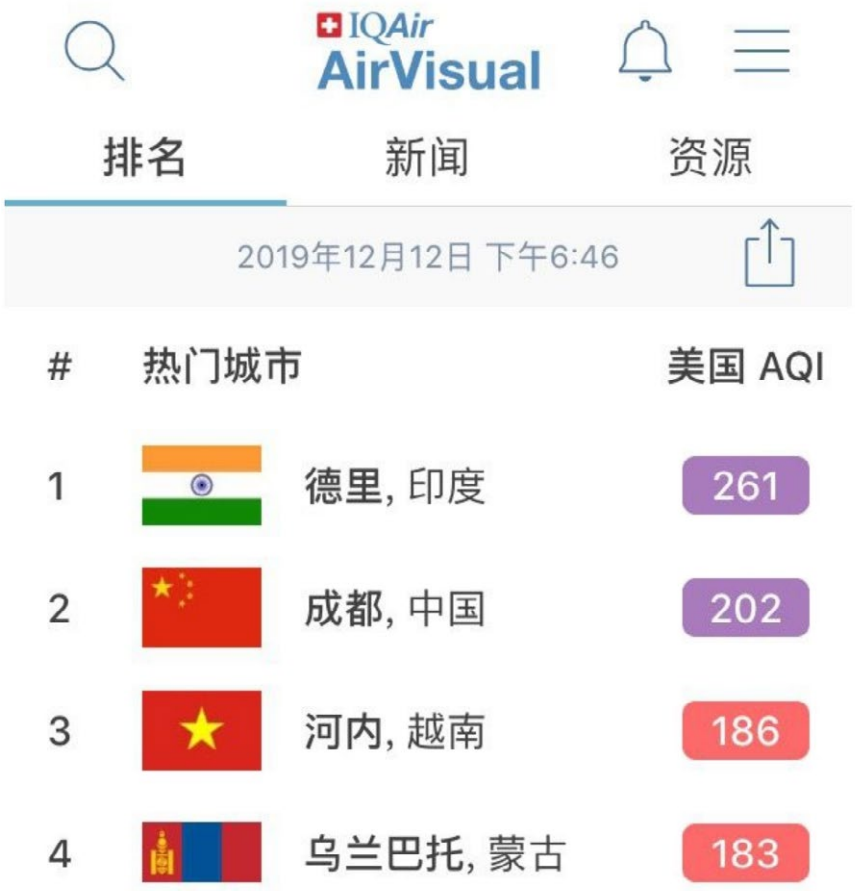
# BREATHING CITY

***Mitigating air pollution through Urban microclimate design***

Hanwen Hu
4919602
P5 Presentation
29 Jun 2020

## CONTENT

# 01 FRAMEWORK

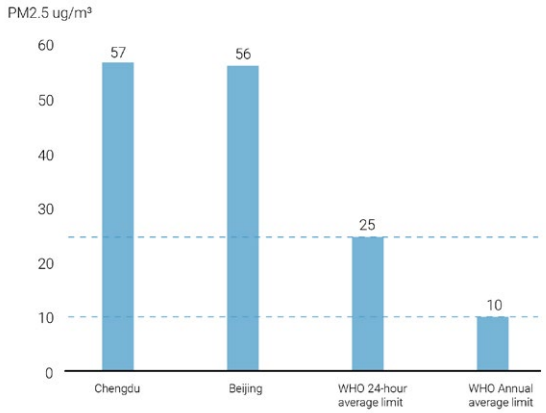



@“巴适”的成都人：你知道现在你那雾霾比北京高吗?

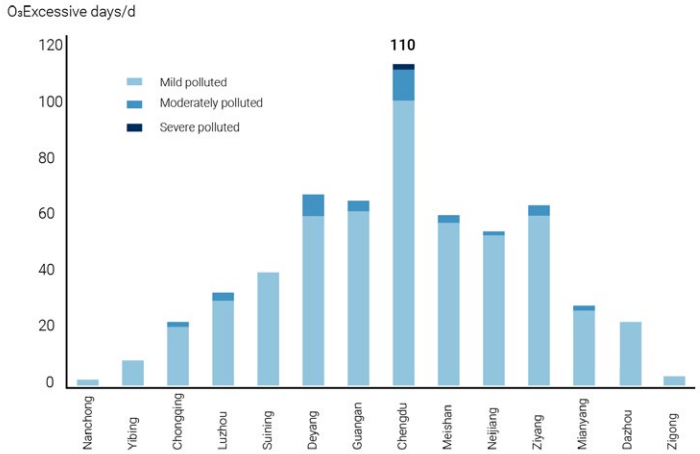
2018年07月31日 星期二 Thomas Talhelm 空气污染, PM2.5

Source:http://finance.sina.com.cn/roll/2016-11-17/doc-ifxxwsix3883646.shtml

# PROBLEM FIELD

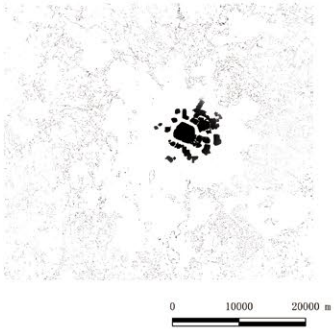



Average PM2.5 in the first half of 2018
Source:Municipal pollution monitors
Analysis Smart Air smartairfilters.com

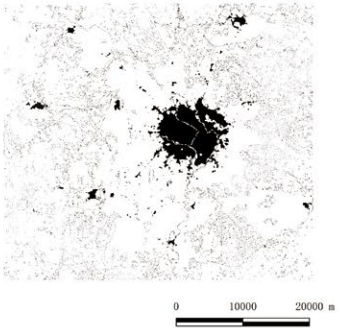



Number of days of $O_3$ concentration non-attainment in CCUA during 2015-2016
Source:China Environmental Testing Center. http://106.37.208.233:20035/
Analysis Smart Air smartairfilters.com

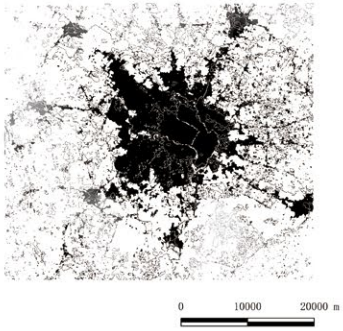
# ***Urbanization of Chengdu***



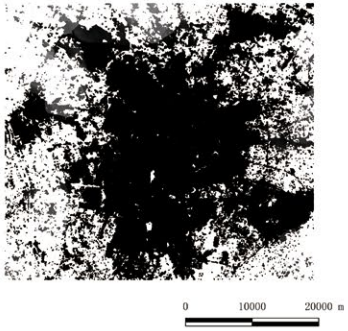

1950



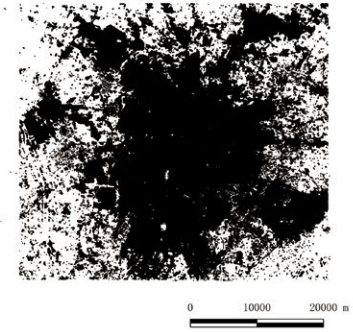

1992




2002



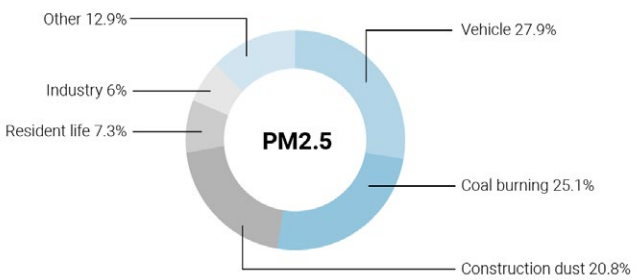

2013




2017

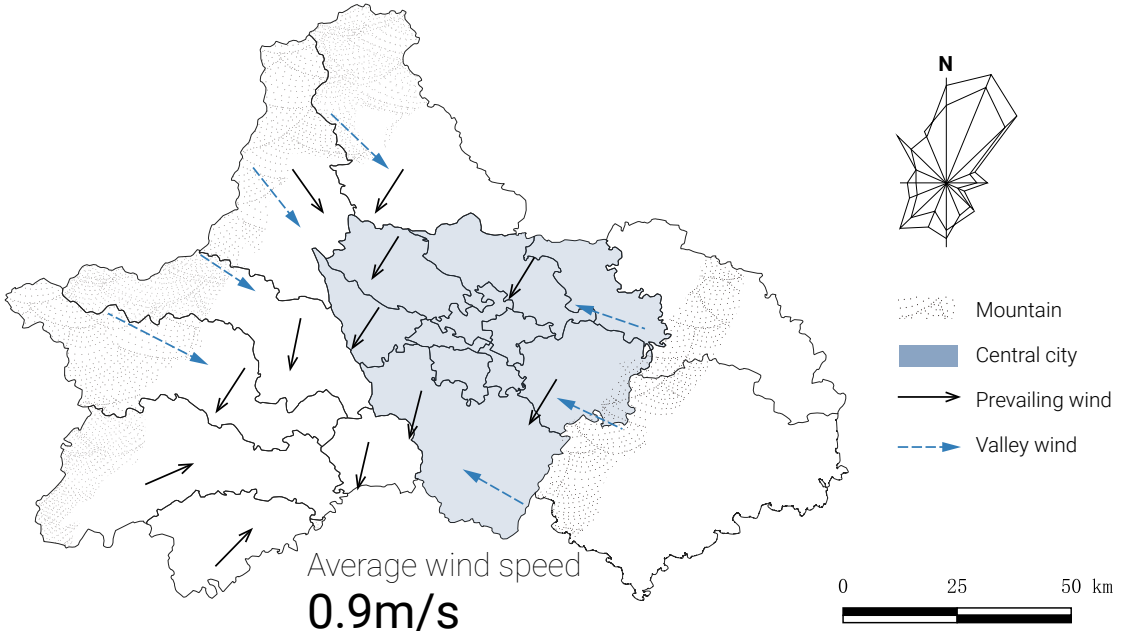
# *PROBLEM ANALYSIS*

**SOURCES**





**DISPERSION**




**CONTROL**

# Problem statement

#1The rapid urbanization of Chengdu has caused a concentration of air pollution.

#2  Poor internal urban ventilation and neglecting the potential of urban microclimates to reduce air pollution.

#3 Insufficient consideration of microclimate and better coordination of urban ventilation is needed.

Source:Google images. https://www.google.com/imgres?imgurl=https%3A%2F%2Flivepast100well.com%2Fwp-content%

## *RESEARCH QUESTION*

**How to mitigate air pollution through urban microclimate design in Chengdu?**

Urbanization of Shanghai
Source: https://www.shplanning.com.cn/Home/News/detailid/151.html

# METHODOLOGY

## SUB QUESTION

*1. What is the relationship between urban morphology, microclimate and air pollution? What the main parameters are included in these three systems?*

*2. What is the climate characteristic of Chengdu and which part is the most unfavorable microclimate and* ***vulnerable area*** *for air pollution?*

*3. What are the urban morphological characteristics are most relevant can be identified for the mitigation of air pollution through urban microclimate mechanism in canyon scale?*

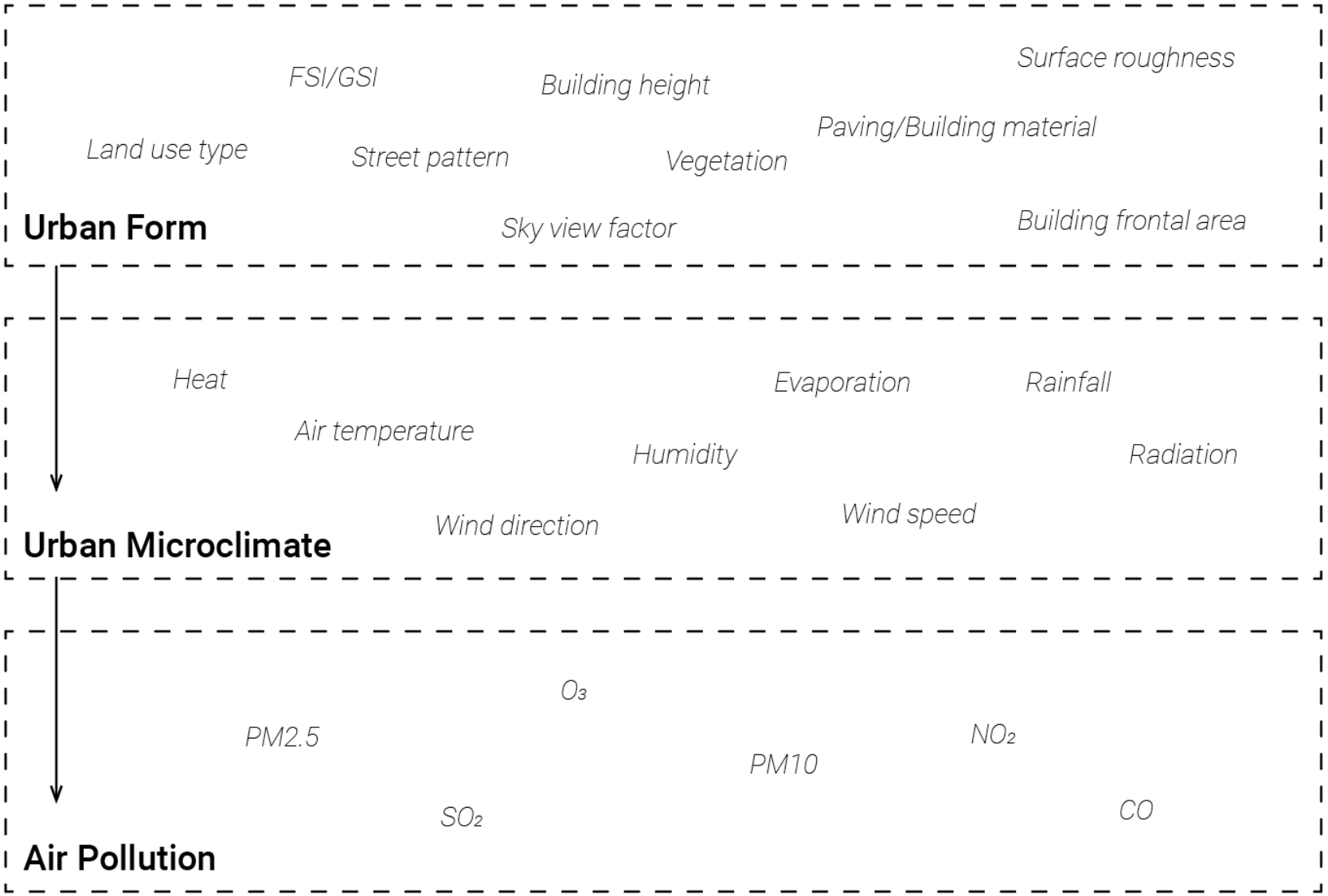
*4. In what way is the microclimate affected by different morphological features? In what way is the air pollution affected by different microclimate?*

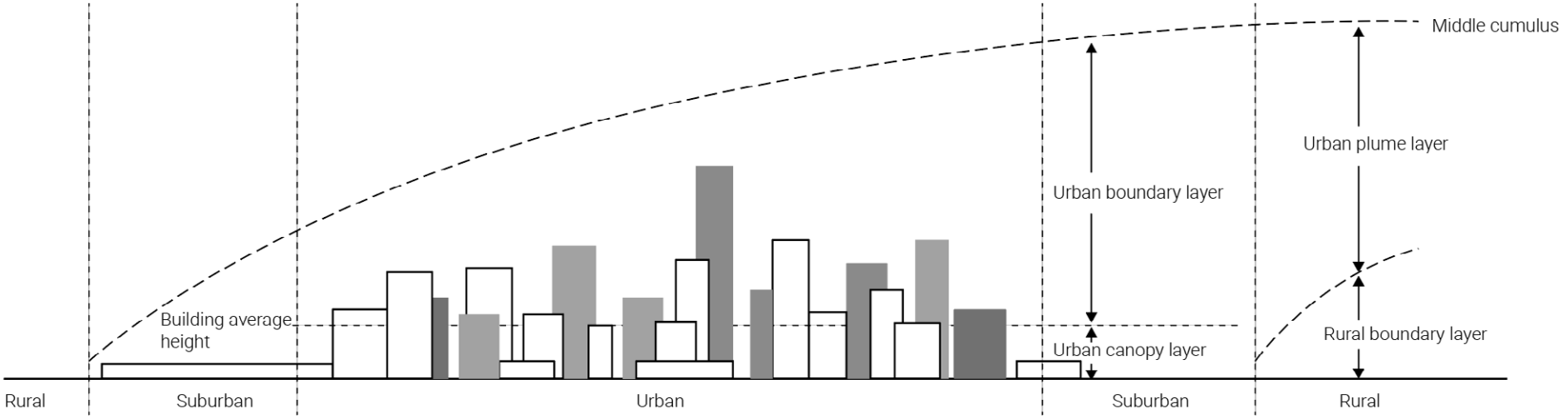
*5. What kind of* ***spatial interventions*** *in terms of microclimate most effective to mitigate air pollution?*

*6. How to integrate microclimate design and air pollution issues in the* ***urban design process****?*

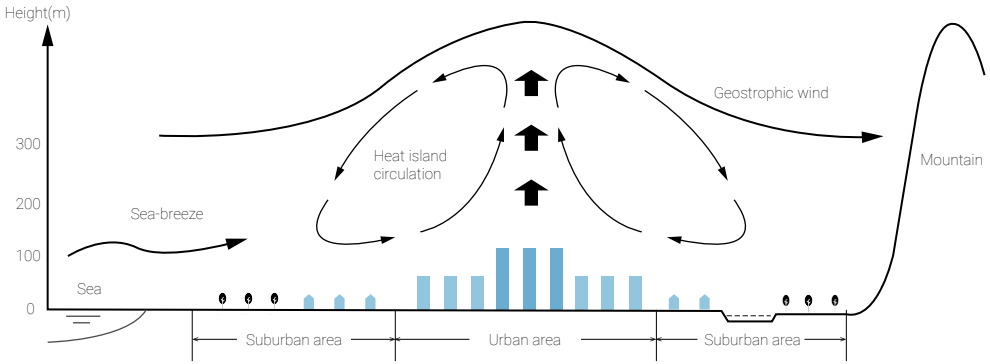
*7. To what extent are the interventions on one typical site transferable to the rest?*

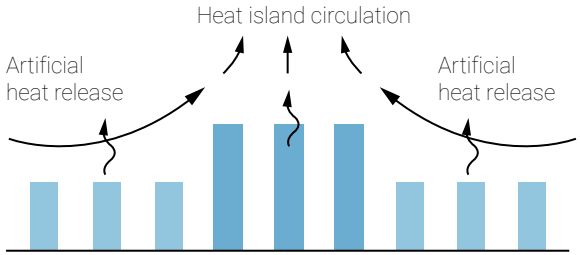
## *RELATIVE PARAMETERS*






Source:Various physical processes at mesoscale,local scale,and microscale. Source Oke(1987)

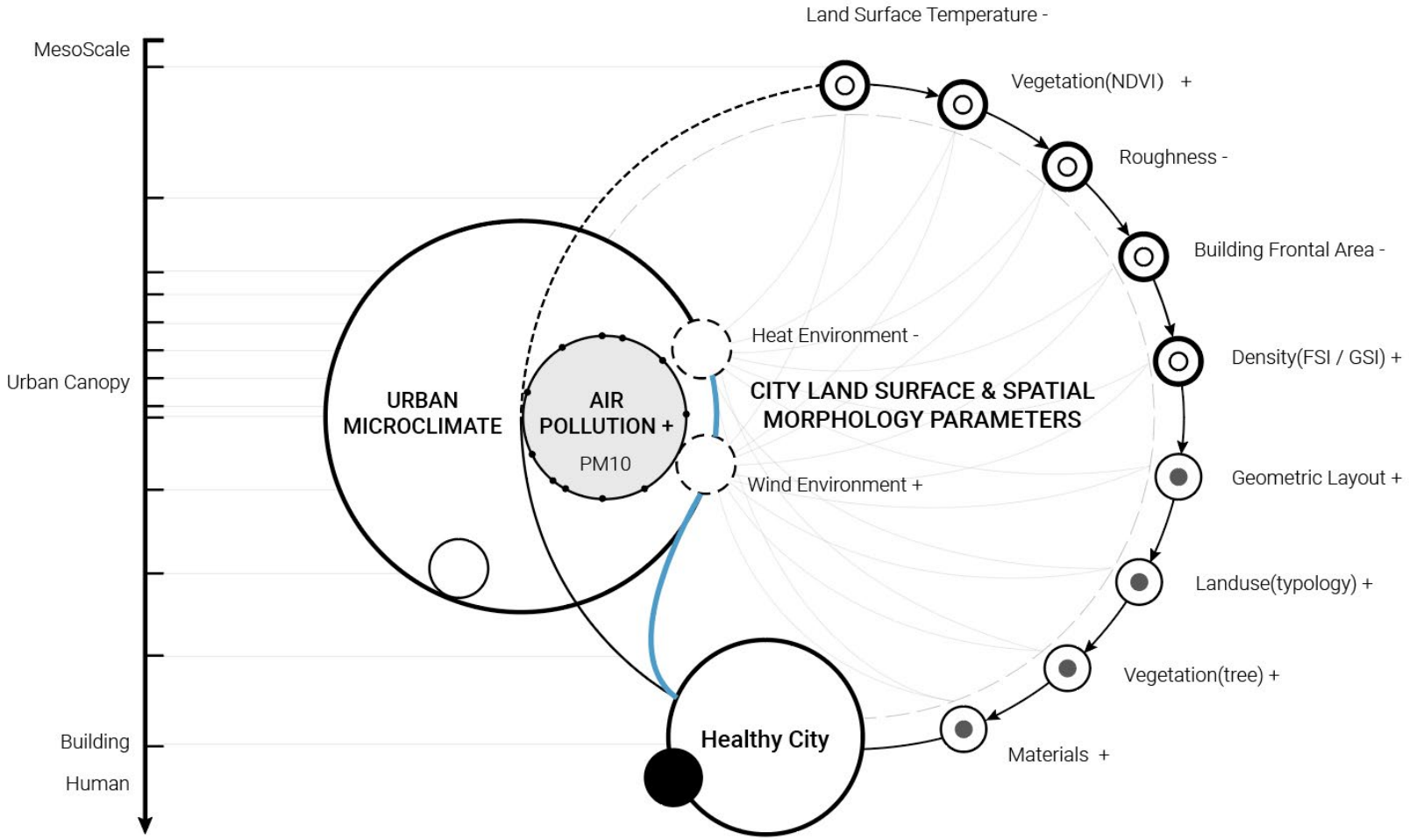



Mechanisms of operation of the wind-heat environment
Source:Murphy, C., Gardoni, P., & McKim, R. (2018).

# MATRIX OF ANALYSIS

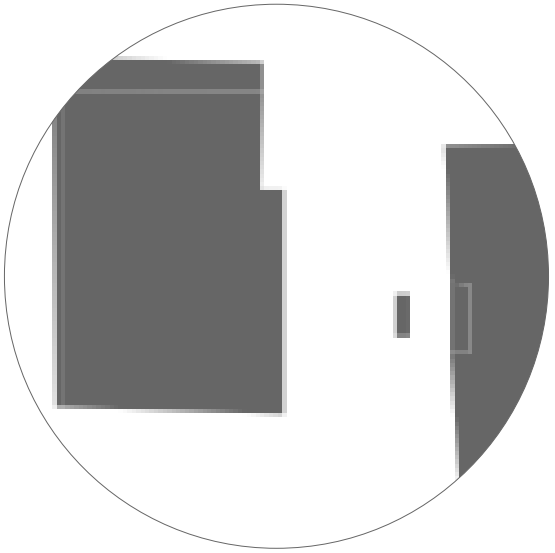
# CONCEPTUAL FRAMEWORK



# Scale

*City scale*

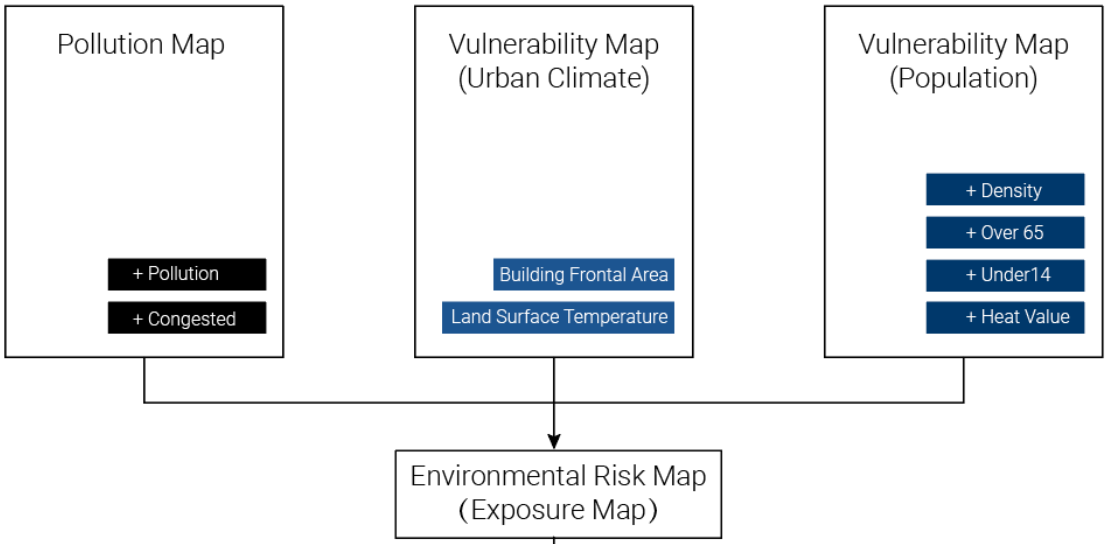
*Canyon scale*



*Building scale*

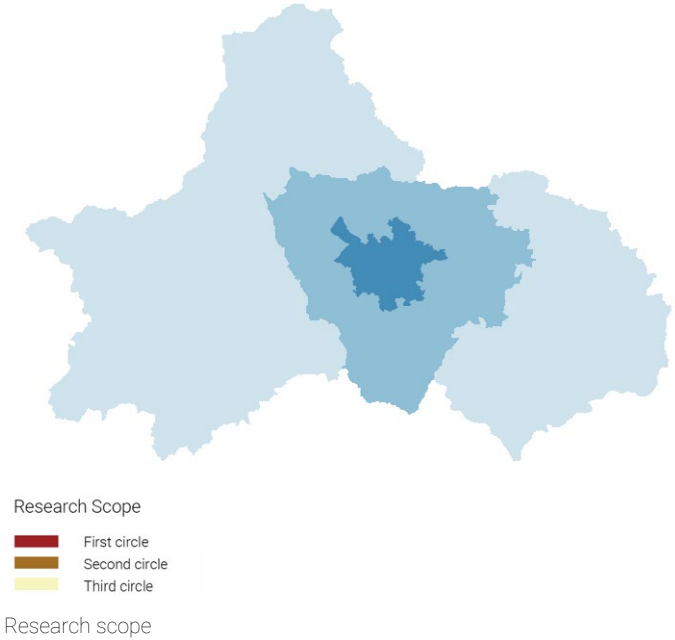
# 02 ANALYSIS

# RISK ASSESSMENT APPROACH: Environmental Risk Mapping

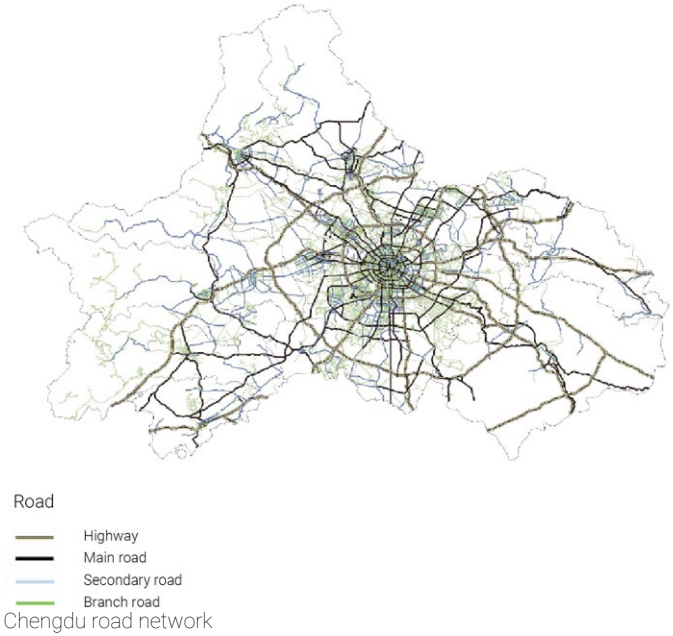


# 4.1 POLLUTION MAP(TRAFFIC)

## *4.1 Introduction*



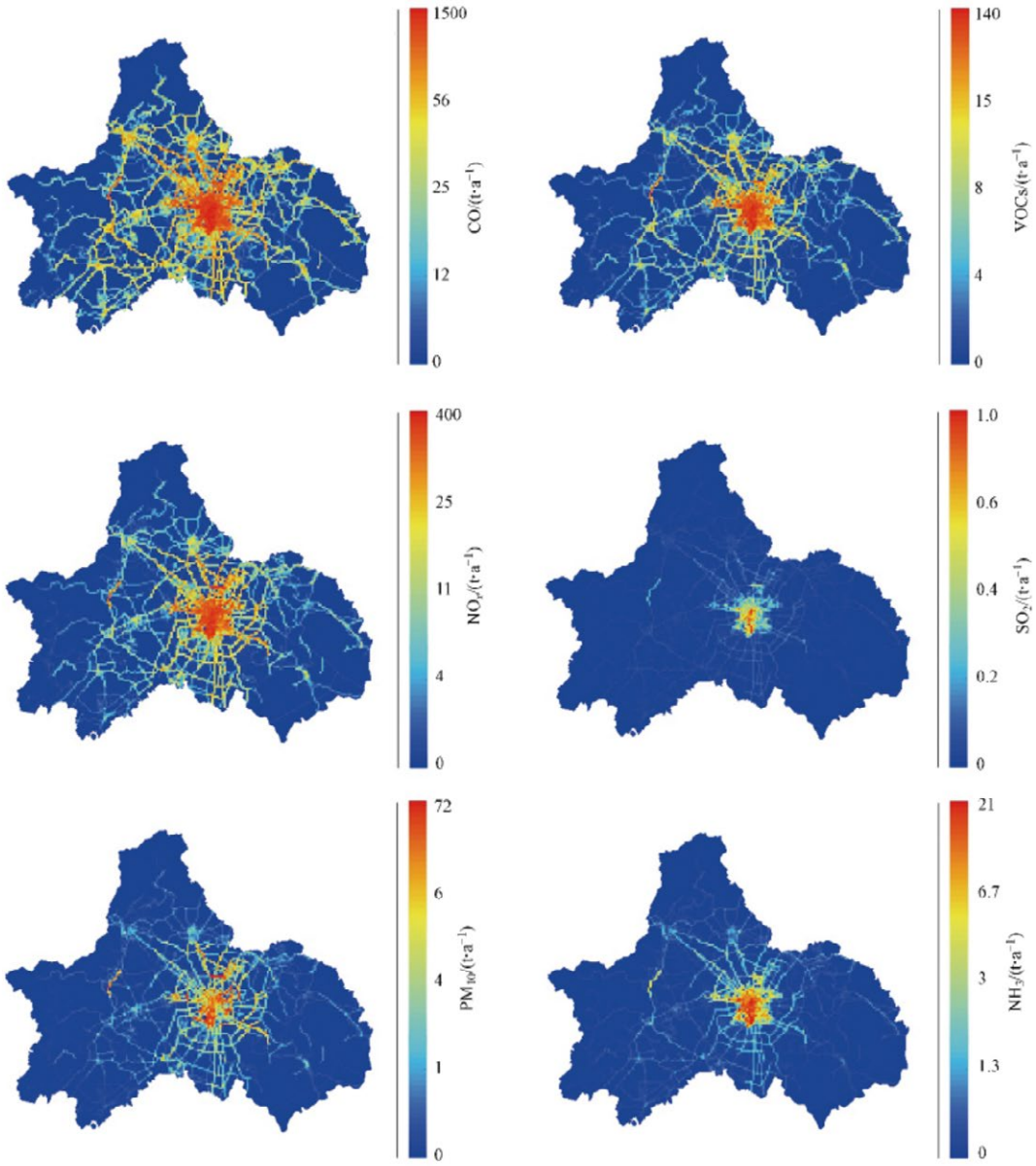

Research scope




Chengdu road network

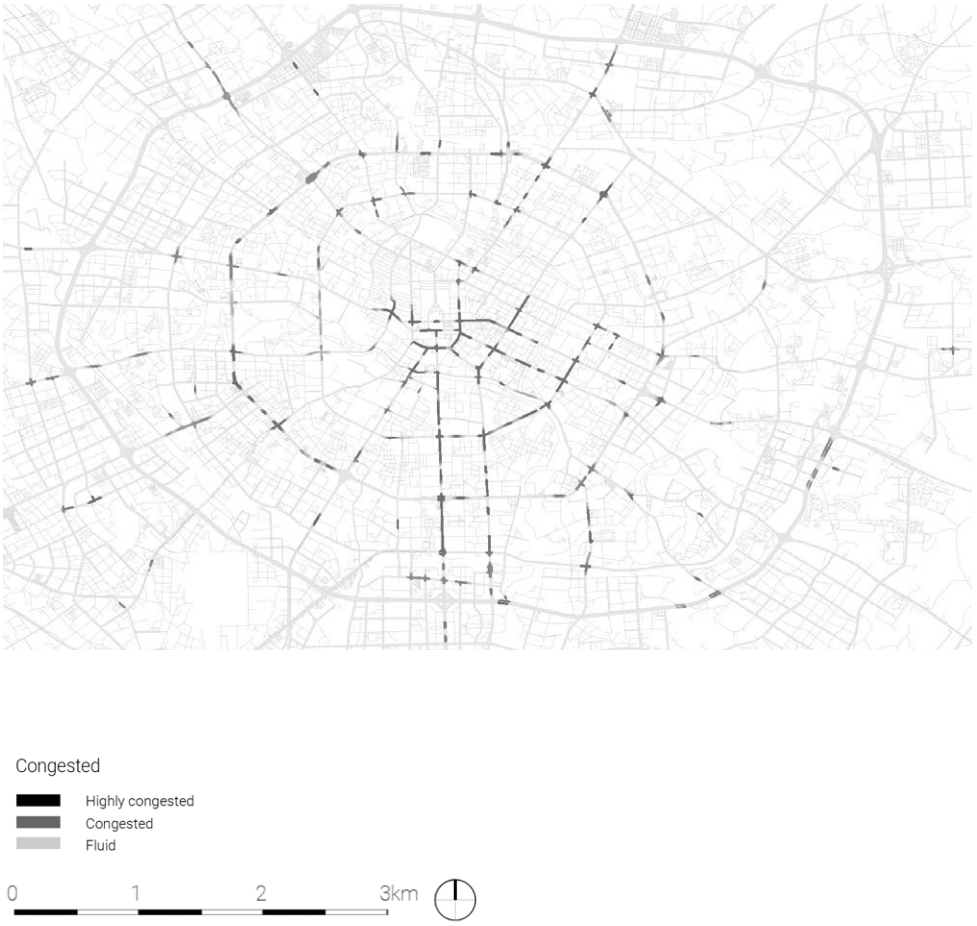
Source:http://www.openstreetmap.org/

## *Spatial distribution of road source emissions in Chengdu*




Chengdu road network
Source:Zhou zihang, et al, 2018. On-road mobile source emission inventory and spatial distribution characteristics in Chengdu

# Traffic flows

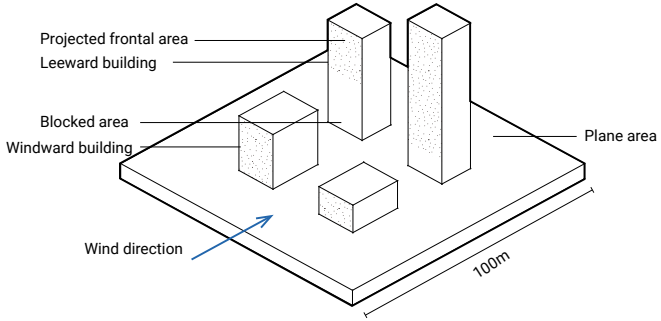




PM10 concentration in the Second Ring Road of Chengdu, Traffic flow map
Source：Huang rui, 2015. The green roof landscape study for alleviating the air pollution in calm-wind and high density cities. CBNData Di Di (2016.07-09)

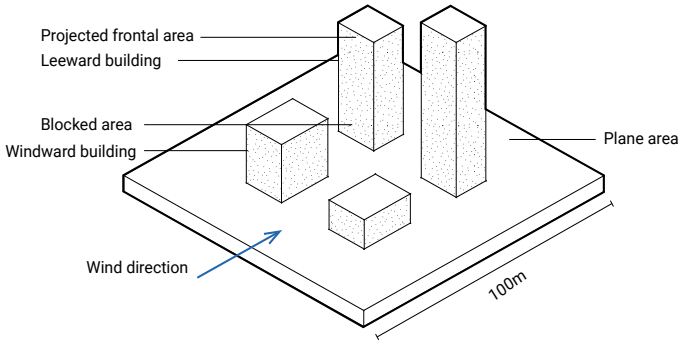
# 4.2 VULNERABILITY MAP(URBAN CLIMATE)

## *4.2.1 Frontal Area Index*

Regional boundary selection: building block grid-regular grid 200×200m

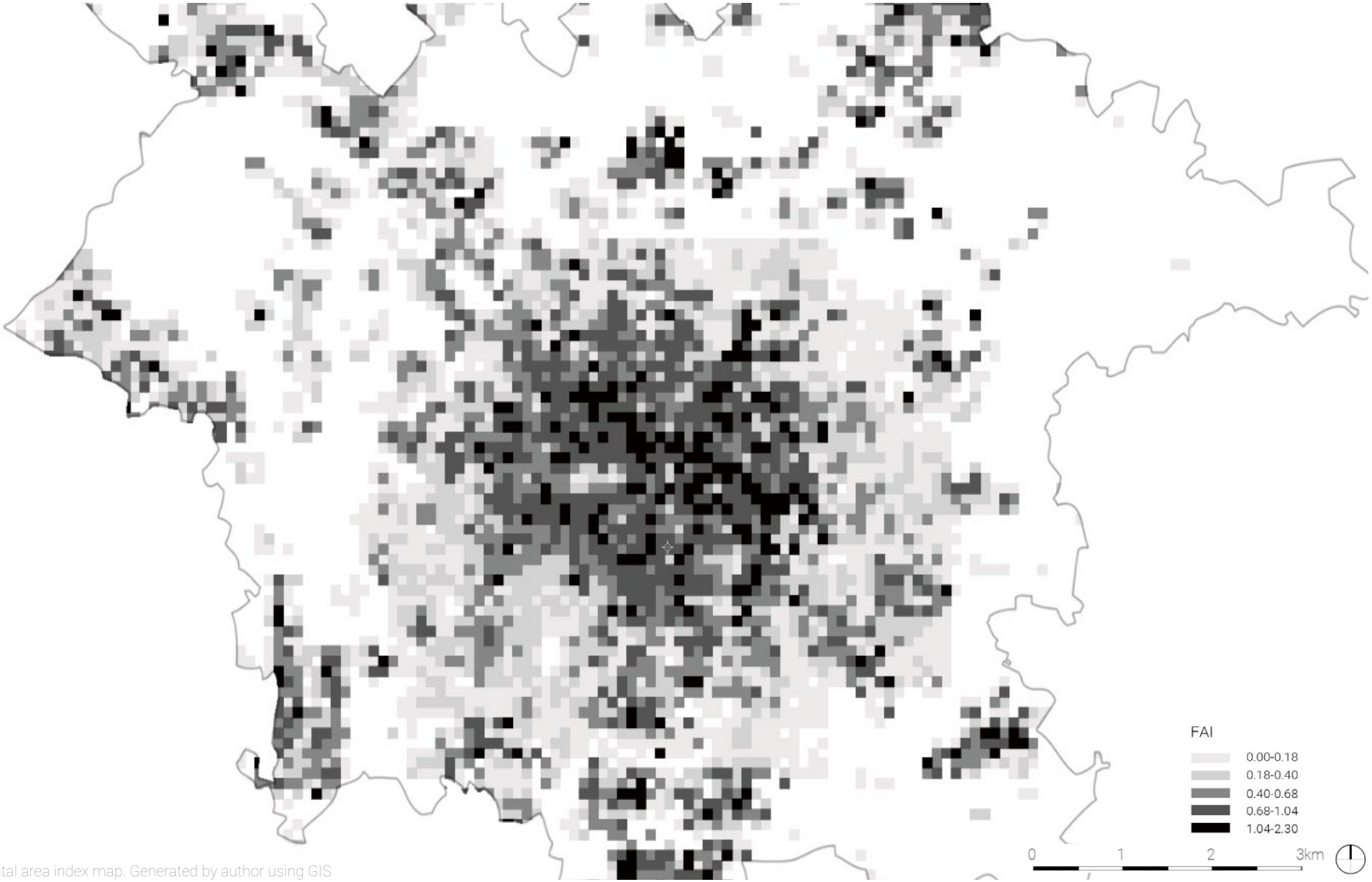



Example of frontal area calculation
Source:Man Sing Wong, Janet E, Nichol, To P H, et al,2010.




Frontal area calculation
Source:Liu junyong,2012

### *4.2.1 Frontal Area Index Map*




Frontal area index map. Generated by author using GIS
Source: Geospatial Data Cloud

# 4.3 VULNERABILITY MAP(POPULATION)

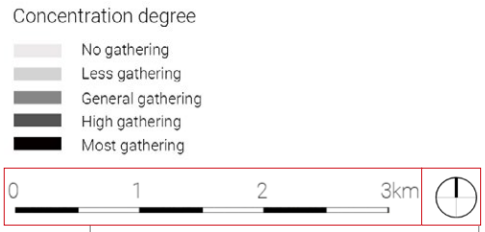
## *4.3.1 Heat value map*

***12.25 Mean***

***12.26 9.00***

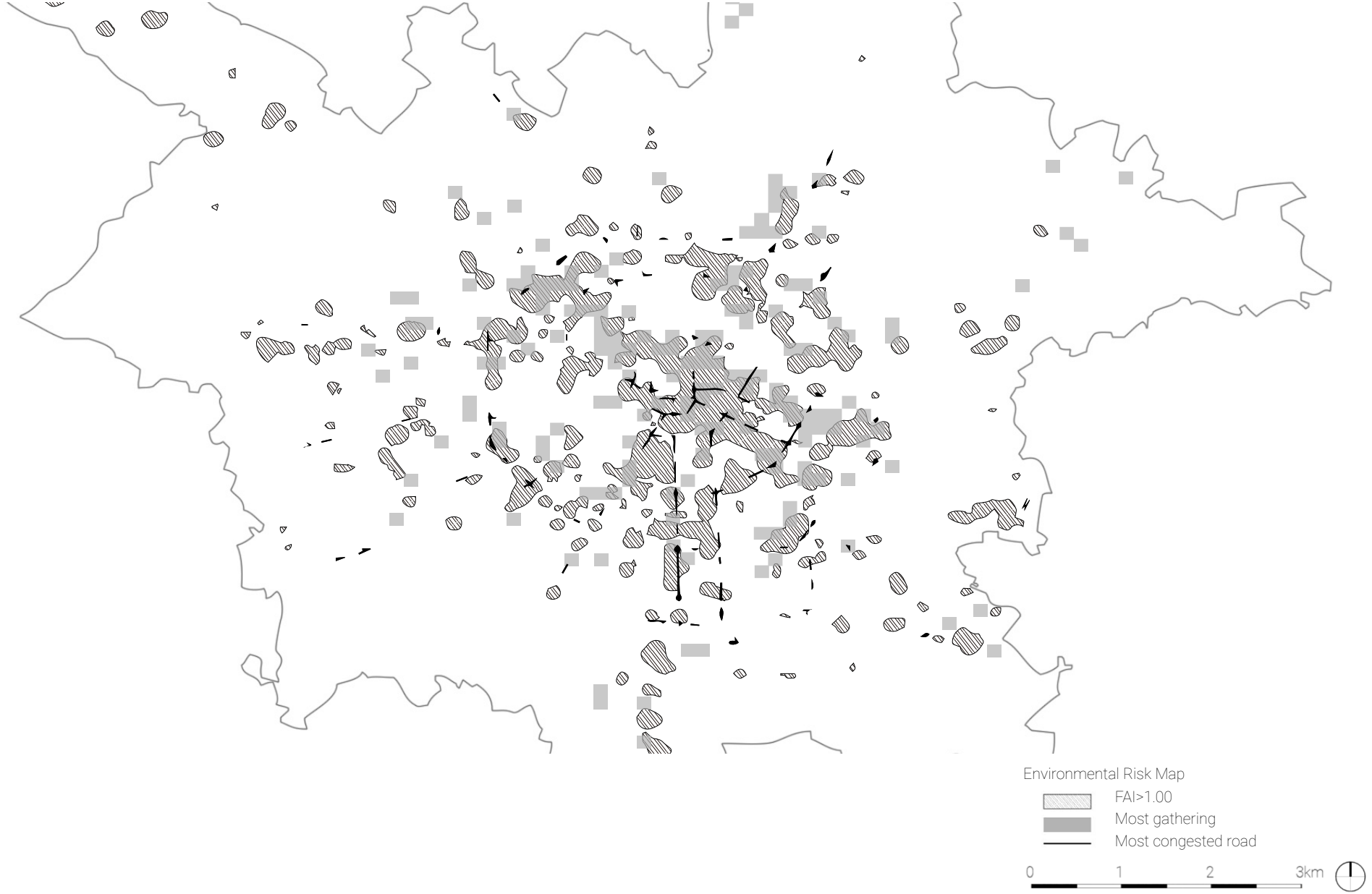
***12.26 23.00***

***12.26 Mean***



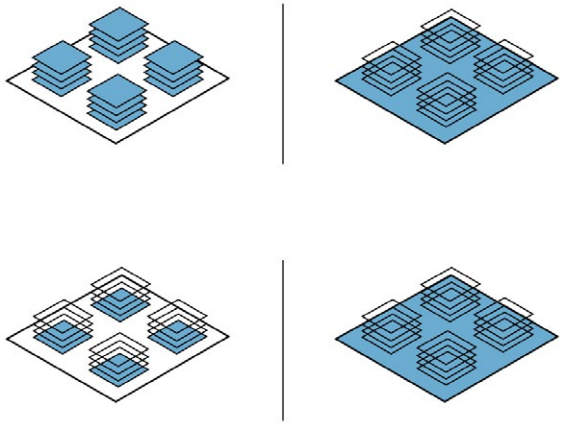

Heat value average and high average map (2016.12.25)
Baidu heat map (2016.12.26 9:00)
Baidu heat map (2016.12.26 23:00)
Heat value average map (2016.12.26)
Source: Analysis of the distribution characteristics of crowd activities in downtown Chengdu based on Baidu heat map

# Environmental risk map



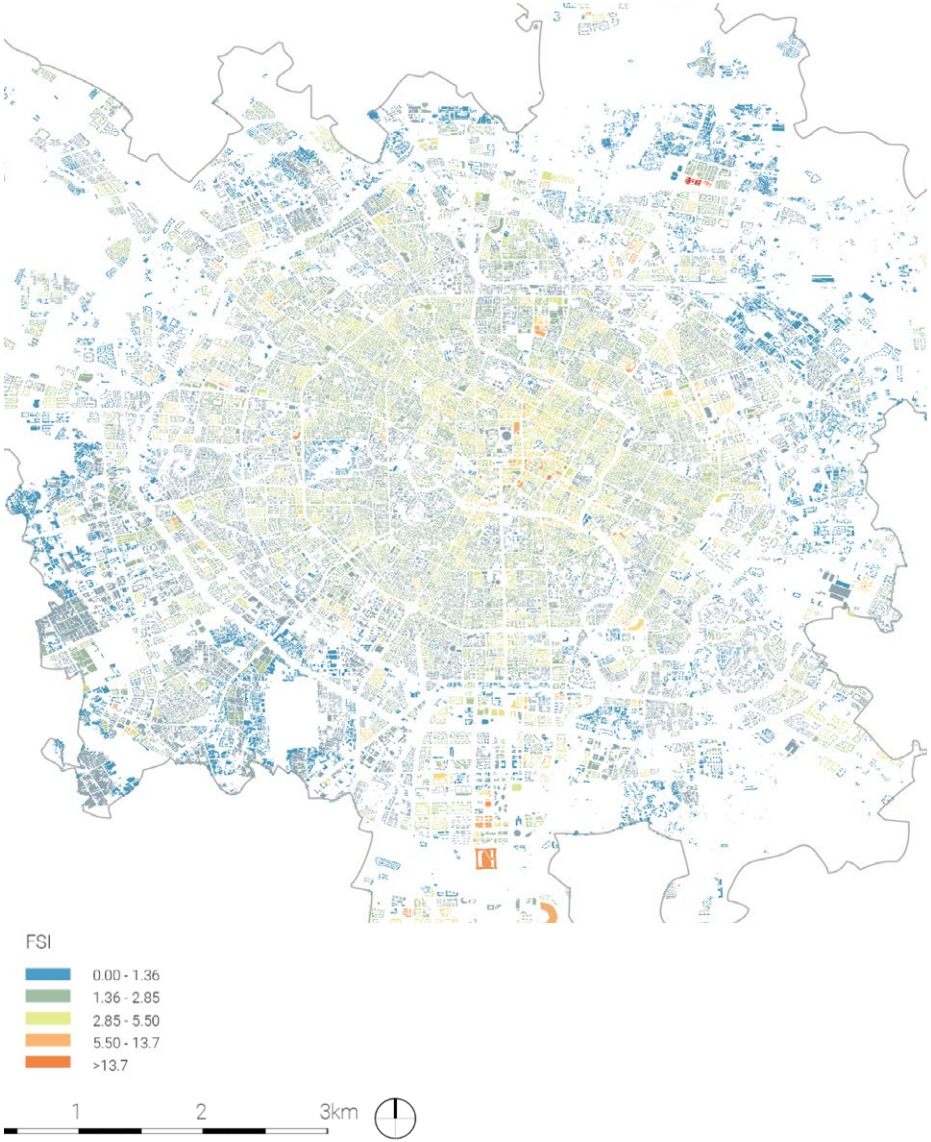
## *4.4 Site selection*

Density

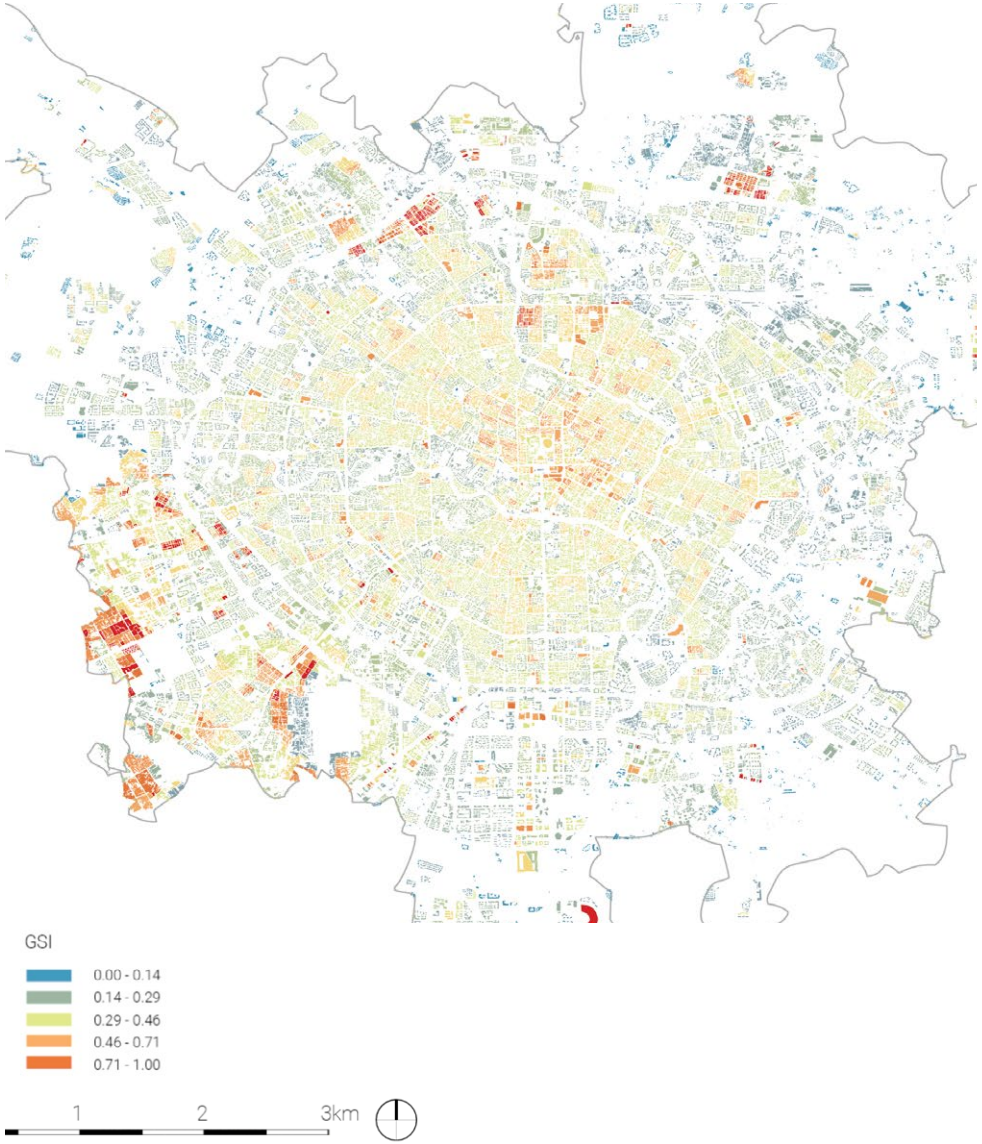


Numerator and denominator for the calculation of the FSI and GSI.
Source: Berghauser, 2010

## 4.4.1 FSI




## 4.4.2 GSI

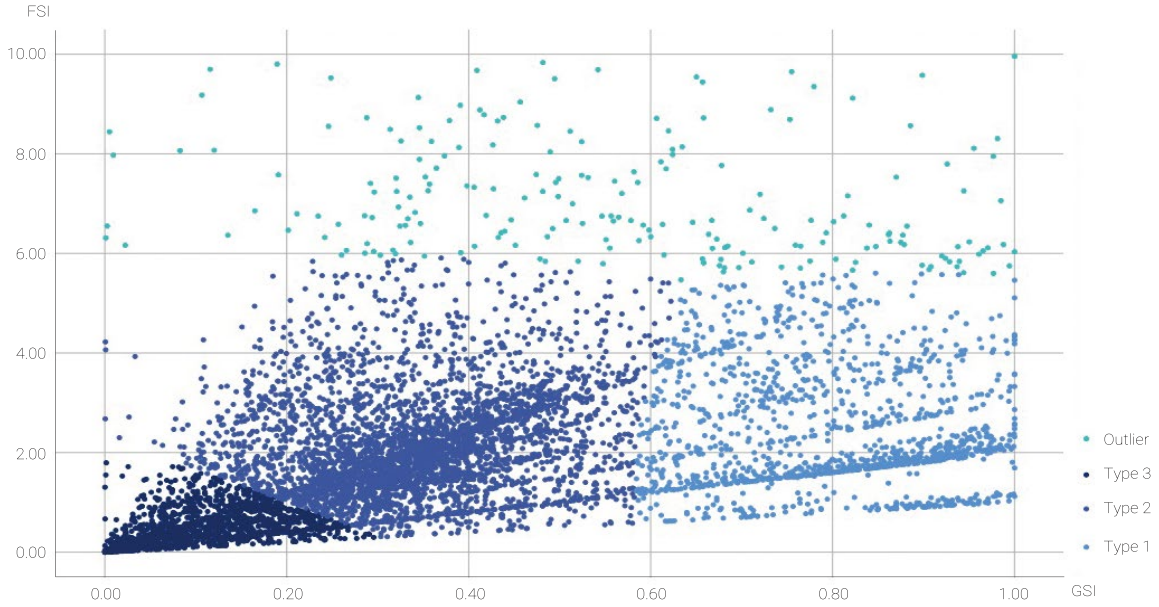



FSI map. GSI map. Generated by author using GIS software, based on the GIS file provided by the Geospatial Data Cloud of Chengdu in 2017.
Source: Geospatial Data Cloud

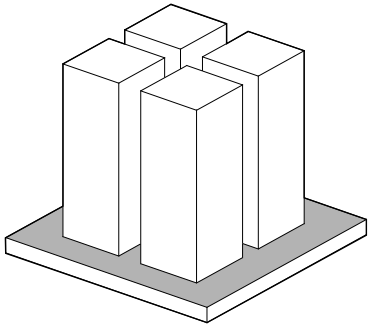
## *Generation of A Density Typology*

| Type | Mean FSI | Mean GSI | Quantity | Percentage |
|---|---|---|---|---|
| 1 | 2.37 | 0.48 | 4537 | 63.6% |
| 2 | 0.90 | 0.20 | 1551 | 21.7% |
| 3 | 0.21 | 0.04 | 747 | 10.5% |
| Outliers | 6.17 | 0.68 | 300 | 4.2% |

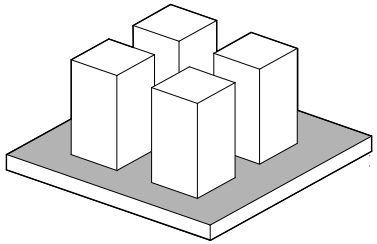
Mean FSI, GSI and quantity for each density type,relative size of cluster.



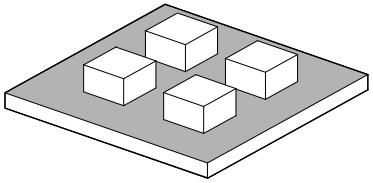

Spatial correlation figure of FSI and GSI and three clusters.
Elaborated by the author using SPSS software.



1) Represents the **most densely** populated areas in Chengdu, the city center and commercial areas. It is related to the type of land use.



2) Represents some **medium-density** areas, such as multi-story residential or industrial areas.

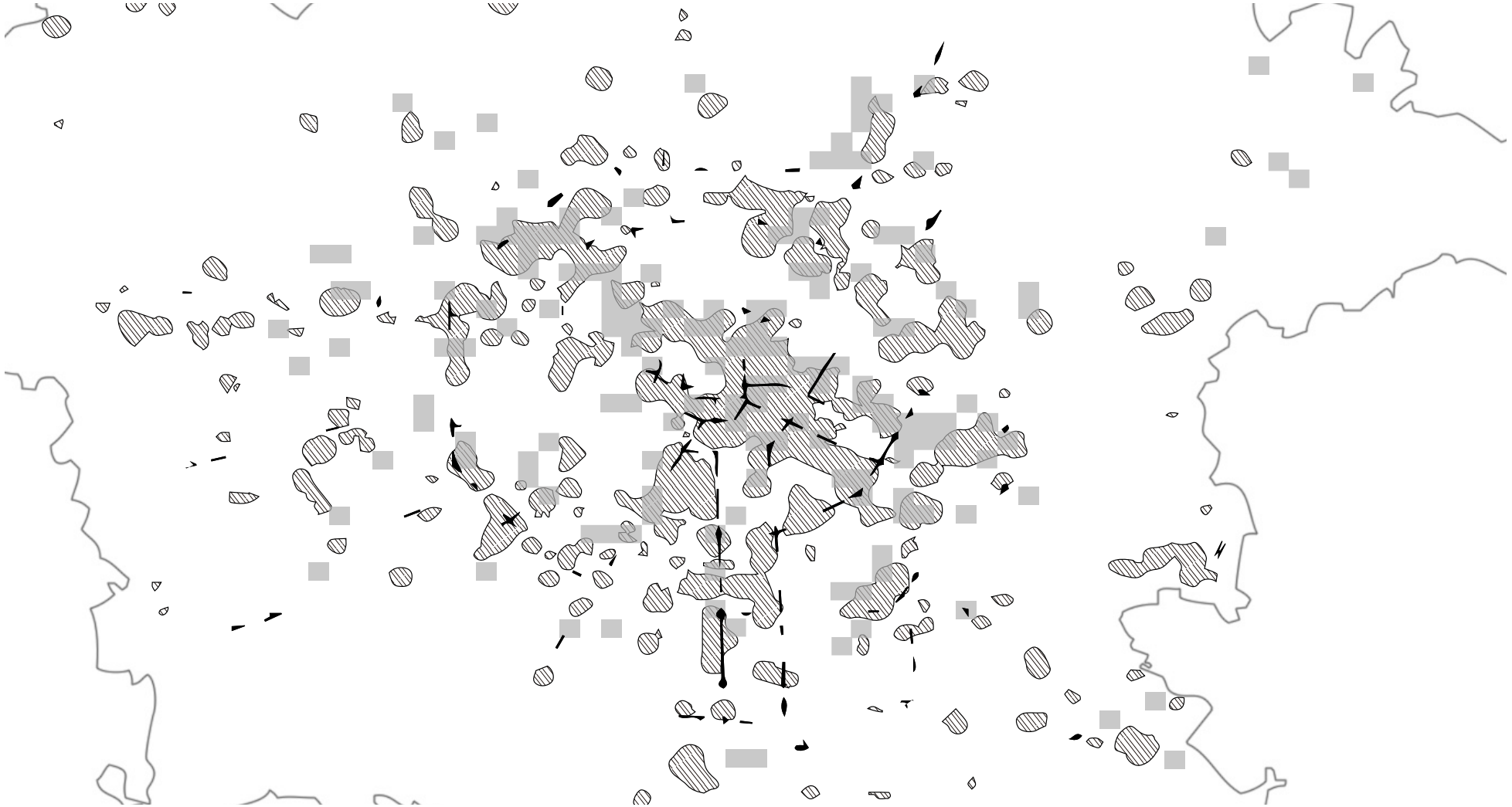


3) Represents buildings with **relatively low** FSI and GSI, corresponding to some separate houses and single land types in Chengdu.

### *4.4.3 Density type map*


Density typology map. Generated by the author using SPSS, based on previous GSI and FSI maps.

# Environmental risk map




Density Types
1
2
3
1
2
3km


Site selection map.

# CANYON SCALE ANALYSIS

## SITE 1 DAYE ROAD

### Introduction
+ core commercial districts
+ heavy traffic, slow speeds
+ long outdoor exposure time

### Potential
+ complex wind and heat environment corresponding to high-rise buildings
+ Increase the quality of public space.

## SITE 2 NIJIAQIAO NEIGHBOURHOOD

### Introduction
+ complex social and demographic composition
+ moderate green space, narrow streets
+ exhaust pollution on the streets is difficult to dispel

### Potential
+ multi-storey residential buildings and high-rise office buildings on both sides
+ consider the different social demographics(office workers and residents)

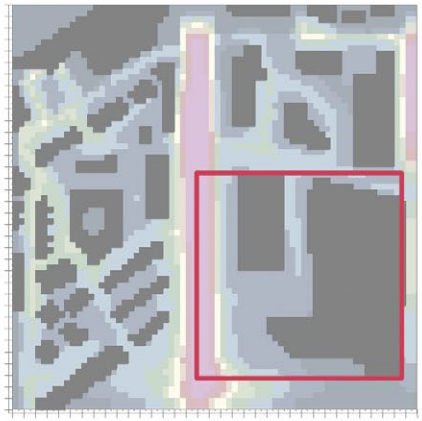
## SITE 3 TIANFU AVENUE


### Introduction
+ major north-south traffic artery
+ close to South Railway Station, heavy pollution
+ flower and tree avenue

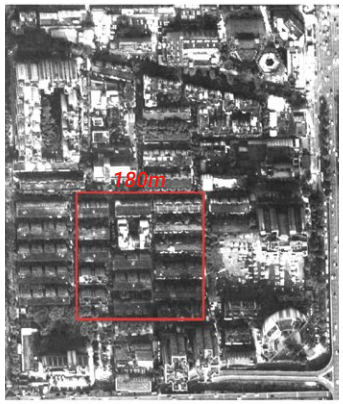
### Potential
+ more effective plant configuration for air pollution
+ Increase the quality of space near the overpass

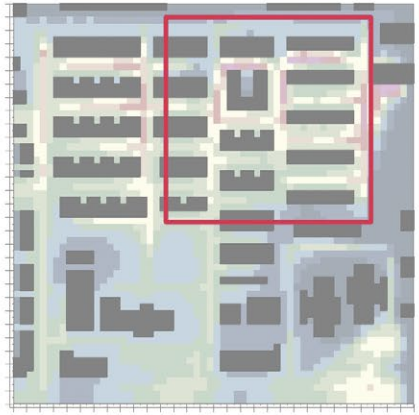
Daye Road, Nijiaqiao Road, Tianfu Avenue
Source: Baidu Street View Map

*Daye road*

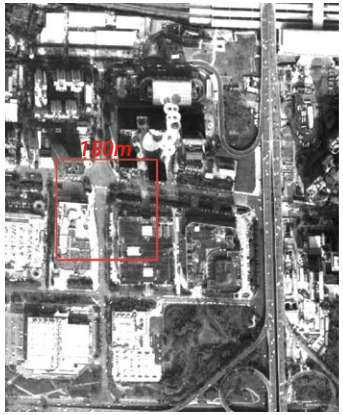



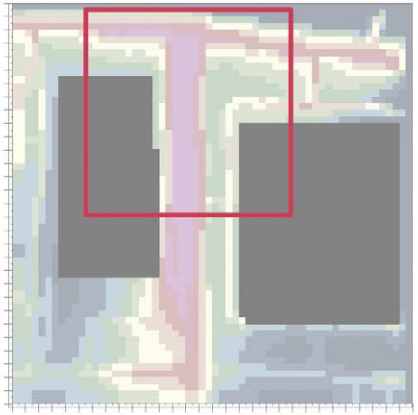

*Nijiaqiao neighbourhood*




*Tianfu avenue*

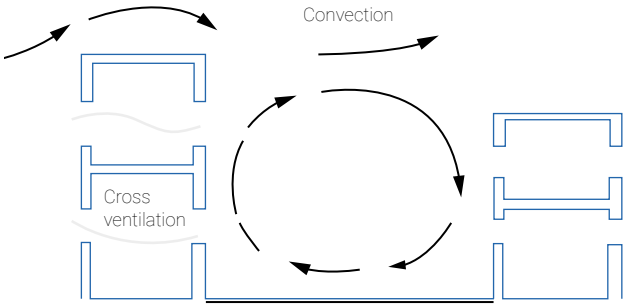


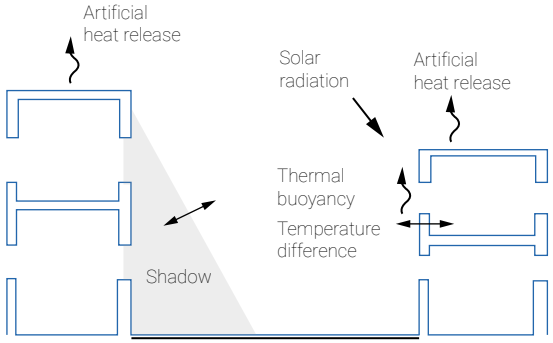



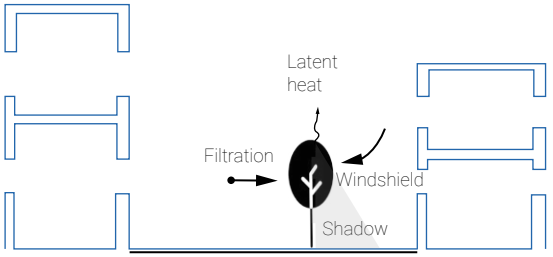

In the following analysis, in order to allow for a more precisely analysis of the site and to improve the accuracy of the software simulations.

The area with the highest pollutant concentration (180m x 180m) from the three sites was selected from the PM10 concentration simulation results for detailed analysis, as described later (the simulation remains 300m x 300m within this section).

Scale down of Daye road, Nijiaqiao neighbourhood and Tianfu avenue.
Source: Author.




**Urban morphology**

+Roughness

+Wind

**Urban surface**

+Surfaces colour

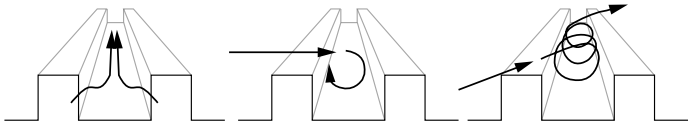
+Surfaces material

+Sunlight hours

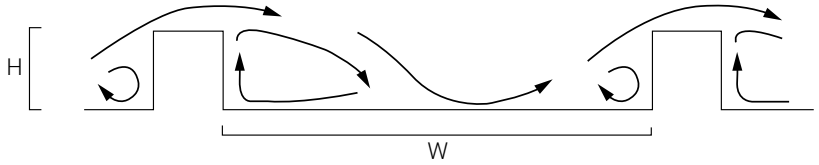
**Urban green**

Various scales related to wind climate
Source:Murphy, C., Gardoni, P., & McKim, R. (2018). Climate change and its impacts : risks and inequalities.

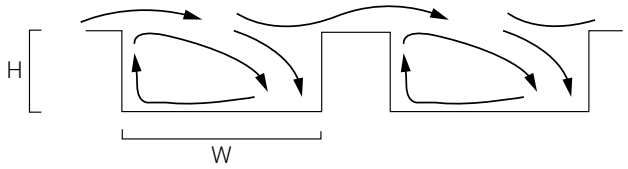
# 5.1 Roughness



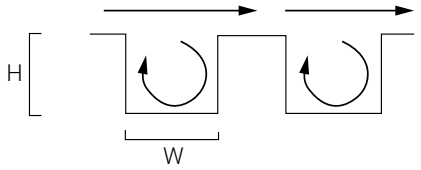
Flow patterns in the urban canyon, related to the wind direction at roof height; parallel, perpendicular or at an angle to the canyon axis




Isolated roughness flow

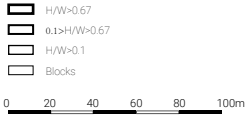



Wake interference flow

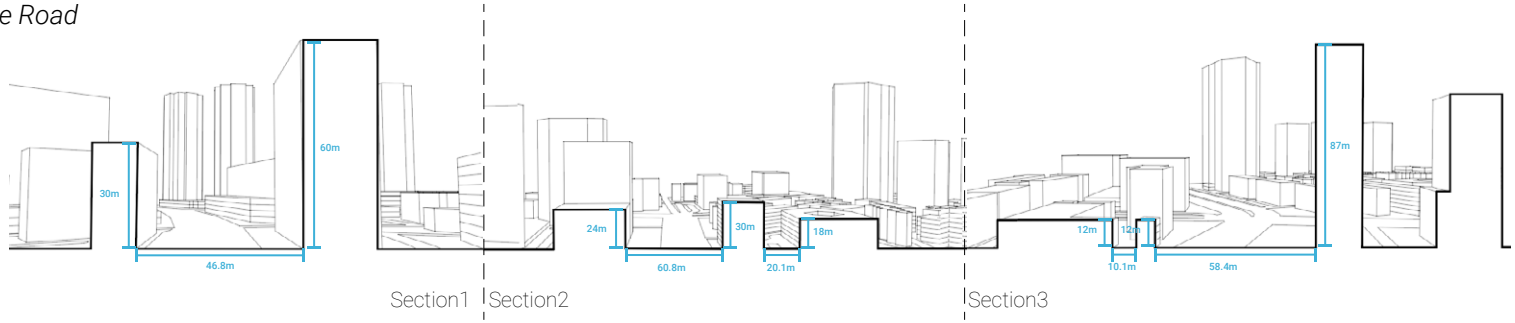



Skimming flow

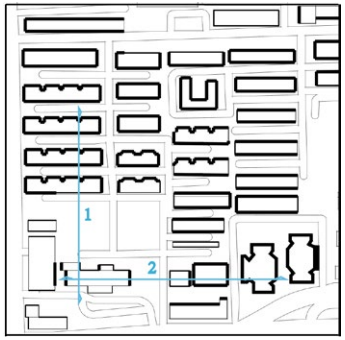
Flow regimes associated with different geometries
Source: Oke, T.R. (1987). Boundary layer climates. New York, Routledge. After Oke,Pijpers-Van Esch, M. (2015). Designing the Urban Microclimate A framework for a design-decision support tool for the dissemination of knowledge on the urban microclimate to the urban design process. PhD, Delft University of Technology.

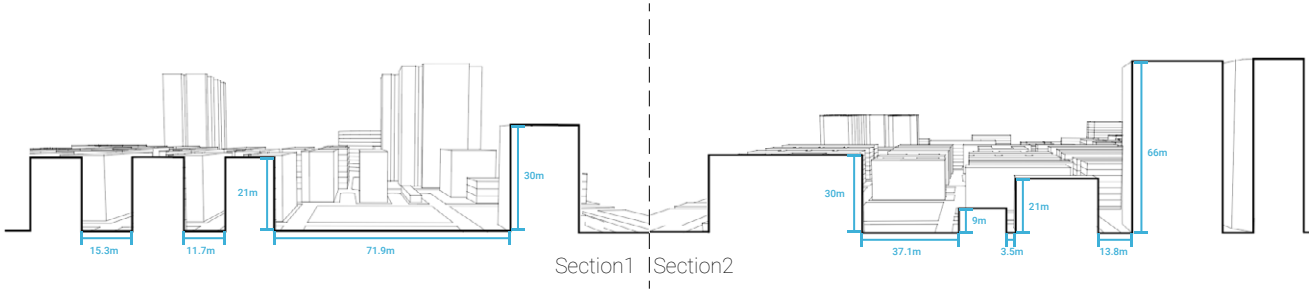



*Daye Road*

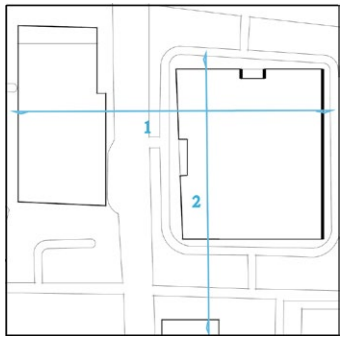



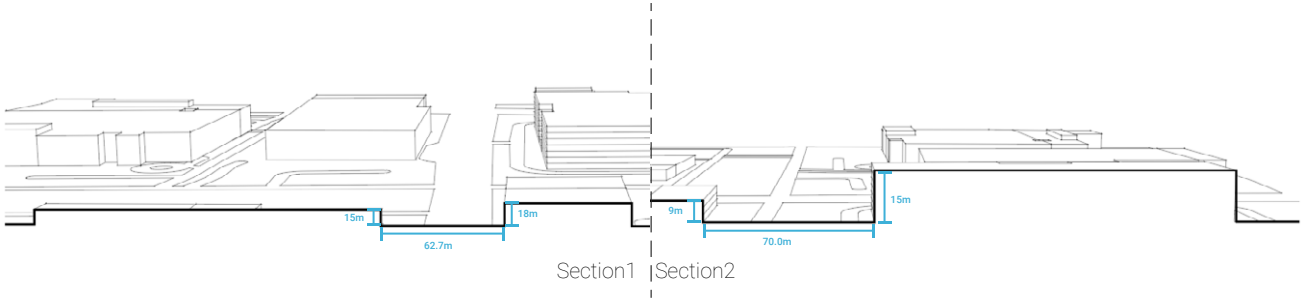

*Nijiaqiao Neighbourhood*



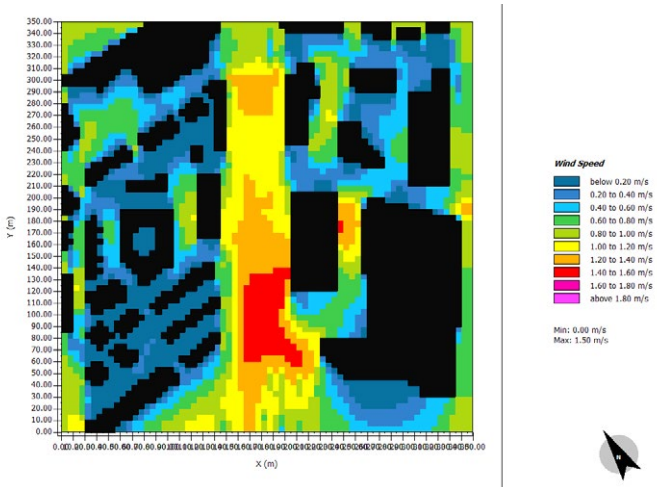

*Tianfu Avenue*



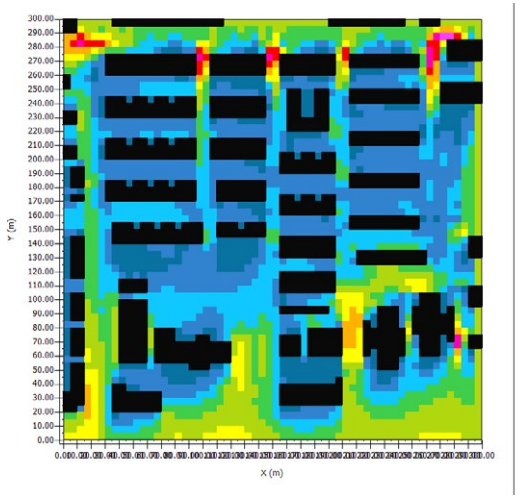



# 5.2 Wind speed

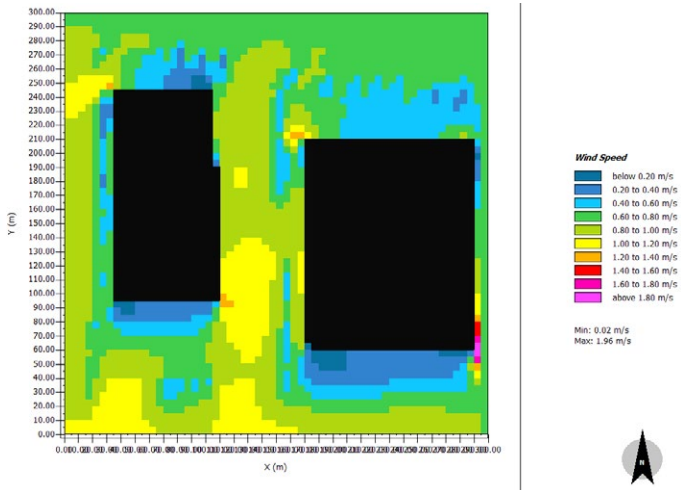
### Daye Road




### Nijiaqiao Neighborhood

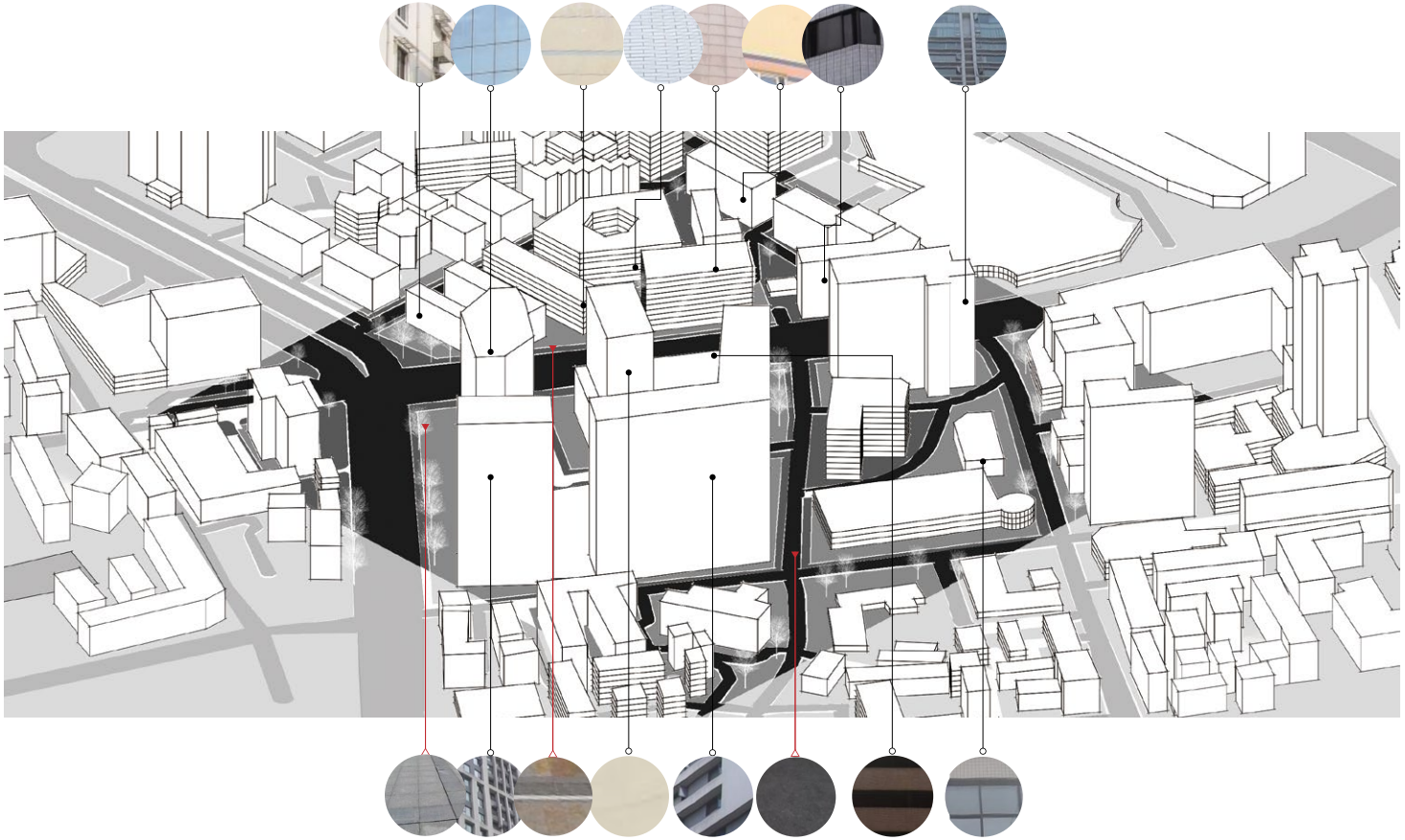



### Tianfu Avenue



# *5.3 Urban surface*

## Daye Road



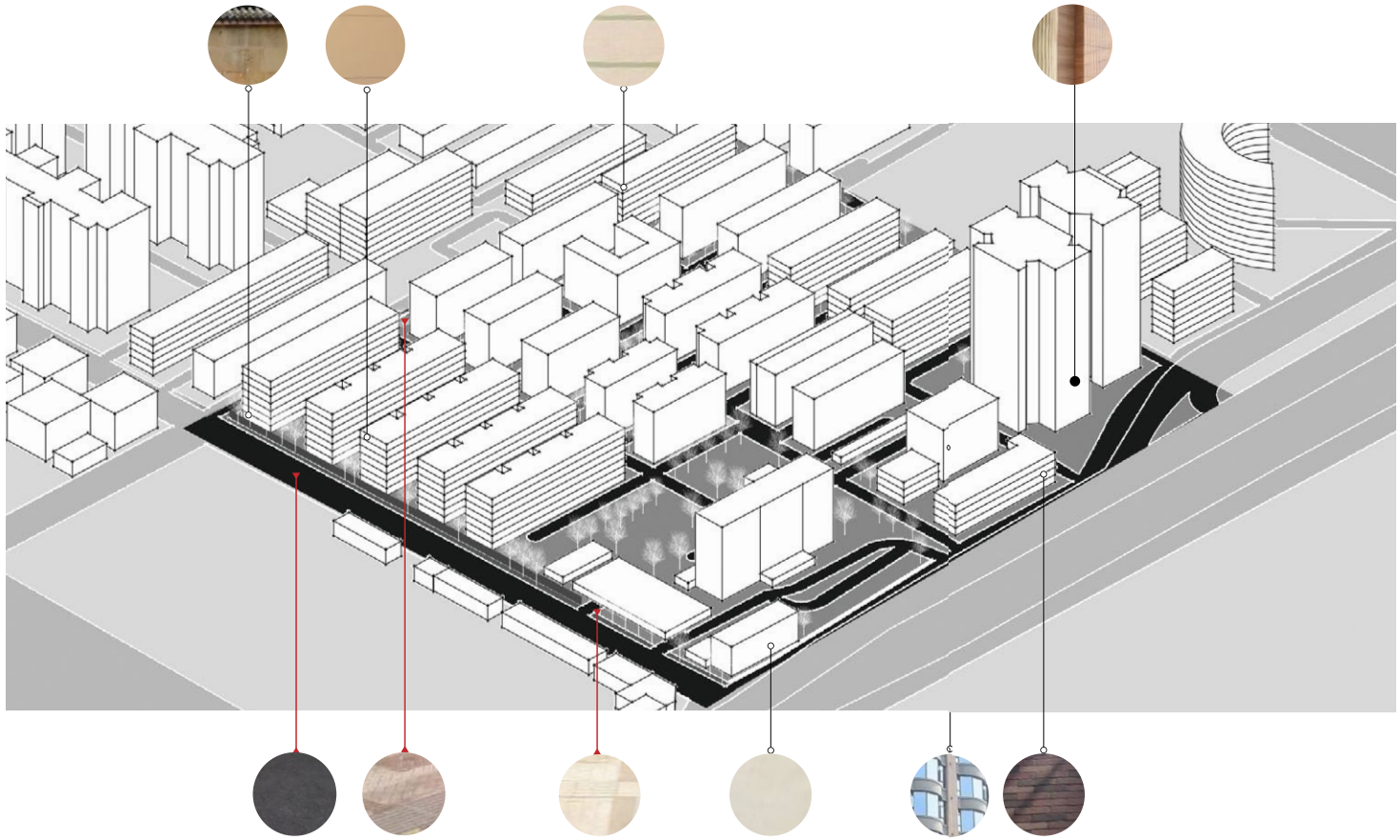
Colour schemes

Facades

Paved

The main streets on the surface of Daye road are composed of asphalt, and the sidewalk covering is almost entirely composed of granite stone, with the main color being gray beige. Facades dominate, covering almost 70% of the city's surface. The façade is mainly glass and light-colored paint. Other materials and colors are used as embellishments in a small area, and the reflectivity is high.

# Nijiaqiao Neighbourhood



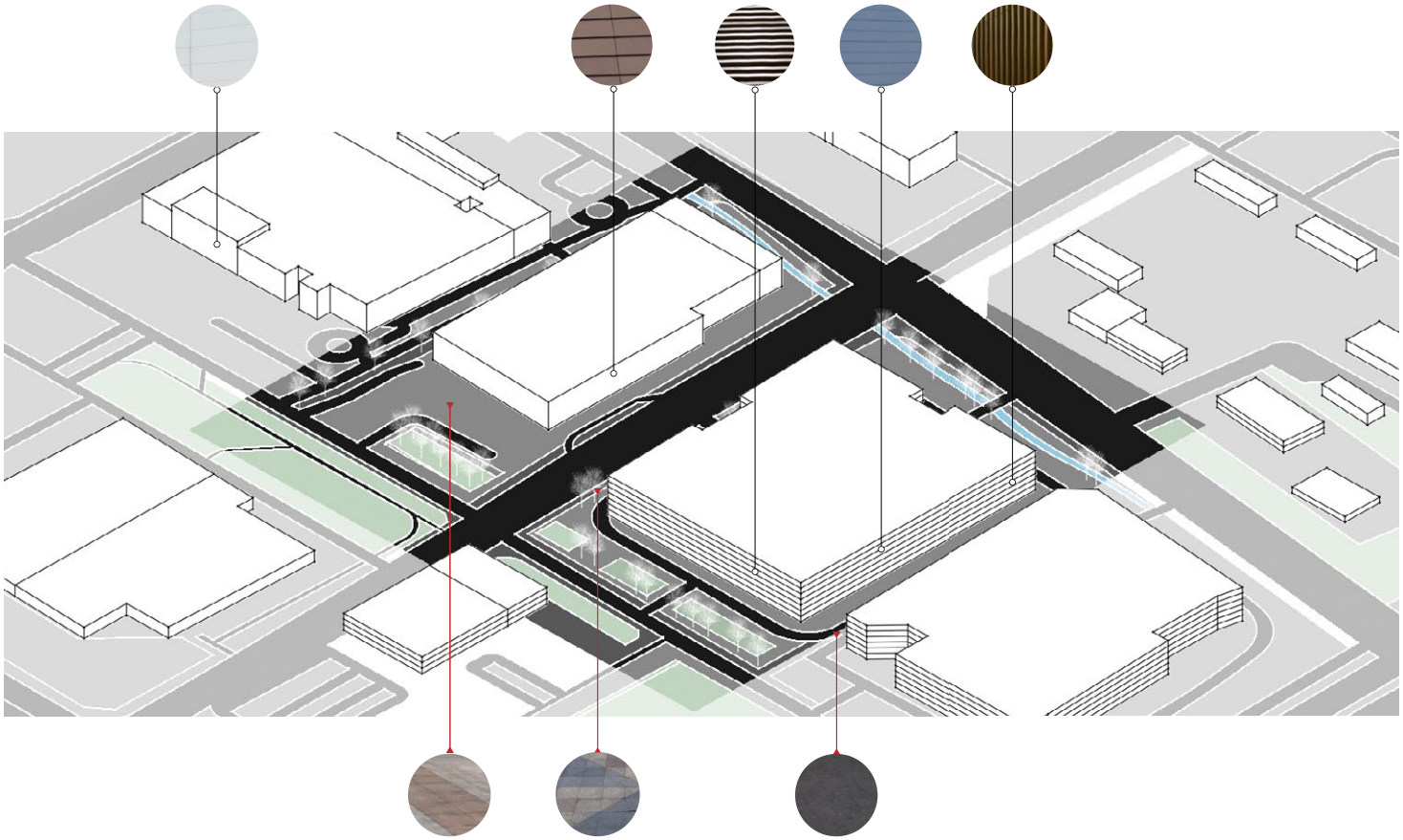
Colour schemes

Facades

Paved

The surface of Nijiaqiao Neighborhood is dominated by light yellow and white, and the bottom hotel surface is composed of yellow paint and glass. The middle two are made of brick red brick and glass. In general, light-colored surfaces have higher reflectivity, and the heat storage capacity of traditional materials masonry is relatively small and the surface temperature is low. The ground roadway is asphalt, and the sidewalk is dominated by beige granite and red brick. The outer wall of the neiborhood is made of white cement and wood-colored cement.

# Tianfu Avenue



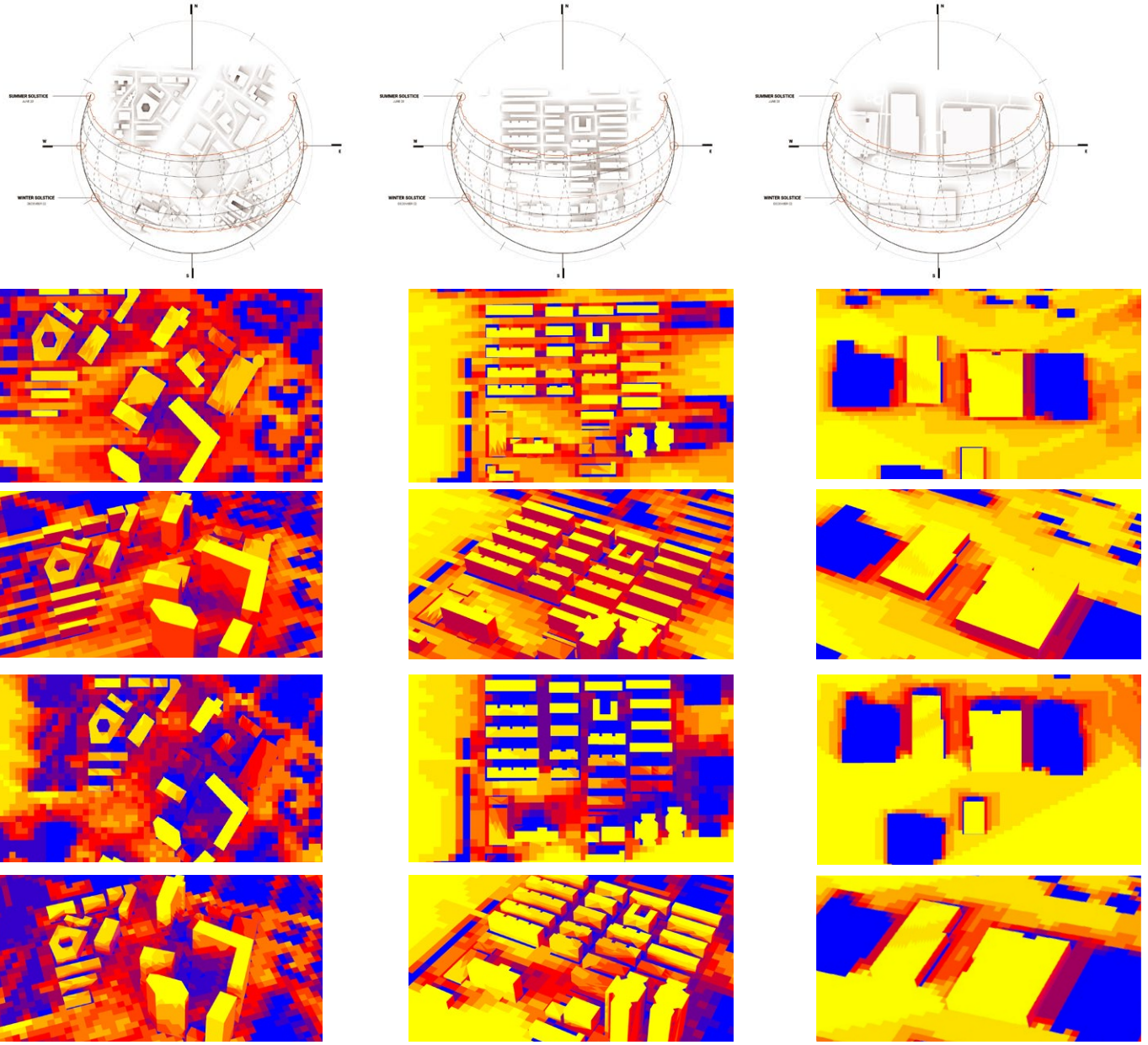
Colour schemes

Facades

Paved

Large commercial buildings on both sides of Tianfu Avenue are mainly brick red veneer on one side, and the white, yellow and dark brown surfaces on the other side are more evenly distributed.

# 5.4 Sunlight hours analysis




*Summer solstice*

*Winter solstice*

Source: The hourly meteorological data files required by the building energy simulation software EnergyPlus were generated. The weather data of summer solstice were extracted by using ladybug

# *5.5 Urban green*

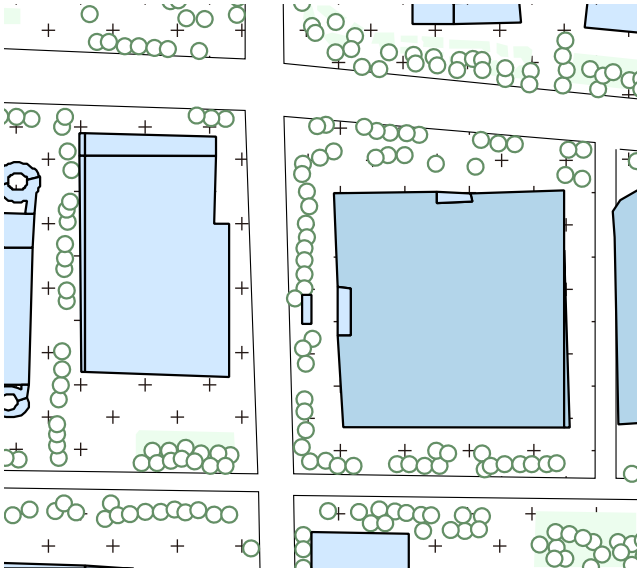
## Daye Road

Daye Road has a higher building density and a lower road greening rate. Compared with urban greening, the building form has a greater impact on the site's microclimate.

## Nijiaqiao Neighborhood

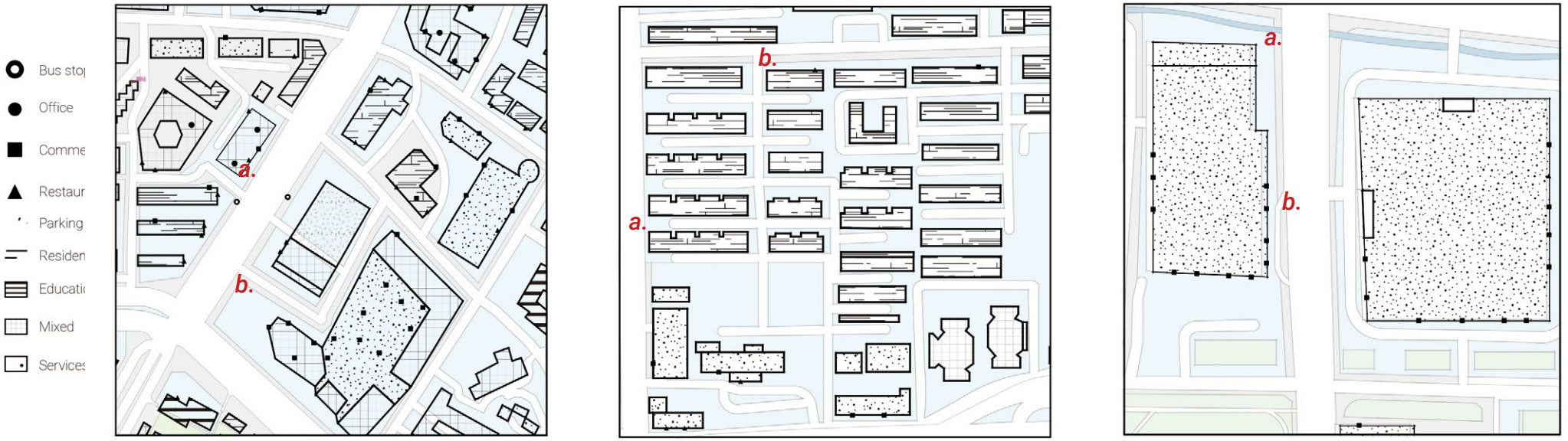
The interior of the Nijiaqiao community has high greenery, and the streets from north to south are narrow. The shadow of the trees on both sides almost completely shields the road.

## Tianfu Avenue



Compared with other sites, Tianfu Avenue has more open space and more greenery, and the street trees have a higher degree of cover to the building facade.

# 5.6 Land use

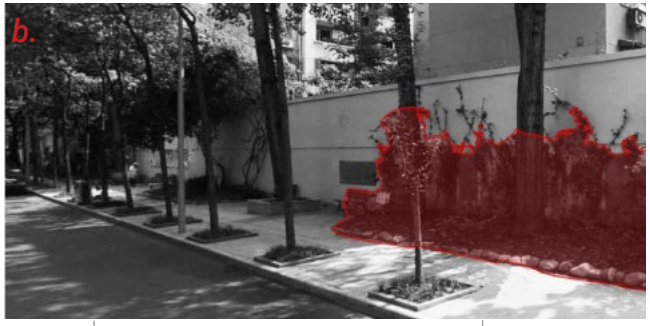

Bus stop
Office
Comme
Restaur
Parking
Residen
Educati
Mixed
Services
a.
b.
a.
b.
a.
b.

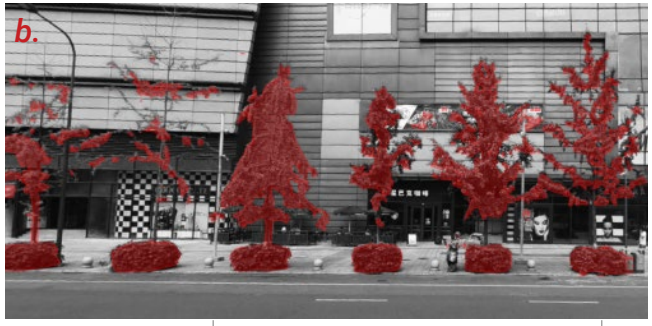

a.
交通执法


a.


a.


b.

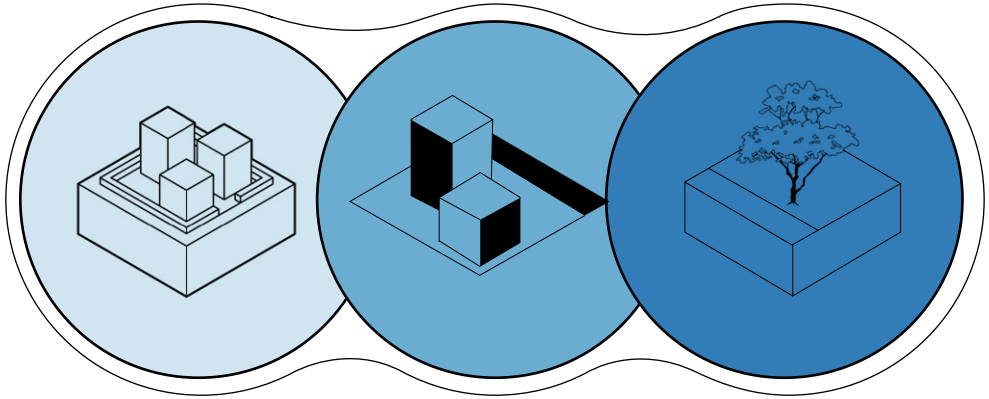

b.


b.

## *Conclusion*

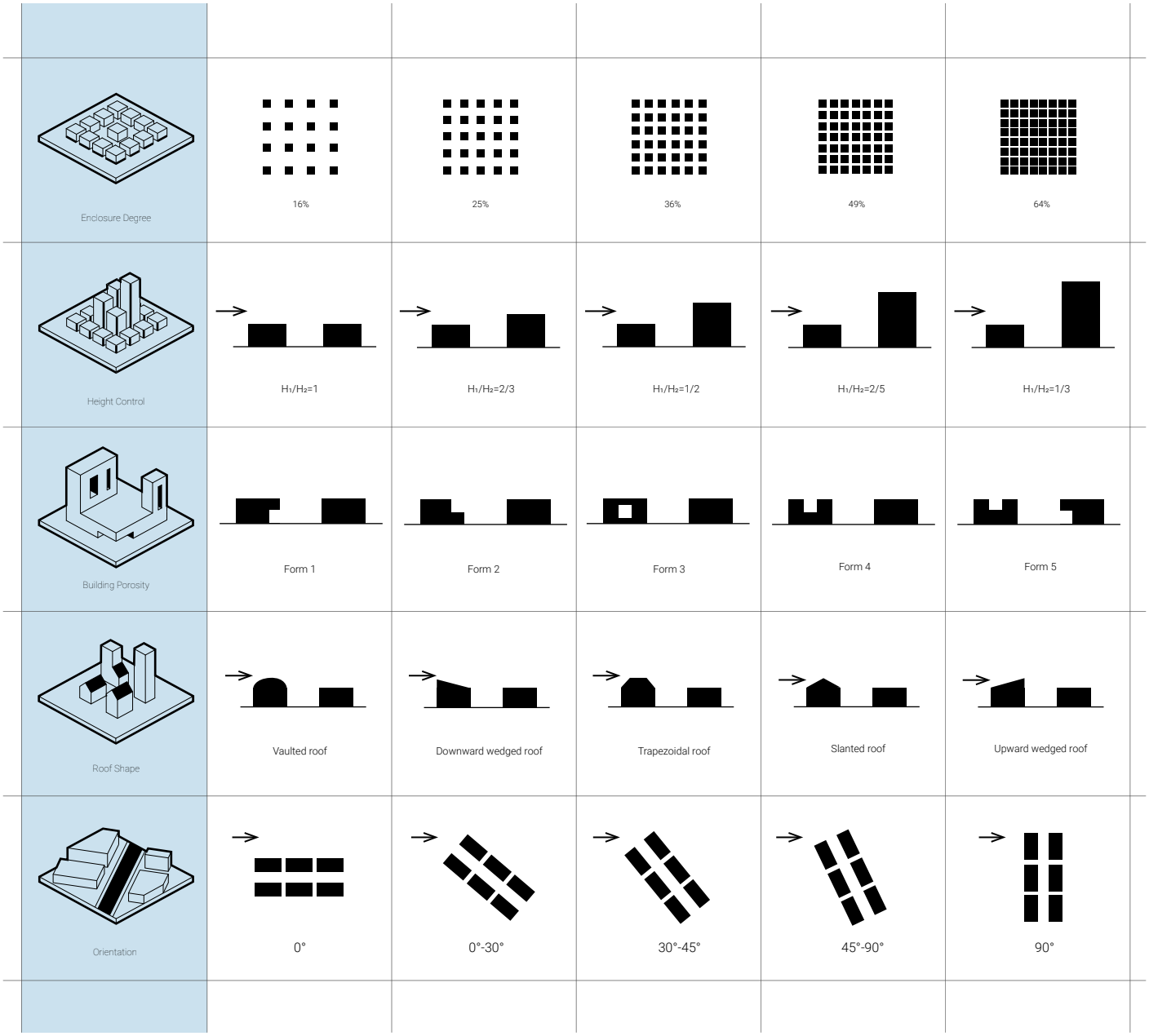
| | Daye Road | Nijiaqiao Neighborhood | Tianfu Avenue |
|---|---|---|---|
| Typology | Semi-open | Semi-open | Open |
| Roughness | $0.67 < H/W$ | $0.1 < H/W < 0.7$ | $H/W < 0.1$ |
| Roof shape | Flat | Flat | Flat |
| Colour | Light | Light | Medium light |
| Facade | Ceramic tile, Glass | Brick | Aluminum gusset |
| Radiation acceptance | Much | Moderate | Moderate |
| Pavement | Granite, Brick | Granite, Brick | Granite, Brick |
| Vegetation | Little green | Moderate green | Much green |
| Land use | Mixed | Residential | Commercial |

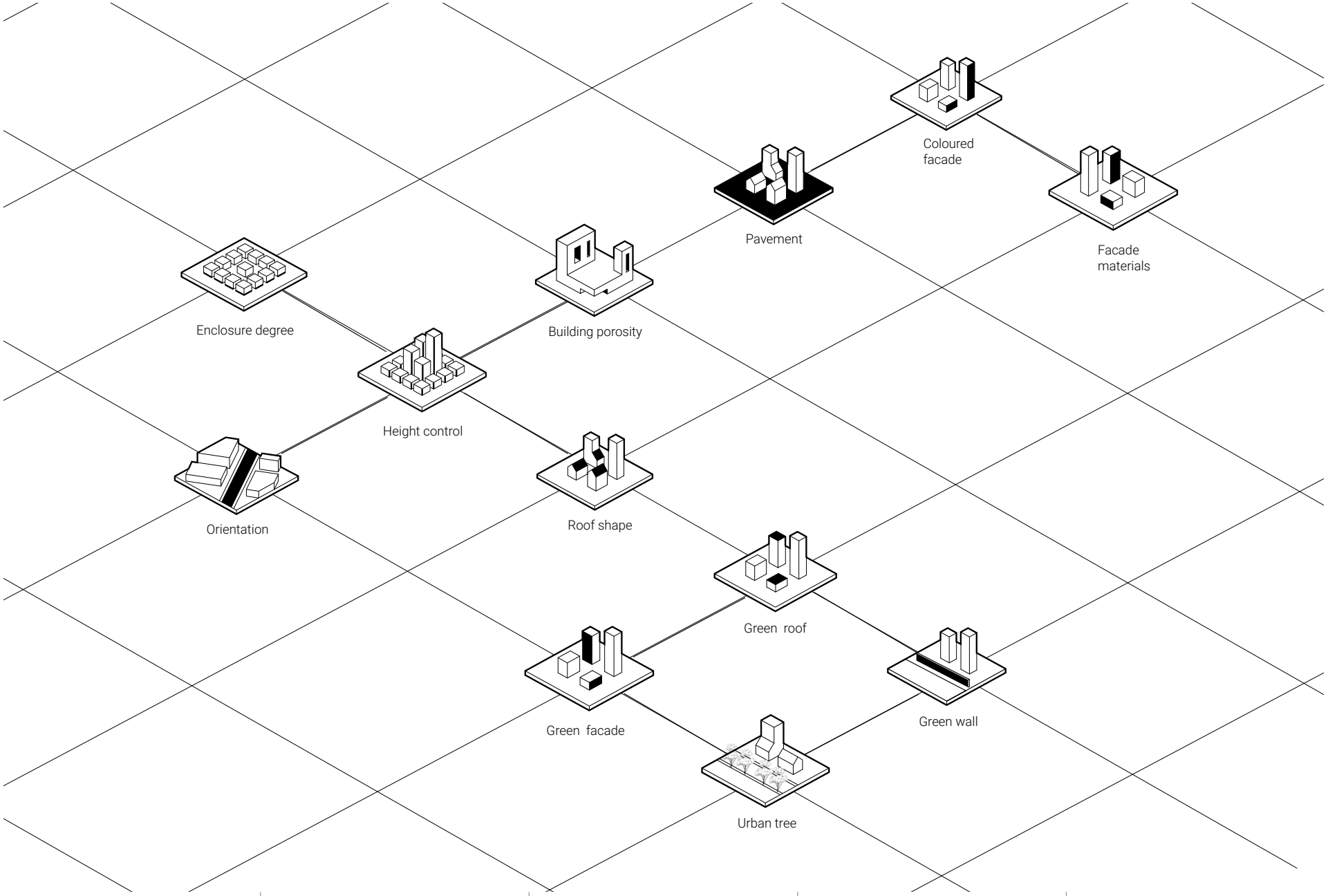
# 03 PRINCIPLES

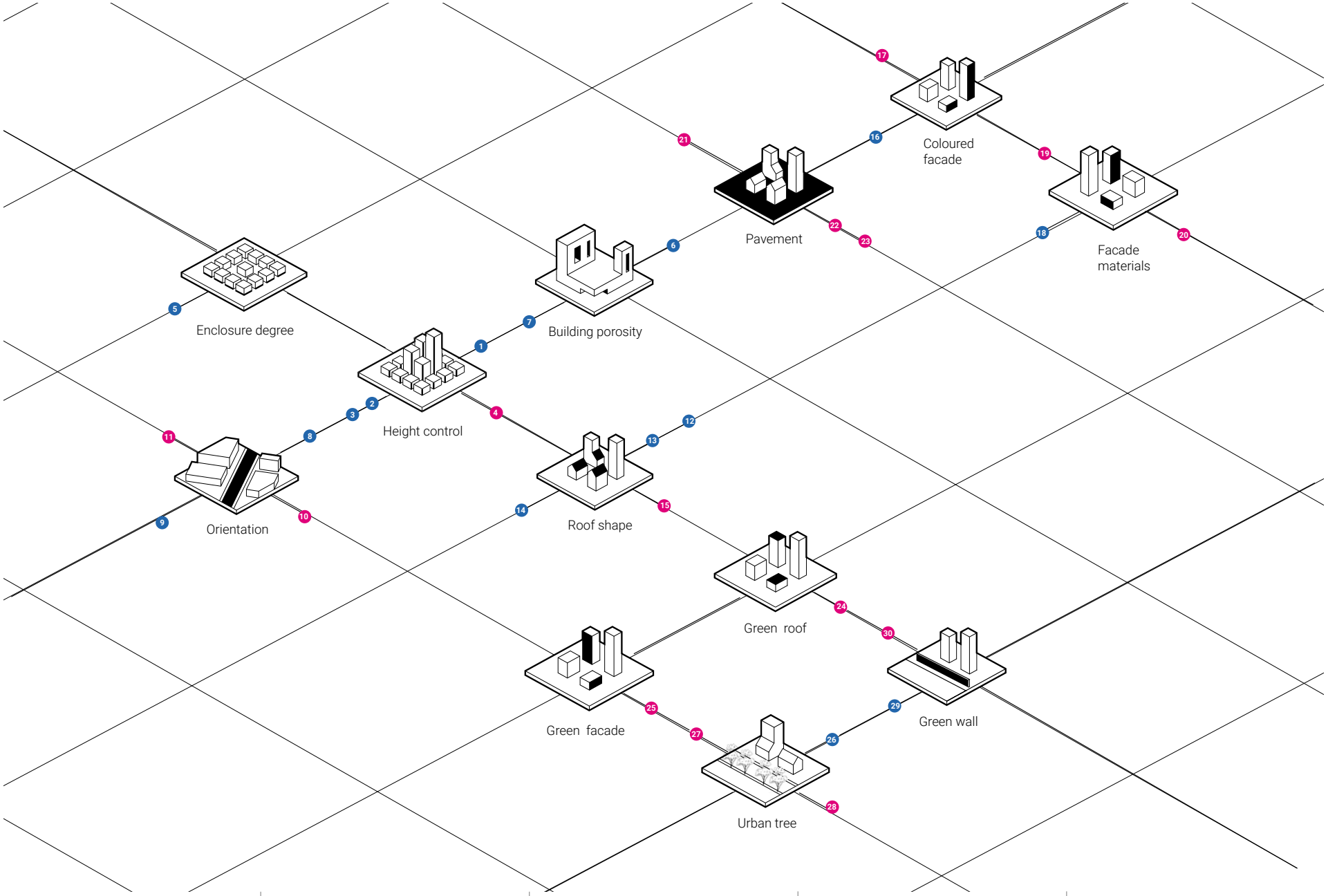


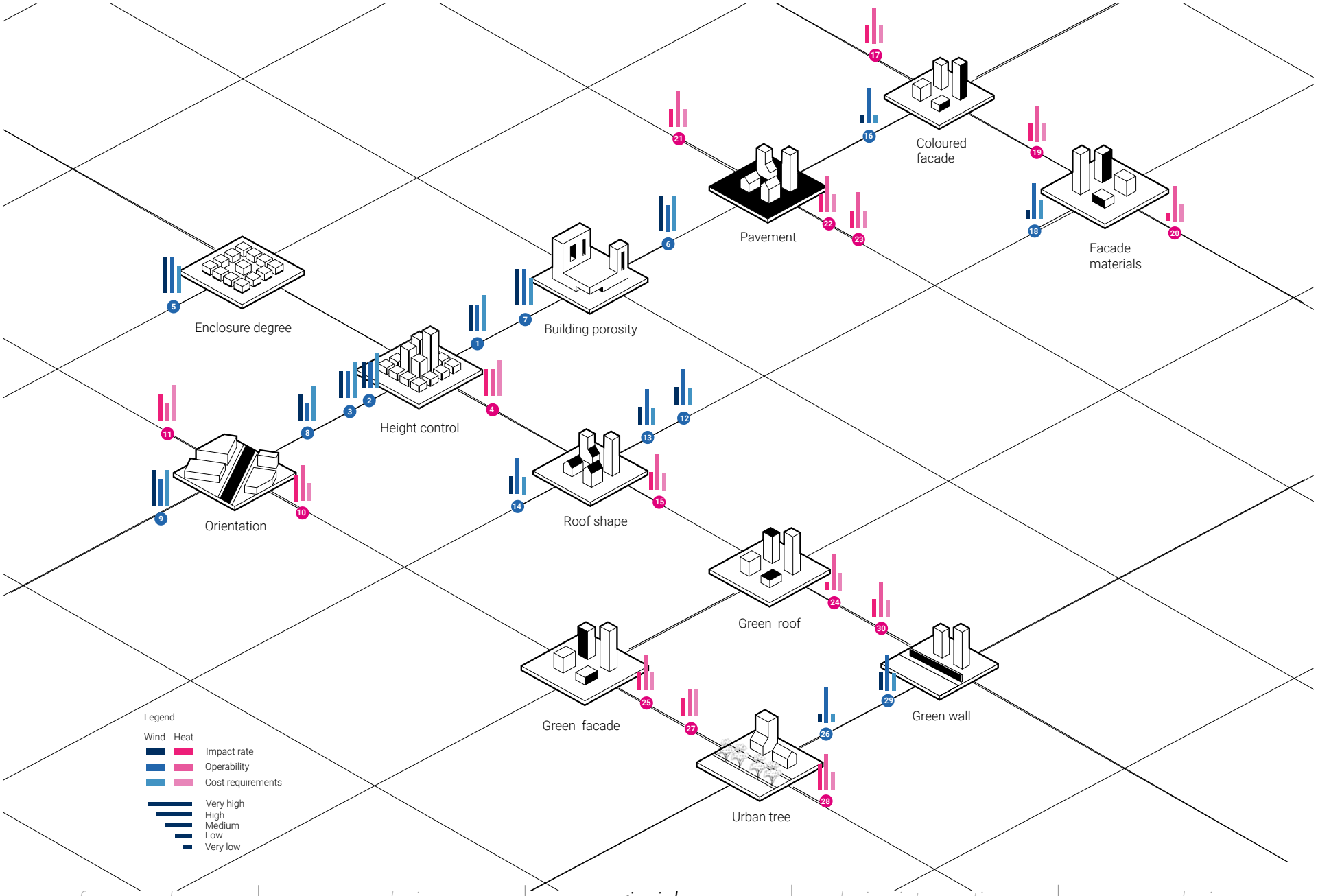
| Urban Morphology | Urban Surface | Urban Green |
|---|---|---|
| +Height control | +Coloured facade | +Green roof |
| +Enclosure degree | +Materialization | +Green facade |
| +Building porosity | +Pavement | +Urban tree |
| +Orientation | | +Green wall |
| +Roof shape | | |

# The possibility of different types of strategies



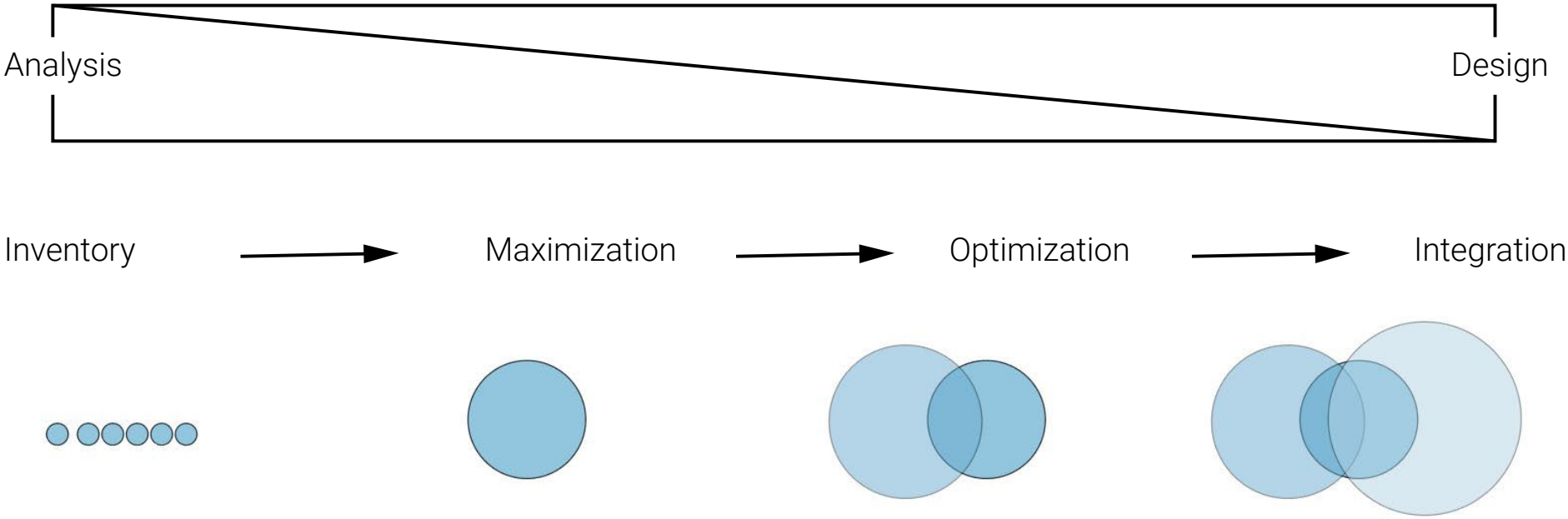

Coloured facade
Pavement
Facade materials
Enclosure degree
Building porosity
Height control
Orientation
Roof shape
Green roof
Green facade
Green wall
Urban tree


Coloured facade
Pavement
Facade materials
Enclosure degree
Building porosity
Height control
Orientation
Roof shape
Green roof
Green facade
Green wall
Urban tree


Enclosure degree
Building porosity
Pavement
Coloured facade
Facade materials
Height control
Orientation
Roof shape
Green roof
Green facade
Green wall
Urban tree
Legend
Wind Heat
Impact rate
Operability
Cost requirements
Very high
High
Medium
Low
Very low

# 04 DESIGN INTERVENTIONS

# *Design approach*




***Using the maximisation approach, environmental and urban space issues can be included alongside the air polltion theme design. The three site studies in this chapter follow the same integration process***

# 1.DAYE ROAD

# *Design objectives*

## *Analysis*

High density, large building height difference, high reflective walls, enclosed high-rise building group unit

High temperature, relatively low wind speed, higher wind speed in the corner flow area

High traffic flow, high human flow, low greening rate, lack of public space

## *Maximisation* 6 16

Change the material and color of urban surfaces, reduce frontal area, coordinate the urban cold and heat sources

## *Optimisation* 3 7 15 24 25

Reflective and green roofs, the fountain installation on the square serves as cooling and dust retention, adjust building function according to air quality

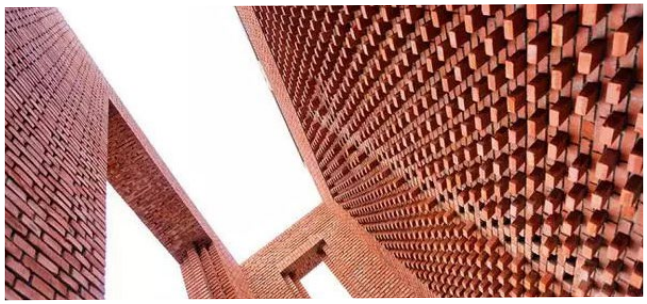
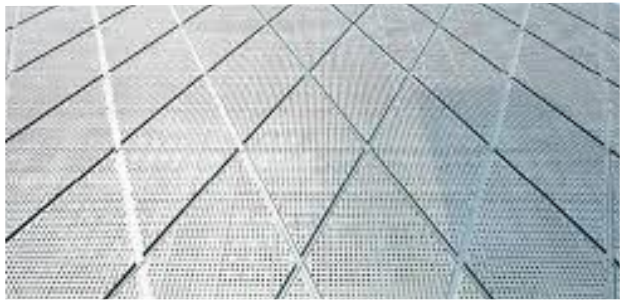
## *Integration*

Use building ground floor to shade, vegetation and higher permeability surfaces, mental benefits provided by green roofs

use the color of the facade to speed up the wind speed, especially in a city center with a large building facade. The use of temperature differences and accelerate the process of thermal stratificationcould be used to accelerate airflows, although in an uncontrolled way. Three different materials are used for simulation here, which initially shows that different surfaces have effects on wind,heat environment and air pollution.The hypothesis tested in daye road and design proposals are as follows:

The color and material of the facade will affect the thermal stratification process in the street, so when using dark or low emissivity materials' facades, the air will rise faster along the facade surface, thereby increasing the wind speed and increasing the increase the mixture of air between the canopy layer and the boundary layer.

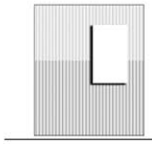
-Glass(all the building surfaces)
-Brick
-Aluminum(grey)

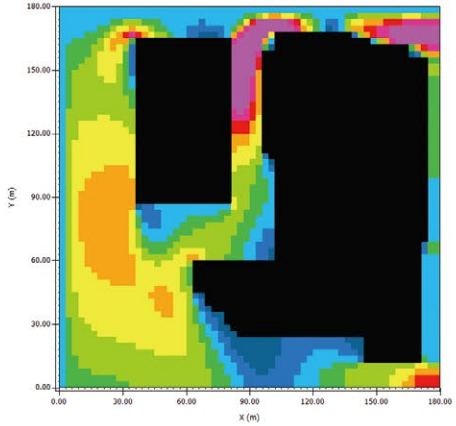
Glass, brick and aluminum veneer curtain wall building.
Source: https://www.hotbak.net/key/%E9%AB%98%E5%B1%82%E5%BB%BA%E7%AD%91%E7%8E%BB%E7%92%83.html
https://dy.163.com/v2/article/detail/D7LB3UH20520CIDT.html
http://www.024cai.net/product/717.htm

Glass

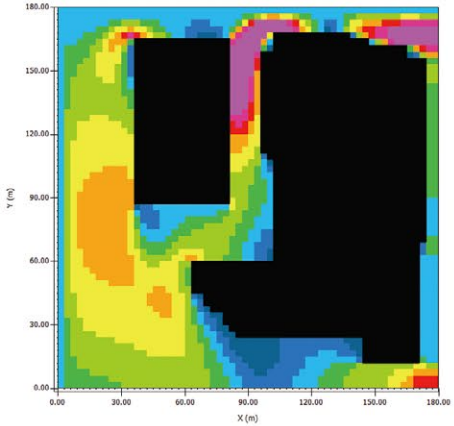
Brick



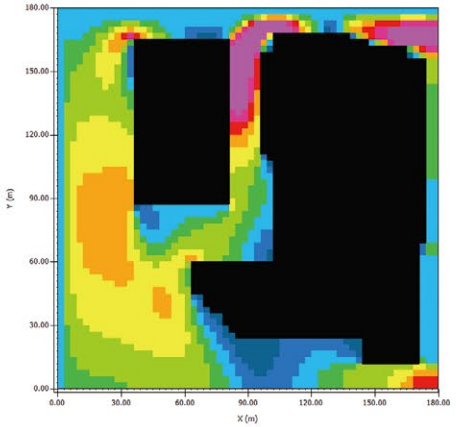
Aluminum




Max:6.06m/s



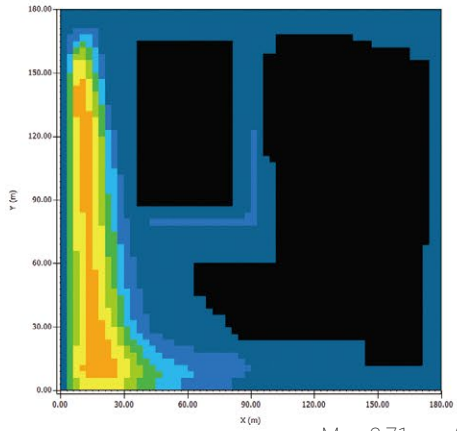

Max:6.04m/s



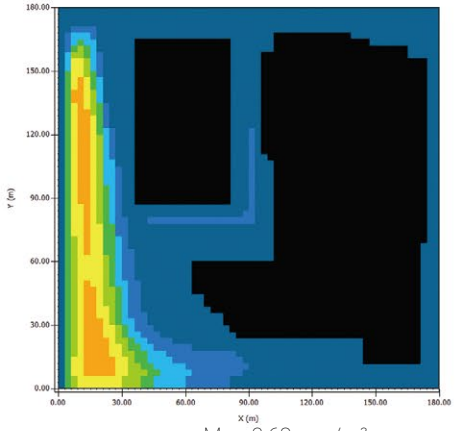

Max:6.12m/s

Wind speed

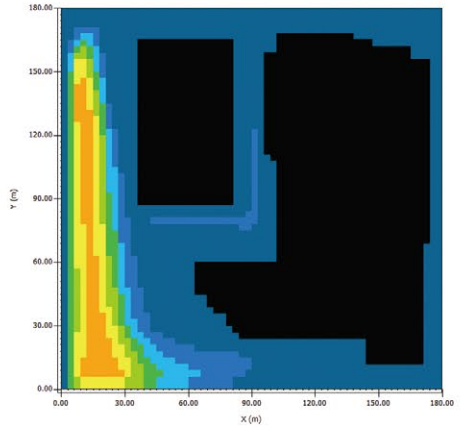
- below 0.40 m/s
- 0.40 to 0.80 m/s
- 0.80 to 1.20 m/s
- 1.20 to 1.60 m/s
- 1.60 to 2.00 m/s
- 2.00 to 2.40 m/s
- 2.40 to 2.80 m/s
- 2.80 to 3.20 m/s
- 3.20 to 3.60 m/s
- above 3.60 m/s




Max:.2.71mcg/m³




Max:.2.68mcg/m³

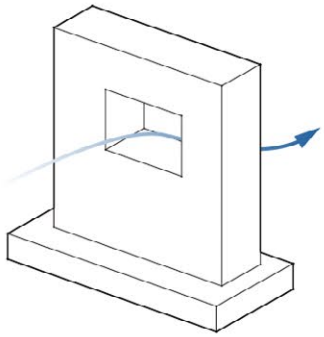



Max:.2.74mcg/m³

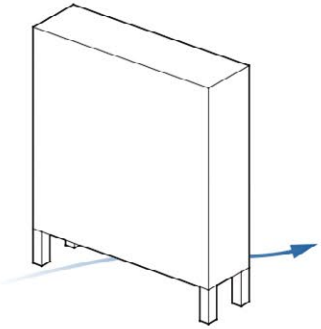
PM10 concentration

- below 0.40 µg/m3
- 0.40 to 0.80 µg/m3
- 0.80 to 1.20 µg/m3
- 1.20 to 1.60 µg/m3
- 1.60 to 2.00 µg/m3
- 2.00 to 2.40 µg/m3
- 2.40 to 2.80 µg/m3
- 2.80 to 3.20 µg/m3
- 3.20 to 3.60 µg/m3
- above 3.60 µg/m3

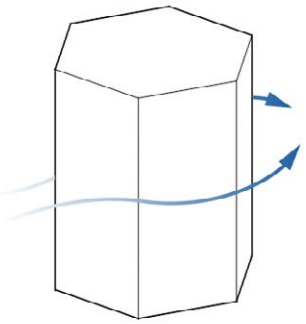
***Opening in building facade***



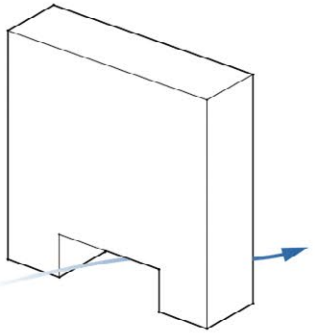
***Increase ground zone air volume***



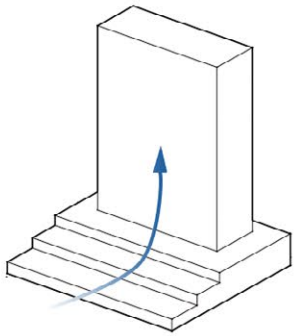
***Reduce building frontage***



***Air passage/ Ventilation bay***



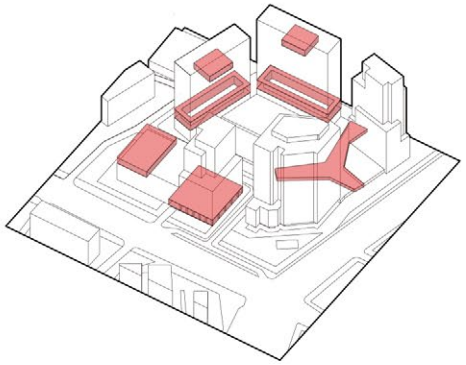
***Guilding air flow***



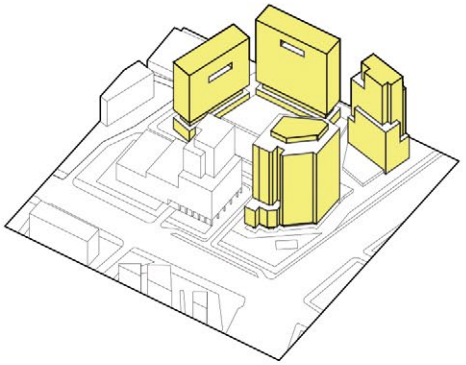
***Building morphology***

For high-rise or large mass platform buildings, it will seriously hinder urban ventilation and form a large wind shadow area on the back of the building. For a single building form, opening in building facade, increase ground zone air volume,reduce building frontage,air passage/ventilation bay and guilding air flow are advantageous design methods.

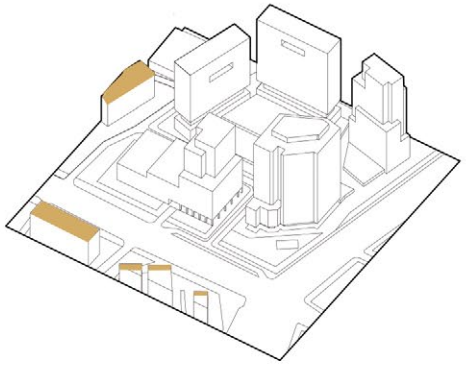
The impact on the above-ground buildings should be reduced by controlling the building quality as much as possible, reducing the size of the windward surface, optimizing the building form, destroying large buildings or developing underground spaces, and thus reducing the impact on ventilation.



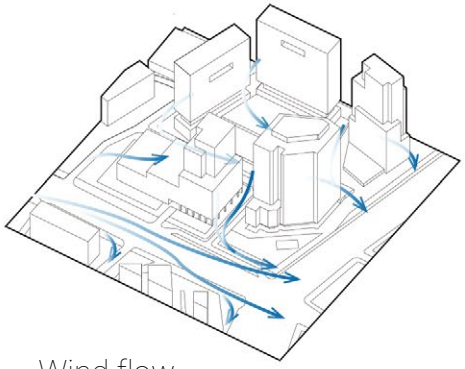
Porosity



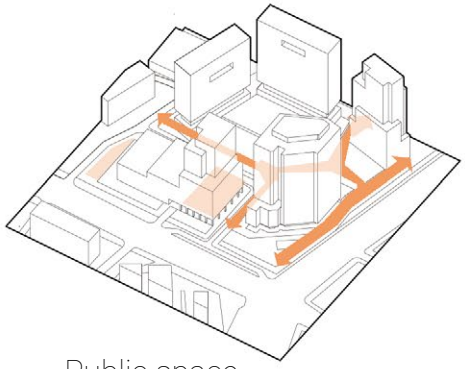
Light surface



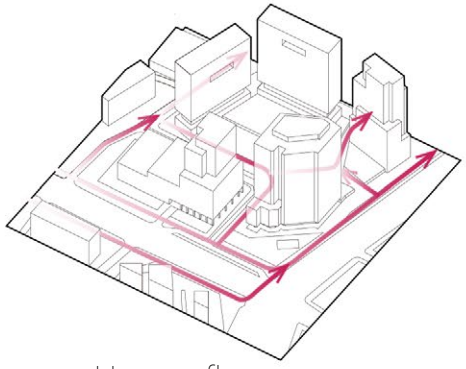
Pitched roof



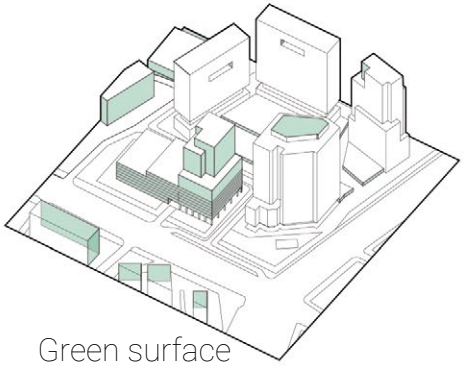
Wind flow



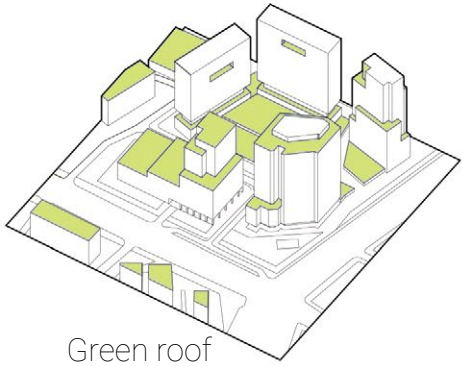
Public space



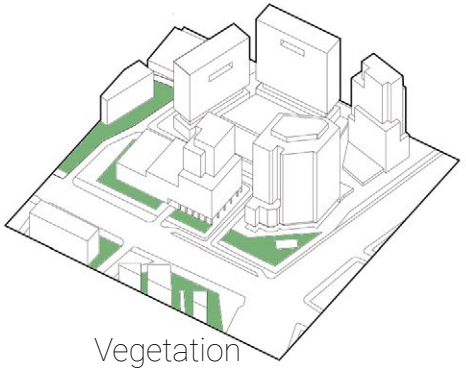
Human flow



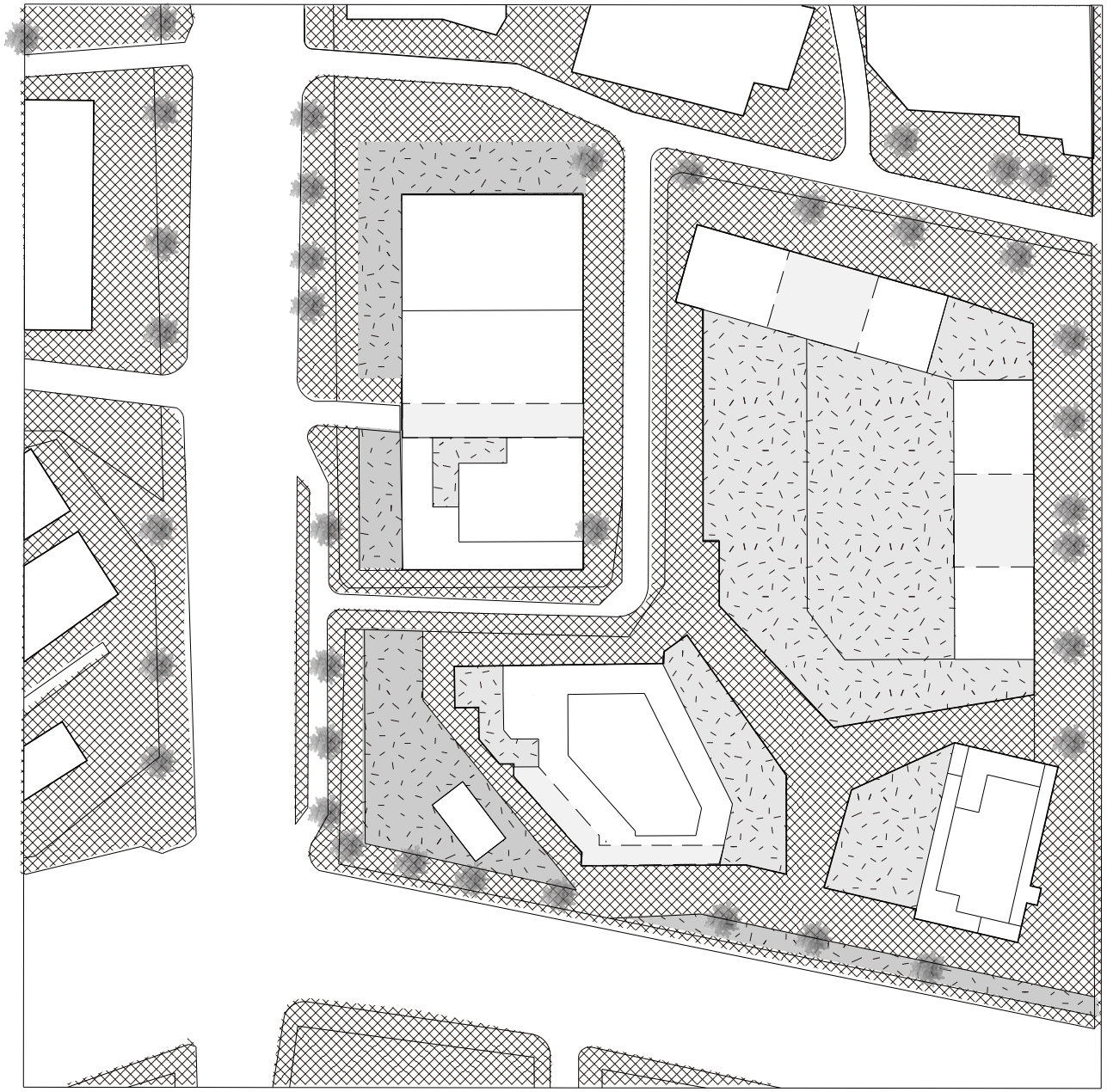
Green surface



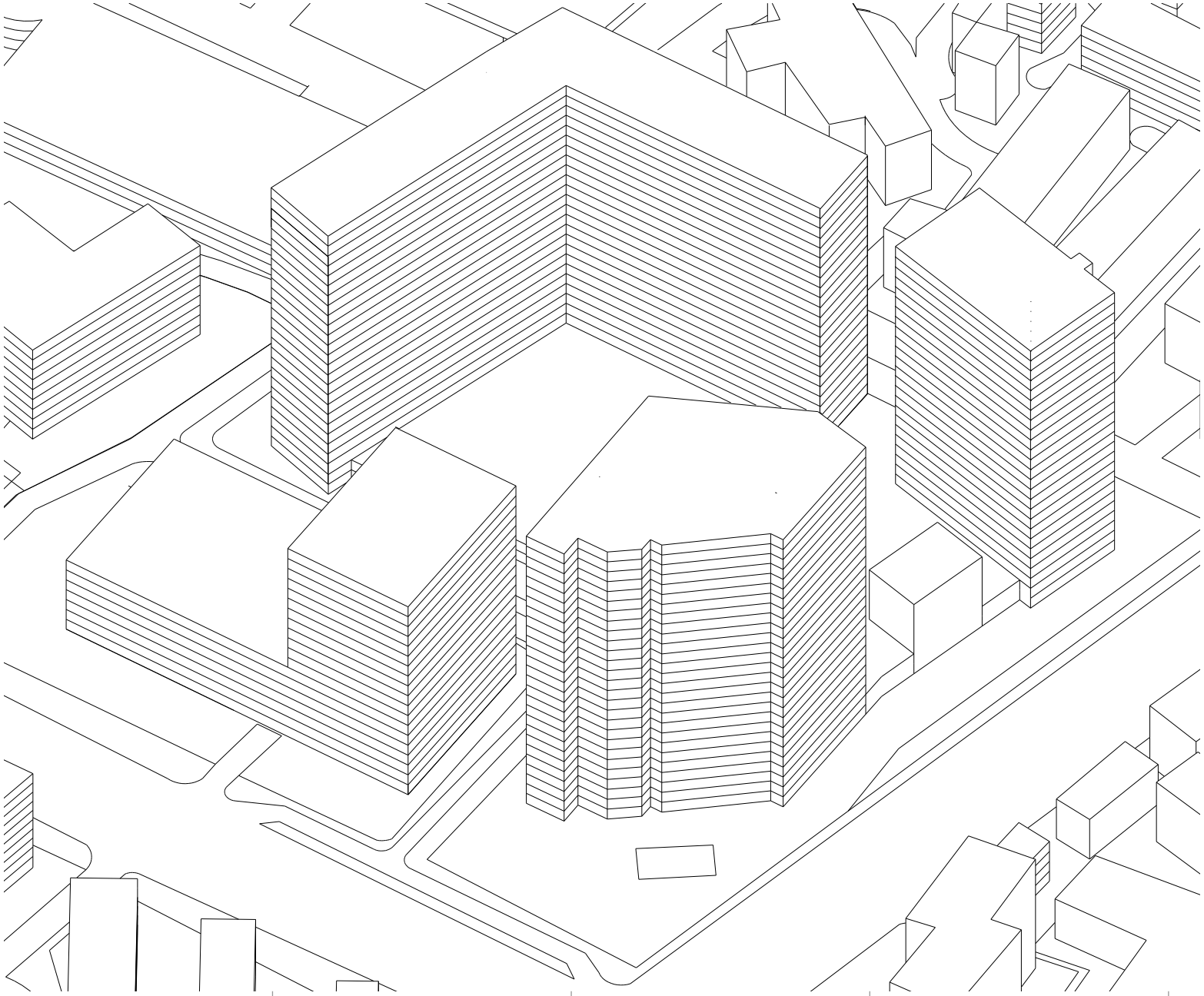
Green roof



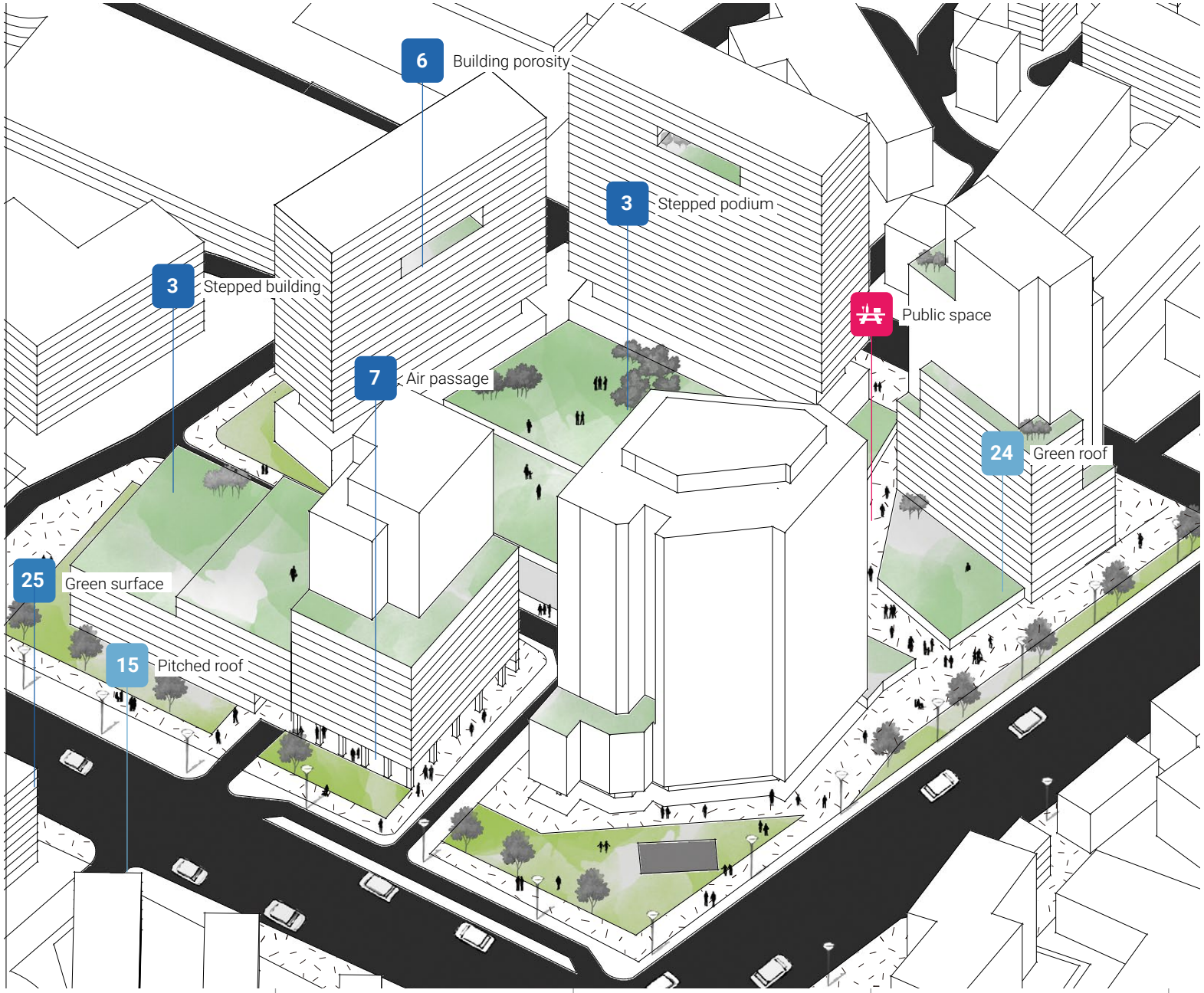
Vegetation



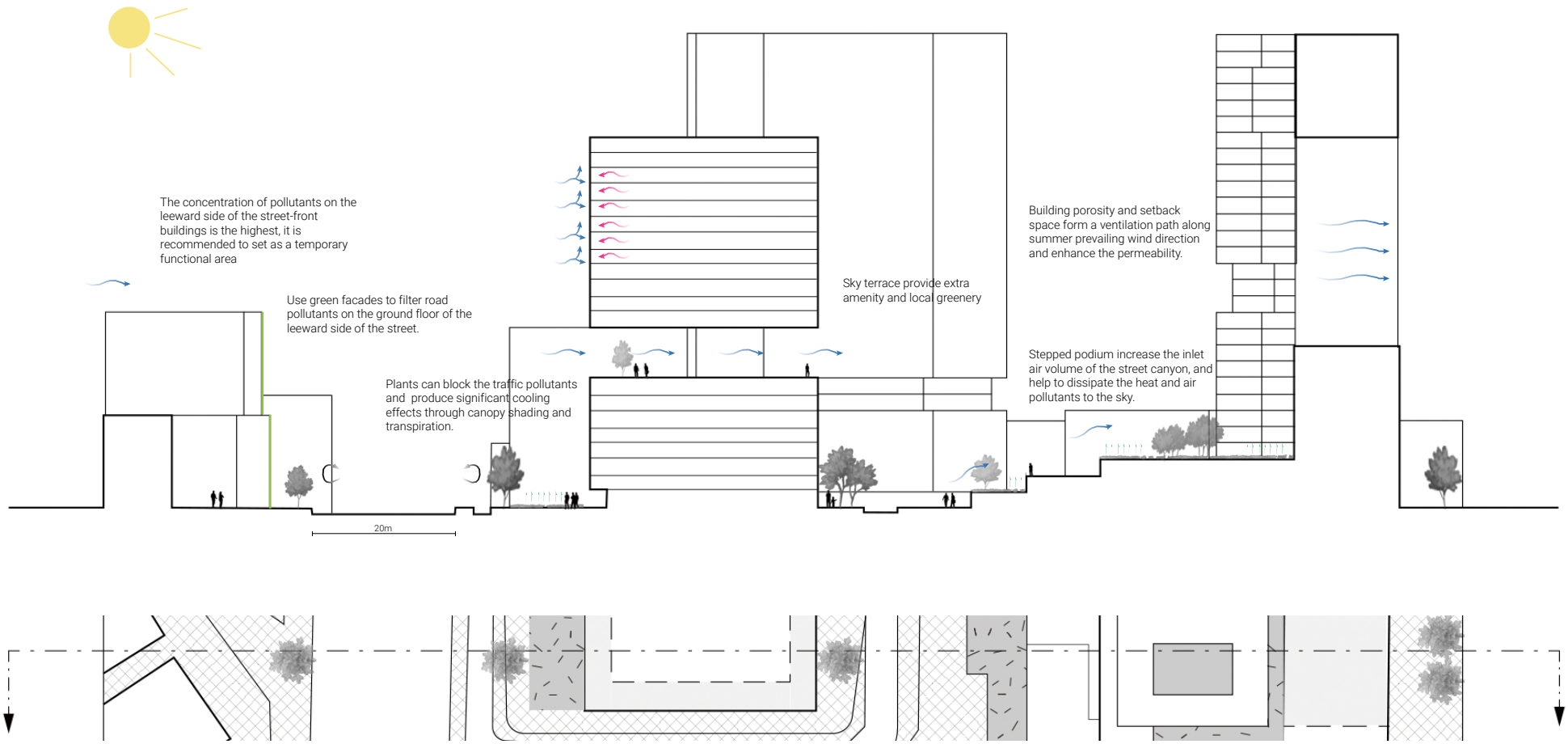

Daye road design plan.



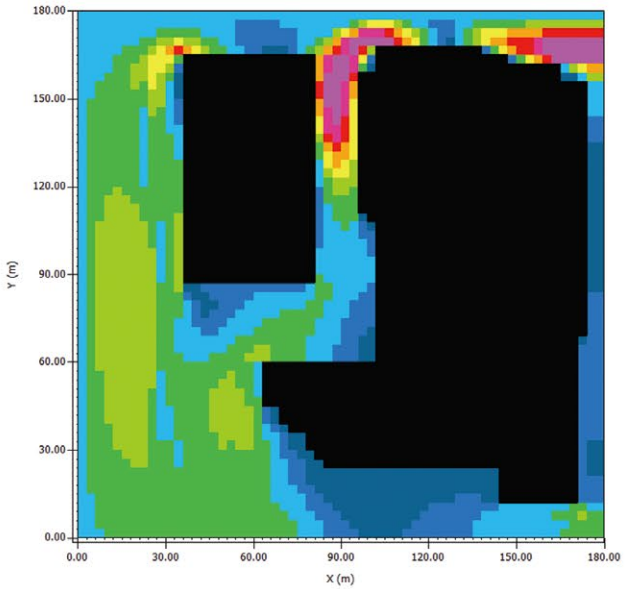
Daye road before.



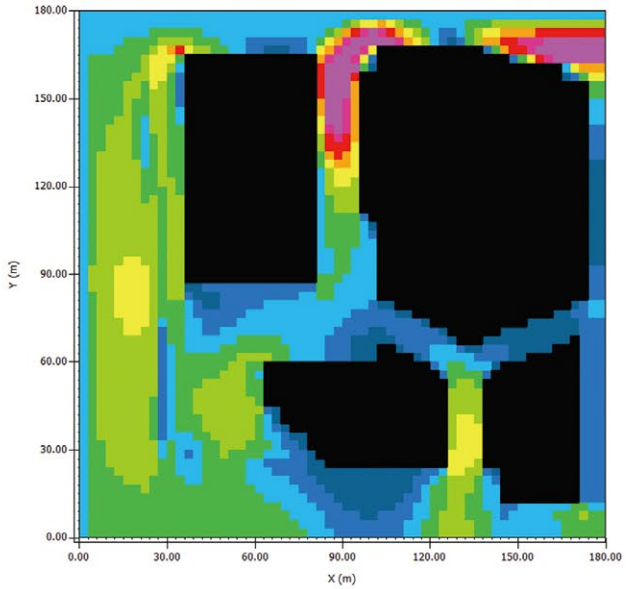

Daye road design principles.


The concentration of pollutants on the leeward side of the street-front buildings is the highest, it is recommended to set as a temporary functional area
Use green facades to filter road pollutants on the ground floor of the leeward side of the street.
Plants can block the traffic pollutants and produce significant cooling effects through canopy shading and transpiration.
Sky terrace provide extra amenity and local greenery
Building porosity and setback space form a ventilation path along summer prevailing wind direction and enhance the permeability.
Stepped podium increase the inlet air volume of the street canyon, and help to dissipate the heat and air pollutants to the sky.
20m

## *Current*



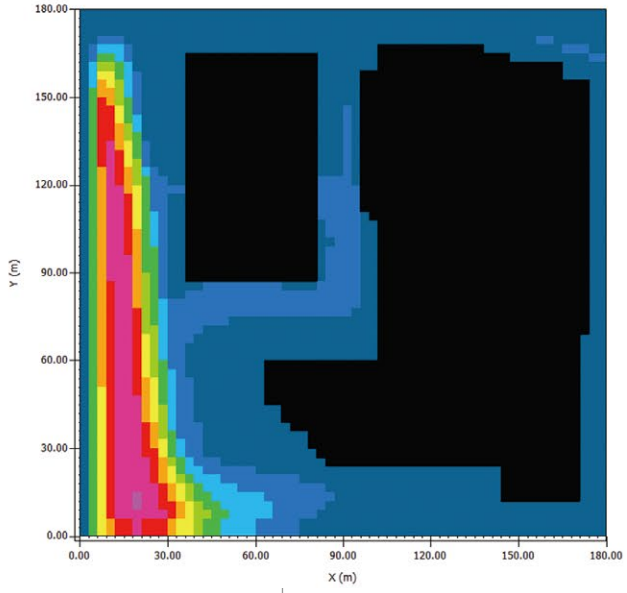

## *Design*

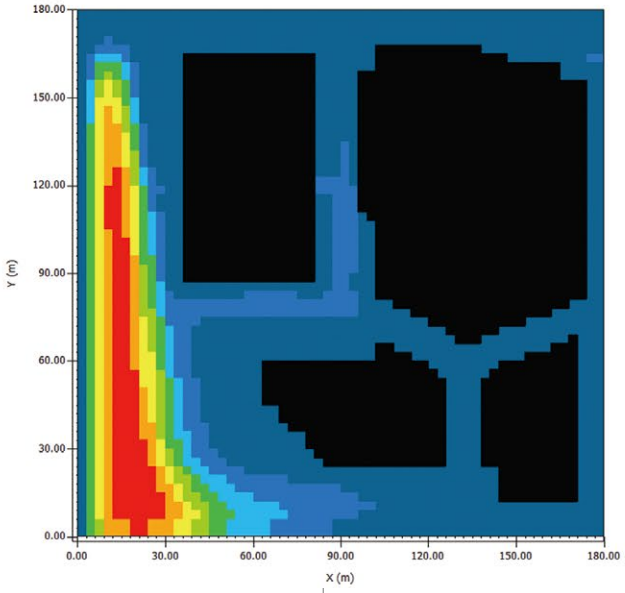



***Wind Speed***

h=1.5000m

- below 0.40 m/s
- 0.40 to 0.80 m/s
- 0.80 to 1.20 m/s
- 1.20 to 1.60 m/s
- 1.60 to 2.00 m/s
- 2.00 to 2.40 m/s
- 2.40 to 2.80 m/s
- 2.80 to 3.20 m/s
- 3.20 to 3.60 m/s
- above 3.60 m/s




***pm10 Concentration***

h=1.5000m

- below 0.40 µg/m3
- 0.40 to 0.80 µg/m3
- 0.80 to 1.20 µg/m3
- 1.20 to 1.60 µg/m3
- 1.60 to 2.00 µg/m3
- 2.00 to 2.40 µg/m3
- 2.40 to 2.80 µg/m3
- 2.80 to 3.20 µg/m3
- 3.20 to 3.60 µg/m3
- above 3.60 µg/m3

Daye road.
Source: Author

## 2.NIJIAQIAO NEIGHBOURHOOD

# *Design objectives*

## *Analysis*

Medium density, average building height, determinant residential area, semi-enclosed multi-story building group unit

Moderate reflective walls, medium heat island effect, low wind speed, slab type multi-story building along the street that are nearly perpendicular to the wind direction form a large static wind area

## *Maximisation* 6

Change urban mopholo-gy, slab type multi-story building are arranged in a scattered manner to form an air corridor that matches the prevailing wind direction in summer

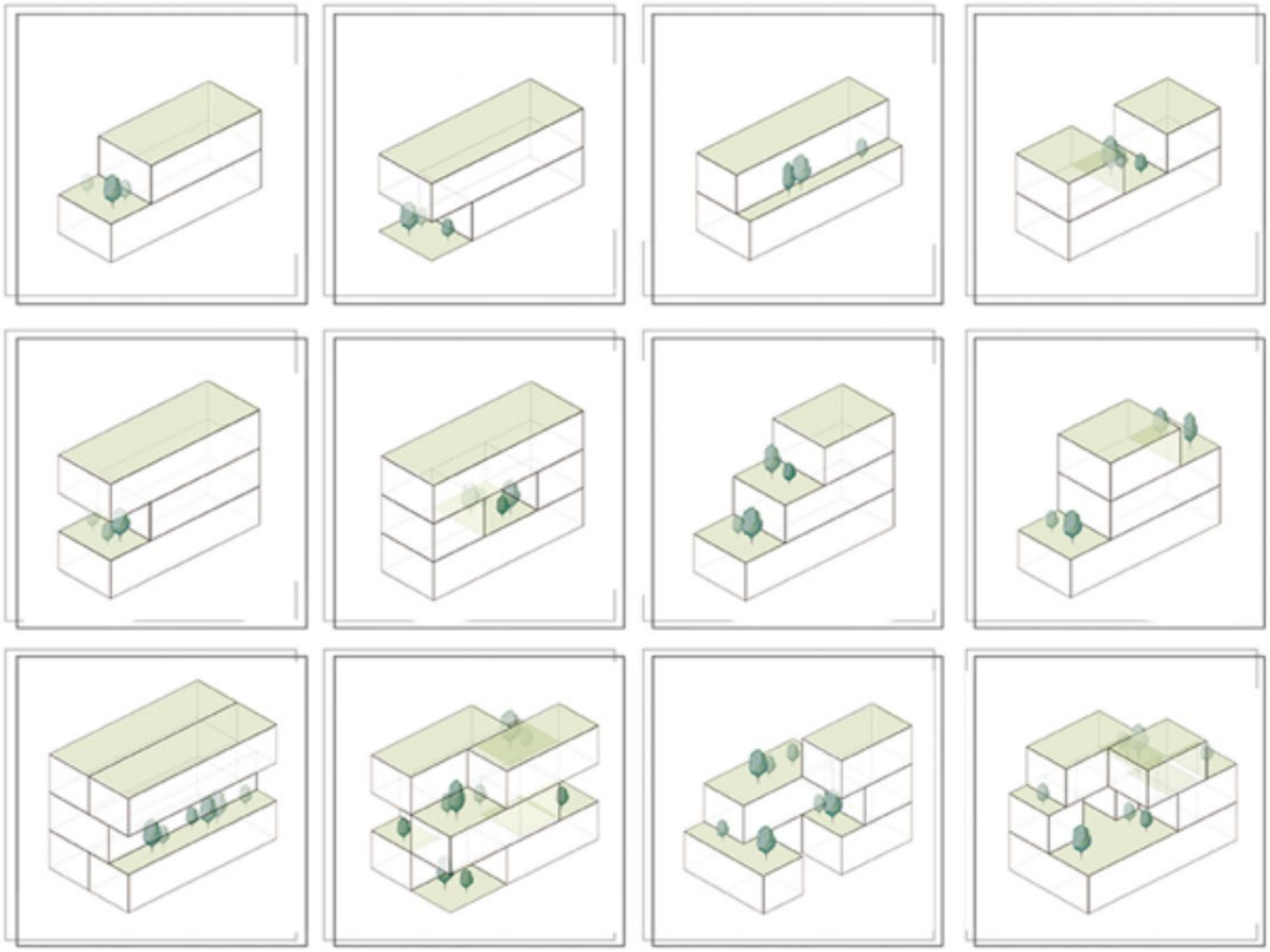
## *Optimisation* 3 7 15 17 24 29

Use insulation and sunscreen, add extra layers and trees to provide shadows for the sidewalk, add spaces with high SVF such as squares

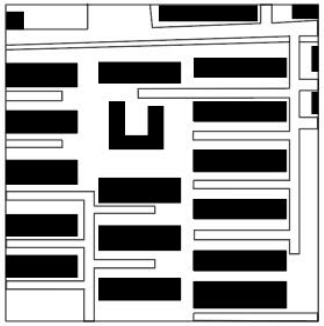
## *Integration*

Add additional public space and improve residents' vitality, mental benefits provided by green roof
improve the use of solar energy,

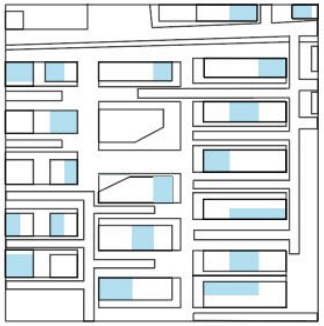
## *Building porosity proposals*



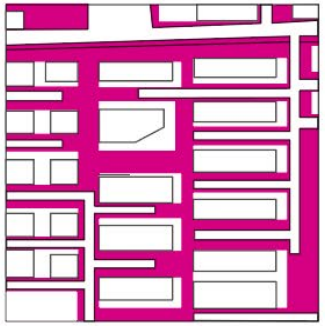
Current



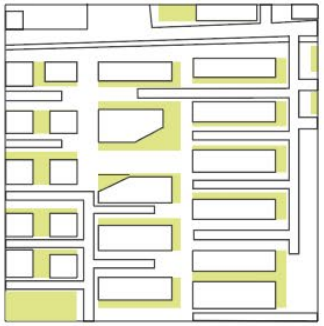
Porosity



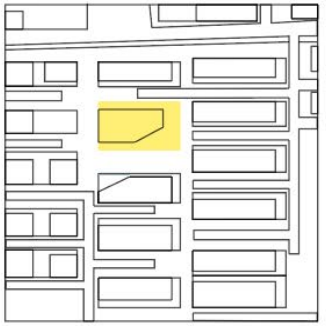
Pavement



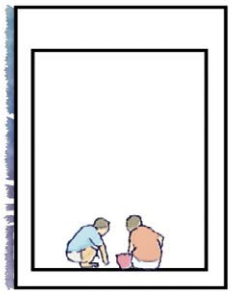
Green space



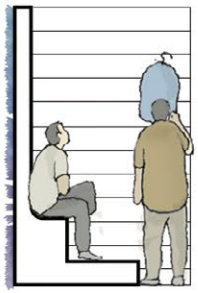
Public space



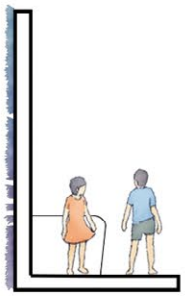
# *Active wall proposals*



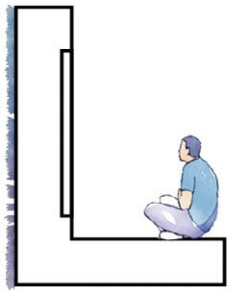
*01*



*02*

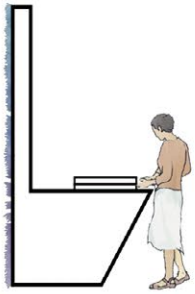


*03*



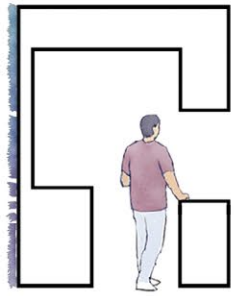
*04*

*05*

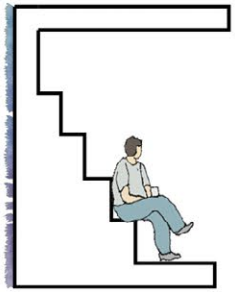


*06*

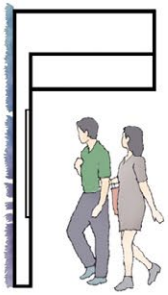
*07*



*08*

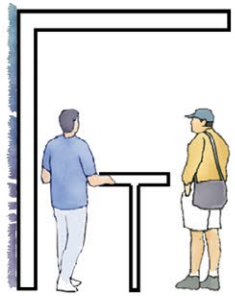


*09*

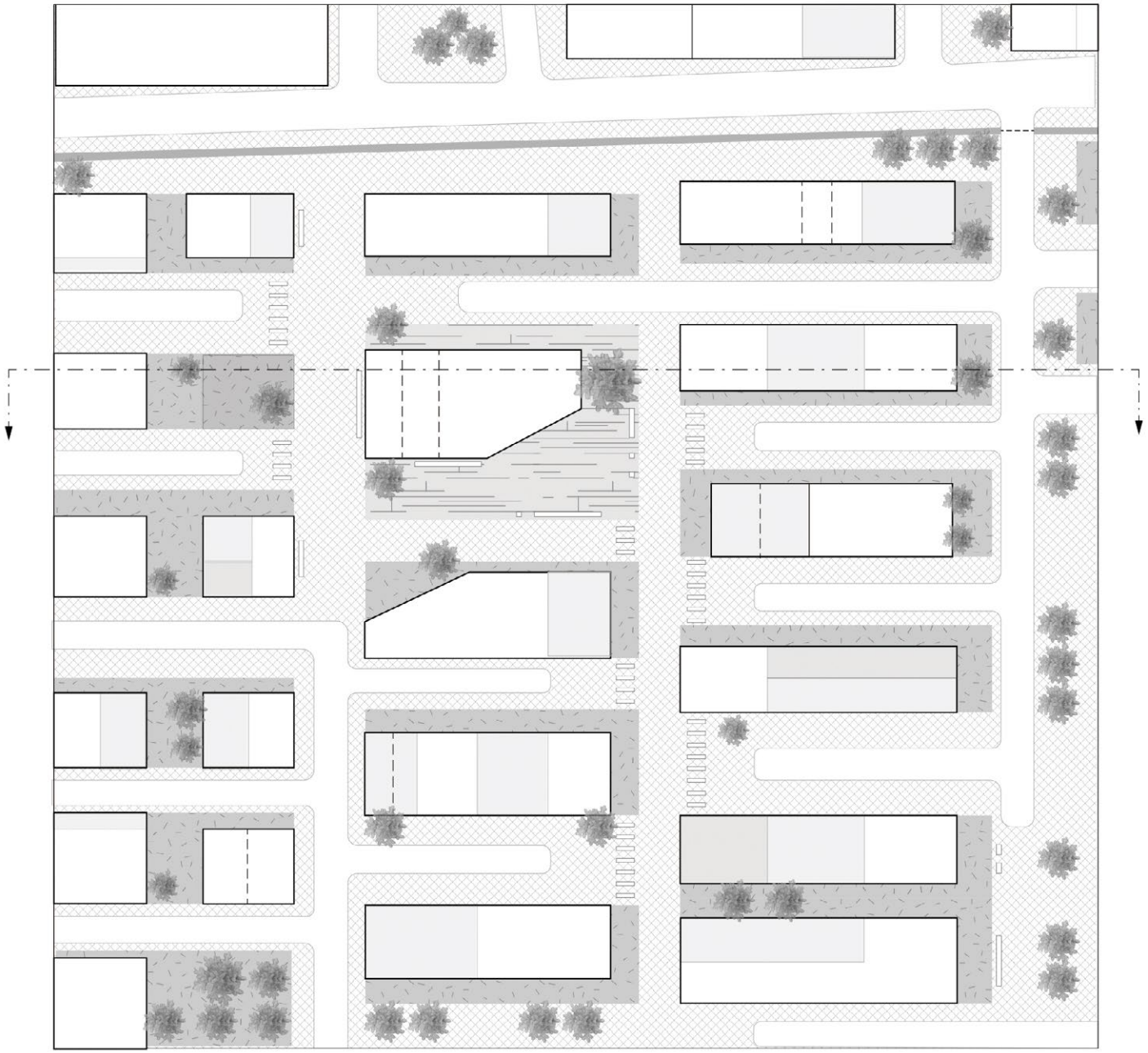


*10*

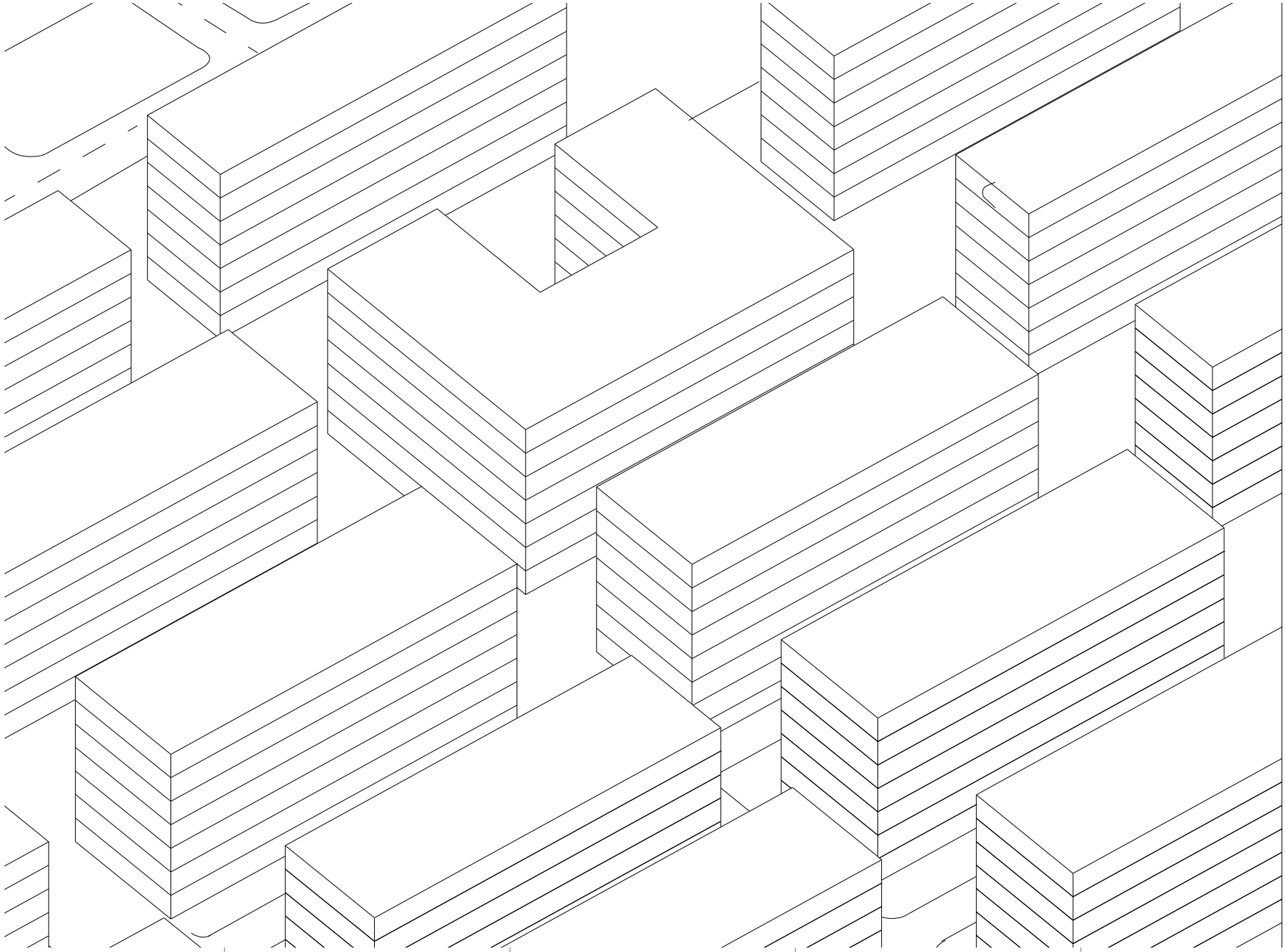
*11*

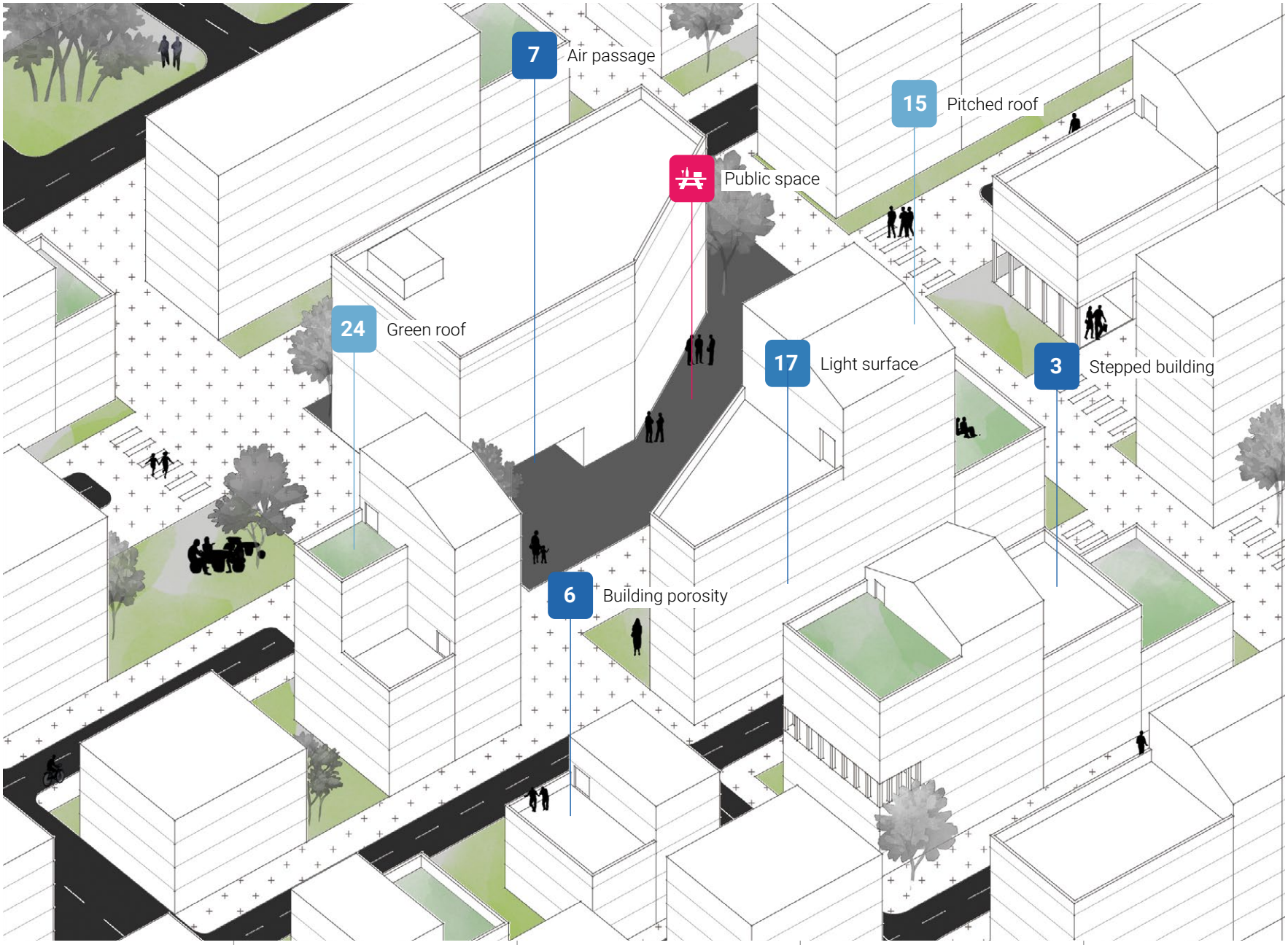


*12*

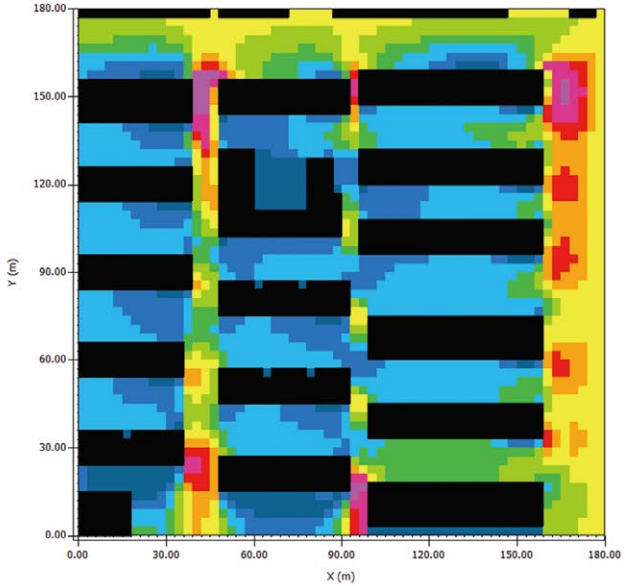


0 50m

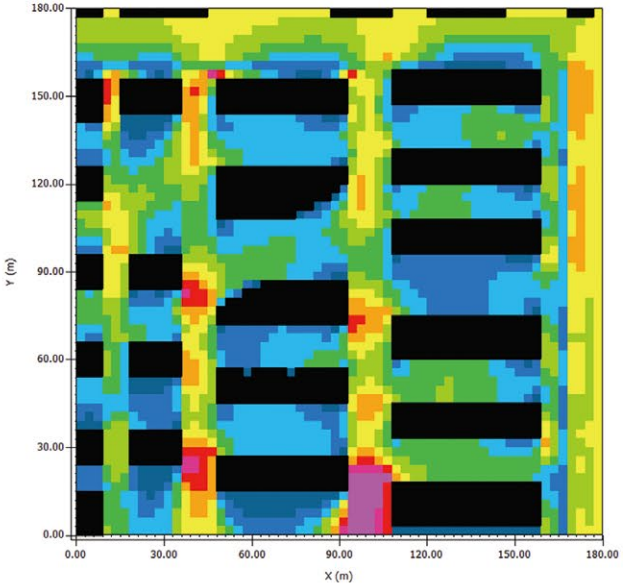


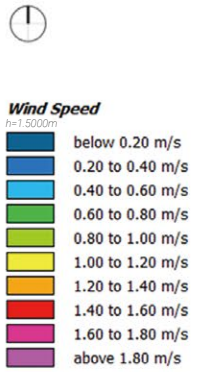

7
Air passage
15
Pitched roof
Public space
24
Green roof
17
Light surface
3
Stepped building
6
Building porosity

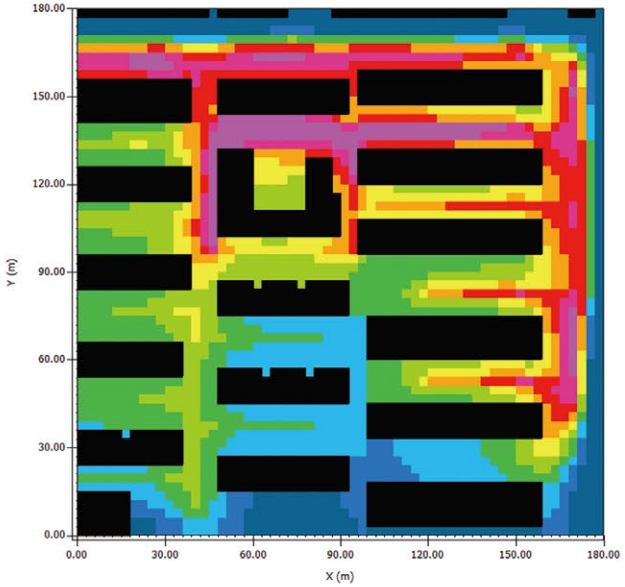
## *Current*

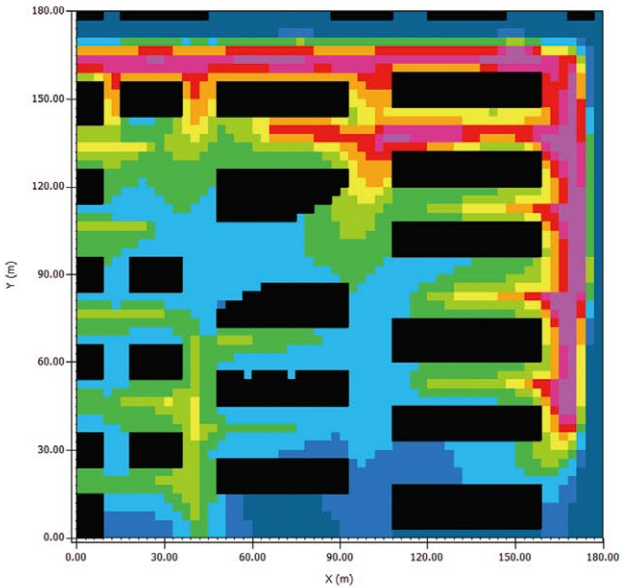


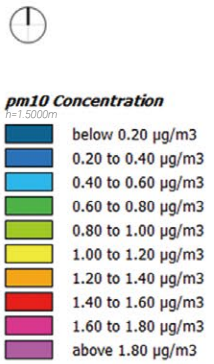

## *Design*

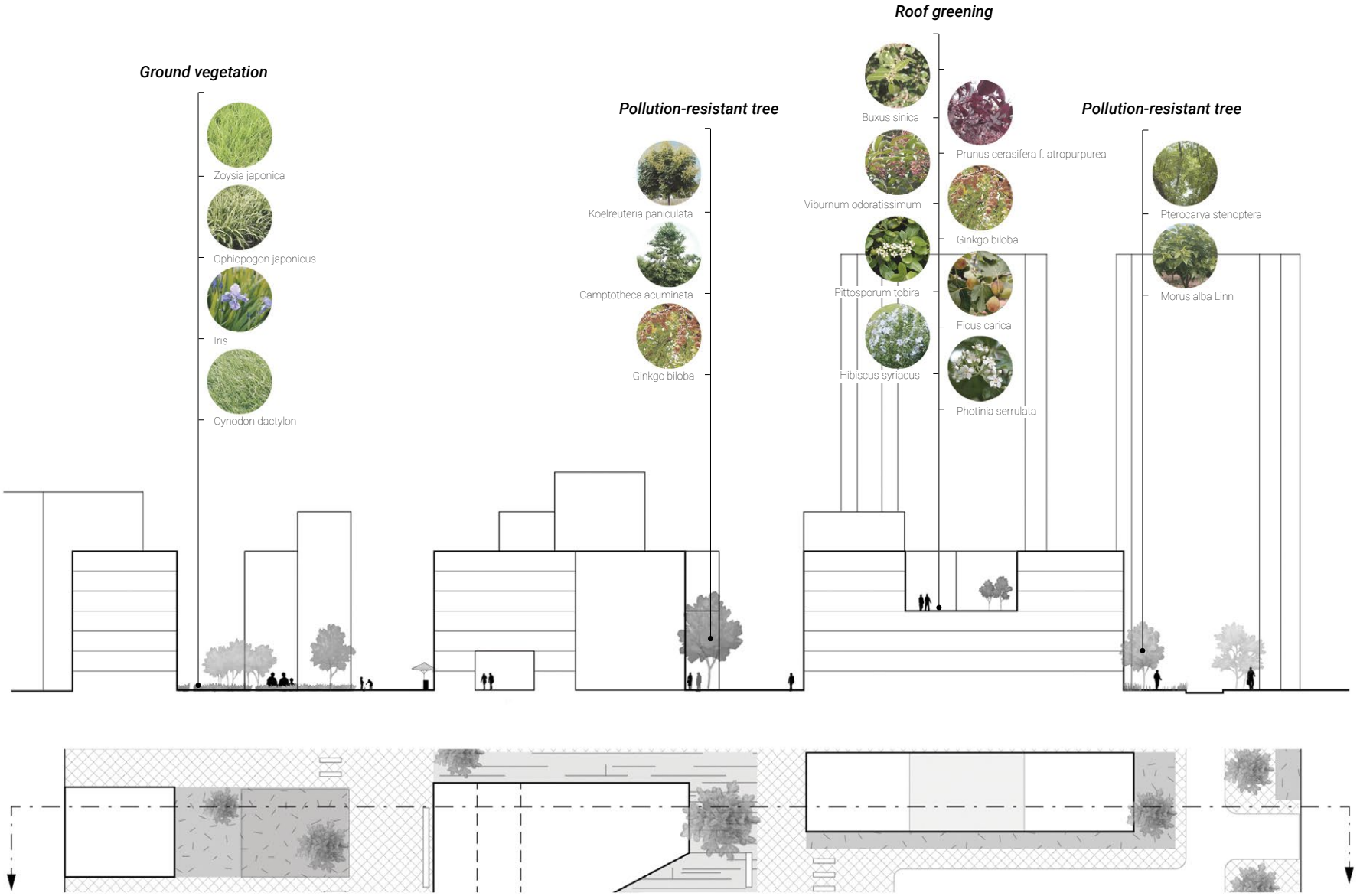


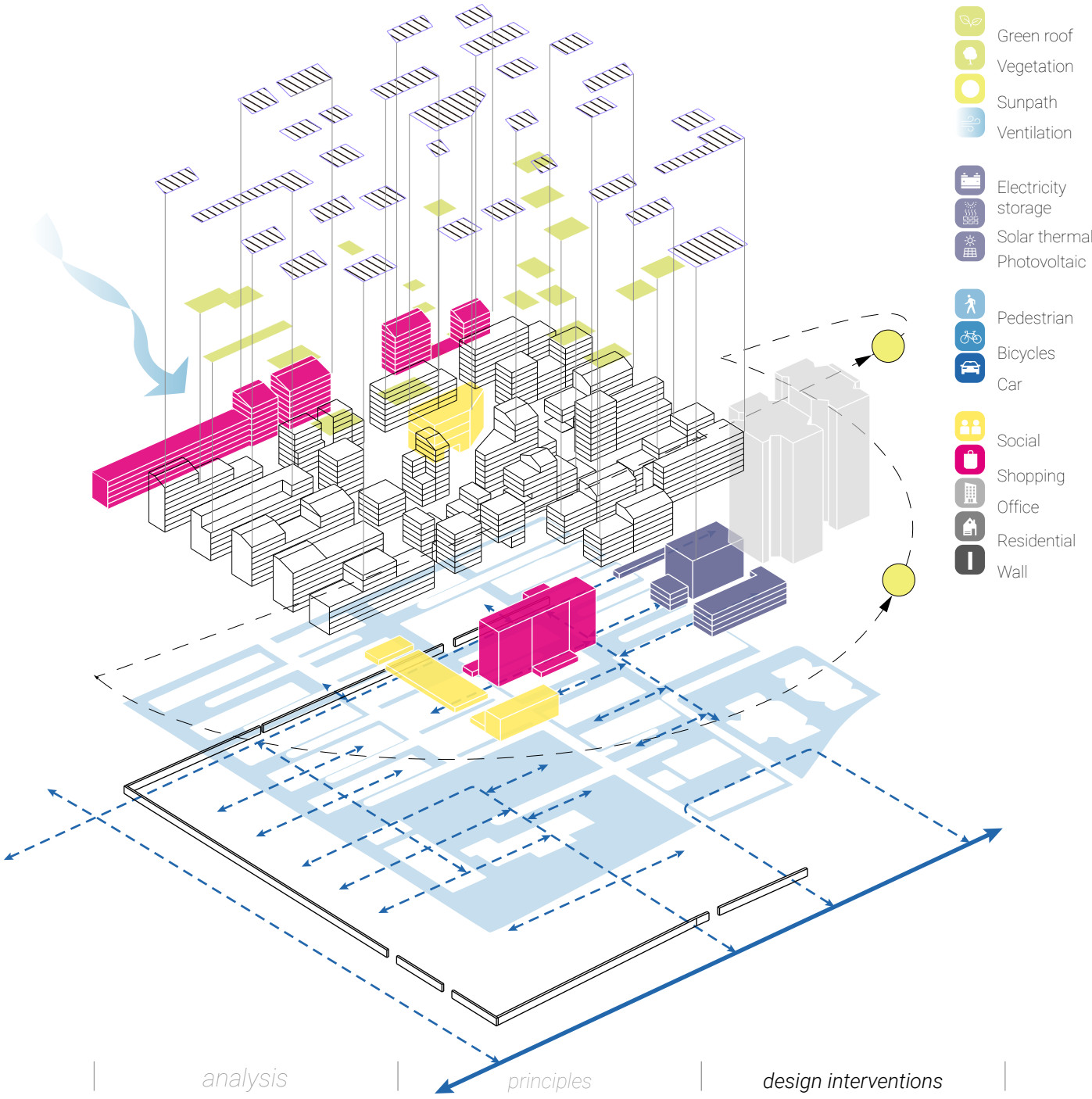




Ground vegetation
Zoysia japonica
Ophiopogon japonicus
Iris
Cynodon dactylon
Pollution-resistant tree
Koelreuteria paniculata
Camptotheca acuminata
Ginkgo biloba
Roof greening
Buxus sinica
Prunus cerasifera f. atropurpurea
Viburnum odoratissimum
Ginkgo biloba
Pittosporum tobira
Ficus carica
Hibiscus syriacus
Photinia serrulata
Pollution-resistant tree
Pterocarya stenoptera
Morus alba Linn


Green roof
Vegetation
Sunpath
Ventilation
Electricity storage
Solar thermal
Photovoltaic
Pedestrian
Bicycles
Car
Social
Shopping
Office
Residential
Wall

# 3.TIANFU AVENUE

# *Design objectives*

## *Analysis*

Low density, average building height, much green, non-enclosed large mass multi-story building unit

Static wind zone with low heat island effect

Low outdoor attraction, high greening but low accessibility

## *Maximisation* 26

Adjust the form of urban road greening to reduce air pollution in outdoor exposed areas of the population

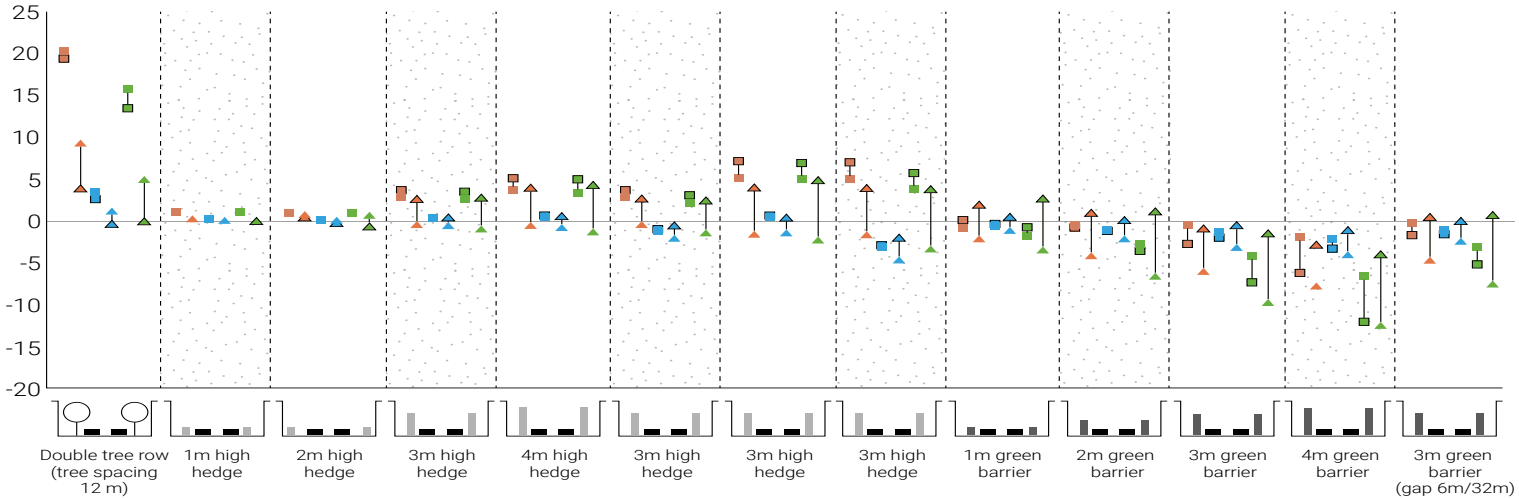
## *Optimisation* 7 16 21 23 25

The dark facade promotes ventilation and the building adds extra insulation, permeable pavement for water infiltration.

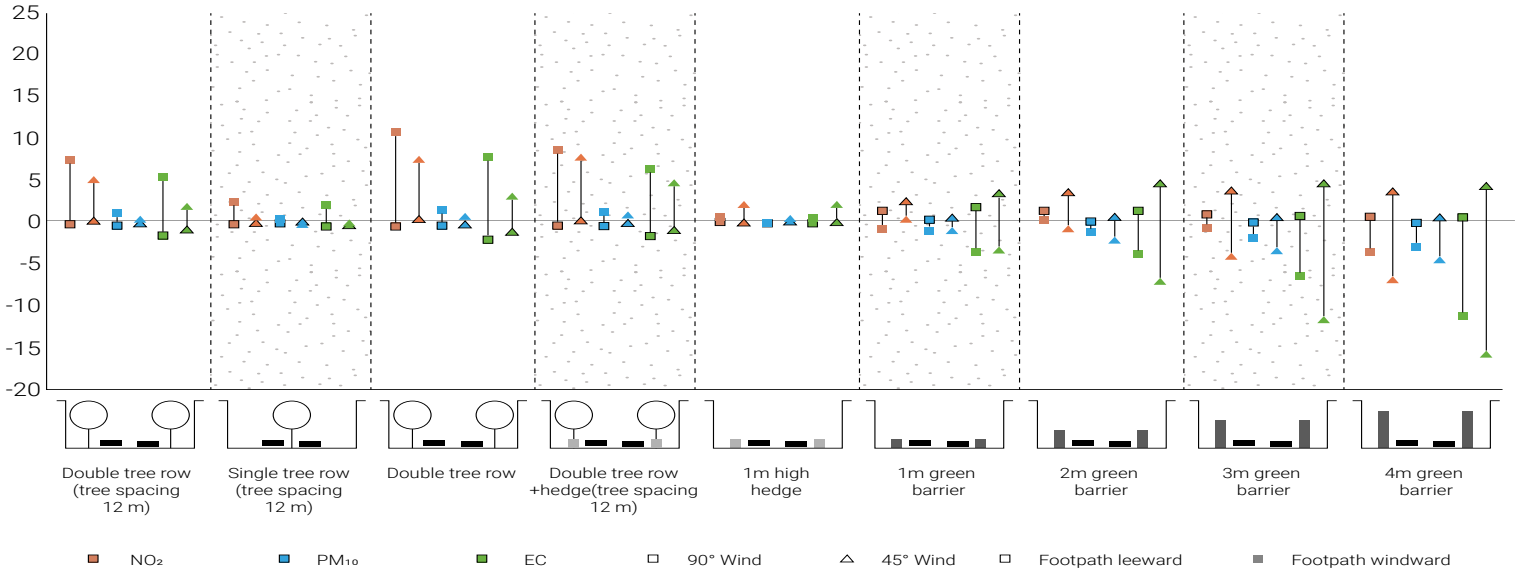
## *Integration*

Use urban canvas and urban trees to shade, Increase solar energy supply, increase attractiveness shopping streets to add vitality to public spaces, provide more shade, redesign of square

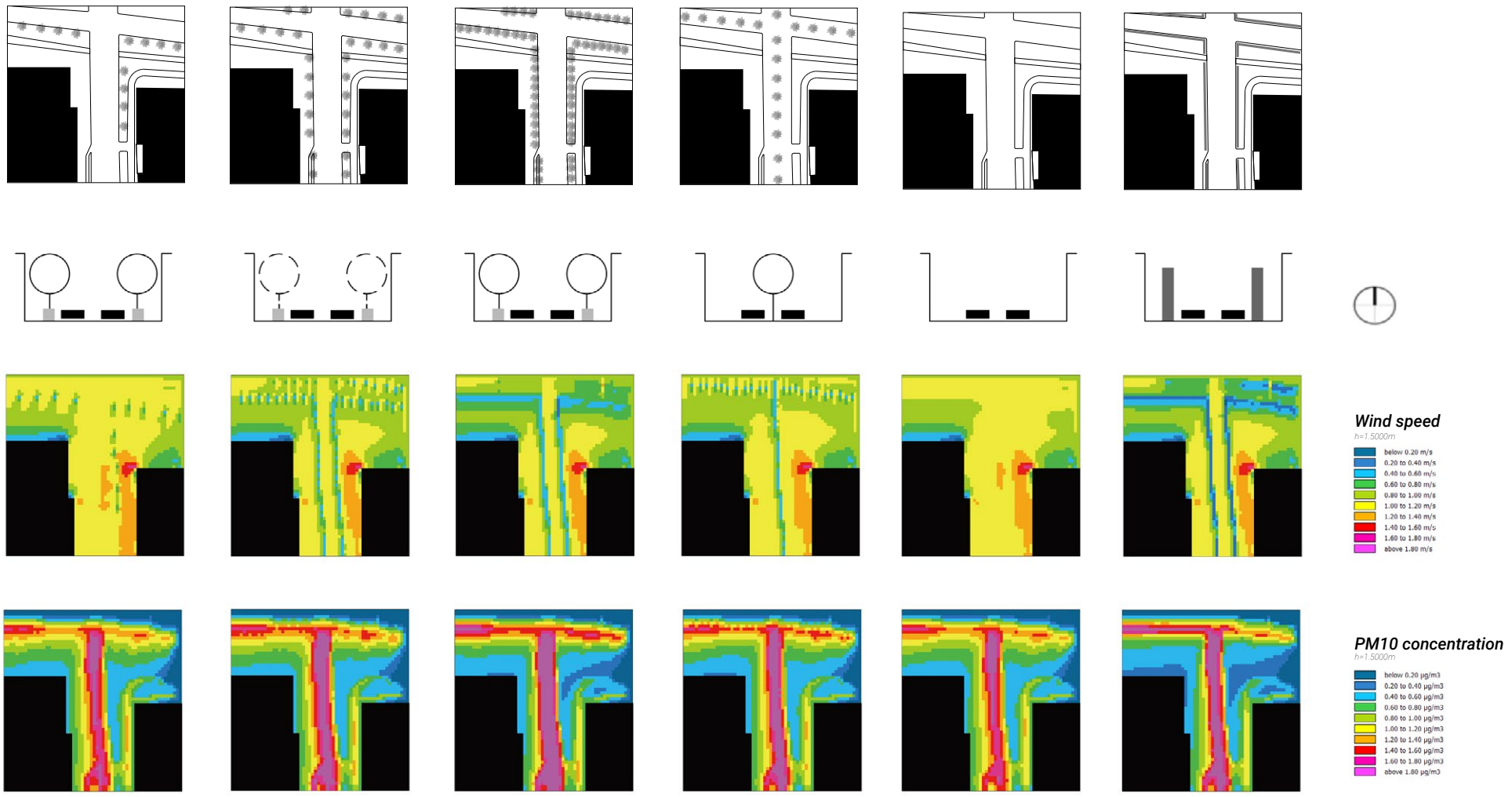
Relative difference in concentration [%]




Relative difference in concentration [%]

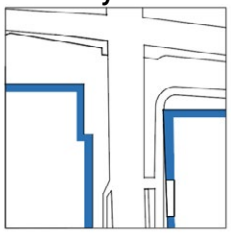



Effects of urban vegetation in urban canyons
Source: VOS, P., MAIHEU, B., VANKERKOM, J. & JANSSEN, S. (2013). Improving local air quality in cities: To tree or not to tree? Urban Environmental Pollution, 183, 113-122

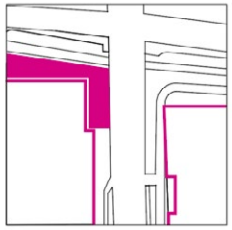

Current
Loose
Dense
One line
No trees
4m green barrier
Wind speed
h=1.5000m
below 0.20 m/s
0.20 to 0.40 m/s
0.40 to 0.60 m/s
0.60 to 0.80 m/s
0.80 to 1.00 m/s
1.00 to 1.20 m/s
1.20 to 1.40 m/s
1.40 to 1.60 m/s
1.60 to 1.80 m/s
above 1.80 m/s
PM10 concentration
h=1.5000m
below 0.20 µg/m3
0.20 to 0.40 µg/m3
0.40 to 0.60 µg/m3
0.60 to 0.80 µg/m3
0.80 to 1.00 µg/m3
1.00 to 1.20 µg/m3
1.20 to 1.40 µg/m3
1.40 to 1.60 µg/m3
1.60 to 1.80 µg/m3
above 1.80 µg/m3

Current

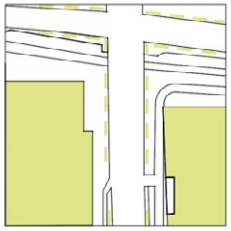
Porosity



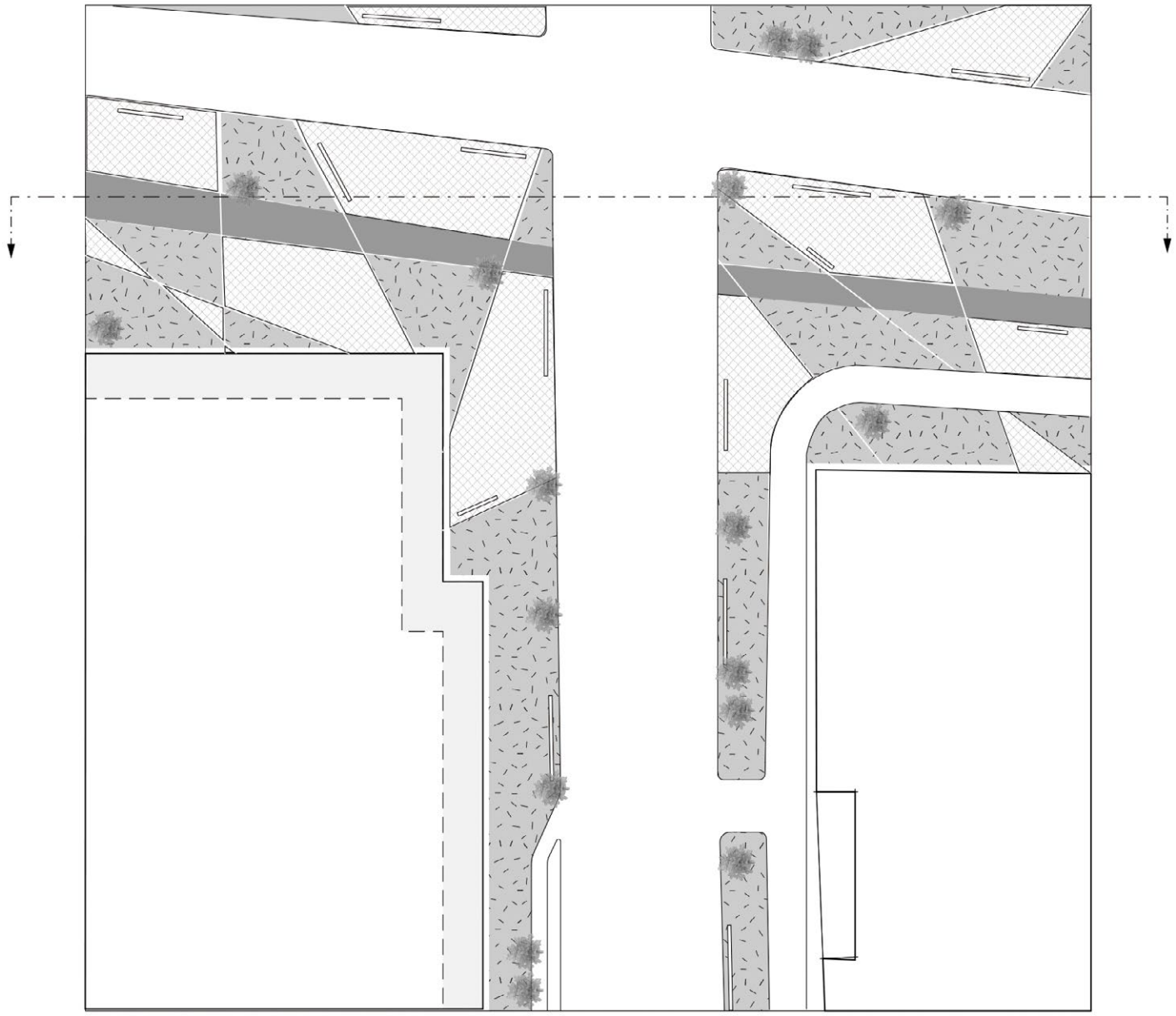
Pavement



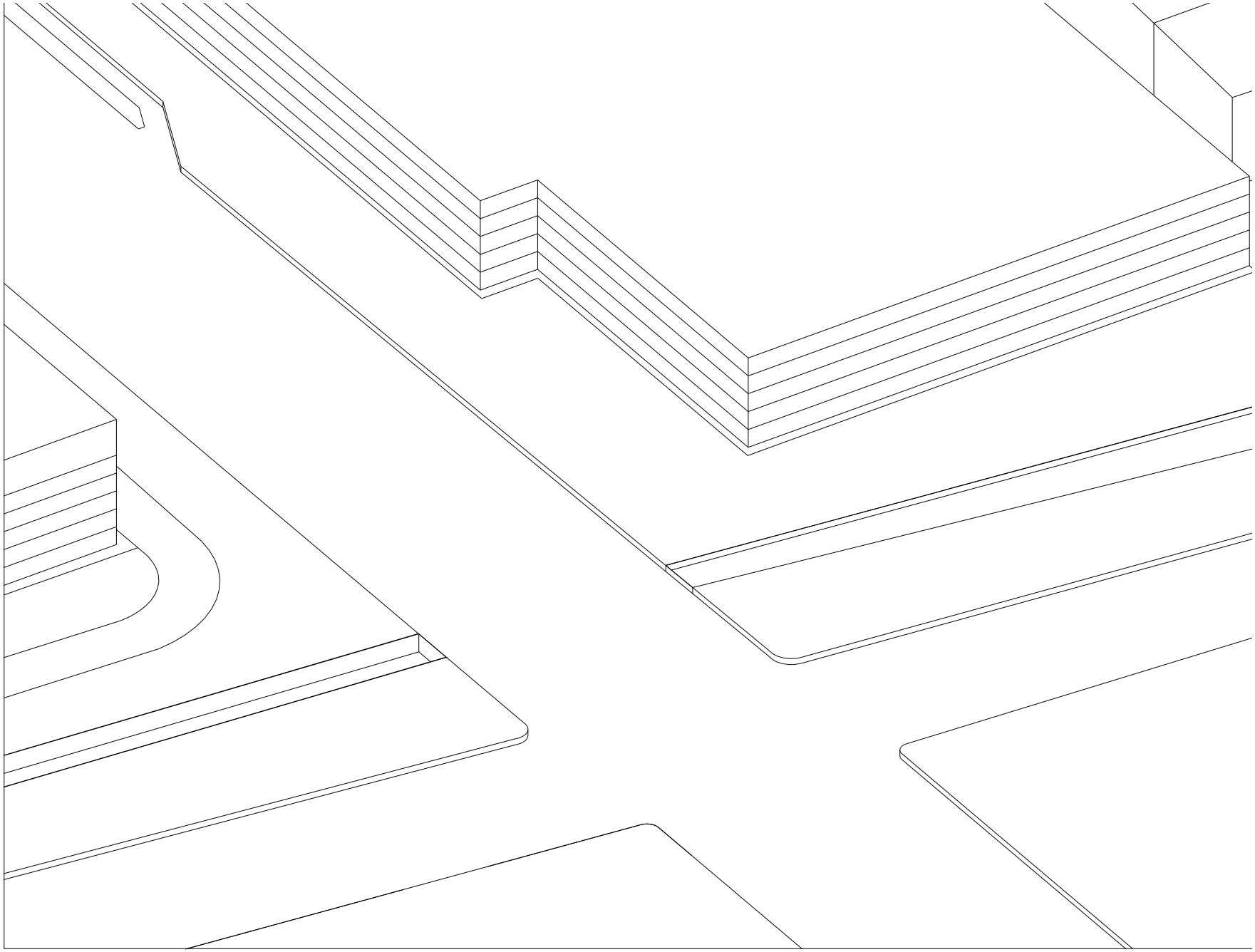
Green roof

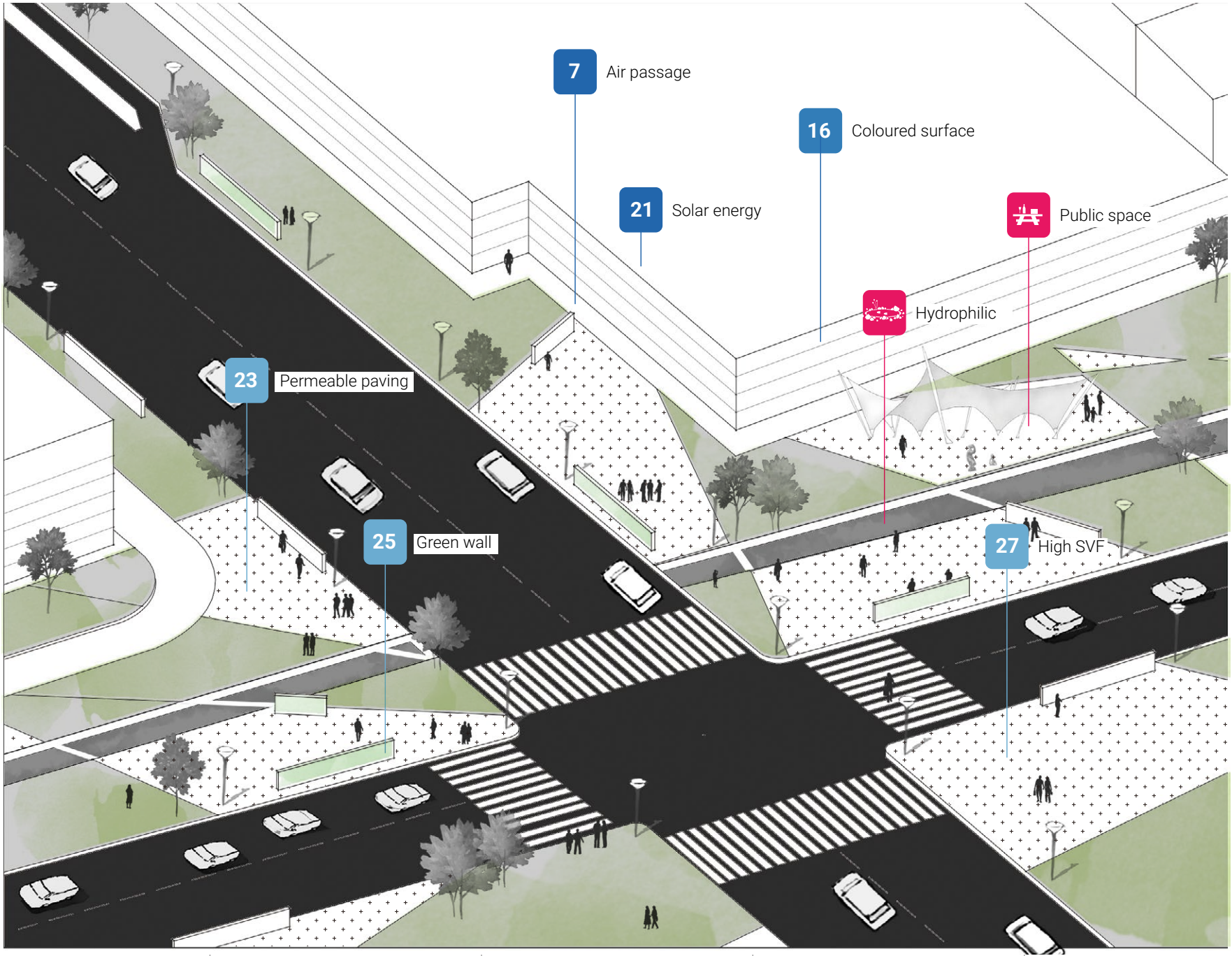


Public space

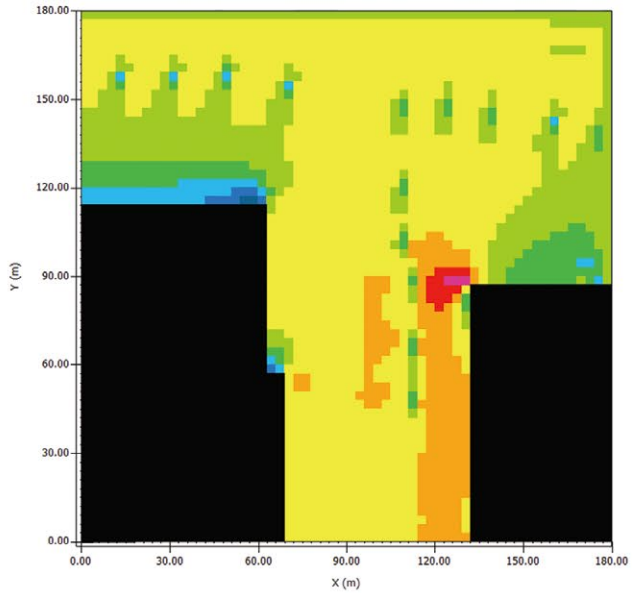


0 50m

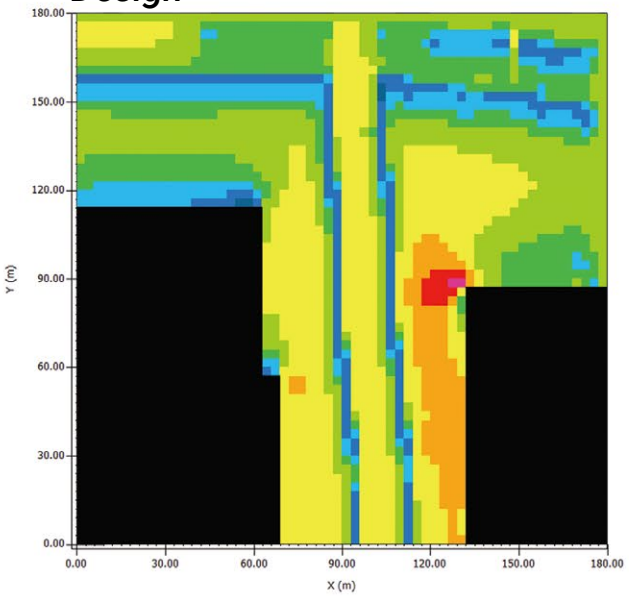



7
Air passage
16
Coloured surface
21
Solar energy
Public space
Hydrophilic
23
Permeable paving
25
Green wall
27
High SVF

## *Current*



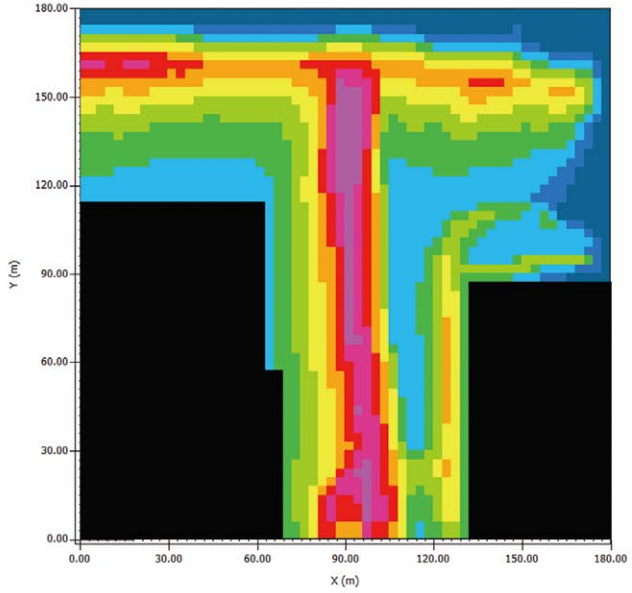

## *Design*

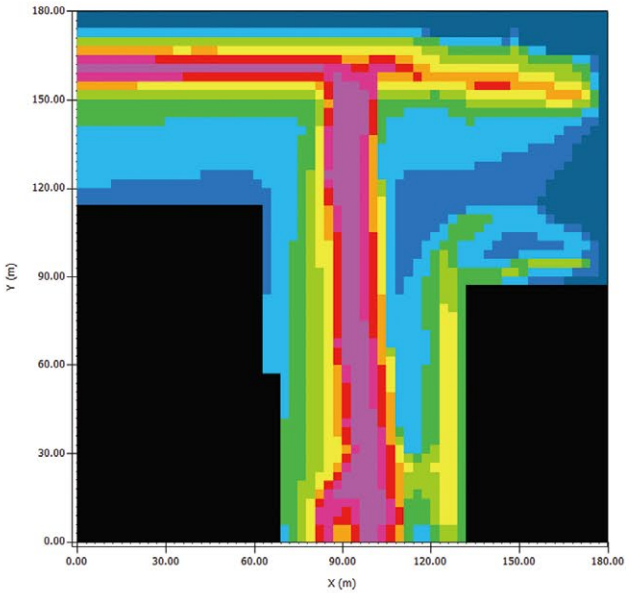



***Wind Speed***

h=1.5000m

- below 0.20 m/s
- 0.20 to 0.40 m/s
- 0.40 to 0.60 m/s
- 0.60 to 0.80 m/s
- 0.80 to 1.00 m/s
- 1.00 to 1.20 m/s
- 1.20 to 1.40 m/s
- 1.40 to 1.60 m/s
- 1.60 to 1.80 m/s
- above 1.80 m/s

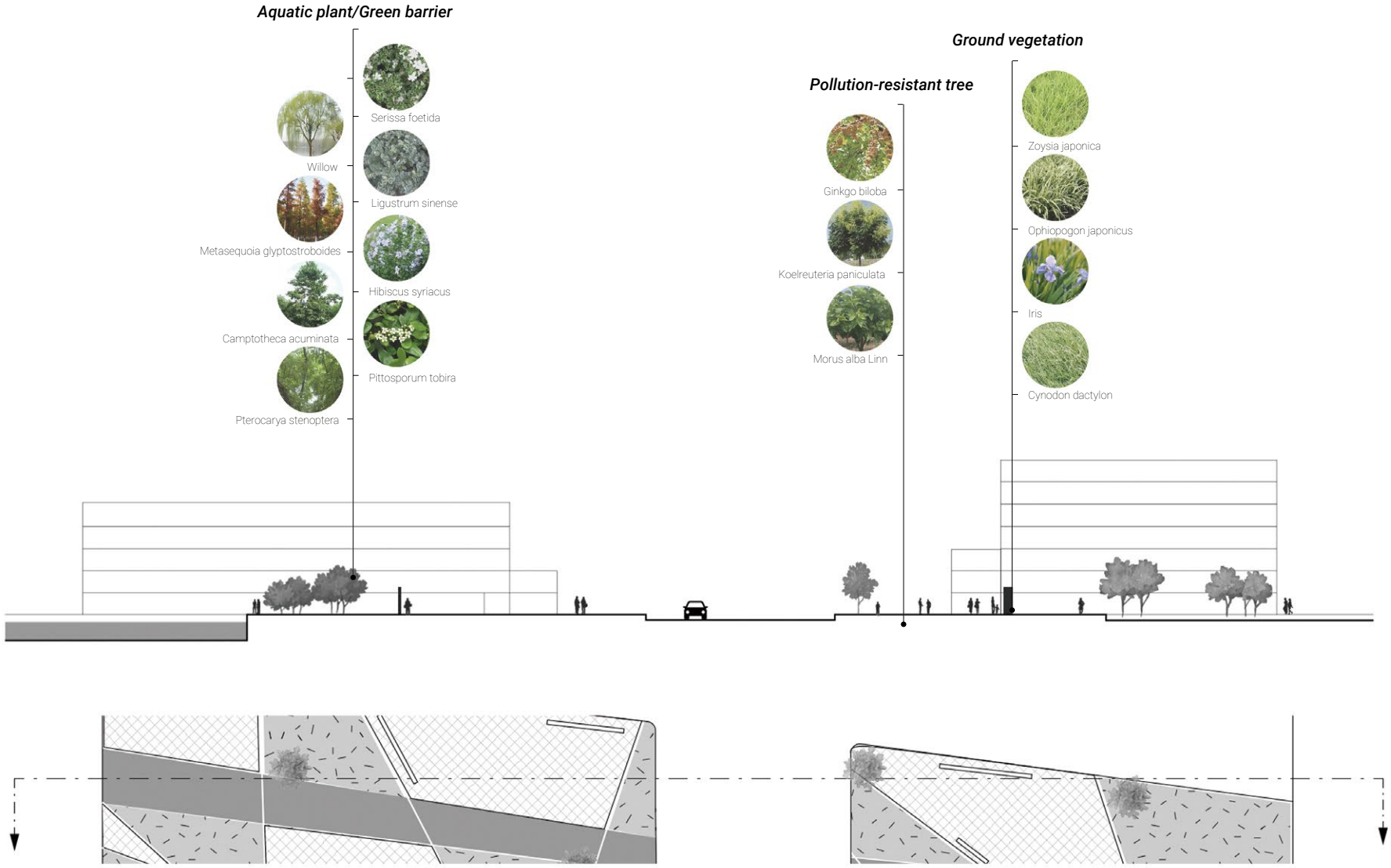



***pm10 Concentration***

h=1.5000m

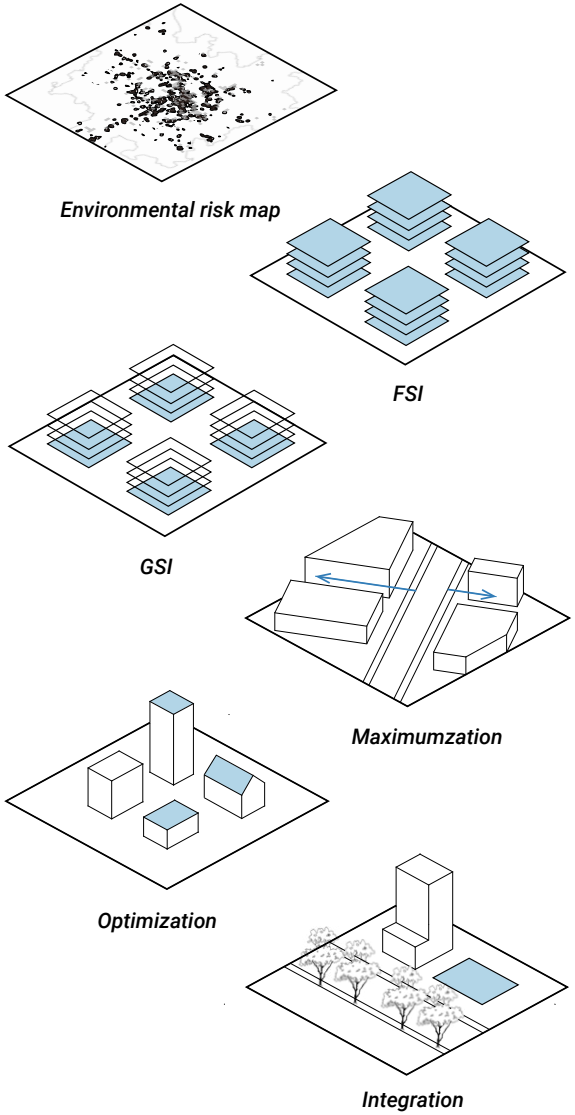
- below 0.20 µg/m3
- 0.20 to 0.40 µg/m3
- 0.40 to 0.60 µg/m3
- 0.60 to 0.80 µg/m3
- 0.80 to 1.00 µg/m3
- 1.00 to 1.20 µg/m3
- 1.20 to 1.40 µg/m3
- 1.40 to 1.60 µg/m3
- 1.60 to 1.80 µg/m3
- above 1.80 µg/m3


Aquatic plant/Green barrier
Serissa foetida
Willow
Ligustrum sinense
Metasequoia glyptostroboides
Hibiscus syriacus
Camptotheca acuminata
Pittosporum tobira
Pterocarya stenoptera
Pollution-resistant tree
Ginkgo biloba
Koelreuteria paniculata
Morus alba Linn
Ground vegetation
Zoysia japonica
Ophiopogon japonicus
Iris
Cynodon dactylon

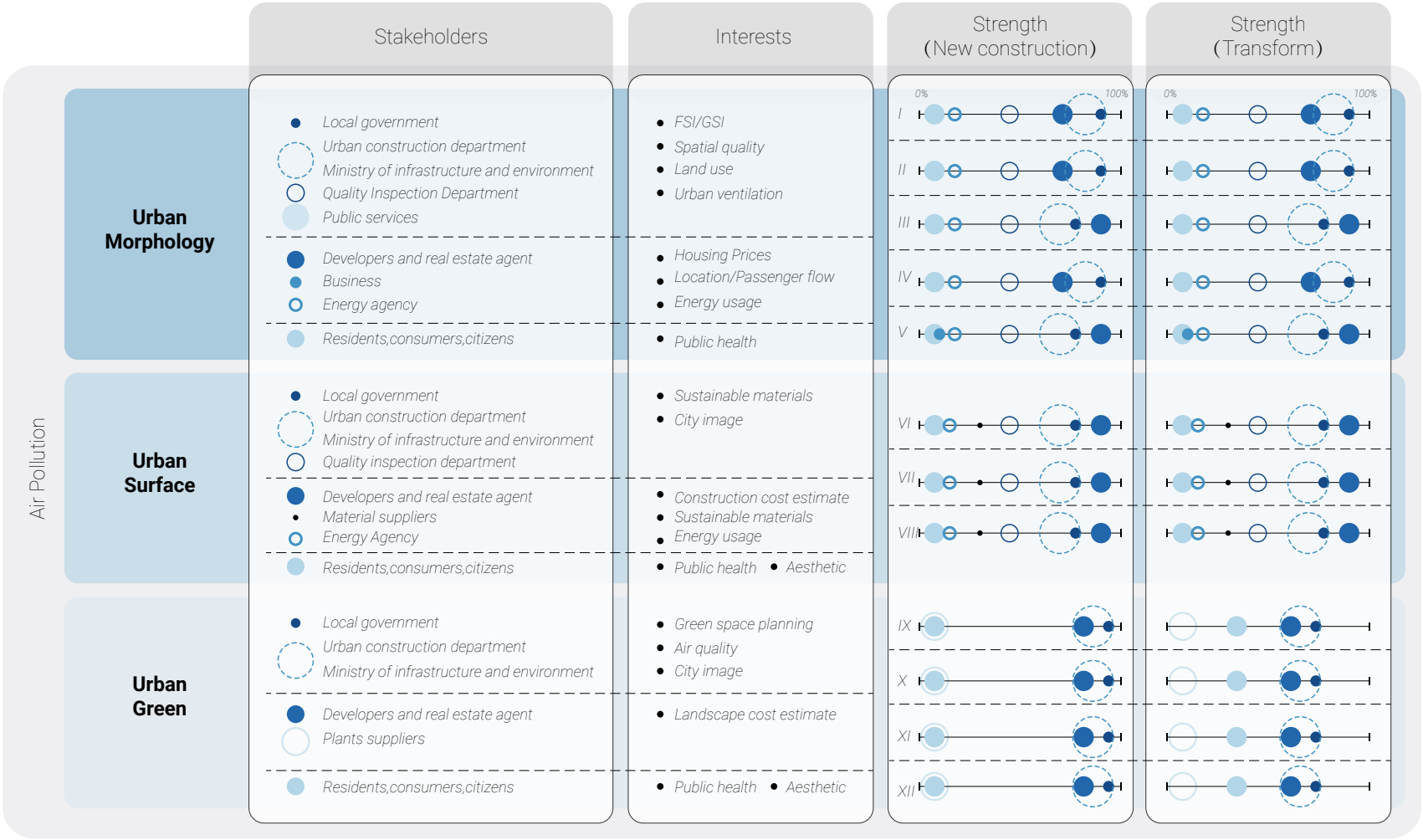
# FEASIBILITY

Transferability
Policy support
Stakeholder engagement
Projects time-lines

# *Transferability*



# Stakeholders



# Policy support

1 Adhere to the gas to define the form, combined with ecological green partition and the city's internal roads, rivers, parks to delineate urban ventilation corridors, the central city and new areas of the eastern city, a total of 8 primary ventilation corridors and 26 secondary ventilation corridors are planned, and strictly control the land, industry and building form within the scope of the ventilation corridors.
—— «Urban Master Plan of Chengdu(2016-2035)»

2. Carry out urban design for the whole area and key regions and important nodes, strengthen urban space control and optimize urban form.
—— «Urban Master Plan of Chengdu(2016-2035)»

3. The building colors in Chengdu are mainly guided by gray, warm yellow, and brick red.Specifically to "black-led building colors need to be used carefully, gray-led supplemented by colored embellishments, warm yellow-led high-rise office buildings, and warm yellow-led office buildings. The yellow dominated residential buildings reinforce the comfortable and pleasant feeling, while the brick-red dominated buildings reinforce the contemporary character and lively atmosphere". Delineate urban color zoning, strengthen control requirements, and exert the important role of urban color in shaping the city's appearance.
—— «Guidelines for Architectural Planning and Design in Chengdu (2013)»

4. Strengthening urban greening construction, combining urban development and industrial layout, and striving to raise the level of urban greening and enhance the environment's self-cleaning capacity. Ecological vegetation and landscapes will be created to curb the generation of dust.
—— «The Twelfth Five-Year Plan for the Prevention and Control of Air Pollution in Key Regions»

5. Greening the whole area, building "park cities", strengthening the ecological protection and restoration of ecological zones, greening ecological corridors, greening parks, greening roads, greening neighborhoods and three-dimensional greening.
—— «Urban Master Plan of Chengdu(2016-2035)»

6. Build an ecological system that connects urban and rural areas, effectively increasing wind speed and volume, diluting air pollution and reducing the heat island effect.  Strictly protect existing green spaces in the central city.
—— «Action Plan for the Prevention and Control of Air Pollution in Chengdu (2014-2017)»

7. Encourage public participation in atmospheric governance, and actively carry out various forms of activities focusing on the prevention and control of respirable and fine particulate matter. Popularizing scientific knowledge of air pollution prevention and control, and continuously enhancing the public's ability to participate in environmental protection.
—— «The Twelfth Five-Year Plan for the Prevention and Control of Air Pollution in Key Regions»
—— «Action Plan for the Prevention and Control of Air Pollution in Chengdu (2014-2017)»

# Suggestions

**City scale**
Strengthen the protection of open space, control the intensity of land development, and optimize the layout of urban buildings.The construction of ventilation corridors.

**Block scale**
Control urban height and building layout according to local microclimate. Consider the impact on pollution when laying out urban greenery.

**Building scale**
The targeted optimization of the building form through building porosity to enhance ventilation. Avoid large-area demolition and construction, consider the distribution of pollutants to set building functions, reduce the impact of air pollution on human health, and encourage the public to participate in green roofs and facade greening.

# Financial considerations

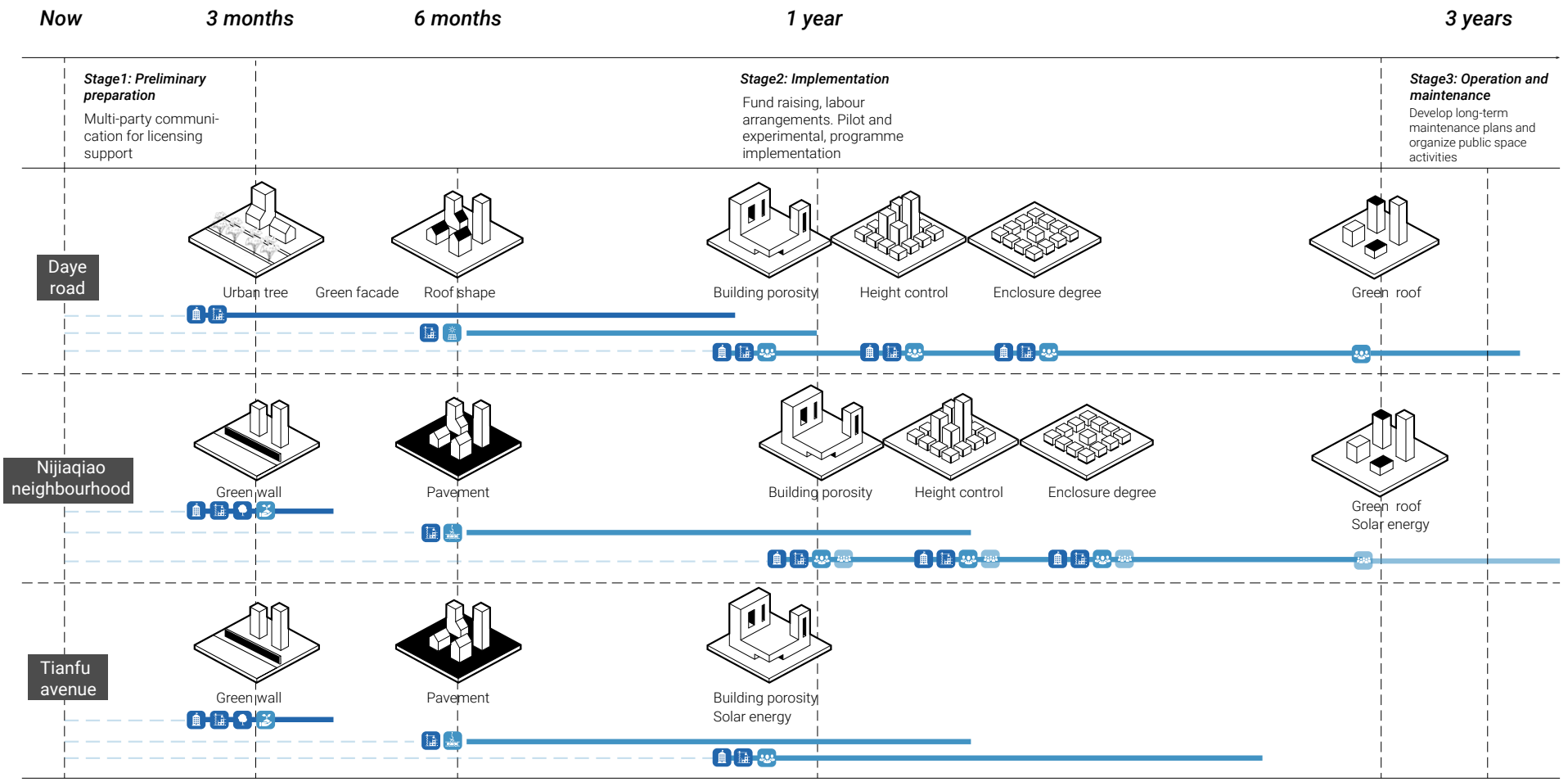
1.Government-led capital compensation

2.Financial share of urban construction

3.Introduction of social capital

4.Market-based fund raising

# Projects time-lines



# 05 CONCLUSIONS

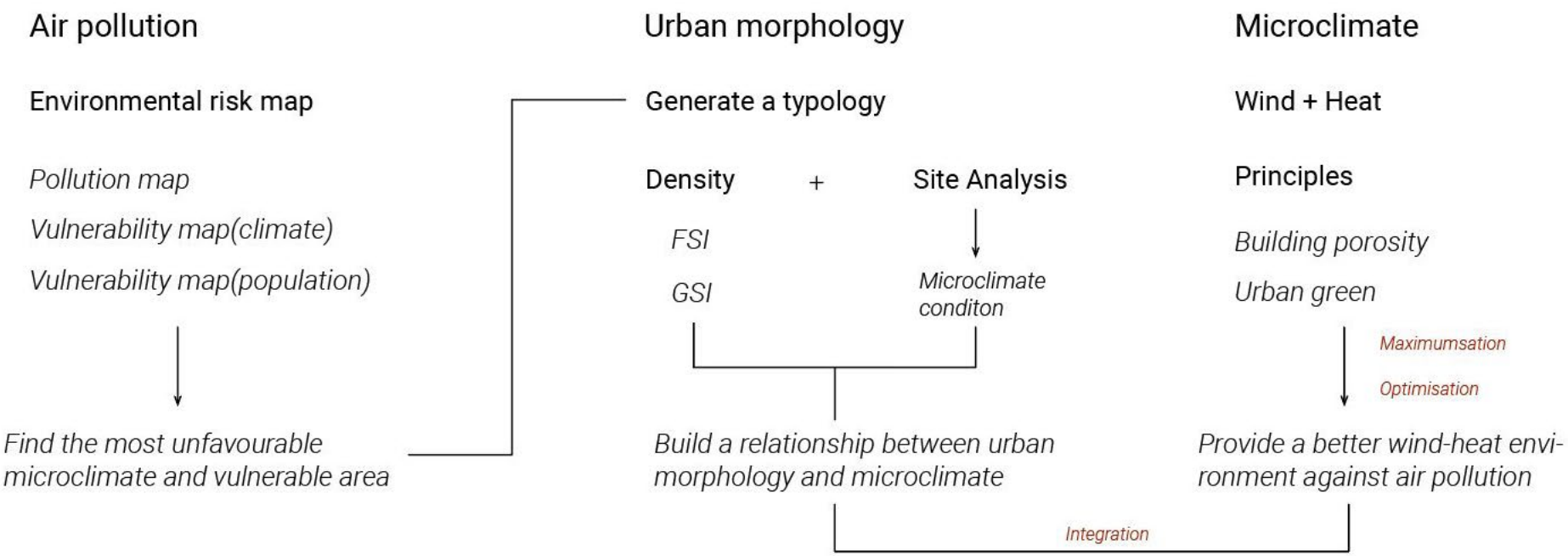
# Conclusion

***Main research question: How to mitigate air pollution through urban microclimate design in Chengdu?***

*Most effective urban characteristics*

*spatial interventions*

*integrate into the urban design process*




THANK YOU!