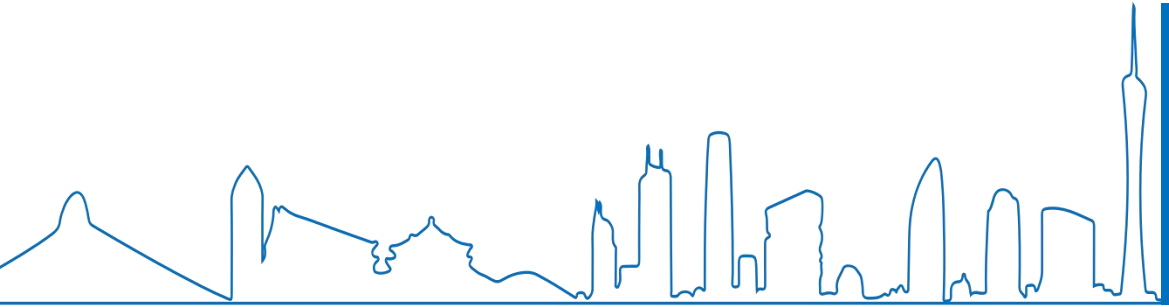


COOL CITY ACTION

Exploration of Sustainable Urban Cooling in Guangzhou

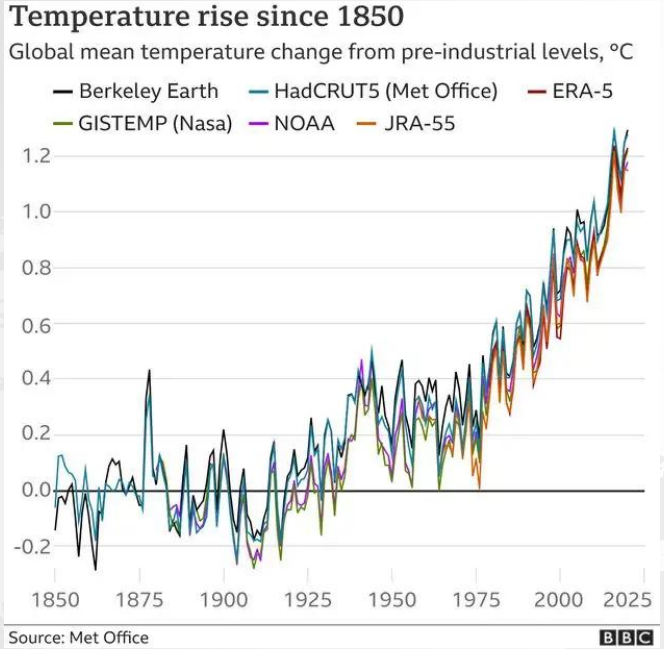
Guangzhou Municipal Planning and Natural Resources Bureau

2023.04

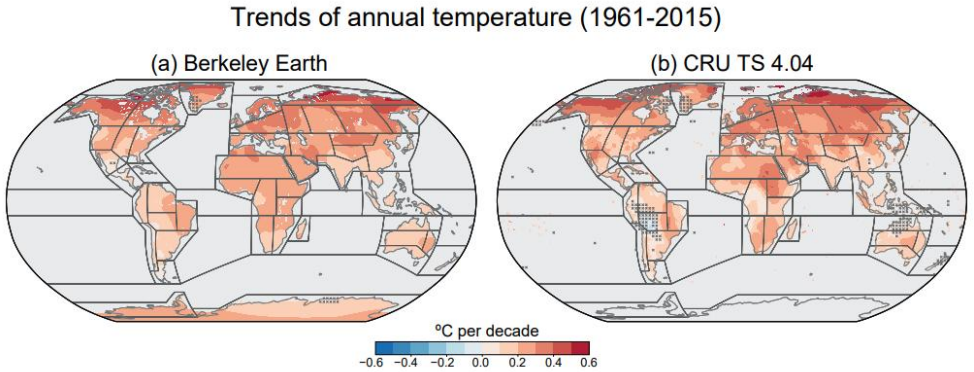
1

Guangzhou’s climate change challenges

Addressing Climate Crisis Requires Global Collaboration



Trends in global temperature changes since 1850 (BBC)

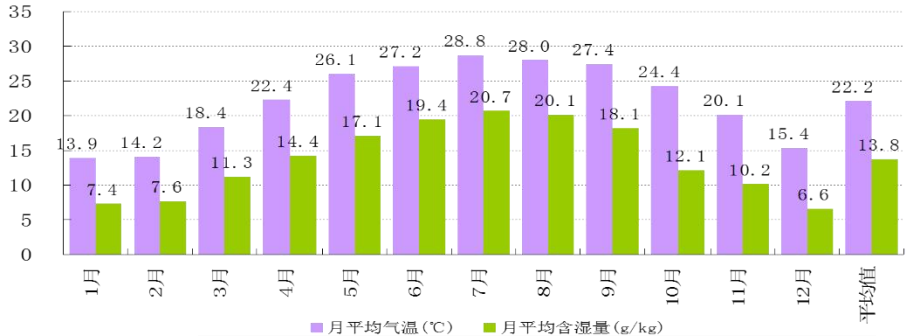


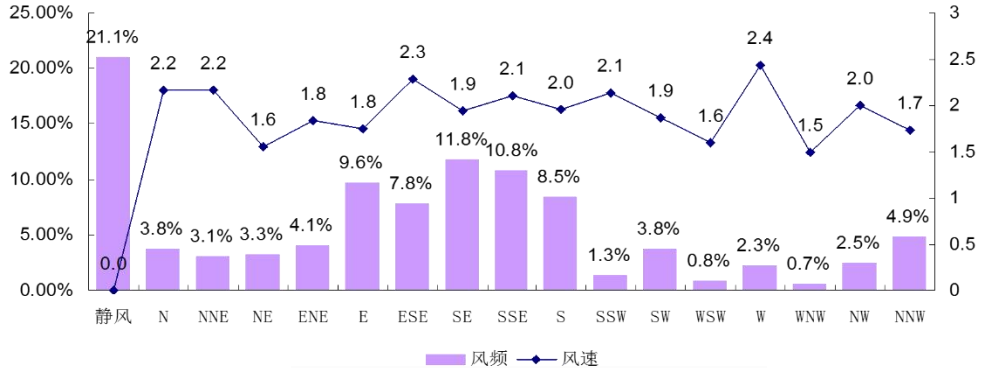
Trends of annual temperature (IPCC 6th Climate Impact Report)

News report on extreme high temperatures in Europe in June 2022

Climate Issues and Challenges

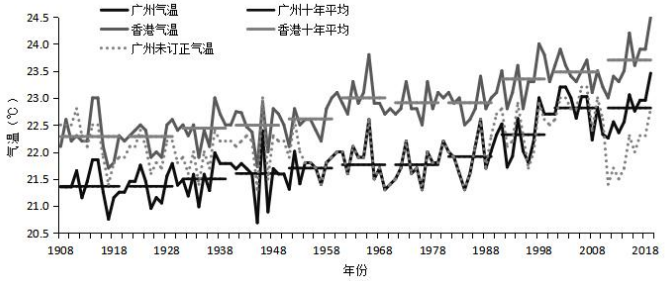
- Subtropical monsoon climate: concurrent rain and heat, high temperatures, humidity, and heavy rainfall.



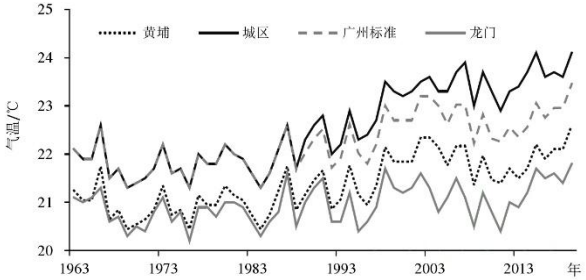


Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Average highest temperature (℃)	18.29	18.08	22.15	25.88	30.05	30.89	33.43	32.25	31.81	28.93	25.28	21.22
Average lowest temperature (℃)	10.60	11.08	15.21	19.90	22.67	24.71	25.71	25.29	24.08	20.81	16.23	11.24
Average relative humidity (%)	74.10	74.30	83.05	84.13	79.35	84.51	81.85	83.31	77.97	60.86	67.66	61.00
Daytime comfort level	C	C	N	N	H	H	H	H	H	N	N	C
Nighttime comfort level	C	C	C	N	H	H	H	H	H	N	C	C

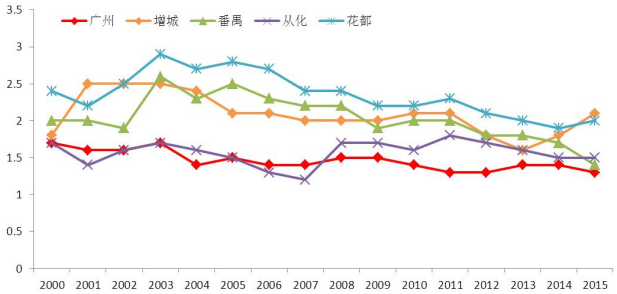
Urban Heat Islands and Extreme Weather Risks



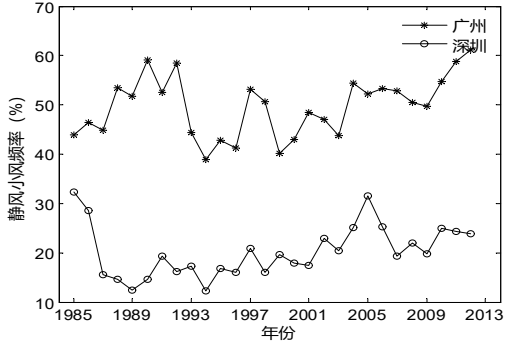
Average urban warming rate is 1.39°C per century



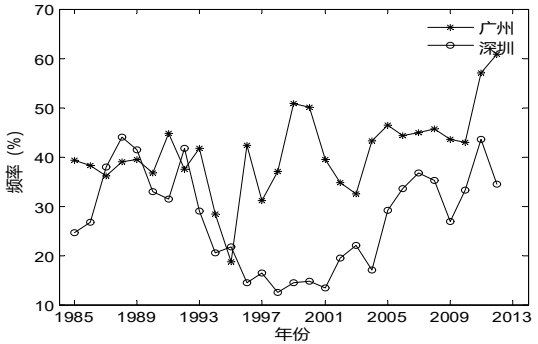
The contribution of urbanization to warming is 56%



The average wind speed in cities has decreased by 30% over the past 20 years.



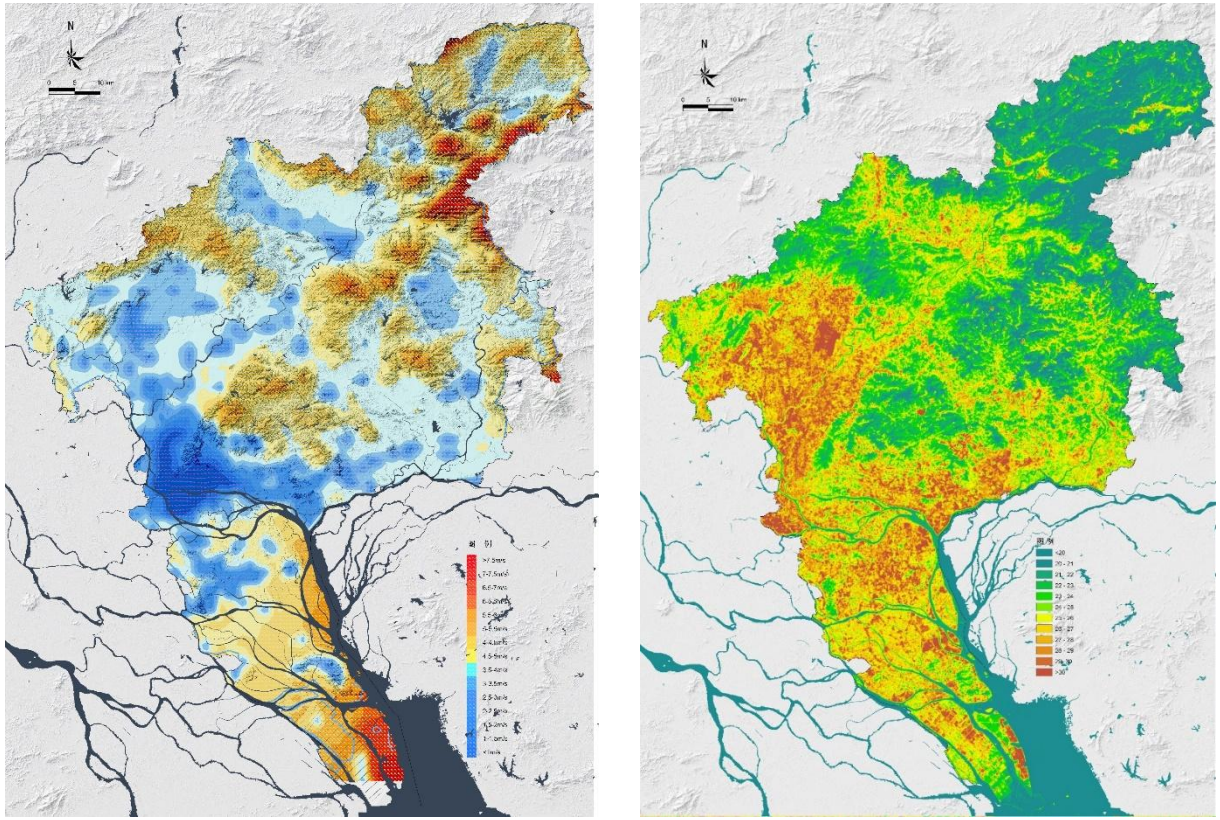
The frequency of calm and light winds has increased by 6.1% per decade.



The frequency of prevailing winds has increased by 3.7% per decade.

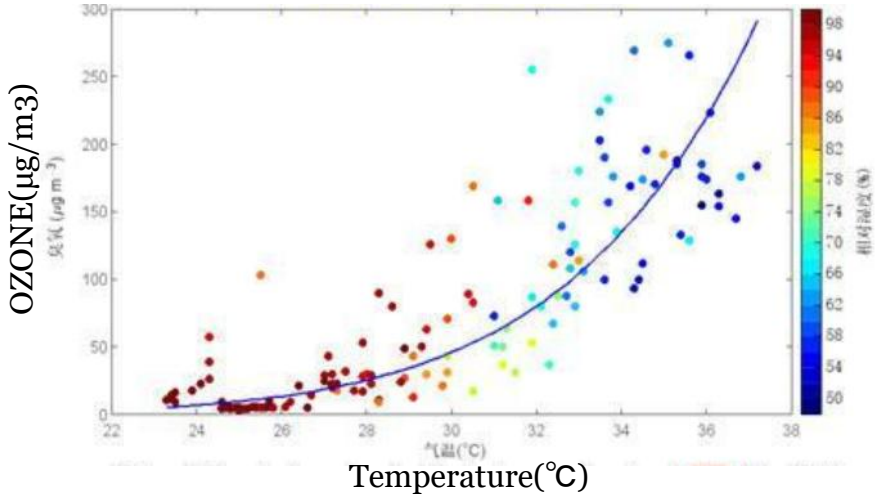
Urban Heat Islands and Heatwaves

- **Urban heat island** concentration zones and **calm wind** core areas have been formed.
- **Heatwaves** have become more frequent, and may become a new normal in the future.

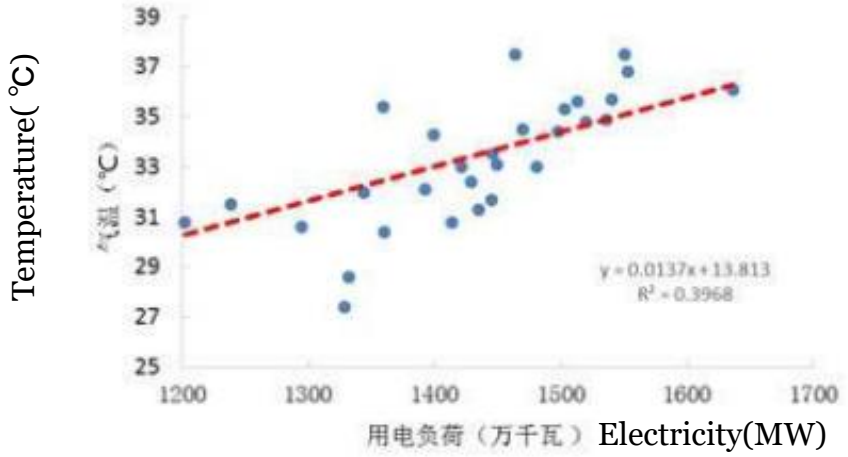


Guangzhou's densely built-up areas have formed distinct **urban heat island concentration zones** and **calm and light wind core areas**.

- **Warming has adverse effects on environmental quality and public health**



- **High demand for cooling and high energy consumption**



Typical Environment **Representative City** **Universal Problem**

Guangzhou: Exploring a Sample of Global Sustainable Cooling

Responding to expectations of international and national communities
Showcasing responsibility and mission as a mega-city

Urban Cooling: New Issue in Urban Sustainability

In 2019, the World Bank launched Sustainable Urban Cooling program.

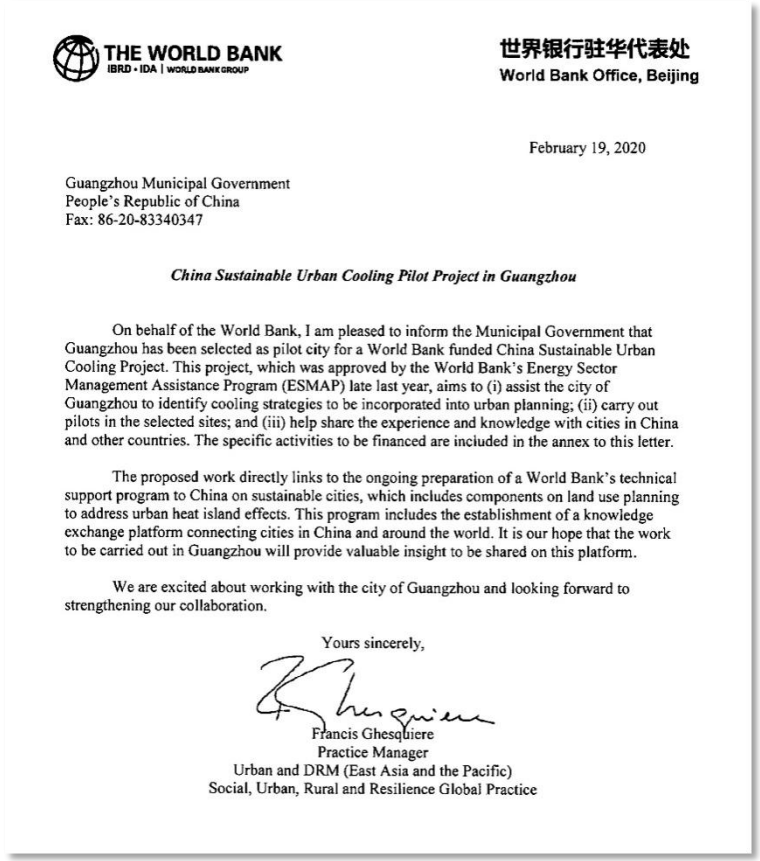
In 2020, Guangzhou was selected as the first pilot city to carry out the "China Sustainable Urban Cooling Project".

Pilot Tasks

Assist Guangzhou in selecting **cooling strategies** that can be integrated into urban planning.

Select and carry out **pilot projects**.

Help Guangzhou **share experiences and knowledge** with cities at home and abroad。



THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

世界银行驻华代表处
World Bank Office, Beijing

February 19, 2020

Guangzhou Municipal Government
People's Republic of China
Fax: 86-20-83340347

China Sustainable Urban Cooling Pilot Project in Guangzhou

On behalf of the World Bank, I am pleased to inform the Municipal Government that Guangzhou has been selected as pilot city for a World Bank funded China Sustainable Urban Cooling Project. This project, which was approved by the World Bank's Energy Sector Management Assistance Program (ESMAP) late last year, aims to (i) assist the city of Guangzhou to identify cooling strategies to be incorporated into urban planning; (ii) carry out pilots in the selected sites; and (iii) help share the experience and knowledge with cities in China and other countries. The specific activities to be financed are included in the annex to this letter.

The proposed work directly links to the ongoing preparation of a World Bank's technical support program to China on sustainable cities, which includes components on land use planning to address urban heat island effects. This program includes the establishment of a knowledge exchange platform connecting cities in China and around the world. It is our hope that the work to be carried out in Guangzhou will provide valuable insight to be shared on this platform.

We are excited about working with the city of Guangzhou and looking forward to strengthening our collaboration.

Yours sincerely,

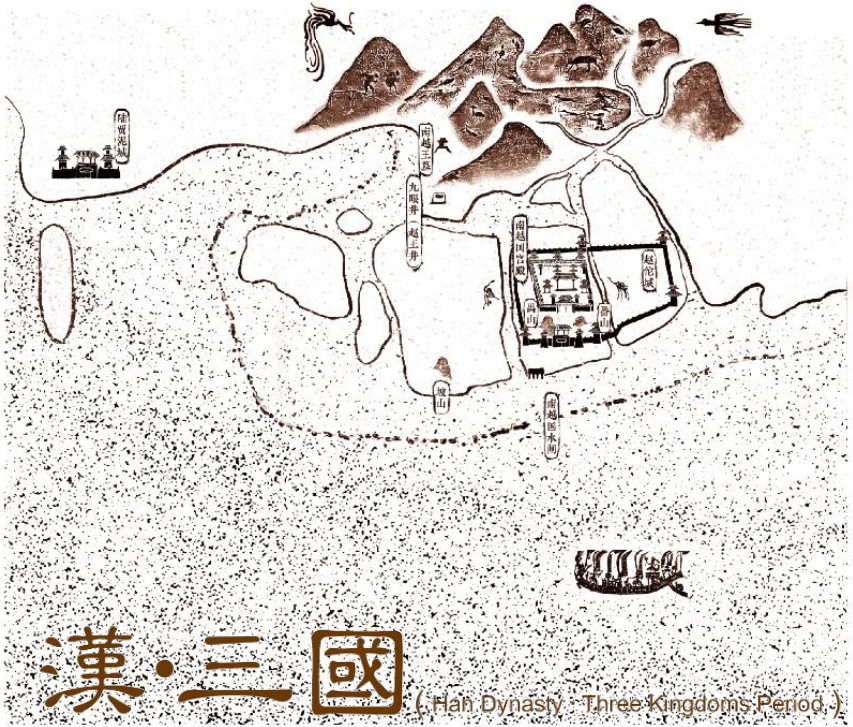
Francis Ghesquiere
Practice Manager
Urban and DRM (East Asia and the Pacific)
Social, Urban, Rural and Resilience Global Practice

2

Guangzhou’s Cool City practice and exploration

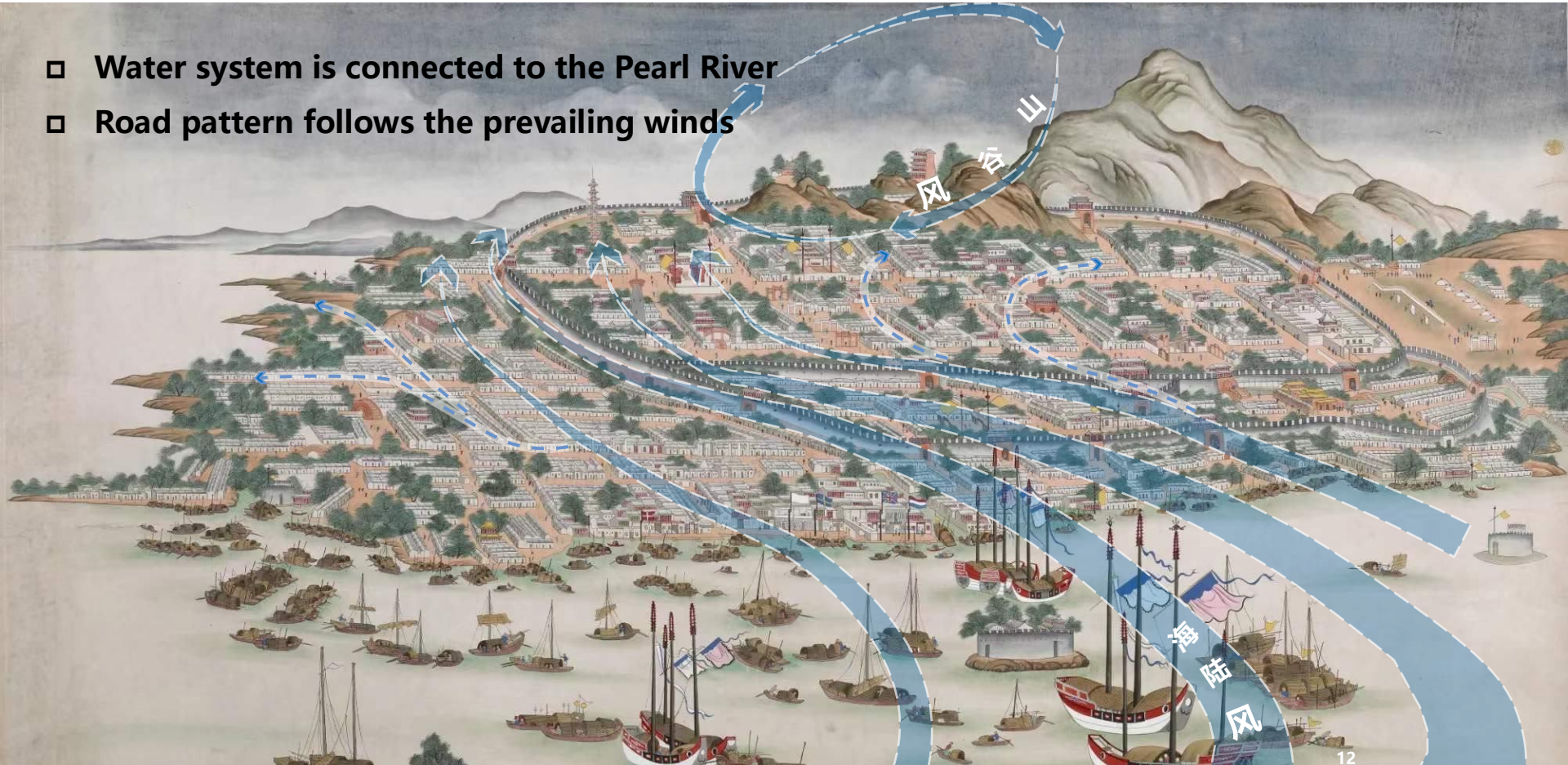
Historical Climate Adaptation in City Location

- Mountains in north can block the cold wind from the northwest in winter.
- The summer wind is unimpeded since the city is facing the southeastern coast.



Historical Climate Adaptation in Urban Spatial Pattern

- Water system is connected to the Pearl River
- Road pattern follows the prevailing winds

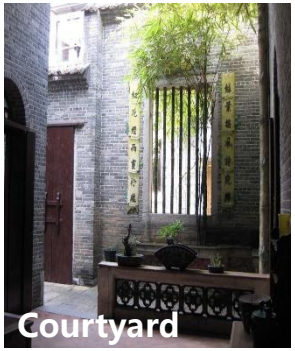


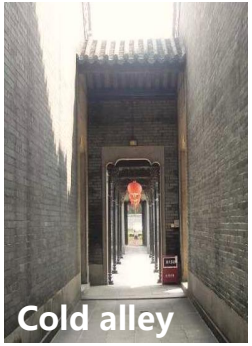
Traditional villages layouts: with water ponds in the front ,houses in the back and alleyways in comb shapes

Historical Climate Adaptation in Traditional Lingnan Architecture

Climate-adaptive construction experiences in ventilation, insulation and shading.

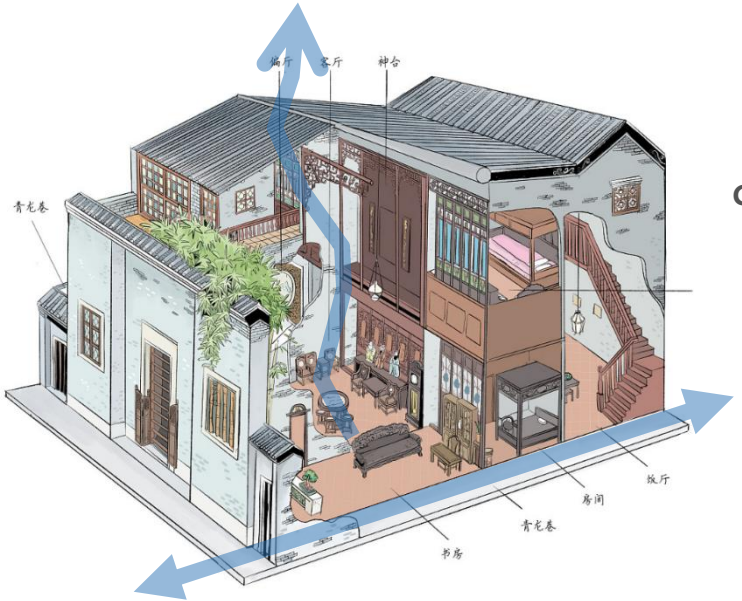
Passive cooling measures in traditional lingnan architecture

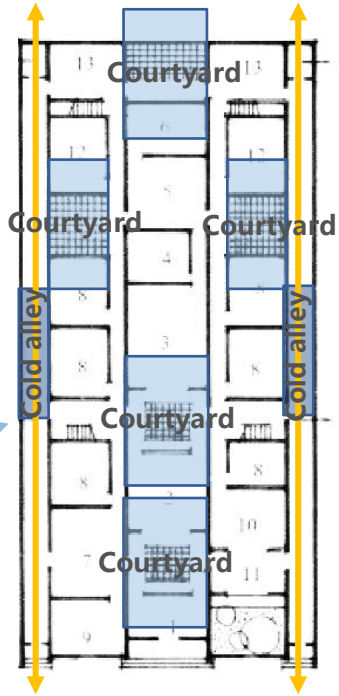

Courtyard


Cold alley

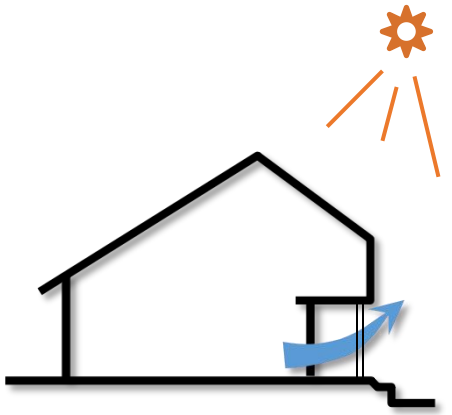

Tanglongmen

Xiguan Mansion in Guangzhou





Historical Climate Adaptation in Traditional Lingnan Architecture



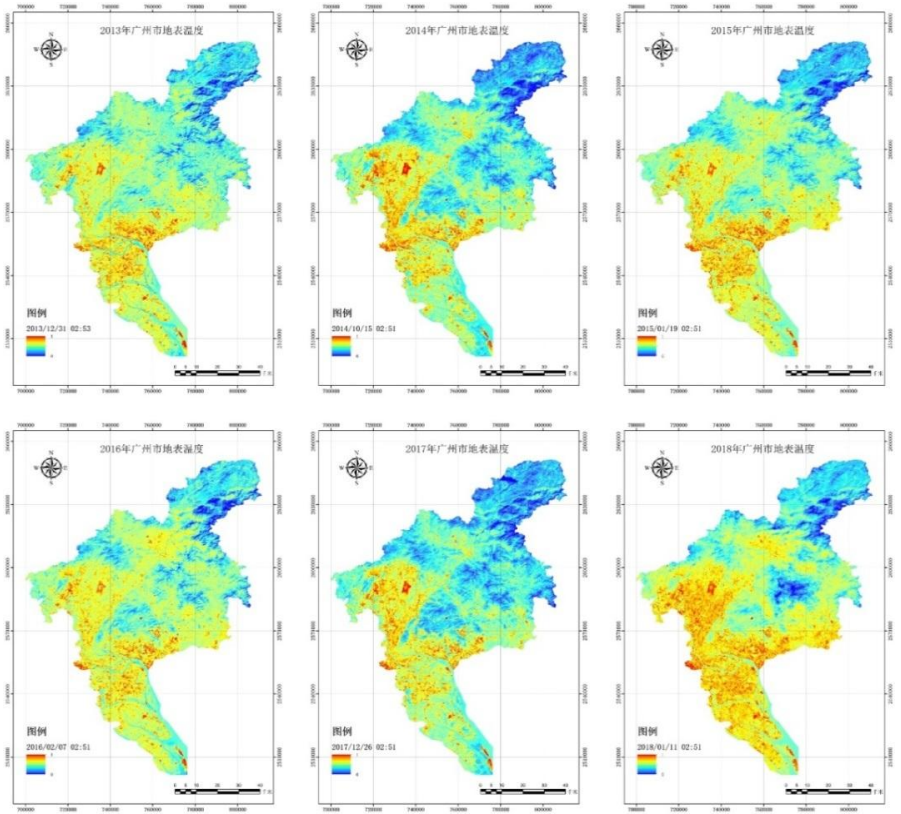
Arcade:
Built on stilts, create a comfortable walking space providing shade and ventilation.

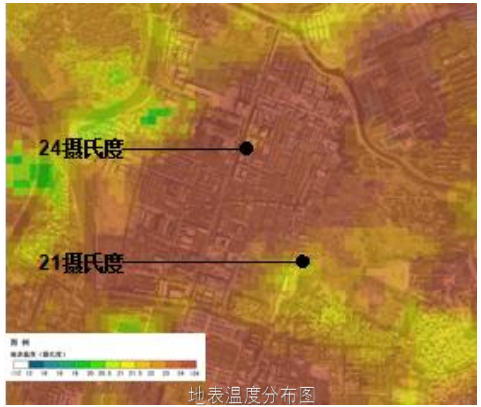
Action Framework

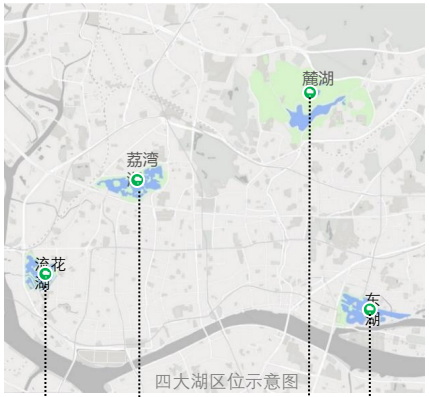
Basic Research & Technological Support	Environmental Monitoring	Wind-heat Assessment	Questionnaire surveys
Strategic System	City Level	District Level	Block Level
Pilot Projects	Urban Renewal Yongqingfang Ⅱ	New Town Development Knowledge City	Urban Central Wetland Haizhu Wetland
Policy Guidance	Guangzhou Urban Cooling Strategy and Guidelines		
	Guiding Opinions on Advocating Sustainable Urban Cooling in Urban Renewal Work		

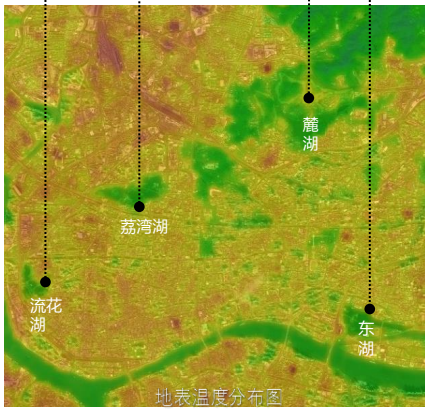
URBAN HEAT ISLAND PATTERN

Studied the relationship between the distribution pattern of urban heat island and land use.



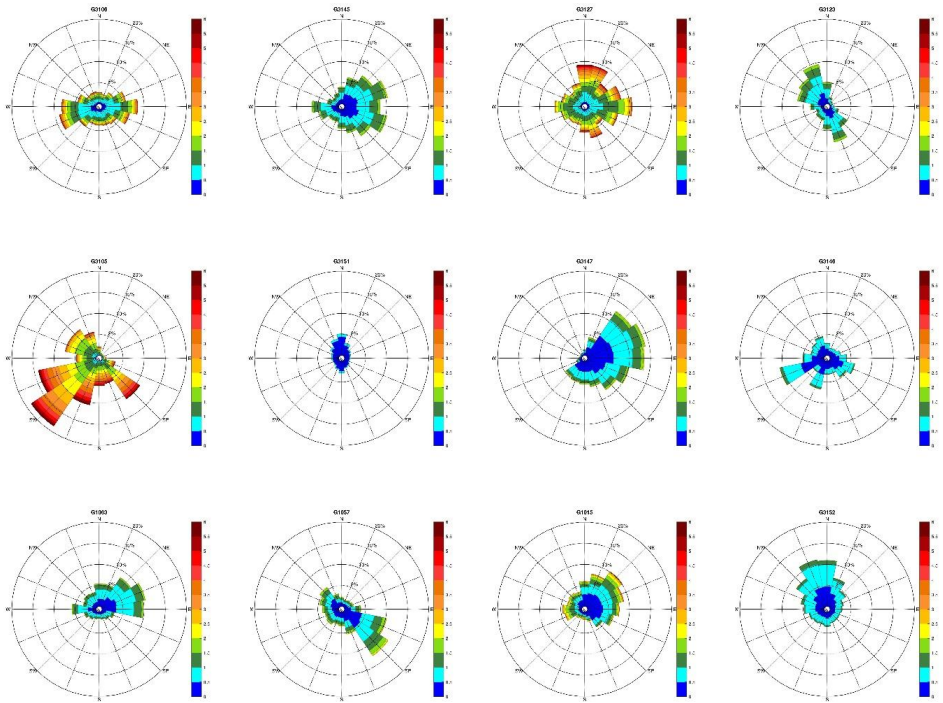




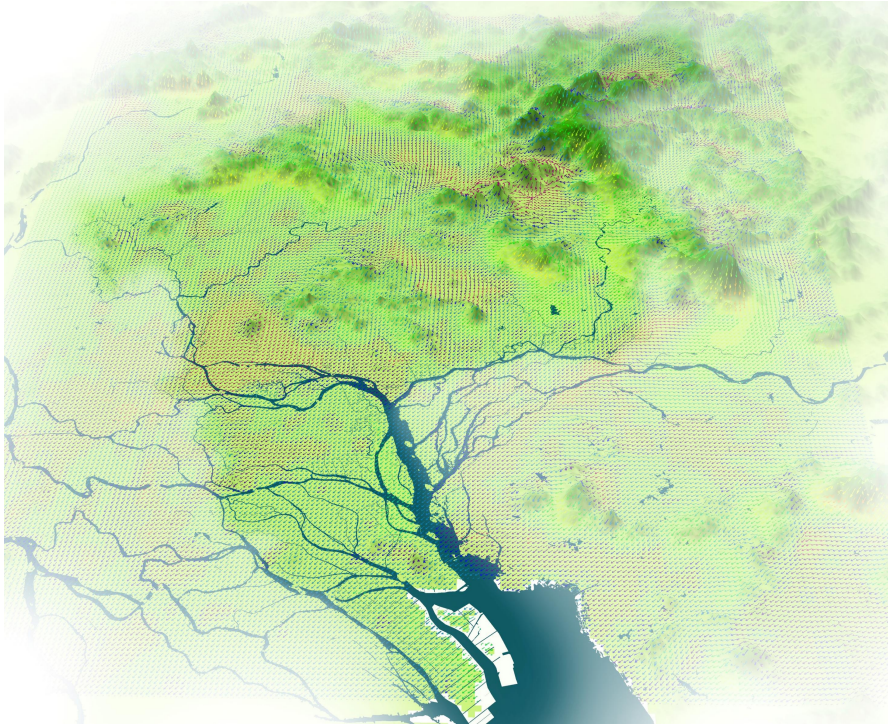


WIND FIELD PATTERN

Explored different wind field characteristics and Identified areas needs to be improved.



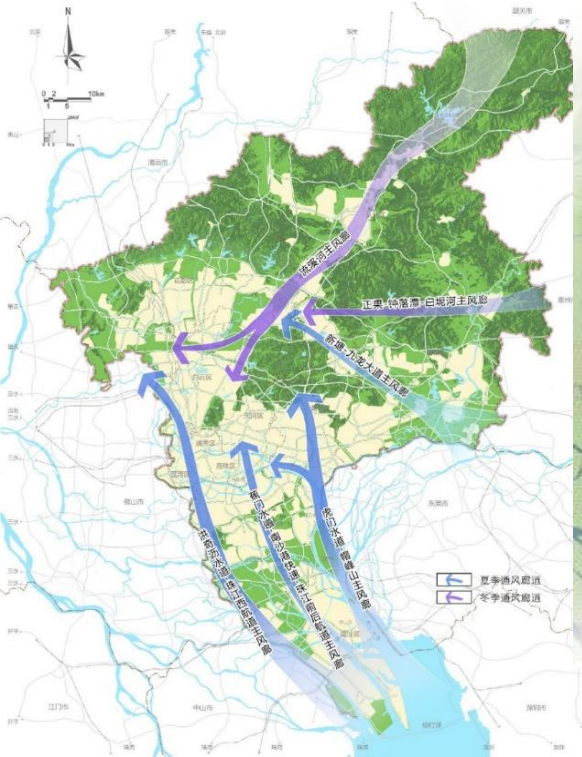
Wind rose diagram of the meteorological station

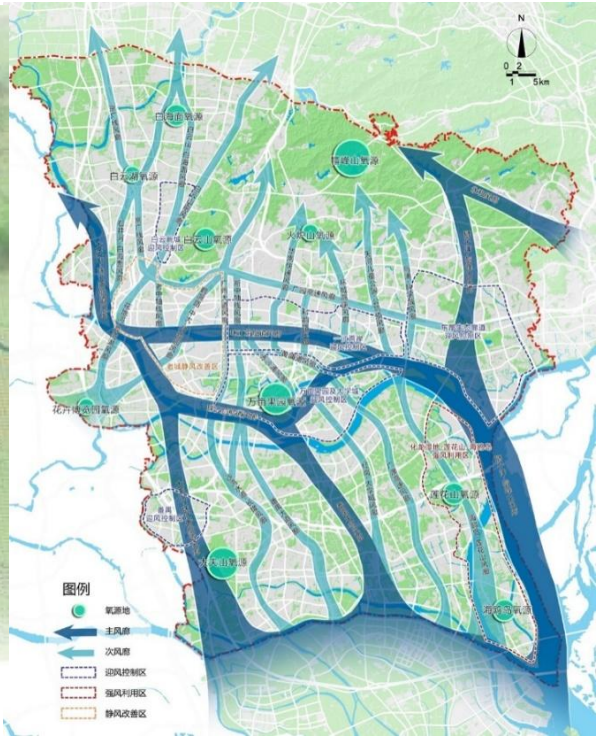


WRF WIND MAP

Urban Level: Establish Ventilation Corridors, Promote Natural Ventilation

Build a "six-main and multi-level" ventilation corridor system by combining open spaces such as green areas, rivers, and roads.

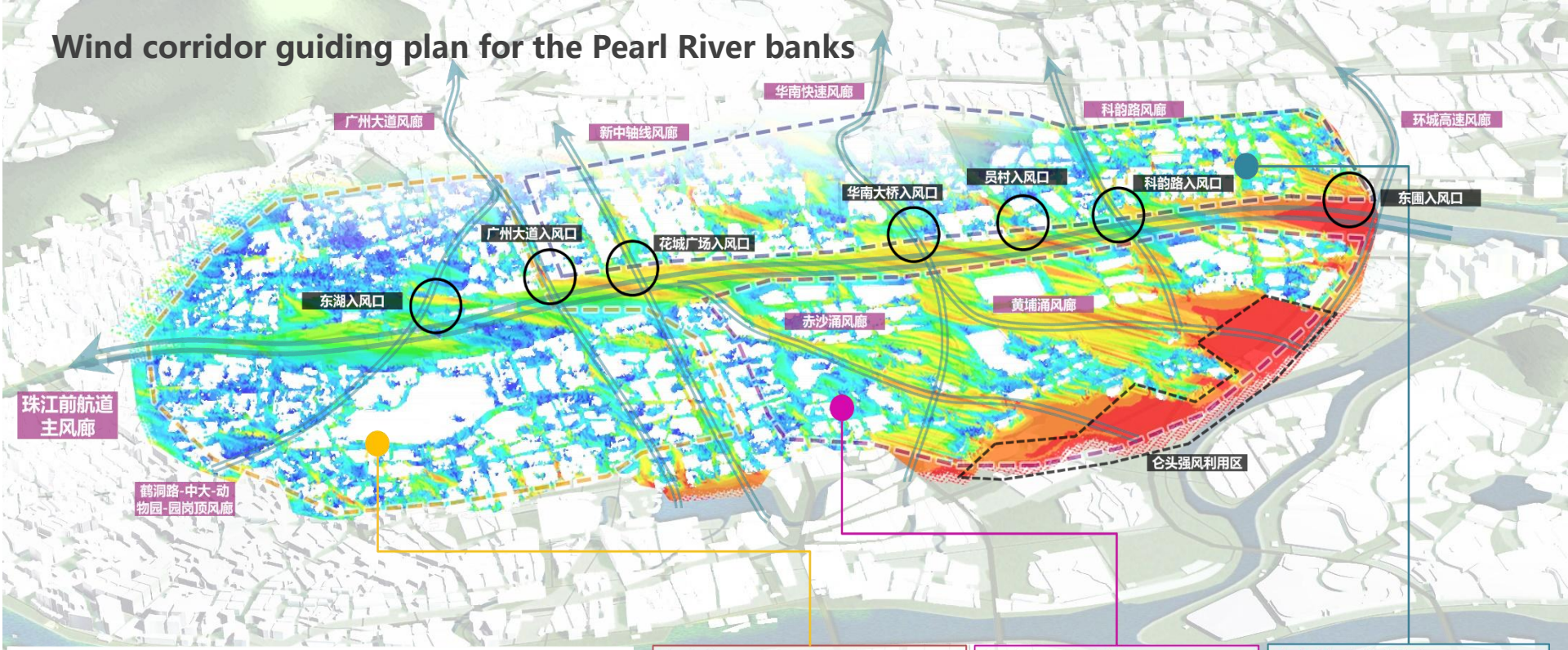




ventilation corridor system of Guangzhou

Combining urban design, control the development intensity, open space, and building width of the ventilation corridors.

Wind corridor guiding plan for the Pearl River banks



- **核心区“西弱东强”格局明显**：根据Fluent对重点管控区盛行东南风的模拟结果，珠江前航道东部两岸廊道风速相对较高，是影响城市风环境的关键地区，应对入风口进行严格管控；西部老城区通风潜力低，注重集中建设区的风道挖潜。

静风 强风（10m/s以上）

老城静风改善区：

旧城更新过程中须进行风环境模拟评估，严格执行建设指引以改善周边风环境，沿岸地区优先考虑风道挖潜。

海珠迎风控制区：

盛行东南风进入重点管控区的主要入口，应限制开发

- 仑头强风利用区限制开发，保持开敞性；
- 南北向通风廊道周边严控增量。

强风利用区

东部迎风控制区：

- 通风廊道周边加强布局控制，维持畅通；
- 有效入风口严控增量，严禁屏风建筑，建筑设计须考虑风向严格执行建设指引。

有效入风口

Pilot projects of old town generation and new town development

Yongqingfang Ⅱ

Site and architectural level

Urban renewal flagship project

Market-driven

Towards implementation

Knowledge City

Block level

Benchmark for eco-cities

Government-led, market implementation

Towards planning and management

Engaging multiple stakeholders

A collaborative platform was built for the government, developers, experts, and planners to promote the implementation of cooling strategies.

集体决策

与设计团队沟通

采访居民、业主和商户

技术团队内部讨论

与施工团队沟通

与开发商沟通

与政府机构沟通

世界银行专家咨询

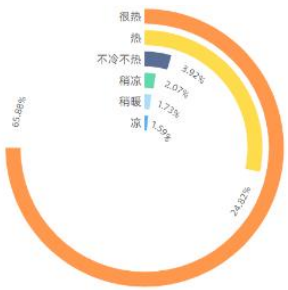
Conduct Thermal Comfort Survey, Promote Public Participation

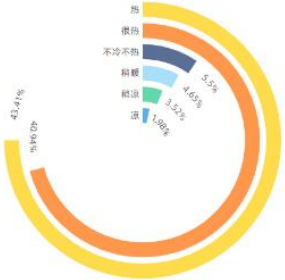
Combining questionnaires and interviews, investigate residents' heat preferences and improvement needs.

Conduct Thermal Comfort Survey, Promote Public Participation

Thermal sensation

90% think it's hot outdoors in summer



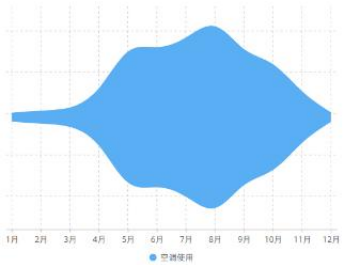


Indoor temperature without air conditioning:

84% feel hot, very hot

Air conditioner usage

The annual air conditioning usage is up to **6**months.

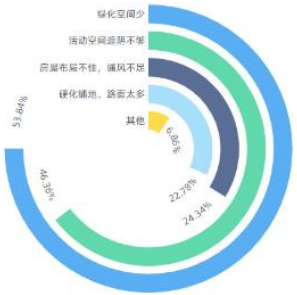


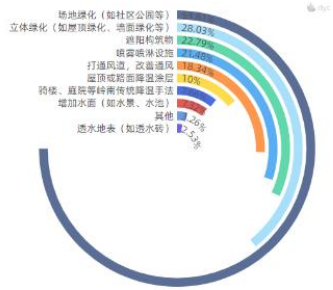
50% of residents use air conditioning for more than 8 hours.

Living environment

The biggest issue: lack of

green spaces

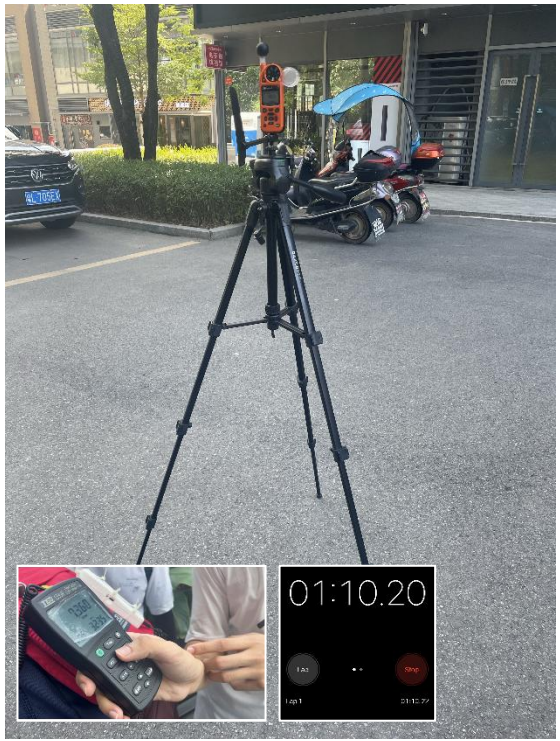




Improvement measures: site and **vertical greening**

Conduct Thermal Walk, Study Thermal Environment Mechanism

Conducting pedestrian perception experiments, collecting data on subjective and objective thermal comfort, building microclimate perception analysis models.



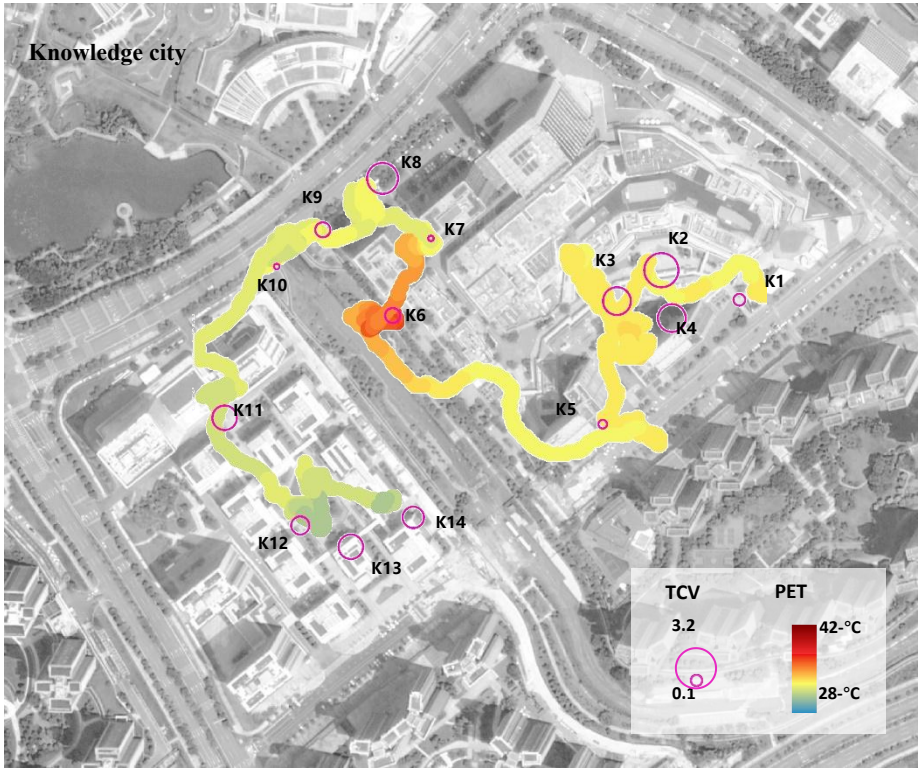
Site Monitoring

Mobile Monitoring

Experimental Site

Conduct Thermal Walk, Study Thermal Environment Mechanism

Investigating how the built environment of a city affects people's comfort levels

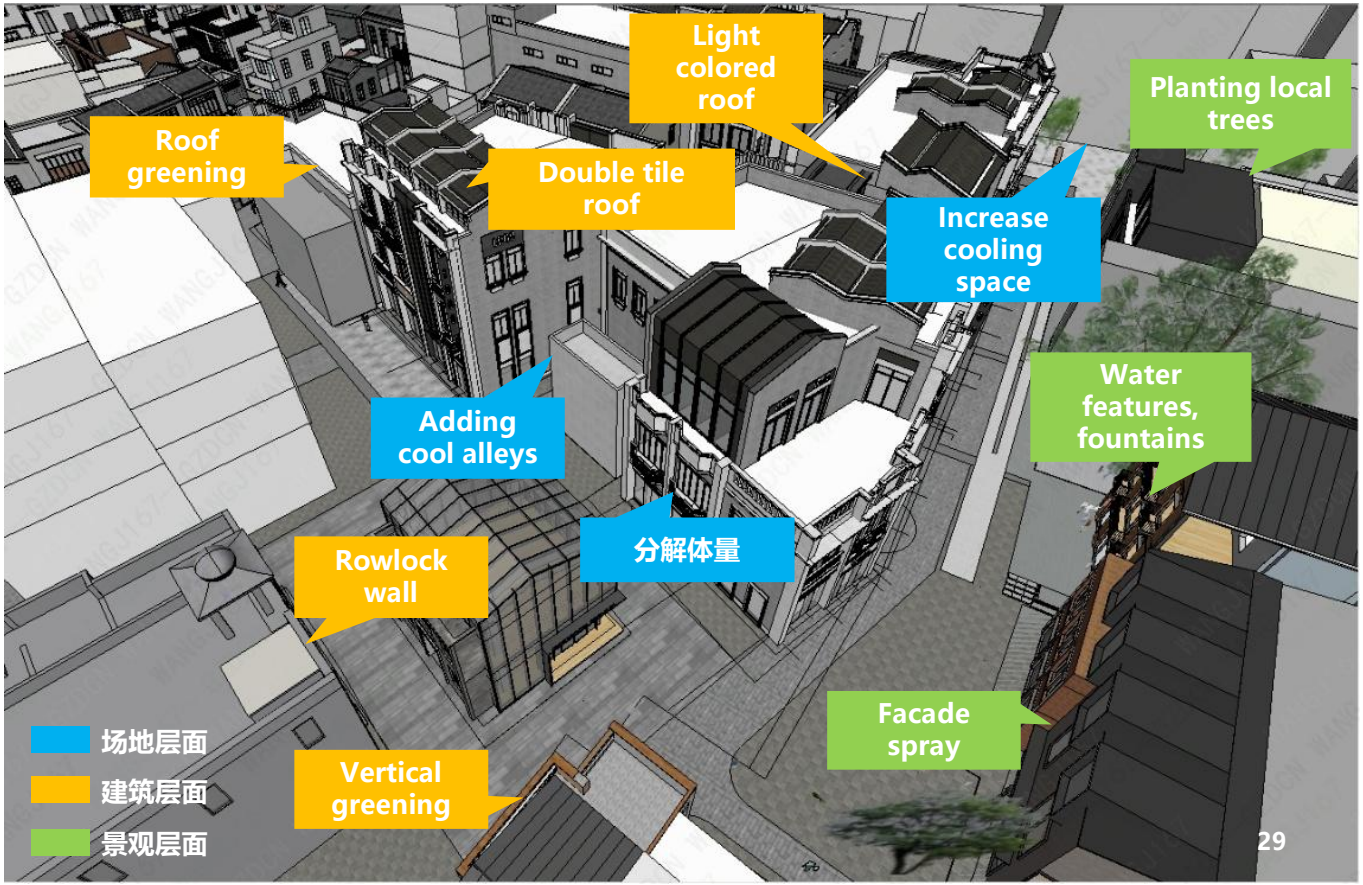


Yongqingfang Ⅱ

- ✓ Improving microclimate in old city renovation.
- ✓ A market-driven urban cooling practice.

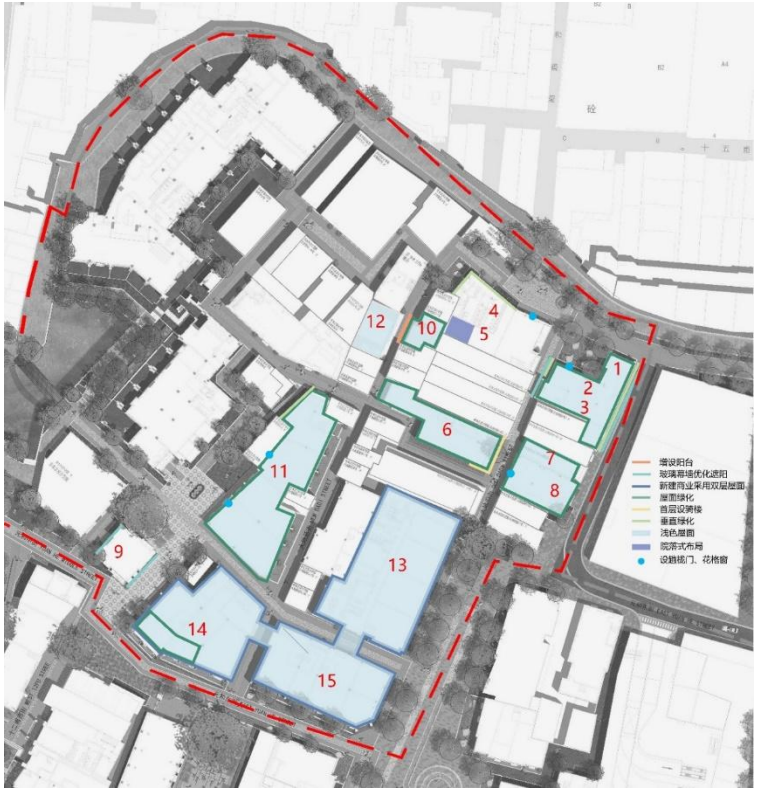
Key Cooling Measures at Two Levels

- Interpret the wisdom of traditional architecture in ventilation, shading, and insulation.
- Explore the use of low-cost, mature modern technology.



Yongqingfang Ⅱ: Urban Cooling in Urban Renewal

Considering property ownership, microclimate conditions, and building characteristics, select 15 cooling sites, covering 9 measures.

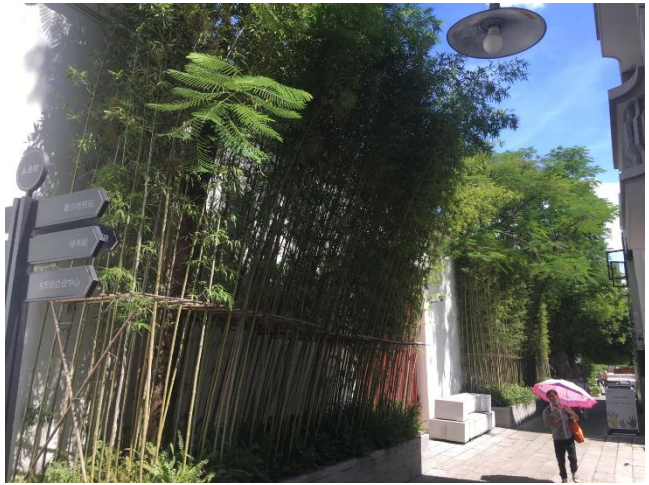


	Measures	Description	Location	Size
Traditional Lingnan regional architectural cooling methods	Courtyard layout	Improved courtyard layout to increase ventilation	4, 5	20 m²
	Arcades	Usage of arcades or void ground space to offer protection from wind, rain, and excessive sunshine.	6	≈16 m²
	Balconies	Installation of balconies on the first floor or above to shield rooms from excessive sunlight.	10	≈27 m²
	Flexible doors and windows	Usage of traditional, flexible windows and doors that improve ventilation	2, 5, 8	—
	Double-layered tile roof	Addition of double-layered tile surfaces.	13, 14, 15	≈350 m²
Modern low-cost cooling measures	Passive shading	Installation of shading structures on the east, west, and south curtain walls, as well as on rooftop skylights	1, 2, 9	≈320 m²
	Cool roof	Addition of a reflective coating on roofs	1, 2, 3, 4, 6, 8, 11, 13, 14, 15	≈1080 m² (minus the sloped roofs)
	Vertical greenery	Installation of vertical greening that will grow up the walls	1, 2, 4, 11	≈240 m²
	Green roof	Flexible rooftop greening	1, 2, 3, 6, 7, 8, 10, 11	Total length ≈50 m
		Fixed rooftop greening	14	≈220 m²

Promote 3D Greening

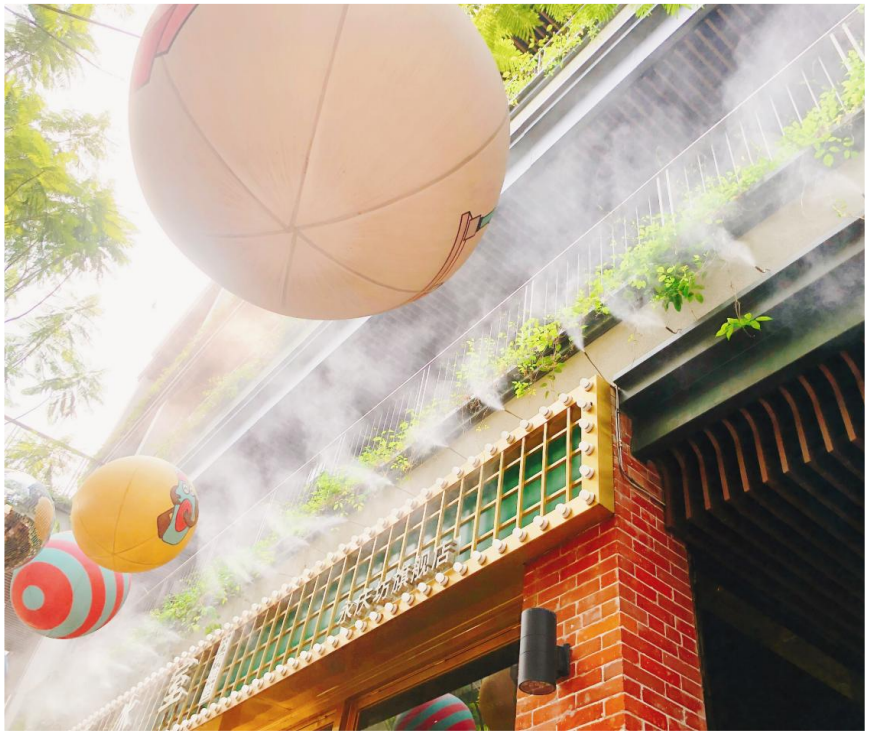
Vertical greenery on traditional architecture

垂直绿化可选用竹子等具有古典气息的地载式植物



Install Water Mist System

Water mist system on building facades in narrow streets improves thermal comfort

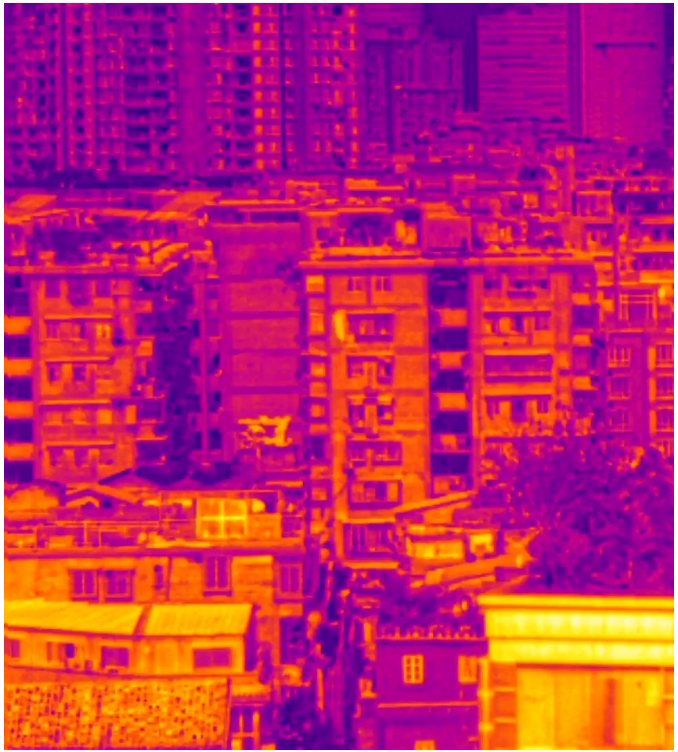


Build a Shaded Square

The old trees have been preserved and combined with water bodies create a shaded square for cooling off.

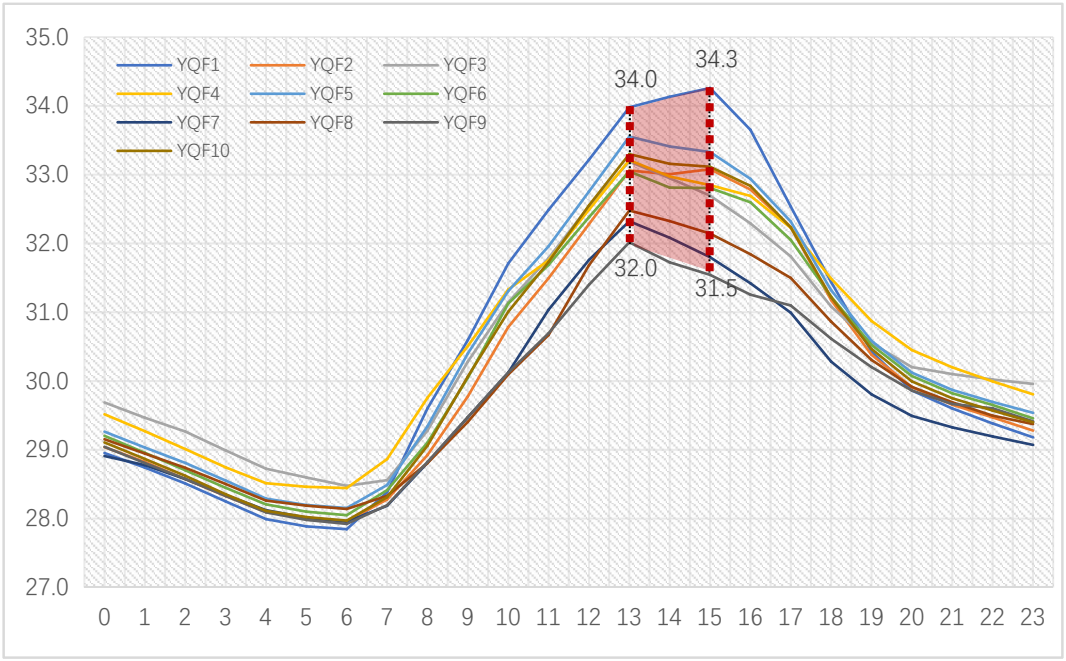
Conduct Meteorological Monitoring

Thermal monitoring was used to obtain long-term observation data to support the validation of cooling measures.



Yongqingfang Ⅱ: Urban Cooling in Urban Renewal

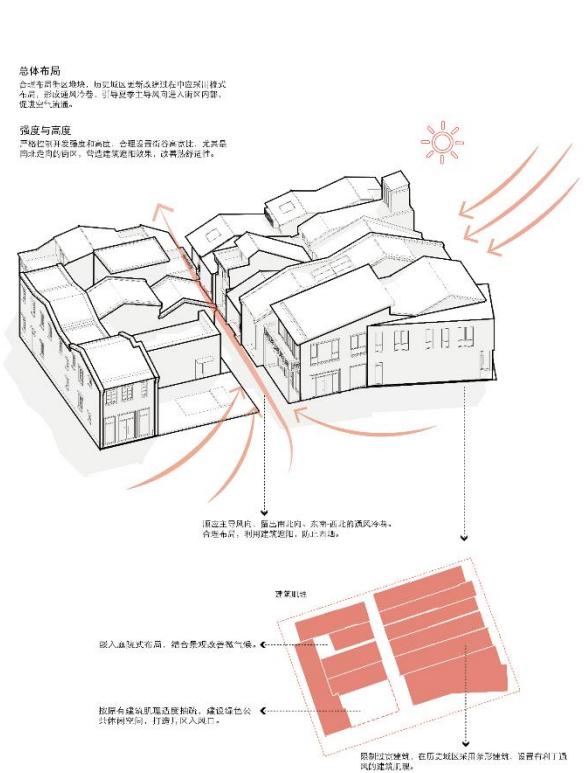
The temperature in the cool alleys can be lowered by 2-3 ℃ at noon.

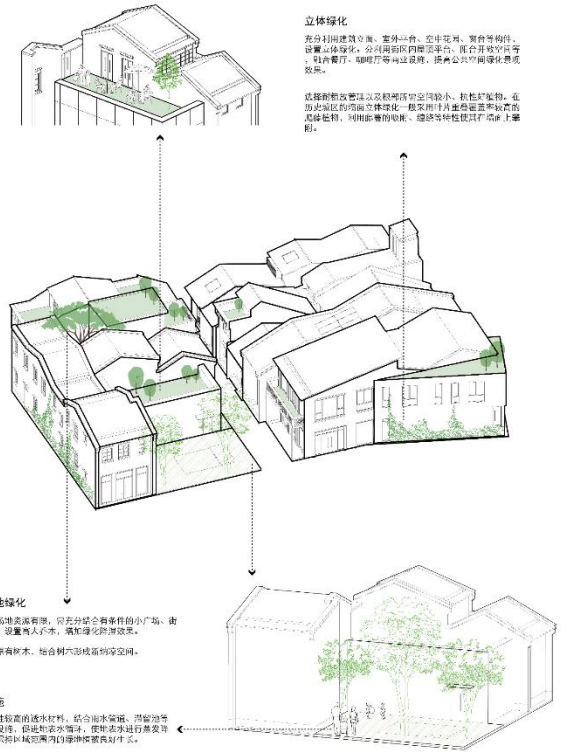


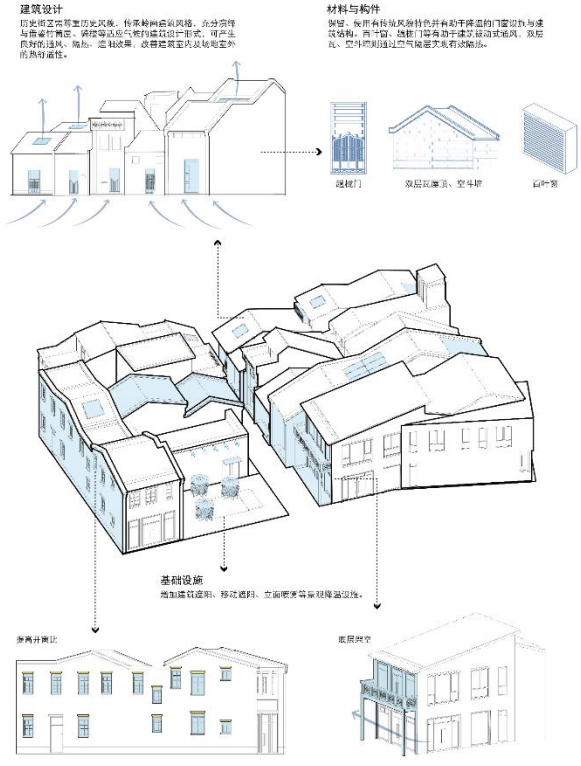
24-hour daily temperature variation chart on a typical summer day

Map of the distribution of average temperature in August.

Cooling Design Guidelines for Planning, Construction, and Management







Knowledge City

Focusing on the entire process from planning, design to implementation

Knowledge City: Urban Cooling in New Town

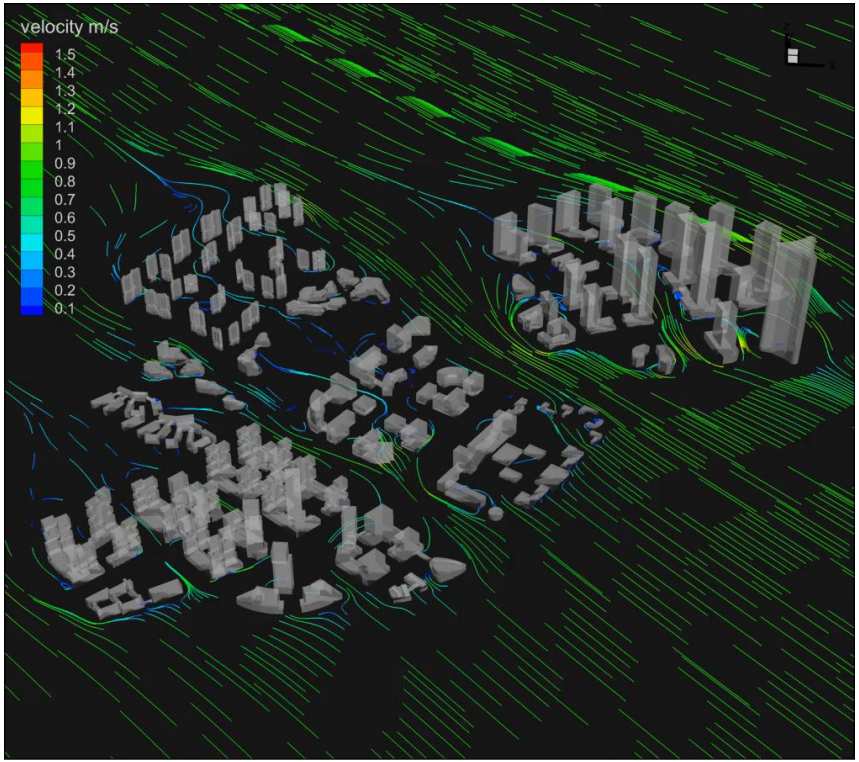
- Integrate sustainable cooling concept from the planning stage.
- Transmit the measures to the construction and management phase.

Original plan

Optimized plan

Knowledge City: Urban Cooling in New Town

Assess the ventilation effect of the design scheme, and optimized it to ensure maximum use of passive cooling.



1.风流通

后排建筑受遮挡影响较大，建筑组团内部风速较小；沿河界面通风潜力小，风未有效进入组团内部。

2.温度

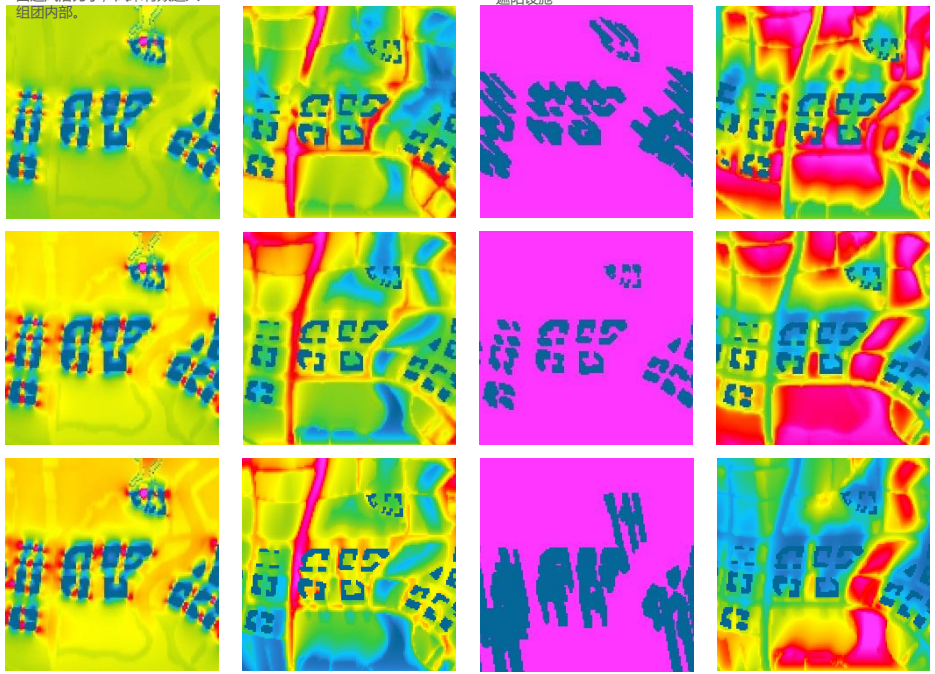
内部中庭因受到水体绿地的影响，反映出较低的空气温度。

3.太阳辐射

建筑的高度轮廓与布局可形成有效的遮阳，但需要补充一些遮阳设施

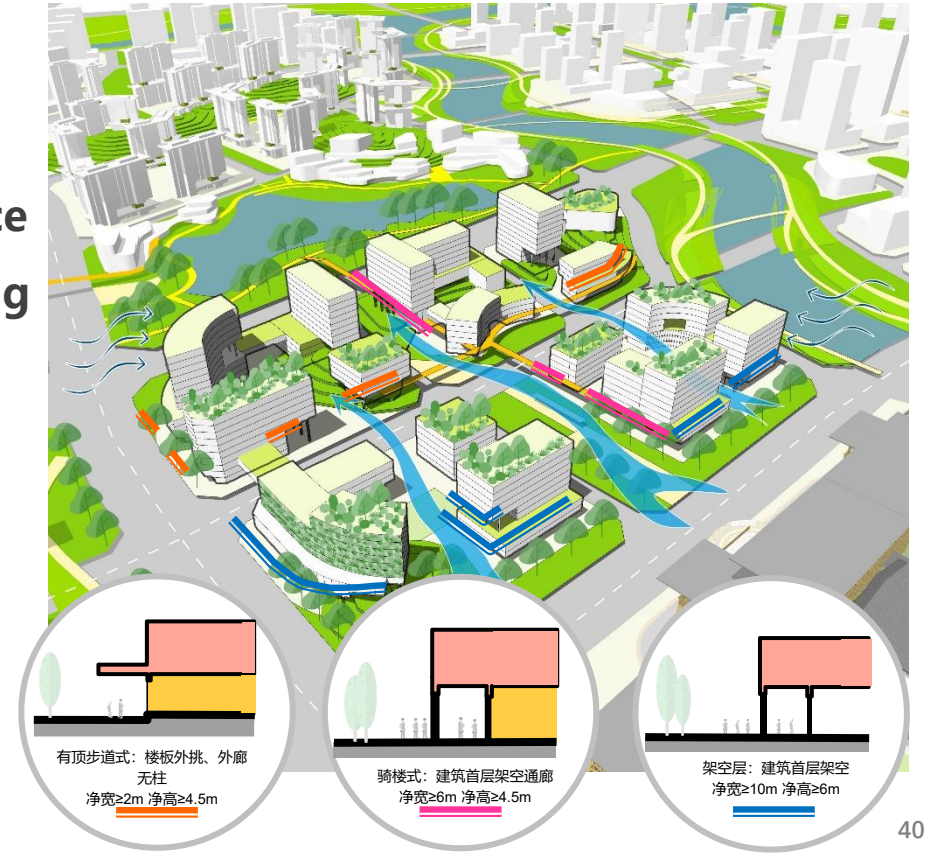
4.湿度

受九龙湖影响明显。河流和水库的影响更小。



Knowledge City: Urban Cooling in New Town

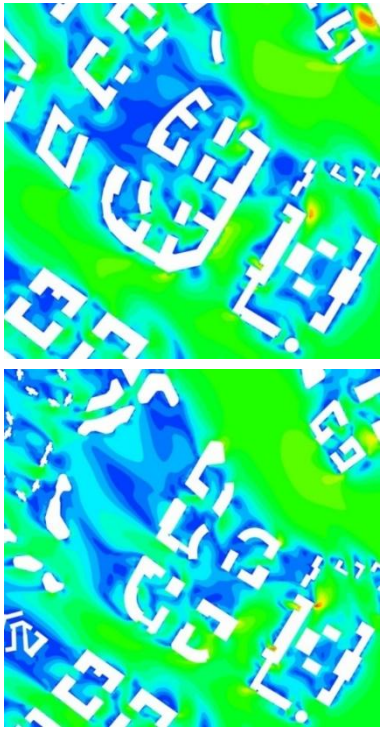
- Maximize ventilation
- Maximize shading
- Passive ventilation design for outdoor space
- Use water bodies and vegetation for cooling
- Micro-topography design



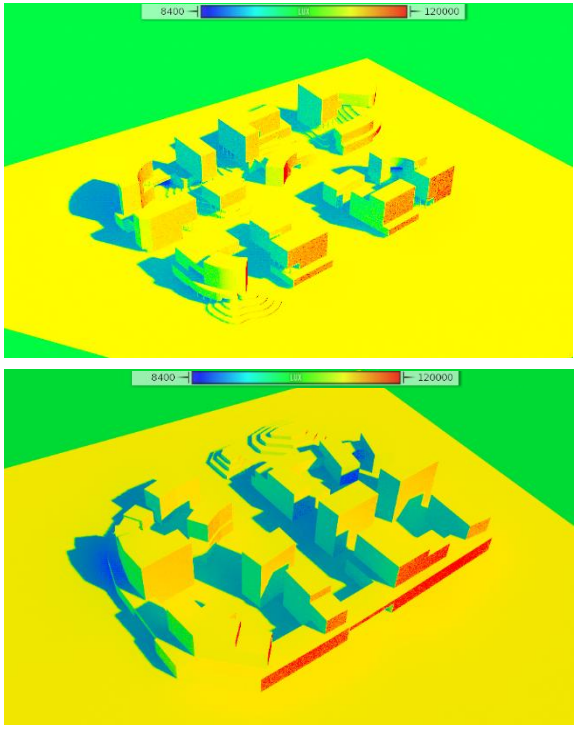
Assess the Improvement of Thermal Environment

The ventilation efficiency of the plan has increased by 32%, the shading of site buildings has increased by 15%, and the highest temperature in summer has decreased by about 1 ℃.

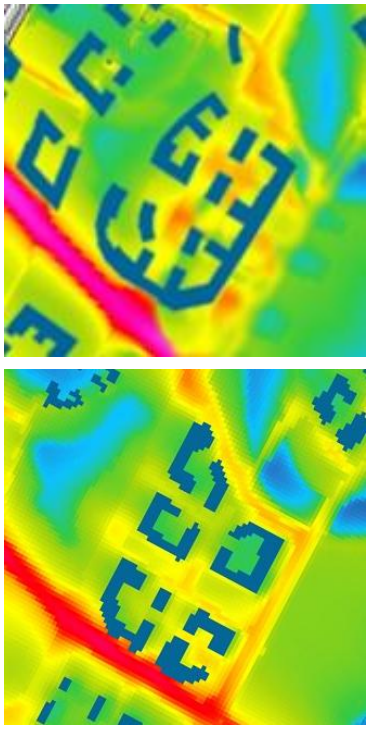
方案优化



风流通效率提升32%



场地建筑阴影提升15%



夏季最高气温降低1度左右

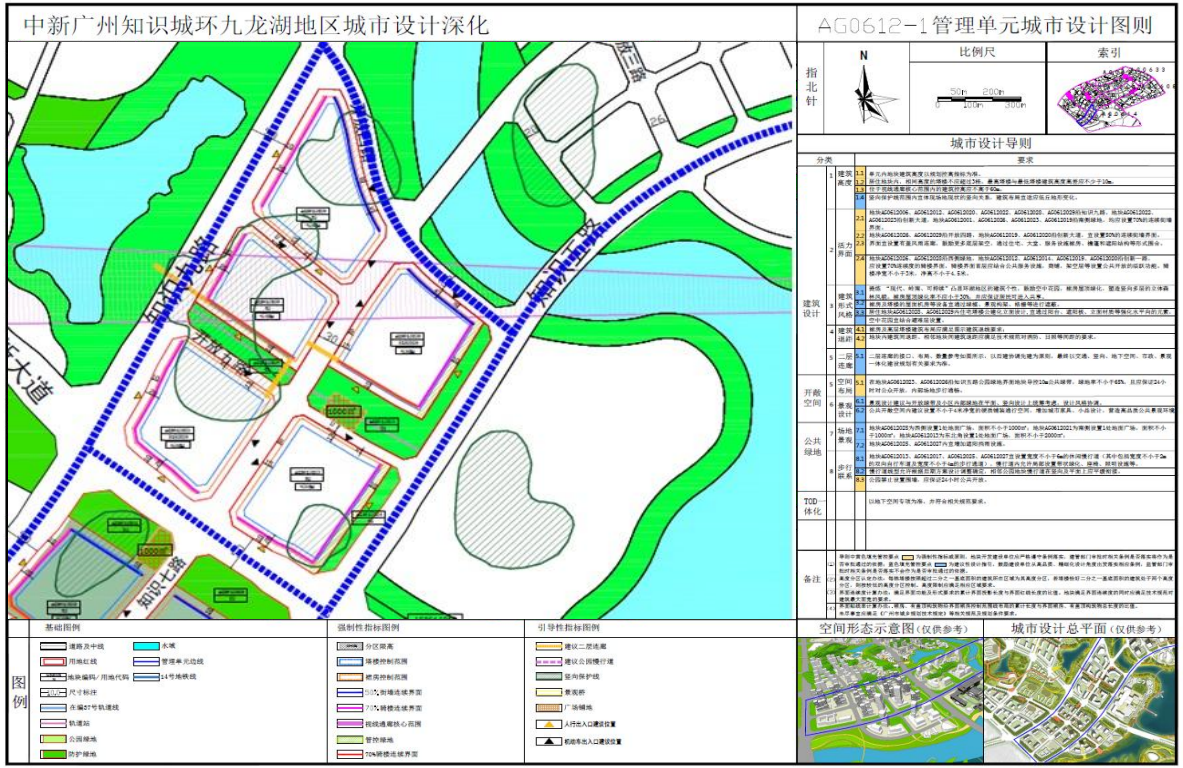
Incorporate Cooling Requirements into Urban Design Guidelines

管控要素

- 建筑高度
- 活力界面
- 建筑形式风格
- 建筑退距

管控细则

分区限高、街墙界面、骑楼界面、立体绿化、竖向保护、视线通廊公建化立面等



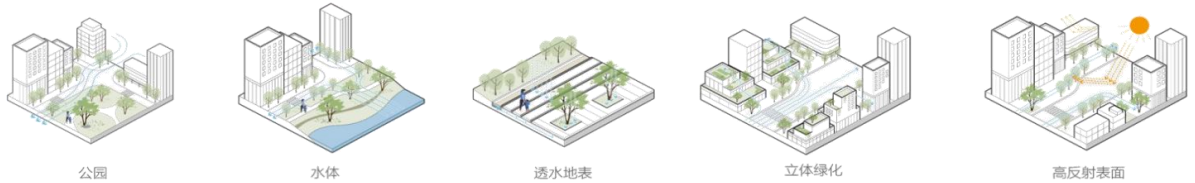
Encourage measures related to sustainable urban cooling.

Encourage vertical greening, roof greening.

Urban Cooling Strategy & Guidelines

优化格局：让自然做功、引风入城、通风降湿

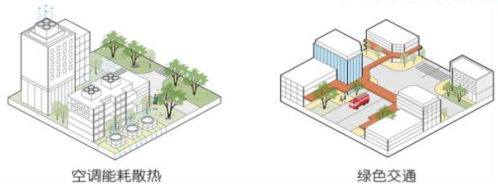
改善城市表面：绿色渗透、会呼吸的城市



改良城市与建筑设计：最大化通风、遮阳与防潮

应用景观与设施降温

减少能耗散热



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