainability when the new houses may not be adapted to the local prerequisites of floods.<br><br>Many old cultural valuable buildings are torn down in Phnom Penh and it seems to be a continuing trend. There may be more losses of cultural important and characteristic buildings in the future. |
| Aesthetical | Phnom Penh is truly the city of smells. The nose is more important than the eyes. It is an amazing experience to wander around in a food market and pass all the different smells. People barbeque on the street. The monks light essences in the temples.<br><br>Phnom Penh is a very detailed city. You can see it in the intriguing paving patterns on the ground. You can see it on the house facades and roofs. They are scattered with religious symbols and other details. The little religious figures that are placed all over the city also remind you of the importance of details. | The great interest in details can make you lost in the overall context. It is hard to follow a red thread in the city. Every street has its special tree, every sidewalk has its special pattern etc and it gives you no feeling of context. There is a lack of a complete city planning, which would make the different parts of the city more naturally attached to one another.<br><br>Bad smells can make the city feel even dirtier than it is. Our nose is a very sensitive organ and communicates with our brain before we understand why we do or don't like a place.<br><br>Sounds work in similar ways. Phnom Penh both looks and sounds very busy. The constant noise can wear you out quickly. The traffic is the main source of noise and another one is the sound of the constant construction works.<br><br>The city beauty is unevenly spread. In the most central parts of Phnom Penh around the Royal Palace, there are many parks with beautiful plants and the houses are rigorously decorated. In other parts of the city there are no parks and no attention has been given to house facades, streets or courtyards. | It would be possible to use the many beautiful and characteristic symbols on houses and sidewalks in other parts of Phnom Penh as well. It could enhance and evenly spread the beauty of the city.<br><br>The many different inputs from sight, hearing, nose and touch makes Phnom Penh to a city that leaves few people unaffected. This is giving the opportunity to profile in any ways.<br><br>The river constitutes a beautiful and aesthetical appealing view with much potential. It gives the city centre life. The shore could be made even more accessible for people to enjoy.<br><br>Restoration of facades and public space would make a huge difference and people might cherish their city more. | The city is in desperate need of restoring. The atmosphere is very decadent and it feels like no one is taking care of the existing buildings and courtyards. People are not careful about their environments, which make them degrade even more. |

# URBAN ECOLOGICAL STORM WATER MANAGEMENT

CYCLE OF WATER IN NATURAL ENVIRONMENTS

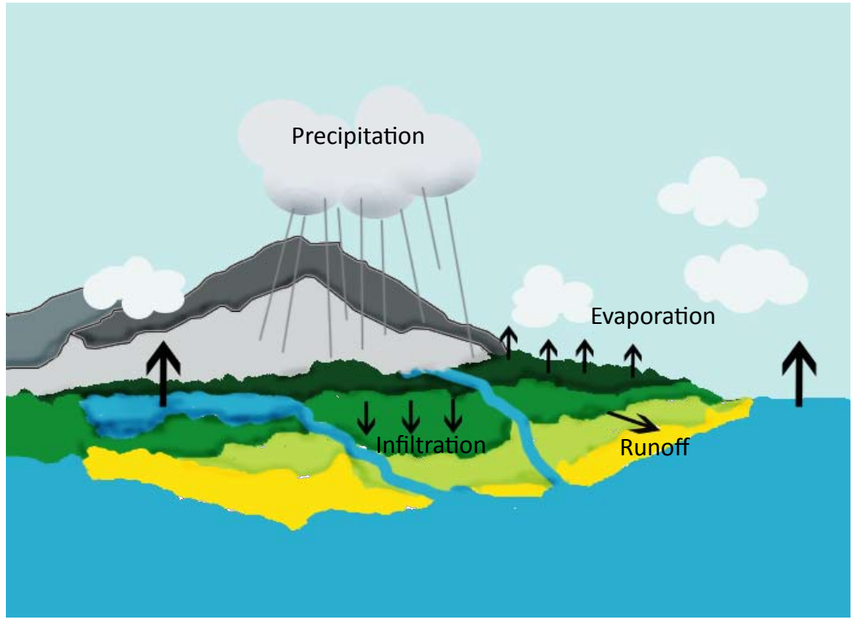



Figure no 1

PRINCIPALS FOR ECOLOGICAL STORM WATER MANAGEMENT

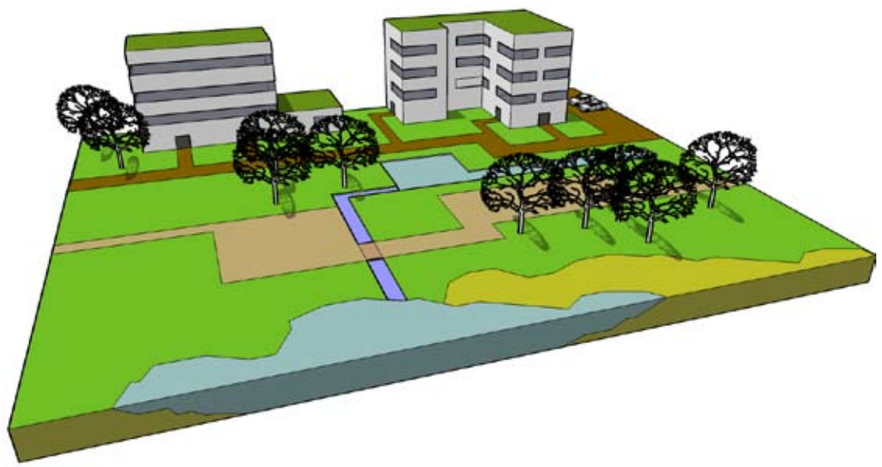


Figure no 2

Storm water management is incorporated in the design. Rain water is recieved by vegetated house roofs and infiltrating ground materials. Storm water is led through a canal system to natural water courses. Cleaning processes can take place on the way by vegetation capturing pollutants.

A courtyard with a high percentage of infiltrating surfaces.
(Photo: Johan Thiberg, Vegtech)

Precipitation is normally not a problem in natural environments (see figure no 1). In urban environments on the other hand, the water from precipitation has nowhere to go. Hard surfaces are everywhere in cities and make infiltration impossible. The surface water runs off to the lowest points. Sometimes this cause severe problems, especially during heavy rainfall. The question of sustainable solutions for urban storm water has become more and more important while we tend to build on the natures low points[115]. Economical forces are often leading urban development and in cities all over the world houses close to water are the most profitable. New constructions therefore tend to be placed on low points and this lead to a need for sustainable storm water solutions. Also the trend to build dense urban environments and densify old city structures is creating a need for managing storm water in a sustainable manner. Densification often results in constructions on low point areas that before were saved as green spaces and detention ponds for storm water. The loss of infiltrating ground results in an increased runoff that the drainage system cannot cope with and inundation becomes a problem. Normally, the storm water in cities is lead th-

115 Field Study, 28 08 2008

| Table 11 ECOLOGICAL STORM WATER MANAGEMENT – BENEFITS AND SOLUTIONS | |
|---|---|
| Benefits | Flood control and better management of storm water at source |
| | Pollution control |
| | Recharging of groundwater regimes and aquifers |
| | Reduced construction and maintenance costs |
| | Improved environment |
| Solutions | Permeable Paving |
| | Filter drains |
| | Swales |
| | Ponds and Wetlands |
| | Vegetation areas |

| Table 12 TECHNIQUES USED TO CLEAN STORM WATER |
|---|
| Deal with the source of pollution |
| Infiltration in ground |
| Construct a type of treatment facility<br>-Sedimentation facilities (Under or over ground)<br>-Different types of filters<br>-Separation with lamellas<br>-Sedimentation basins placed in the recipient<br>-Wetlands and temporary wetlands<br>-Local treatment of storm water, for example infiltration |
| Direct the water to a treatment plant |

rough pipes and let out without any treatment in watercourses. This conventional way of managing storm water is becoming more and more unsustainable. The watercourses where the storm water ends up become contaminated with heavy metals, nutrients and other substances harmful to the environment. This way of handling storm water also increases the society's vulnerability to climate change[116]. During storms and heavy rains the pipes can easily get brimmed and inundation of the streets follow. In severe cases it can lead to flooding of entire neighbourhoods.

All these problems may be avoided or diminished with an ecological storm water management. This means that the natural flows of the water are imitated (see figure no 2). An ecologically designed storm water system make sure that as much as possible of the precipitation is taken care of locally where it falls.

# Techniques

The benefits from ecological storm water management are numerous (see table no 11). With ecological techniques of managing storm water, the problems of contamination, over-fertilization and flooding are mitigated. Another common term for ecological storm water management is Sustainable Urban Drainage Systems (SUDS).

In Sweden some, but not all, of the storm water from cities is now treated in treatment plants or other treatment facilities before entering the natural watercourses (See table 12). It is also becoming more conventional to use dams and temporary wetlands to treat and manage storm water. In many countries and especially in developing countries, these systems are unfamiliar or not taken into use and the storm water is lead through pipes directly to the rivers and lakes.

## Infiltration

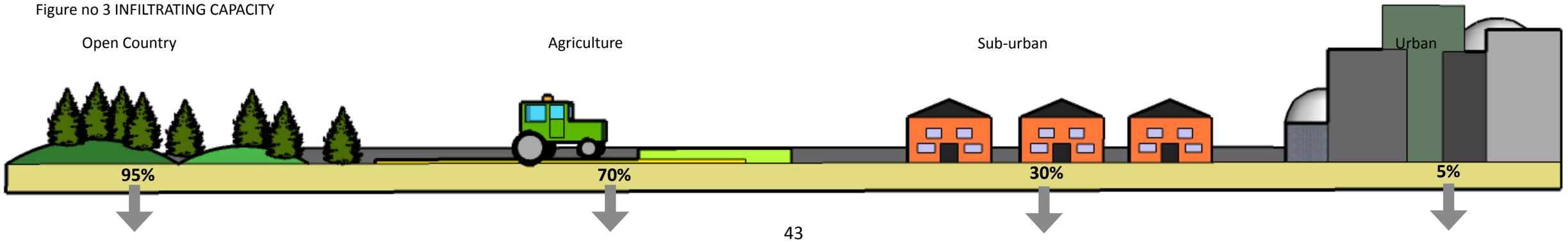
The best cure for urban flooding is to prevent the cause of flooding. Minimising runoff is easiest implemented by reducing paved areas (see figure no 3). Less runoff also reduces the wash-off of pollutants. Local infiltration is an uncomplicated way of dealing with storm water drainage. It enables storm water to be dealt with "at source" rather than being diverted into the often over-burdened sewer systems. Urban design, with good prerequisites for infiltration, is the best way to imitate nature's way of dealing with precipitation. There is a long list of infiltrating materials suitable in urban areas[117] (see table no 13).

Since more and more of the urban surface is covered with roads, paving and houses, new technologies are demanded and needed in order to release the pressure on the sewer systems. Many paved or asphalted areas could be replaced with infiltrating paving such as grass, plantations, gravel or permeable paving (see figures no 4-8). Proper foundation with adjusted infiltrating devices, such as soakaways (see figure no 9), also helps to provide efficient infiltration[118].

With ever increasing numbers of vehicles and machines being used by society, we see more pollutants, especially hydrocarbons and heavy metals, being released into the environment. Permeable systems enable pollutants to be trapped by the sub-base or by a geo-textile[119]. Another way to deal with pollutants is to never let them resolve in water. To put an outdoor roof over extra-polluted areas is an efficient way of reducing wash-off. To manage paved areas through cleaning and regular sweeping is another way to reduce polluted runoff[120].

116 Modin, M, 2008 and Ebeling, E, 2008
117 Ciria
118 Coombes, P, 2002
119 pavingexpert
120 Ciria

Figure no 3 INFILTRATING CAPACITY



| Table 13 INFILTRATING SURFACES | |
|---|---|
| Grass | Grass is an excellent infiltrator. It cleans polluted water through binding and sedimentation of polluted particles. The grass roots also have the ability to capture nutrients and may also reduce the speed of water runoff in sloping areas. Reinforced grass surfaces are appropriate in parking lots or other environments with light or slow traffic. Types of grass can be used in swales and filter strips. Grass is overall an easy material to work with for landscape designers and it brings beauty as well as flood control to the design. It is also possible to direct runoff to nearby grass areas. Designs without curbesides facilitate the directing of water (Field Study, 28 08 2008). |
| Filter stripes and swales | Filter stripes and swales are vegetated surface features that drain water evenly off impermeable areas. |
| Plantings and trees | Planting areas with a variety of vegetation are also beautiful and useful features in urban design. Without curbsides, water can be directed straight into the plantings for cleaning and infiltration. Since vegetation is in constant need of water to survive, it is energy saving to use the storm water at source. The choice of vegetation is crucial in a successful urban design. There are trees that can handle periodically stagnant water and be able to absorb large amounts of water and evaporate it into the atmosphere. Street trees are put under a lot of pressure from the traffic. The trees may both lack and be in abundance of water due to urban impervious surfaces. Good analysis of the local urban environment enables the designer to handpick the most tolerable species for the unique sites of his/her designs. |
| Gravel | Gravel is a material with a good infiltration capacity and it copes with traffic and other pressure. There are many different kinds, colours and size fractions to choose from. Gravel is used in most infiltration devices, such as swales, permeable grounding and foundations, soakaways etc. |
| Soakaways | Soakaways enable storm water to be dealt with "at source". They are a type of infiltration device, a simple way of dispersing surface and storm water in situations where connection to the storm water system is impractical or unjustified. Two determining factors for successful soakaway design are the volume of water to be drained and the percolation rate of the soil/sub-soil (or, in some sites, the depth to the water table) (pavingexpert). |
| Permeable paving | There are mainly two types of permeable paving systems:<br>1. Infiltration – surface water is directed via voids within areas of solid paving.<br>2. Porous – water is drained directly through the surface (pavingexpert). |
| Avoiding infiltration | Infiltration devices must be avoided or carefully designed in areas with:<br>-High water table levels<br>-Soil salinity hazard<br>-Windblown or loose sands<br>-Clay soils that collapse in contact with water<br>-Soils with an hydraulic conductivity of less than 0.36 mm/hr (Coombes, P, 2002). |

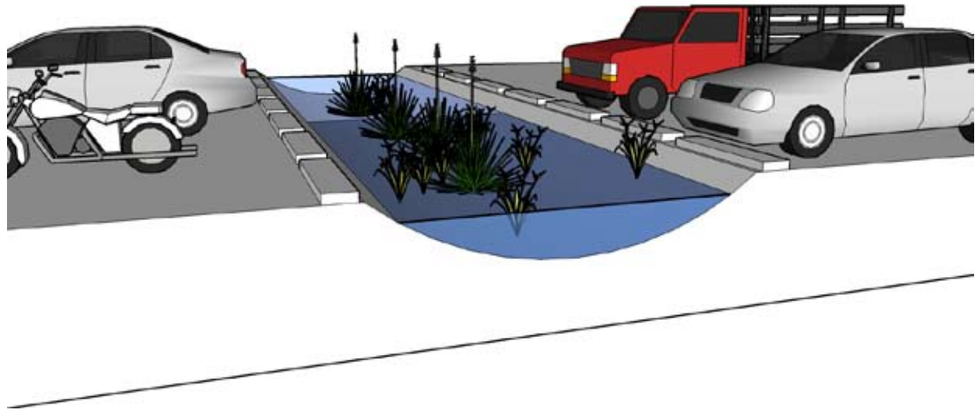


Figure no 4
Specialised plantings developed to cope with heavy rains yet also periods of draught are the Rain Gardens. Rain Gardens don't need to be large or complicated. They just need to be positioned so that they catch rain-water coming from any hard surface (roof, driveway, parking space etc.). The Rain Gardens need to be dug to create a shallow depression in order to hold the water. The planting material needs to survive periodic flood-ing and often long periods of draught. Native plant material is mostly suitable since they over centuries have adapted to the local weathers.

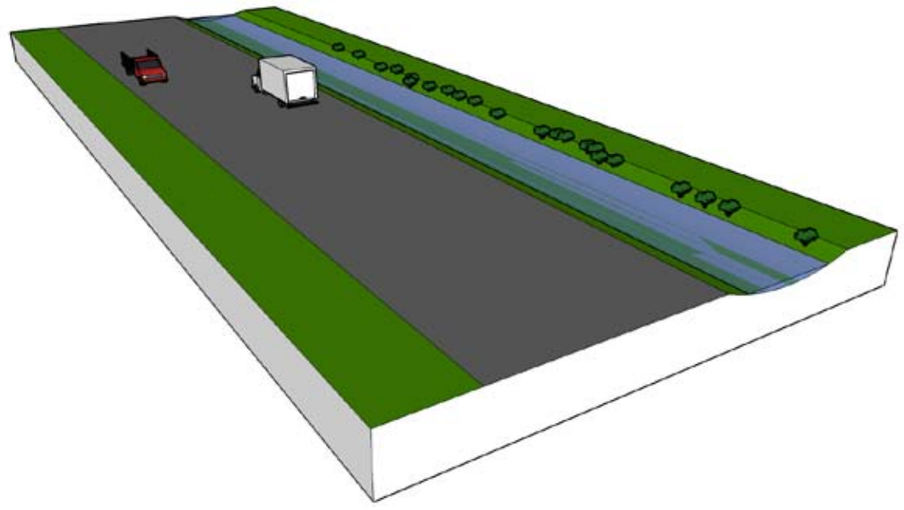


Figure no 5
Swales are long shallow channels that can be water filled in times of heavy rainfalls and dry out during dry seasons.

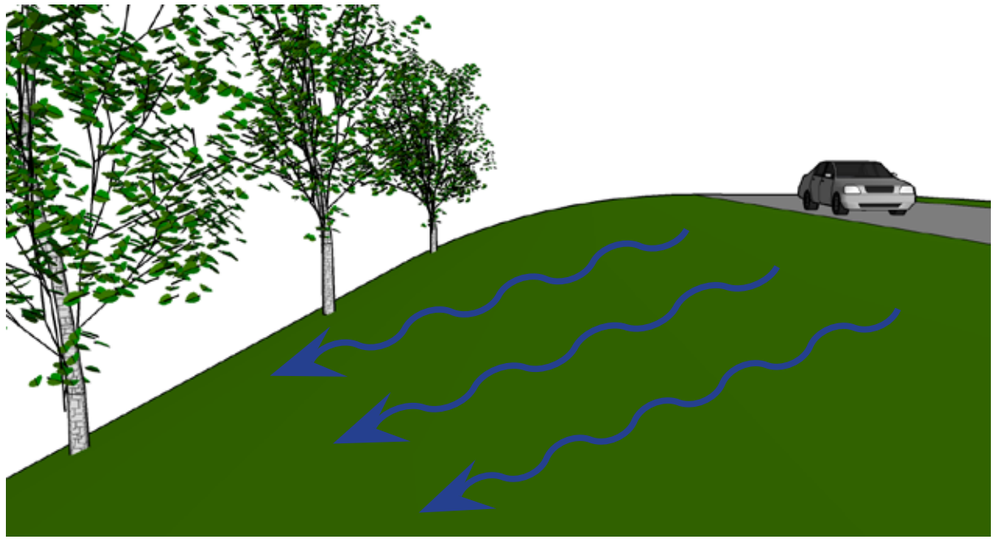
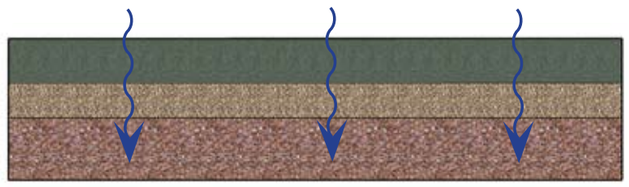


Figure no 6
Filter strips are gently sloping areas of ground that can reduce the speed of water flows and infiltrate excessive water. Vegetation can absorb pollutants discharged in traffic environments.

POROUS PERMEABLE PAVING



INFILTRATING PERMEABLE PAVING

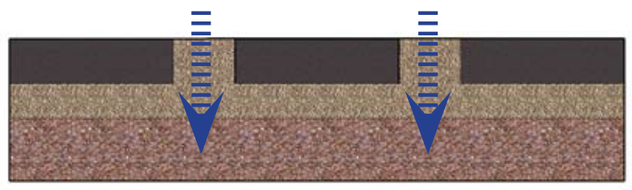


Figure no 7-8
Permeable pavings allow the water to infiltrate but are yet roadworthy. Rain water either percolates through the infiltrating paving (porous paving) or finds its way through voids between the paving blocks (infiltrating paving).

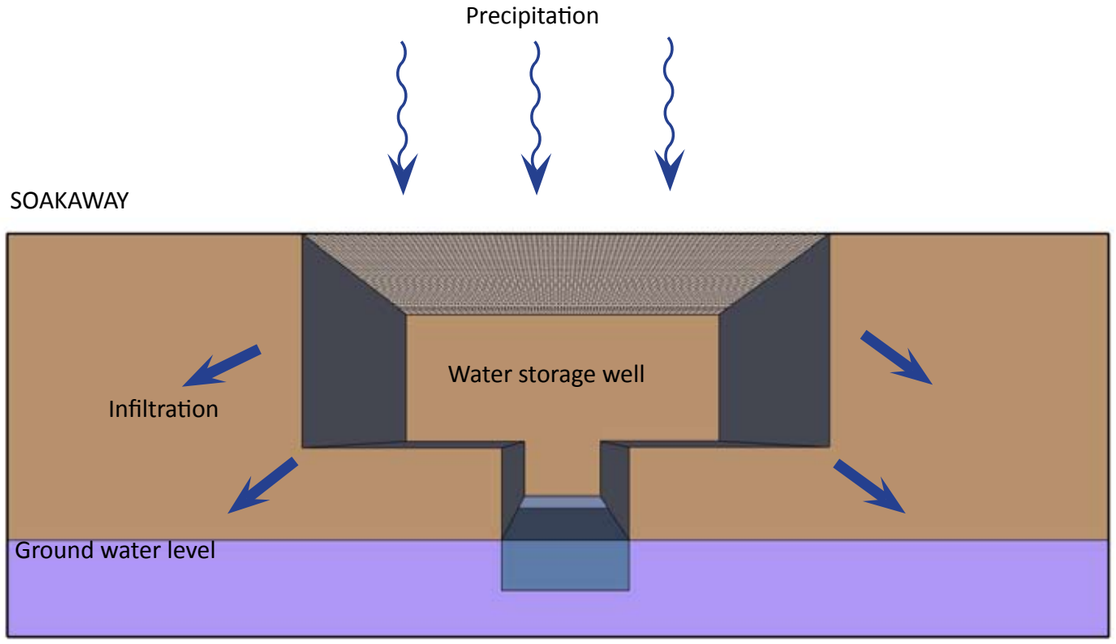



Figure no 9
The basic principle of a soakaway is that of a “reverse well” i.e. a “hole-in-the-ground” that loses water rather than collecting water.

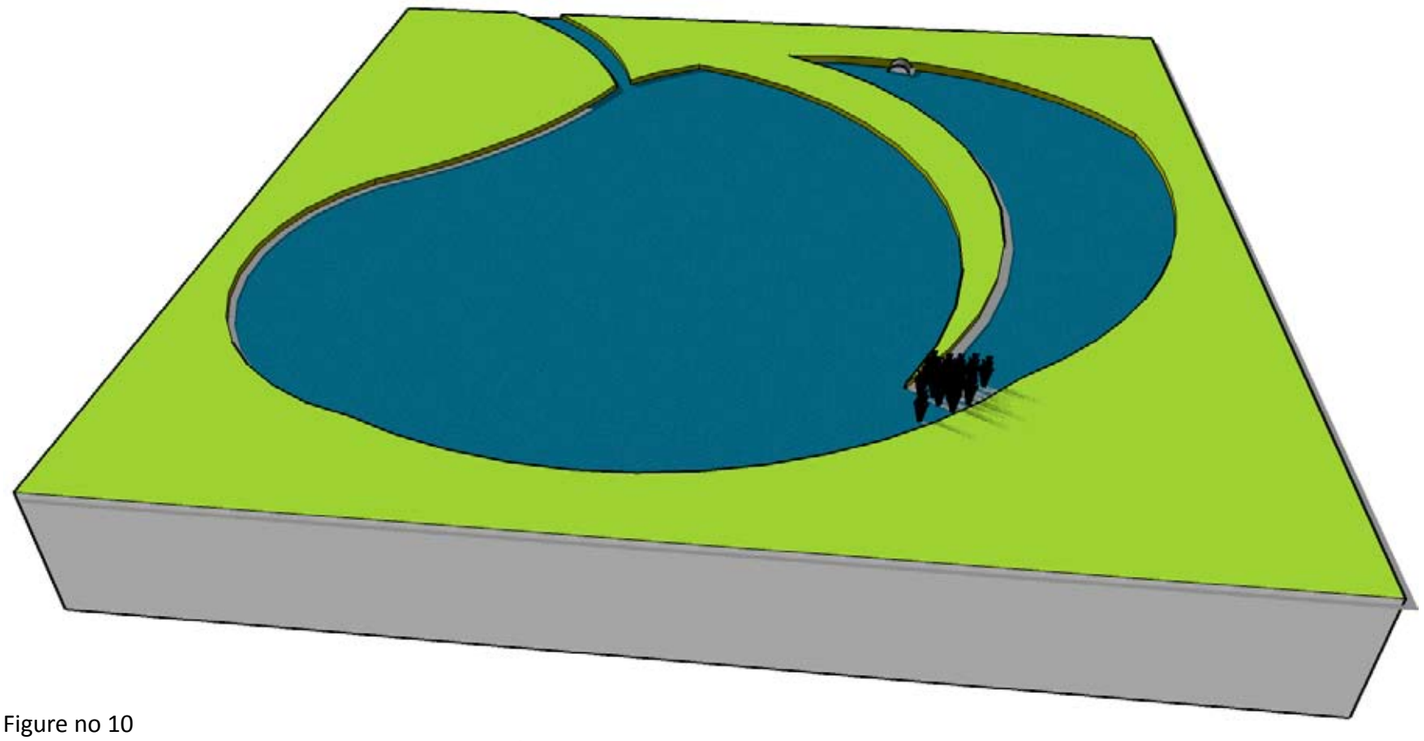


Figure no 10
A storm water pond should be designed to slow down the flow, so that sedimentation can take place. It should prevent resuspension and promote diffusion. The water should circulate through the whole pond and stay there as long as possible. If the water stands still there is a risk for unwanted growth of algea.

## Storage – ponds, temporary wetlands and wetlands

Water polluted by traffic, industries or other pollution sources should normally be treated before entering natural watersheds in the surrounding environment. This can be done with a series of ponds specially designed to clean the water (see figures no 10-14). This might be the type of ecological storm water solution most familiar to people. The ponds also function as storage areas in wet weather and are allowed to dry out in dry seasons. The ponds unburden the communal drainage pipes and are important during heavy rains to prevent flooding. Water from residential areas and sidewalks that does not infiltrate on site can also be lead to a detention pond where it is treated and partly infiltrated before continuing to the local drainage system.

Storm water ponds generally last for ten years before they need to be emptied and sediments removed. The vegetation on the other hand, tends to endure for a long time in storm water ponds and normally does not have to be replaced[121]. Storm water ponds close to houses can be seen as an asset but also as a danger for children wanting to play near the water. Fences are sometimes put up after the construction of a pond, when the risks for injuries are estimated to be high. The fences affect, many times negatively, the design and planned social function of the pond and its surroundings[122]. Lakes are natural storage ponds. Water levels in lakes fluctuate with increased rainfall. The shores of lakes are shaped to be able to flood. Nearby construction may prevent the natural fluctuating cycles of the lake.

Precipitation is not spread evenly throughout the year therefore some areas in the ecological storm water system are not always water-filled. These areas are called temporary wetlands and function as buffer zones protecting the built environment from flooding with their ability to store large amounts of water in times of intense rainfalls. During dry periods, temporary wetlands can play another role. They can for example function as a neighbourhood park or a sports area[123].

Wetlands are in between terrestrial ecosystems and aquatic systems and they host considerable biodiversity (see figure no 15). They are becoming increasingly crucial in the light of climate change and are also very important recourses to cities from many different perspectives. For example they have the potential to naturally store redundant water and biologically clean water. No other type of ecosystem is so important to millions of migratory birds, fish, amphibians, insects, plants and trees. Wetland conservation and management is a necessary component of

121 Field Study, 28 08 2008
122 Field Study, 14 08 2008
123 Field Study, 28 08 2008

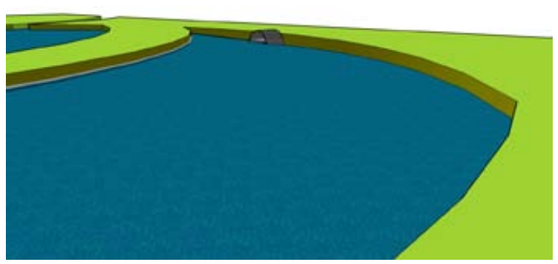


Figure no 11
Deep zone for sedimentation at the inlet.

Figure no 12
A land strip forces the contaminated water to flow through the whole pond.

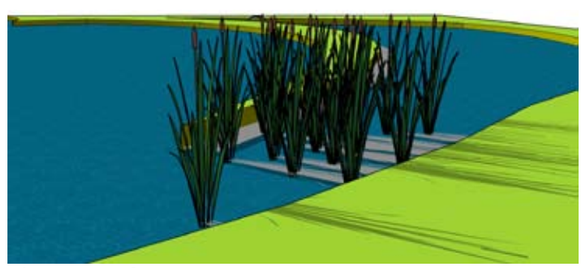


Figure no 13
Thick rows of vegetation can be placed across the direction of the water flow. The plants should be specially selected to absorb heavy metals, other pollutants and nutrients from the water.

Figure no 14
Deeper zone for open, vegetation free water surface.

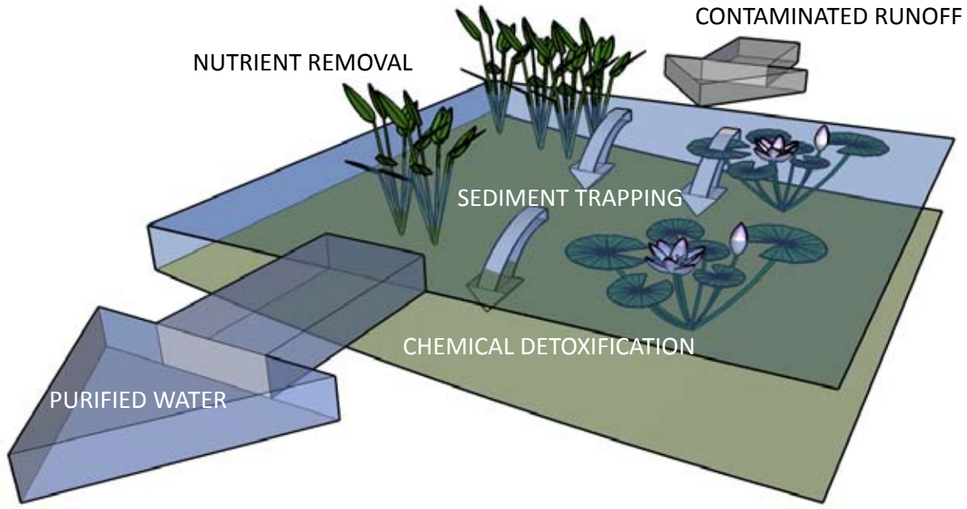



Figure no 15
Processes in a wetland

| Table 14 ADJUSTED ARCHITECTURE | |
|---|---|
| Rooftop vegetation | Benefits from rooftop vegetation:<br>-Prevent the "Heat Island Effect"<br>-Environmentally friendly storm water management<br>-Buildings become more energy effective<br>-Cleans the air<br>-Bring natural air humidity<br>-Mitigate the effect from noise<br>-Create carbon dioxide neutral buildings<br>-Increase the biological diversity<br>-Beautification<br>-Healthy citizens<br>(Veg Tech, 2008) |
| Water harvesting | Cisterns on the roof of houses collect rainwater that can be stored and used for future domestic purposes, instead of further straining the municipal drainage network. |
| Floodable housing | Houses on stilts, Floating houses, Amphibic houses<br>It is especially important to construct buildings adjusted to flooding in the cities where hard surfaces enhance the inundation process. |

Sedum is a family of plants that is perfect for rooftop vegetation. The sedum plants endure dry hot periods as well as cold wet periods and absorb water very efficiently. According to measurements made in Germany and in the Swedish city district Augustenborg in Malmö, 50% of the annual precipitation is absorbed by rooftop vegetation of sedum. One square meter of dry sedum can absorb 15 litres of water. Roofs covered with sedum can thus absorb 10-100% of the rain depending on intensity (Study visit Veg Techs Stockholm office, 2008-07-02, Johan Thiberg). (Photo: Gunilla Englund)

Vertical vegetation is suitable in dense urban environments. Climbing plants can grow either on facades or on wires. (Photo: Thomas Brandmeier, Ranktechnik)

progress rather than a luxury that only wealthy nations can afford[124]. The reduction of wetlands is a global problem and in many countries wetlands have become subjects of conservation efforts[125].

## Adjusted Architecture

The rooftop garden is a type of urban agriculture that has been popular for many years and is adapted throughout the world. Many types of traditional housing use some type of rooftop vegetation. Rooftop gardens have also been used in modern architecture lately. The construction is energy efficient and manages to store and evaporate storm water[126] (see table no 14).

Vertical vegetation is a smart solution for dense urban environments. The vertical plants absorb storm water and demand little space. Vertical farming is a relatively new idea in the search to sustain the growing urban population. Dr. Dickson Despommier, professor of environmental sciences and microbiology at Columbia University is one of the pioneers behind these ideas. He believes in "Farmscrapers" or "Green towers" in urban environments as an addition to other forms of urban agriculture[127].

124 Wetlands International
125 Men, N. Lim, S. Ann, V. Ly, S, 2008
126 Veg Tech, 2008
127 Dr. Despommier

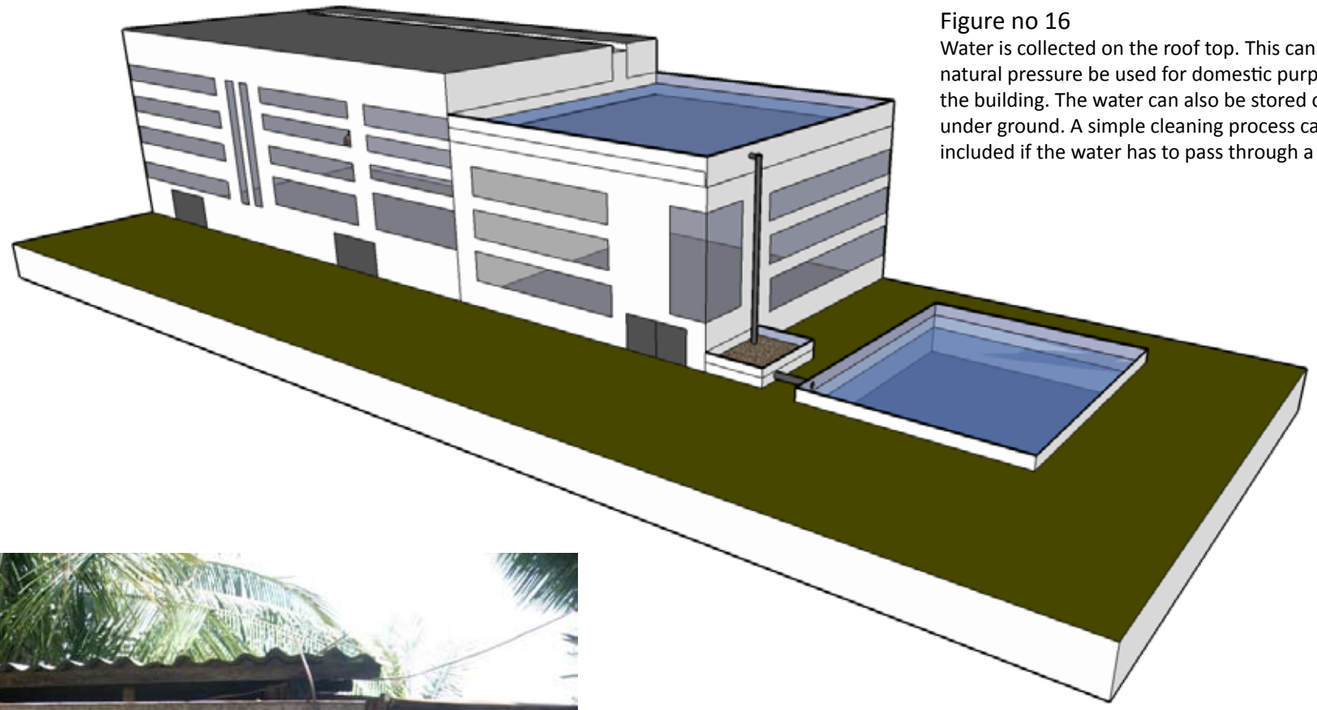


Figure no 16
Water is collected on the roof top. This can by natural pressure be used for domestic purposes in the building. The water can also be stored on or under ground. A simple cleaning process can be included if the water has to pass through a filter.

There are many good reasons to store rainwater in order to reduce the use of clean drinking water. This old method is called water harvesting and has great potential in a sustainable city (see figure no 16). Many people living in separate houses in Cambodia harvest rainwater (see pictures below).

There are many ways to construct buildings to prevent them from flooding. In Cambodia, where it rains half the year, techniques have been developed for centuries, such as houses on stilts (see figure no 17). In Phnom Penh the technique seems to have been forgotten. High-rised concrete buildings stand directly on the ground for stability. New building techniques and materials fascinate and old wisdom is forgotten.

In Phnom Penh there is a desperate need of water in the dry season and an abundance of water in the rainy season. The water storage is used for different purposes since superfluous use of drinking water is unthinkable. (Photo: Sara Ryttar)

Clay barrels are the most used water harvesting containers in Phnom Penh. (Photo: Sara Ryttar)

On the Cambodian countryside almost every household has their own combined detention/water harvesting/cultivating pond on their front lawn. (Photo: Sara Ryttar)

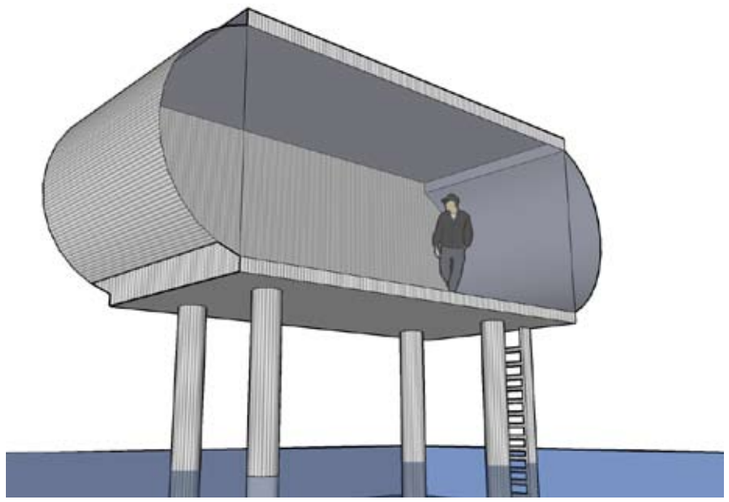


Figure no 17
Houses on stilts have been seen in modern architecture recently all over the world. There is a new interest in adapting natural variations in water levels. This interest has increased with the growing awareness of the consequenses of climate change.

Restaurant on stilts on the Cambodian countryside. Most of the Cambodian traditional houses are wooden and stand on stilts. Water levels can rise several meters before it reaches the floor of the house. This technique is seen all over Cambodia, especially in the countryside. (Photo: Joakim Englund)

House boats on the Mekong River. One efficient adjustment to the fluctuating water levels. It is not uncommon to see whole families travelling along the rivers in small boats carrying complete households in Phnom Penh. These boats are the homes of these people and in many cases even their work place and transportation. (Photo: Gunilla Englund)

Floating houses on the Bassac River. (Photo: Sara Ryttar)

Another way of dealing with rising water levels is simply to adjust to them. Houseboats are a popular alternative to terrestrial living all over the world and since climate change will risen the water levels there is a great concern which has lead to research and new techniques and ideas. The Netherlands are one of the leading countries in the development. Entire floating city districts have been constructed[128].

Since the Dutch have a constant struggle with rising water levels, they have developed a new type of living, the so-called amphibic houses, a hybrid between the house on stilts and the houseboat (see figure no 18-19). Their aim is to construct entire floating societies, including houses, roads and schools.

128 Hans Dahlquist, 2005

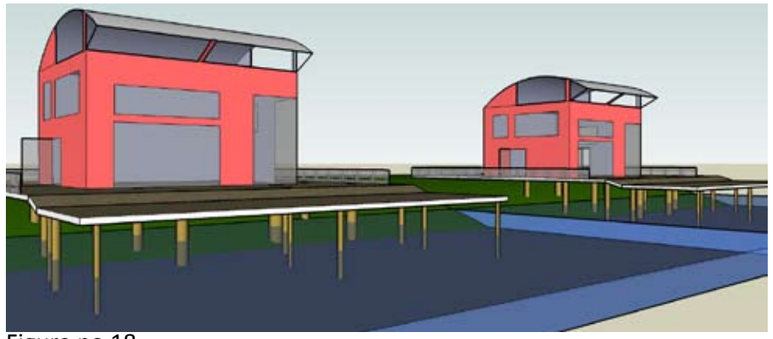


Figure no 18
Amphibic houses on stilts in low water level. The houses are light wooden structures resting on hollow concrete fundament that function as pontoons. These are connected to steal stilts that are anchored to the ground with a sliding device. This device enables the houses to float up and down when water levels rise and fall.

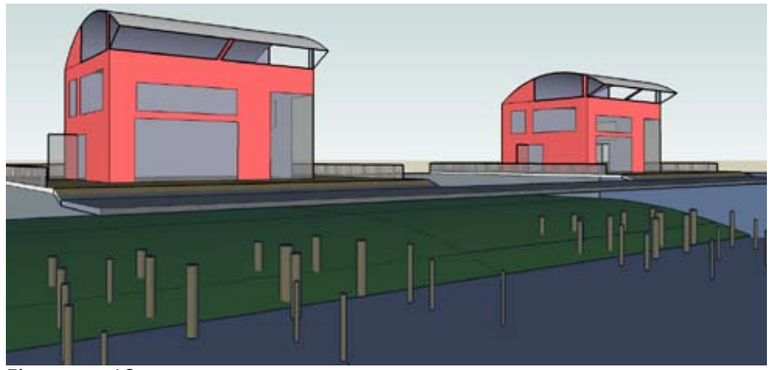


Figure no 19
Floating amphibic houses during high water level.

Climbing plants on a bus stop in Bangkok. The vegetation provides shade and absorbs storm water.
(Photo: Johan Thiberg, Vegtech)

| Table 15 EXAMPLES OF COUNTRIES THAT INVEST IN ECOLOGICAL STORM WATER SOLUTIONS | |
|---|---|
| Holland | Has stopped building dikes and instead started designing landscapes to receive floods |
| China | Construct wetlands close to cities for water treatment, recreation and environmental benefits<br>Design cities to deal with flood water |
| Italy, Venice | Continue using the old technique of canals instead of roads in the city |
| Sweden | New residential areas are designed to take care of precipitation locally |

| Table 16 STORM WATER AS A DESIGN FEATURE IN NEW CITY DESIGN | |
|---|---|
| Hammarby Sjöstad, Stockholm, Sweden | Old harbour blocks transformed to a modern residential area with focus on ecological design. Storm water is managed in carefully designed open systems. |
| Bo01, Malmö, Sweden | Old harbour blocks transformed to a modern residential area with focus on ecological design. Storm water is managed in carefully designed open systems. |
| Augustenborg, Malmö, Sweden | Residential area from the 1950´s, upgraded in the 1990´s. Local storm water management and ecological solutions are important parts of the design. Green roofs, storm water dams and many permeable areas. |
| Red Riddon Park – Tanghe River Park, Quinhuangdo China | Flood protection park created in 2006, which bring new forms and design to Chinese landscape architecture. Allows the park to flood on greenways along the river. (Topos 63/2008) |
| Blue City, East Groningen, Netherlands | De Zwartze Hond proposes a plan where a nature reserve, recreational areas and residential areas will border an artificial 800-hectare lake. (Topos 57/2006) |
| Singapore | A new design proposal suggest natural canals, green roofs, decentralized detention ponds and permeable areas that will reduce the amount of polluted storm water to the sea and make Singapore a more pleasant city. (Topos 59/2007) |
| Hong Kong Wetland Park, China | Created to replace a wetland that was lost due to a new housing area. The new wetland is a recreational, ecological and educational area. (Topos 55/2006) |

# New perspectives and trends.

The advantages of copying nature when designing urban storm water solutions are becoming evident to many city planners and decision makers. Techniques and knowledge related to such ecological storm water management have been around for many years but it is not until recently countries like USA, Canada and Japan have started using them for solving urban problems[129]. Architects and planners all over the world are now starting to follow the spreading trend of ecological design. Maybe it is the beginning of a green revolution?

One of the new trends is to design cities that manage high water flows without building dikes, walls and other reinforcements. Instead of fighting against the natural and inevitable flows of water the new plans try to adjust to them and incorporate the water in the design. This way of designing for high water flows is seen all over the world but perhaps mostly in Holland and wealthy Asian countries like China and Singapore[130] (see table no 15 and 16). In these regions the questions of rising sea levels and increased rainfall are becoming more and more crucial as the effects from climate change escalate.

## Recapturing old solutions

Many of the most practical and ecological ways of dealing with storm water and floods have been around for centuries. Houses on stilts, floating houses, green roofs, temporary wetlands and detention ponds are all techniques that have been used in urban environments before.

In Cambodia there is an old and well-developed culture of living in harmony with seasonal changes in rainfall and water levels. Low-lying areas are by tradition popular places to live on

129 Veg Tech, 2008
130 Chen L. Lin R, 2006, Dreiseitl H, 2007, Padua M. G, 2008, Venhuizen H, 2006

Main storm water canal in Hammarby Sjöstad. The canal has fixed concrete borders. (Photo: Gunilla Englund)

Main storm water canal in Hammarby Sjöstad. The vegetated surface gets inundated during heavy rain. (Photo: Sara Ryttar)

Storm water drainage in Bo01. The flower beds are not connected to the drainage system. (Photo: Sara Ryttar)

Typical street in Bo01. There are few permeable areas and the storm water circulates rather than infiltrates. (Photo: Sara Ryttar)

In Augustenborg there are many infiltrating green areas. (Photo: Gunilla Englund)

Urban agriculture in Augustenborg has positive effects on ecology, social contacts and storm water management. (Photo: Sara Ryttar)

because they offer possibilities for fishing and farming. Cambodians have therefore developed techniques for building houses adapted to seasonal flooding. The most common traditional houses stand on stilts. There are also some examples of floating houses. Phnom Penh used to have many canals, lakes and ponds that took care of the storm water locally inside the city. The decision makers were aware of this urban system of watercourses and its services and they made sure it was well maintained. Unfortunately, this knowledge that was around for so many years is lost in today's rapidly expanding Phnom Penh. Plans of new developments are not inspired by the old and sustainable techniques of building houses and designing water in the urban areas.

Other countries, like China and Holland, are rediscovering the benefits of old techniques - maybe it is time for Cambodia to do the same?

## Storm water as an element in modern city design

Exciting and revolutionary landscape architecture can be developed with the feature of water in urban design. Instead of hiding surplus water from rain and floods it can be used as an invigorating element in parks, courtyards and squares. Water brings seasonal changes in to otherwise unchanging urban environments.

Hammarby Sjöstad, Bo01 and Augustenborg are three city districts in Sweden that was built or upgraded with an environmental focus. Storm water management is an essential part of the design in all three areas, though they represent different techniques and trends.

Hammarby Sjöstad as well as Bo01 is situated on old harbour and industrial blocks in major Swedish cities. The places are surrounded by water and water is also a very important element in the design to create their unique atmosphere. The goal behind both areas is a modern and dense but yet ecologically sustainable residential district[131]. Ecological solutions are used in everything from house constructions to storm water and waste systems. Storm water is incorporated in the design. It is made visible through carefully designed open canals in the courtyards and the public areas.

In spite of the ecological approach, the storm water in both Hammarby Sjöstad and Bo01 is exceptionally used for beautification of the area. Reuse of the water, such as watering plants and trees is not part of the design. The design promotes a flow of water rather than a circuit. The water has few opportunities to infiltrate directly into the ground, due to a lot of hard surfaces[132]. The canals have no vegetation and are made out of concrete which prevents the water from infiltrating into the ground. The concreted canals also make rubbish more visible[133]. The outdoor open spaces are described as green with a high green area index[134], but the feeling you get when you visit the area is the opposite. There are a lot of hard impermeable ground materials and most of the storm water must be transported to other places instead of infiltrated on site[135].

In contrast to Hammarby Sjöstad and Bo01, Augustenborg is indeed a green neighbourhood and rainwater is directly infiltrated into the ground. Many house roofs are covered with vegetation. Incorporated in the courtyards are storm water detention ponds, surrounded by trees and other vegetation. The ponds are both functional and beautiful[136].

131 Hammarbysjostad.se and Malmö Stad
132 Field Study, 2008-03-22 and 2008-03-03
133 Field Study, 2008-07-02
134 Malmö Stad
135 Field Study, 2008-03-22 and 2008-03-03
136 Field Study, 2008-03-22

# PROPOSAL - BOENG CHEUNG EK

SARA RYTTAR

Top: Cultivation of aquatic plants on Cheung Ek wetland. The city sky line is visible in the horizon. Above: Woman living by the wetland. (Photos: S. Ryttar)

**The task:** to exploit the wetland area of Cheung Ek with residential areas.

**The goal:** to present a solution to the task that solves the need of expansion and also preserves the characteristics and services of the wetland. The solution shall be aesthetical and ecological and designed to be a sustainable and liveable area.

**The idea:** an area that is designed to endure floods and heavy rains and make a minimum impact on the ecosystem of the wetland is met with a solution of integrated houses, parks and waterways

Box 1. GENERAL INFORMATION ABOUT CHEUNG EK WETLAND

Water surface area: Dry season: 1 300 ha  Rain season: 2 000 ha

Amount of total storm water from Phnom Penh that discharge in Cheung Ek: 80%

Population: 650 000 persons
Farmers: 205 families

Muong 2000, Muong 2004

# Introduction

The wetland Boeng Cheung Ek is the largest of the four wetlands surrounding Phnom Penh[1]. It receives untreated storm water and wastewater from the city and functions as a natural treatment plant[2]. Cheung Ek also has an important role in protecting the city from flooding.

Phnom Penh city is at the moment undergoing a fast expansion and the area where Cheung Ek is situated is becoming more and more central. The future for the wetland is uncertain. Plans of filling and building on Cheung Ek has recently been presented[3]. During recent years it has become popular to build new city districts on wetlands close to Phnom Penh. These developments have unfortunately lead to a complete loss of large areas of wetlands.

If Cheung Ek wetland is taken away it would most certainly lead to severe problems for the future sustainability of Phnom Penh. Among other things, an effective area for flood protection would disappear. This is particularly disastrous in a time of climate change. If Cheung Ek becomes drained and filled, Phnom Penh looses an asset of great value that other cities are making an effort to restore or create - a wetland.

The exploitation of Cheung Ek wetland has not yet started and no plans are determined. Thus, there is still time to make good choices and to come forth with a proposal for Cheung Ek that is equivalent with a sustainable development. Or can Phnom Penh city and its surroundings handle the lost of yet another wetland area?

1 Muong 2004
2 Livre Blanc, 2007
3 Interview 2008-05-27

STORM WATER FLOW TO CHEUNG EK WETLAND

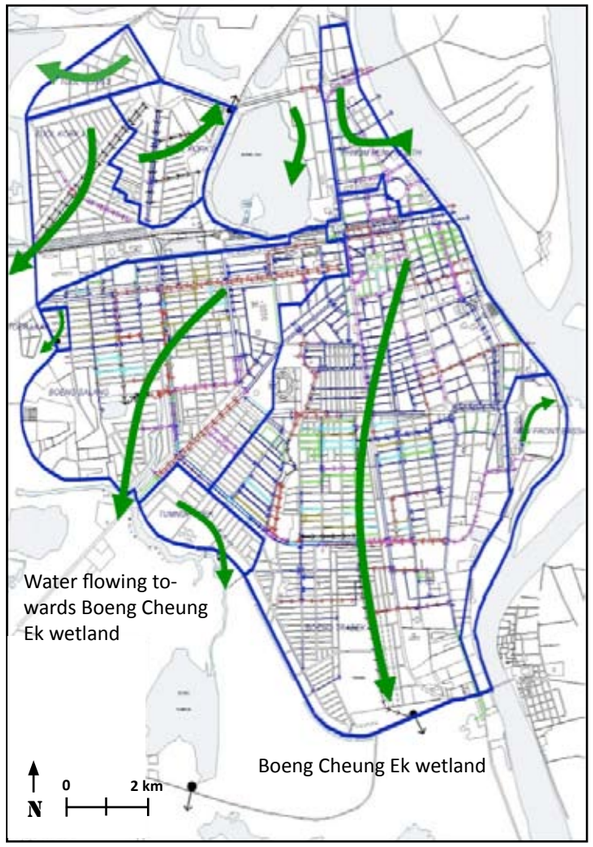



Figure 3. 80% of the water from catchment areas in Phnom Penh is flowing out in Boeng Cheung Ek wetland where the water is purified by natural processes. The river Prek Thnot by Takhmau city receives the water from Cheung Ek before it enters Bassac River. (Map from Livre Blanc)

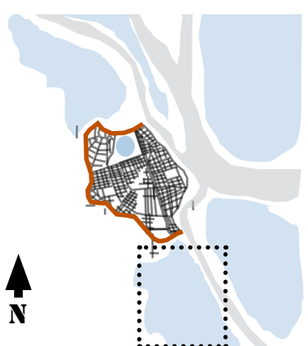



Figure 2. Location of Cheung Ek wetland

Today public transportation between Phnom Penh and Takhmau is made up by private persons driving motorbikes with long coaches for passengers. This system is at the moment functioning rather well but the need for public transportation will grow larger in the near future while the two cities will grow. (Photo: S. Ryttar)

Box 2. ECOSYSTEM SERVICES OF CHEUNG EK WETLAND

- Purification and detoxification of storm- and wastewater with natural biological processes
- Food supply through fish and vegetables
- Provide the main income source for many families selling fish and vegetables
- Provides drinking and household water
- Regulates and prevents floods when serving as a buffer zone
- Regulation of drought through the built detention ponds
- Take up air pollution from the near by city traffic and industries
- Regulation of the global climate change through fixating carbon into the biosphere, reducing carbon dioxide in the air
- Mitigation of climate change impacts by acting as a physical buffering zone for flood water
- Cooling high temperatures, softens the heat island effect
- Habitat for wildlife

# Present situation

Cheung EK wetland connects to Takhmau in the south and to Phnom Penh in the north (see figure 1). Takhmau is assumed to be incorporated in Great Phnom Penh in the near future[4].

Cheung Ek wetland receives the majority of the waste- and storm water from Phnom Penh (see figure 3). Besides cleaning the water before it enters Bassac River, the wetland contributes with many other ecosystem services (see box 2).

The system of natural purification has worked during many years but recently a fast and uncontrolled urban development has occurred in Phnom Penh causing greater water flows to the wetland. Many areas in the city that used to infiltrate storm water are now built on. The developers put trust on the capacity of the surrounding wetlands and rivers to manage the surplus of water flow from the city. Today, increasing amounts of contaminated water masses put pressure on the biological systems in Cheung Ek wetland and causes diseases for people living and working there[5].

4 Livre Blanc, 2007
5 Muong, 2004

PRESENT SITUATION MAP

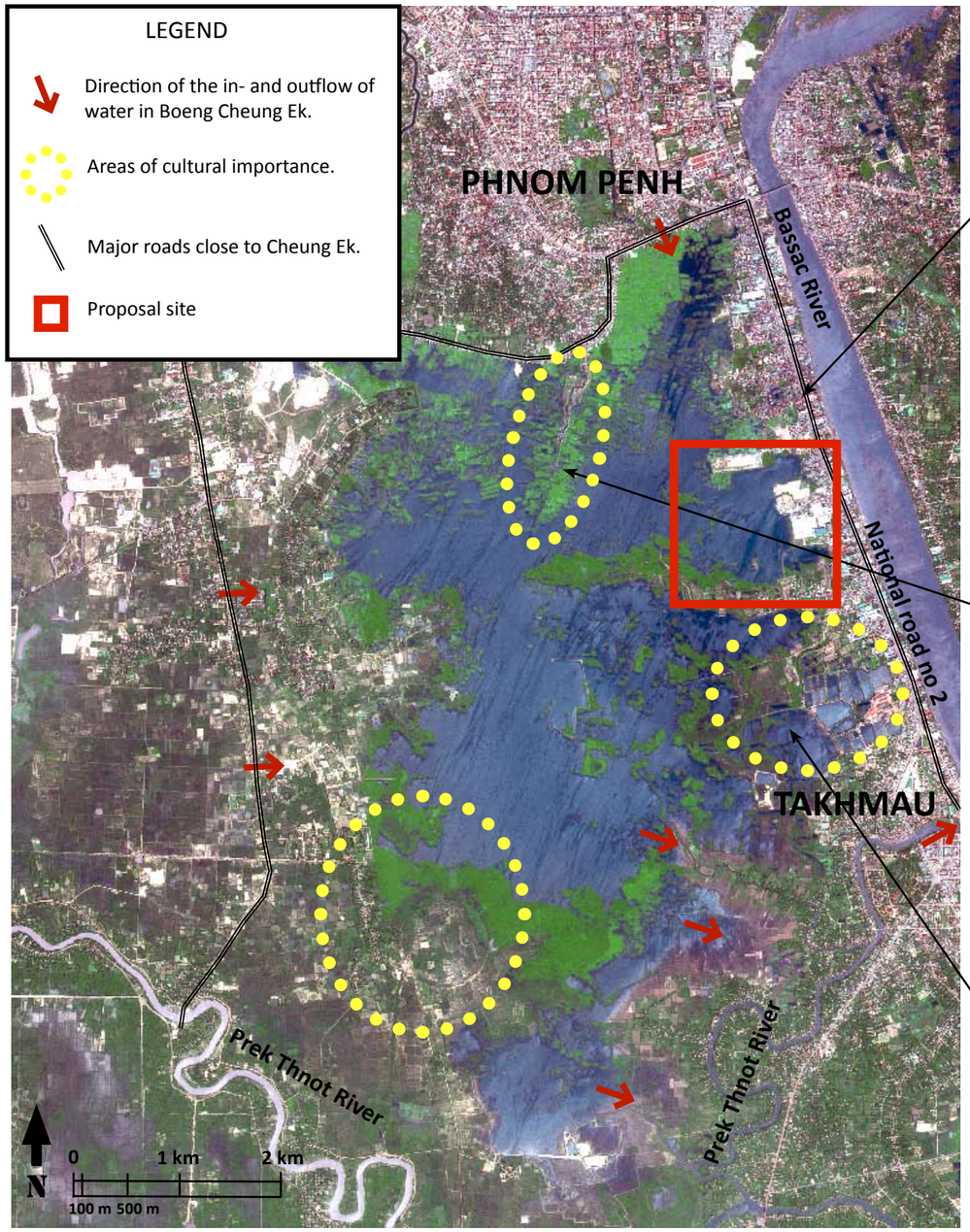



Figure 1. Present situation for Cheung Ek wetland. (Aerial map from JICA)

Phnom Penh and Takhmau are linked by dense settlements along National road no 2, stretching along the east side of the wetland along Bassac River. Schools, industries and private recidences are scattered along the road. View towards South. (Photo: S. Ryttar)

A village on the wetland. It is interesting to see how the inhabitants of Cheung Ek wetland has adapted their living to the character of the area. Villages with houses on stilts can be found in the middle of the wetland. Houses on stilts are also common along the borders to the wetland. During rain season the roads in the wetland are flooded and the villages can only be reached by boat. (Photo: S. Ryttar)

Just north of Takhmau there is an area with squared formed ponds, pleasant paths and farmhouses. The area is forming a traditional and beautiful landscape which has evolved in relation to the wetland. The ponds are used for storing water during seasonal drought and for fish cultivations. (Photo: S. Ryttar)

WATER LEVEL IN CHEUNG EK WETLAND DURING RAIN SEASON

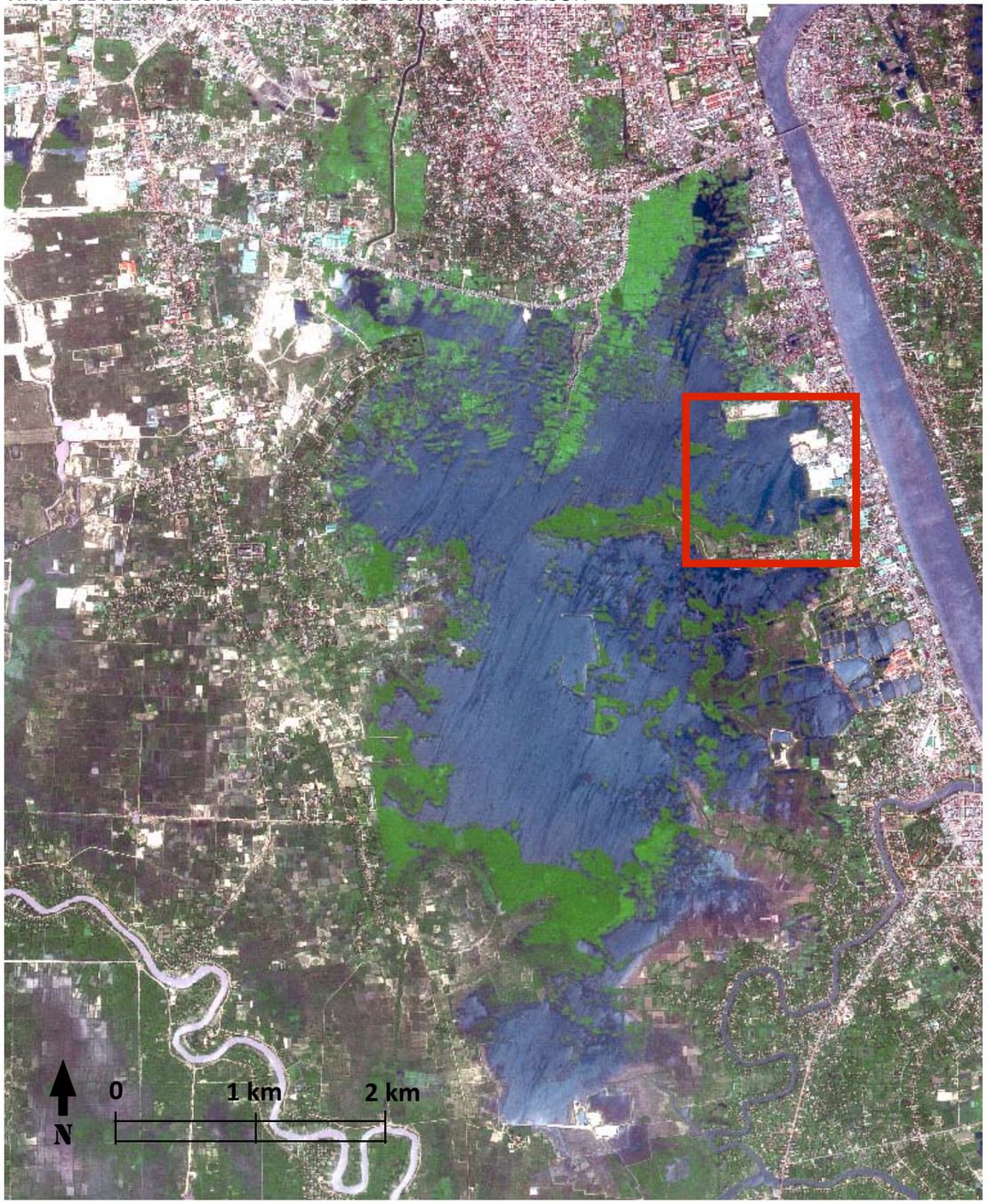



Figure 4. Map from JICA

WATER LEVEL IN CHEUNG EK WETLAND DURING DRY SEASON

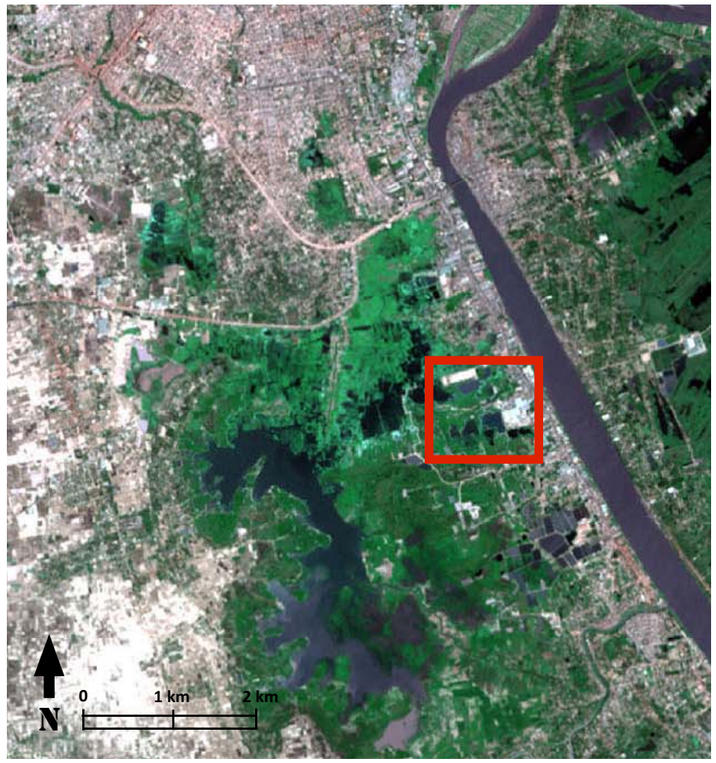



Figure 5. Map from Livre Blanc

The two aerial photos show seasonal changes in water level for Boeng Cheung Ek wetland. The extension of the water body differ much between dry and rain periods. Water from several places gather in this low laying wetland area during a normal rain season. Storm water from Phnom Penh city and water from the flooding rivers are two main sources to the great increase in water level. To these natural variations in water levels come the extreme weather events due to natural variations and climate change that are possible events in this region.

People living in and on the shores of the wetland have adapted their living after the great water fluctuations. During rain seasons some villages in the wetland are only accessible with boat. Most houses are built on stilts to protect the inhabitants from rising water levels.

Ground that is flooded during rain season is walkable in the dry season (see picture below). Many small trails are leading out in the high grass that covers large areas of temporary wetland.

Trail in the wetland during dry season.
(Photo: S. Ryttar)

DEVELOPMENT PLAN FROM AZ COMPANY FOR BOENG CHEUNG EK

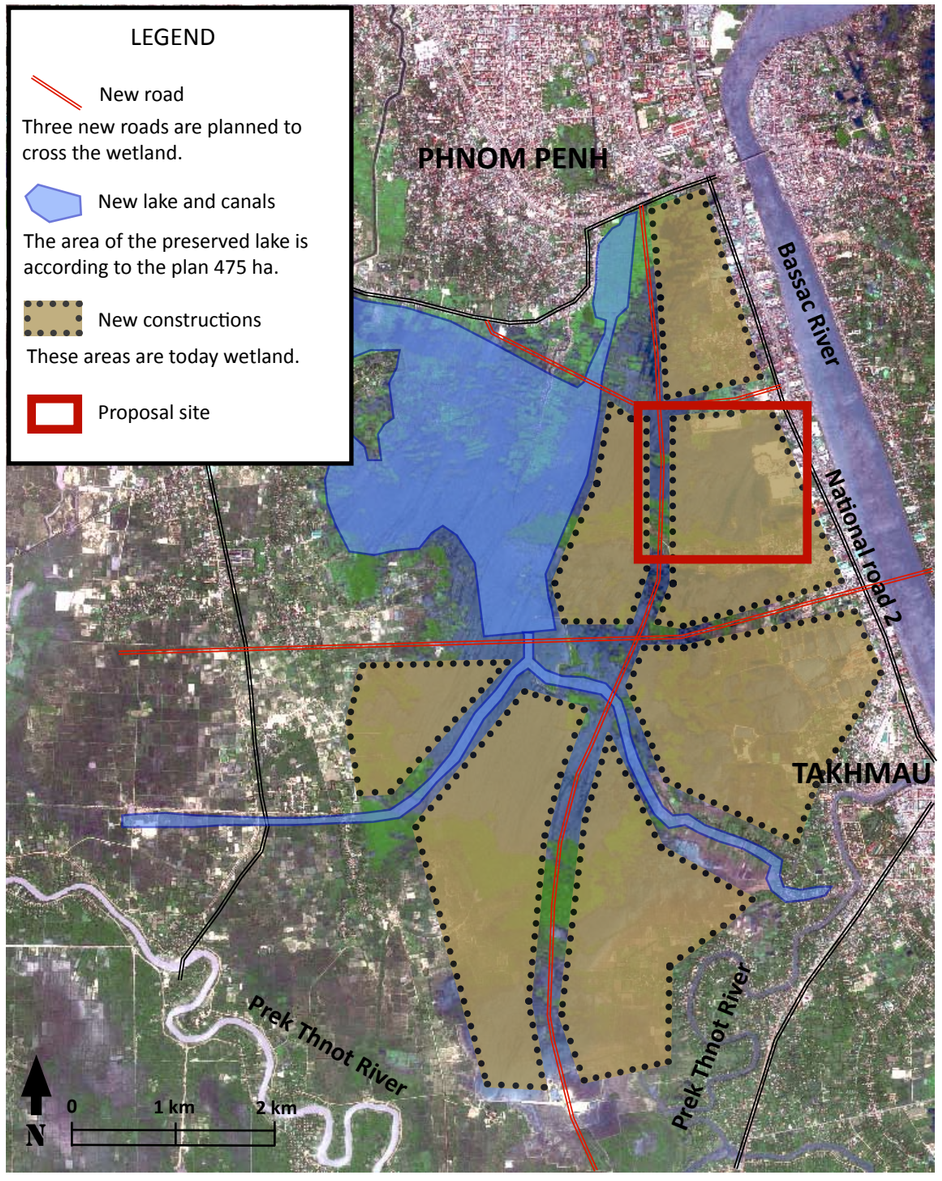



Figure 6. The private company AZ has proposed a development for Cheung Ek wetland. The plan implies that large parts of the wetland will be filled in. The project area is 2630 ha. (Sketch by S. Ryttar after development plan from AZ group of companies)

# Future plans

## AZ company - private investors

At the time being the private company AZ[6] is buying large parts of Cheung Ek wetland from farmers living in the area[7]. The company has also been negotiating with the Municipality of Phnom Penh to make constructions on the wetland[8].

The information about the planned development is limited. Only a few municipal departments and local city district offices have been contacted and invited to a information meeting. Some have received a general map of the planned development. Local people generally know very little about the development plans and rumors are spreading about what is going to happen[9].

Due to the scarce information one can only make assupmtions about what type of development that awaits Boeng Cheung Ek wetland. The exploiter has come forth with a general plan (see figure 6), which shows areas for buildings, roads and preserved water. According to the plan, large areas of what today is wetland will be drained and the water will be restricted to a smaller lake. The reminding areas of former wetland will probably be drained and filled to make way for constructions.

This way of building and planning new city districts reminds of the developments on the wetlands north of Phnom Penh described on page 21. There is a considerable risk that the development on Boeng Cheung Ek wetland will be of similar type as the ones going on in the north.

An assumption that can be made by observations of the developments on the northern wetlands is that the new houses will be built for people in the upper classes. The majority of the new constructions made in Phnom Penh today is focusing on luxury living. Other houses will probably be hotels, offices and shopping centres. If the poor present inhabitants of Cheung Ek wetland are lucky they will receive a small area with “relocation houses”. This way of planning is predominant in Phnom Penh at the time and there is no reason to expect a radically different approach from AZ company.

Yet another assumption is that the style of houses and environments will be formed after western design. The design of other new city districts in Phnom Penh show little connection to the Khmer culture.

6 interview, BAU, 2008-05-14
7 Interview, STT, 2008-05-08
8 Interview 2008-05-11
9 interview, Cheung Ek, 2008-05-11

Box 3. CONSEQUENSES OF THE AZ PLAN

- Greenhouse gases will be released when wetland biomass is erased
- The buffer capacity that protect against floods will be lost or diminished
- The natural cleaning of polluted water from the city will be lost or diminished
- People will loose their livelihoods and homes
- Valuable and rare ecosystems will disappear
- The new constructions address others than the people in need of houses
- A possible future tourist area will be lost
- The surroundings of the culturally important Killing Fields risk to be converted and the value of the sites decreases
- An area suitable for recreation and education will be lost
- The loss of an important food source.

## Analysis of the AZ plan

My conclusion is that the plan propoesd by AZ company will create an increased flood risk. This will be a fact in the new city district as well as in Phnom Penh centre.

North of Phnom Penh, a major part of the wetland has been filled and disappeared. This is done to prepare for new development projects, for example CamKo City and International City, see page 21. The sites have been developed with little thought of sustainable storm water management and seasonal fluctuations of water; the projects therefore risk the future sustainability for themselves but also for the whole city of Phnom Penh.

Looking at the proposed plan for Cheung Ek wetland the attitude regarding storm water and flood protection seem to be similar as for the northern exploitation. According to the plan large parts of the wetland will be filled and built on. The water is directed to a restricted lake area and lead through what seems to be canals with fixed limits. The idea seems to be to diminish the possiblity for the water to fluctuate over larger areas. The seasonal low and high water levels are taken away and controlled as far as possible.

Accordong to the AZ plan 65% of Cheung Ek wetland will disappear. The buffer capacity that today protects the city from floods will be lost or greatly diminished if the present 1300 ha (dry season) is reduced to 475 ha as the AZ plan suggests.

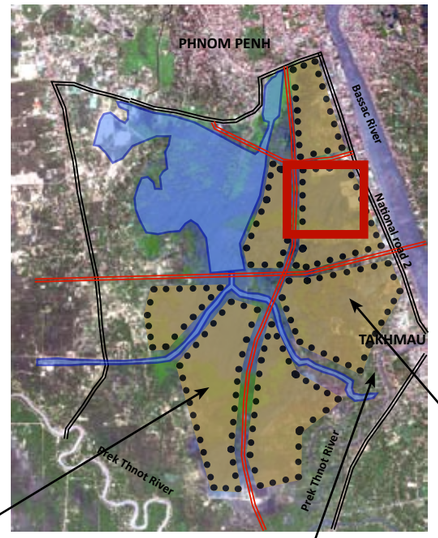
In the AZ plan there are several new roads crossing the wetland. The roads will be built on dikes. These embankments will constitute barriers that prevent the natural flow of water. New pumps are planned to pump the water over the roads.

This way of designing lake, canals and roads is risky. The design restricts and limits water from the seasonal floods instead of adjusting to its natural fluctuations. High flows will put pressure on constructions like pumps and dams. These constructions built to control the water might break which will have devastating consequenses for the new-built districts as well as for the Phnom Penh centre.

The AZ plan shows zones where wetland will be drained, filled and built. The new houses and environments will be constructed on former wetland where redundant water was once stored. When built on, these zones will instead produce runoff water that has to be lead to and stored in the small lake. How much water the areas will generate depend on the portion of hard impervious surfaces.

It is visible that the idea of local storm water management is not applied in new constructed environments on the wetlands north of Phnom Penh. Green surfaces are for certain a part of the design but an overall system for dealing with locally fallen rainwater does not seem to be a part of the plan. Hard ground surfaces are popular design features in new environments near business buildings and shopping centres in Phnom Penh. It is reasonable to suspect that a similar design proposal will be presented for Cheung Ek wetland.

Fishing in Cheung Ek will be prohibited if the exploitation proposed by AZ company is realized. (Photo:S.




Much of the vegetables sold on the markets in Phnom Penh will dissapear if the food production on Cheung Ek wetland is prohibited. (Photo: S. Ryttar)

A wetland has given space to a new city district north of Phnom Penh. The water is successivly drained away and will soon be gone. Houses will take its place. The same development awaits Cheung Ek wetland if the plan from AZ company is realized. (Photo: S. Ryttar)

Erosion is today a common problem in Takhmau city along the borders of Prek Thnot river. Greater water masses as a result from the reduction of wetland area, will make the problem more severe. Larger and faster water flows will threaten the houses and streets by the river in Takhmau. If the water buffering capacity of Cheung Ek wetland is reduced as the AZ plans suggest, the river by Takhmau city might receive greater water flows and flood. (Photo: S. Ryttar)

The traditional irrigation ponds. The AZ plan suggest a road in this area which will disrupt this culturally interesting area. (Photo: S. Ryttar)


Water snails coloured in different spices is today commonly seen on the streets of Phnom Penh but may become rare in the future if the exploitation plan for Cheung Ek is carried through. (Photo: S. Ryttar)

With the AZ proposal the water masses in Prek Thnot River risk to become larger and more polluted than today. Prek Thnot river is already suffering from erosion, especially close to the city Takhmau (see photos to the left). With a radically smaller wetland area there are reasons to beleive that the water level in Prek Thnot river will increase which will cause more erosion and occasionally lead to floodings in Takhmau city.

The smaller wetland area implies less purification of the water. The polluted water from Phnom Penh will cause great damage to the living organisms in the rivers which will have severe and negative consequences for Cambodia where fishing is one of the major food and income sources.

A treatment plant will be nessecary if the wetland is erased. It will be required to avoid pollution of the important rivers. But it is not very likely that a treatment plant can be financed without help from private investors or international aid. As a reference the wetlands north of Phnom Penh have not yet been replaced with a treatment plant.

The canals that lead form the lake to Prek Thnot River seem to be outlined without understanding the natural water flow. The direction of the natural water flow is from the area west of Cheung Ek road into the wetland. The shape of the canal seem to be designed for an opposite flow. Constructions of canals without regard to the natural water flow can lead to flooding and to stagnant water.

The AZ plan will not allow the food production in Cheung Ek to continue. Aquatic cultivations and fishing will be prohibited in the small lake that is preserved in the AZ plan[13]. The Cheung Ek wetland area is today a very productive food source close to the markets in the city. Accordiong to UN the climate changes will have an impact on food production. Especially regions like Cambodia (seasonally dry and tropical) will experience a decrease in crop productivity[14]. It therefore seems like a very unsustainable move to take away large cultivations that serve the markets in Phnom Penh.

Today Cheung Ek consist of many areas worth saving for their aesthetical and cultural values. These areas will be lost if the AZ plan is carried through. Examples of threatened areas are the traditional irrgation ponds and the village in the middle of the wetland.

Naturally there are also some positive effects of the AZ plan. For example it suggests a southern development of Phnom Penh which will incorporate Takhmau in Great Phnom Penh. This is a desirable development according to the Master Plan of Phnom Penh. The AZ plan can result in many residential houses which address the great shortage of apartments in Phnom Penh. A good consequense of the exploitation is if a treatment plant is thought to be of importance. A treatment plant can only be realized if it is initiated and financed by the private investors. An easy way of raising the value of apartments, hotels and shopping centres in the new city district would be to clean the water running through the area.

13 2008-05-16 Meeting in south Sangkhat office, Boeng Tun Pun, Mr Sous Sarin
14 www.un.org/esa/sustdev/sdissues/ climate_change/climatechange.htm

PLAN FOR CHEUNG EK WETLAND IN THE MASTER PLAN OF PHNOM PENH

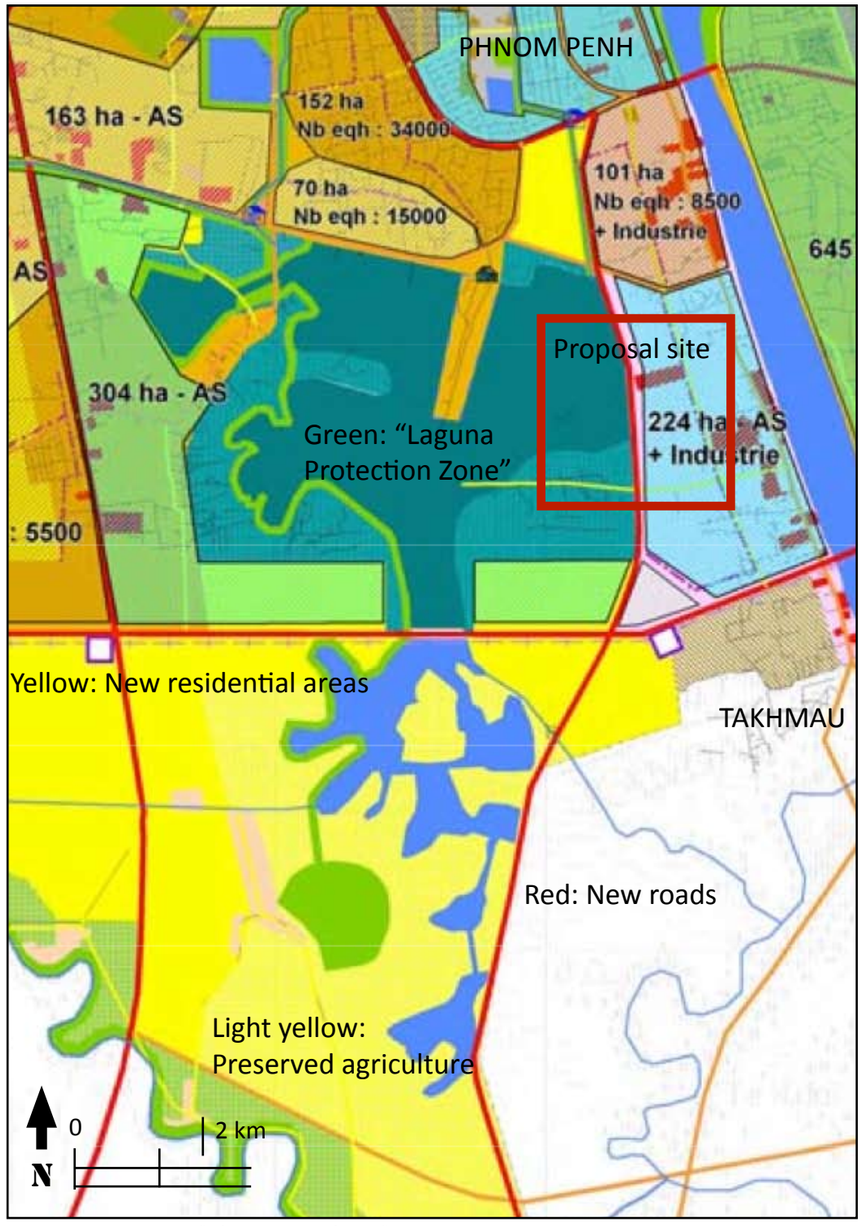



Figure 8. Summary of the Master Plan of Phnom Penh by 2020. The main part of Cheung Ek is preserved, industries are planned at the east side along national road 2. Map from Livre Blanc, text added.

## Boeng Cheung Ek in the Master Plan

The Master Plan of Phnom Penh from 2005 suggest a "Laguna protection zone" in Cheung Ek wetland (see figure 8). According to the Master Plan the main part of the wetland will be part of a green and blue network in Phnom Penh. The green and blue patterns in Boeng Cheung Ek wetland will also serve as a link to Takhmau city.

The southern part of the wetland are planned to be preserved as agricultural land. Two roads are planned to cross Boeng Cheung Ek wetland in both directions. One is crossing the wetland in the middle and the other one is parallell with National road no 2.

PLAN FOR CHEUNG EK WETLAND IN THE GREEN AND BLUE PLAN FOR PHNOM PENH

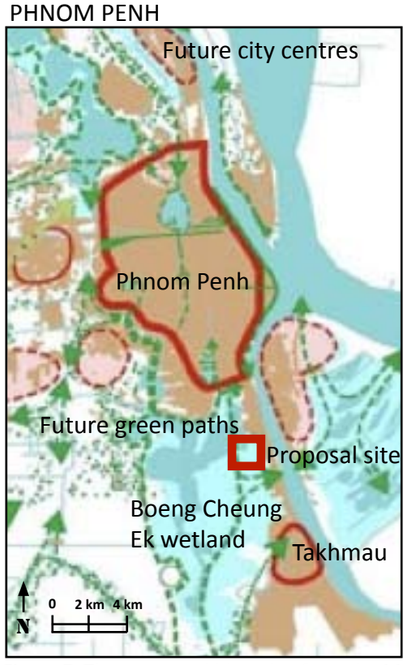



Figure 7. The green and blue plan from the Master Plan of Phnom Penh by 2020. The plan shows that Cheung Ek wetland is planned to be part of a green and blue network. Map from Livre Blanc, text added.

An industrial area is planned in the eastern part of the wetland along National road no 2 and a couple of hundred meters in on the present wetland area. Residential houses are planned in the middle of the wetland along one of the new roads. Villages are preserved on the west side of Boeng Cheung Ek wetland and on narrow strips of land that juts out into the wetland.

The Master Plan suggests a treatment plant by the "Laguna protection zone" that treats the water from Phnom Penh before it enteres the natural environment. The water is planned to be treated by successive and differentiated lakes - filtering, anaerobe lake, lake with macrophytes and also different aquacultures by farmers. This is said to require the protection and improvement of 450 hectares of wetland. The Master Plan claims that this will generate 3 million dollars of annual income for the owners of piscine cultural basins and of floating cultures.

The green and blue plan (see figure 7) is a part of the Master Plan and suggests that large boengs (lakes) will be "perserved to compose an urban facade on water". It also suggests that the limits of the wetlands will be determined and fixed. Green areas are said to be important to frame the blue network and axial perspectives towards water are important to spare. The green and blue plan also suggests the creation of large peripheral urban parks by current large lakes. Boeng Cheung Ek, the Genocide memorial "Killing Fields" and the archeological site are mentioned as possible places for a park.

## Analysis of the Master Plan

The plan shows a future growth of Phnom Penh towards the south and a successive incorporation of Takhmau city. Cheung Ek is in the middle of this southern development and the Master Plan has taken the wetland into account. The planning of different lakes to clean the water also includes the present cultivations of crops and fish on the wetland. This is both ecological, social and economically sound. The purification of the water will continue to be biological but within controlled limits. To include the farmers is a good way of fighting proverty and also to secure food resources from urban agriculture. The food will be locally produced and thus generate few transportations. A protection zone around the lake is also very wise.

However, I question the location of new roads, industrial and residential areas. The road in a north-south axis is constituting a barrier between the wetland in the west and the built area in the east. This will not facilitate the creation of a peripheral park or other green areas that are suggested to border the large lakes. The new road will probably be built on a dike and thus constitute a distinct limit of the wetland and allow little fluctuation of water level.
In the south the north-south road leads through the low point of Boeng Cheung Ek wetland lake. In my opinion this is not a suitable location for a major road; not from a technical point of view, nor from an ecological or hydrological point of view. For the same reason, the new residential area along the east-west road is strangely located. The houses will be situated in the middle of the wetland where the lowest points in the landscape point is located. Problems with flooding will be hard to build away.

The placement of industrial activities along the entire road towards Takhmau does not suit the goal to link the city to Phnom Penh. Residential areas are better in this location, I believe.

SUGGESTION FOR SURROUNDINGS OF THE PROPOSAL SITE

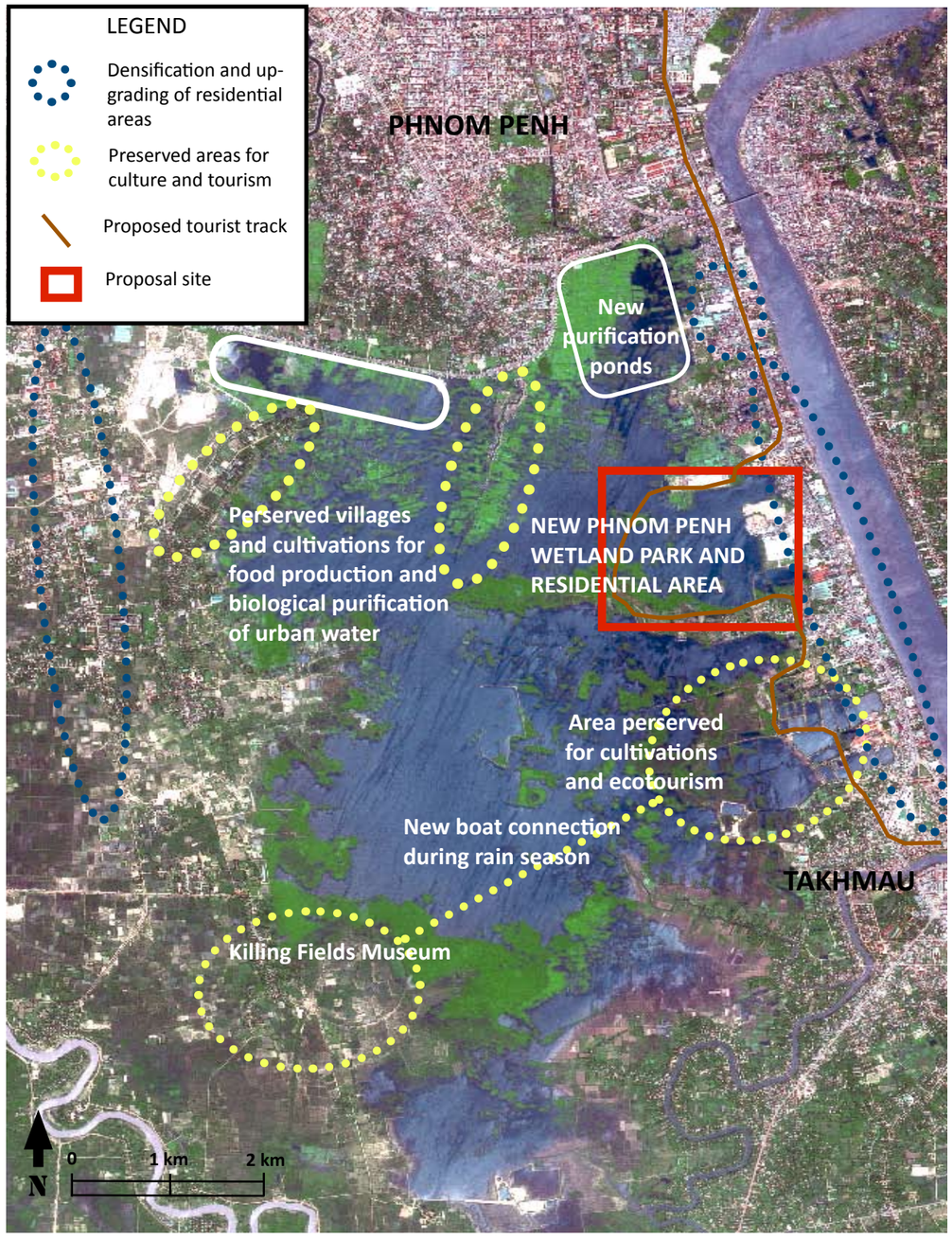



Figure 9. Base map: Aerial map from JICA

# Proposal

This proposal aims to give general guidelines for how residential areas could be constructed to fit in the surroundings on the border to Boeung Cheung Ek wetland. The proposed plan does not aim to meet the need for housing in Phnom Penh but to present recomendations for future developments on Boeng Cheung Ek wetland that takes into account the present economical, social and ecological prerequisites in Phnom Penh. The area for the proposed development is situated half way between Phnom Penh and Takhmau on the border to the wetland.

To make constructions on a wetland is not an easy task. It is difficult to preserve the environmental values of a wetland and at the same time develop housing and infrastructure for many people in direct relation to and even on the wetland. The challange is to develop the area but yet protect the values and services that the wetland hold.

My proposal is based on the analysis of Phnom Penh presented on page 25. The overview plan to the left is a suggestion of how a new residential area in Cheung Ek could fit into the surroundings. The goal is to preserve and enhance ecological, cultural and aesthetical values that can be of great importance to Phnom Penh. The protection of these areas will contribute to a sustainable development. Food production, biological purification of urban water and storage of rain and flood water are all important factors that should be preserved.

This proposal is also based on the Master Plan of Phnom Penh 2020. The Master Plan suggests a protection zone for large parts of Cheung Ek wetland and also a fusion between Phnom Penh and Takhmau. In the over view plan to the left I suggest two areas with treatment ponds for the water entering Cheung Ek. The last steps of the purification is done by aquatic cultivations and by processes in the wetland.

Presently there are many industrial buildings scattered along National road no 2. I suggest that these activities will be gathered in an industrial area. This will facilitate the management of polluted water generated by the industries. I suggest a location close to one of the two areas with purification ponds (see figure 9). A draw back is that this will create a somewhat rough entry to the central parts of Phnom Penh. Nevertheless, it should be possible to design the area close to the road in a welcoming way despite the industrial activities.

Takhmau and Phonm Penh are connected by waterways and water landscapes and this should be enhanced with parks and touristic visiting points. I have made an emphasis on touristic activities because this is an important industry for Cambodia. It will be crucial for the development of Phnom Penh to be able to attract visitors. Parks, culture, exciting nature and architecture are features that Phnom Penh could enhance in order to attract tourists.

I have not suggested any roads crossing the wetland in order to preserve the wetlands capacity to buffer redundant water. Upgrading and widening of the present roads can be a solution to increased traffic. On the other hand, public transportations are also essential. A tram way and a boat link between Phnom Penh and Takhmau could be of great importance when the two cities will integrate.

GENERAL SHAPE OF THE PROPOSAL

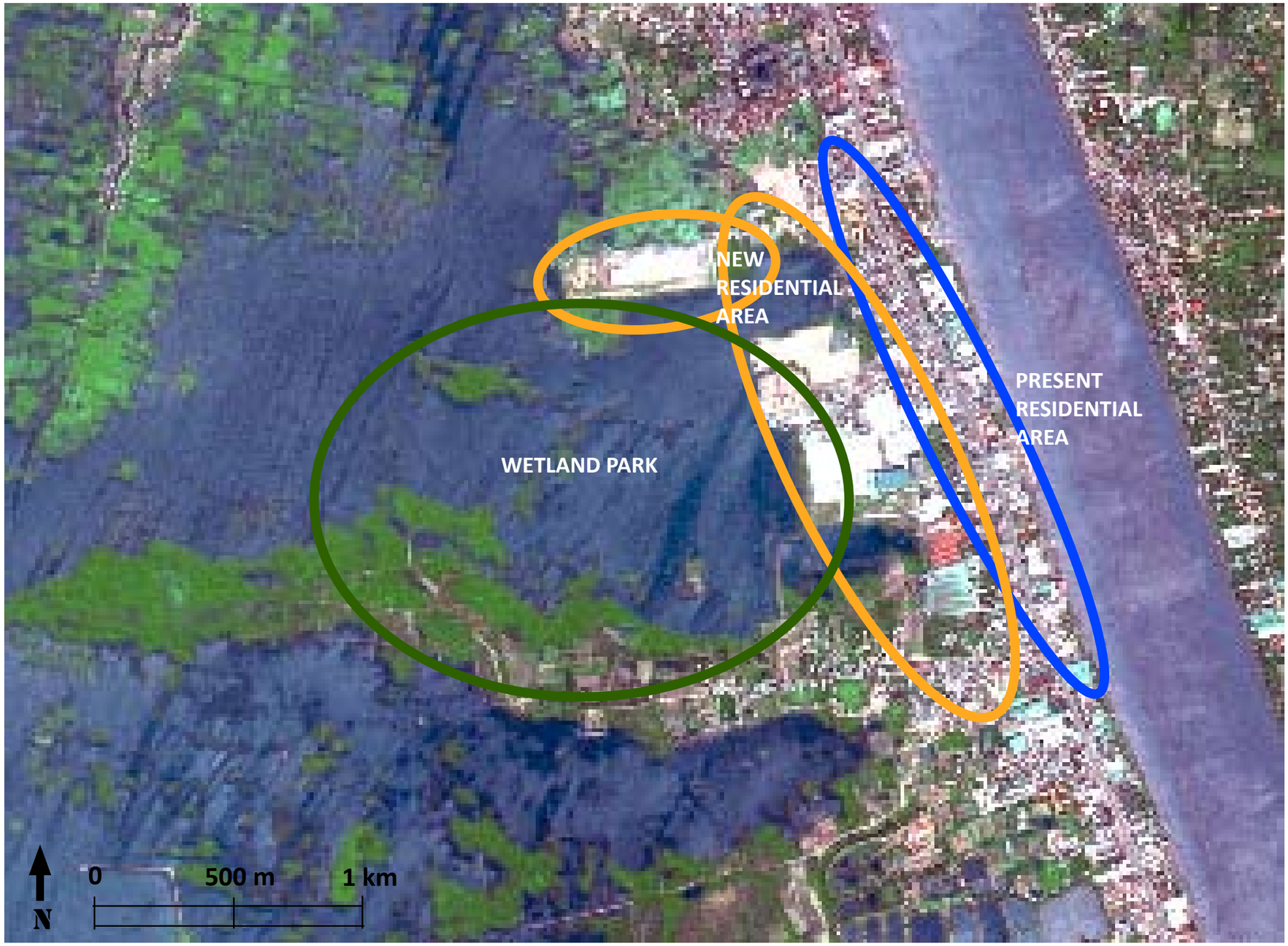



Figure 17. I suggest a development where present residential areas, new residential areas and a wetland park are integrated. The transition between the three type areas should be smooth and made with consideration to the present situation of buildings, cultivations and fluctuations in water level. (Map from JICA)

The proposal imply a larger portion of planned structures along national road no 2. The area will get a more urban character that will fit into the future southern expansion of Phnom Penh. The unplanned structures will be left in an agricultural area south of the proposal site.

The new development will be a linking feature between Phnom Penh and Takhmau. Present paths between the two cities will be incorporated in the new area and new paths will be created.

The development will create many new meeting points and public places in an area that today have the characteristics of a unifrom transportation path. The proposed trekking path (see figure 10) will constitute an alternative way to the busy National road no 2.

Access to the wetland will increase with the proposal. The Wetland Park and the public places located by the wetland will make the wetland more accessible to both inhabitants in the new residential area and visitors. The changing borders to the wetland will remain as today. Fluctuating water will continue to determine the shoreline with large yearly variations.

The square-shape of the present residential areas and irrigation ponds will be emphasized by the new residantial area. New quarters will be placed in a grid that connects to the shape of the present quarters (see figures 18-19).

LOCATION OF THE PROPOSAL SITE

PRESENT SITUATION ON THE PROPOSAL SITE

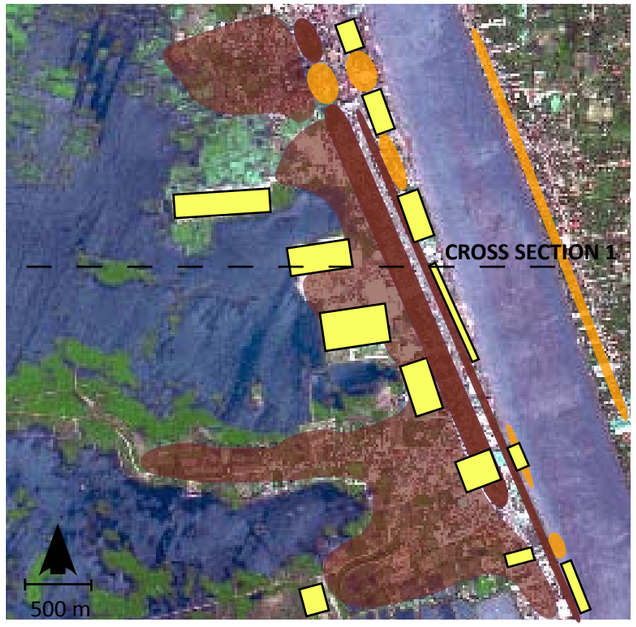



Figure 11. Districts

Houses in unplanned structures

Houses in planned structures

Slum settlements

Industrial areas

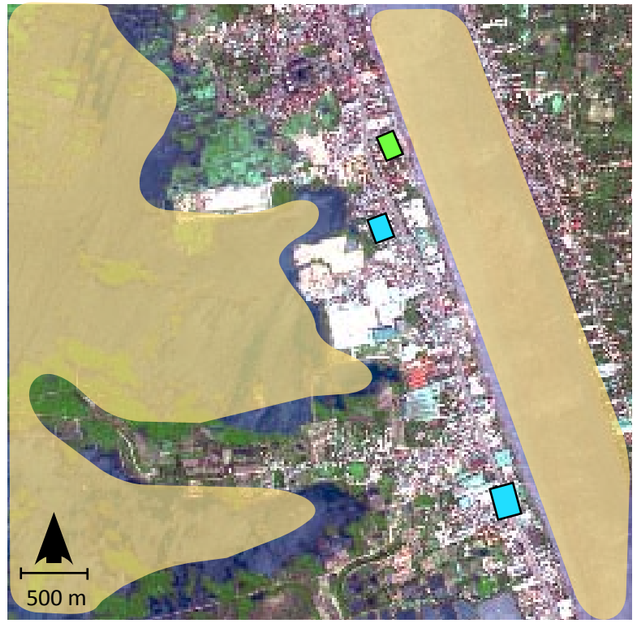



Figure 12. Water surfaces and important buildings

Primary school

Pagoda

Major water surfaces in rain season

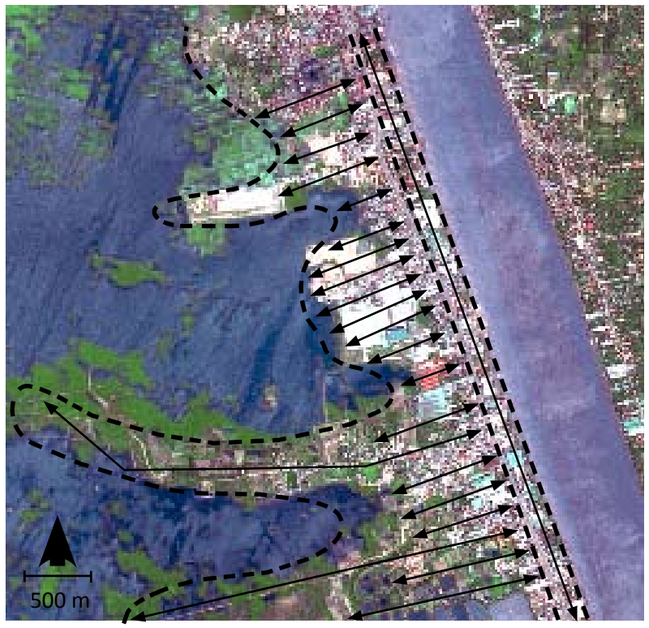


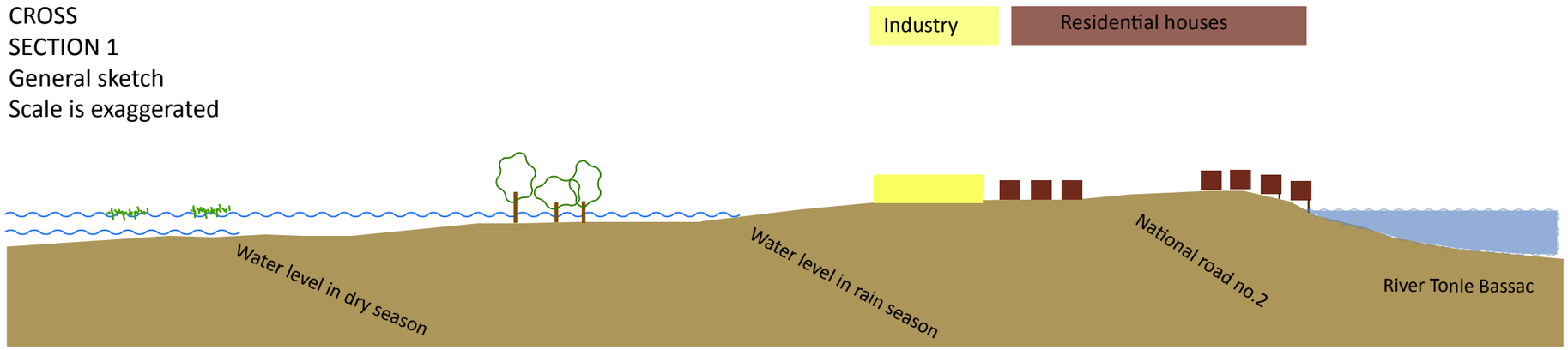

Figure 13. Paths and edges

Streets and trails

Edges: shoreline and national road no 2

LOCATION OF THE PROPOSAL SITE

CROSS SECTION 1
General sketch
Scale is exaggerated



SITUATION WITH THE PROPOSAL

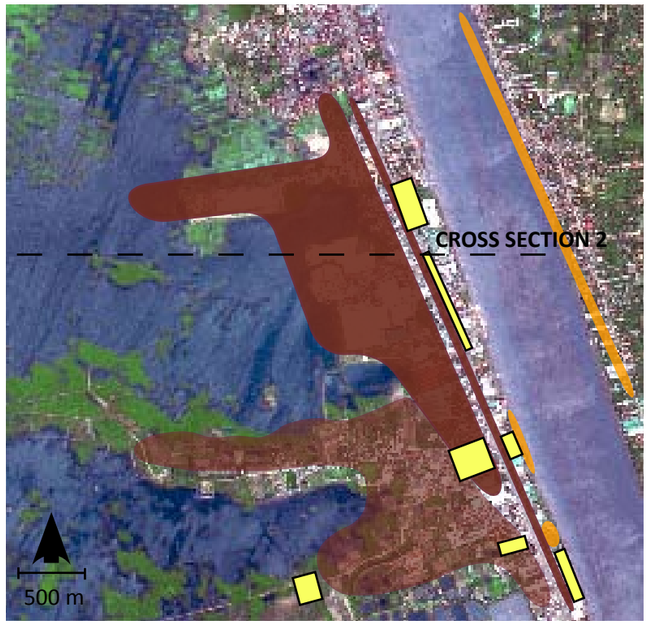



Figure 14. Districts

Houses in unplanned structures

Houses in planned structures

Slum settlements

Industrial areas

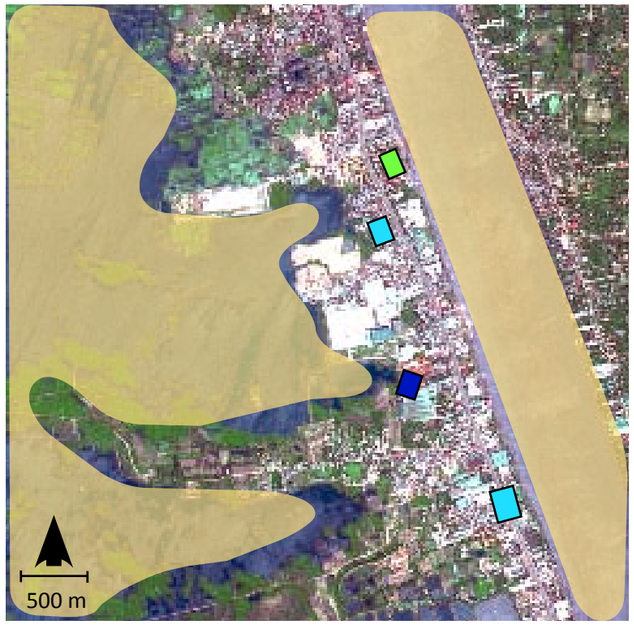



Figure 15. Water surfaces and important buildings

Primary school

Pagoda

Wetland museum

Major water surfaces in rain season

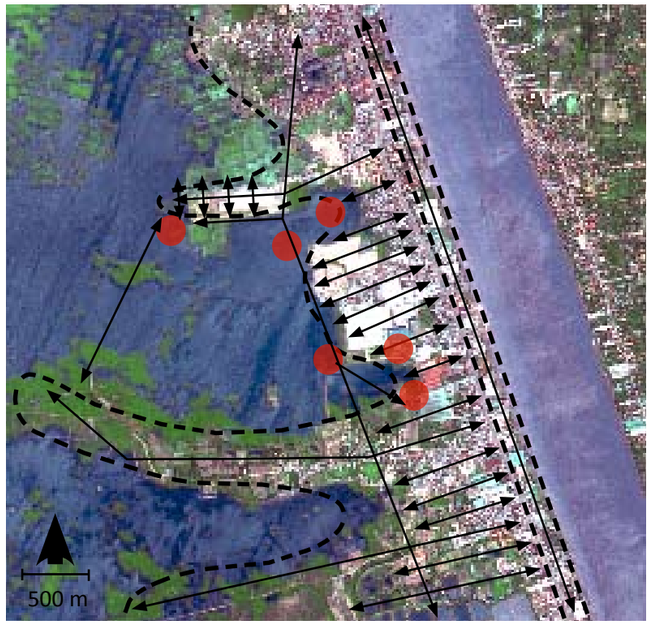


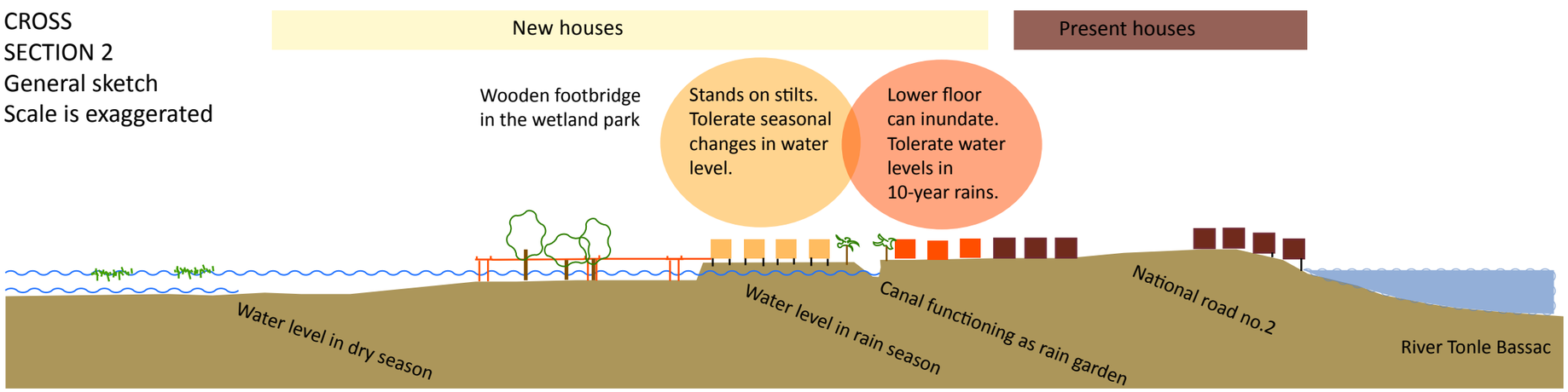

Figure 16. Paths, edges and nodes

Streets and trails

Edges: shoreline and national road no 2

Node: Wetland Park, museum, sport area and squares

CROSS SECTION 2
General sketch
Scale is exaggerated



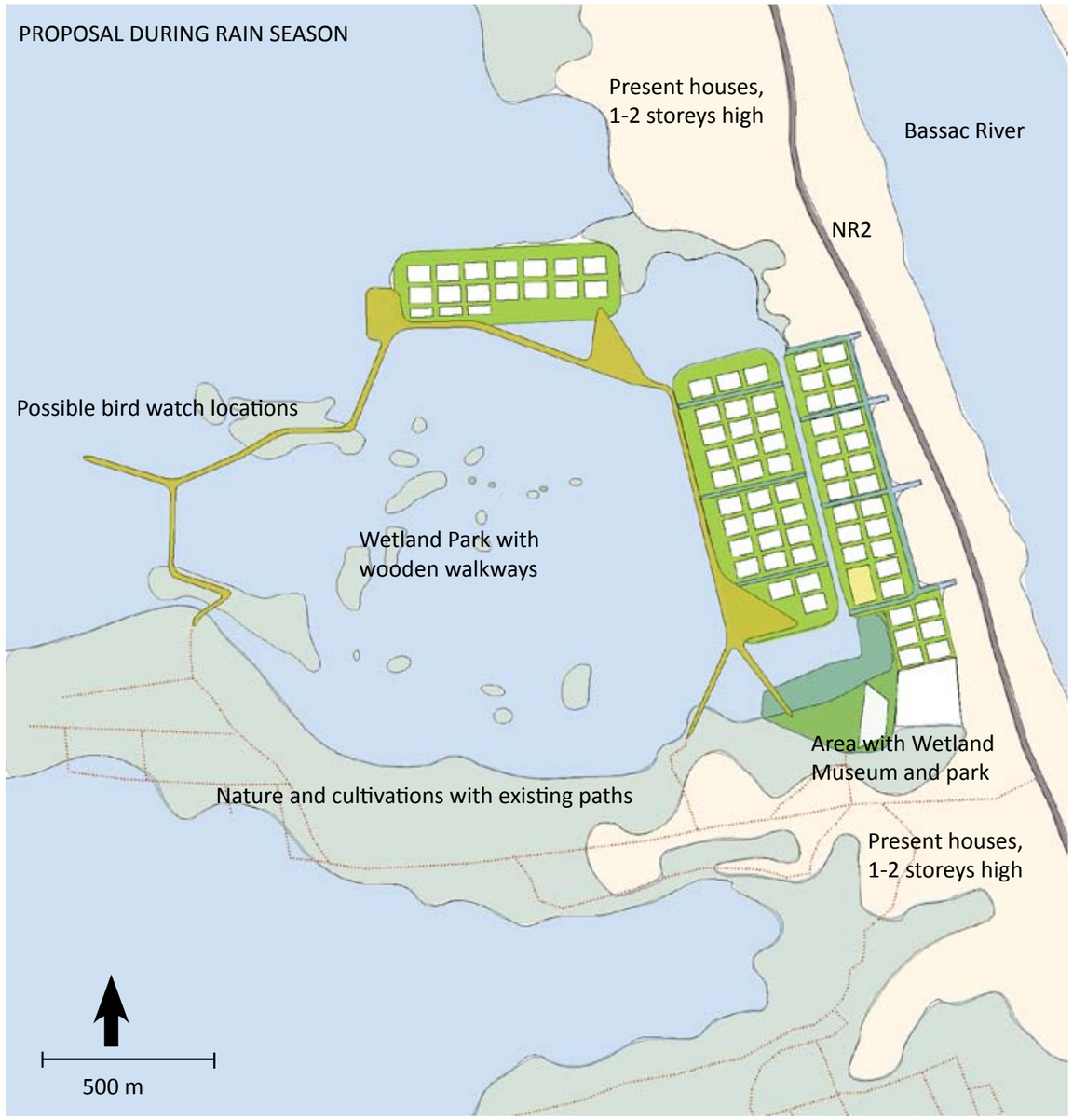



Figure 18. During high water levels the water reaches the borders to the residential area. The rising water will fill canals that are scattered between the quarters. The Wetland Park constitutes of wooden footbridges that connects to existing pathways. During rain season the Wetland Park has a large blue water surface. Public places are scattered along the wooden footbridge. There is also a square for markets etc. within the residential area.

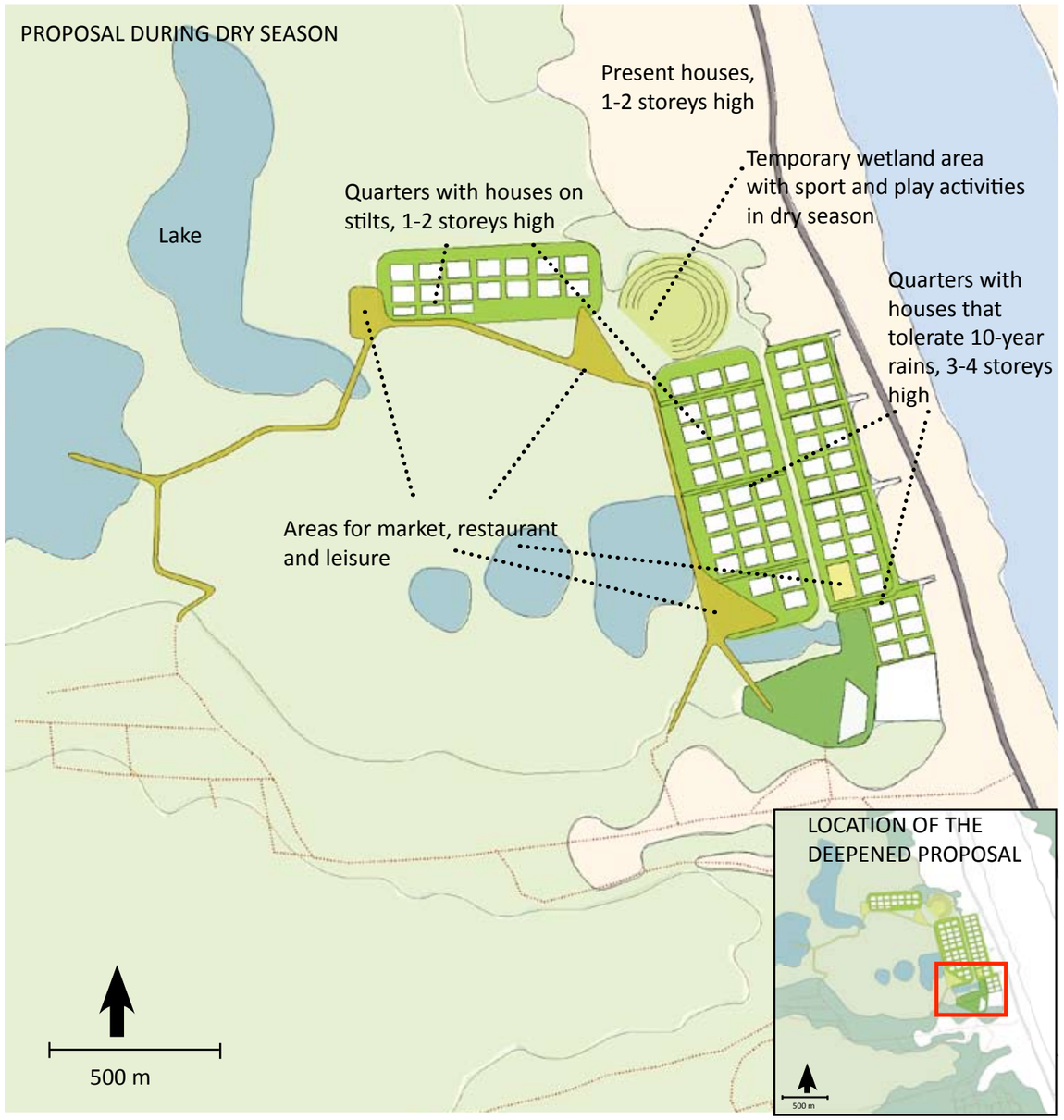



Figure 19. The canals in the residential area are dried out and function as flowerbeds. An area for sport and play activities is dry and can be used. The Wetland Park is green with a few remaining water bodies. The new houses are planned in a grid net that harmonizes with the present structure of houses and irrigation ponds. The houses are of two general types: stilt houses that can tolerate flooding is located closest to the wetland and houses that tolerate to be inuntated during extremely high water levels.

# How does the proposal fulfil the seven criteria for sustainability?

**Cultural**
The proposal emphasises the rich Cambodian culture. The cultural diversity is visible in many ways through architecture, landscape modelling, plant material and way of living. The typical habit of eating and socialising outdoor is enhanced through the many public spaces.

**Biological**
The proposal will protect the urban biodiversity since a large part of the wetland is conserved together with the Wetland Park.

Natural fluctuations of water is allowed to continue, which will benefit speices adapted to this type of environment.

**Economical**
The Wetland Park, the Wetland Museum and the sustainable planned residential area will become a new visiting point for tourists. Phnom Penh is in need of larger parks for both visitors and inhabitants. The proposal site will thus bring many opportunities for businesses of all kind.

**Aestethical**
The aesthetical values of the area will be enhanced. The beauty of the wetland environment will be showed with vistas and a better accessability.

The parks and courtyards will be deisgned to create pleasant environments and the houses will have a style that harmonises with the surrounding environment.

SUSTAINABLE CITY DISTRICT

**Organisational**
The proposal will be an example of a sustainable planned development of a city district on the edge of a wetland. Alternative ways of managing infrastructure like garbage collection and storm water will be presented in the proposal site.

**Social**
The proposal will give more opportunities for social interactions. Public spaces like parks and squares are several. A large market place is also contributing to a better social climate in the area. The proposal offers apartments for all economical classes.

**Physical**
The proposal is a step towards creating a linking area between the two cities Takhmau and Phnom Penh and form the Great Phnom Penh. The proposal will transform the area along National Road no 2 from a transportation path to a place worth visiting. It also makes the best out of the special location on the wetland border.

## Deepened proposal

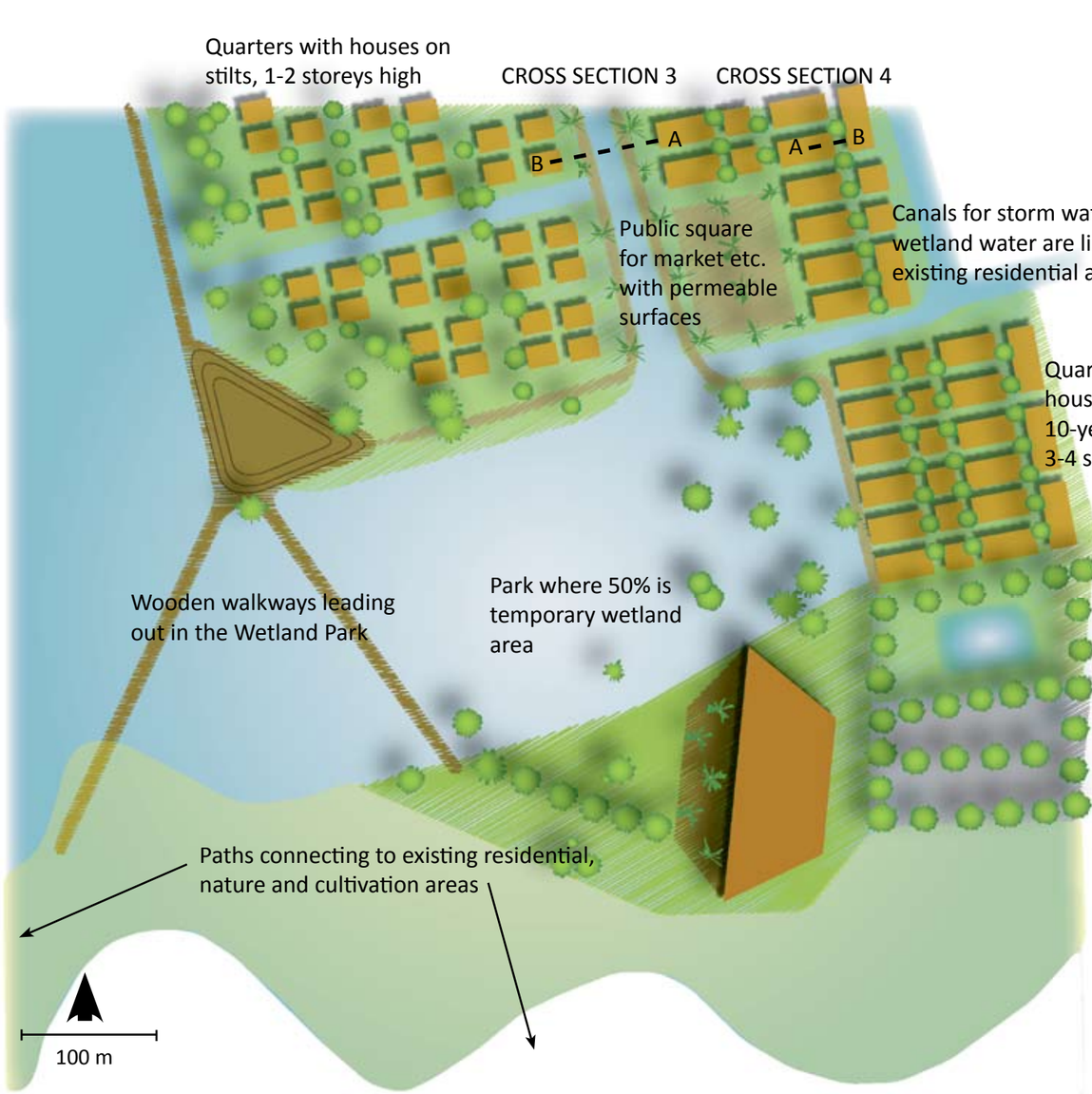



Figure 20. High water level during rain season.
The square is placed close to the water front to make it possible to arrive with boat during rain season and unload aquatic vegetables. During high water levels the park by the Wetland Museum will be partly flooded. Plant species adapted to a life with fluctuating water levels will be planted here. Green roofs and many permeable surfaces will take care of storm water. Redundant water from the heavy rains during rain seasons will be lead to canals that connect to the wetland.

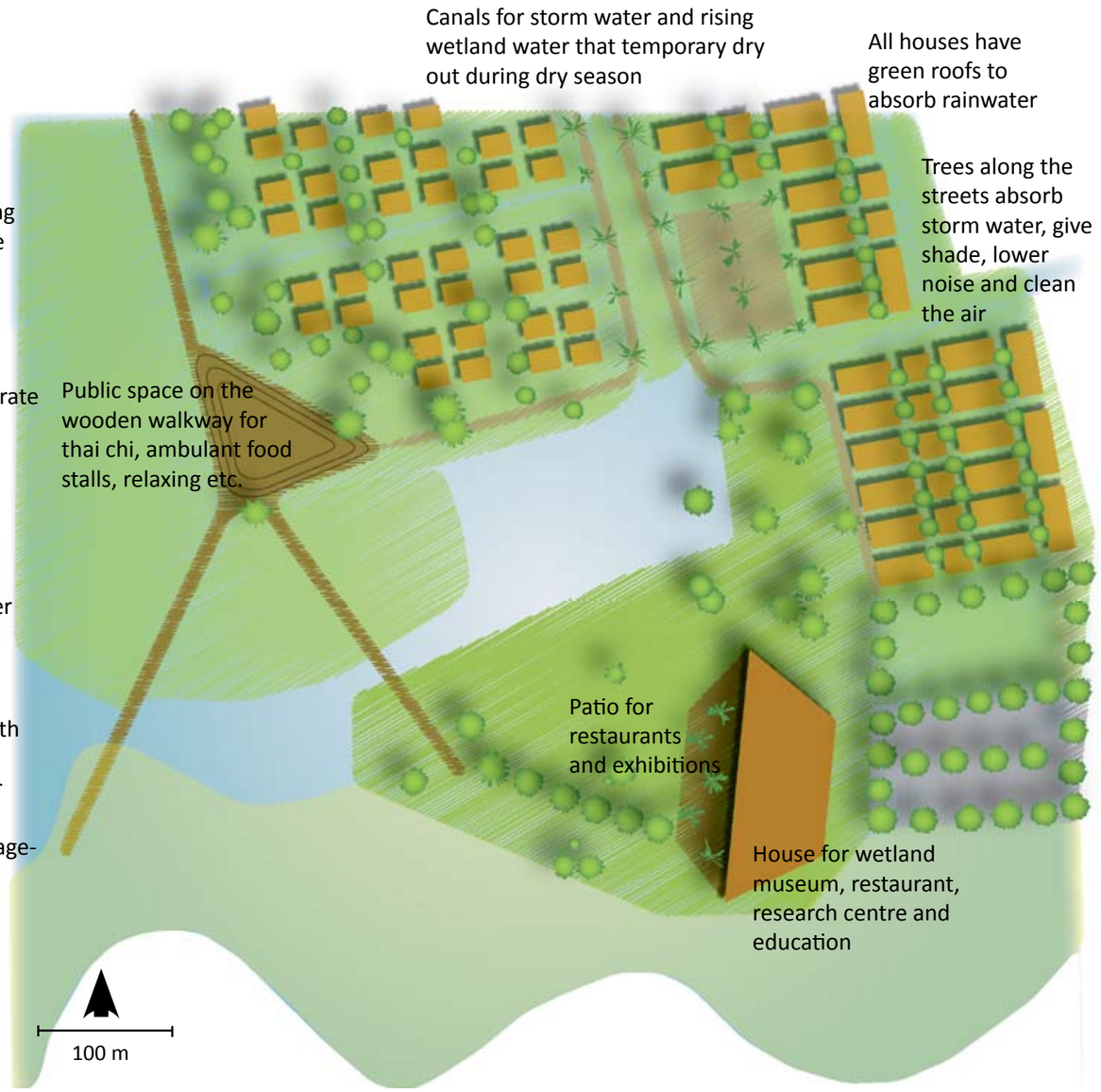
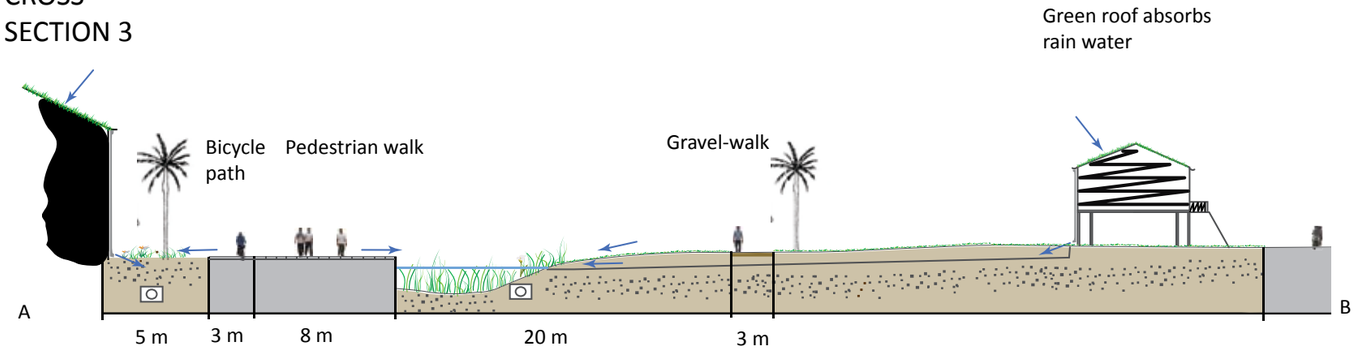



Figure 21. Low water level during dry season.
The canals will be dried out during dry season and function as flowerbeds. The whole park by the Wetland Museum will be dry and can be visited. A small water body will remain. The design of the Wetland Museum as well as houses in the residential area will be influenced by traditional Khmere architecture. The houses on stilts closest to the wetland have 1-2 storeys and the other houses have 3-4 storeys. Higher houses does not suit the location because of the unstable soils. High buildings would also be hard to fit in to the present surroundings of low houses and flat wetland.

## CROSS SECTION 3




Infiltration in flowerbed and courtyard

Major canal with permeaple surfaces. The canal has rain garden features and handles both local storm water and rising water from the wetland.

Small canals lead redundant storm water to the major canal.

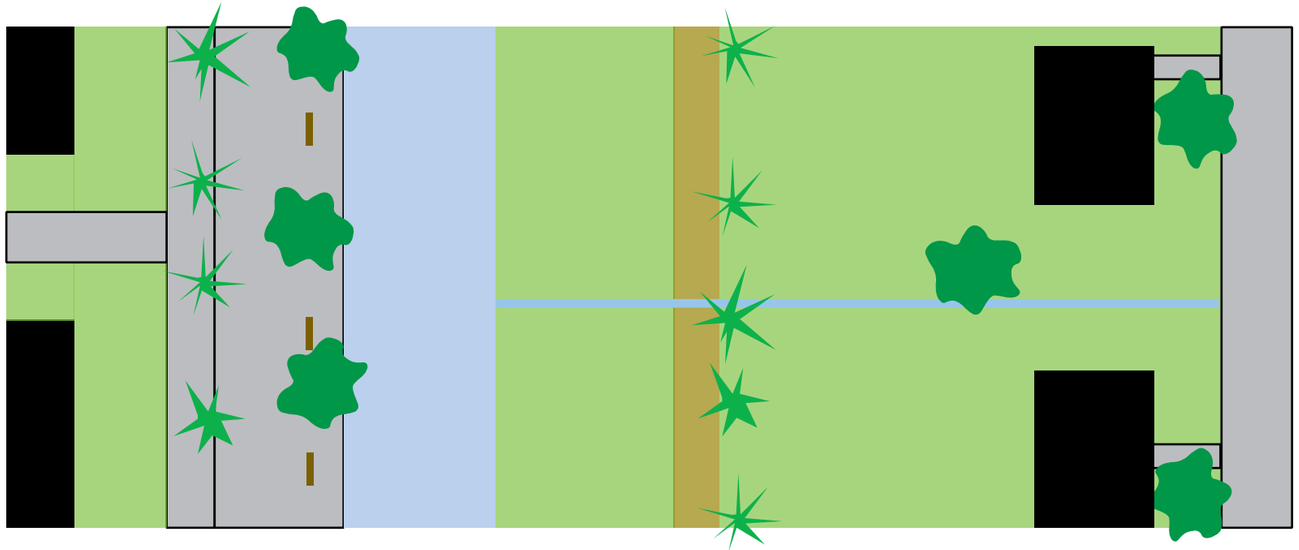
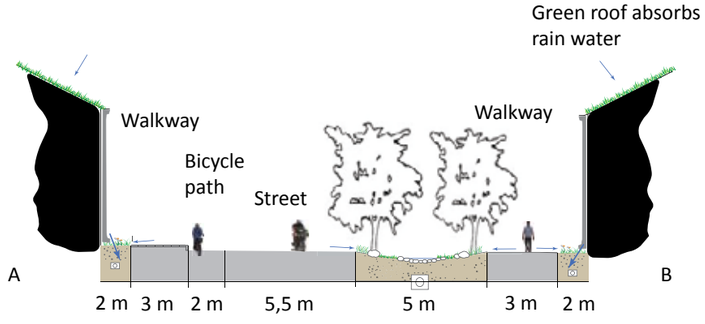


Figure 22. Plan for cross section 3

## CROSS SECTION 4




Infiltration in flowerbed

Rain garden with plants that tolerate both drought and to stand in water.

Infiltration in flowerbed

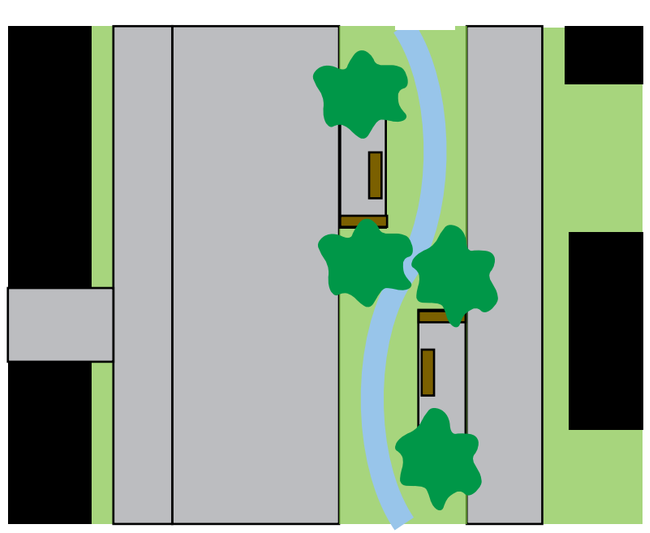


Figure 23. Plan for cross section 4

## INSPIRATION FROM VEGETATION IN AND AROUND PHNOM PENH

Local speices of trees suitable for the Wetland Park. White Frangipani (*Plumeria alba*) and Rain Tree (*Albizia saman*). The Rain Tree tolerate flooding as well as drought and absorbs water very well. (Photo: S. Ryttar)

Example of local water living plants. Lotus (*Nelumbo nucifera*) and Water lettuce (*Pistia stratioles*).
(Photo: S. Ryttar)

### A Wetland Park for recreation, floodprotection and conservation

The park will create an aesthetical and sustainable transition between Boeng Cheung Ek wetland and new exploitation along national road no 2. The Wetland Park is integrated with the new residential area and there are no fixed limits between the two areas. The Wetland Park will also contribute to a stronger connection between Takhmau and Phonm Penh.

Wooden footbridges and a temporary wetland area make up the Wetland Park. Water will be allowed to fluctuate in the park and create different characters in wet and dry seasons. The park will increase accessibility to the wetland and facilitate the understanding of the importance of the wetland area to Phnom Penh. It will also improve the local need for recreation areas.

A Wetland Museum will be situated in the park (see page 68). The museum building will house educational and research centres about for example wetlands and climate change. Phnom Penh Wetland Park will be able to demonstrate the diversity of ecosystems in wetlands and point at the need to conserve them. Cheung Ek wetland presents a unique opportunity to create an area for education and recreation where the theme is the functions and values of wetlands both for the local society and for the world.

About 50% of the park that surrounds the museum is flooded during rain season (see page 70). A variety of trees and plants living in wetland forests will be planted in the park.

There will also be an area for sports and play activities in the Wetland Park. The area can be used during dry season but is water filled during rain season.

The wooden footbridges will lead out in the wetland, making it possibel to take a closer look at the special nature and the vast landscape. At some places, the footbridges will widen to form public places for sports and leisure. There will also be a few locations for bird watching along the wooden footbridges.

The Wetland Park will attract tourists interested in ecology, culture, nature and activities. A tourist-track for bicycle and walking between Takhmau and Phnom Penh will go through the new residential area and the wetland park. Eco tourism has been rising in popularity the latest years. The southern wetland of Phnom Penh is an ideal area for the combination of sustainable tourism and nature preservation. If it is managed in a controlled way the tourism can benefit the socio-economic development of Phnom Penh, create job opportunities for local people and help develop the wetland ecosystem protection. The Wetland Park can for example arrange boat trips on the wetland with local guides.

Possible view from the wooden walkway in the Wetland Park.
(Photomontage by S. Ryttar)

## INSPIRATION FROM RESIDENTIAL AREAS WITH ECOLOGICAL STORM WATER MANAGEMENT

A canal in Bo01 that lets the sea water fluctuate and also receives storm water from the residential area. The canal is an important element in the design. (Photo: S. Ryttar)

Storm water canal in the residential area Hammarby Sjöstad. During high water levels the water can flow over the green park area. (Photo: S. Ryttar)

An area with wooden footbridges in high reed in Hammarby Sjöstad is a popular place to relax as well as it is award-winning landscape architecture. (Photo: S. Ryttar)

The footbridge in Hammarby Sjöstad allows the sea water to fluctuate and yet provide an accessible seafront. (Photo: S. Ryttar)

### A residential area adapted to storm water and flooding

The area will be dealing with two types of water, the locally fallen rain water and the seasonal rising and sinking water of the wetland. Infiltration areas lost due to the new constructions should be compensated in the design of both houses and areas between the houses. Houses will have green roofs and most surfaces will be permeable. The storm water has to be dealt with on site as much as possible to not further enhance the pressure on and pollution of the wetland. Therefore the new residential area will manage the rain water locally.

Green roofs on all new buildings will absorb much of the rain water and minimize the wash-off. The green roofs will also help to cool the indoor temperatures and reduce the need for energy consuming air-conditioning. The houses will have systems for rainwater harvesting.

Water that fall on parking lots and roads in the new residential area will be treated locally by infiltration and storage ponds. Water from walkways and other “clean” surfaces will be directed to plantations, temporary wetlands and open canals.

Water will be an essential part in the design of the residential area. Green and blue paths will form a linking shape between the different parts. The canals will also lead in to the existing residential area to link the new and old together. The areas between the new quarters will be full of small canals. The canals will dry out during dry season and then function as flowerbeds.

Some of the houses will be on stilts and some “normal” but all will be standing on ground that can be inundated and therefore have to be designed to manage floods. The style of the houses will be influenced by traditional Khmer house design. To regulate the indoor climate there will be climbing plants like for examlpe Bouganvilla, growing on the facedes to the houses. Trees that tolerate to grow in both wet and dry soil will be planted on courtyards and public spaces. The trees will bring shade, cool the local climate and also help to reduce the run-off water through their ability to absorb large amounts of water.

The new area could make use of the sunny climate by capturing solar energy. Solar roof panels would suit perfect here. The obstacle is to find financing. Perhaps it could be realized through funding.

A square will be located on a place accessible with boat during wet season. The square will be a marketplace where the farmers of aquatic crops can bring their harvest to sell.

Houses for different social classes will be mixed in the new resideltial area. Boat arrangements will be available for people engaged in water crop cultivation. People that today live on the site and will have to move due to the constructions will receive proper housing in the new area.

Example of a view towards south along the main canal. (Photomontage by S. Ryttar)

# PROPOSAL - BOENG KAK LAKE

GUNILLA ENGLUND

Boeng Kak Lake is a vast urban lake with fantastic views. (Photo: Gunilla Englund)

**The task:** to create a new sustainable city district endurable to flooding, at the location of Boeng Kak Lake under the prerequisites of the new development plan by Shukaku Inc.

**The goal:** to transform Boeng Kak Lake into a pleasant and green environment available to the inhabitants and tourists of Phnom Penh. The goal is to introduce a new thinking around ecological storm water management in addition to the traditional drainage system and to implement these solutions in the design.

**The idea:** to meet the need of city development and to combine that with a sustainable design that creates opportunities of recreation for the inhabitants and visitors of Phnom Penh. To incorporate and integrate the lake in the design and use the changing water levels as a beautiful part of it. To create a dense city district, capable of ecological storm water management that puts less pressure on the existing city drainage network.

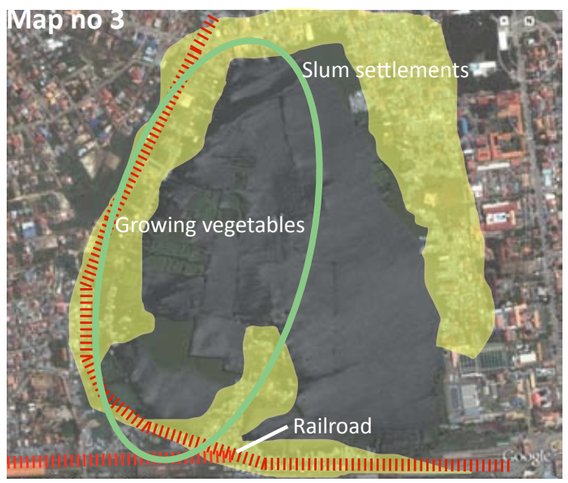
# Introduction

Since there are severe problems with flooding in Phnom Penh today, the city needs as much urban water storage as possible. Recent rapid urbanization has led to filling of many lakes and watercourses within the dikes of Phnom Penh and inundation has increased. The water has nowhere to go and that leads to uncontrolled flooding and stagnant water in the streets, which causes major problems to the city and damage to constructions and housing. The lack of sustainable storm water solutions at source has an enormous negative economical impact. A careful and well planned development of Boeng Kak Lake may incorporate ecological storm water management and increase the beautification and the greenery in the city.

The future of Boeng Kak Lake, however, concerns many. It has recently become public that the lake has been leased to the company Shukaku Inc for 99 years. It is possible that the lake will be erased, filled in and built on. This will change the future city landscape of Phnom Penh and many people are concerned and upset. Contrary to the strategic city planning documents from the municipality, the new development plans promote a total makeover of the Boeng Kak Lake area. The development plans are not accordingly to the national laws of Cambodia. The development of the lake is a hot topic in the news papers and the subject of research, investigations and debate.

Boeng Kak Lake is a beautiful, tranquil place in the otherwise hectic Phnom Penh. It is a place the people of the city is in desperate need of for recreation, beautiful scenery, social interaction, air cleaning and storm water protection. Many describe Boeng Kak Lake as a green lung of Phnom Penh and the loss of a lung would be fatal. It is of great importance for the future of Phnom Penh to develop these last green spots of the city in an ecological and public way, instead of cover them with unidiversified residential buildings that don´t respond to the unique culture of Cambodia. A development towards an ecologically sustainable part of the city would be a message to the world that Cambodia is planning in an unselfish manner that benefits the global earth. It would also serve as a good example for future construction projects. Long term planning and alternative solutions could be the future for Phnom Penh and it could benefit the city ecologically as well as economically.






The area is home to 20 000 people and they live their lives in the Boeng Kak communities.
(Photo: Gunilla Englund)

# Present situation

Boeng Kak Lake is one of the big lakes in Phnom Penh city which has served as a natural water park, public garden, city resort area and entertainment place in the past decades.[1]

Boeng Kak Lake is a 90 ha lake placed in the very heart of Phnom Penh (see map no 1). It equals the size of 129 football fields. A natural lake of this size placed in the middle of a million capital city is very unique and an enormous asset. It is a beautiful place and many people are drawn to it, both tourists and the inhabitants of Phnom Penh.

The lake is situated to the north of the city, just above the Russian Confederation Street and is on all sides surrounded by dikes (see map no 2). It´s east side faces the Tonle Sap River (see map no 1). South of the lake, within the dike, the city railway station is situated and railway lines are running through the area (see map no 3). At present the lake is public domaine, property belonging to the state.[2]

Boeng Kak Lake has become an attractive place for migrants to settle because of its close proximity to Phnom Penh city's service provisions, such as market places, schools, water supply, electricity etc. The number of people living around the Boeng Kak Lake area has increased tremendously in the last two decades and has now an approximate population of 5000 households, which equals approximately 20 000 people.[3] The lake is on every side surrounded by illegal slum settlements (see map no 3). No one takes responsibility for them or their discharge. They have no legal rights or no benefits from the municipality, such as: garbage collection, proper water supply, and proper drainage or sewage systems.[4]

## Environment and use

The state of Boeng Kak Lake is degrading. It is severely polluted and former activities like fishing, farming and bathing is no longer recommendable and may endanger people´s health.

1 Yin, M, 2006
2 Bureau des Affairs, 2007
3 Yin, M, 2006
4 Int. Sotheara, M, 2008

Vegetables are grown in the lake, but the quality is bad since the plants catches hazardous pollutants discharged in the lake. (photo: Gunilla Englund)

The district situated on the peninsula regularly flood during the rainy season. (Photo: Gunilla Englund)

A lot of the houses closest to the lake shore floods every year. (Photos: Gunilla Englund)

Several houses facing the lake are constructed on stilts, since the water level rises 1 - 1,5 meters over the year. The guest-house visitors enjoy a beautiful view over the lake from the porches. (Photos: Gunilla Englund)

The lake used to be a green free zone in the hard urban environment, but is now available only to the residents and tourists staying at the guest houses. The pressure of land reclamation around BKL has caused the physical land use change around the lake and it has decreased in size through illegal constructions and landfillings. This has severely affected the urban ecosystem and the environmental condition of the lake.[5]

A large area north of the city has recently been heavily exploited. Two new development areas are being built; CamKo City and further north The International City (see page no 29). These two areas are built on filled in wetlands. This development has affected the ability of the former wetlands to clean and store waste and storm water from the northern parts of the city, including the Boeng Kak area.[6]

The water level of the lake rises 1-1.5 meters during the rainy season.[7] The water storage capacity is enormous (90 ha x 1.5 m). Most of the houses around the lake are simple structures standing on wooden stilts and is therefore less affected by flooding, even though the water surface can reach inches from the floor boards and cause bad smell and dampness inside. According to the master plan, there are no major problems with flooding in the area. However, the districts situated in the south of the lake, on the peninsula, are regularly inundated.[8]

Leisure around Boeng Kak is exclusively an activity that tourists can appreciate. They enjoy the lake from a guest house porch or an afternoon boat trip.

Catching fish in the lake used to be a common activity, but has now diminished since the fish stand has decreased and the quality of the fish is impaired.[9] Agriculture is not uncommon in and around the lake, but since the vegetation catches the hazardous pollutants of the lake, the vegetables hold a bad quality and are difficult to deal in the market. Therefore the harvest is mostly used and eaten by the farmers

5 Yin , M, 2006
6 Int. Mauret, F, 2008
7 Int. Sihat, N, 2008
8 Bureau des Affairs, 2007
9 Int. Heng, CL, 2008
10 Int, Heng, CL, 2008

Nowadays the lake is treated as a big garbage dump. Storm water, wastewater and garbage are all thrown into the lake to blend. The environment near the lake is hazardous to people´s health. Outhouses are strategically placed and human fecal is dumped right into the lake.
(Photos: Gunilla Englund)

It is difficult to get an overview or move and walk around the Boeng Kak area, since it is hard to access many parts of the lake, because of dense settling or impervious roads or paths. Therefore it is difficult for the inhabitants of Phnom Penh to enjoy their big public lake, without intruding on private property. The people living around the lake are anxious about their future and fear possible eviction. (Photos: Gunilla Englund)

themselves or sold locally.[10]

## The People

Most residents of the city know that the area is about to change dramatically in the near future, but they are not aware of when and what will happen. The settlers are very concerned about their future and many people think they will be evicted and resettled far away from the city centre. The service provisions that the Boeng Kak area provides and the closeness to work opportunities are of high importance to the poor families living around the lake.[11]

Some settlement upgrading has been carried out by local organisations on the east bank of the lake. The streets have been paved and the houses are improved. The people in these areas take this as a sign that their neighborhood is important, worth investing money in and have difficulties understanding that they may face the same future as the rest of the settlers around the lake - possible eviction[12]. A guest house owner told us that the government informed the people when they complained about their uncertain future: ”If people voted for CPP (Cambodian People´s Party), they should have known what the party stands for and therefore have known that the people living around Boeng Kak Lake were going to be evicted.” (A lot of Cambodians are analphabets.)[13]

## Values and development

Many people share the opinion that water is a fascinating element to be close to. To be able to feel water, swim in it, look at it, smell it or hear the waves and sounds of water is something many urban dwellers don´t experience very often. Boeng Kak Lake has and may again offer a fantastic aquatic environment for the urban population of Phnom Penh and create a close intimacy between man and water. Boeng Kak Lake contributes to the city health and management in many different ways. (see Box on p. 85)

The lake has for centuries been a valuable place for the inhabitants of Phnom Penh. In its early

11 Int. Din, S, 2008
12 Int. Seng, K, 2008
13 Int. Bongers, H, 2008

VALUES AND PUBLIC BENEFITS

Retention pond for storm water
Flood protection
Biological cleaning of waste and storm water
Cleaning of air pollutants
Green lung of the city
Big open public space
Cultural heritage
Leisure
City nature
Popular spot for both tourists and locals
Urban Eco tourism (future and existing)
The size of the lake
Increased value of surrounding blocks
Preservation of the reputation of Phnom Penh as the pearl of Asia
International fame and appreciation
City sustainability
The home of many poor people
Fish and farming crops
Vulnerable ecosystem
Beautiful and tranquil place

The northern canal leads surplus water from the Boeng Kak Lake to the Tonle Sap River. Sand bags are protecting the close by houses and land from the rising water levels during the rainy months. (Photos: Gunilla Englund)

stages it served as a flood plain for the Tonle Sap River to avoid inundation in the city. Later it became an enclosed system and its purpose changed. Precipitation alone fluctuates the water levels. A pumping system controls the water levels during the rainy season. The lake and its surroundings turned into a public park and garden and it became a popular place for leisure. Even a zoo appeared before the war. After the Khmer Rouge Regime ended, poor people returned to Phnom Penh and some settled down around the lake.[14]

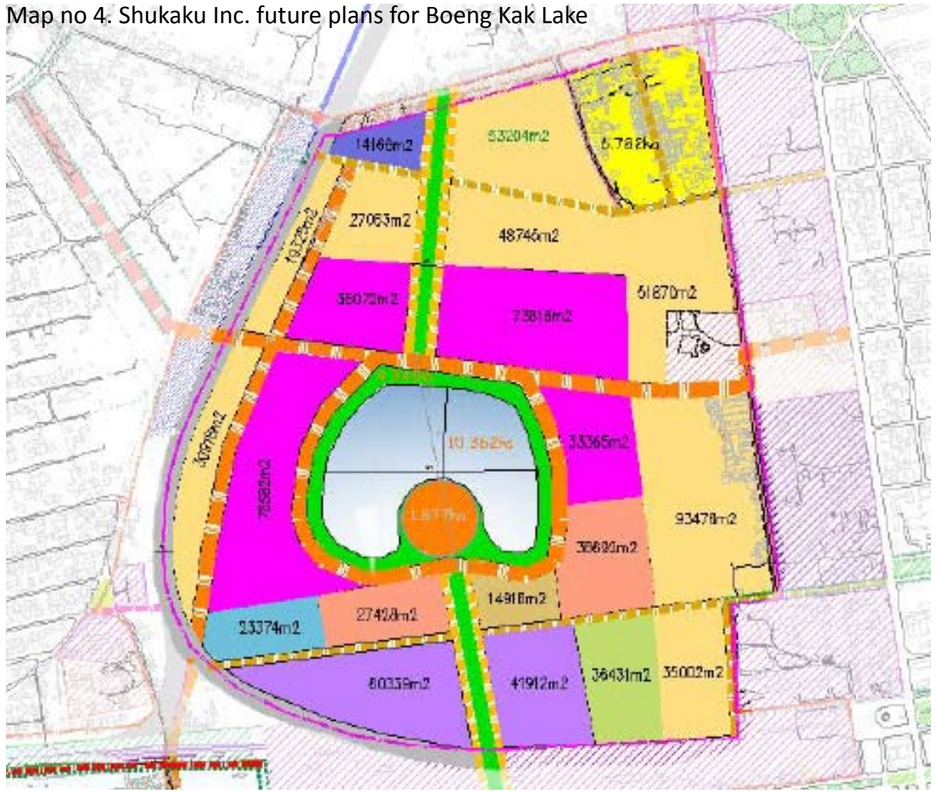
Today the Master Plan proposes that the lake and its surroundings will continue staying blue and green and to make it a place for ecotourism and for the inhabitants to use as a place for leisure (see map no 12). The municipal document Livre Blanc, clearly describes the importance of the urban lakes: " The boengs (lakes), the channels and all the hydraulic works of the city, are useful: it is vital to preserve them. If it would not be possible any more to preserve them, substitution solutions will have to be found..."[15]

In 2003, Phnom Penh municipality, in partnership with the French Embassy, held an international design competition to rejuvenate the Boeung Kak area and restore Phnom Penh to its previous status as "The Pearl of Asia". The winning design, known as PEARL (Preservation, Evolution, Ambition to Regenerate the Lake), maintained over 90 percent of the lake and featured a "vast green space accessible to all".[16]

The future of Boeng Kak Lake looked bright and the green and blue plan, put forward by the municipality described the Boeng Kak Area in 2005: "Possible evolution, recommendations: The development of Boeng Kak is one of the headlight projects of the municipality. Already envisaged in the Hébrard plan, in the Thirties, it is finally close to being born. It will include/understand in particular a linear park, in the south and the west, a walk around and the recombining of an urban frontage."[17]

14 Yin, M, 2006
15 Bureau des Affairs, 2007
16 Rattana, V, 2008 and Int. Vinno, T, 2008
17 Bureau des Affairs, 2005

Map no 4. Shukaku Inc. future plans for Boeng Kak Lake




- High Class Resident
- Housing
- Commerce
- Office
- Entertainment Complex
- Bank
- Land sharing
- Settlement upgrading
- Housing and Commerce
- Conference Centre
- Hotel
- Lake
- Public and green space
- Main Road
- Sub Road

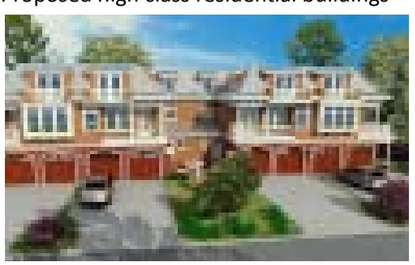

Proposed housing

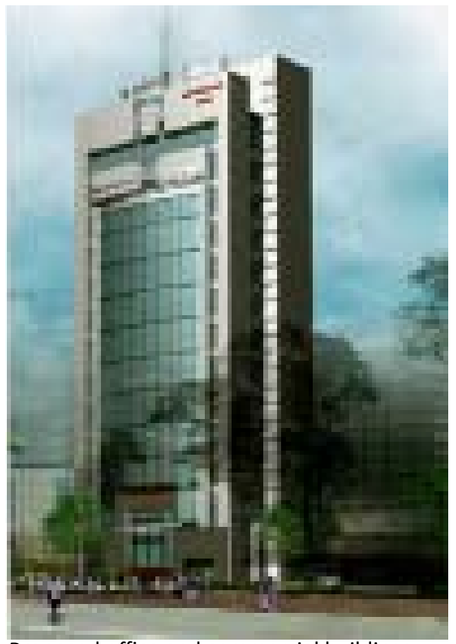

Proposed housing


Proposed high class residential buildings


Proposed conference centre on the peninsula


Proposed high class residential buildings


Proposed high class residential buildings


Proposed office and commercial buildings

# Future plans

Boeng Kak Lake has for decades been an important element of Phnom Pehn´s urban landscape. The use of the area has changed over time, but now it faces its greatest change ever.

The Master plan (see page no 30) is indicating protection of “reserves of storm” and “ecological zones”, lakes and rivers, which includes Pong Peay lake (north of the city, where CamKo City is being built) and Boeng Kak lake. Now Pong Peay lake is already filled in and the Boeng Kak area lease agreement is allowing filling in on 80 ha of the lake out of 90 ha. This is not in accordance with the master plan. Therefore, it is not clear what plan the Municipality of Phnom Penh is following[18]. According to the Land Law, lakes are public property and should not be sold or leased for more than 15 years.

## Construction Plans

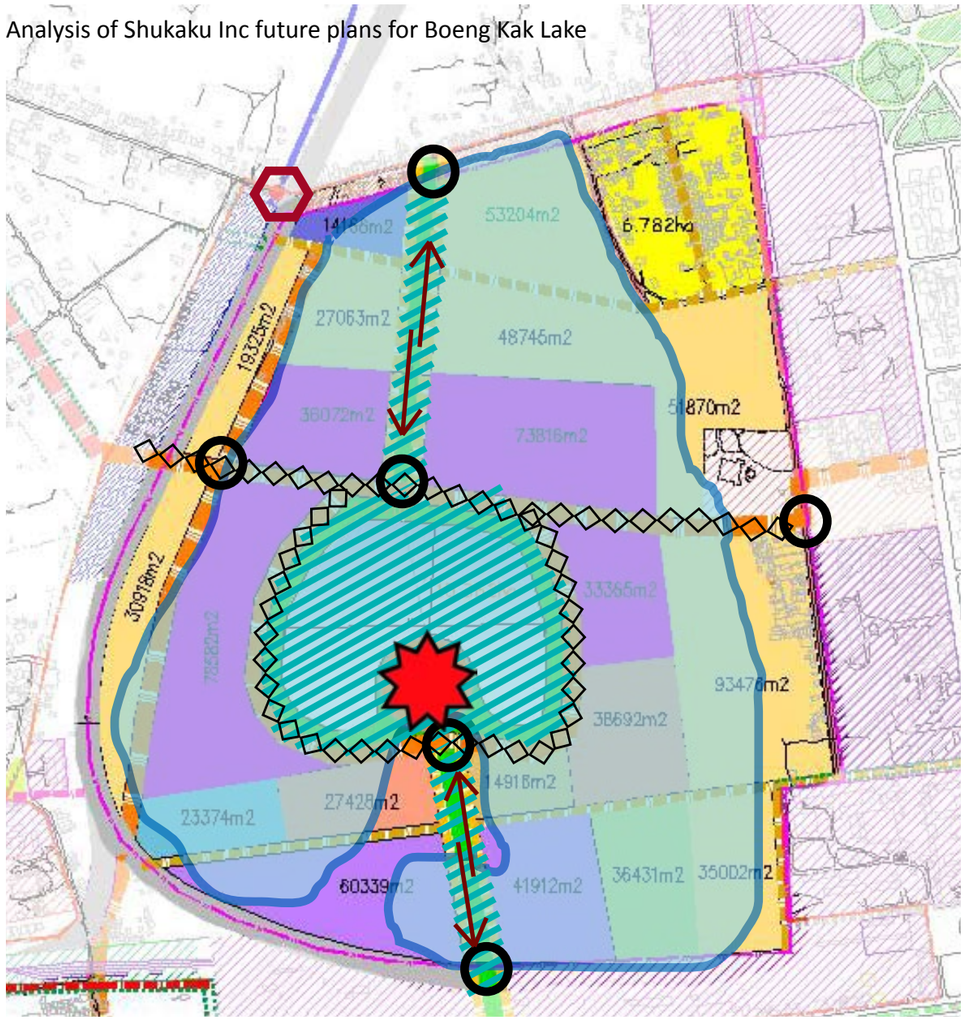
The Cambodian company Shukaku Inc. has signed a leasing contract with the government for the next 99 years. The municipality doesn´t have much information about the development plans of the lake even though the lake has already started being filled with sand.[19]

The two ongoing development projects north of the city are examples of typical city development of Phnom Penh. It is likely that Boeng Kak Lake will be exploited in a similar manner, by emptying the lake from water and filling it with sand, which will affect the surrounding environment.

The development of the project has been fast. In January 2006, a “first discussion plan” was presented to the Municipality, which shows a rough drawn map and some illustrations of the housing and environment. The latest plans, were presented and approved in March 2006 (see map no 4). The plans are in general to save 10 ha (10 %) of the lake and build residential, office, hotel and commercial buildings in blocks around it. A green strip is proposed along the remains of the lake, circumscribed by a 30 me-

18 Bureau des Affairs, 2007
19 Int. Cheam, P, 2008
20 The NGO forum Cambodia, 2007

Analysis of Shukaku Inc future plans for Boeng Kak Lake




ters wide road. A south–north promenade is also proposed linked to an existing promenade in the southern part of the area. The plans are indicating a majority of housing for the rich, and multi storey buildings. The greatest differences between the discussion plan and the approved plan are that the high class residential area has increased by more than the double and the settlement upgrading area has been heavily reduced and moved away from the lake in the approved plan. Furthermore, a two ha green park and leisure area has been taken out of the proposal and a cultural centre on the peninsula has transformed into a conference centre.

## Future Complications

The appearance of the physical environment will change dramatically.

During the rainy season, the water level in the rivers rise above the ground level of Phnom Penh which makes it impossible for the drainage to enter the river without an advanced and efficient pumping system. When the river water is above the level of the drainage system of the city, the rain water requires spaces to be retained. If this space for the retention of rain water will not be available (as would be the case when 90 percent of the lake will be filled up), Phnom Penh will be flooded even when there is only little rain fall.[20] Changing the natural course of an ecosystem will cause chain reactions in other parts of the ecological system.

The Boeung Kak Lake development plan will have multi dimensional impacts. These impacts will not be limited to the Boeung Kak area but to the whole of Phnom Penh. These kinds of projects require an “Environmental Impact Assessment” (EIA) prior to approval of the project. Since the agreement between the Municipality of Phnom Penh and Shukaku Inc does not mention anything related to an EIA and since there is no information available that any company or authority carried out an EIA prior to the agreement, it seems that an EIA has not been carried out.[21]

The water storing capacity of the area will be reduced and inundation will follow.

Future development of Boeng Kak Lake will lead to an increase in storm water that will have to be pumped out of the area into the northern canal that leads to the river, in order to avoid flooding. This will lead to an increased untreated water outlet in the sensitive Tonle Sap River, which provides Cambodia and Phnom Penh with fish, clean water and farming crops.[22]

Moreover, the open space that the lake is providing is needed to clean the air. The observed increasing numbers of vehicles in Phnom Penh demands more open space in the city.[23]

The law states that the property must not be damaged or its public service functions should not be changed. The fact that the lake will be reduced by 90% must be considered as a big change.[24]

The area will not be of public character and therefore exclude a majority of Phnom Penh´s population.

The rich people, supposed to live in the high class residential areas, are consuming more utilities, such as electricity and water and produce more waste compared to middle and low income families. Additionally, multi storey buildings mean more dense population and more concentration of activities in the city. This kind of development ultimately puts more pressure on the city infrastructure which is already overloaded like the city roads.[25]

The proposed settlement upgrading area will be far from sufficient for the 5000 families living around the lake today. The population density is already high and the people face an even more crowded future or eviction.

The 30 meters wide road around the lake will cause barriers and affect the impression of the lake. The noise level will increase and the air will become polluted and unpleasant to breathe.

A lot of impermeable paving will obstruct the infiltration of rainwater into the ground. Few green areas will increase air pollution and prevent people from enjoying and relaxing in their outdoor environment.

21 Int. Goad, H, 2008
22 Int. Mauret, F and Int. Vinno, T
23 The NGO Forum Cambodia
24The NGO Forum Cambodia
25 The NGO Forum Cambodia

ILLUSTRATION PLAN
wet season


High rise buidings

Low raised buidings

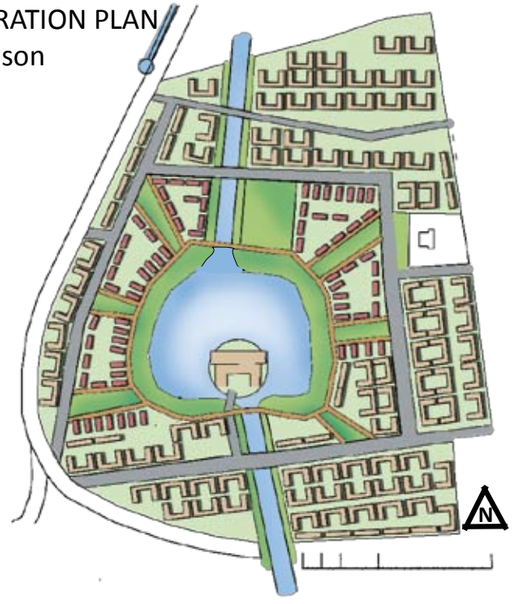
Green open space

Water

Road

Size of lake proposed by Shukaku Inc.

ILLUSTRATION PLAN
dry season



# Proposal

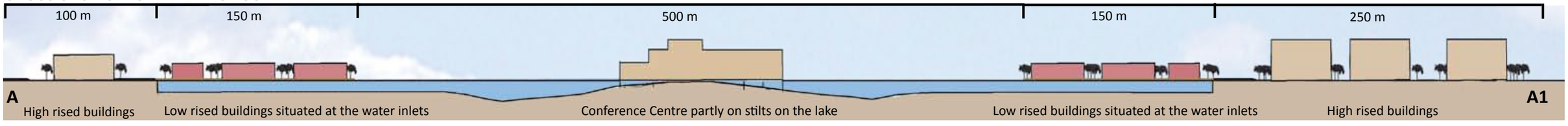
Since Phnom Penh is a city built on water and transforms with the changing seasons, I want to enhance this phenomenon and create a fluctuating landscape that change its character depending on the season. There will be mostly blue patterns during the rainy months which turn green during the dryer months. I want to create beautiful, playful and essential storm water features incorporated in the urban landscape that changes character over the year. It is important that the design will be beautiful, yet useful all year around.

My proposal will maintain the building blocks as the Shukaku plans propose, since it is very likely that the plans will be realised. Modifications will be made for the housing close to the lake and around the canal and some reduction of residential quarters to fit in a big urban park as it was suggested in the first discussion plan. I believe a public park would be extremely important for the new development area to make it pleasant and sustainable. I will draw a picture of how an area designed from an ecological storm water perspective could look like.

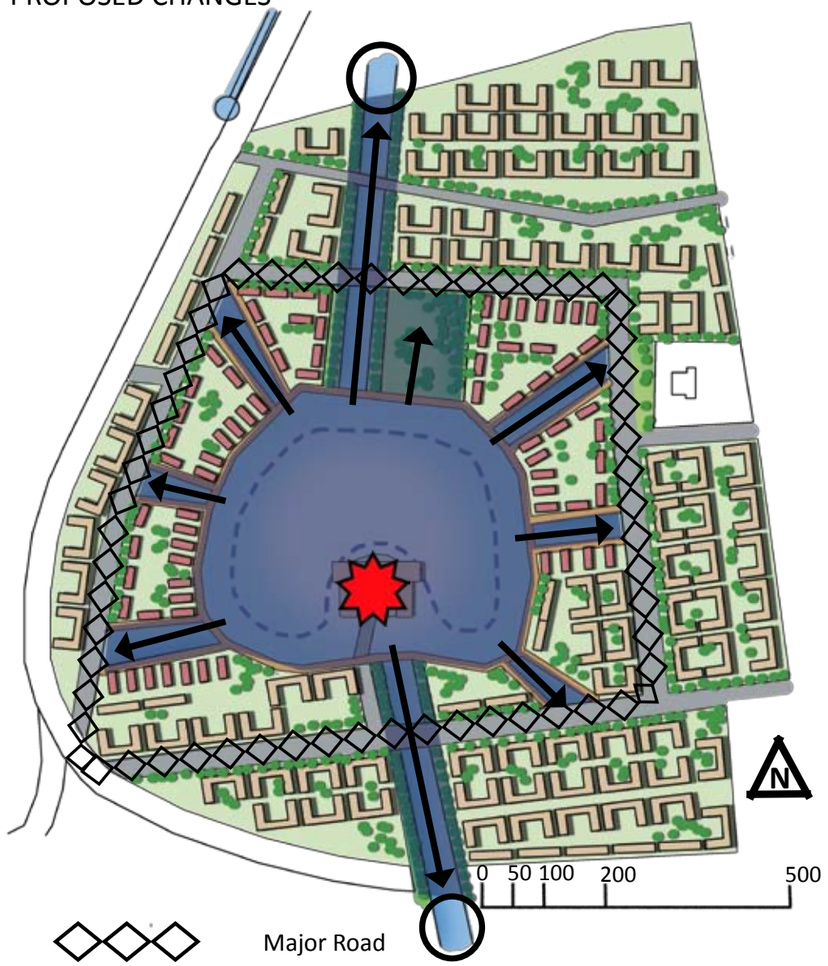
## PROPOSAL PROGRAM

Preserve as much as possible of the existing lake.
Create new smaller lakes/ponds in the housing/business areas
Create shallow dips on squares, playgrounds, parks etc to control flooding in case of heavy rain.
Create interesting and beautiful water solutions that would work both in dry season and wet season.
Reduce the hard surfaces as much as possible. Integate grass and other vegetation in urban blocks.
Incorporate infiltration areas and strips in streets and parking places.
Maintaini the natural cycles of water & nutrients in the landscape as much as possible.
Create buildings and urban form that fit the landscape & respond to the climate
Use locally produced building materials as much as possible
Use native plants adapted to the climate
Integrate rain gardens in sensitive areas prone to flooding.
Integrate water as a natural element in the living areas.
Promote management, Cleansing and well designed collection points.
Make the water accessible with piers, bridge decks, floating pontoons etc.
Integrate important public spaces and buildings with the water
Make the remaining lake an attraction available for everyone

CROSS SECTION OF THE PROPOSED AREA



PROPOSED CHANGES




Major Road

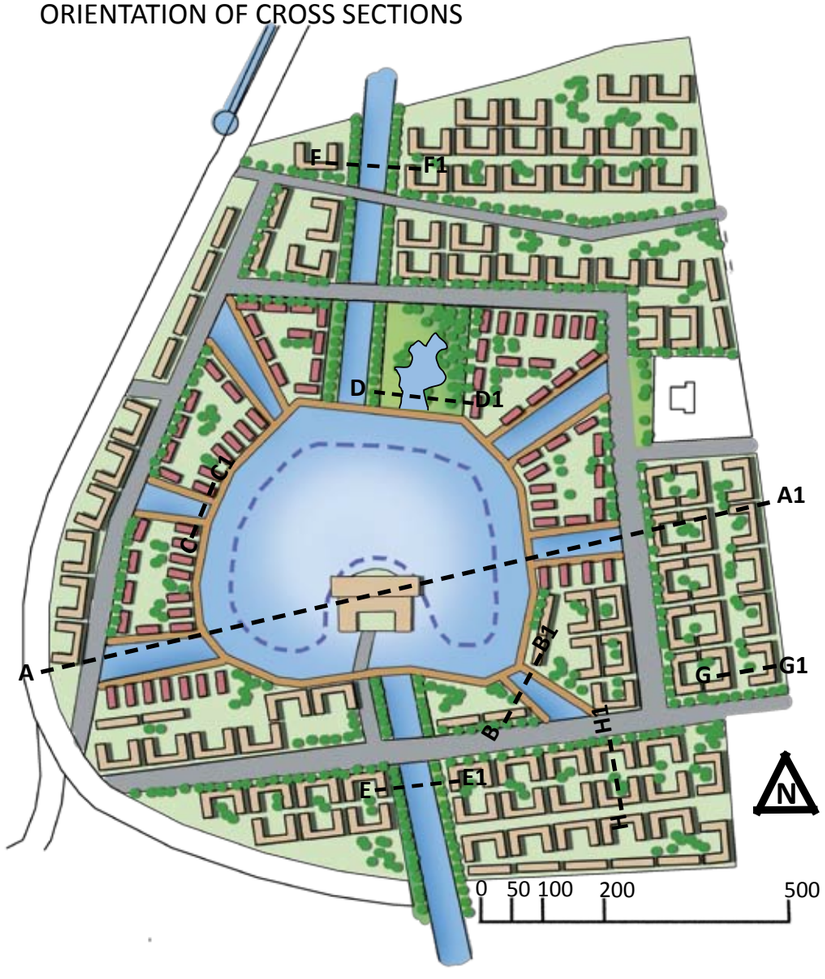
Further outstanding landmark on island

Water spread

Junction and possible future connection to the city

Vistas

ORIENTATION OF CROSS SECTIONS



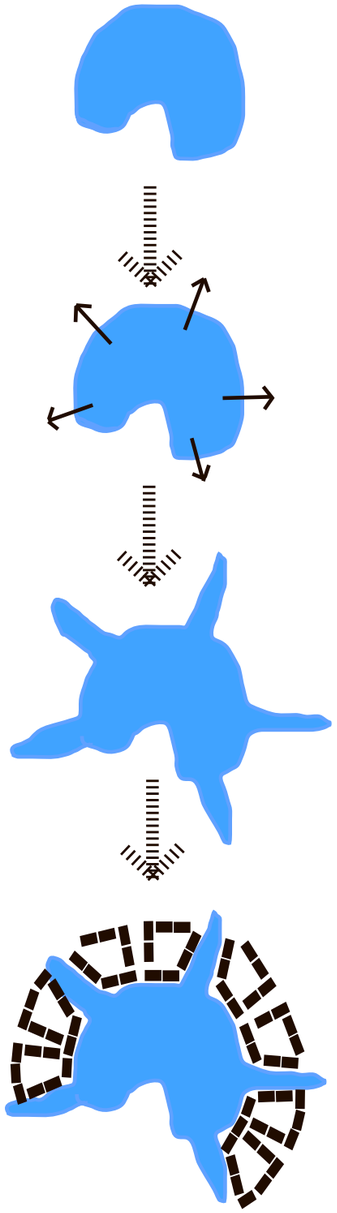

The lake is widened through water inlets in the residential quarters. The south-north promenade will be transformed into a traffic free zone along a wide canal connected to the lake. A big urban park, located just north of the lake will be allowed to inundate with storm water and rising water levels from the lake. All these measures together will more than double the water storing capacity of the lake. Infiltrating surfaces, green rooftop vegetation and court yard ponds will further enlarge the water storage area.

Green public space will disappear during the rainy months. Access close to the water will be arranged through bridges and piers. During the dry months, many of the earlier water covered spaces will turn green and provide people with important public space for leisure and relaxation.

The wide canal will fortify the position of the lake as the heart of the district and the conference centre will be an even more outstanding landmark. The canal is an important element in the design to connect to the rest of the city. The canal could in the future continue through the city as a central axis and important vista and beatiful pedestrian path.

The wide road around the lake is moved and a traffic free environment will contribute to a more tranquil atmosphere around the lake.

The emissions in the Tonle Sap River will be reduced thanks to the increased water storage capacity of the lake.



A landing promenade provides access to the lake even in the rainy season. The inlets from the lake form the residential quarters.

Inspiration: A landing promenade along the canal in Hammarby sjöstad, Stockholm. (Photo: Gunilla Englund)

Inspiration: An inlet from the sea in the residential quarters in Bo01, Malmö. (Photo: Sara Ryttar)

## The Lake

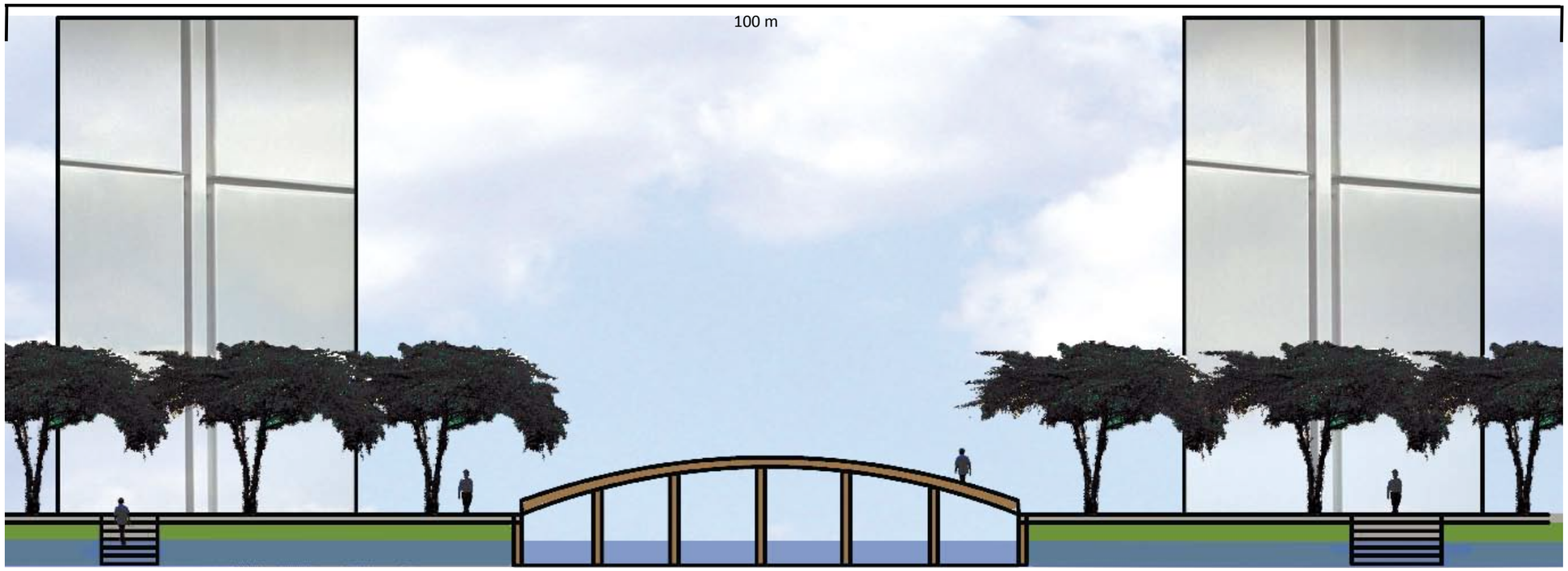
The lake will be the heart of the new city district and serve as an easily accessible public space, free from traffic and noise.

The proposed 30 meters wide road around the lake will be moved from its close position of the lake to the other side of the proposed residential, hotel and commercial housing, in order to create a quiet atmosphere around the lake. Reduction of vehicles close to the lake will be of great importance for improving people´s experience of the lake.

Some of the closest high class residential houses will stand on stilts or be of amphibic character. The green narrow park that surrounds the lake will be flooded in the wet season and some of the closest houses will partly be standing in water. Inlets from the lake will cut through the block structure and the house blocks will be formed around the inlets. The water levels in the inlets will also fluctuate with seasons changing.

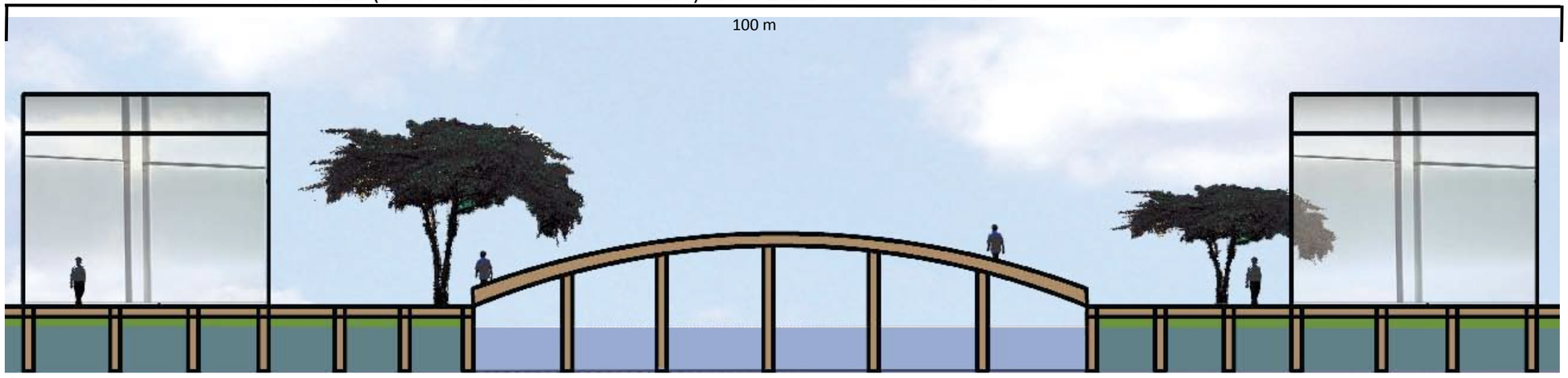
Piers and a landing promenade around the lake will allow access to the lake and provide possibilities to enjoy and use the lake even in the wet season. The commercial buildings will have great views over the lake, partly standing in the water. Restaurants and coffee shops may be incorporated in terraces overlooking the lake.

CROSS SECTION THROUGH AN INLET (HIGH RISE BUILDINGS) WITH SITTING STAIRS AND FIRM GROUND.




**B** **B1**

CROSS SECTION THROUGH AN INLET (LOW RISE BUILDINGS ON STILTS) WITH LANDING PROMENADE



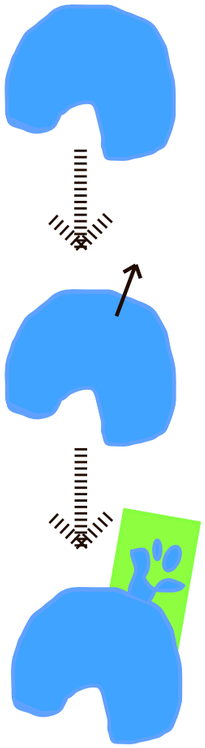

**C** **C1**

The water level will rise and fall during the year and in times of lows the narrow park will serve its purpose as a green public space with vegetation that can revive after a few months of inundation. The piers and landing promenade will be interesting and interactive elements even in the dry season.

Access to and from the lake will be less operated than the proposed plans. The area around the lake is kept as traffic free as possible to maintain the tranquility that contrasts the otherwise hectic streets of Phnom Penh. The lake will be a place for relaxation, leisure and public activities and the visitors will get this feeling on their way in to the lake, through creating green passages between the residential and commercial complexes, “a web of green”.

The conference centre in the middle of the lake will be constructed on an island. The fluctuating water levels will decide the size of the island. The building will partly stand on stilts.

The proposed south-north boulevard connecting to the lake will be transformed into a wide canal. The park will also be in connection with the lake. The canal together with the inlets and the park will increase the water storing capacity of the lake.



A vegetative part of the park, with trees adapted to the aquatic environment.
(Photo montage: Gunilla Englund)

View over the park, the canal and the closest residential areas. (Photo montage: Gunilla Englund)

## The Park

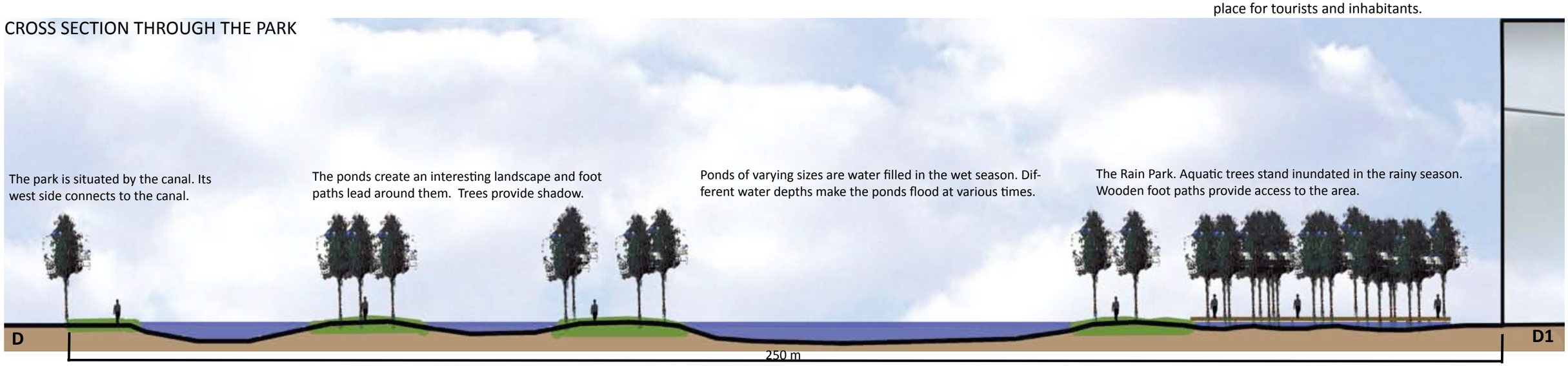
The rain garden concept (see p. 44) can be widened into a big rain park. A rain park would integrate dams and ponds of different sizes and depths connected through one another in different patterns. Rocks, bridges, plants and trees make the park an interesting place all year around. Trees can stand in the water ponds for weeks and many species in Cambodia are from evolution specially developed for this purpose. A less formal park would provide Phnom Penh with a more diversified supply of parks. It would serve as an inspiring contrast to the other one-dimensional parks of Phnom Penh.

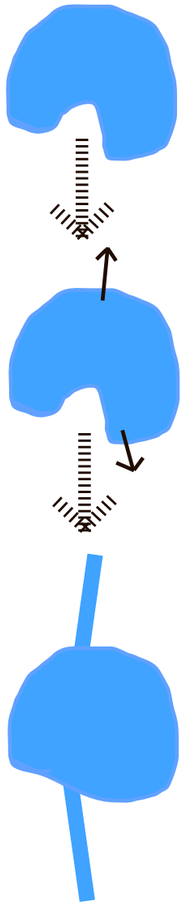
The park will be intimately connected with the lake and the fluctuating water levels of the lake will effect the park and its appearance.

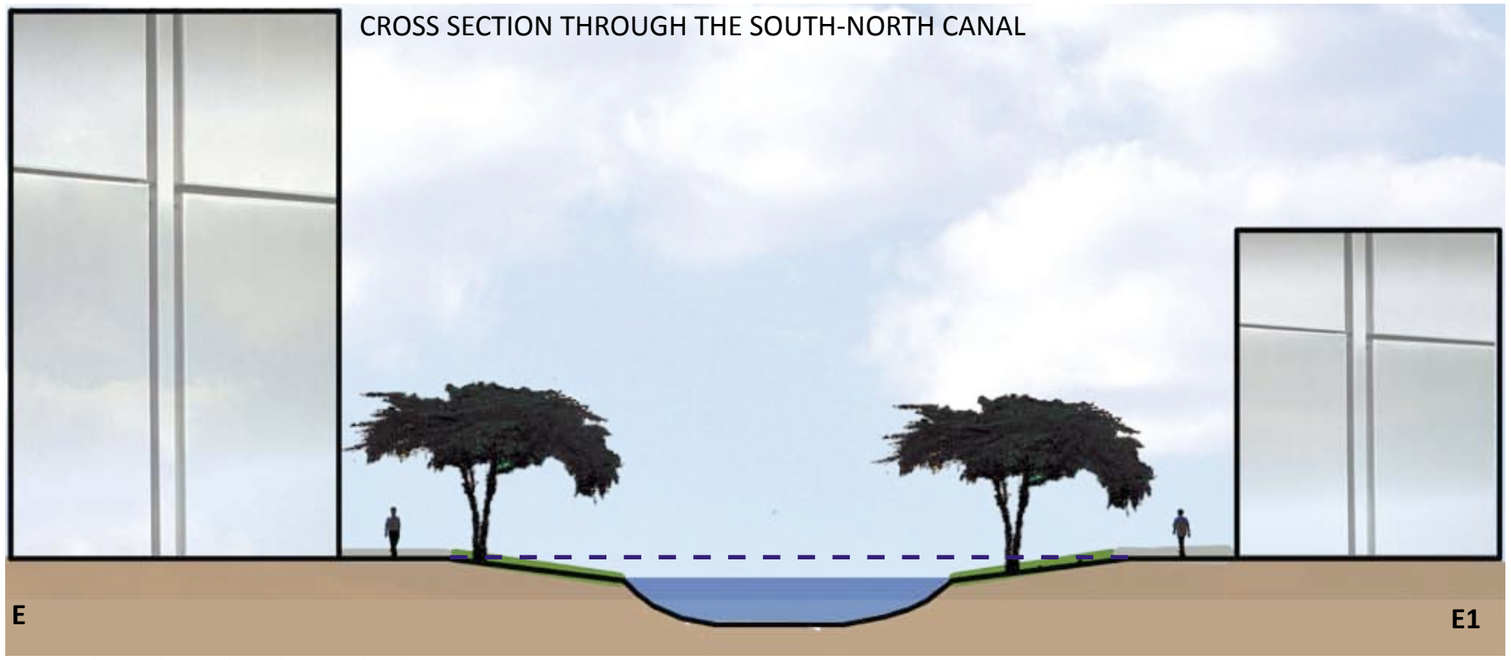
Since flooding is a natural effect of the changing seasons in Cambodia, a rain park would help to put the new city district in a unique and place specific context.

The flood plains of the great Tonle Sap Lake are flooded every year and the landscape is under water almost the entire season. The flood water brings essential nutrition and helps to create the unique landscape around the great lake. Many trees are adapted to an aquatic life. The mangrove tree or the rain tree are two examples. To copy this natural event in a park in an urban environment would be an interesting challenge and a meaningful place for tourists and inhabitants.

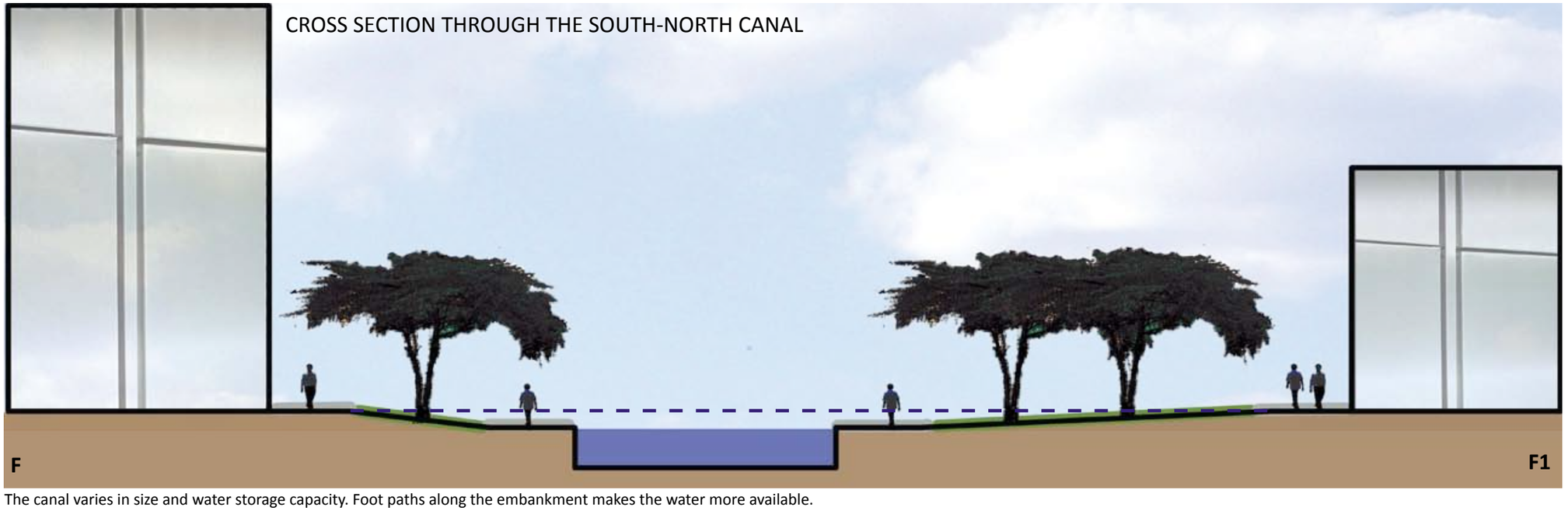
CROSS SECTION THROUGH THE PARK








Vegetated grass slopes allows the water level to rise.




The canal varies in size and water storage capacity. Foot paths along the embankment makes the water more available.

## The Canal

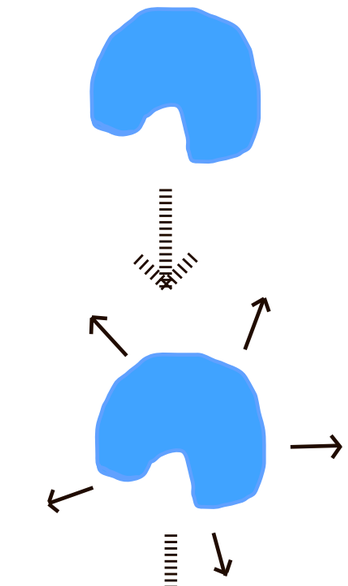
The proposed south-north going broad boulevard will be transformed into a wide canal with vegetated slopes and walking and bicycle paths on each side. It will be connected to the lake and will further enhance the water storing capacity of the lake. The canal will stay waterfilled all year around.

Since the canal/boulevard is disconnected from the wide ringroad through bridge crosses, it will stay traffic free. Footbridges will allow pedestrians to cross the canal.

The canal promenade may in the future connect to the rest of the city and be a pleasant way of entering the Boeng Kak Lake district.

The canal stretches through the Boeng Kak area. The conference centre form a distinct land-mark in the middle of the lake. (Photo montage: Gunilla Englund)

Inspiration: A footbridge across the canal in Hammarby sjöstad, Stockholm.
(Top photo: Sara Ryttar, bottom: Gunilla Englund)



A tree plantation area provide infiltration and shade. (Left: illustration from draft of Boeng Kak development project, Right: photo montage: Gunilla Englund)

Facade vegetation and vegetaded roofs. (Left: illustration from draft of Boeng Kak development project, Right: photo montage: Gunilla Englund)

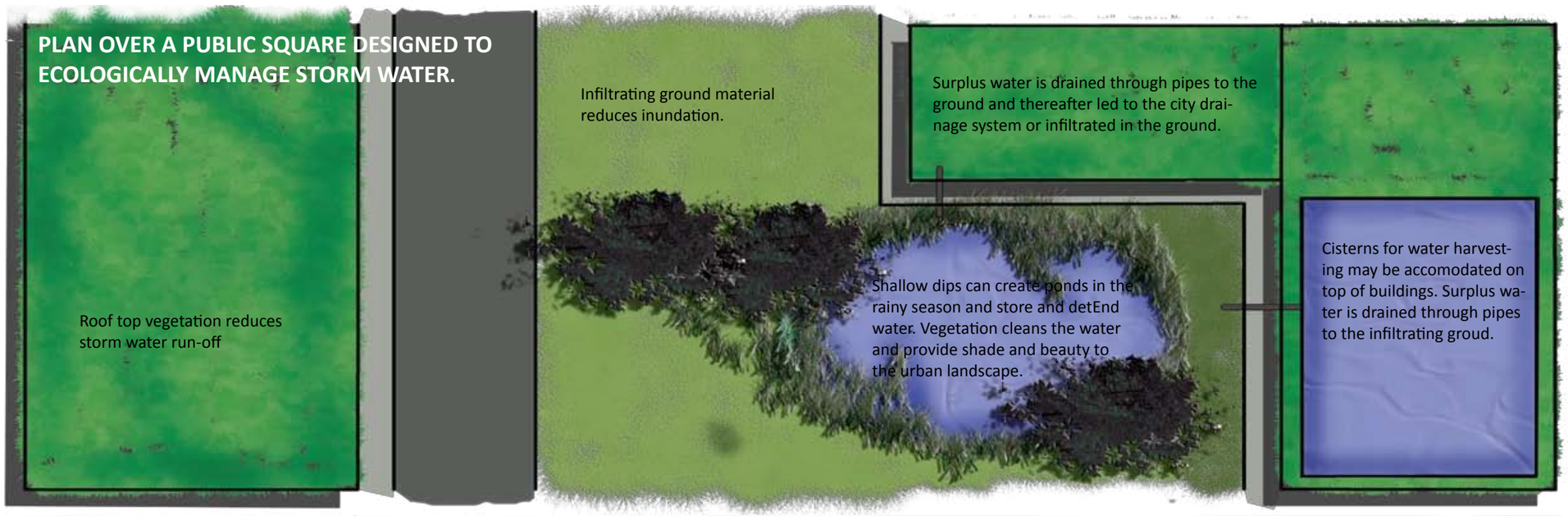
## Open Spaces

Since different types of residential environments are proposed in the Shukaku plans, the outdoor environments will appear diverse. Mutual for them all are that they are private or semi-private and will have to cope with and handle storm water in periods of rain. This will be accomplished in different ways.

In case of heavy rainfall it is important to be able to control big masses of water and to direct them to places specially designed for the purpose of storing, infiltrating and cleaning the water. Court yards, walking paths, street refuges, school yards, gardens, parks etc will have to be able to store water in the rainy season. The solutions will rationalise the storm water run-off. Permeable shallow dips, immersed surfaces and vegetation will serve as water reservoirs and infiltrators. A foot path might serve as a creek in the rainy season or parts of a square can serve as an urban pond.

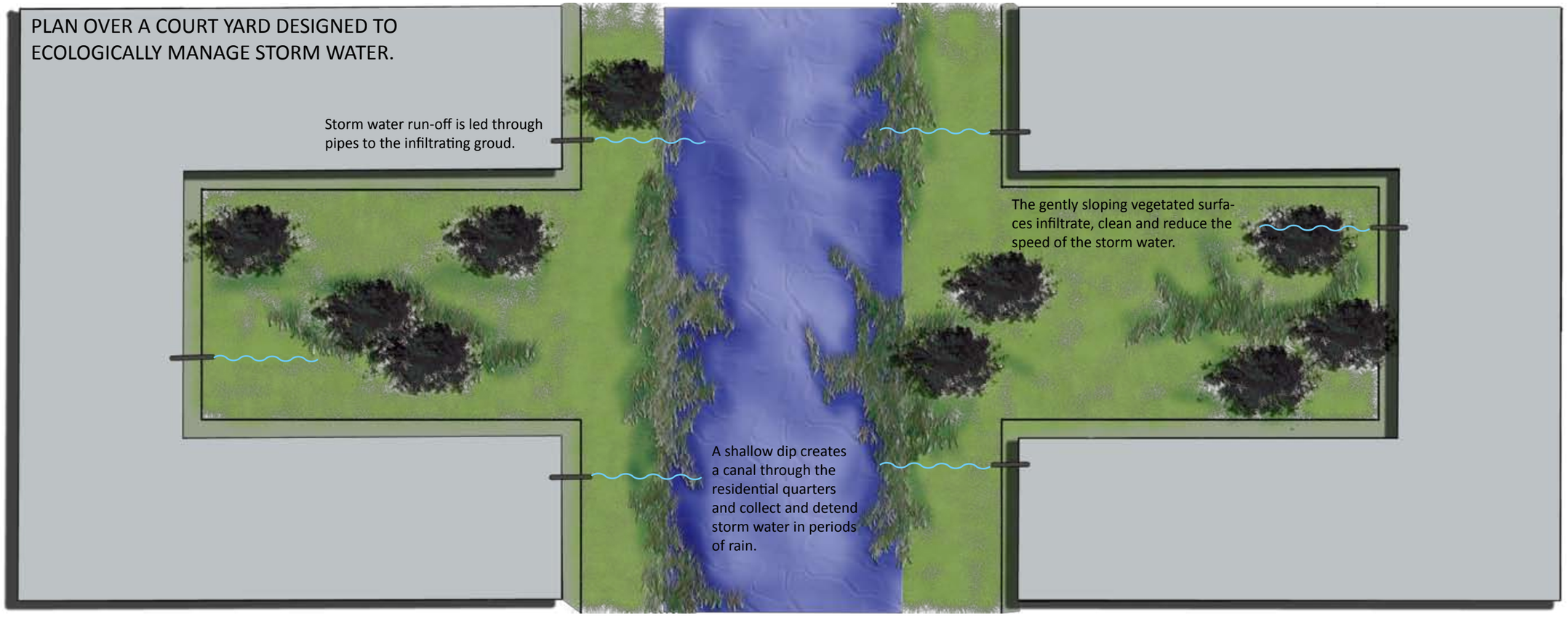
A majority of the houses will comprise green roofs or roof gardens, in order to reduce storm water run-off. Water harvesting will also be a part of the storm water management. Water cisterns collect water on the roofs of the houses (see p.48). Household water may also be stored under the houses if they don´t stand directly on the ground. Harvested water could even be used in a big public swimming pool.

The Shukaku illustrations show a lot of hard surfaced impervious environments. These will be modified and partly turned into infiltrating areas.

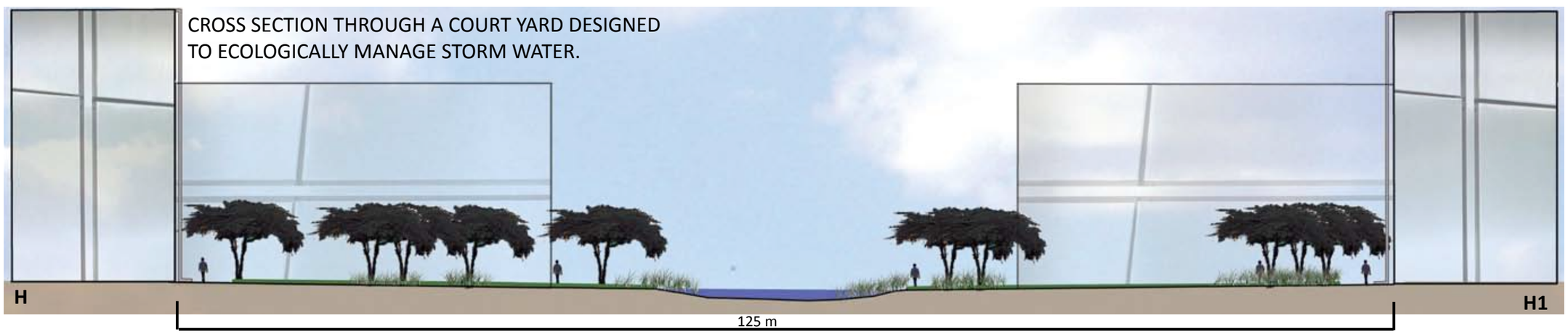

PLAN OVER A PUBLIC SQUARE DESIGNED TO ECOLOGICALLY MANAGE STORM WATER.
Roof top vegetation reduces storm water run-off
Infiltrating ground material reduces inundation.
Surplus water is drained through pipes to the ground and thereafter led to the city drainage system or infiltrated in the ground.
Shallow dips can create ponds in the rainy season and store and detEnd water. Vegetation cleans the water and provide shade and beauty to the urban landscape.
Cisterns for water harvesting may be accomodated on top of buildings. Surplus water is drained through pipes to the infiltrating groud.


CROSS SECTION THROUGH A PUBLIC SQUARE DESIGNED TO ECOLOGICALLY MANAGE STORM WATER.
G
75m
G1

PLAN OVER A COURT YARD DESIGNED TO ECOLOGICALLY MANAGE STORM WATER.




CROSS SECTION THROUGH A COURT YARD DESIGNED TO ECOLOGICALLY MANAGE STORM WATER.



BOX - INFILTRATION

Streets and sidewalks will incorporate trenches with water storage capacity. The trenches will infiltrate water slowly into the ground, while making the streets roadworthy.

Squares and other open areas will incorporate shallow dips into the design, in order to in a controlled manner direct and collect water in one place. Immersed parts of a square may contain an outflow via an infiltration well into the ground.

More vegetation and planting areas will be incorporated in the public spaces. Not only will the storm water management improve, but more pleasant and intimate environments will form and trees can provide well needed shade.

New lakes and ponds can be created in the public parks and gardens during the rainy period. Some may function as temporary wetlands or ponds, while others may contain their water, depending on the size of the pond.

Moving water is an amusing water element. If water is directed and collected, a steady flow can be created and incorporated in parks, squares and residential areas.

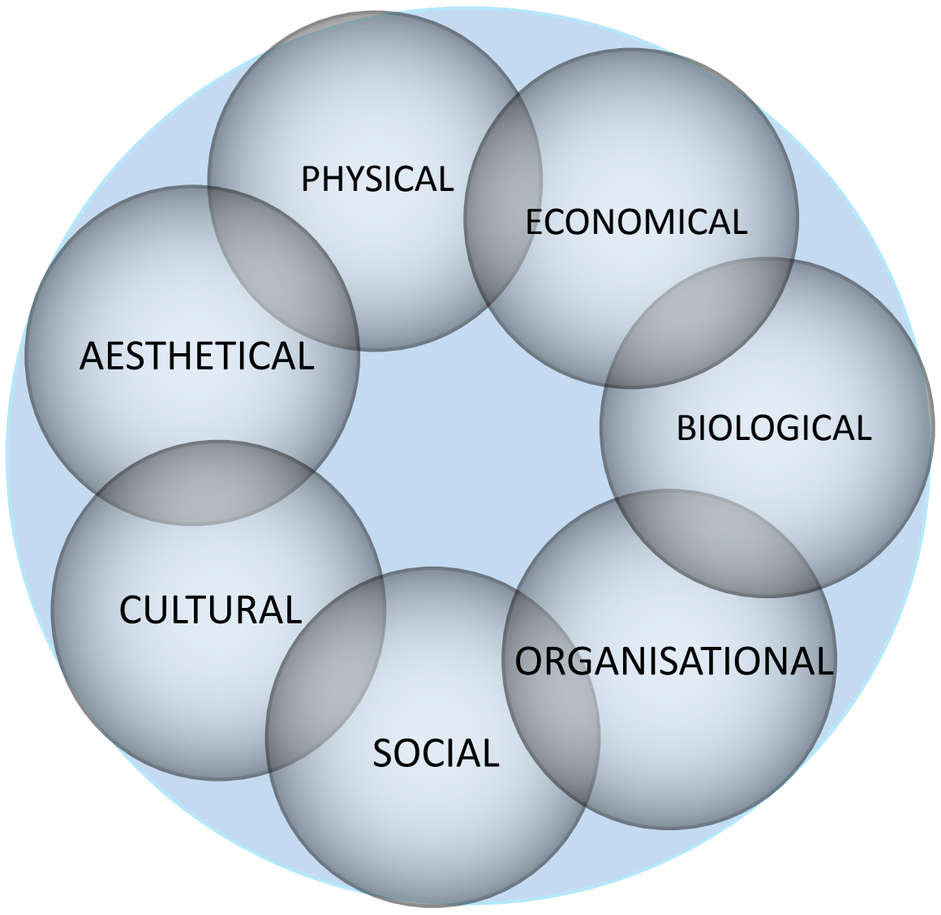
Vegetation areas.

Inspiration: Swedish examples from Hammarby sjöstad and Bo01. A stone path or running corse turnes into a water creek during rain. Inundation area and immersed pond area incorporated in residential blocks. (Photo: Left and middle: Gunilla Englund, Right: Sara Ryttar)

Inspiration: French examples of immersed square and a park that is allowed to innundate. A landing promenade gives access to the park in wet weather. (Photo: Thomas Larm, SWECO environment)

Inspiration: French examples of a storm water park and an infiltrating road side trench.
(Photo: Thomas Larm, SWECO environment)

# How does the proposal fulfill the seven criteria for sustainability?




The seven criteria for a sustaiability society.

## Physical:

Instead of fighting against the physical position of Phnom Penh in a water landscape, the design enhances it and makes it an important element in the design.

Boeng Kak Lake has great opportunities of becoming an eco tourism attraction, offering recreation, biodiversity and flood prevention.

## Economical:

The design proposal will bring more water and greenery to a very central place of Phnom Penh and the benefits will be several. Beautiful urban environments enhance property value.

Serious investors would consider Phnom Penh a long term good investment if sustainable urban solutions were the norm. Long term planning would benefit the whole city and everyone in it. Ecological storm water solutions, as in the proposal, are economically beneficial in the long run.

## Biological:

The Boeng Kak Lake proposal takes charge of native species and biotopes, which are adapted to the local climate and therefore hardy to weather and flooding.

The proposal will make Boeng Kak Lake area a tropical city district in bloom where green and blue structures play the leading role. The area could further connect to the rest of the city and a green web could develop.

Ecological storm water solutions would reduce the polluted storm water runoff to the rivers, which would lead to less degradation of the habitats of sensitive plants and animals in the rivers.

Traffic free environments will put less pressure on flora and fauna. Many trees and rich vegetation, as the Boeng Kak Lake design proposes, will capture and absorb dangerous air pollutants. Boeng Kak Lake will continue to be “the green lung of the city”.

## Organisational:

The design proposal makes sure that the public places in the area increases compared to the Shukaku Inc plans. The proposal enlarges the size of the lake and its water storing capacity compared to the Shukaku Inc. proposal.

A well considered privatisation without destroying the qualities in the city will benefit different groups of people. The Boeng Kak Lake proposal incorporates many different housing alternatives and the lake, park, canal and other open spaces will be of public character and available to everyone.

Ecological storm water solutions in the design proposal will put less strain on the present storm water drainage infrastructure in Phnom Penh through increased local water storing possibilities and infiltration.

The design proposal could make a good example of a poor capital Asian city thinking sustainable.

## Social:

The Boeng Kak Lake proposal promotes outdoor activity. The park, the public lake, the canal, the walking paths, shadow from the trees and many public places will be welcoming environments for many urban inhabitants. The traffic free spaces create a pleasant street life and may become an oasis in the otherwise hectic Phnom Penh.

The beautification of the city may lead to an enlarged carefulness and protectiveness for the public outdoor environments in general.

## Cultural:

Traditional architecture and construction techniques in a modern and adjusted way are great ways of enhancing a cultural heritage. This can be done (as proposed in the Boeng Kak Lake design proposal) by using local building materials, native plants, houses on stilts and taking advantage of fluctuating water levels, which is old traditional wisdom.

## Aesthetical:

The proposal makes sure that the lake will continue to be a beautiful calm and contrasting environment in the city.

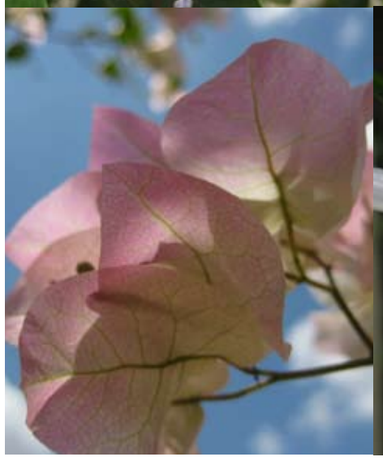
The proposal also enables possible future green and blue patterns connecting to the rest of the city. Boeng Kak Lake has the possibility to be the hub of a green and blue city web.

Reduction of noise, bad smells and bad air quality in a less congested traffic environment are positive effects of the design proposal. Pedestrian friendly environments enable inhabitants and tourists to discover Phnom Penh by foot.











The beauty of the Cambodian nature is astonishing and truley inspiring. The vegetation and the fantastic plastic force enables a fast establishments of plants. (Photos: Gunilla Englund)

# DISCUSSION

The development of Cambodia's capital city Phnom Penh is going in haste towards a precarious future. Planners and politicians are not able to slow down the process because of prevalent corruption and lack of organization and competence. Many planners and people engaged in environmental and social questions want to see a sustainable development for their city and they have a vision of how it could be done, but they lack the options to make it happen. One of the fundamental issues to deal with before Phnom Penh can become a healthy city is the widespread corruption and legal insecurity. As it is now, money is leading the development. It seems like anyone who can pay can buy and do what he or she wants with almost any area in Phnom Penh. The consequences for the storm water management are devastating.

Is it possible to create a sustainable society from today's policy that people can build what and wherever they want? Or is it only possible to create a harmonious society with limited freedom of establishment? Cambodia has experienced two extremities regarding city planning. The Cambodian people spent more than half a decade without any right of determination under the Khmer Rouge Regime. People could not decide where, how or with whom they wanted to live and an insecure and miserable society developed. Today when illegal settlements pop up in every free space in the city and private investors rule the city development, the society is yet again suffering. The importance of just city planning couldn't be more obvious. City planning is all about finding the "happy medium". Long term planning and well-processed and democratic development plans are necessary tools to create a sustainable society and to find the equilibrium between anarchism and autocracy.

A severe problem is the lack of an accepted Master Plan for Phnom Penh. Furthermore, the sector-based plans existing in the local levels contain big gaps, have no coherence between them and do not correspond to the economical and social reality. Because of this, new constructions by private companies do not have any city plans to observe. This has lead to a city development that is about to be scattered over the surrounding landscape. Surprisingly many of the unplanned development of satellite cities are located on wetlands or lakes outside the city centre. The not yet accepted Master Plan can still be followed in the southern parts of Phnom Penh but not in the north. There are almost no detention points left in the north because of the constructions on the wetlands. The persistent obsession for constructing on wetlands and lakes can be explained, not only by economical reasons, but also by the human nature. People tend to search for locations just next to a waterfront to settle. Houses close to open water are popular in the rest of the world as well.

Filling of the wetlands outside Phnom Penh will result in more severe flooding. There are also many detention points for storm water inside the city centre that are threatened by unplanned land filling and constructions. The volume of the water stored in these detention points will be reduced and this will lead to flooding in the city. It has been observed that the rapid change of land use pattern, especially on the lakes and watershed areas of Phnom Penh during the last few decades, has led to often reoccurring heavy floods in the city. It is generally assumed by all people we have talked to, that this occurs as a result of poor urban planning and deterioration of drainage and sewage systems.

The unplanned development in Phnom Penh is occurring in a time when climate change is causing increased precipitation in the region. The change in precipitation will increase flooding in Phnom Penh if the situation is not dealt with. In Phnom Penh as in many other parts of the urbanised world, storm water will be one of the major questions in the future. Cambodia is not one of the countries that face the biggest threats from climate change, Bangladesh, for example has a much more frightening prognosis. But there are changes coming for Cambodia as well and the need to adapt to these changes is urgent. When planning for a future development of Phnom Penh the questions of more frequent flooding, higher temperatures and more intense rainfalls should be taken into consideration. Measurements should be taken in the design of the expansion of the city. A climate change perspective should be added to the Master plan of Phnom Penh and other physical development plans. Phnom Penh could then be much more able to adapt to climate change. More awareness is needed at many institutional levels to implement such strategies.

One of the questions we found most important during our study in Phnom Penh was: Is there a predominant and directing view regarding city development in Phnom Penh and who has formulated it? This question is relevant because storm water management in Phnom Penh is closely related to the urban planning. The location of the city on marshy land just next to a great river demands careful general planning to manage the great water bodies threatening to flood the city in the rainy seasons. The Office of Urban Affairs (BAU), Public Works and Transports, City of Paris and JICA all have contributed to recently published documents where strategies and plans for the future development of Phnom Penh is put out. But we found that there was a great difference between the formulated desired development of Phnom Penh and the development happening in reality. So we asked ourselves: Who is responsible for the actual and physical development that is happening at time being in Phnom Penh? We found out that foreign investors, corrupt politicians, JICA and to a certain extent even slum dwellers are the ones making a visual change to the city profile. Many of them are acting out of immediate and short-term needs such as own profit, fast money, private investment or shelter for their families. None of these reasons make sure that a structured and sustainable city development is taking place. Questions regarding social, technical, ecological and even economical sustainability are forgotten or overseen. It seems to us like the existing planning documents are too little integrated in the actual decision making regarding city planning in the municipality.

We assume that discussions have to take place between the municipality and the private actors before major urban constructions take place. In these discussions the city's goals and visions have to play an important part. If this is not done, the city is in danger of becoming a result of many short-term projects, isolated from each other and the original city. In some years from now, these small steps can cause huge negative effects for the Phnom Penh region. These effects could come from big floods from heavier rains caused by climate change, a dam that break upstream in China or the ecosystem around the city where food and clean water now is produced could collapse . The list can be long and affect Phnom Penh in disastrous ways if the city planning is not thoughtfully carried through.

Cambodian environmental laws like "Laws and Regulations of Environmental Protection and Natural Resources Management (LEPNRM)" and "Law on Land Use Planning, Urbanisation and Construction (LLUPUC)" are valuable and crucial in order to create an ecologically sustainable city and develop a long-term city planning strategy. It is necessary that the laws are implemented and that the legal system is working properly. Environmental protection is a number one priority in Phnom Penh City, since there are strong forces operating in opposite ways.

The municipality has to take responsibility for the planning of public spaces. These places are important in linking the city together. The loss of public spaces will lead to problems for storm water management in Phnom Penh. It will also have negative consequences for the social life, the diversity and the accessibility of the city. Why are green areas in Phnom Penh seen as unimportant and why are the existing green areas not being used? Maybe the reason can be that green areas in Phnom Penh are not appropriately adjusted to the specific site. They are therefore seen as less important and risk to be erased.

The loss of public space leads to a reduction of trees and other vegetation in the city. This is a great loss for Phnom Penh since it was once known as the "Pearl of Asia" because of its character of a green garden city. The great benefits that come from urban vegetation are also reduced. If Phnom Penh is to be a sustainable city it has to have vegetation to clean the air from pollutions, absorb storm water, reduce city noise, regulate the climate, reduce the urban heat island effect and provide shade. In Phnom Penh the capacity of trees and plants to take care of excessive waters are especially important. Besides the environmental effects, green spaces also contribute to the city health by offering recreational areas for the people. Today, there is a great need for more trees and green public space in Phnom Penh.

Since the inhabitants of Phnom Penh spend so much of their time outside, their outdoor environment is of outmost importance. Pocket parks, nature inspired parks and green areas to provide shadow for people taking siestas could improve people's lives and the beauty and importance of diverse public spaces could be appreciated and acknowledged. Today there is only one type of public park represented in Phnom Penh – the decorative, monumental and symmetrically strict park. The maintenance costs are high and few people use them. To incorporate more playful and less strict public parks in Phnom Penh could attract more people and increase the importance, value and appreciation for them. The city is in need of a web of green. Public spaces should not only be a luxury for the people living in the upper class parts of Phnom Penh. To integrate vegetation in smaller areas, like the pocket park, could make a huge impact on the storm water management since infiltrating surfaces would increase.

One of the future challenges facing the decision makers in Phnom Penh is to create solutions regarding storm water management and green-blue pathways in the new development areas. The new constructions are transforming a natural landscape with a natural ability to store and clean excessive water (natural wetlands, rivers and lakes), into a city landscape with hard surfaces and few green impermeable areas. The wetlands and lakes that used to handle wastewater and storm water from the city is diminishing and in its place, new city structures that generate more wastewater and storm water are developing. Today, the total wastewater and storm water volume from the city is increasing and at the same time the areas that have the capacity to handle it are shrinking. The problem is transferred to locations further away from the city centre and these locations have to handle an even larger amount of polluted water. Wetlands are very sensitive ecological structures. Once destroyed, it is very hard to recreate their natural complicated biodiversity.

Another important challenge is to connect the new satellite cities to the city centre and to create a city structure that will welcome a mixture of people. Today the satellite cities appear to be city islands that could be placed outside any Asian capital and represent the opposite to the diversity and charm that Phnom Penh has to offer. These new city districts seems to be planned to become alternative worlds where the inhabitants don't have to see the poverty and degradation in the city centre. The isolation of the new city centres is both physical and psychological. The physical linking with the city is minimal and is made up by planned motorways. The connection to the airport is clearly important to the projects and secured by motorways. The future inhabitants are obviously assumed to be more interested in going to the airport than taking part of life in the city centre. It is also assumed that the residents of these areas have cars. In today's Phnom Penh it is only the wealthiest people that can afford a car. It seems clear to us that it is the needs and demands of these wealthy people that create the style in which the new city centres are built and also where they are built.

The psychological isolation of the satellite cities is made up by the obvious adjustments towards a certain economical elite with gated communities and high priced homes. There is little varia-

tion in house prices and types of buildings. To call the new areas “City centres” is misleading because centres should be available for everyone. The unplanned development of satellite cities does not attend the problem of the many poor families living in slum settlements in and around Phnom Penh. Segregation between rich and poor will most certainly increase in Phnom Penh as a result from these new developments. We don’t believe that the realisation of these areas will improve the understanding and solidarity between the citizens of Phnom Penh. To avoid segregation and to make the new satellite cities feel more “alive”, a strategy of mixed income classes and ethnicities could be a winning concept.

One step towards an improvement of the city environment in Phnom Penh would be a sustainable public transportation system that people actually want to use would be one step in the direction of improvement. Open trams operating it the whole city, which people can jump on and off as they wish, is one idea. The trams should connect to the new satellite cities and also to Takhmau city.  Open coaches, who offer airy breezes when in motion, are suitable for the hot climate in Phnom Penh and make a less expensive alternative to air-conditioned coaches. Since trams don’t need asphalted roads to move, the rails could be placed in a green strip in the middle of the street, which also would work as an infiltration area for storm water and a green element in a gray and hard traffic environment. Funding could come from the Municipality or even better; be financed by the private investors as a part of the payment to the city for using its land areas for their constructions. Investors building satellite cities in the outskirts of Phnom Penh should definitely contribute to build up the public transports necessary for the inhabitants in the new areas. To build for car bourn traffic alone cannot be an acceptable solution for the Municipality of Phnom Penh.

Today investors find an interest in Cambodia and Phnom Penh because of low prices, few regulations and the prognosis of a fast growing country and capital. The investors are welcomed because of the need to raise the living standard for the people and to develop the country. The decision makers in Phnom Penh don’t want to lose the investors to other concurrent metropolises of the South-East Asia. The investors are free to operate without many constrains from environmental or social aspects. This, as we have discussed earlier, might lead to a decline of many important values. A likely development will be that Phnom Penh transforms to be an unpleasant city, both for investors and inhabitants. The new developments on wetlands and lakes threaten to reduce the charm and identity of Phnom Penh. With the ongoing constructions Phnom Penh risk to be transformed into a uniform, westernized city and its former identity as the “Pearl of Asia” will be lost forever.

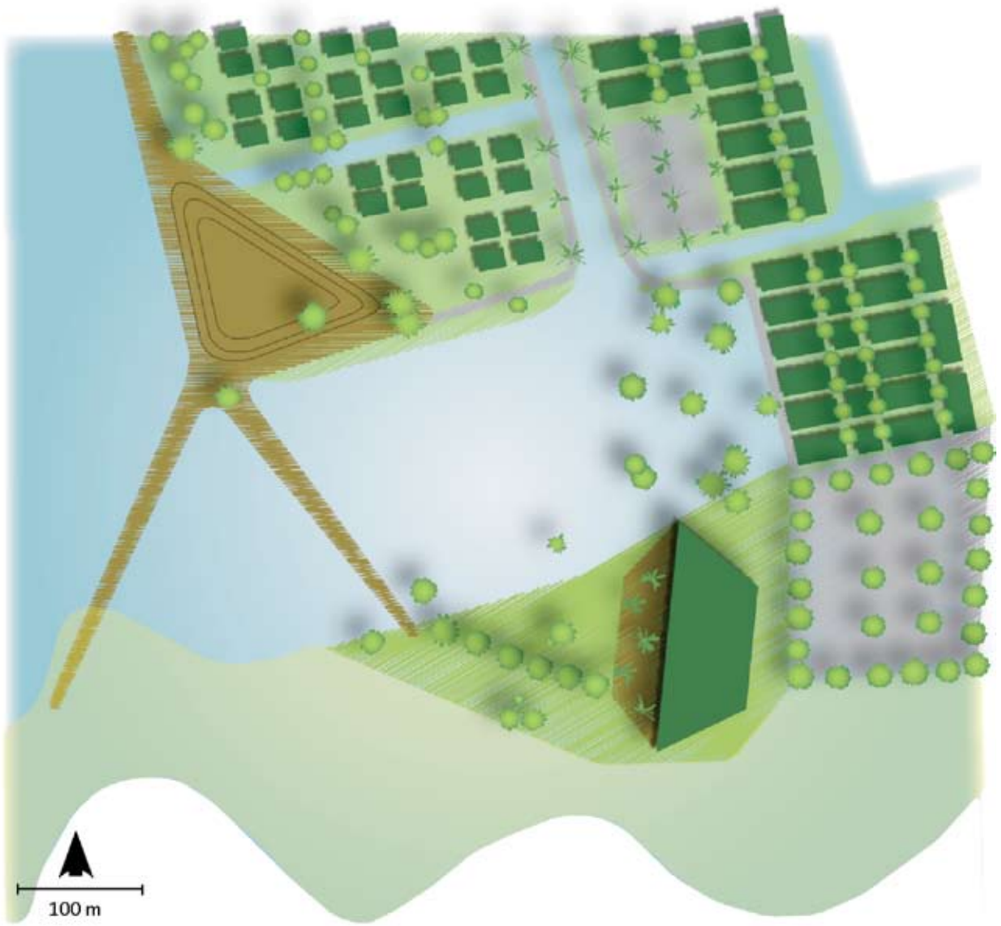
We believe that it is possible to combine the need for development and investment with environmental and social welfare. Indeed, we want to state that it is crucial that the environmental and social aspects are dealt with to reach a sustainable economical development. Phnom Penh has a great environmental asset in its many ponds, lakes and wetlands. These water structures are characteristics of the city and can be developed in an attractive manner. It is a question of identity to attract new inhabitants, tourists and investors as well as creating a pleasant living environment for the present residents. Our suggestion is to preserve the open ponds, lakes and wetlands that remain. They are exceptional assets to the city and increase its attractiveness.  We believe that Phnom Penh can develop to be a modern “Pearl of Asia”.

To further enhance Phnom Penh`s identity of a city developed on a wetland and to clarify the beginning of the transformation towards a modern and sustainable city, we suggest the name “Blue Pearl of Asia”. In Phnom Penh, as in many other cities, dikes, embankments and other barriers have for a long time been considered to be the best protection against rising water levels. Phnom Penh is located on marshy land unsuitable for construction. With the prevalent way of building, new embankments are needed when the city grow. The defense techniques used today are complicated, uncertain and extremely costly. The techniques are based on defying nature and catastrophes can therefore result in devastating consequences.

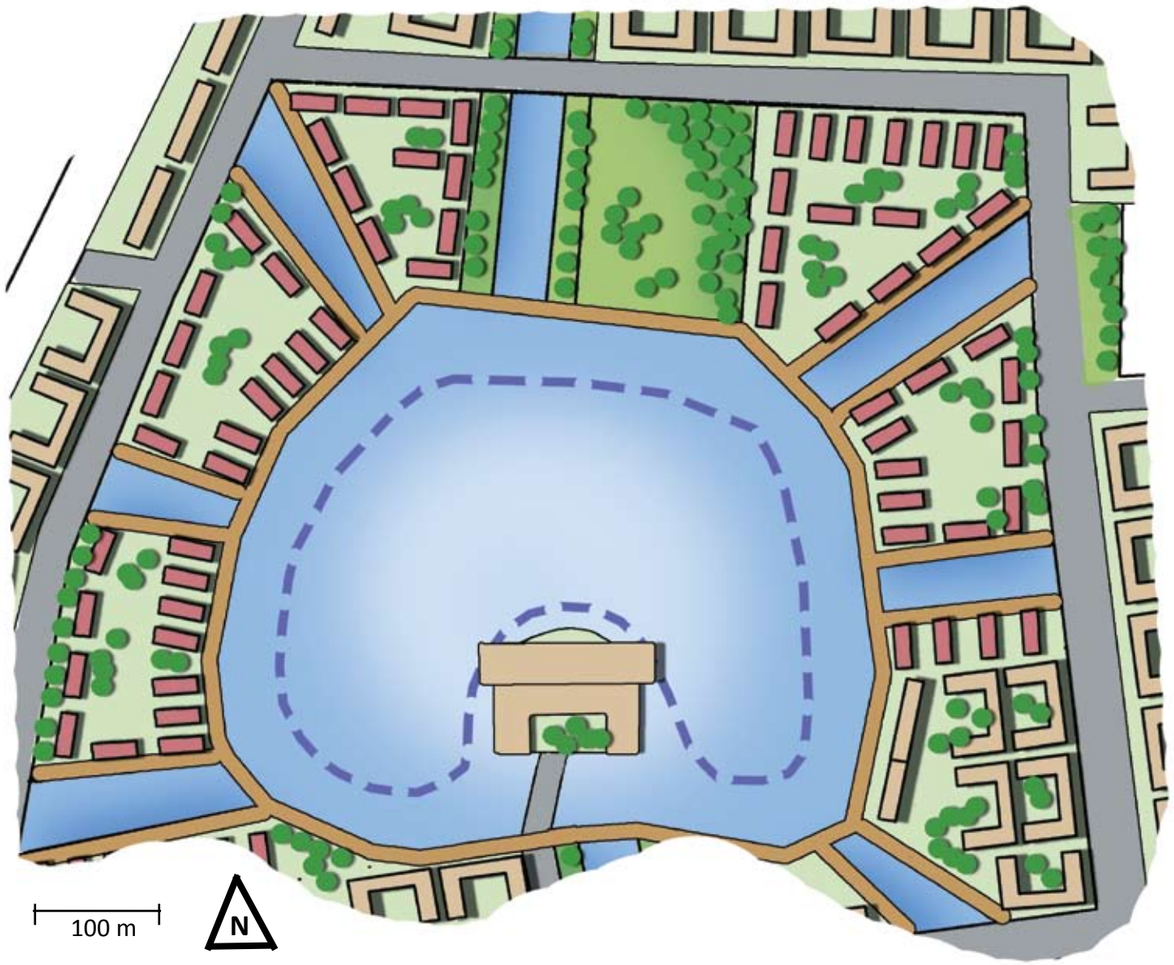
Following the ancient trends to adjust to the rising and falling water levels is on the other hand a sustainable way of dealing with water from floods and rainfalls. Flooding is with this method not a problem, but instead a beautiful element to incorporate into city planning and design. This is a good possible future planning strategy for Phnom Penh and other cities threatened by inundations. The way that the decision makers choose for the development of Phnom Penh is crucial for the future existence of the city.

Phnom Penh has a fantastic asset in the many water structures in and around the city. In the rest of the world it has just recently been recognized how important wetlands are to humanity. The wetlands play an important role in protecting societies from floods and have many complex values for sustainability. This has led to massive expenditures to restore lost or degraded hydrological and biological functions of wetlands in many countries. The wetlands of Phnom Penh are valuable economical resources. Preservation of wetlands has numerous advantages and the city will also be stronger in possible future crisis, such as shortage of fresh water, climate change and overpopulation.

Besides protection of the water structures Phnom Penh also needs to expand and develop new housing for the growing number of inhabitants and the people now living in inadequate informal settlements. We suggest a phased expansion of areas close to wetlands and lakes to protect the sensitive ecosystems. Careful consideration has to be given to nature and inhabitants. The expansion and development should primarily be focused on existing residential areas along the rivers to the south and north of the




Proposed sparse suburban district.




Proposed dense inner city district.

city. We also think that it would be beneficial to restore the existing residential areas. Today many houses and areas developed in the fifties and sixties are decayed.

In our individual design proposals we have focused on two areas in Phnom Penh that are about to be developed. Both are important water storage areas threatened to be filled in. We have tried to come forth with proposals that are realistic and that contribute to a sustainable development of Phnom Penh.

Neither one of our two individual proposals aim to solve the lack of housing that Phnom Penh experience. Our proposals should be seen as just proposals of how Phnom Penh can develop housing close to wetlands and lakes without threatening the natural balance. Some areas of wetlands and lakes must be exploited for Phnom Penh to be able to expand. There is no other way to go because this type of landscape surrounds the whole city. It is important to protect the water landscape of Phnom Penh and it is equally important to create more apartments and houses for the growing number of inhabitants. Therefore there is a need for sustainable solutions for urban development and it is an urgent matter to imply these solutions to the current fast expansion of the city.

Our proposed developments for Boeng Kak Lake and Boeng Cheung Ek will bring Phnom Penh closer towards becoming ”The Blue Pearl Of Asia” and closer towards becoming a sustainable city. The proposals aim to reduce some of the weaknesses and threats identified in the SWOT-analysis. The proposals also aim to enhance some of the found strengths in Phnom Penh and catch a few of the opportunities.

If realised, the proposals will benefit Phnom Penh in all the seven dimensions used to describe sustainability. Biologically the city will be able to hold a larger biodiversity. Culturally the Cambodian identity will be enhanced when promoting traditional architecture and lifestyle. Economically Phnom Penh will be able to attract more tourists. Physically the prerequisites on the two sites will be optimised. Organisationally a green web and a sustainable storm water system will be promoted. Socially there will be more public places enhancing outdoor activities. Aesthetically Phnom Penh will become a more pleasant city to live in and to visit.

Phnom Penh is currently growing in a north-south direction. It is also possible that an eastern development explodes in the next coming years. Wetlands, river shorelines and lakes characterise all these areas. The urban expansion is necessary and will interfere in this sensitive web of aquatic ecosystems. The question is how much the development must interfere. How can a development proceed and yet take into account the natural environment that supports the city? Hopefully, our proposals give an idea of how such a development could look like.

The locations of the two proposals differ in their prerequisites. Boeng Kak lake is a centrally located lake with the demand for an urban high density design. Boeng Cheung Ek wetland is located outside the central parts of Phnom Pehn and the prerequisites regarding density and urban character is different. The area has a suburban character rather than central. Because of these different backgrounds the proposals give solutions to two styles of development that are occurring in Phnom Penh at the moment. One is the central development that causes filling and destruction of lakes and ponds in the centre. The other one is the development on wetlands around the city.

It has been a challenge to try to apply our Swedish thoughts of sustainable storm water management solutions to the prerequisites in Cambodia. We made an effort to understand and describe the problems with urban flooding in Phnom Penh from a holistic point of view. The complex nature of the storm water problem in Phnom Penh has not been easy to grasp and many questions remain. Though, we believe we gained a good understanding of the many challenges that Phnom Penh faces and that we managed to present possible solutions to these challenges.

# REFERENCES

## Bibliography


Asian Development Bank. (2006). Urbanisation and sustainability in Asia. Cities Without Slums.

Bergkamp, G. Orlando, B. (1999). Wetlands and climate change – Exploring collaboration between the Convention on Wetlands and the UN Framework Convention on Climate Change. Background paper from IUCN. The Ramsar convention on wetlands. IUCN.

Bureau des Affaires urbaines de la Municipalité de Phnom Penh. (2007). LIVRE BLANC DU DEVELOPPEMENT ET DE L'AMENAGEMENT DE PHNOM PENH. Diagnostic economique, social et enviromental. Tendances, Prospective et Orientations. Avant-projet de Schema Directeur d´Urbansime de Phnom Penh 2020. Phnom Penh: Office of Urban Affairs.

Coombes, P. (2002). Infiltration devices, The Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) as WaterSmart Practice Note No. 5.

Dany, V. Eliyan, C. Levels Of Cr, Cu, And Zn In Food Stuffs From a Wastewater Treatment Wetland, Phnom Penh: a Preliminary Assessment Of Health Risks. Phnom Penh: Department of Environmental Science, Faculty of Science, Royal University of Phnom Penh.

Ebeling, E. (2008). Det kan vara farligt att ligga lågt. Om stadsplanering inför stigande vattennivåer. Exempel från Göteborg, Kristianstad och Arvika. Uppsala: SLU.

Environment, M. o. (2001). Vulnerability and Adaptation Assessment to Climate Change, Phnom Penh.

Environment, M. o. (August 2002). Cambodia's Initial National Communication. Phnom Penh.

Environment, M. o. ( March 2005). Analysis of policies to address climate change impacts in Cambodia. Phnom Penh.

Environment, M. o. ( October 2006). National Adaption Program of Action to Climate Change (NAPA). Phnom Penh.

Health, M. o. (2004). Health Statistic Report for 2002. Phnom Penh.

EVS Environment Consultants. (1996). Coastal and Marine Environmental Management for Cambodia: Final Report. Phnom Penh.

The Habitat Agenda, Istanbul Declaration on Human Settlements. (2006). UN Habitat.

IPCC. (2000). Special Report on Emissions Scenario 2 Special Report on Emissions Scenario, Family A2.

IPCC. (2000). Special Report on Emissions Scenario 1 Special Report on Emissions Scenario, Family B1.

IPCC. (2001). IPCC climate change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.

Irvine, K. N. (2007). The role of Phnom Penh´s wetlands in sustainably treating sewage Discharge to the Mekong/Bassac river system. Buffalo State University of New York.

JICA. (1999). The study on drainage improvement and flood control. Departmant of Public Works and Transport, Municipality of Phnom Penh.

Kusler, J., et. al. (1999). Wetlands and climate change: scientific knowledge and management options. White Paper Institute for Wetland Science and Public Policy, Association of State Wetland Managers, Wetlands International.

Men, N. Lim, S. Ann, V. Ly, S. (2008). Water Quality and Pollution Control in Phnom Penh, Cambodia. Phnom Penh.

Modin, M. (2008). Klimatsäkrare städer - klimatförändringar, stadsplanering och översvämningar. Uppsala: SLU.

Molyvann, V. (2003). Modern Khmer Cities. Phnom Penh, Cambodia: Reyum Publishing.

Municipality of Phnom Penh. (1999). Strategy to Build the Capacity of the Municipality of Phnom Penh for Urban Poverty Reduction. Phnom Penh.

Municipality of Phnom Penh. (2005). City Development Strategy 2005-2015. Phnom Penh.

Muong, S. (2000). Feasibility study for setting up a decision support system for urban wastewater management strategies – Phnom Penh. Phnom Penh: Ministry of Environment.

Muong, S. (2004). Avoiding Adverse Health Impacts from Contaminated Vegetables. Options for Three Wetlands in Phnom Penh, Cambodia, Research Report No. 2004-RR5, Economy and Environment Program for Southeast Asia. Phnom Penh: Ministry of Environment.

Nareth, M. et. al. (2008). Water Quality and Pollution Control in Phnom Penh, Cambodia. Institute of Technology of Cambodia, Department of Rural Engineering. Phnom Penh.

National Committee on Disaster Management. (2002). Disaster Management in Cambodia, Phnom Penh: NCDM.

Planning Department of Phnom Penh Municipality. (2004). Profiles of Phnom Penh City. Phnom Penh.
The Royal Government of Cambodia. (1997). First Five Year Socio-economic Development Plan, SEDP I (1996-2000). Phnom Penh.

The Royal Government of Cambodia. (2001). Second Five Year Socio-economic Development Plan, SEDP II (2001-2005). Phnom Penh.

The Royal Government of Cambodia. (2006). National Strategic Development Plan 2006-2010. Phnom Penh.
Seshimo, K. Chen, M. (2004). Infrastructure Assessment in the Context of Rapid Urbanization: The case of Cambodia. ASCE.

Seyha, S. Vuong T. A. Case Study: Skin Problems of a farmer engaged in Water Morning Glory cultivation in Beoung Cheung Ek Lake, Phnom Penh, Cambodia. Royal University of Agriculture, Phnom Penh, Cambodia and National Institute of Hygiene and Epidemiology, Hanoi, Vietnam.

Sophy, E. (2002). Study on Development Plans of Phnom Penh Metropolitan Area. Phnom Penh: The Green Group.

UN Habitat. Phnom Penh History. Phnom Penh. (Not published document)

Vanna, P. (2000). Potential impacts of climate change on Cambodia coastal zone 1. Climate Change National Technical Committee, Cambodia.

Veg Tech. (2008). Vegetationsteknik. Stockholm.

The World Bank. (2007) The little green data book. Washington D.C. U.S.A.

Yin, M. (2006). Environmental changes associated with land reclamation around Boeng Kok Lake in Phnom Penh - Cambodia. Thailand: Asian Institute of Technology.

Yin, R. (1994). Case Study Research. Thousand Paks, London, New Dehli: Sage Publications.

# Interviews

Bongers, H. (16 05 2008). Guest House owner at Boeng Kak Lake. G. Englund & S. Ryttar, Interviewers)

Cheam, P. (06 05 2008). Architect and Urban Planner at BAU Office at the Municipality of Phnom Penh. (G. Englund, & S. Ryttar, Interviewers)

Din, S. (30 04 2008). Habitat Programme Manager at UN Habitat in Phnom Penh. (G. Englund, & S. Ryttar, Interviewers)

Goad, H. (23 05 2008). Landscape Architect. (G. Englund, & S. Ryttar, Interviewers)

Heng, C L. (16 05 2008). Inhabitant at Boeng Kak Lake. (G. Englund, Interviewer)

Mr Heng Horn. (11 05 2008). Inhabitant in the village Phum Prey Ta Khong, Sangkhat: Chark Eng Rev, Boeng Cheung Ek wetland. (G. Englund, & S. Ryttar, Interviewers)

Hultén, S. (09 05 2008). Architect, Archetype. (G. Englund, & S. Ryttar, Interviewers)

Kok, S. (21 05 2008), (22 05 2008), (26 05 2008), (26 05 2008). Lecturer at the Department of Environment at the Royal University of Phnom Penh. (G. Englund, & S. Ryttar, Interviewers)

Mr Long Heum. (11 05 2008). Village leader, Phum Prey Ta Khong, Sangkhat: Chark Eng Rev, Boeng Cheung Ek wetland. (G. Englund, & S. Ryttar, Interviewers)

Mauret, F. (14 05 2008). Project director at BAU Office at the Municipality of Phnom Penh. (G. Englund, & S. Ryttar, Interviewers)

Mrs Ok Vanny. (16 05 2008). Inhabitant in the village Cheung Ek. (S. Ryttar, Interviewer)

Mrs Pov Ken. (11 05 2008). Inhabitant in the village Phum Prey Ta Khong, Sangkhat: Chark Eng Rev, Boeng Cheung Ek wetland. (G. Englund, & S. Ryttar, Interviewers)

Phon Phin. (17 05 2008). Inhabitant in Takhmau. (G. Englund, & S. Ryttar, Interviewers)

Ratanak, T. (07 05 2008). Deputy Director, Division of Urban Public Garden And Greenery. (G. Englund, & S. Ryttar, Interviewers)

Sarann, L. Vannak, A. (12 05 2008). Lecturer of rural technology and lecturer of water quality and storm water at the Department of Rural Engineering at ITC (Institute of Technology in Cambodia). (G. Englund, & S. Ryttar, Interviewers)

Sarin, S. (16 05 2008). Chief of Sangkhat office Boeng Tun Pun. (G. Englund, & S. Ryttar, Interviewers)

Seng, K. (08 05 2008). Coordinator STT (Samakum Theang Tuot), Architect, . (G. Englund, & S. Ryttar, Interviewers)

Sinat, N. (16 05 2008). Inhabitant at Boeng Kak Lake. (G. Englund, Interviewer)

Sophan, M. (27 05 2008). Civil Engineer, Chief of Public Works Office. (G. Englund, & S. Ryttar, Interviewers)

Sotheara, M. 16 05 2008). Inhabitant at Boeng Kak Lake. (G. Englund, Interviewer)

Symann, R. (07 05 2008). Coordinator Good Governance, DED (Deutscher Entwicklungsdienst). (G. Englund, & S. Ryttar, Interviewers)

Vannara, T. (den 16 05 2008). Advocacy and Communication Program Manager at CEPA (Culture and Evironment Preservation Assosiation) in Phnom Penh. (G. Englund, & S. Ryttar, Interviewers)

Mr Veang Vang. (16 05 2008). Inhabitant in the village Khakva, Boeng Cheung wetland. (S. Ryttar, Interviewer)

Vibol, C. (08 05 2008). Program Officer Infrastucture at JICA (Japan International Cooperation Agency) in Phnom Penh. (G. Englund, & S. Ryttar, Interviewers)

Vinno, T. (12 05 2008). Architect and teacher at Royal University of Fine Arts. (G. Englund, & S. Ryttar, Interviewers)

# Field Studies

Augustenborg, Malmö. (22 03 2008)

Bo01, Malmö. (22 03 2008)

Boeng Cheung Ek wetland. (27 04 2008), (11 05 2008), (16 05 2008), (17 05 2008)

Cambodian countryside. (01-05 05 2008)

CamKo City. (11 05 2008)

French tree park. (10 05 2008)

Hammarby Sjöstad, Stockholm. (03 03 2008)

Informal settlements at the Casino area. (09 05 2008)

Informal settlements by Tchekoslovakia road (08 05 2008)

Informal settlements by Boeng Kak lake (08 05 2008)

International City. (11 05 2008)

Kampot. (23 05 2008)

Phnom Penh river walk. (30 04 2008), (15 05 2008)

Ramböll, Uppsala. (14 08 2008)

Royal Palace. (15 05 2008)

Salang canal. (11 05 2008)

Sianoukville. (19-22 05 2008)

Siem Reap. (01-05 05 2008)

SWECO Environment, Stockholm. (02 10 2008)

Takhmau. (16 05 2008)

Trabek canal. (27 04 2008)

Trabek pumping station. (27 04 2008)

Veg Tech, Fagerås. (03 07 2008)

Veg Tech, Stockholm. (02 07 2008)

WRS, Uppsala. (11 08 2008)

WSP, Stockholm. (28 08 2008)

# Internet

Ciria
http://www.ciria.org.uk/suds/index.html

Dr. Dickson Despommier, Ph.D.
www.verticalfarm.com, 2008-09-17

Embassy of the United States, Phnom Penh, Cambodia.
cambodia.usembassy.gov/cheung_ek.html

Geo Worldbank
http://geo.worldbank.org/

Hammarbysjostad.se
www.hammarbysjostad.se

Malmö Stad
http://www.malmo.se/download/18.2c0511de10ef52779278000184/fb59_dagvatten_final.pdf, 11-01-06

Ministry of Environment, Cambodia
www.camnet.com.kh/moe/

Municipality of Phnom Penh
www.phnompenh.gov.kh

National Institute of Statistics, Cambodia www.statsnis.org/SURVEYS/cips2004/cips_statis.htm
SIDA. (2006, April 11). From www.sida.se/sida/jsp/sida.jsp?d=835&a=14363&searchWords=urbanisering

Pavingexpert
http://www.pavingexpert.com/

UNDP Human development reports
http://hdr.undp.org/en/statistics/

UNDP Human development reports 2007/2008 Country facts sheets, Cambodia
http://hdrstats.undp.org/countries/data_sheets/cty_ds_KHM.html

UN Department of Economic and Social Affairs, Division for Sustainable Development
www.un.org/esa/sustdev/sdissues/climate_change/climatechange.htm

UN Habitat Phnom Penh, Phnom Penh Urban Poverty Reduction Project, April 2008
www.unhabitat.org/content.asp?cid=4912&catid=260&typeid=13&subMenuId=0

Wetlands International
http://global.wetlands.org/

World Health Organisation
www.who.int/countries/khm/en/

World City Co., Ltd. CamKo City
www.worldcitycambodia.com

YLP Group Co., Ltd. International City
www.ylpgroup.com

# Articles

Padua M. G. 2008. Red Ribbon Park. Topos nr. 63

Ball, M. ( September 28-29 2002) Olympic Stadium Developers Jeopardize Original Design. The Cambodia Daily.

Berg, P.G. Florman, C. (2005) Planering för uthållighet. En tredje väg? Nr. 6 Arkitekten

Chen L. Lin R. 2006. The Hong Kong Wetland Park. Topos nr. 55.

Dreiseitl H. 2007. New Waterscapes for Singapore. Topos nr. 59.

Hallemar, D. (2008) Ljus framtid för Sorgenfri. Nr 6 Arkitekten

Lauri, T. (2008) Stad utan slut. Nr 6 Arkitekten

Liu, J. (August 03 2007) Worries remain as Cambodia recovers. Asia Business Report, BBC World, Phnom Penh, Cambodia

Hans Dahlquist. (07-12-2005). Flytande holländaren kastar ankar. NyTeknik.

The NGO Forum Cambodia. (June 2007) Boeng Kak Lake Lease Agreement. Cambodia Development Watch Magazine, Year III, No. 1

Padua M. G. 2008. Red Ribbon Park. Topos nr. 63

Rattana, V. (September 29, 2008). Displacement and development. Phnom Penh Post.

Sisovann, P. (June 15, 2007) Ministry Urges Phnom Penh to Create More Green Areas. The Cambodia Daily Vol 37 issue 22.

Temanummer Stad (2008) Nr 3 Sveriges Natur

Venhuizen H. 2006. Living on Estate Agents´ Water. Topos nr. 57.

# Maps and photographs

AZ group Ltd. AZ development plan. (2008)

Google Earth. Arial photos of Boeng Kak Lake (2008)

JICA. Aerial photo of south Phnom Penh. (2004)

JICA. Aerial photo of Phnom Penh area. (2004)

Shukaku Inc Draft of Boeng Kak Lake Development Project, BAU (27-01-2006)

Shukaku Inc Approved Last-model of Boeng Kak Lake Development Project, BAU (29-03-2006)