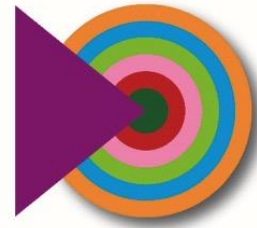


Urban Climate Concepts for Urban Planning 21st April Centre Khmer Studies, Build for People Project



Urban climate what for?

Scientists give answer (Ren Chao HKU, Lutz Katzschner Sebastian Kupski INKEK, Bunleng Se, Nyda Chhin RUPP)



លំនៅដ្ឋានដែលមានចីរភាពសម្រាប់ប្រជាជន - BUILD4PEOPLE

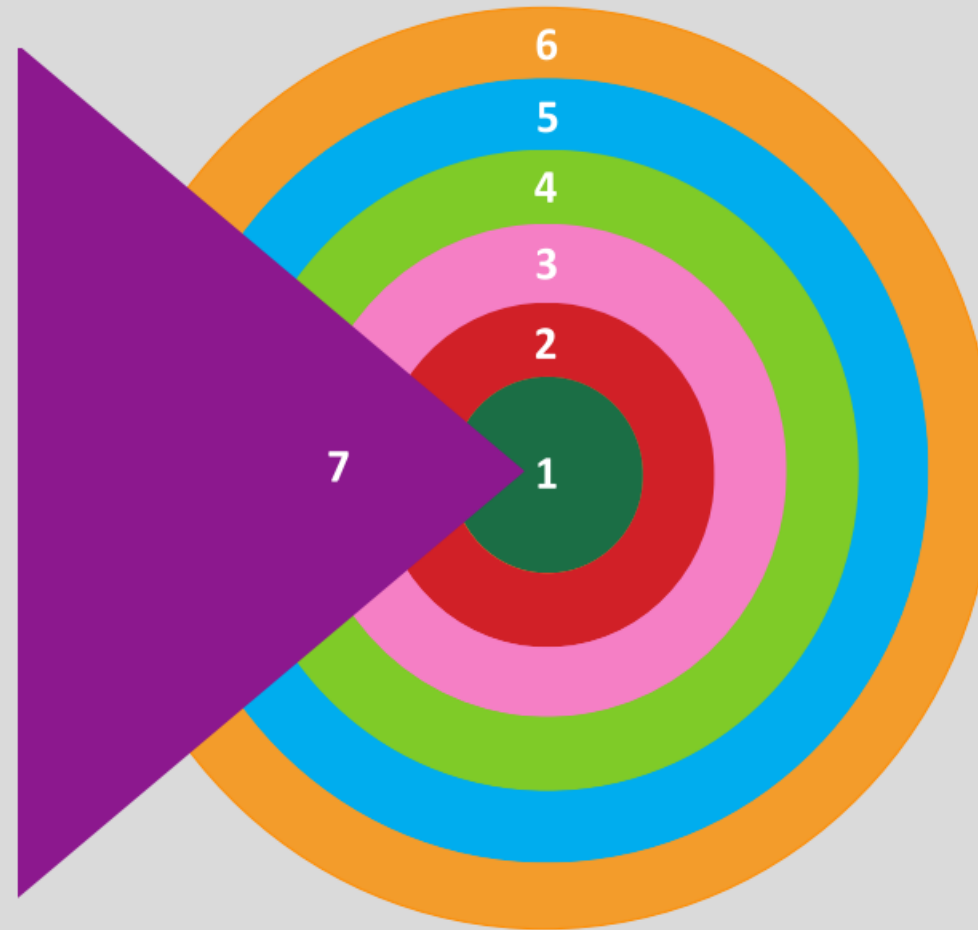


INKEK institute for climate and energy strategies



កញ្ចប់ការងារ - Work Packages

1. ការផ្លាស់ប្តូរឥរិយាបថ
Behaviour Change
2. អគារដែលមាននិរន្តរភាព
Sustainable Building
3. សហគមន៍ដែលមានចីរភាព
Sustainable Neighbourhoods
4. ទីក្រុងបៃតង
Urban Green
5. អាកាសធាតុទីក្រុង
Urban Climate
6. ការផ្លាស់ប្តូរទីក្រុងដោយនិរន្តរភាព
Sustainable Urban Transformation
7. ការសម្របសម្រួល, ការទំនាក់ទំនង និង ការផ្សព្វផ្សាយ
Coordination, Communication & Dissemination



Source: Build4People



„ដើម្បីកែលម្អក្នុងអោយមានសុខុមាលភាព គឺត្រូវមានខ្យល់។ សំខាន់គឺ
ឈប់គិតរឿងព្រំ។ យើងត្រូវគិតអោយបានឆ្ងាយពីការនាំយកខ្យល់ចូល
តំបន់អ្នក“ រូលហ្វី ម៉ែហ្សឺស្ទីឌ(នាយកប្រតិបត្តិនៃ អ៊ីអេមកី នៅ ធូបឺងឆិន)

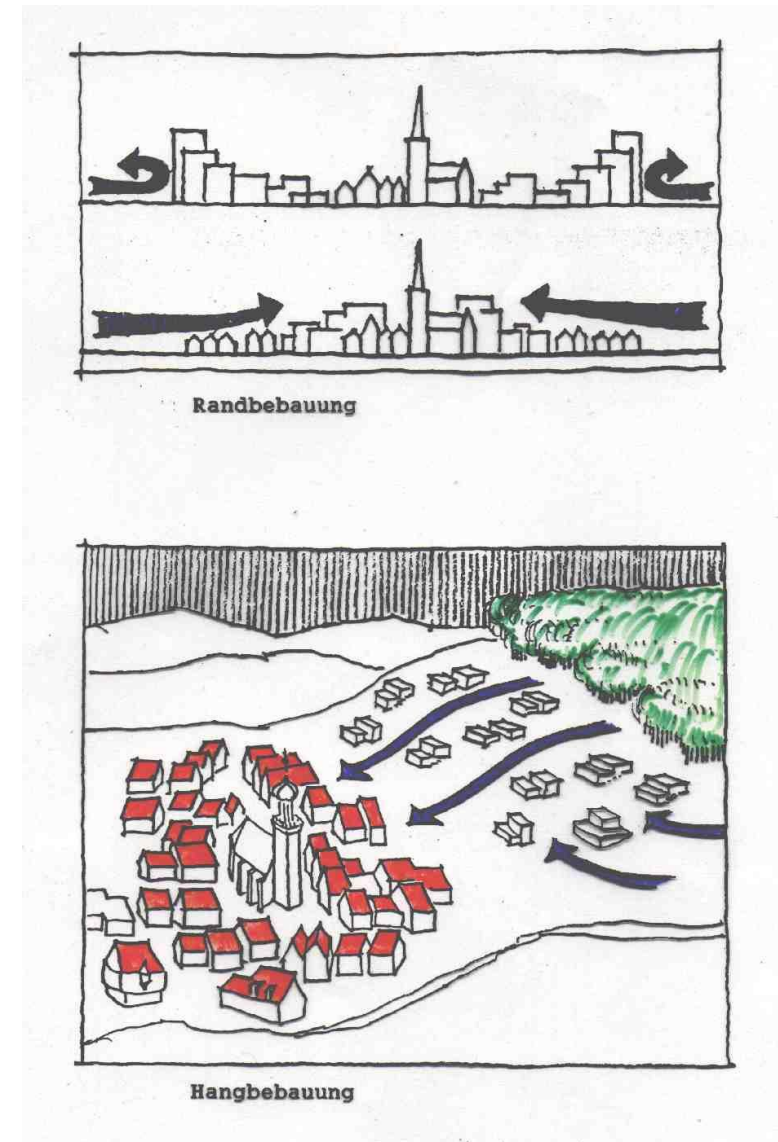
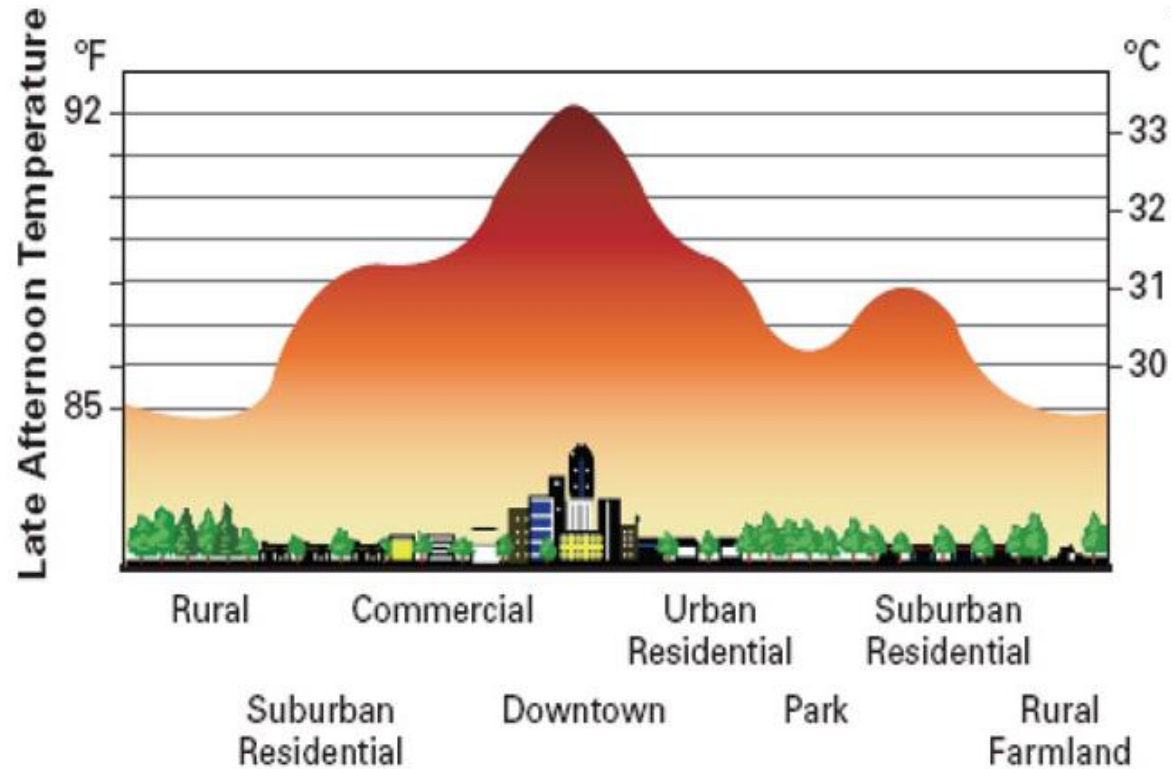
„To improve urban comfort here, you have to catch the wind.
Important is therefore not to stop thinking at the boundaries. You
need to look far beyond and invite the wind into your areas!“
Lutz Katschner (INKEK, University Kassel)

Main Issues:

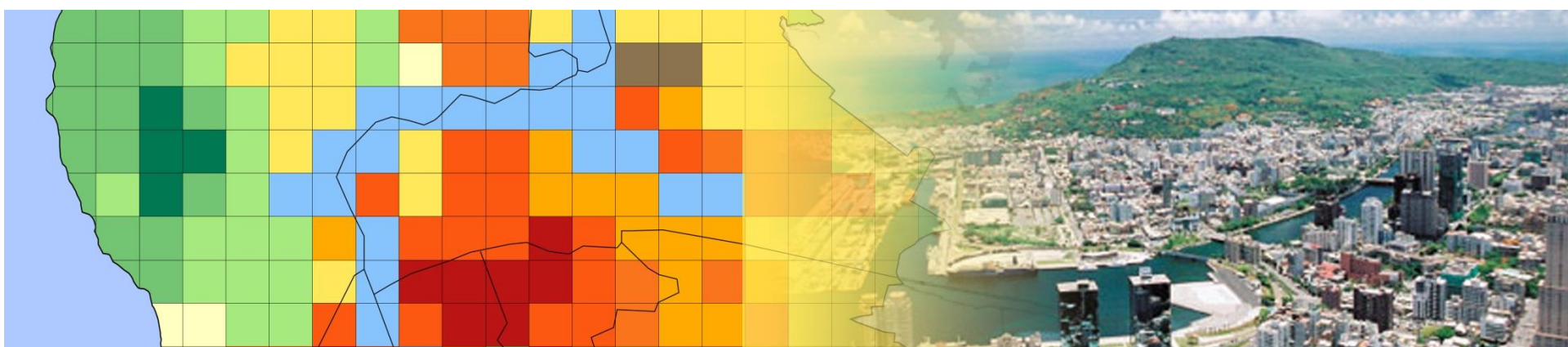
Urban heat island

Ventilation for city design and energy

Thermal comfort and quality of live



Design for Changing Climate



Dr. Chao REN
Faculty of Architecture
The University of Hong Kong

Urban Climatic Map Study for Hong Kong

http://www.pland.gov.hk/pland_en/p_study/prog_s/ucmapweb/index.htm

Urban Climatic Map and Standards for Wind Environment

Feasibility Study

都市氣候圖及
風環境評估標準
可行性研究



Planning Department

規劃署



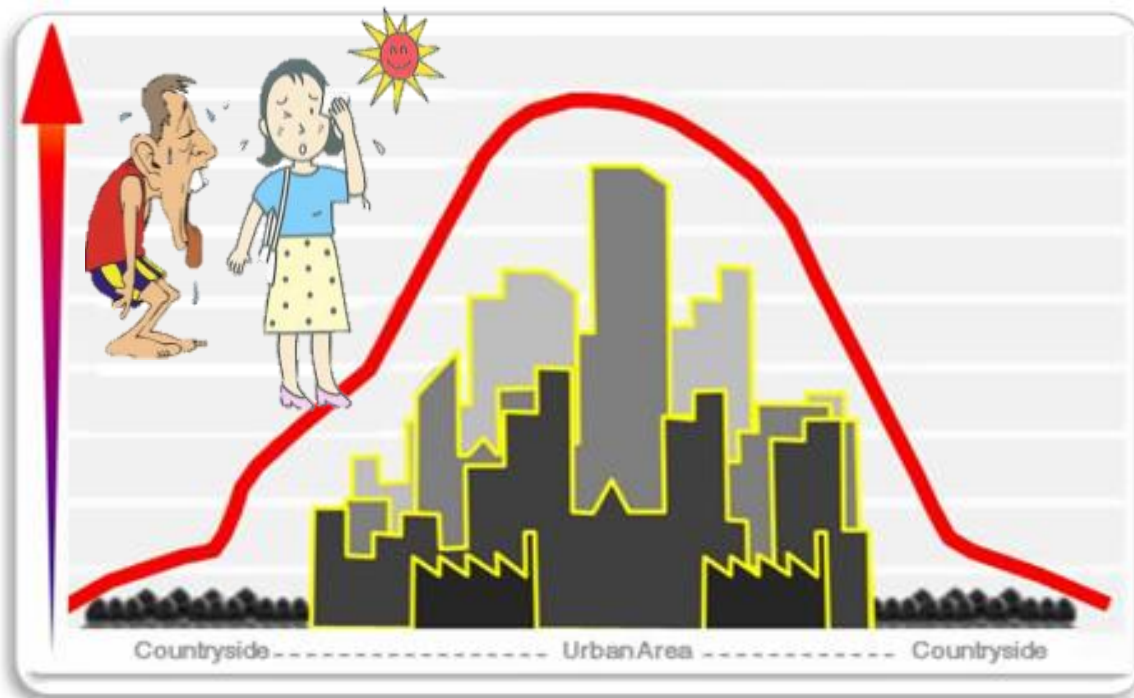
CUHK

香港中文大學

Enter English Webpage

進入中文網頁

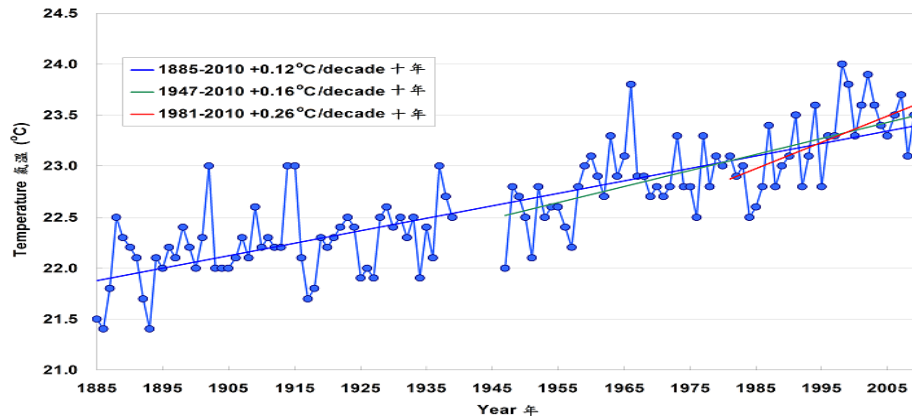
Key Issues



- Sub-tropical Climate
- High Density Urban Development
- Urban Heat Island Effect Intensifying

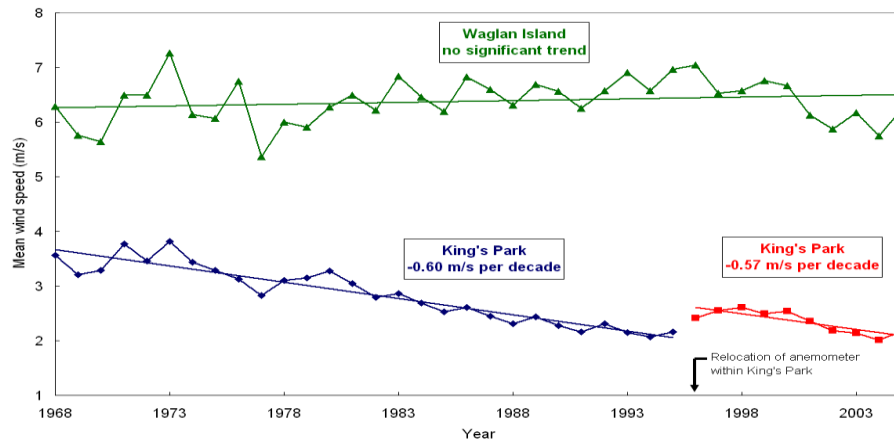


Key Issues



Accelerating Increase in Urban Temperatures

- 1947 to 2010: $\uparrow 0.16^{\circ}\text{C}$ per decade
- 1981 to 2010: $\uparrow 0.26^{\circ}\text{C}$ per decade



Deteriorating Urban Wind

- Waglan Island: No significant trend
- King's Park: $\downarrow 0.60 \text{ m/s per decade}$



Key Issues



Increase in Energy Consumption

EPD's Project:

Provision of Service for Characterising the Climate Change Impact in Hong Kong

Increasing electricity demand percentage per year	Temperature increase by		
	1°C	2°C	3°C
Domestic	9.02%	16.15%	30.97%
Commercial	3.13%	6.26%	9.38%
Industrial	2.64%	5.28%	7.91%
Total	4.53%	9.52%	14.98%

Table 3.4 Percentage Increase of Energy Consumption due to Temperature Rise



Available online at www.sciencedirect.com



Energy 31 (2006) 2623–2637

ENERGY

www.elsevier.com/locate/energy

Review

Impact of urban temperature on energy consumption
of Hong Kong

W.Y. Fung^a, K.S. Lam^{a,*}, W.T. Hung^a, S.W. Pang^b, Y.L. Lee^b

^aDepartment of Civil and Structural Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

^bAir Management Group, Environmental Protection Department, HKSAR, 33/F Revenue Tower, 5 Gloucester Road, Wai Chai, Hong Kong

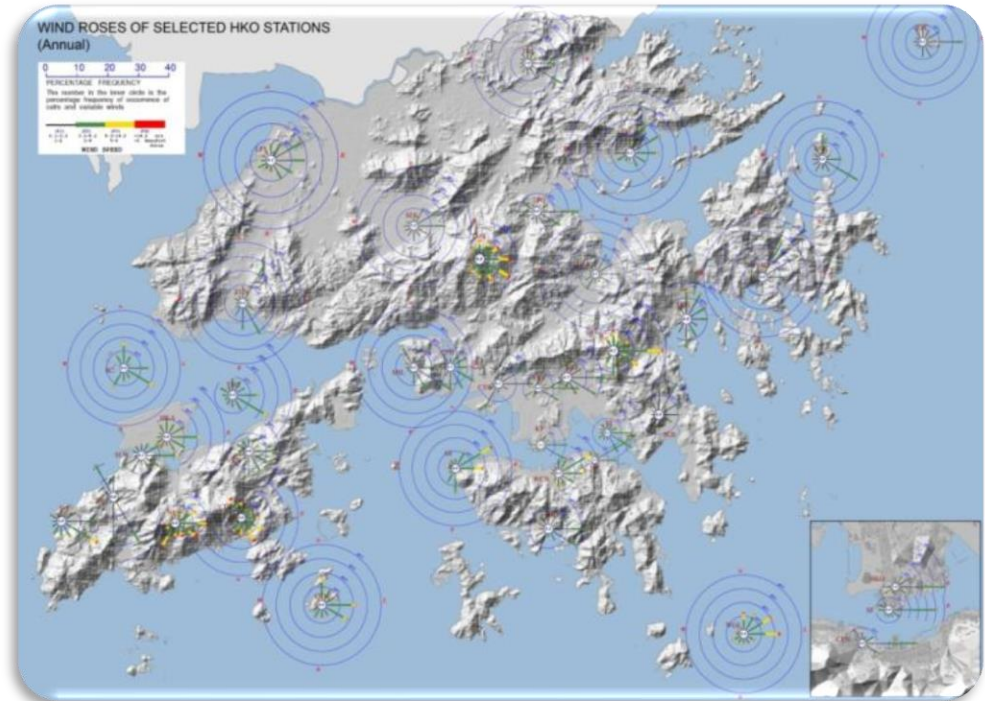
Key Issues



**Hong Kong is well endowed with wind.
It only needs to be optimized by planners and
designers with better designs, achieving better wind
environment and reducing Urban Heat Island effect.**

Hong Kong Observation Station Name	At pedestrian level hourly mean (m/s)
Hong Kong Observatory	1.57
Sha Tin	1.84
Tseung Kwan O	1.12
Sai Kung	2.09
Wong Chuk Hang	1.75
Tsing Yi Shell Oil Depot	1.66
Cheung Sha Wan	1.62
Kai Tak	2.51
Kowloon Star Ferry	2.44
North Point	2.24
Central Pier	2.27
Tuen Mun Government Offices	1.63

*The pedestrian level hourly mean wind speed is extrapolated based on the observations of selected HKO urban stations.



Background

2005

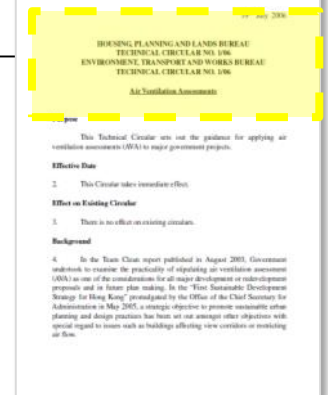
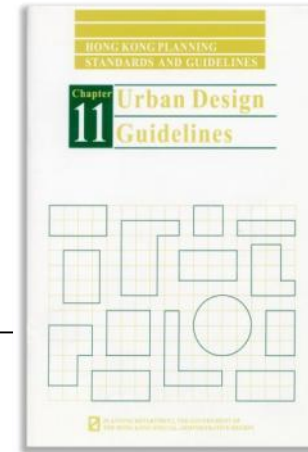
- Completion of 'Feasibility Study on Establishment of Air Ventilation Assessment (AVA) System' (AVA Study)

2006

- AVA incorporated into HKPSG Chapter 11
- HPLB-ETWB joint Technical Circular No. 1/06 on AVA promulgated
- 'Urban Climatic Map and Standards for Wind Environment Feasibility Study'** (the Study) commissioned

2009

- Technical Expert Workshops conducted on the methodology of the Urban Climatic Analysis Map

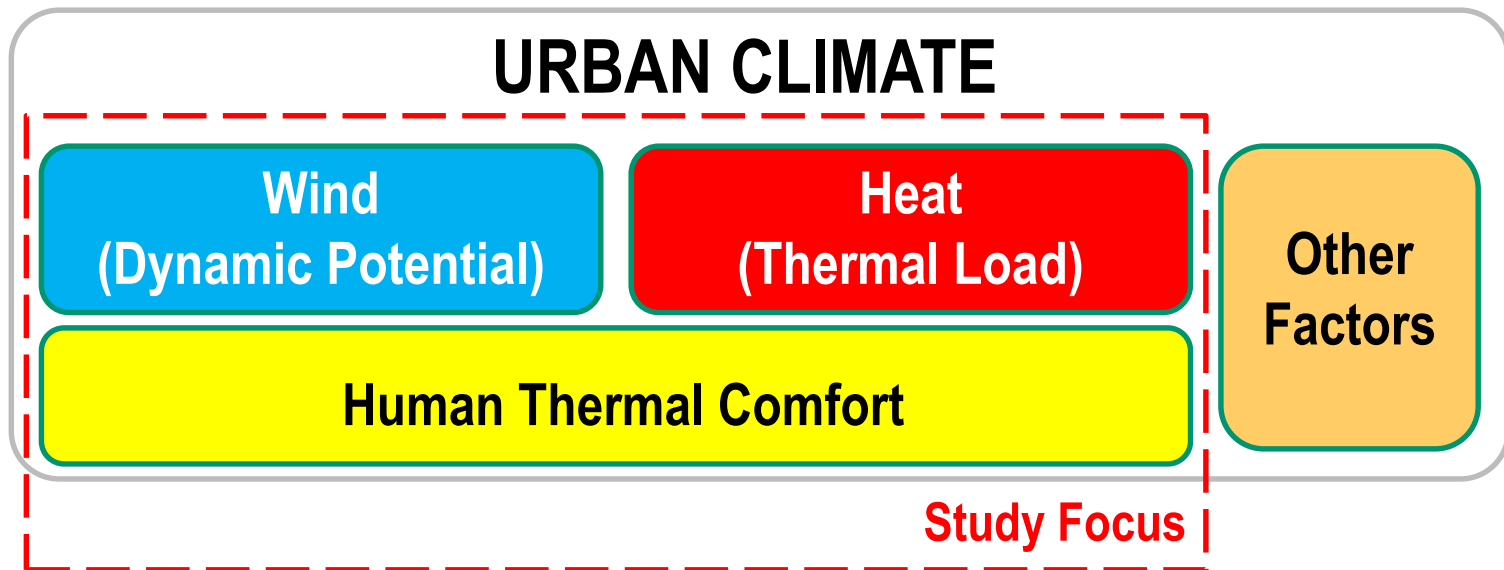


2010

- Sustainable Development Council's 51 recommendations include the UCMaP

Study Objectives

- Formulate **Urban Climatic Maps**
- Establish a **Wind Performance Criterion**
- Refine the **Air Ventilation Assessment System**

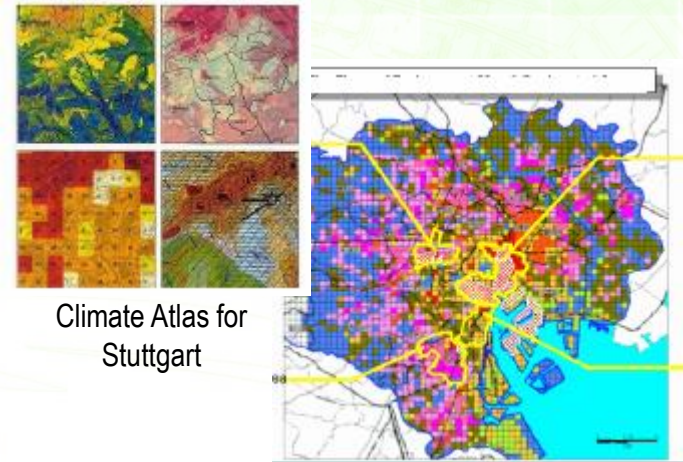


Urban Climatic Maps

URBAN CLIMATIC MAPS

Urban Climatic
Analysis
Map
(UC-AnMap)

Urban Climatic
Planning
Recommendations
Map (UC-ReMap)



Climate Atlas for
Stuttgart

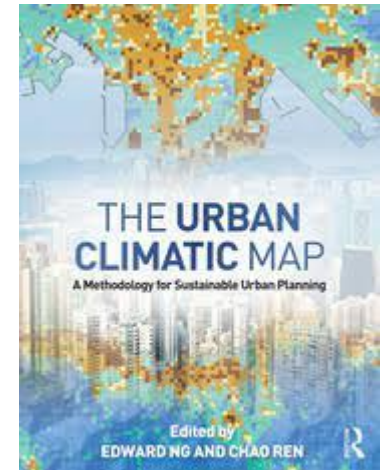
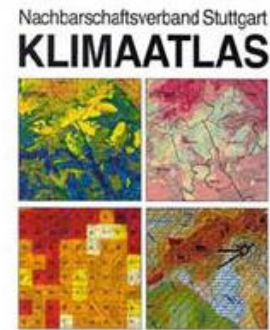
Urban Climatic Map Studies in Tokyo



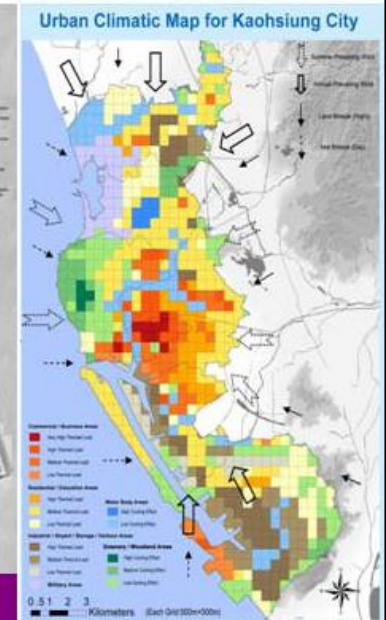
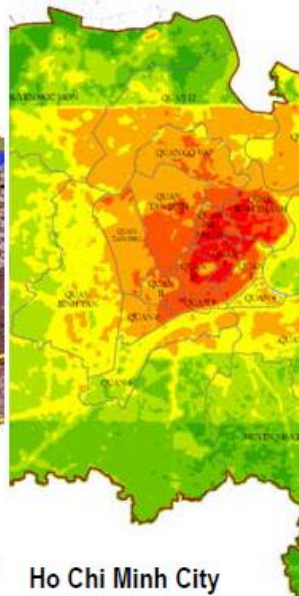
International Application of UC Map

Urban Climatic Maps

Urban Climatic Map for better planning – early Urban Climatic Map efforts in Germany and Japan



Recent Urban Climatic Map efforts by our team

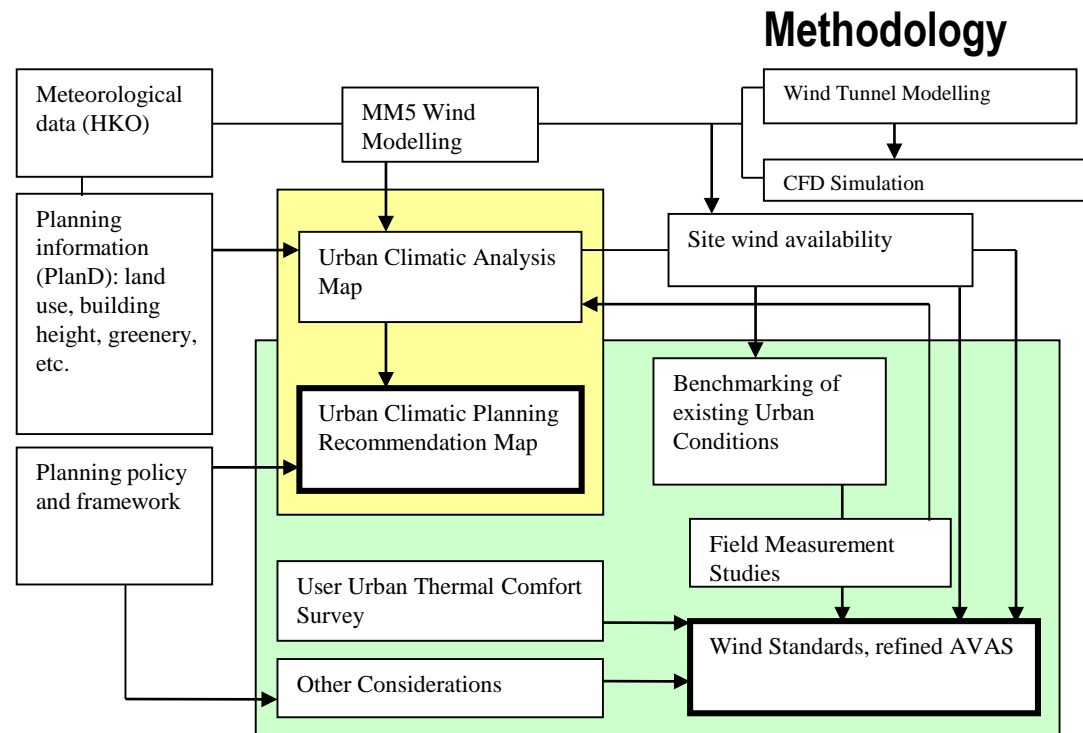


The Study

Objectives

For an urban climatic (District) level of understanding:

- Establish a strategic understanding of the urban climate of Hong Kong for district planning (Urban Climatic Analysis Map & Urban Climatic Planning Recommendation Map)



What influences Urban Climate?

Time

- day
- season

City location

- climate
- topography
- rural surrounds

Weather

- Wind
- Cloud
- Temperature
- RH
- Radiation

City form

- material & fabric
- structure
- building cover
- land use

City size

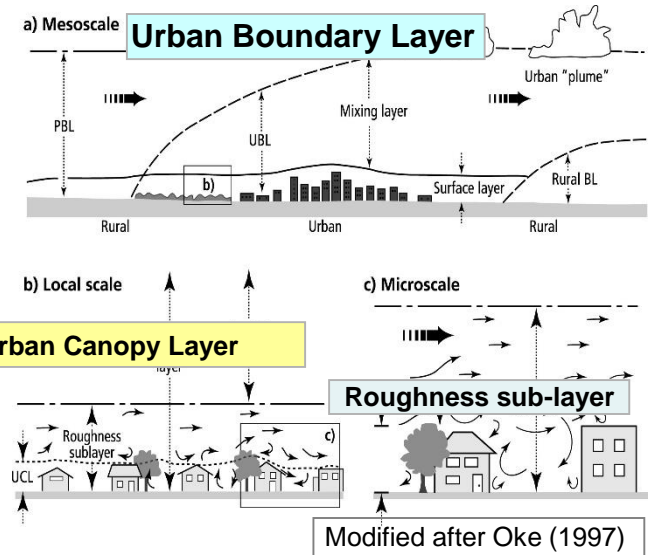
- size
- density of land uses

Urban Climate

‘Fixed’ – Location

‘Modulators’ – Time, Weather

‘Manageable’ (policy, **planning**, design) – **Size**, **Form**, Metabolism



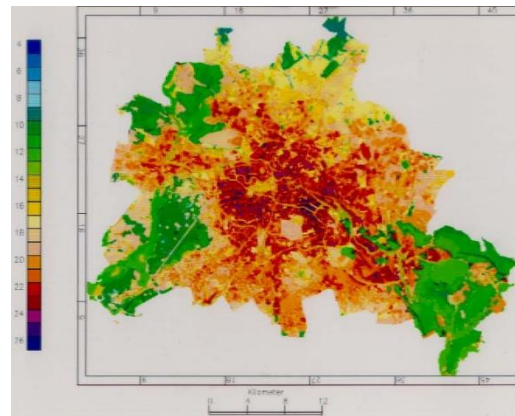
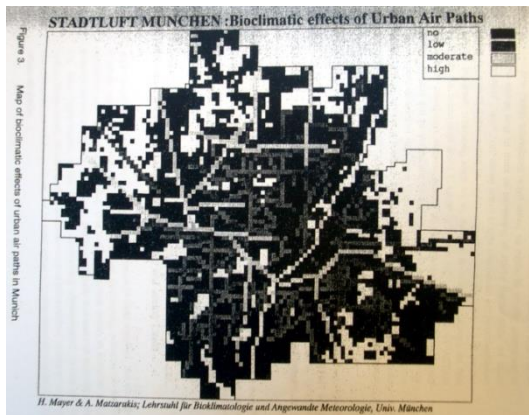
Every city is different, for sub-tropical climate, optimising the city environment for human thermal comfort in the summer months and providing urban air ventilation are essential considerations for planners

What is Urban Climatic Map?

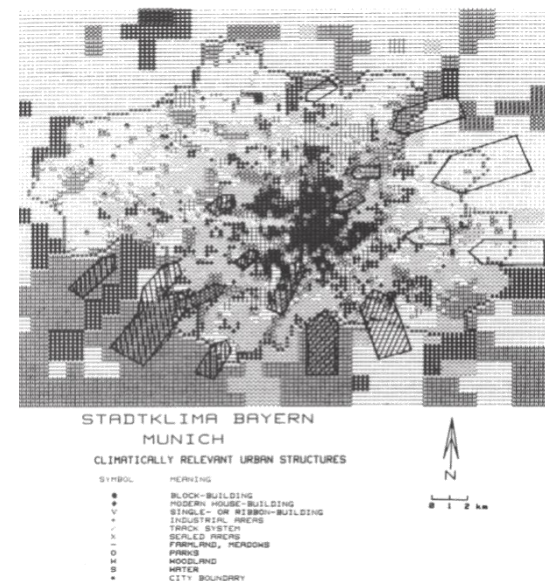
Urban Climatic Map integrates urban climatic factors and town planning considerations. It provides a **strategic information** platform and **urban climatic planning framework** to planners for making informed planning decisions.

Urban Climatic Map has 2 components:

- The Urban Climatic Analysis Map
- The Urban Climatic Planning Recommendation Map



Berlin UC-Maps 1988-1992



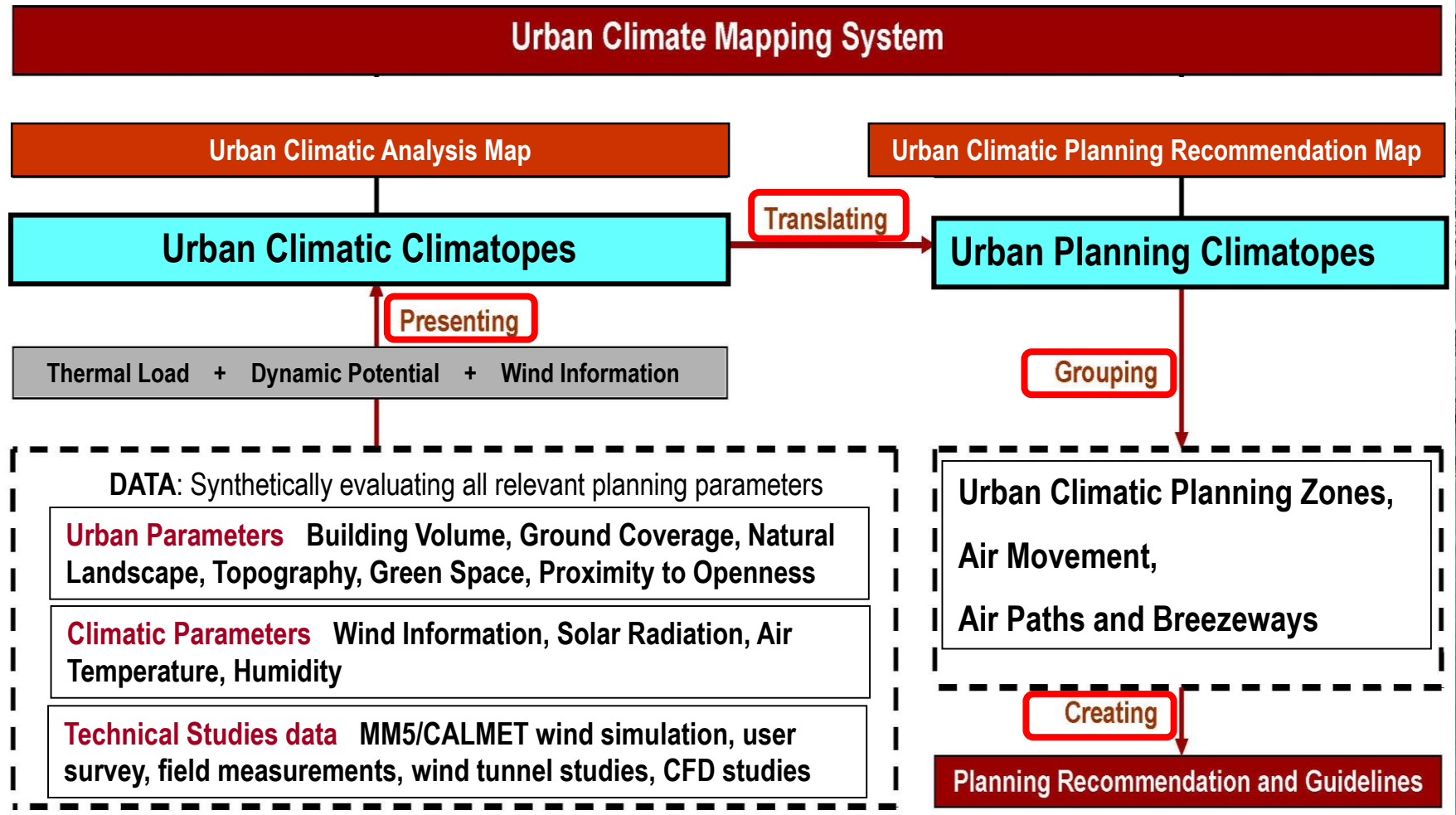
Examples and References



Many countries around the world, more advanced in Germany and Japan, have already formulated their Urban Climatic Maps.

The draft HK Urban Climatic Analysis Map

Framework of Hong Kong Urban Climatic Maps



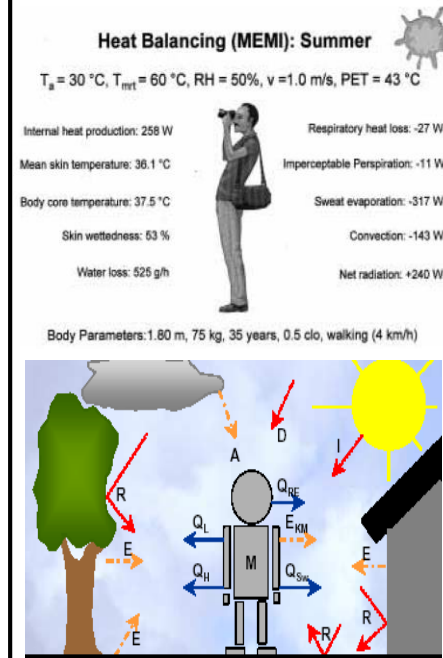
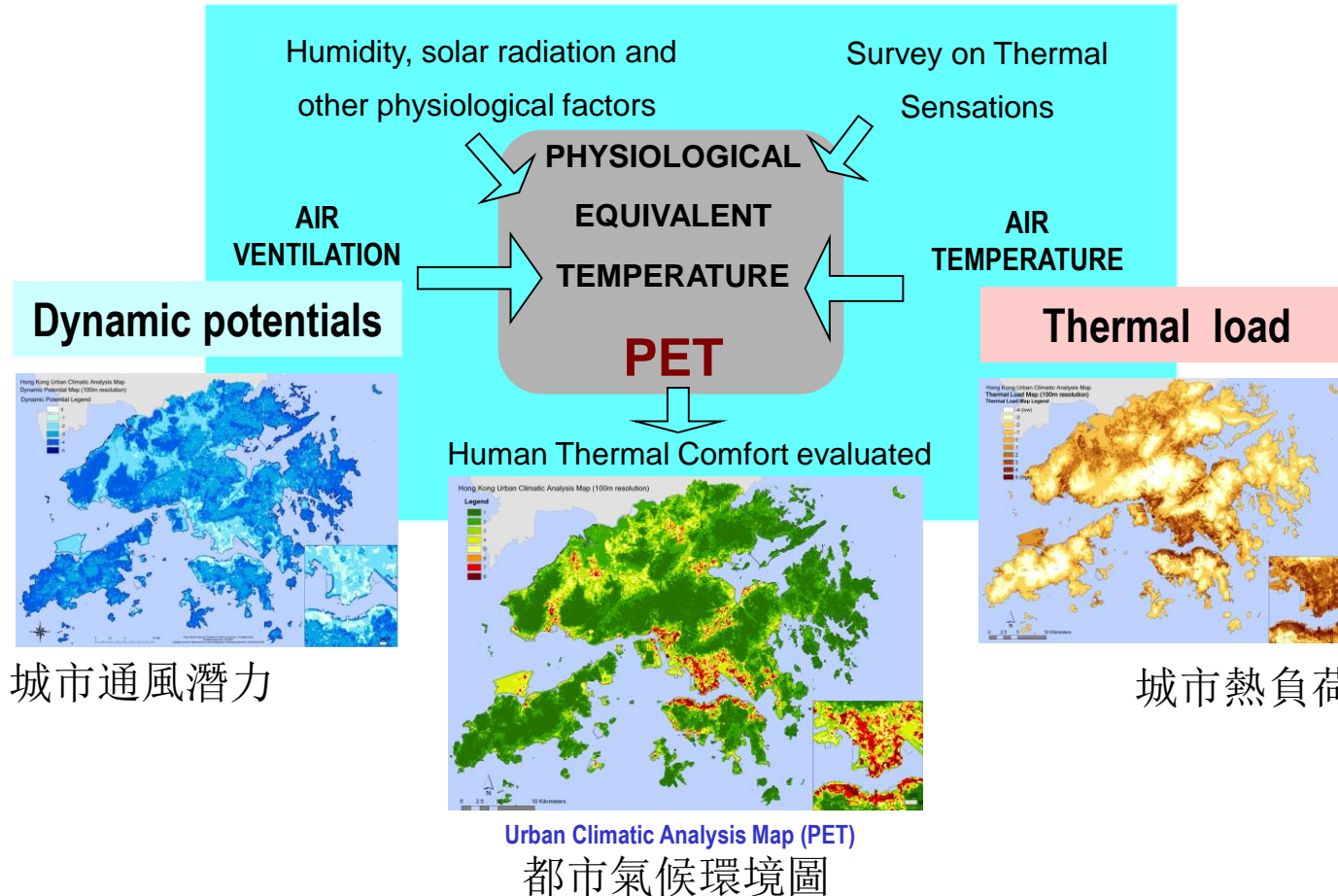
The draft HK Urban Climatic Analysis Map

The concept of

人體熱能(等效)溫度

Physiological Equivalent Temperature (PET)

as the synergizing variable for the HK Urban Climatic Analysis Map



note

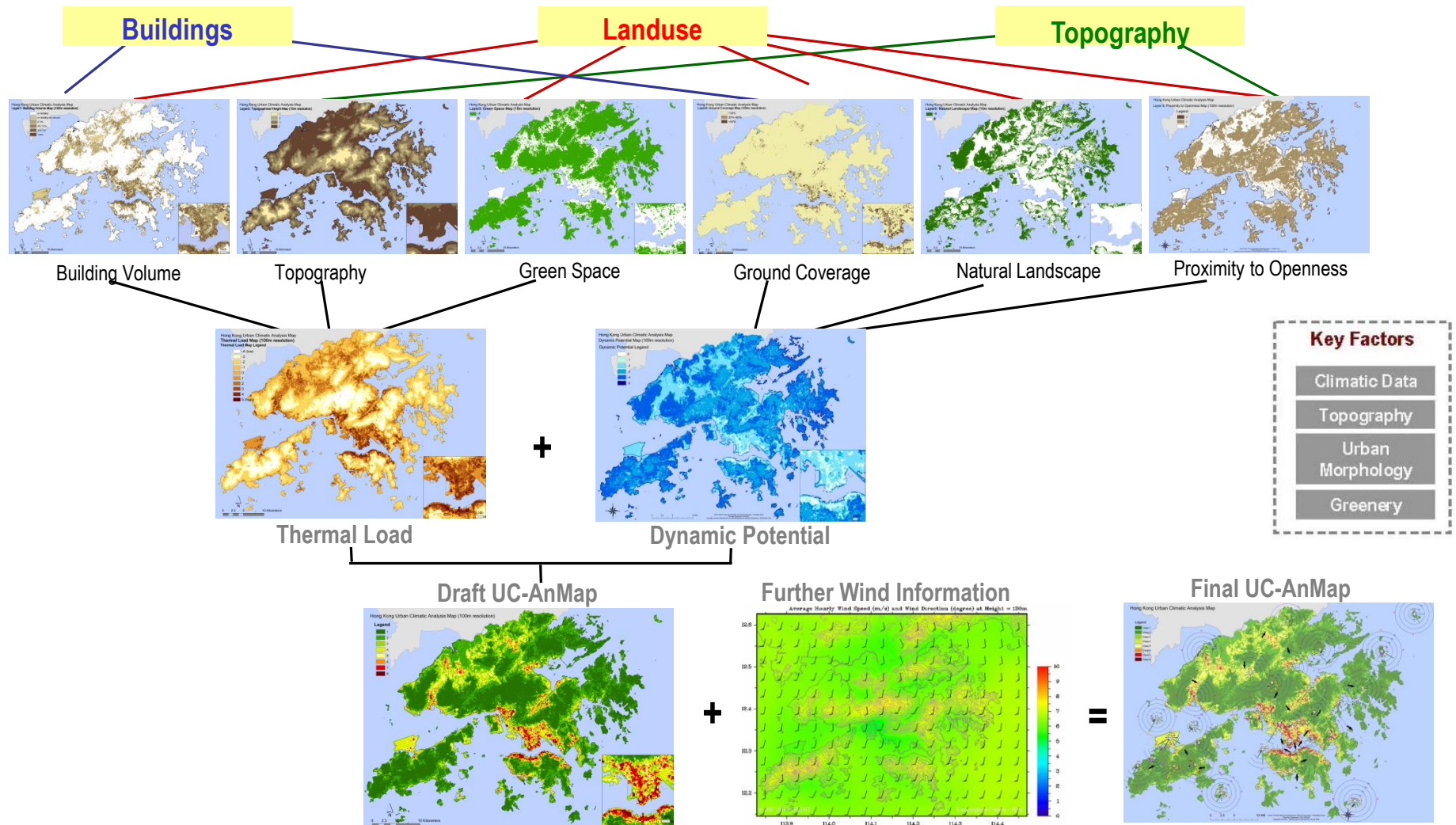
Physiological Equivalent Temperature (PET) is the temperature of a reference environment based on a heat balance model that combines various climatic and physiological variables including air temperature, relative humidity, solar radiation, air movement, clothing and metabolic rate to give a synergetic indication of human thermal comfort. It is an index widely used to understand the thermal comfort environment

城市通風潛力

城市熱負荷

The draft HK Urban Climatic Analysis Map

Layer structure of UC-AnMap

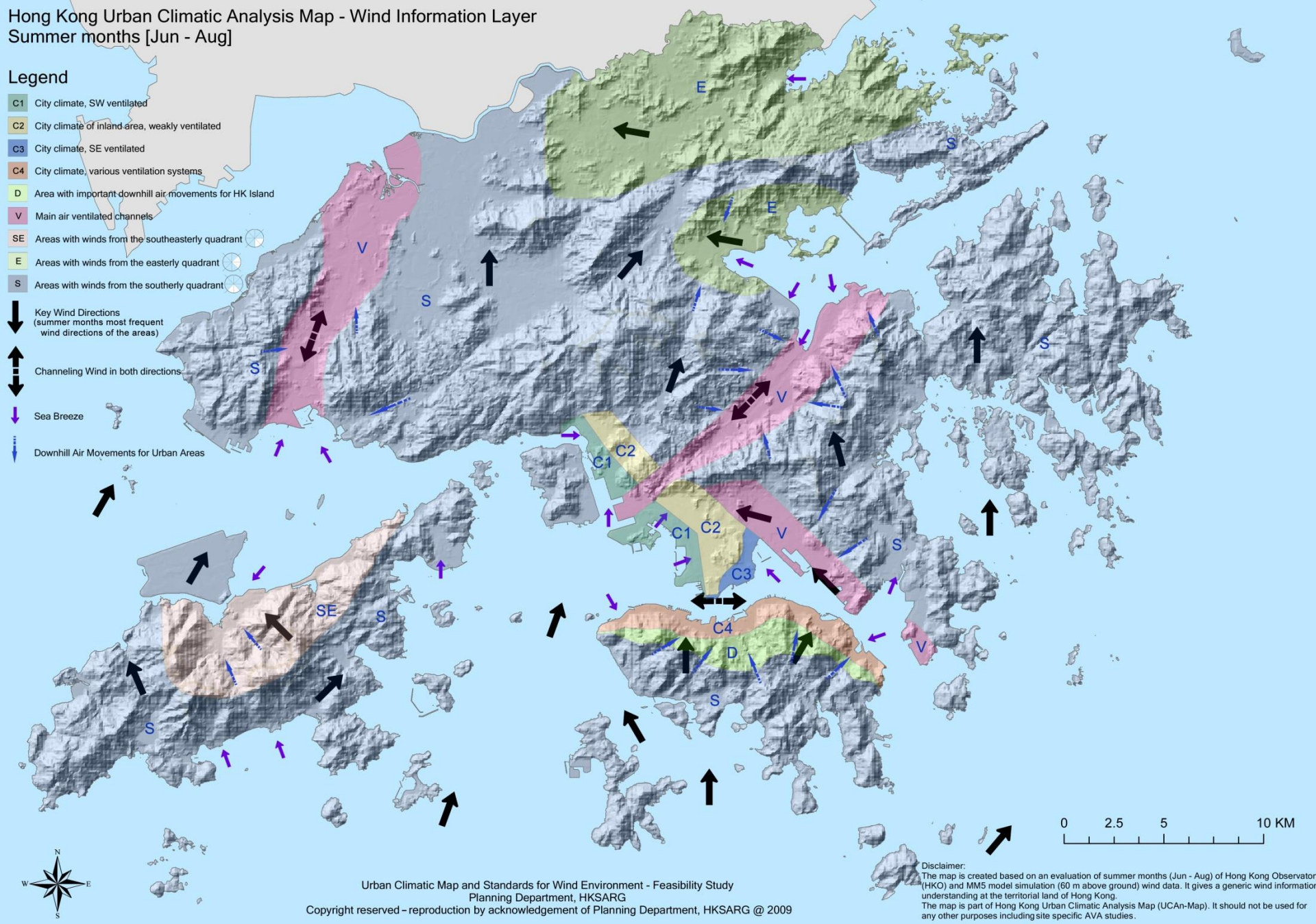


Hong Kong Urban Climatic Analysis Map - Wind Information Layer

Summer months [Jun - Aug]

Legend

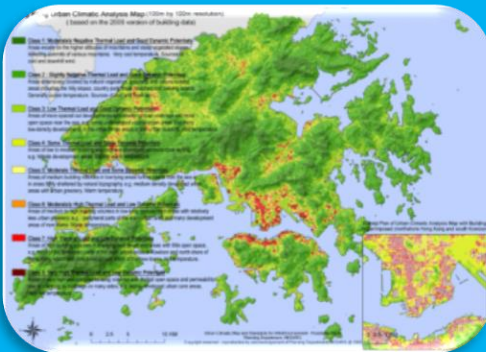
- C1 City climate, SW ventilated
- C2 City climate of inland-area, weakly ventilated
- C3 City climate, SE ventilated
- C4 City climate, various ventilation systems
- D Area with important downhill air movements for HK Island
- V Main air ventilated channels
- SE Areas with winds from the southeasterly quadrant
- E Areas with winds from the easterly quadrant
- S Areas with winds from the southerly quadrant
- Key Wind Directions (summer months most frequent wind directions of the areas)
- Channeling Wind in both directions
- Sea Breeze
- Downhill Air Movements for Urban Areas



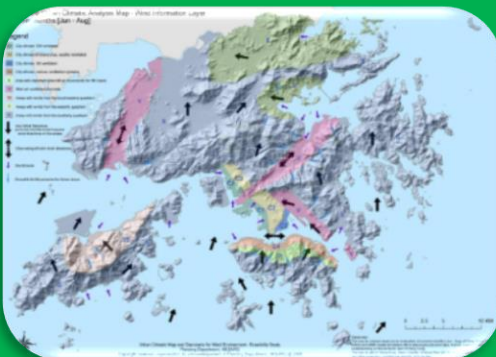
Urban Climatic Maps

UC-AnMap

UC-AnMap








Wind Information



Wind Information

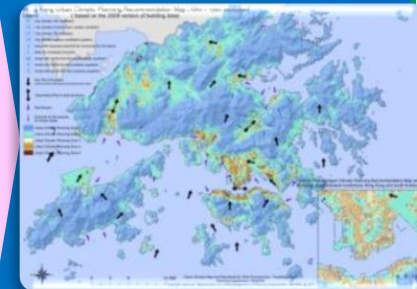
UC-ReMap

UC-AnMap 8 Urban Climatic Classes

No	Urban Climatic Analysis Class	Impact on Thermal Comfort	Urban Climatic Planning Zone (UCPZ)
1	Moderate negative Thermal Load and Good Dynamics Potentials	Moderate	UCPZ 1  Urban climatically valuable area
2	Some negative Thermal Load and Good Dynamics Potentials	Slight	
3	Low Thermal Load and Good Dynamics Potentials	Neutral	UCPZ 2  Neutral urban climatically sensitive area
4	Some Thermal Load and Some Dynamics Potentials	Slight	
5	Moderate Thermal Load and Some Dynamics Potentials	Moderate	UCPZ 3  Moderate urban climatically sensitive area
6	Moderately High Thermal Load and Low Dynamics Potentials	Moderately strong	UCPZ 4  Highly urban climatically sensitive area
7	High Thermal Load and Low Dynamics Potentials	Strong	
8	Very High Thermal Load and Low Dynamics Potentials	Very strong	UCPZ 5  Very highly urban climatically sensitive area

UC-ReMap 5 Urban Climatic Planning Zones

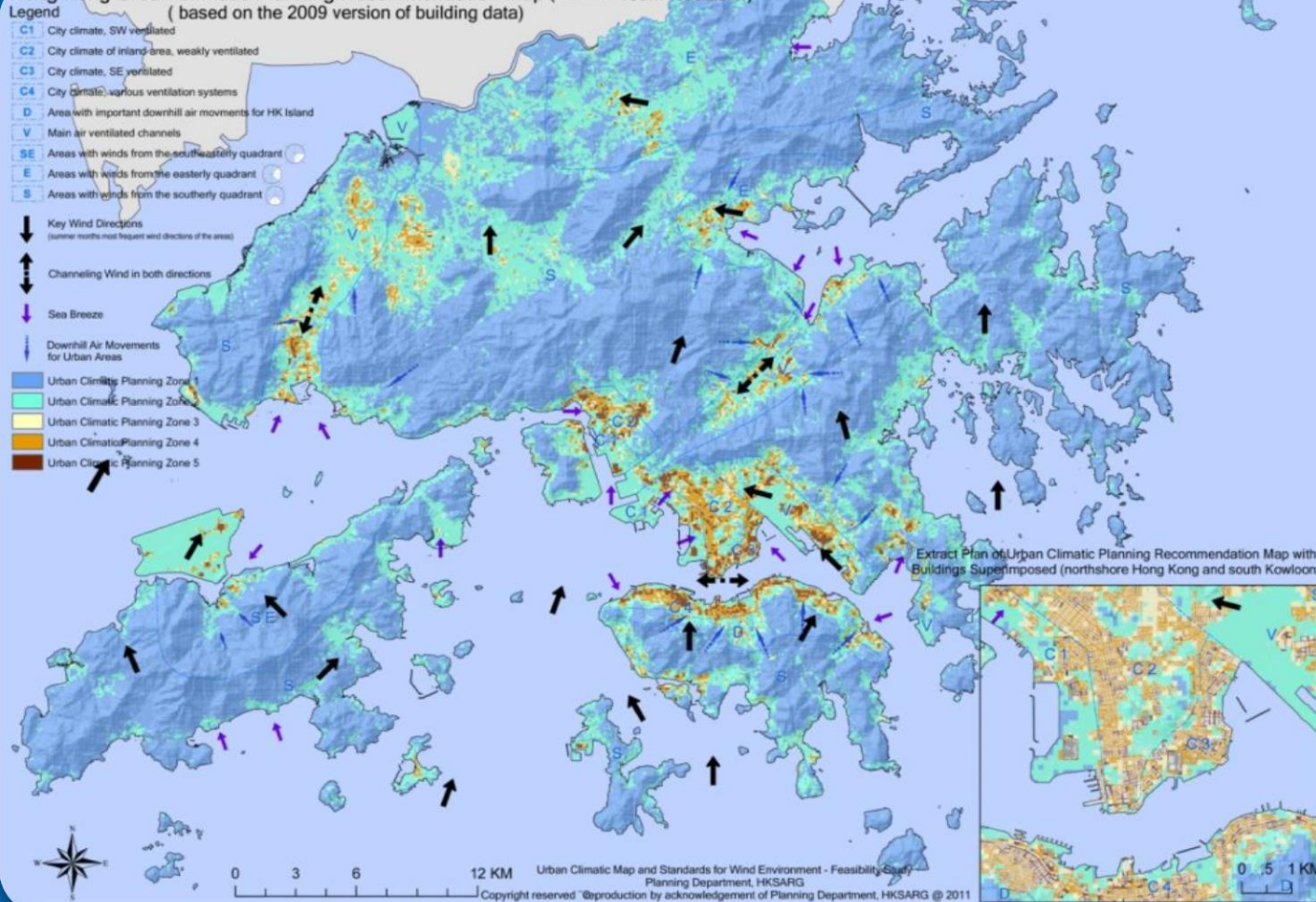
UC-ReMap



Urban Climatic Maps

UC-AnMap

Hong Kong Urban Climatic Planning Recommendation Map (100m × 100m resolution)
(based on the 2009 version of building data)



UC-ReMap

UCPZ 1

UCPZ 2

UCPZ 3

UCPZ 4

UCPZ 5

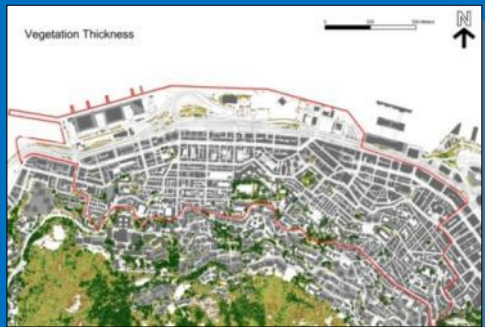
Urban Climatic Maps

UC-AnMap

UC-ReMap

Application:-

- Identifies appropriate **planning and design measures to improve urban climate**
- Provides a **strategic urban climatic information platform** for guiding the planning and development process for future development, e.g. the location of new development areas in UCPZ 2
- Provides an **urban climatic planning framework** for reviewing statutory town plans and formulating suitable planning parameters



Understanding



Analysis



Strategies

Reference should also be made to strategic and district considerations and site circumstances

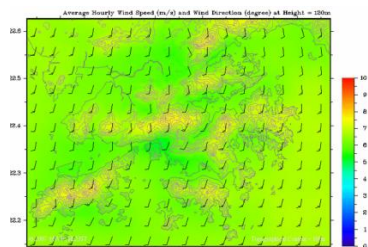
Urban Climatic Maps and HK's Planning Framework

Urban Climatic Maps and HK's Planning Framework

Urban Climatic Analysis Map



+



Wind information



Urban Climatic Planning Recommendation Map



inform



法定圖則
Statutory Plan

Provide boundary conditions and background understanding for

Detail further additional studies:
Micro-climatic and AVA



發展大綱圖
Outline Development Plan



詳細藍圖
Layout Plan



全港發展策略
Territorial Development Strategy



香港規劃標準與準則
Hong Kong Planning Standards & Guidelines

技術通告 空氣流通評估方法技術指南

房屋及規劃地政局 + 環境運輸及工務局

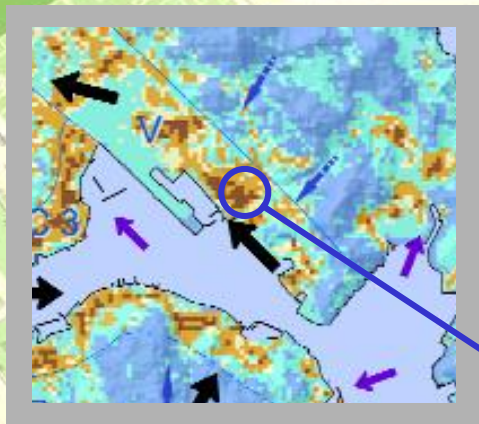
**HOUSING, PLANNING AND LANDS BUREAU TECHNICAL CIRCULAR
NO. 1/06 ENVIRONMENT, TRANSPORT AND WORKS BUREAU
TECHNICAL CIRCULAR NO. 1/06 (*version 2, 2012*)**



**HONG KONG PLANNING STANDARDS
AND GUIDELINES**

Ch11 Urban Design Guidelines

11. Guidelines on Air Ventilation & Urban Climate



No “wall” building

Not 100% site coverage

Greening Intensified at grade

Setback from narrow streets

Permeable podium

Inner-site air corridor & air-path connectivity

<http://www.ura.org.hk/en/projects/redevelopment/kwun-tong-town-centre-project/project-update.aspx>

觀塘市中心重建計劃：建築物空間分佈妥善，令景觀開揚及空氣流通，達到優良效果。

Kwun Tong Town Centre redevelopment: Buildings are adequately spaced out to maximise views and air ventilation.



走入新觀塘市中心，綠樹成陰將令你目不暇給。
市建局模擬圖片

深入其中



■新市鎮內，除有現代化商場外，亦保留傳統小店舖。



改造後的觀塘中心，有60層高的商廈（圖右），亦有五幢住宅大廈。

未來社區

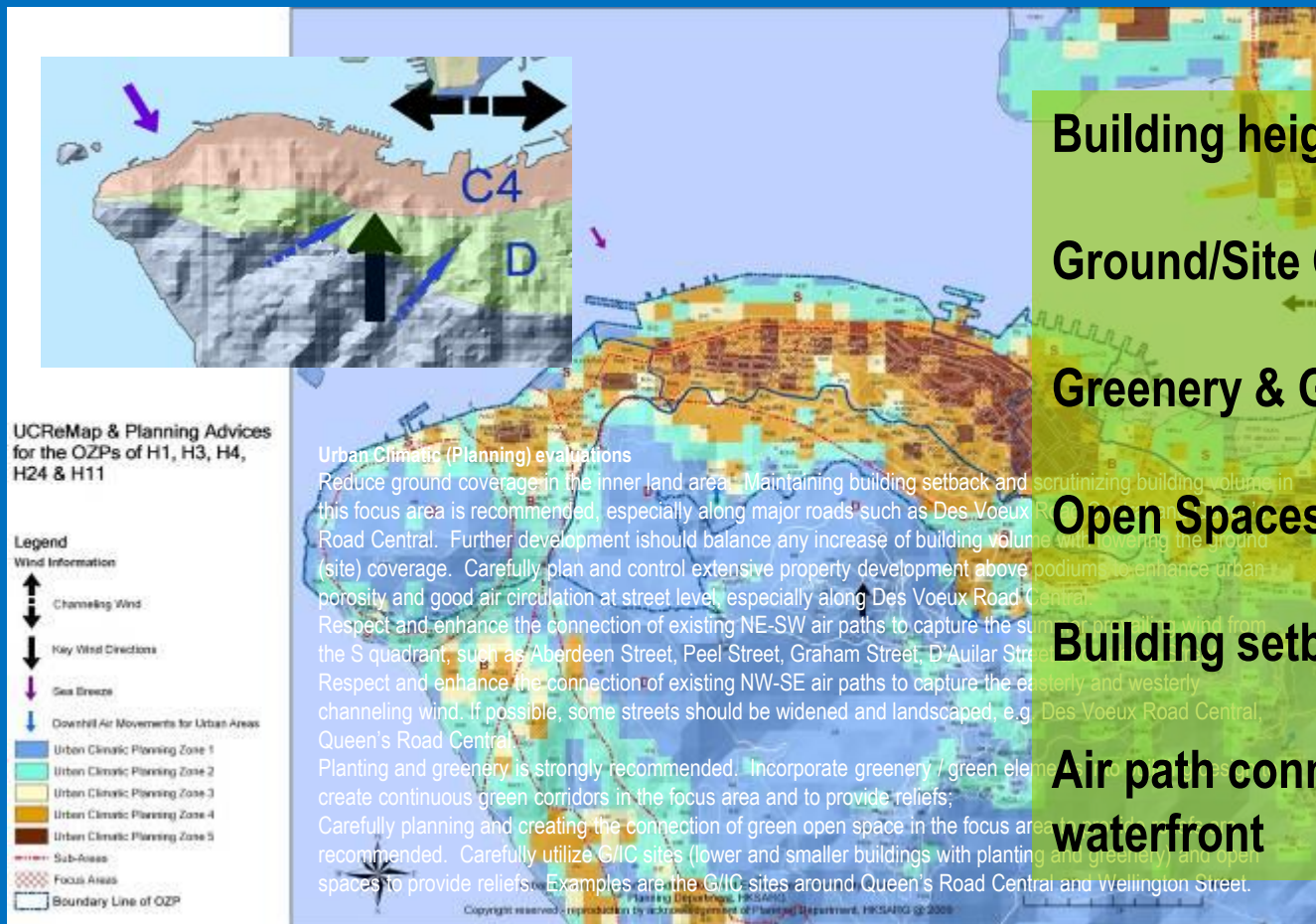
現在 市建局決用300億元，改造舊樓林立的觀塘部份地區（紅線內），計劃需時12年。



Urban Climatic Maps – OZP Reviews

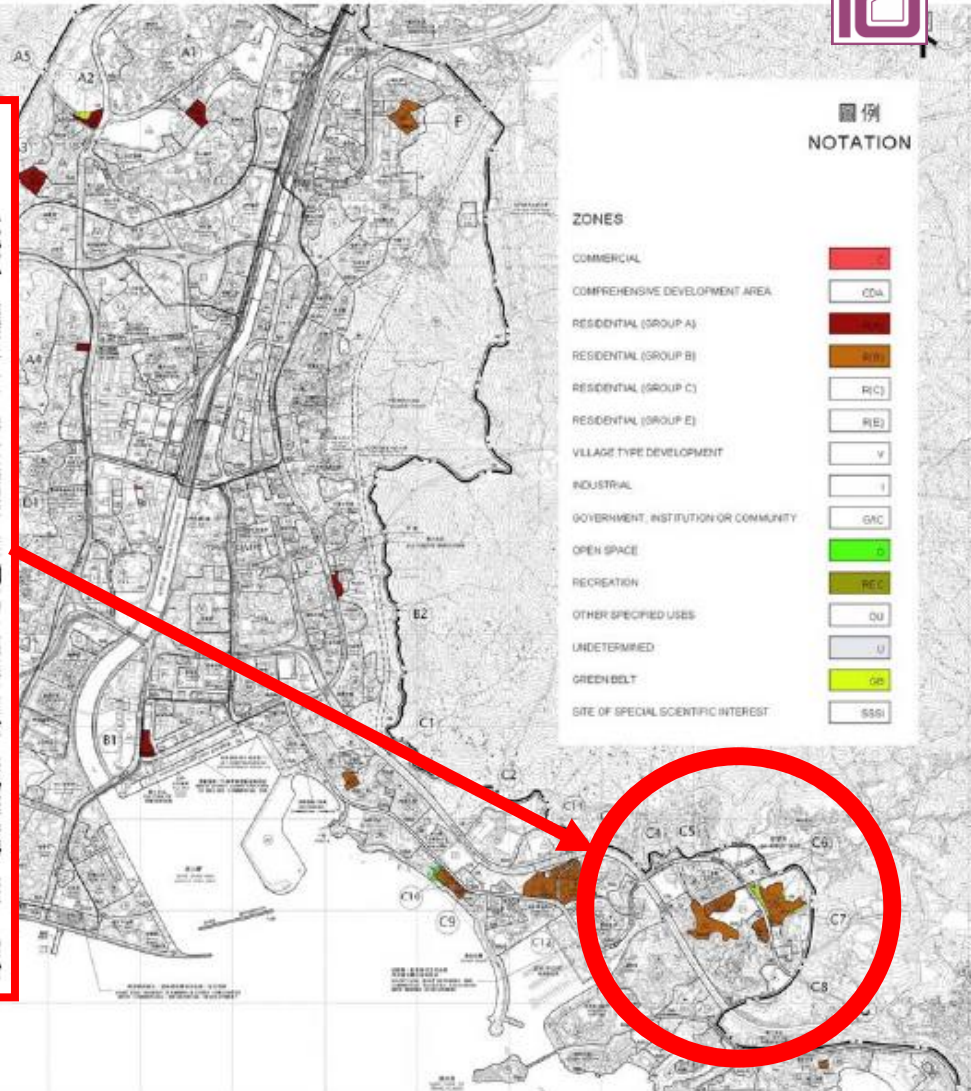
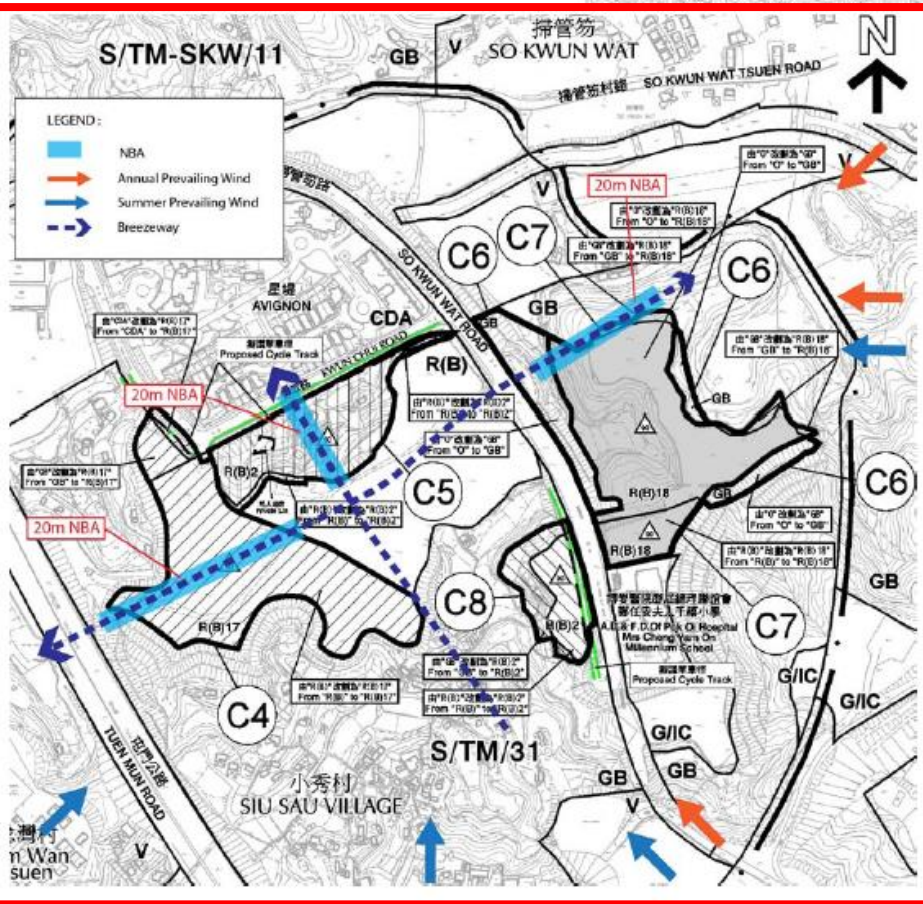
UC-AnMap

UC-ReMap

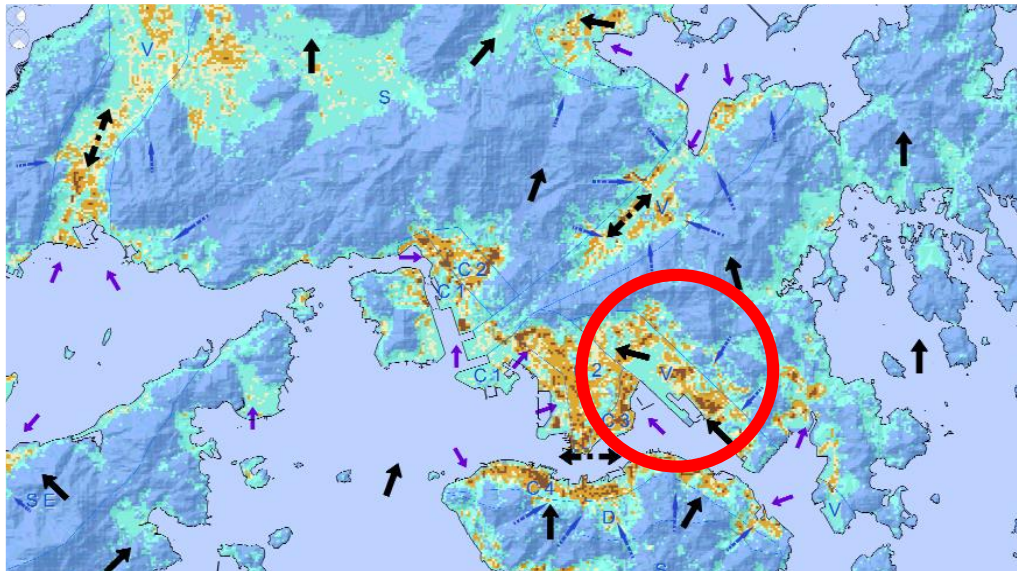
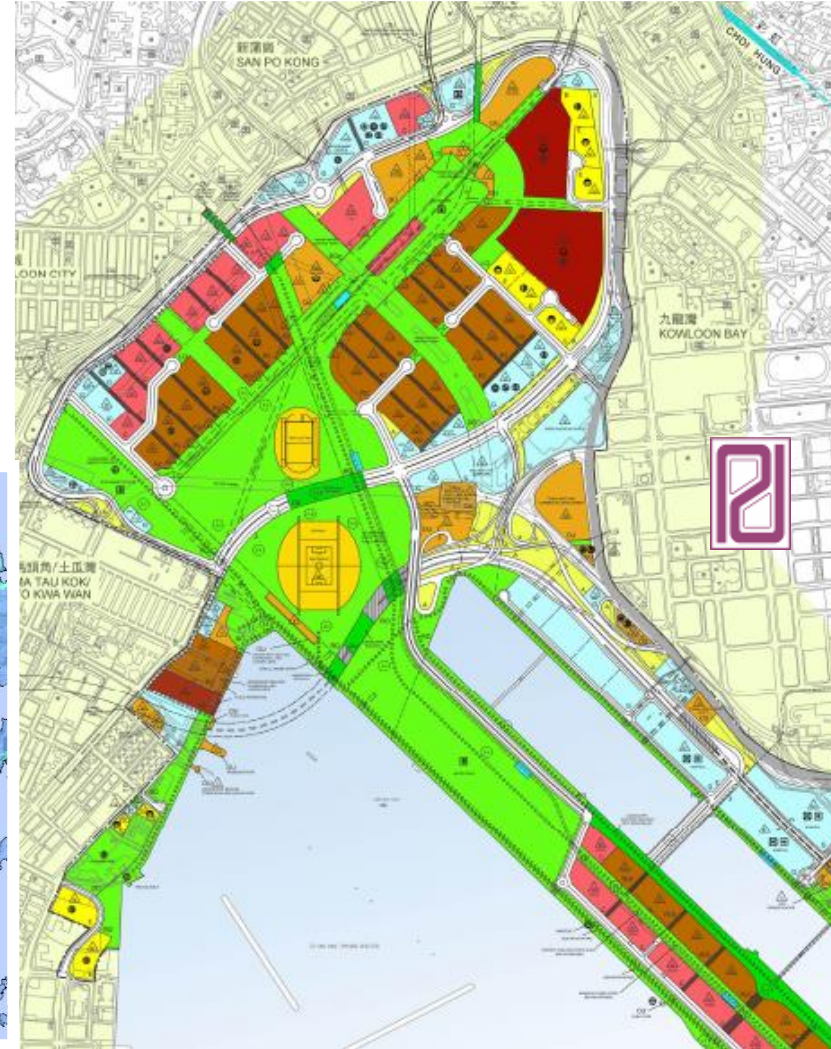
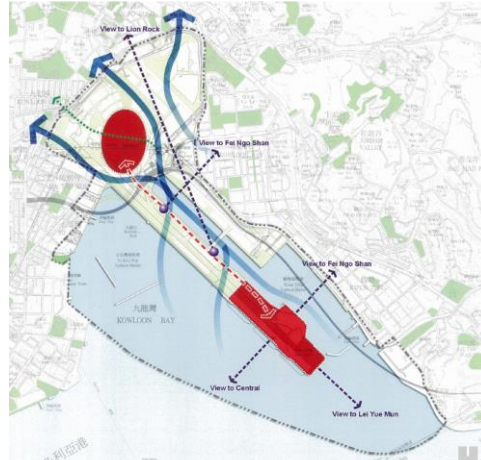
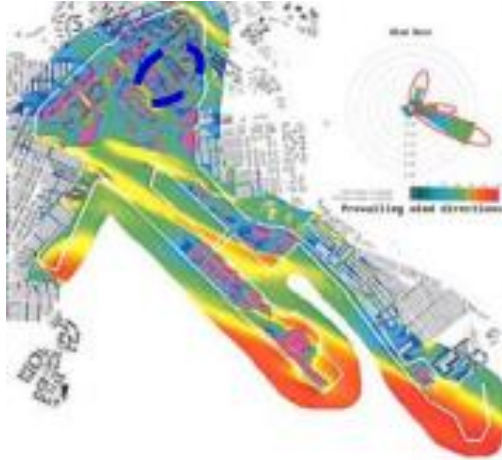


An example of OZP Review utilising the UC-Map understanding

Urban Climatic Maps – OZP Reviews



Urban Climatic Maps – NDA Reviews

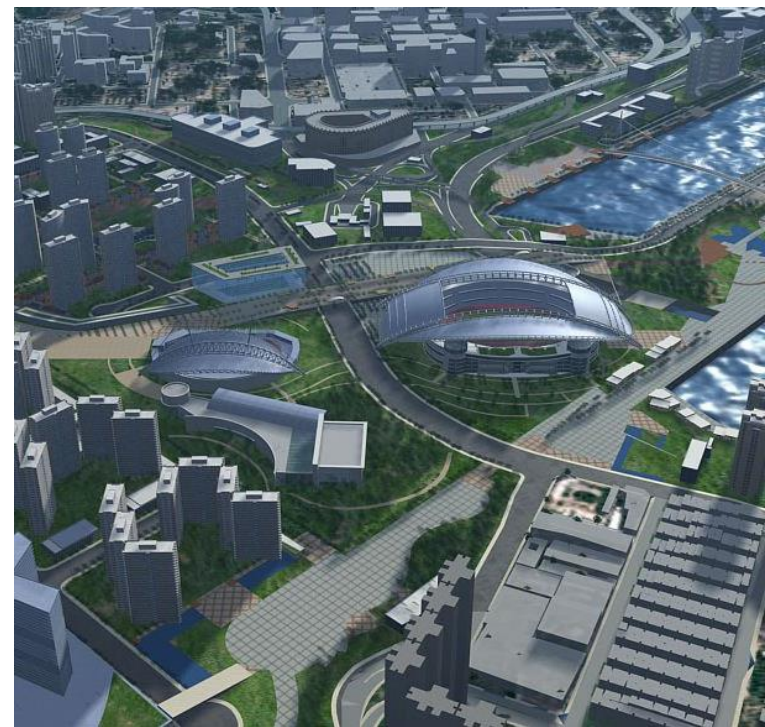


Urban Climatic Maps – NDA Reviews



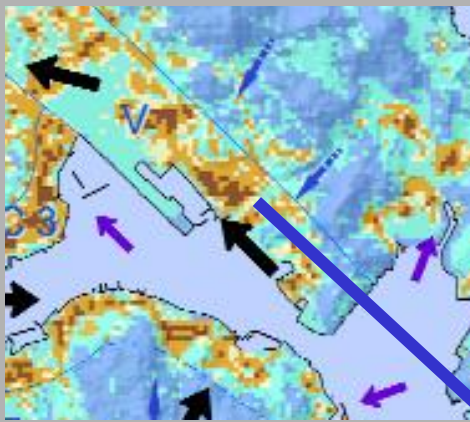
Yau Ma Tei
Government
Land

Kowloon East



Layout and Building Design 布局和建筑物设计

Urban Climatic Maps – Project Reviews



總體規劃大綱示意圖
NOTIONAL MASTER LAYOUT PLAN

No “wall” building

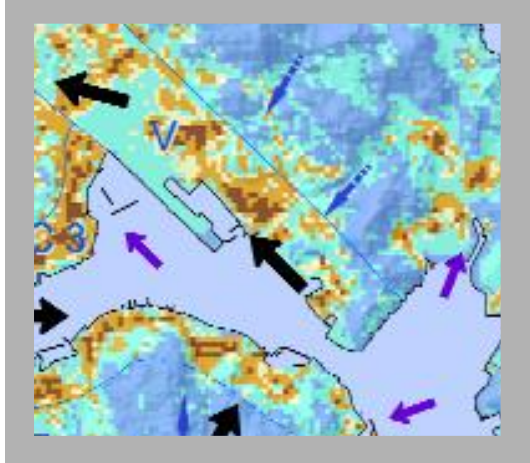
Not 100% site coverage

**Greening
Intensified at
grade**

**Setback from
narrow streets**

**Permeable
podium**

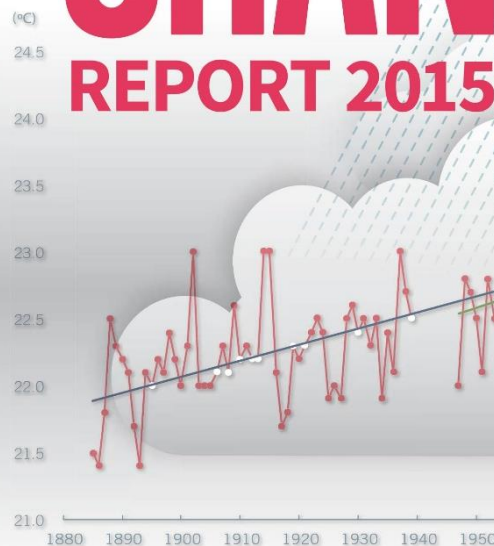
Urban Climatic Maps – Project Reviews



KWUN TONG
TOWN CENTRE PROJECT



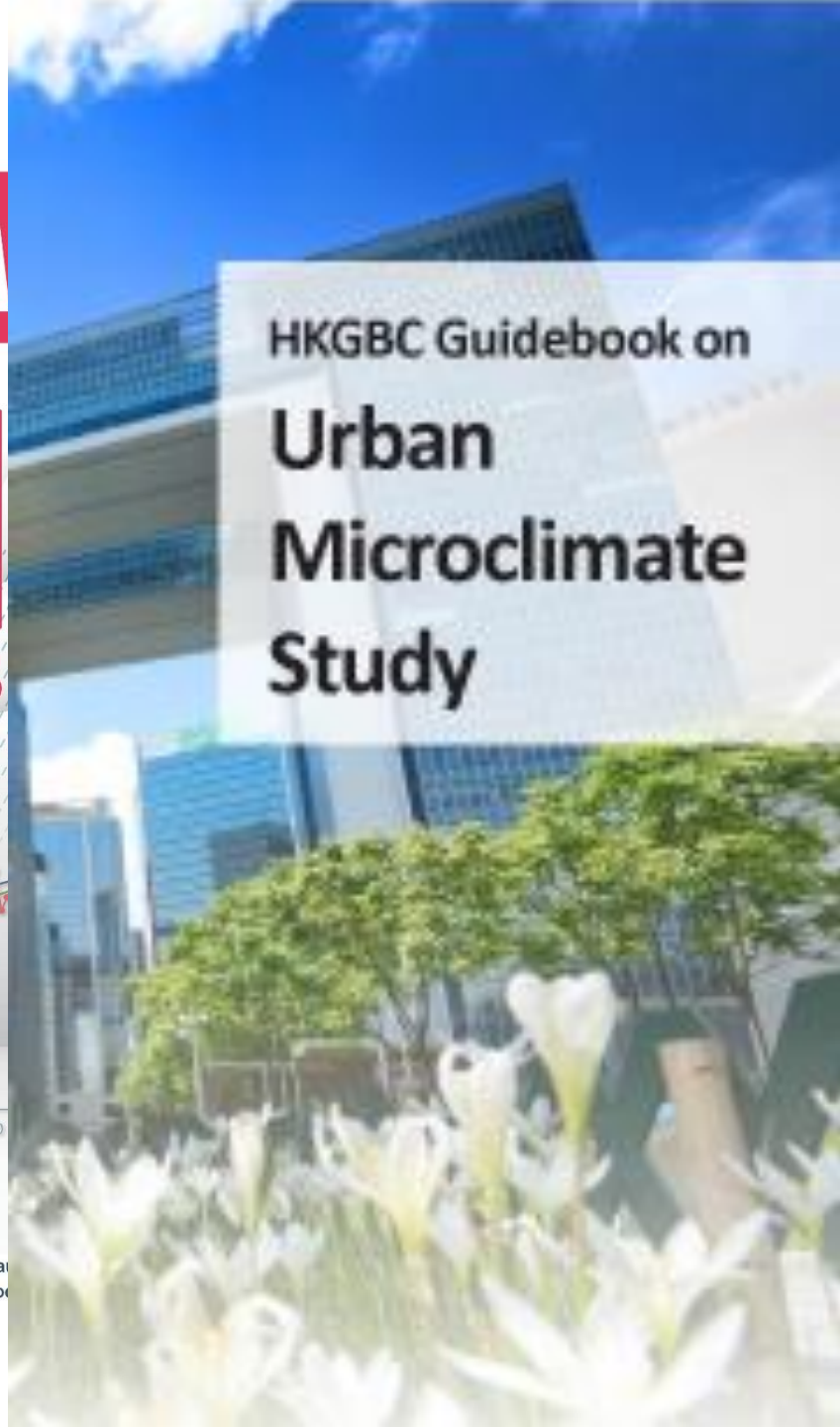
HONG KONG CLIMATE CHANGE REPORT 2015



Environment Bureau in collaboration with
Development Bureau | Transport & Housing Bureau
Commerce & Economic Development Bureau | Food and Environmental Hygiene Department

November 2015

HKGBC Guidebook on Urban Microclimate Study



風水綠家園

Eco - Planning of Kaohsiung City by Using Urban Climatic Map



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The Chinese University of Hong Kong

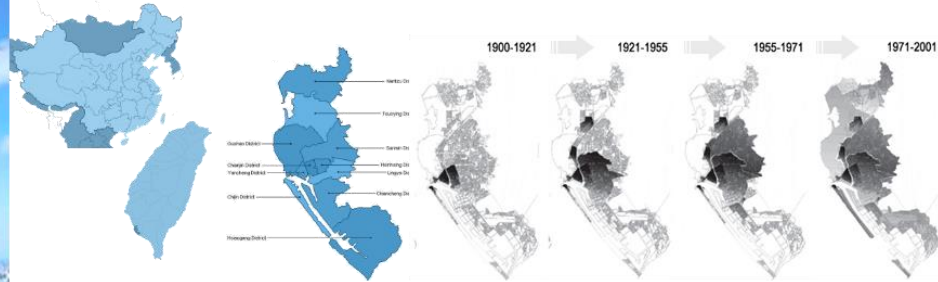


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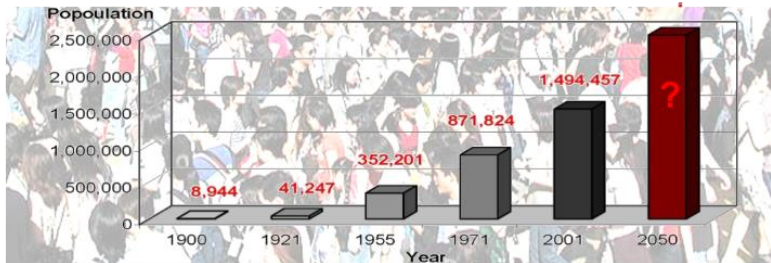
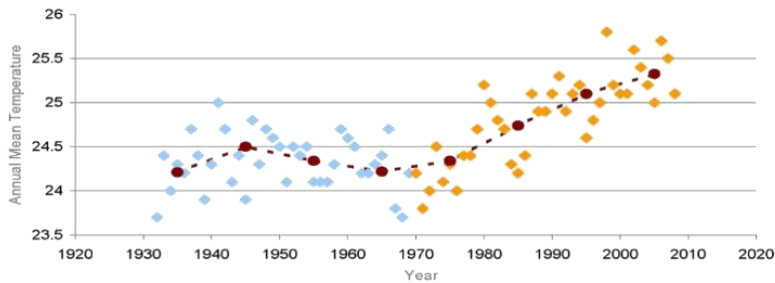


Introduction

Recently, facing the global climate change, **climatic adaptation** and **sustainable development** are the two main targets for the Kaohsiung government. Our study aims to create the eco-planning by using **Urban Climatic Map**, which provides a synthetic evaluation on current climatic and environmental conditions and strategic planning recommendations of Kaohsiung city.

Achievements of the Study

- An Urban Climatic Map has been created to guide better eco-planning to improve the living quality of Kaohsiung
(繪製高雄都市氣候環境圖，指導生態規劃設計，提升市民生活品質);
- The Urban Climatic Map acts as a platform for international collaborations of topical issues of global concern on climate change
(構建國際交流平台，應對全球氣候變化議題);
- Strategic sustainable development recommendations have been proposed for the politicians, governors and the general public to focus their efforts to create a world-class city of Kaohsiung
(製定策略性可持續發展規劃建議，令高雄邁向國際化都市);

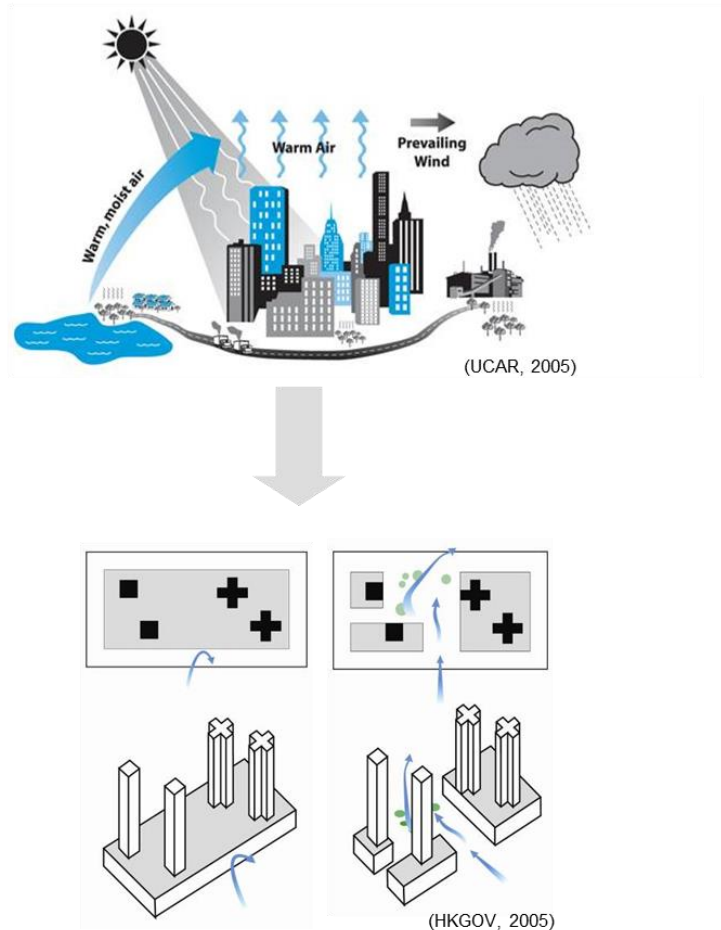


Problem & Challenge

Kaohsiung City is a coastal city with a high population density situated in the sub-tropical climate region with hot and humid summers. It went through a period of major urbanization in the last half century. Recently Kaohsiung is facing several problems and challenges, which degrades living quality and threatens public health.

1. Air temperature goes up faster since the 1970s.
2. Air pollution problem needs to be improved.
3. High urban density exists.
4. Population continues to increase.
5. Urban Heat Island intensifies people's discomfort.

Thus, there is a need to optimize the urban planning so as to achieve a more comfortable and healthier urban living environment.



Study & Design Concept

The study focuses on four urban climatic and environmental aspects to analyze and to make design strategies.



means the urban climatic information, especially wind and urban heat island information.



means the water system including rivers, ponds, lakes and sea.



means the greenery, forest and open space.



means the urban context and structure information, including the land use and planning information.

Thermal and **Air Ventilation Environment** will be the focus and subject of the study. They are particularly in relationship to the **Thermal Stress** and **Dynamic Potential** of the urban environment. They are two significant urban climatic factors for town planning and urban design in Kaohsiung.

Methodology

Data Collection & Evaluation

- Meteorological Data from Taiwan Central Weather Bureau
- Land use and Planning Data from Urban Development Bureau, Kaohsiung Gov.
- Population Data from Department of Budget, Accounting & Statistics, Kaohsiung Gov.
- Simulated Climatic Data from Reports on INTA and Kaohsiung Gov.' website

Thermal Stress

- Topography
- Population Density
- Land Use
- Urban Heat Island Intensity

Dynamic Potential

- Natural Landscape
- Sea & River

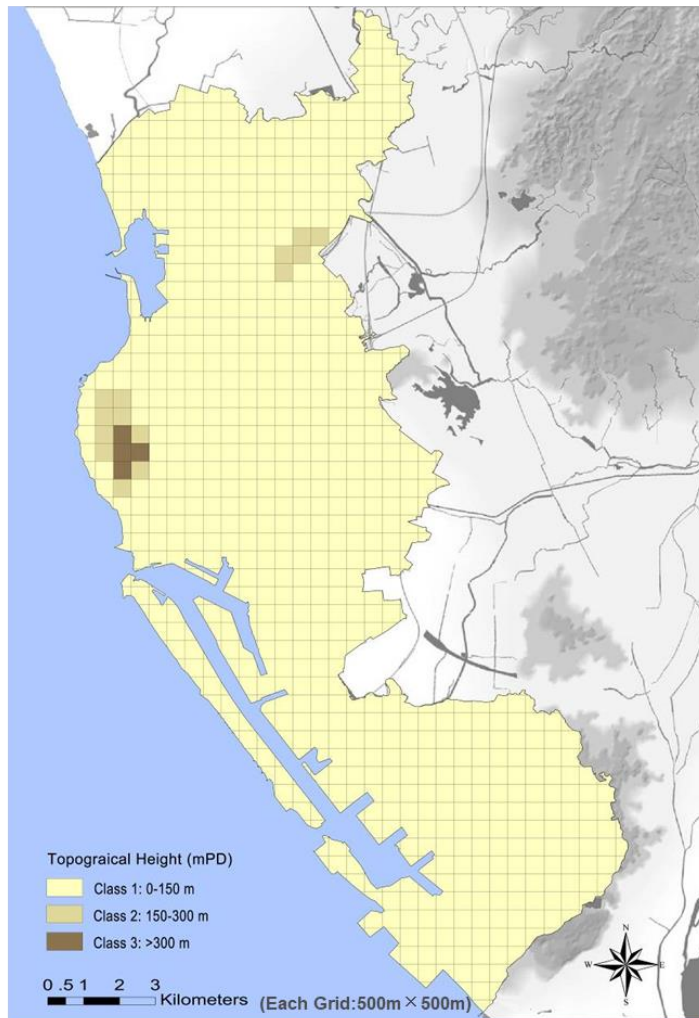
Wind Information

- Prevailing Wind Information
- Land & Sea Breezes Effect

Develop Basic Input Layers

Evaluation & Analysis

Kaohsiung Urban Climatic Map & Planning Recommendations

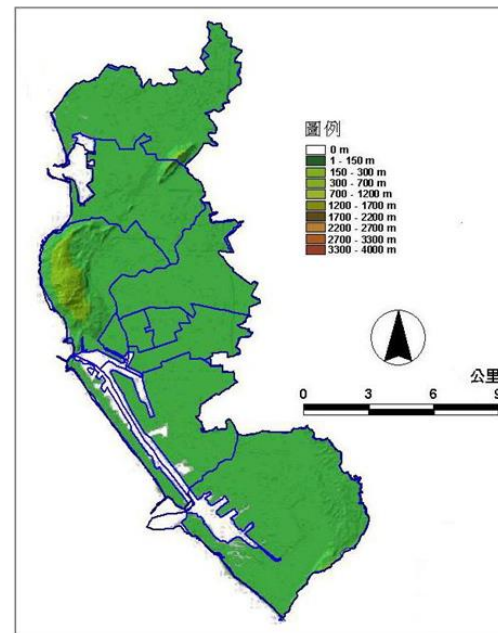


Thermal Stress – Layer 1 : Topography

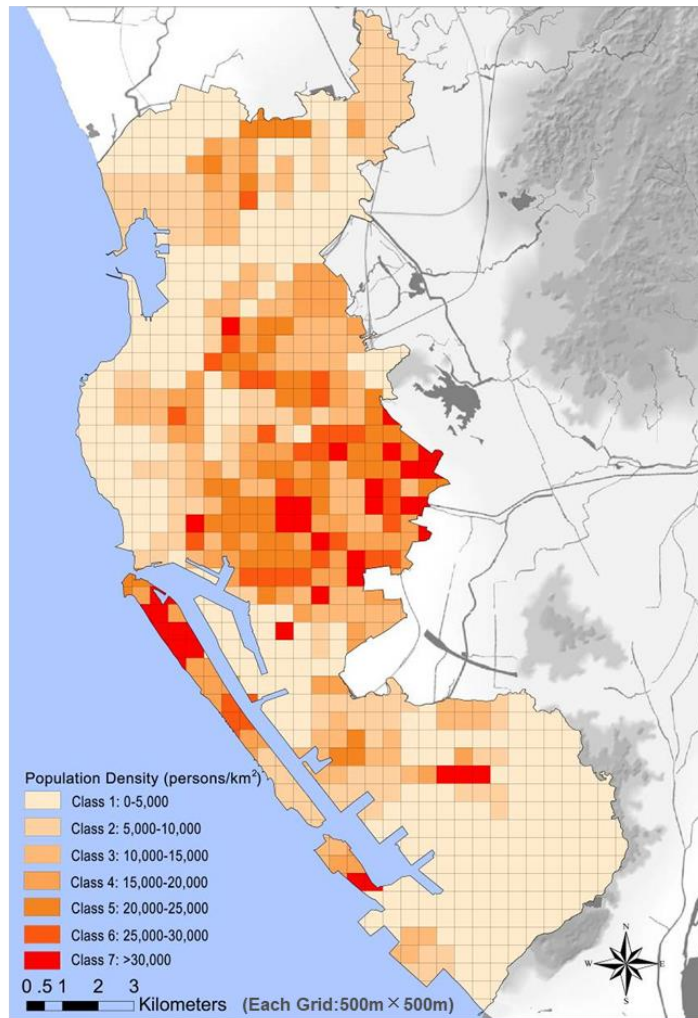
The whole area of Kaohsiung city is almost flat. There are only two small mountains. So the topographical cooling effect is limited in Kaohsiung.

- Banpingshan: 233m
- Shoushan (Chaishan): 356m

The classification of this layer is based on the topographical height.



(高雄都市發展局, 2009)

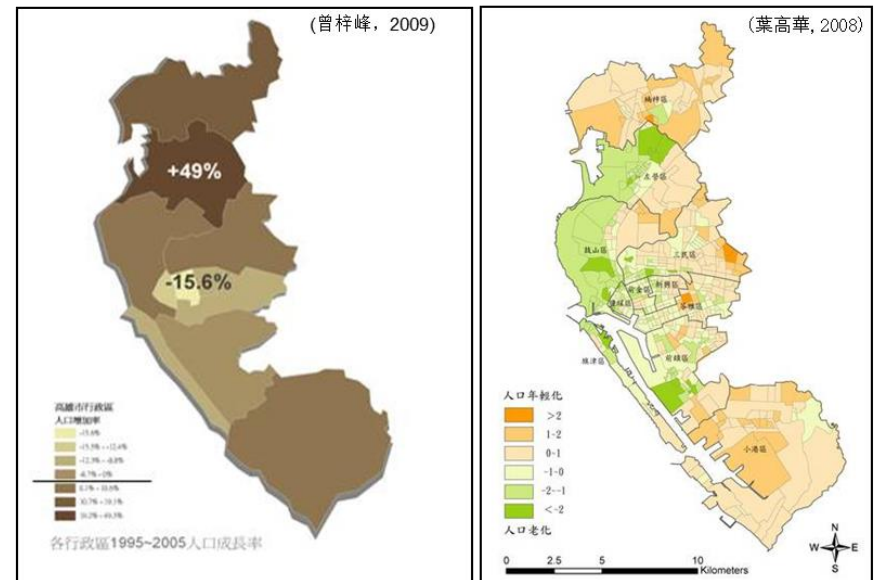


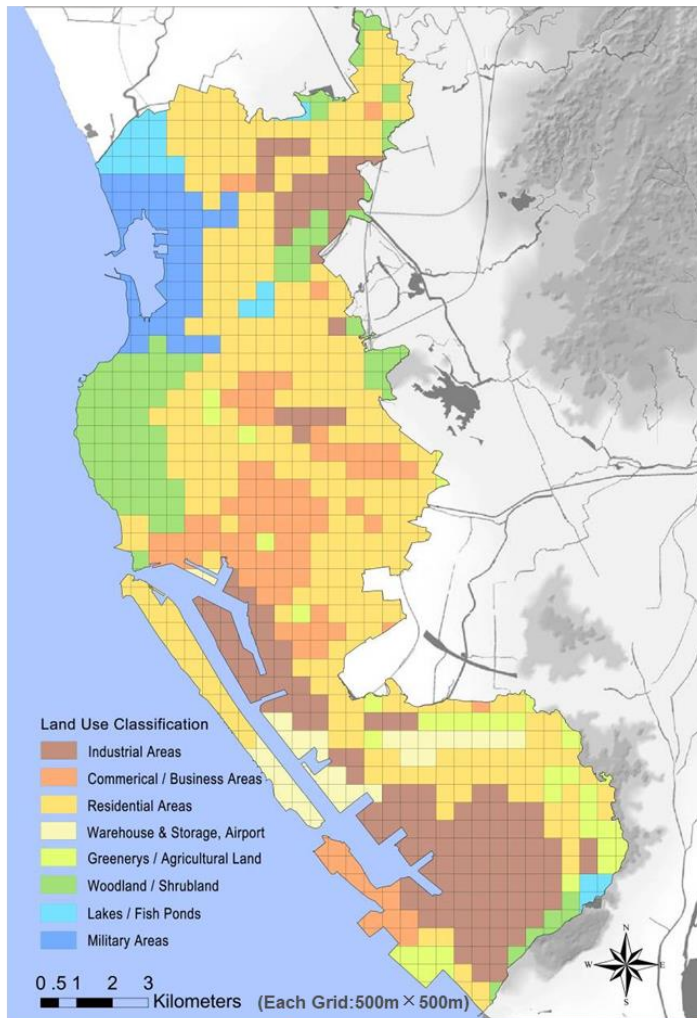
Thermal Stress – Layer 2 : Population Density

The population density (PD) of Kaohsiung city is about 9,900 persons per km². According to the population data from the Dept. of Budget, Accounting & Statistics of Kaohsiung Gov, it could be found that Singing District has the highest population density of **above 28,000 persons per km²**.

The classification of this layer is based on the population density.

District	Nanzih	Zuoying	Gushan	Sanmin	Lingya	Sinsing	Cianjin	Yancheng	Cianjhen	Cijin	Saigang
PD	6,614	9,746	8,581	17,986	22,845	28,657	15,973	19,7897	10,492	20,400	3,845



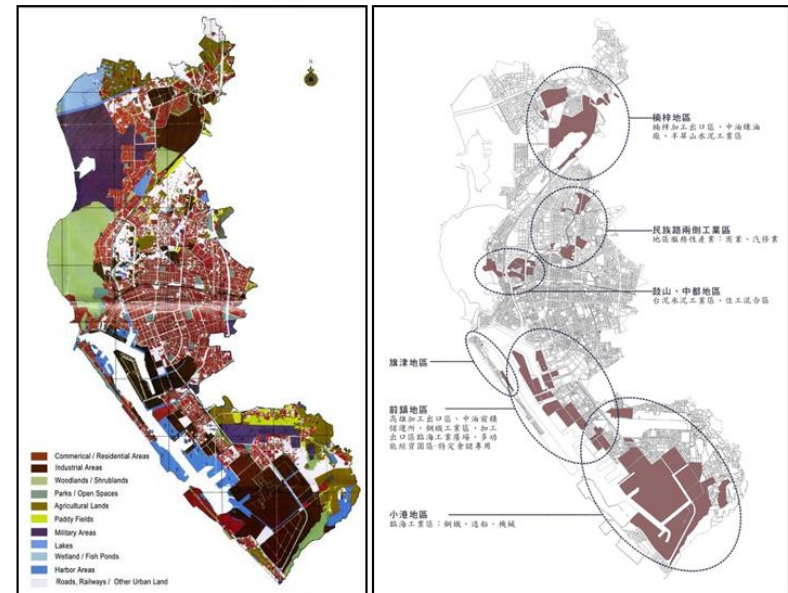


Thermal Stress – Layer 3 : Land Use

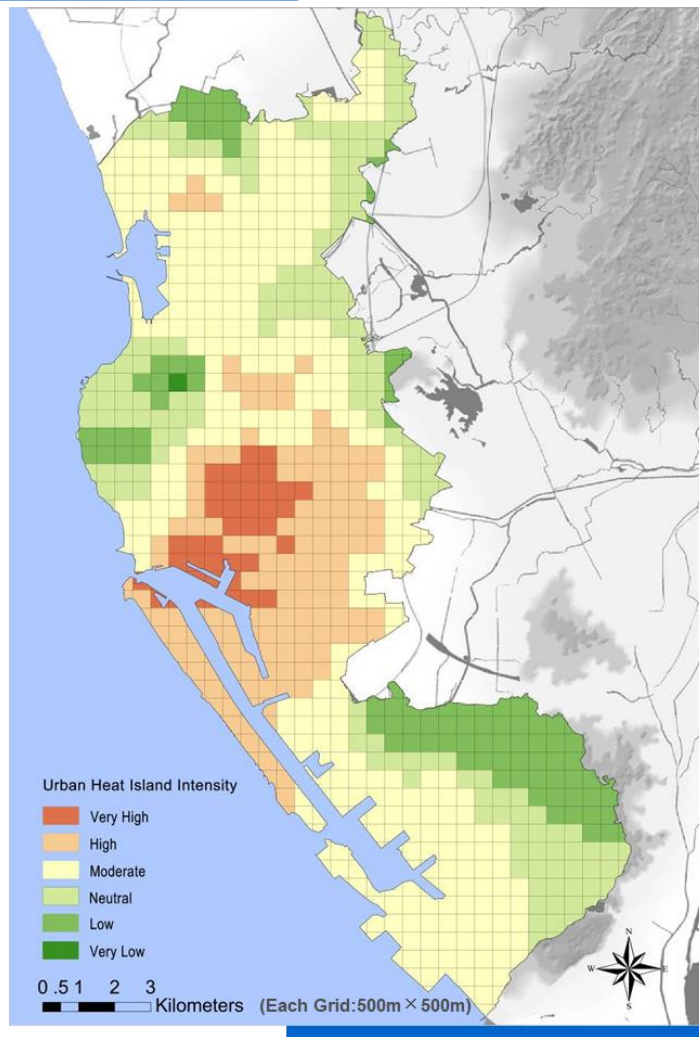
According to the Land use and Planning Data from Urban Development Bureau, Kaohsiung Gov., the layer of Land Use could be created as a raster map.

Each grid is a unite as **climatope** (Klimatope).

The classification of this layer is based on their similar urban climatic characteristic of different land uses, such as thermal capacity, surface roughness, and anthropogenic heat release.



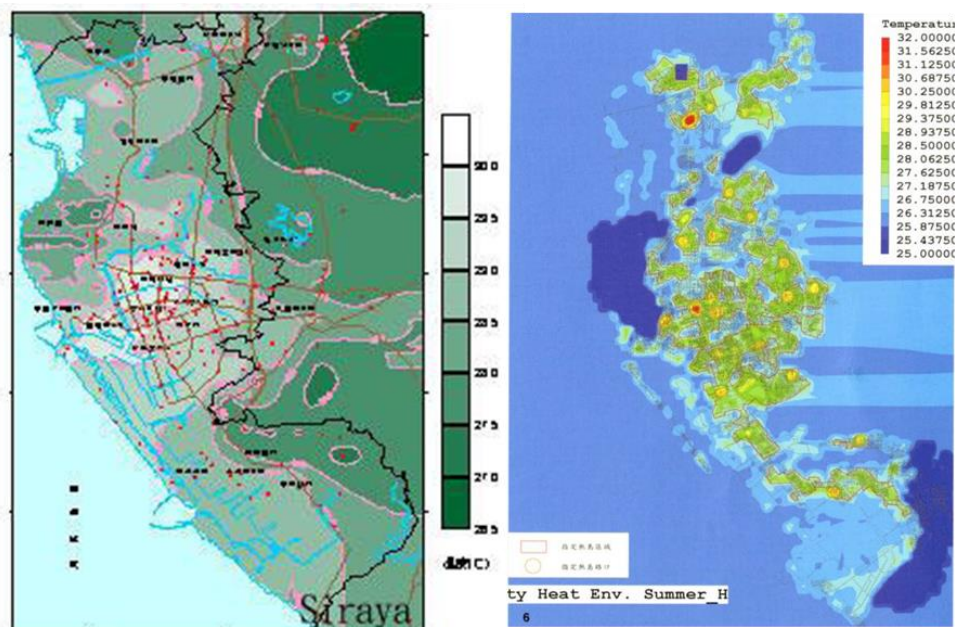
(黃暉榮, 2000; 高雄都市發展局, 2009)



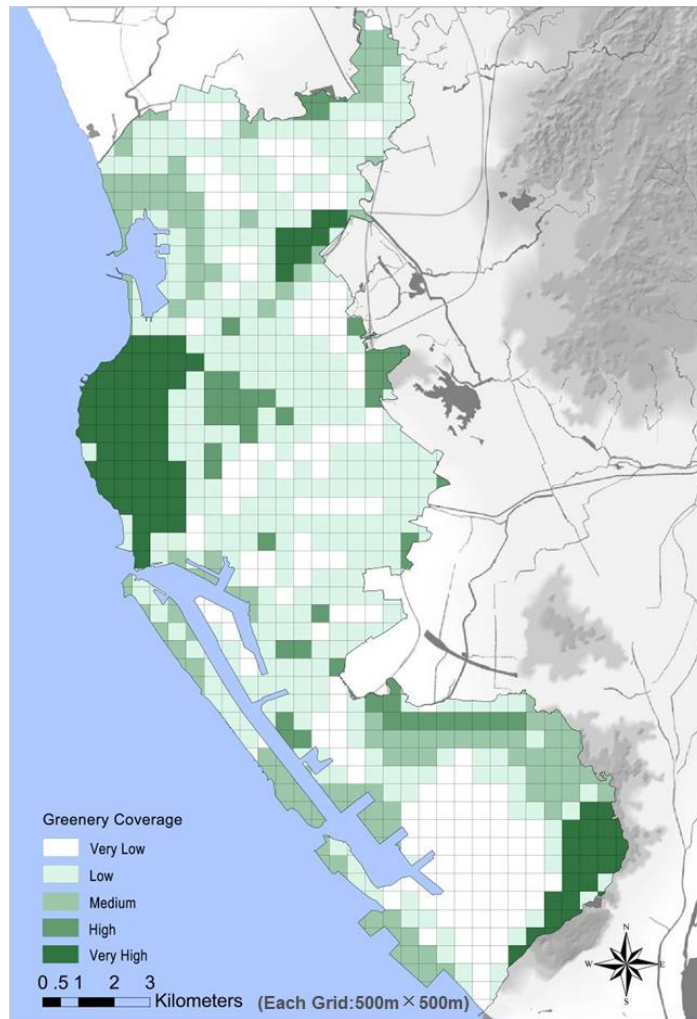
Thermal Stress – Layer 4 : Urban Heat Island

According to the previous study conducted by Taiwanese researchers, it could be found that the Urban Heat Island Intensity in Kaohsiung city is about **2.5-3.0 degree C**; this effect is much stronger in nighttime than in daytime.

The classification of this layer is based on the summer UHI intensity from the result of the field measurements and CFD simulation.



(李魁鵬等, 1999; 李彦頤, 2009; 高雄都市發展局, 2009)



Dynamic Potential – Layer 5 : Natural Landscape

Greenery and vegetation have a cooling effect to the surrounding neighborhood areas. The percentage of greenery is 4.5m²/person in Kaohsiung(高雄市公園綠地導覽手冊,2003), which is lower than the Taiwan local standard.

The classification of this layer is based on the **greenery coverage** and **type**.

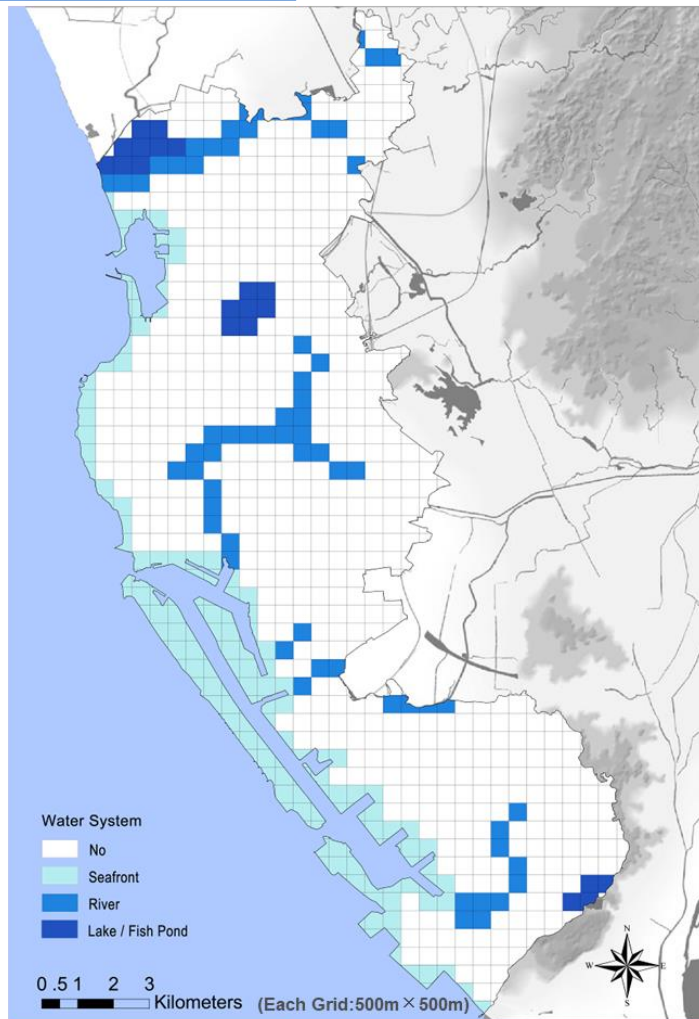
No vegetation: **Very Low**; Low vegetation: **Low**;

Agricultural Land / Military area / Grass Land: **Medium**;

Large Urban Parks: **High**; Forest / Large Woodland: **Very High**;



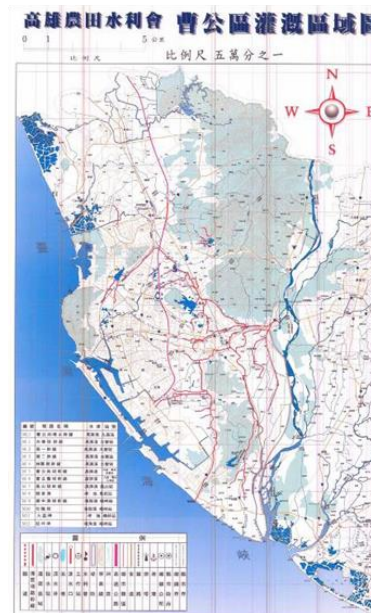
(孫繼智, 2007; 高雄都市發展局, 2007); (After(「風の道」に関する調査研究業務調査報告書, 2007))



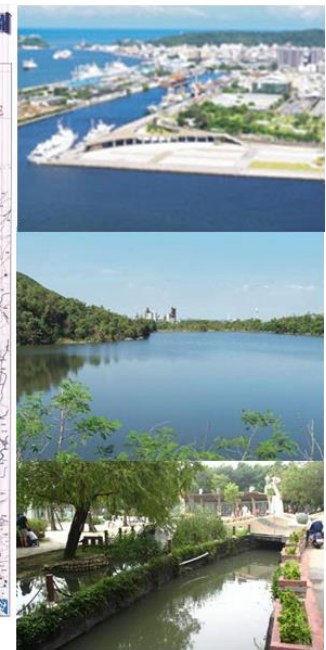
Dynamic Potential – Layer 6 : Water System

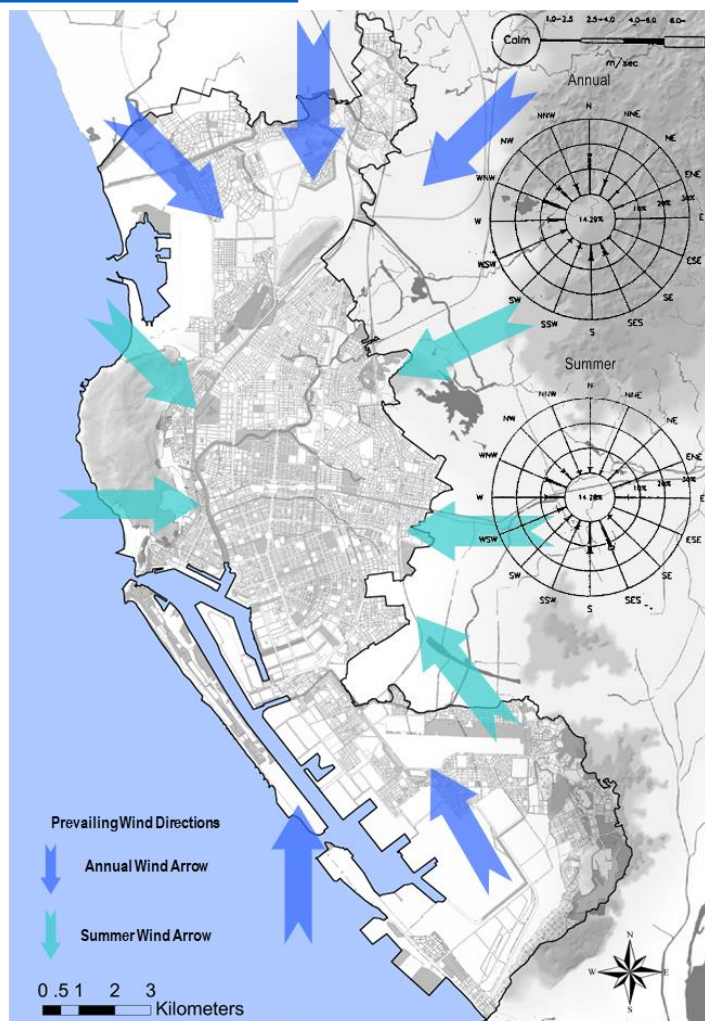
Kaohsiung city has a long coastline. Love river runs through the central urban area. Lianchih Pond is also located at the inland area. Some paddy fields and fish ponds are located at the north part of Kaohsiung city. There are two small canals, the Yansheigang Canal and Cianjhen Canal. All these water systems have a cooling effect on the waterfront areas.

The classification of this layer is based on the type of water system, including **sea**, **river**, **lake** and **fish pond**. Its resolution is 500m.



(孫繼智, 2007; 高雄都市發展局, 2007)





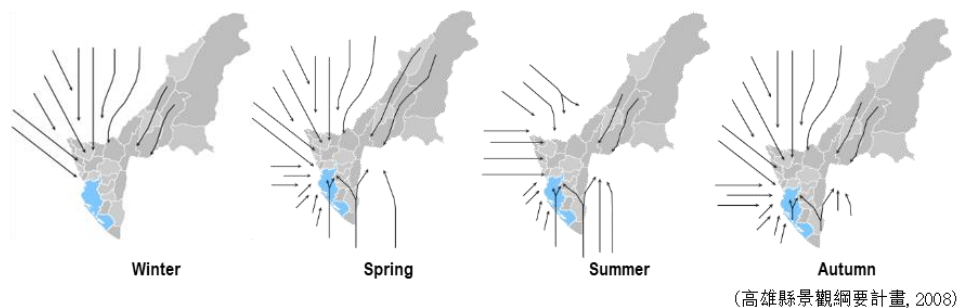
Wind Information – Layer 7 : Prevailing Wind Direction

According to the long-term meteorological record, it could be found that the mean wind speed in Kaohsiung city is quite low, around 2.7 m/s throughout the whole year.

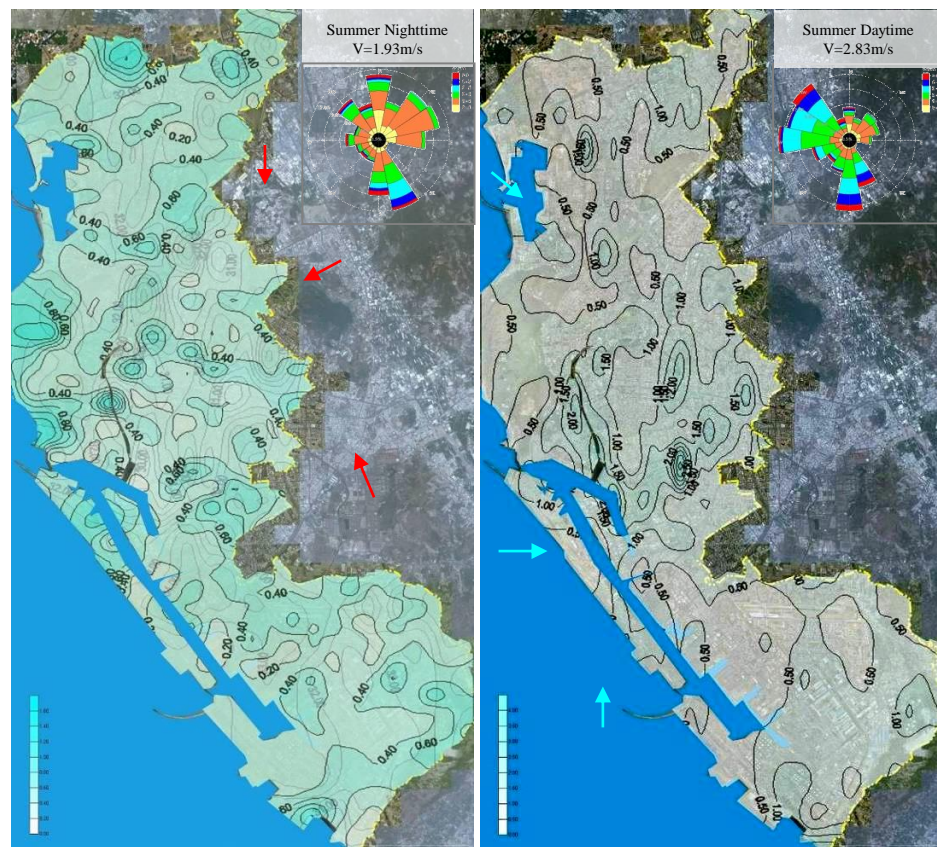
Annual prevailing wind direction is mainly from the **N, WNW, NEN, S and SES**;
Summer prevailing wind direction is mainly from the **WNW, W, ENE, E and SES**.

Mean Wind Speed (m/s)													
Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Kaohsiung	3.0	2.8	2.6	2.4	2.5	2.9	3.2	2.9	2.7	2.2	2.3	2.6	2.7
Siaogang	3.0	3.4	3.3	2.8	2.6	3.1	3.4	3.0	2.7	2.3	2.4	2.8	3.0
Prevailing Wind Direction													
Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Kaohsiung	N	N	N	N.E	S	S	E	E	E	E	N	N	N
Siaogang	N	N	N	N.E	S	S	E	E	E	E	N	N	N

(高雄市志卷一, 2008; 陈子文, 2006; 台湾中央气象局, 2009)



(高雄縣景觀綱要計畫, 2008)



Wind Velocity in night time

Wind Velocity in day time

(李彦頤, 2009a & 2009b; 高雄都市發展局, 2009)

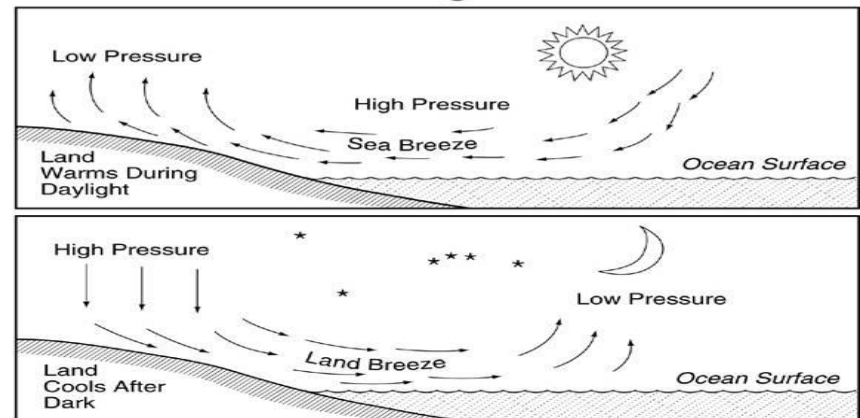
Wind Information – Layer 8 : Land & Sea Breezes

Since Kaohsiung is a coastal city, the phenomenon of land & sea breezes could be observed, which can be used to improve the urban thermal environment.

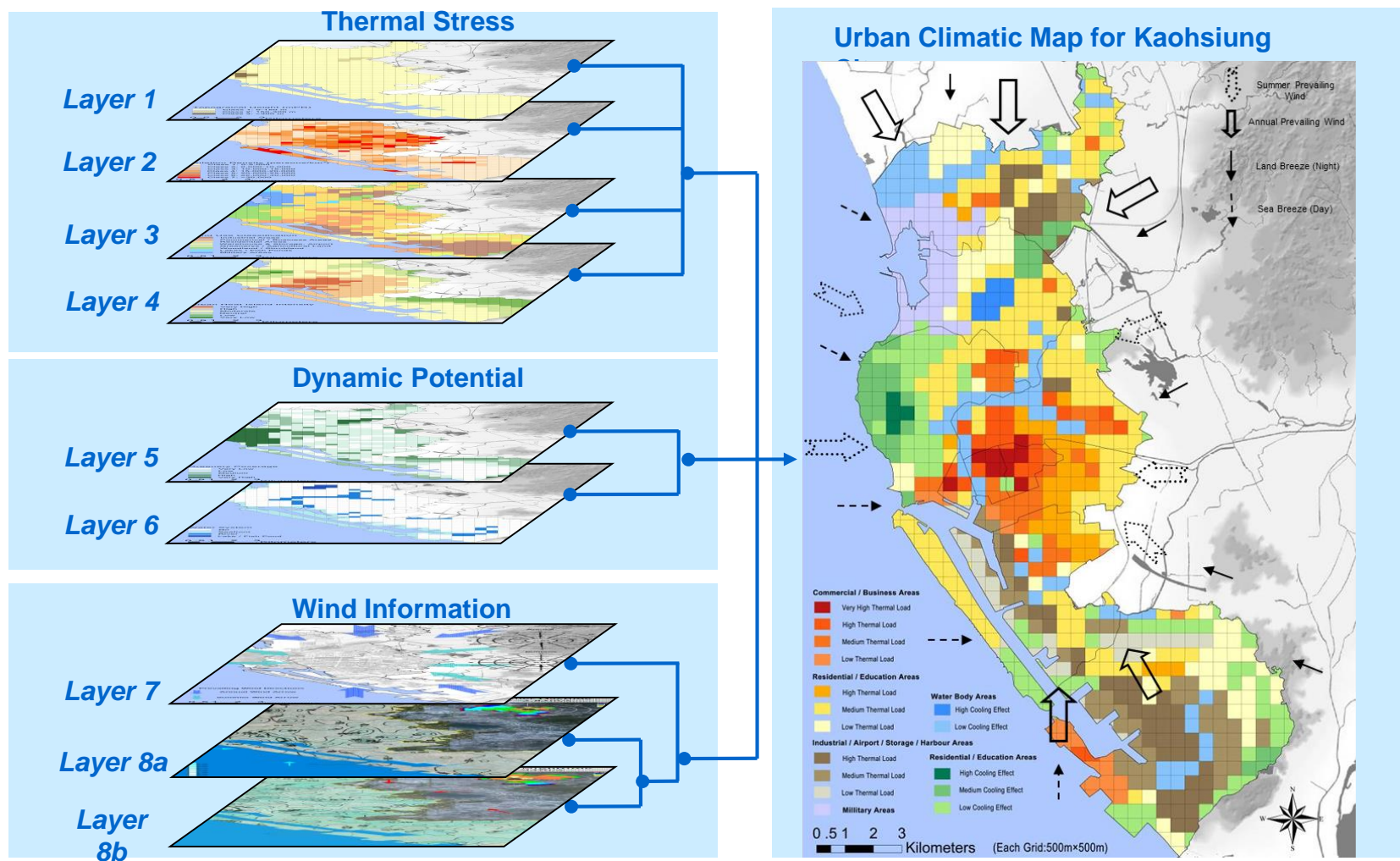
During the night time, land breezes come from the **ENE, N and SES** directions, so the high wind velocity areas focuses on the inland areas, such as the east part of Zuoying District and Cianjhen District.

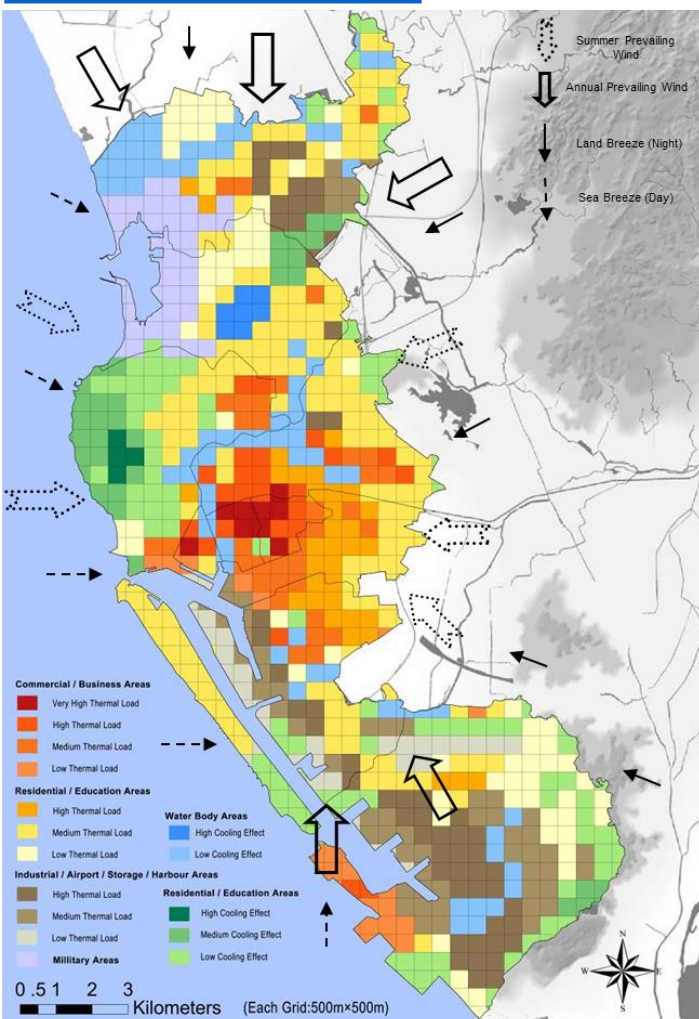
During the day time, sea breezes come from the **WNW, W and S** directions, so the high wind velocity areas focuses on the waterfront, such the outlet of Love river in Cianjin District.

Land and Sea Breeze Regimes

Adapted from William L. Donn, *Meteorology with Marine Applications*.

(Military Geography, 1998)





Urban Climatic Map & General Recommendations for 11 Districts

The Level of Plan Action	District Name	Urban Climatic and Environmental Characteristics	Menu of Effective Control Measures					
			Greenery	Shading	Cool Albedo	An-Heat Release	Air Exchange	Air Pollution
Mitigation Action Necessary	Cianjin	High to very high thermal stress and low dynamic potential due to high ground coverage, high Anthropogenic Heat (An-Heat) Release, various commercial activities and low greenery coverage;	▲▲	▲	▲	▼▼	▲▲	▼
Some Action Required	Yancheng		▲▲	▲	▲	▼▼	▲▲	▼
Preserve & Enhance	Sinsing		▲▲	▲	▲	▼▼	▲	▼
	Lingya	High to medium thermal stress and low to medium dynamic potential due to low to medium ground coverage, medium An-Heat Release, some commercial activities, lots of industrial activities and low greenery coverage;	▲▲	▲▲	▲	▼▼	▲▲	▼
	Sanmin		▲▲	▲	▲	▼	▲	▼▼
	Cianjhen		▲▲	▲	▲▲	▼▼	▲	▼▼
	Siaogang		▲▲	▲	▲▲	▼▼	▲	▼▼
	Zuoying	Medium to low thermal stress and medium to high dynamic potential due to low to medium ground coverage, low An-Heat Release, some commercial and industrial activities and medium to high greenery coverage;	▲	▲▲	▲	▼	▲▲	▼
	Nanzih		▲	▲	▲▲	▼▼	▲	▼▼
	Cijin		▲	▲	▲▲	▼	▲▲	-▼
	Gushan		—	▲	—	—	▲	—

▲ : Recommend to improve the existing condition;
 ▼ : Recommend to mitigate the existing condition;
 — : Maintain or Protect the existing condition,

▲▲ : Strongly recommend to improve the existing condition;
 ▼▼ : Strongly recommend to mitigate the existing condition;

Kaohsiung Map	Level of Plan Action	Urban Climatic and Environmental Characteristics	No.	District Name	Menu of Effective Control Measures					
					Greenery	Shading	Cool Albedo	An-Heat Release	Air Exchange	Air Pollution
<p> ■ Mitigation Action Necessary ■ Some Action Required ■ Preserve & Enhance </p>	Mitigation Action Necessary	High to very high thermal stress and low dynamic potential due to high ground coverage, high Anthropogenic Heat (An-Heat) Release, various commercial activities and low greenery coverage;	①	Cianjin	▲ ▲	▲	▲	▼ ▼	▲ ▲	▼
			②	Yancheng	▲ ▲	▲	▲	▼ ▼	▲ ▲	▼
			③	Sinsing	▲ ▲	▲	▲	▼ ▼	▲	▼
	Some Action Required	High to medium thermal stress and low to medium dynamic potential due to low to medium ground coverage, medium An-Heat Release, some commercial activities, lots of industrial activities and low greenery coverage;	④	Lingya	▲ ▲	▲ ▲	▲	▼ ▼	▲ ▲	▼
			⑤	Sanmin	▲ ▲	▲	▲	▼	▲	▼ ▼
			⑥	Cianjhen	▲ ▲	▲	▲ ▲	▼ ▼	▲	▼ ▼
			⑦	Siaogang	▲ ▲	▲	▲ ▲	▼ ▼	▲	▼ ▼
	Preserve & Enhance	Medium to low thermal stress and medium to high dynamic potential due to low to medium ground coverage, low An-Heat Release, some commercial and industrial activities and medium to high greenery coverage;	⑧	Zuoying	▲	▲ ▲	▲	▼	▲ ▲	▼
			⑨	Nanzih	▲	▲	▲ ▲	▼ ▼	▲	▼ ▼
			⑩	Cijin	▲	▲	▲ ▲	▼	▲ ▲	- ▼
				Gushan	—	▲	—	—	▲	—

▲ : Recommend to improve the existing condition;

▼ : Recommend to mitigate the existing condition;

—, : Maintain or Protect the existing condition,

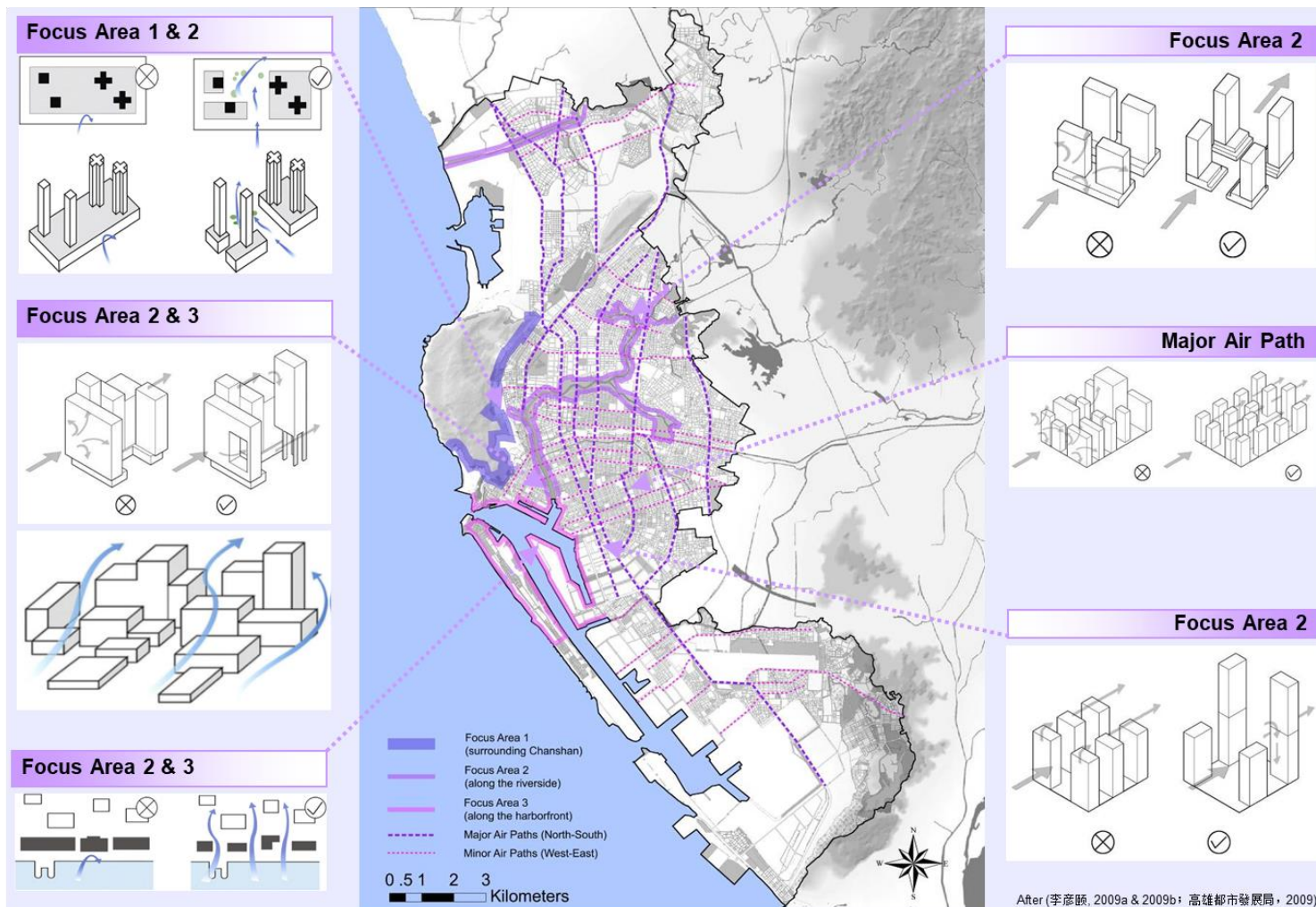
▲ ▲ : Strongly recommend to improve the existing

▼ ▼ : Strongly recommend to mitigate the existing condition;



Recommendation on Wind Aspect

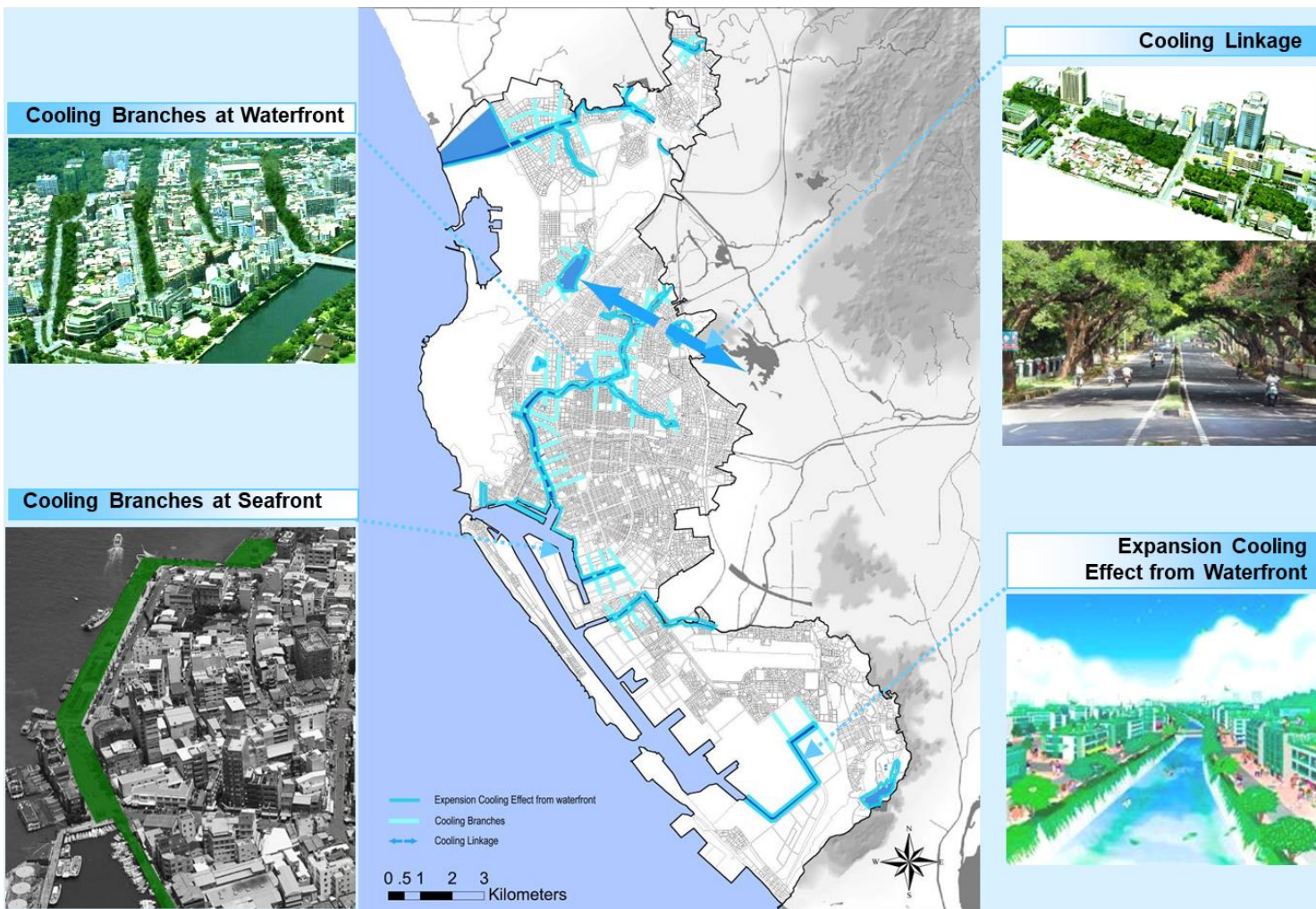
1. Respect the cooling effect from the Eastern Chanshan; minimize the development's impact; and form air path from hillside to downtown areas.
2. Respect the cooling effect from the river; Building blocks with various height to allow the penetration of cooling effect from riverside to inner urban areas;
3. Respect the sea breeze penetration; Do not form the Wall Effect Buildings at the Harbour front;
4. N-S orientated main roads are important major air paths; Buildings should be orientated with respect to the major air paths (annual & summer).
5. W-E orientated main roads are important minor air paths, esp. in summer; Building should be orientated with respect to the minor air paths.





Recommendation on Water Aspect

1. Respect the cooling effect from water systems, including river, lake, ponds & seafront; minimize the development's impact at waterfront and landscape the waterfront.
2. Form cooling branches along major transportation links highlighted in light blue color in the right map; appropriate greenery or landscape designs along these branches are strongly recommended.
3. Link the Lian Chinh Pond, Jinshih lake and Chengcing Lake by using greenery or vegetations to benefit the surround areas of these water bodies and mitigate the urban heat island intensity;

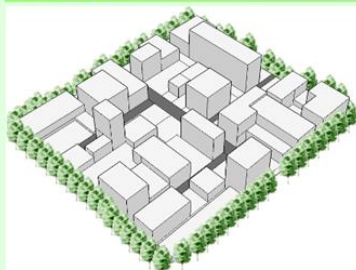




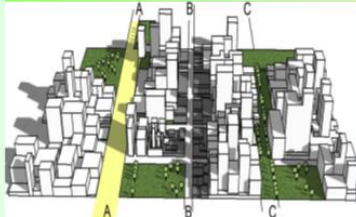
Recommendation on Greenery Aspect

1. Green rail track can be adopted to mitigate the anthropogenic heat release and air pollution along railways in dense urban areas;
2. Form green circles in the central urban areas to mitigate urban heat island intensity and anthropogenic heat releases. Provide shading at pedestrian level to create comfortable walking systems.
3. Form green circles around the industrial areas to mitigate the distribution of air pollution;
4. Create Green linkage between Chanshan, Lianchih Pond and Banpinshan to maximize the cooling effect;
5. Develop Green Fingers to let the cooling effect from Chanshan East hillsides to high-dense centre urban areas;
6. Create Green Belt to bring sea breezes to inner areas and improve the air exchange;

Green Belt



Greenery Finger



Green Circle surrounding the Industrial Areas



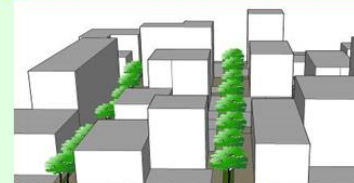
Green Rail Track



Green Circle in Central Urban Areas



Green Line Along Major Roadside



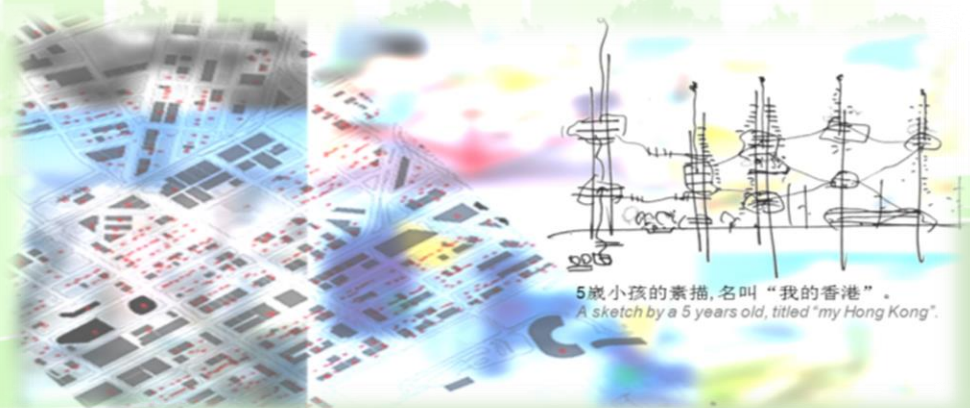
家園



Our Vision

***“Towards quality urban living,
for now and for the future”***

Better planning and building design to improve urban air ventilation and urban climate for healthier and more comfortable and sustainable urban living



5歲小孩的素描, 名叫“我的香港”。
A sketch by a 5 years old, titled “my Hong Kong”.

The background features a stylized city skyline with various skyscrapers in shades of green and yellow. In front of the skyline is a row of green trees. The bottom of the image has a green wavy line representing a field or water. A faint, light green map overlay is visible in the upper half of the image.

Thanks for your attention!

Build4People Project

Enhancing Quality of Life through Sustainable Urban Transformation in Cambodia

គម្រោងសាងសង់សម្រាប់ប្រជាជន
ការលើកកម្ពស់ គុណភាពជីវិត របស់
អ្នកទីក្រុង ដោយ ការ បម្លែង ទៅជា
ក្រុង មានចីរភាពនៅកម្ពុជា

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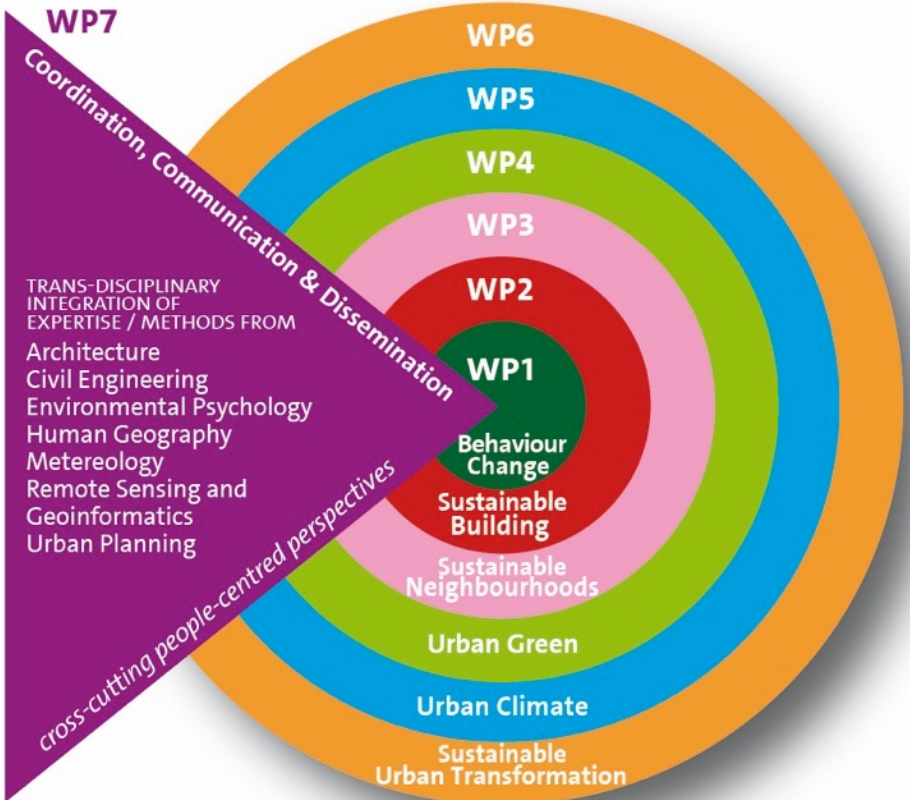
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Conceptualization of urban climate condition in Phnom Penh

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CKS-B4P Webinar
“Urban Climate in the Planning Process”
21 April 2022

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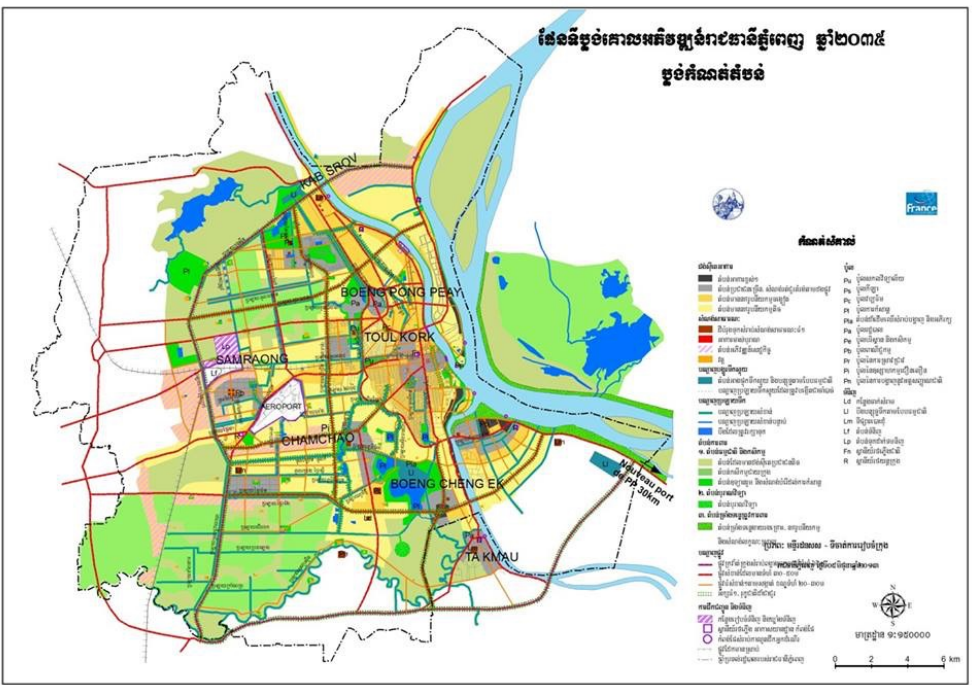
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- Climate condition in PP
- Materials and Methods
- Preliminary Results
- Conclusion



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Enhancing Quality of Life through Sustainable Urban Transformation in Cambodia

គម្រោងសាងសង់សម្រាប់ប្រជាជន
ការលើកកម្ពស់ គុណភាពជីវិត របស់
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ក្រុង មានចីរភាពនៅកម្ពុជា

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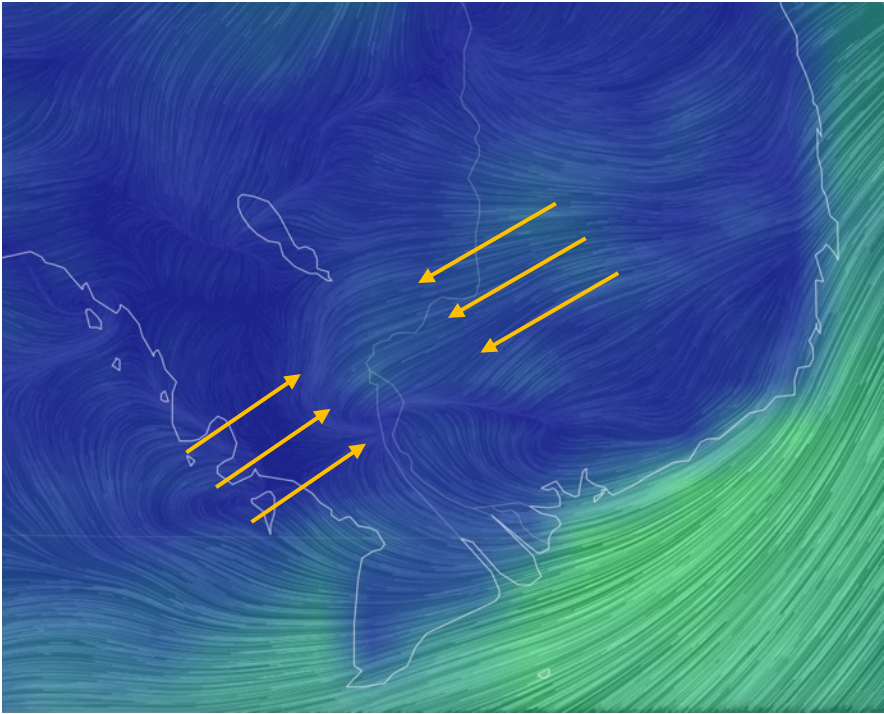
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CLIMATE CONDITIONS

- PP has a tropical climate, with distinctive wet and dry seasons, which is hot year-round with only minor variations.
- PP experiences the heaviest precipitation from September to October with the driest period in January and February.
- Precipitation in the city comes with southerly or southwesterly monsoon circulation.
- PP experiences seasonal monsoon floods and sometimes river overflows its banks leading to bank erosion as well.



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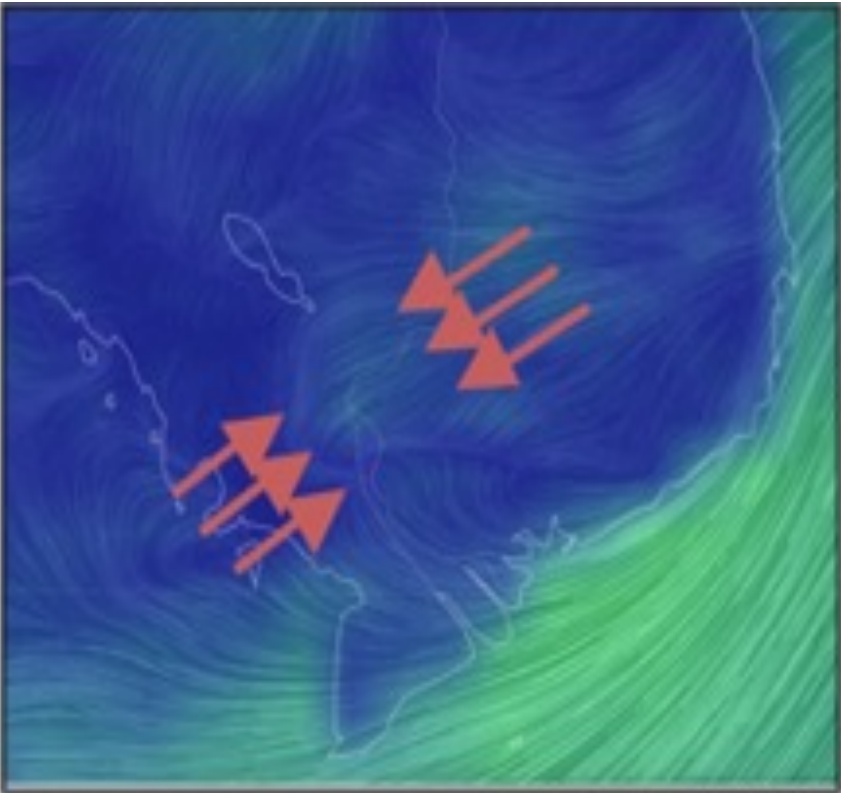
WIND DIRECTIONS AND WIND CHARACTERISTICS

Incoming winds
(main wind direction)

predominate direction

weaker incoming wind

thermal induced pattern



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MATERIALS



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METHODS

The UHI intensity (Oke 1973, Steeneveld et al. 2011):

$$UHI = T_{urban} - T_{suburban} \tag{1}$$

The UHI rate (Ma et al., 2009; Wolberg, 2006):

$$UHI\% = \frac{(\Delta u - \Delta s)}{\Delta u} \tag{2}$$

The diurnal VUHI (DV) and the seasonal VUHI during daytime (SV_{day}) and nighttime (SV_{night}) (Sun et al., 2019):

$$DV = UHI_{day} - UHI_{night} \tag{3}$$

$$SV_{day} = UHI_{day}^{dry} - UHI_{day}^{wet} \tag{4}$$

$$SV_{night} = UHI_{night}^{dry} - UHI_{night}^{wet} \tag{5}$$

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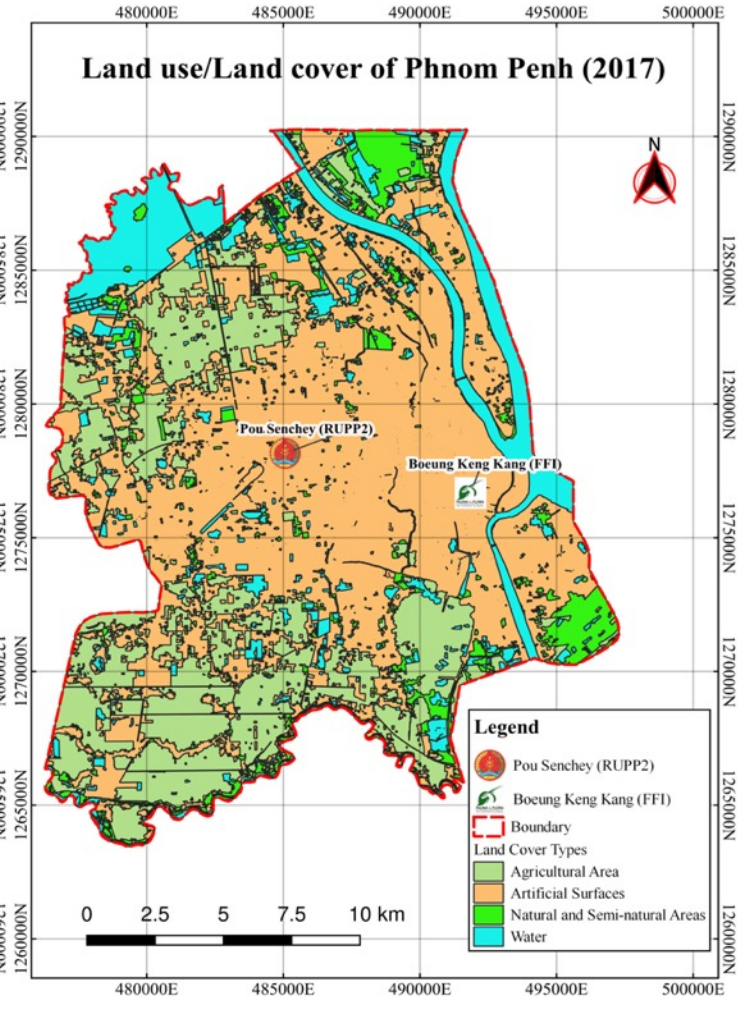
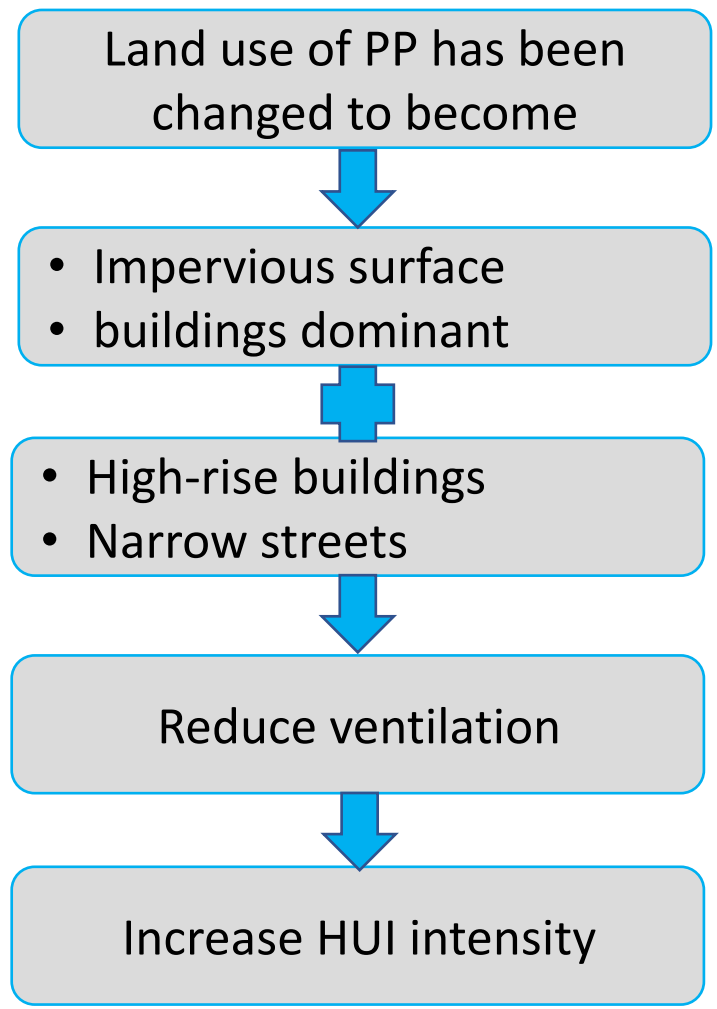
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LAND USE CHANGE



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TEMPERATURE DIFFERENCE

- Temperature difference between urban and sub-urban areas:
 - CBDs (Boeung Keng Kang (FFI)):
 - Max: 15.1°C
 - Min: 2.9°C
 - Mean: 10.1°C
 - Suburban (Pou Senchey (RUPP2)):
 - Max: 13.1°C
 - Min: 2.2°C
 - Mean: 8.9°C



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UHI INTENSITY AND RATE

➤ The increased intensity and rate of the UHI between the CBDs and suburban areas on average:

Intensity	=	1.3°C
Rate	=	0.15%

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VARIABILITY OF THE UHI (VUHI)

- Maximum and minimum **daytime** temperature difference:
 - CBDs (Boeung Keng Kang (FFI)): 15°C and 2.7°C
 - Suburban (Pou Senchey (RUPP2)): 12.9°C and 2.4°C
- Maximum and minimum **night-time** temperature difference:
 - CBDs (Boeung Keng Kang (FFI)): 9.1°C and 0.7°C
 - Suburban (Pou Senchey (RUPP2)): 9.6°C and 0.2°C

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VARIABILITY OF THE UHI (VUHI)

- The diurnal variability of the UHI (VUHI) on average:
 - CBDs (Boeung Keng Kang (FFI)): 5.1°C
 - Suburban (Pou Senchey (RUPP2)): 3.7°C
- Daytime and night-time UHI intensity in **dry season** (November-April) on average:
 - CBDs (Boeung Keng Kang (FFI)): 10.3°C and 5.6°C
 - Suburban (Pou Senchey (RUPP2)): 8.7°C and 5.7°C
- Daytime and night-time UHI intensity in **wet season** (May-October) on average:
 - CBDs (Boeung Keng Kang (FFI)): 9.3°C and 3.8°C
 - Suburban (Pou Senchey (RUPP2)): 8.0°C and 3.7°C



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VARIABILITY OF THE UHI (VUHI)

- Seasonal VUHI during *daytime*:
 - CBDs (Boeung Keng Kang (FFI)): 1.0°C
 - Suburban (Pou Senchey (RUPP2)): 0.8°C
- Seasonal VUHI during *night-time*:
 - CBDs (Boeung Keng Kang (FFI)): 1.9°C
 - Suburban (Pou Senchey (RUPP2)): 2.0°C



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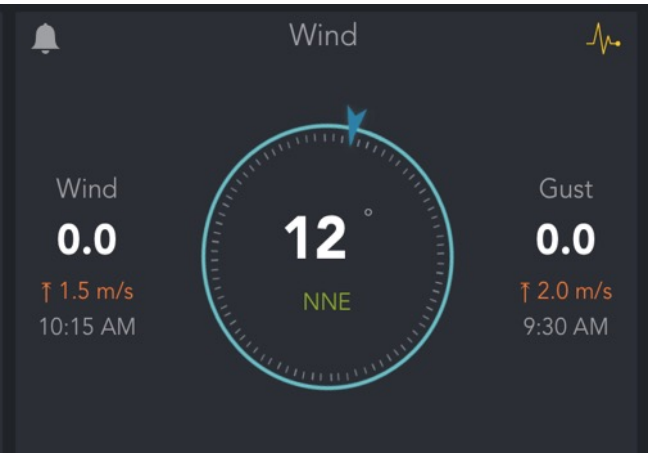
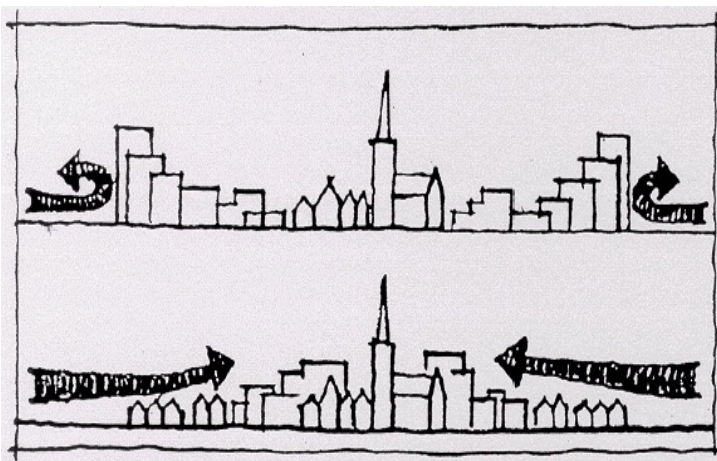
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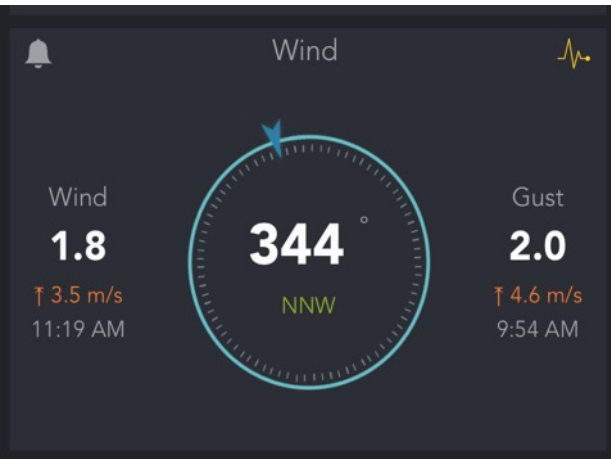


VENTILATION

- Ventilation plays a crucial role to reduce the intensity of UHI in the city scale.
- Weather data observations indicated that more urbanizing areas are very low wind blow, compared to suburban areas.



Boeung Keng Kang (FFI)
4:27 PM (10/01/2021)



Pousen Chey (RUPP2)
4:27 PM (10/01/2021)

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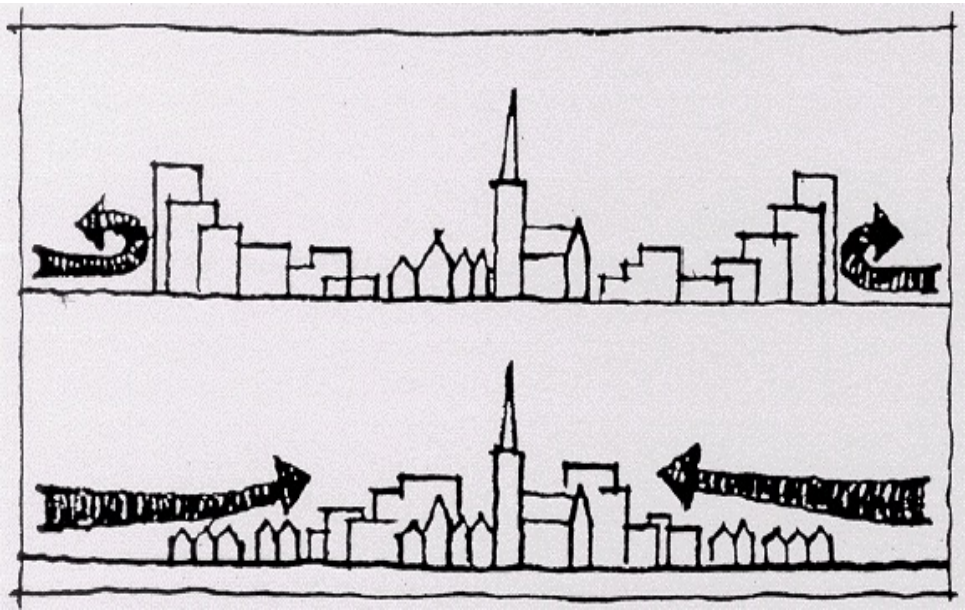
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VENTILATION

- Southwesterly winds can mitigate the intensity of the UHI
- The high, dense buildings in the CBDs may reduce inflowing winds => an increased intensity of the UHI.



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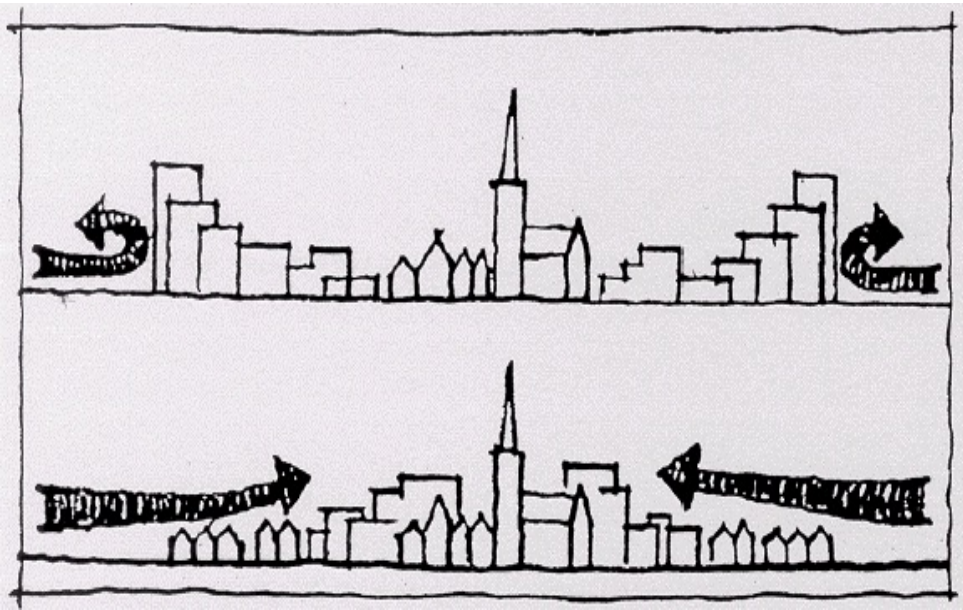
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VENTILATION

- Wind velocity between CBDs and sub-urban areas:
 - CBDs (Boeung Keng Kang (FFI)):
 - Max: 3.1 m.s^{-2}
 - Min: 0.4 m.s^{-2}
 - Suburban (Pou Senchey (RUPP2)):
 - Max: 7.8 m.s^{-2}
 - Min: 1.4 m.s^{-2}
 - *Thus, the difference in wind velocity rate was 1.8 m s^{-1} on average.*



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VENTILATION

- Wind flow at the CBDs:
 - dry seasons (November–April) is North and Northwest direction, but it has changed to South and Southwest direction during February and March.
 - wet season (May–October) is North and Northwest direction, but it has changed to South and Southwest during August.
- Wind flow at the suburban areas:
 - dry season are North and Northeast direction, but it has turned to South and Southwest direction during March and April.
 - wet season at the suburban areas South and Southwest direction, but it has turned to North, Northwest and Northeast direction during September and October.

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CONCLUSION: KEY FINDINGS

- Temperature difference:
 - CBDs (Boeung Keng Kang (FFI)): **10.1°C**
 - Suburban areas (Pou Senchey (RUPP2)): **8.9°C**
- The increased intensity of UHIs between CBDs and suburban areas is **1.3°C**.
- The increased rate of UHIs between CBDs and suburban areas is **0.15%**.

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CONCLUSION: KEY FINDINGS

- Maximum and minimum **daytime** temperature difference:
 - CBDs (Boeung Keng Kang (FFI)): 15°C and 2.7°C
 - Suburban (Pou Senchey (RUPP2)): 12.9°C and 2.4°C
- Maximum and minimum **night-time** temperature difference:
 - CBDs (Boeung Keng Kang (FFI)): 9.1°C and 0.7°C
 - Suburban (Pou Senchey (RUPP2)): 9.6°C and 0.2°C

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CONCLUSION: KEY FINDINGS

- The diurnal variability of the UHI (VUHI) on average:
 - CBDs (Boeung Keng Kang (FFI)): 5.1°C
 - Suburban (Pou Senchey (RUPP2)): 3.7°C
- Daytime and night-time UHI intensity in **dry season** on average:
 - CBDs (Boeung Keng Kang (FFI)): 10.3°C and 5.6°C
 - Suburban (Pou Senchey (RUPP2)): 8.7°C and 5.7°C
- Daytime and night-time UHI intensity in **wet season** on average:
 - CBDs (Boeung Keng Kang (FFI)): 9.3°C and 3.8°C
 - Suburban (Pou Senchey (RUPP2)): 8.0°C and 3.7°C

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គម្រោងសាងសង់សម្រាប់ប្រជាជន
ការលើកកម្ពស់ គុណភាពជីវិត របស់
អ្នកទីក្រុង ដោយ ការ បង្កើន ទៅជា
ក្រុង មានចីរភាពនៅកម្ពុជា

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CONCLUSION: KEY FINDINGS

- Seasonal VUHI during **daytime**:
 - CBDs (Boeung Keng Kang (FFI)): 1.0°C
 - Suburban (Pou Senchey (RUPP2)): 0.8°C
- Seasonal VUHI during **night-time**:
 - CBDs (Boeung Keng Kang (FFI)): 1.9°C
 - Suburban (Pou Senchey (RUPP2)): 2.0°C

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VENTILATION

➤ Wind flow:

- CBDs came from almost the same direction as North and Northwest during dry and wet seasons.
- suburban areas moved from North and Northwest during dry season and South and Southwest direction during wet season.

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CONCLUSION: KEY FINDINGS

- Wind velocity between CBDs and sub-urban areas:
 - CBDs (Boeung Keng Kang (FFI)): 1.8 m.s^{-2}
 - Suburban (Pou Senchey (RUPP2)): 4.6 m.s^{-2}
- *Thus, the difference in wind velocity rate was 1.8 m s^{-1} on average*

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