

# DIGITAL URBAN DESIGN

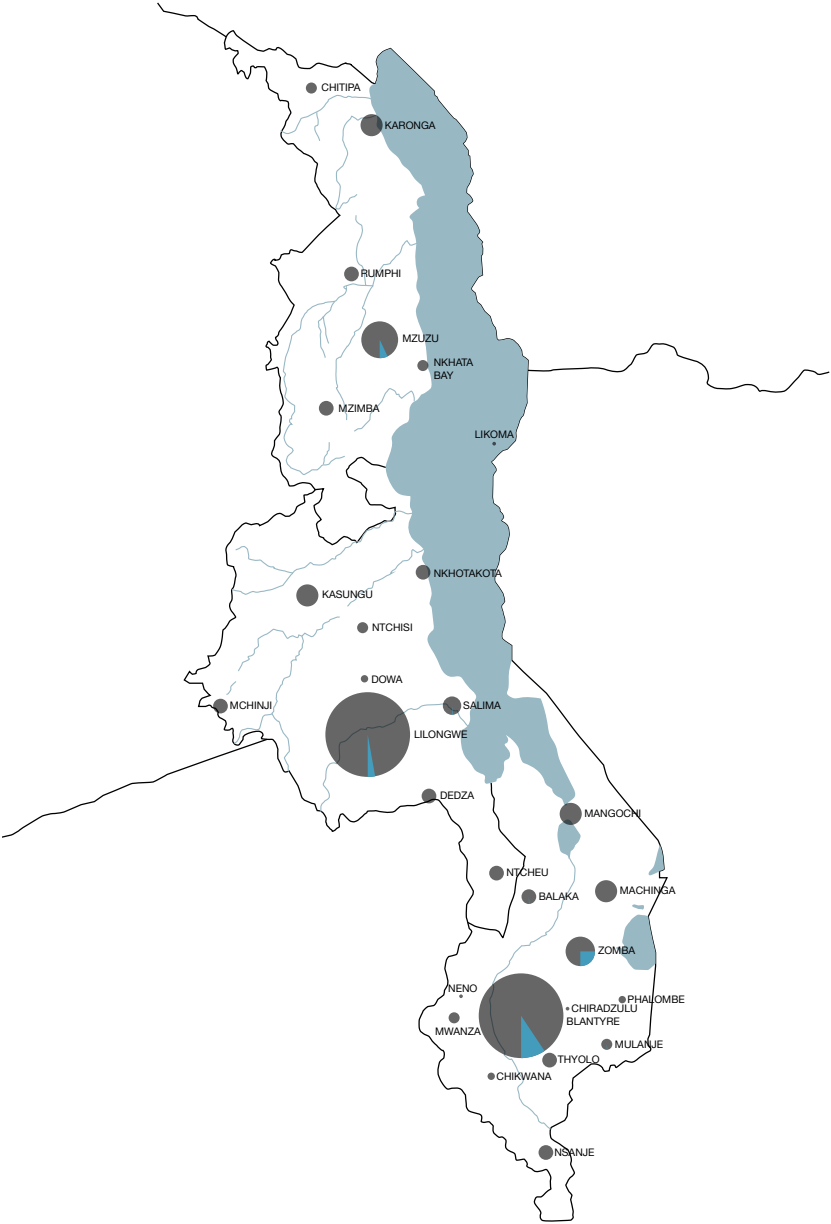
| Rhinoceros & Grasshopper  
| Bachelor thesis 'Urban Framework'  
| Tjark Gall



# TASK & BACKGROUND



Malawi | Sub-Saharan Africa



Lilongwe | Malawi

## TASK

- #1 housing for 8 million people until 2055
- #2 framework for growth of structure
- #3 improve infrastructure for basic services
- #4 simplify planning/formalisation process



# TASK & BACKGROUND

INDUSTRIAL  
ZONE

CITY CENTER  
CAPITAL HILL

LARGEST INFORMAL  
SETTLEMENT

INTERNATIONAL  
AIRPORT

LINGADZI NAMILOMBA  
FOREST RESERVE

OLD TOWN

 **URBAN SQUATTING**  
area 30 x 50 km  0 3 km



# CONCEPT & APPROACH

**DISTRICT I**  
90 sqkm | 80 % built area  
1,008,000 people  
14,000 ppl/sqkm

**DISTRICT II**  
79 sqkm | 80 % built area  
1,140,000 people  
18,000 ppl/sqkm

**DISTRICT III**  
26 sqkm | 90 % built area  
470,000 people  
20,000 ppl/sqkm

**DISTRICT IV**  
74 sqkm | 80 % built area  
947,000 people  
16,000 ppl/sqkm

**DISTRICT V**  
63 sqkm | 80 % built area  
806,000 people  
16,000 ppl/sqkm

**DISTRICT VII**  
48 sqkm | 80 % built area  
615,000 people  
16,000 ppl/sqkm

**DISTRICT VII**  
34 sqkm | 80 % built area  
435,000 people  
16,000 ppl/sqkm

**DISTRICT VIII**  
83 sqkm | 90 % built area  
1,062,000 people  
20,000 ppl/sqkm

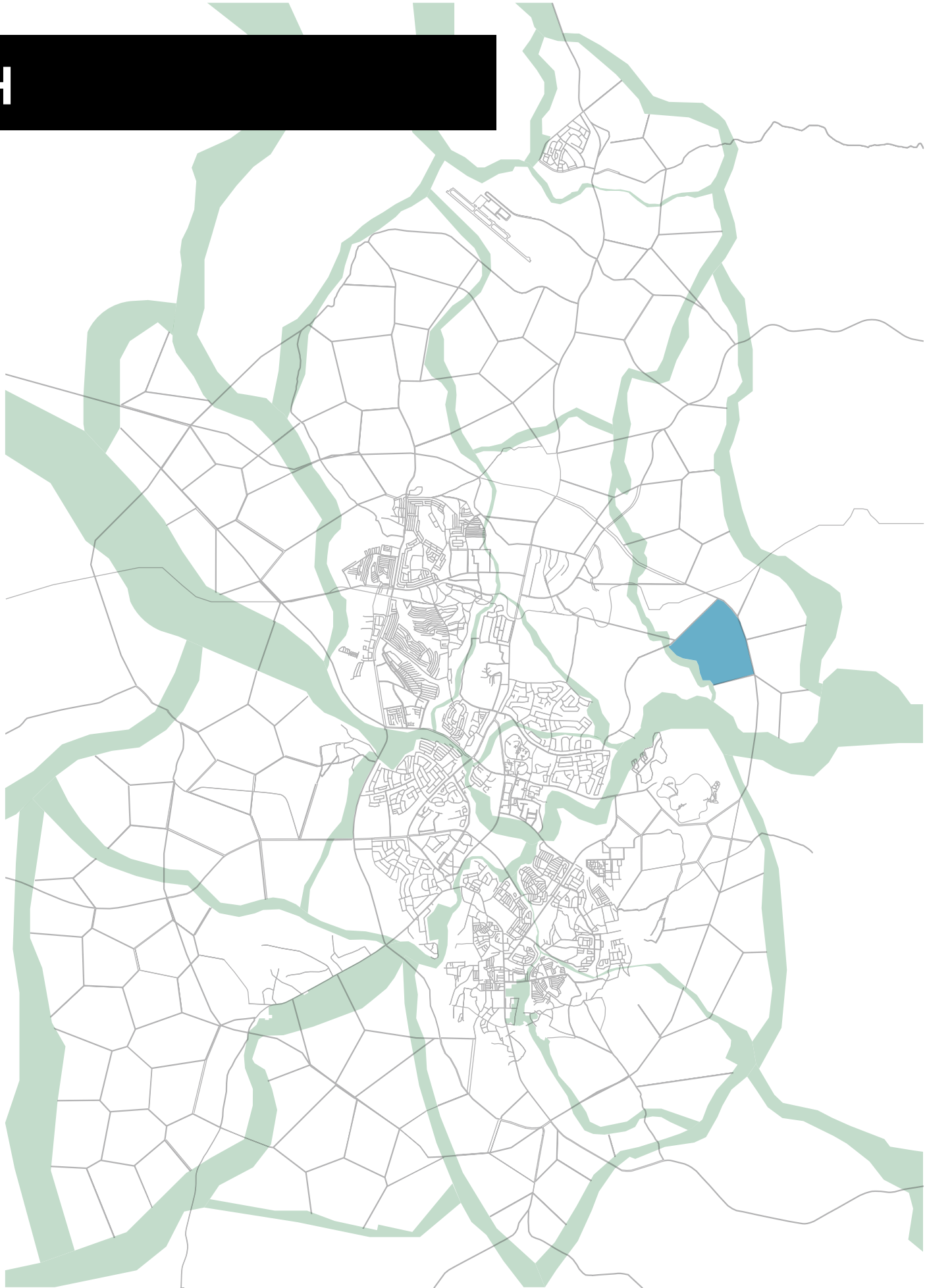
**PLANNING AREAS**  
area 30 x 50 km



0 3 km



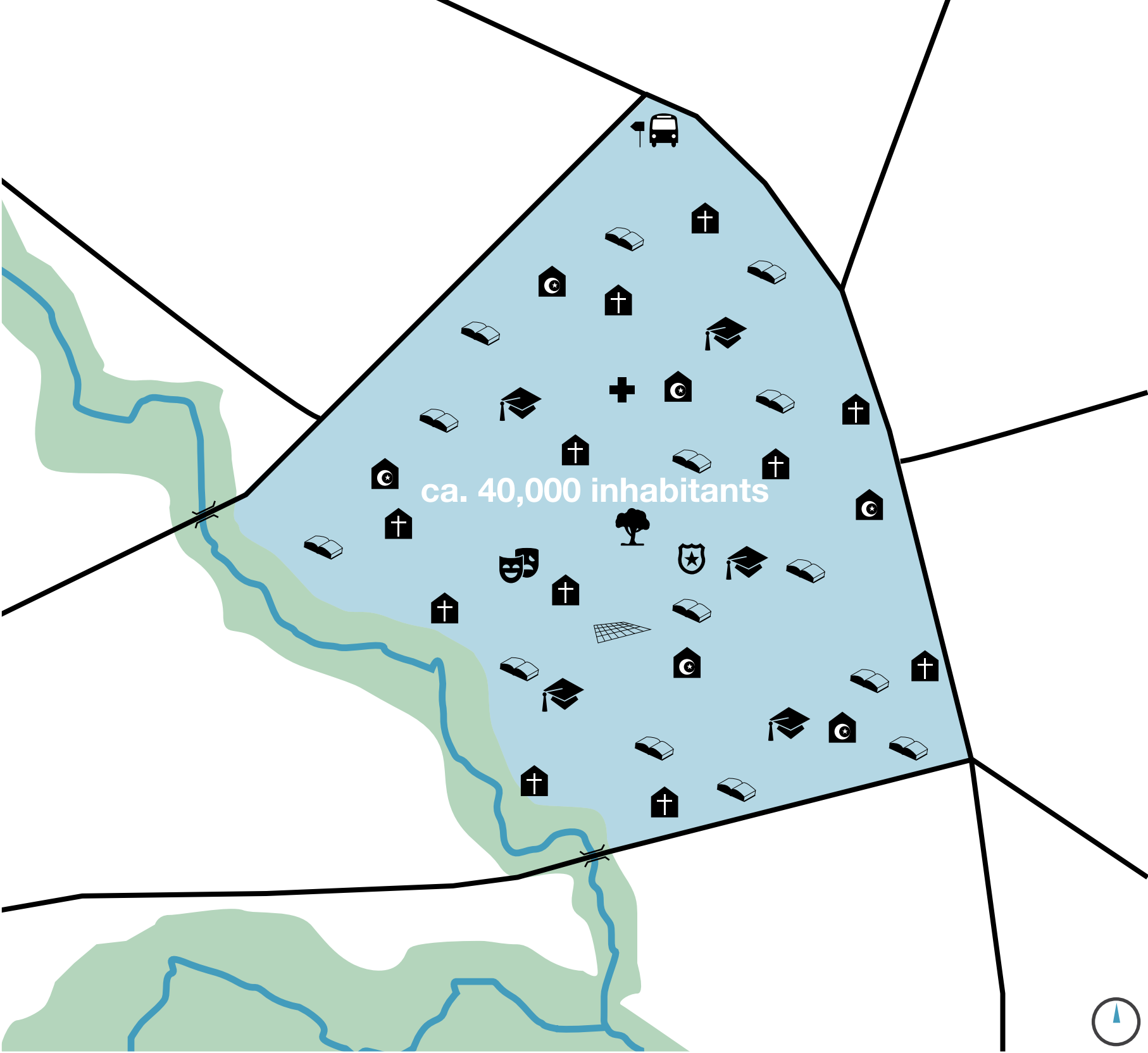
# CONCEPT & APPROACH



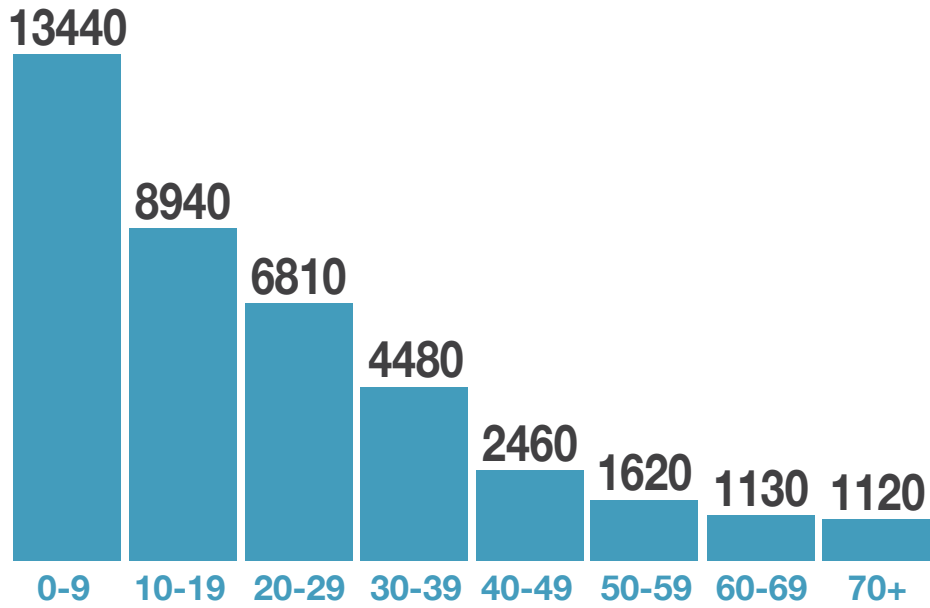
 **NEW INFRASTRUCTURE  
VORONOI GRID**  
area 30 x 50 km 



# CONCEPT & APPROACH



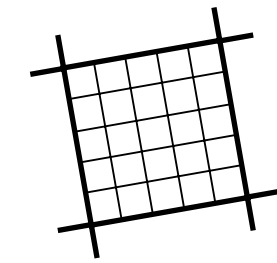
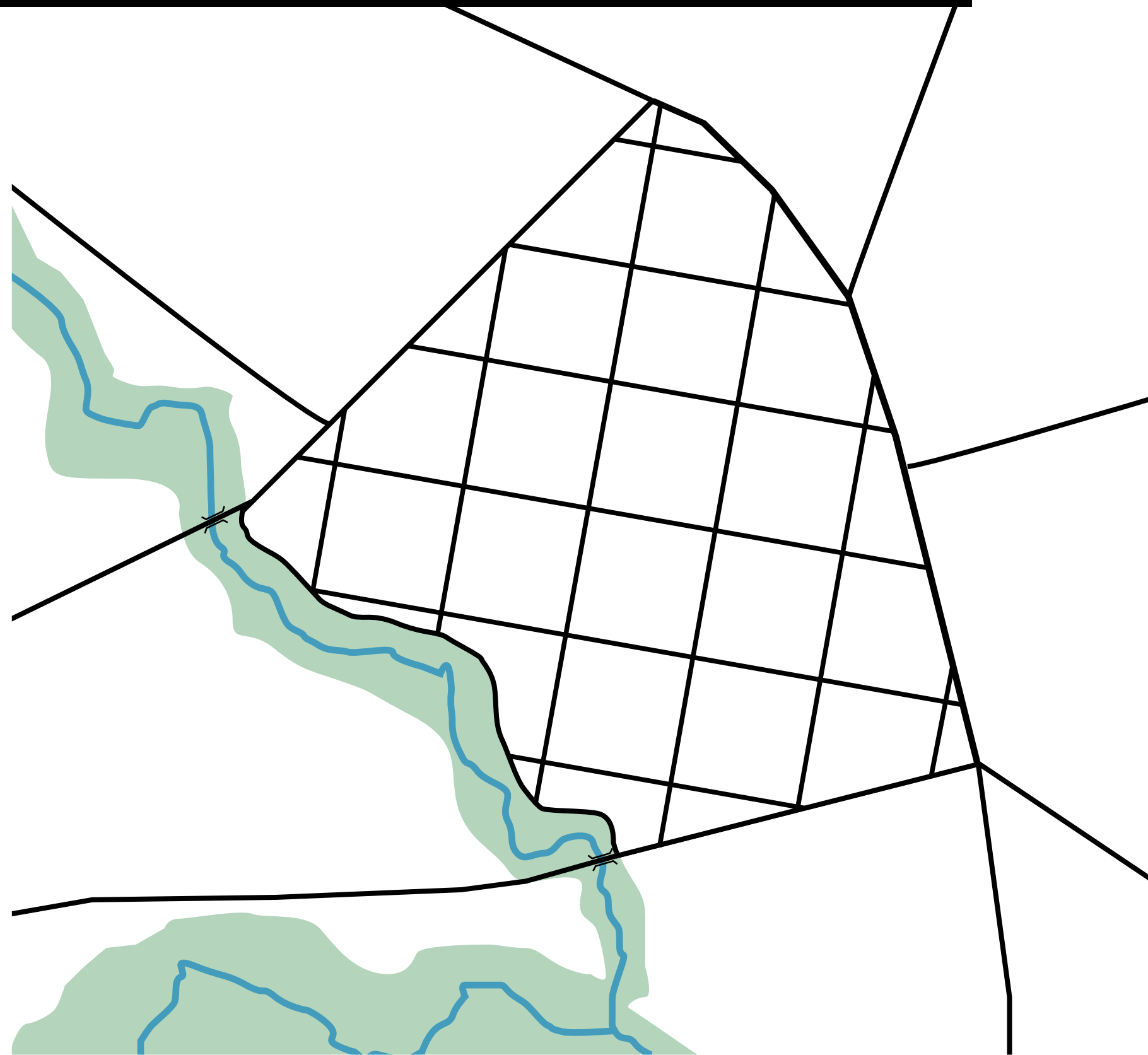
- hospital
- main police station
- civic center
- central public park
- central public square
- regional bus station
- 5 secondary schools
- 15 elementary schools
- 10 churches/cementary
- 6 mosques



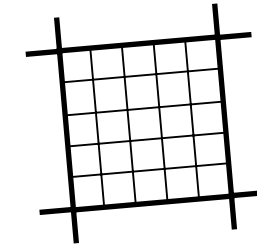
Population distribution by age for 40,000 ppl.  
based on 2008 census (NSO Malawi, 2008)



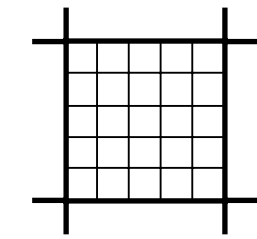
# CONCEPT & APPROACH



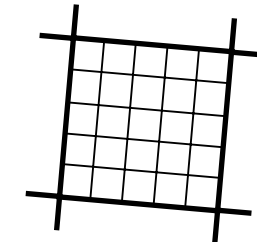
Rotation  
**-10°**



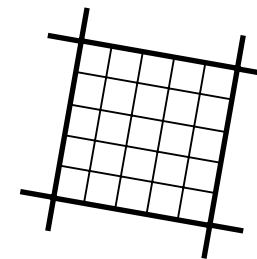
Rotation  
**-5°**



Rotation  
**0°**



Rotation  
**5°**



Rotation  
**10°**

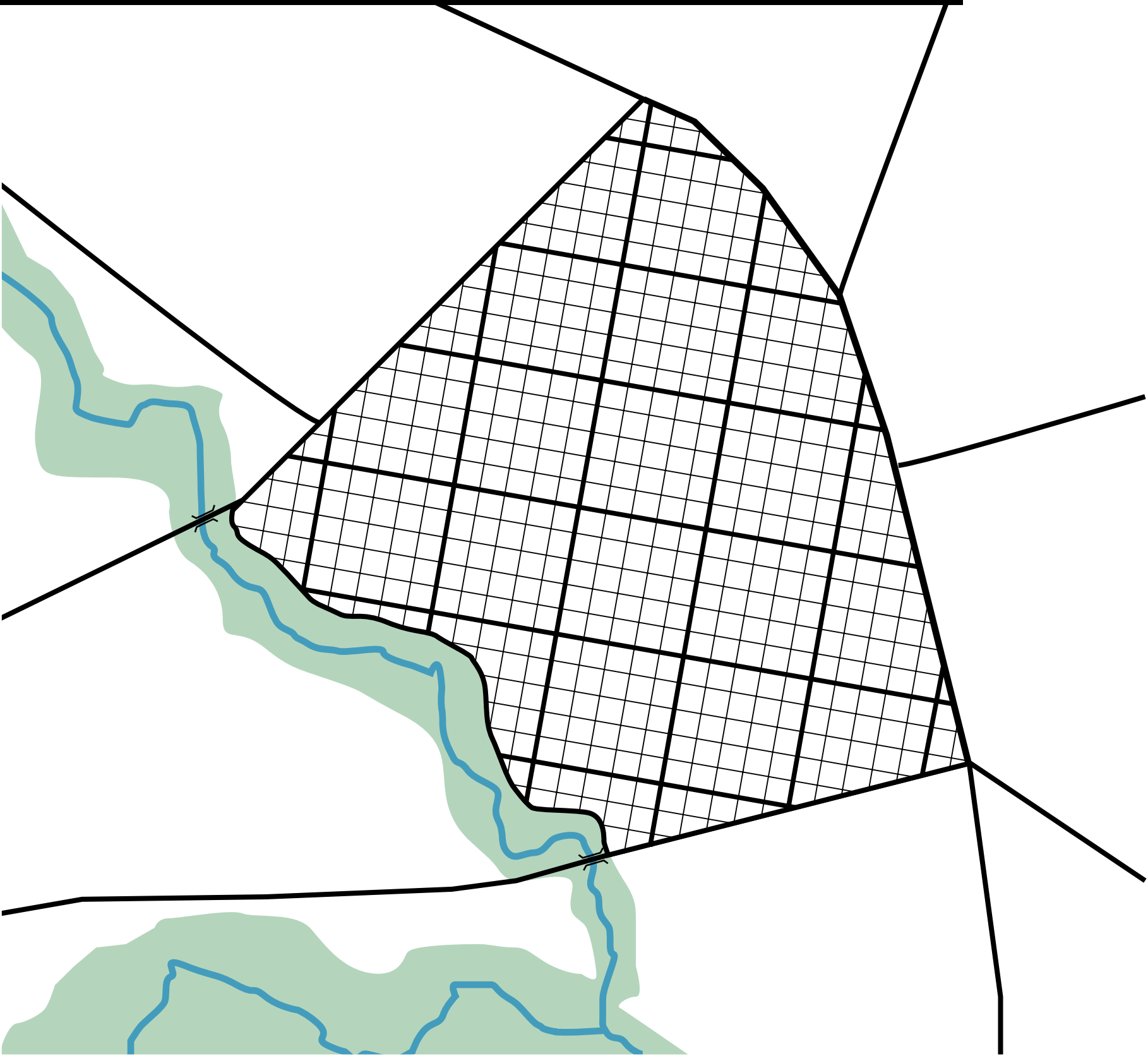


**BLOCK GRID**

~ 2000 inhabitants



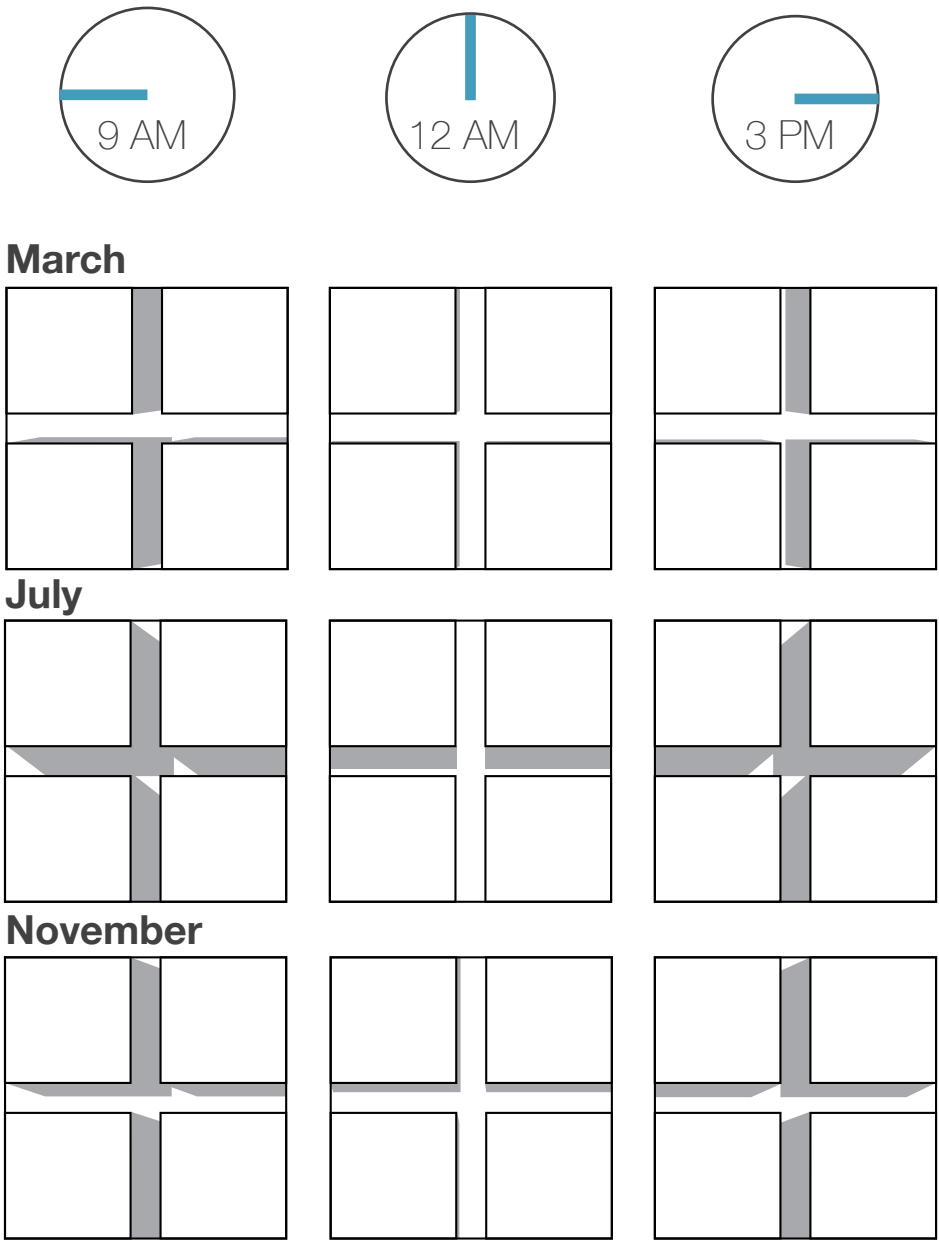
# CONCEPT & APPROACH




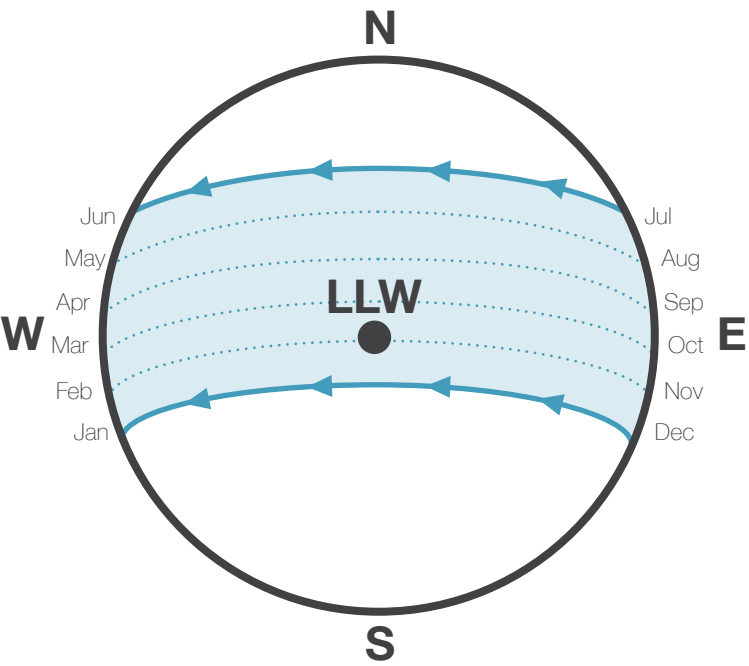
- Rotation **-10°**
- Rotation **-5°**
- Rotation **0°**
- Rotation **5°**
- Rotation **10°**

 **NEIGHBORHOOD GRID**  
~ 100 inhabitants

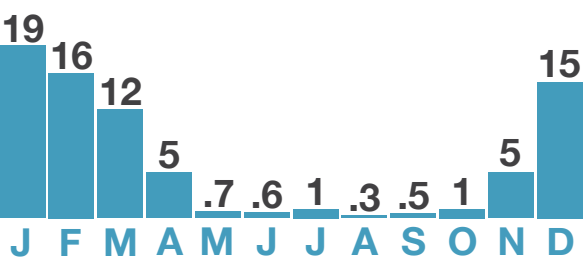
# CONCEPT & APPROACH



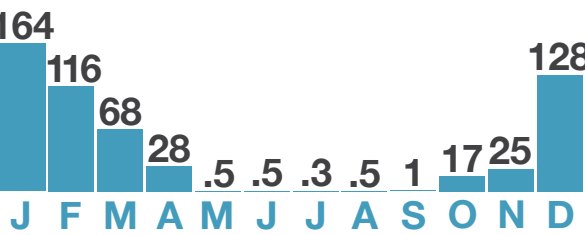
 **Shading of streets** 0° rotation  
(example of March, July and November)



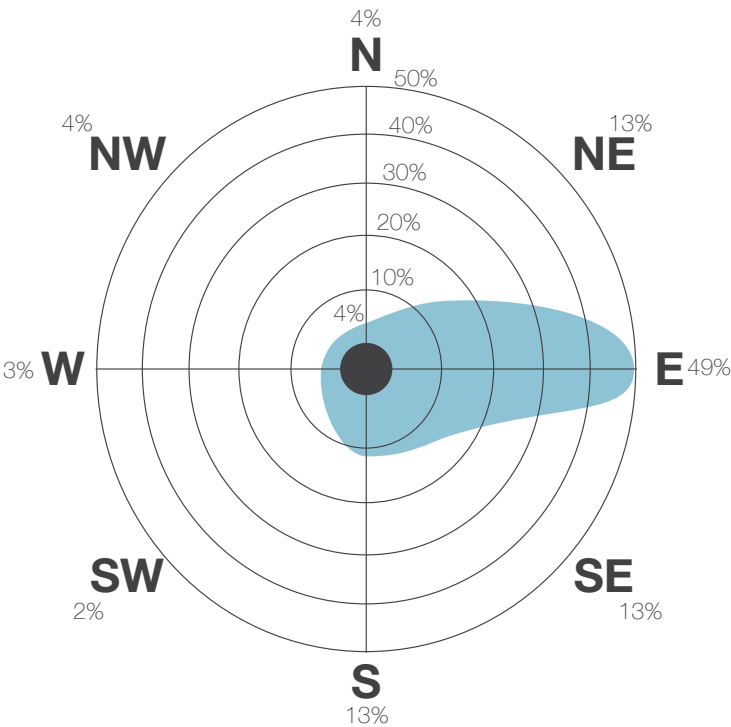
**Sun positions during the year**



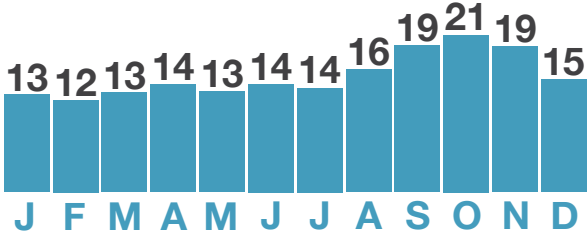
**Days with precipitation > 0.1 mm**  
(average = 74.9 days/year/2000 - 2015)



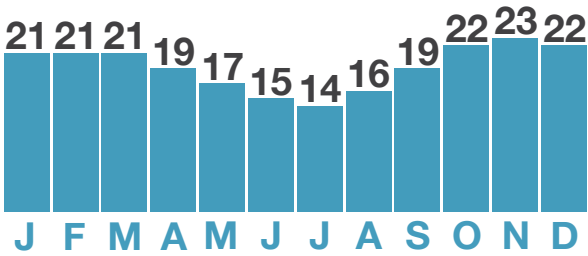
**Precipitation in mm** (2000 - 2015)  
(average = 547.5 mm/year | 2000 - 2015)



**Main wind directions** (2000 - 2015)



**Wind speed** in kph, average 15.4 kph (2000 - 2015)

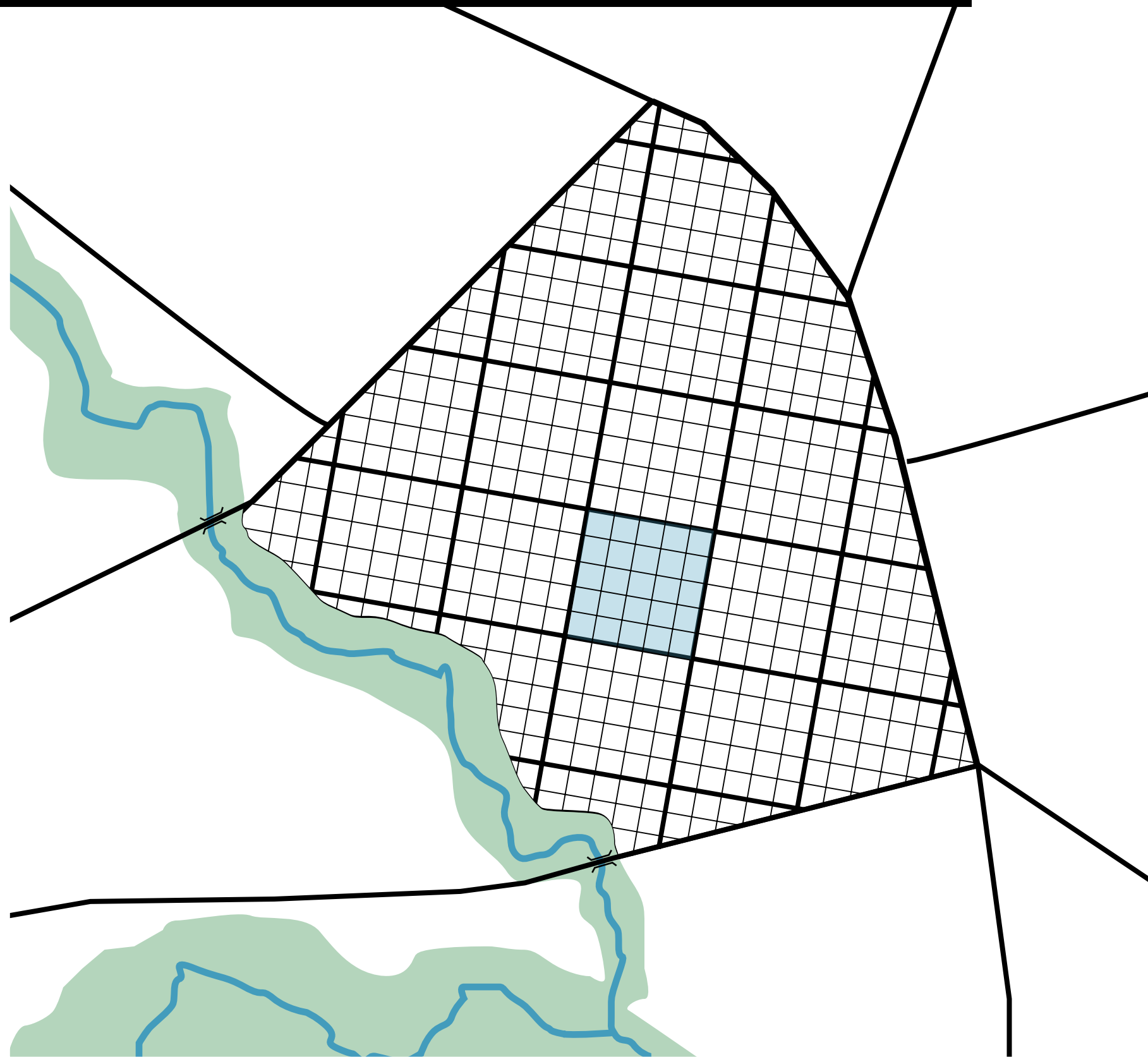


**Temperature** in °C, average 19 °C (2005-2015)

**Sources:** WeatherOnline Ltd., SunCalc.net, Weatherbase

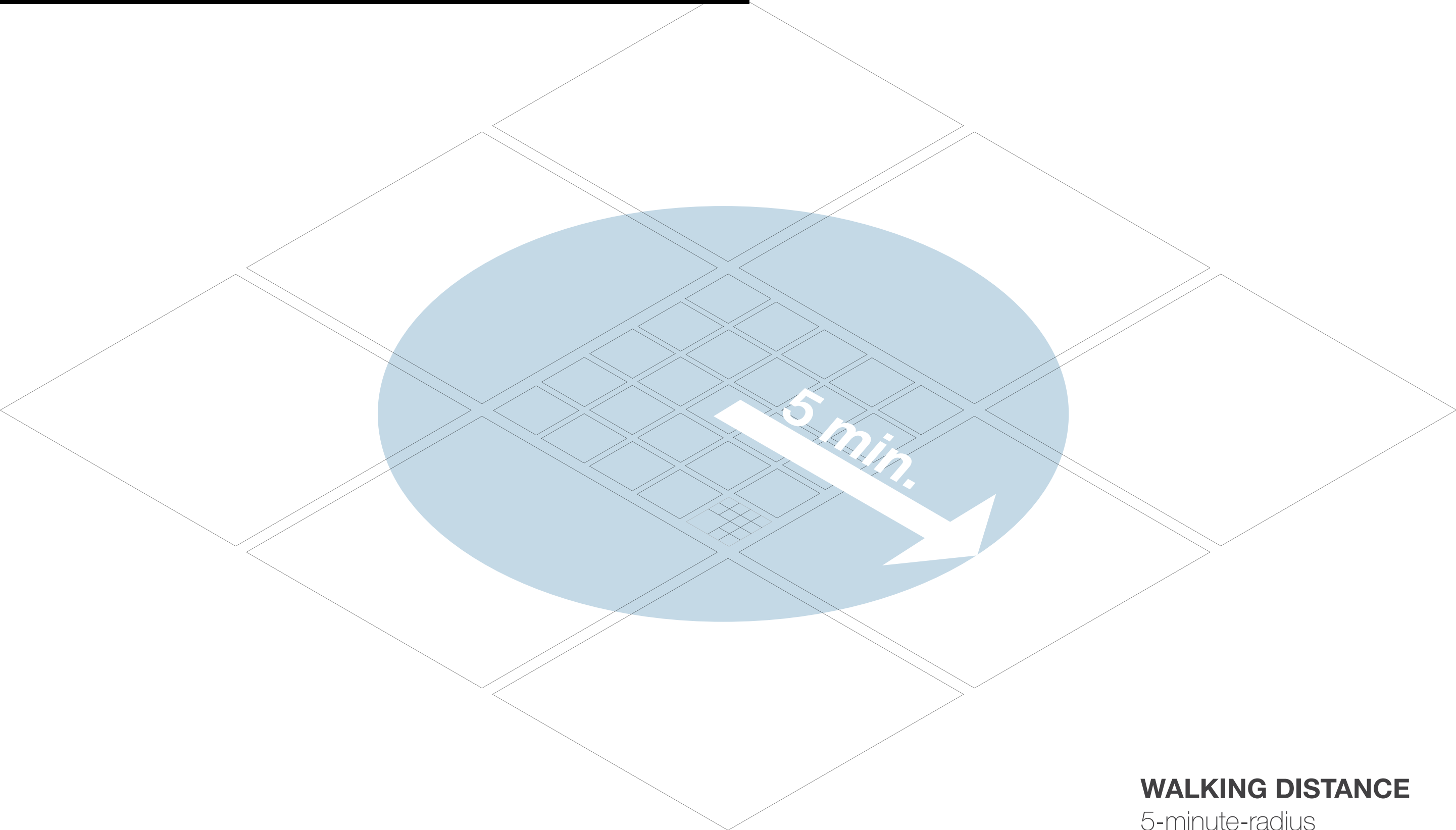


# CONCEPT & APPROACH



 **BLOCK ORGANISATION**  
~ 2,000 inhabitants

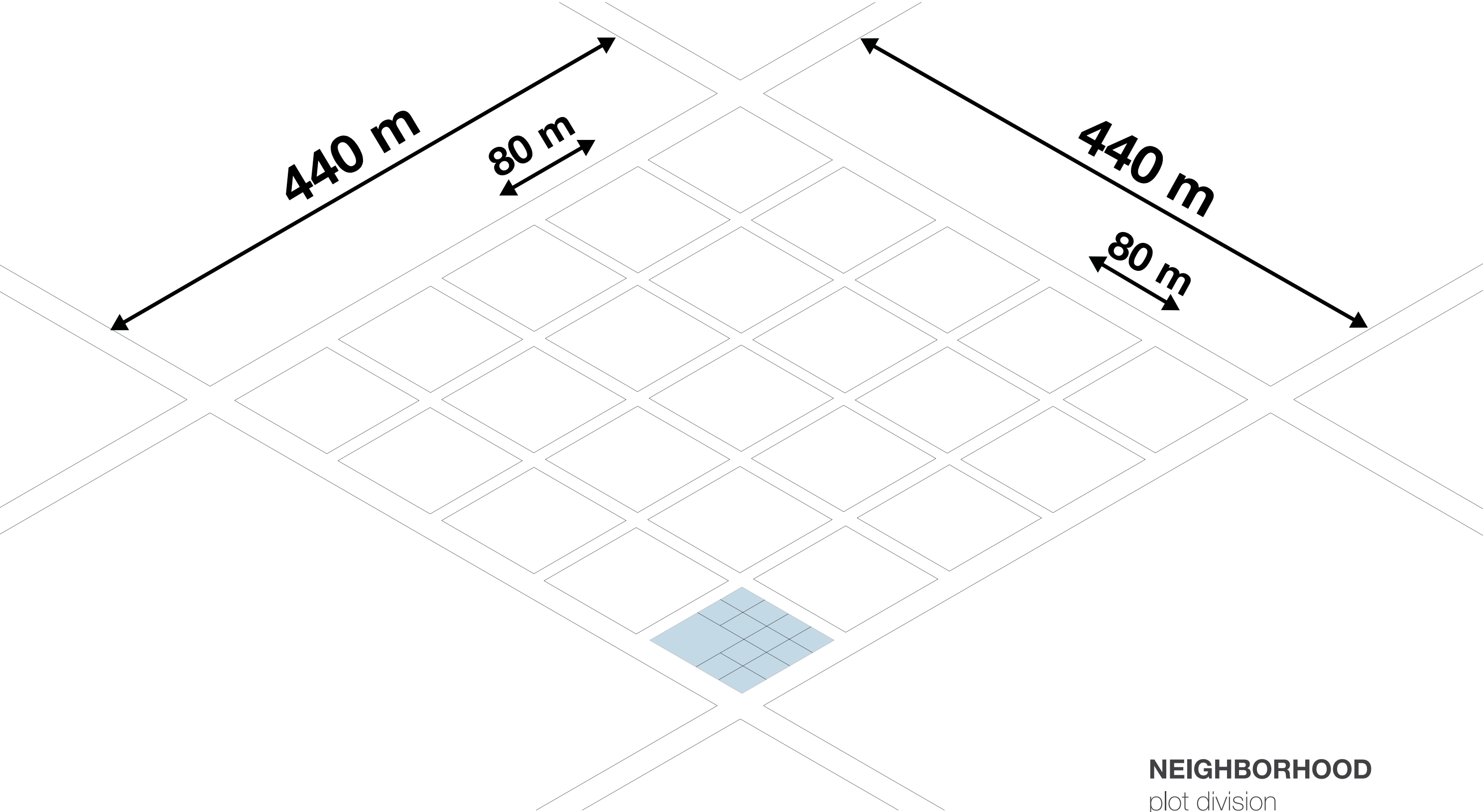
CONCEPT & APPROACH



**WALKING DISTANCE**  
5-minute-radius



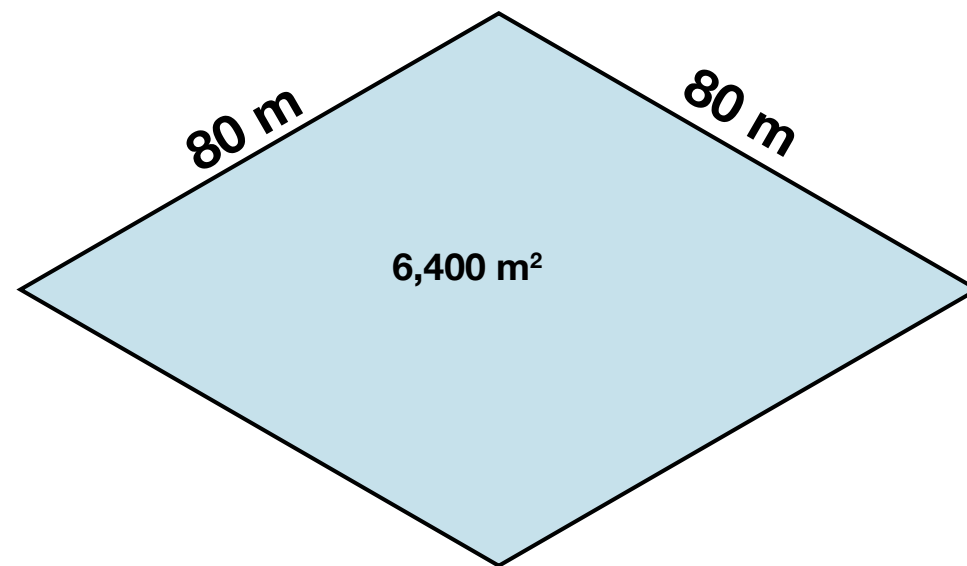
CONCEPT & APPROACH



# CONCEPT & APPROACH

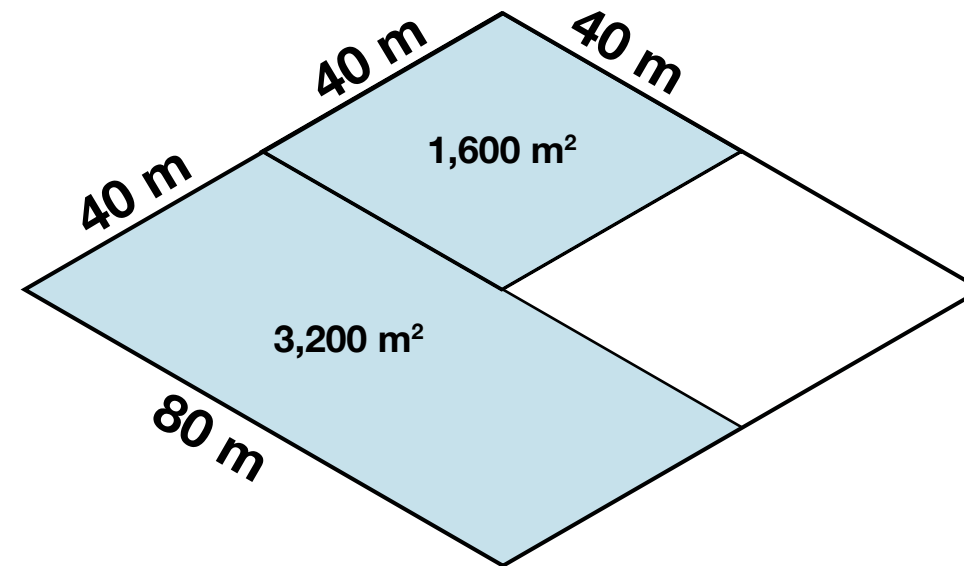
## NEIGHBORHOOD

plot division



### PLOT SIZE 6,400 M²

- SPECIAL FUNCTIONS
- RICHER NEIGHBOURHOODS
- DISTRICT PARKS

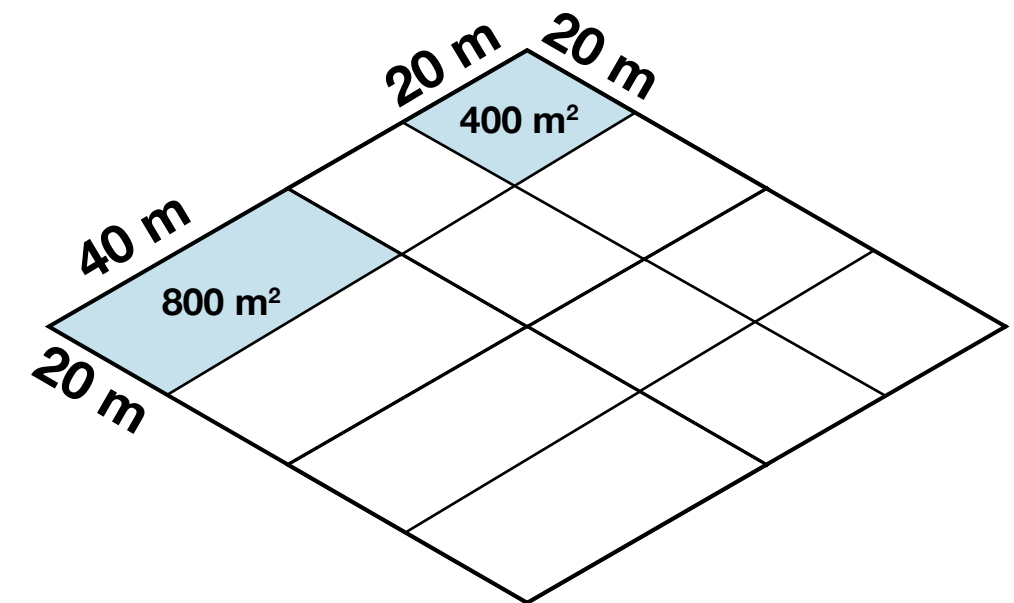


### PLOT SIZE 3,200 M²

- SPECIAL FUNCTIONS
- LARGE MIDDLE CLASS PLOTS
- SMALL BUSINESSES

### PLOT SIZE 1,600 M²

- SMALL MIDDLE CLASS PLOTS
- NEIGHBORHOOD FUNCTIONS



### PLOT SIZE 800 M²

- COMMERCIAL USE
- RESIDENTIAL WITH GARDEN
- LOCAL BUSINESSES

### PLOT SIZE 400 M²

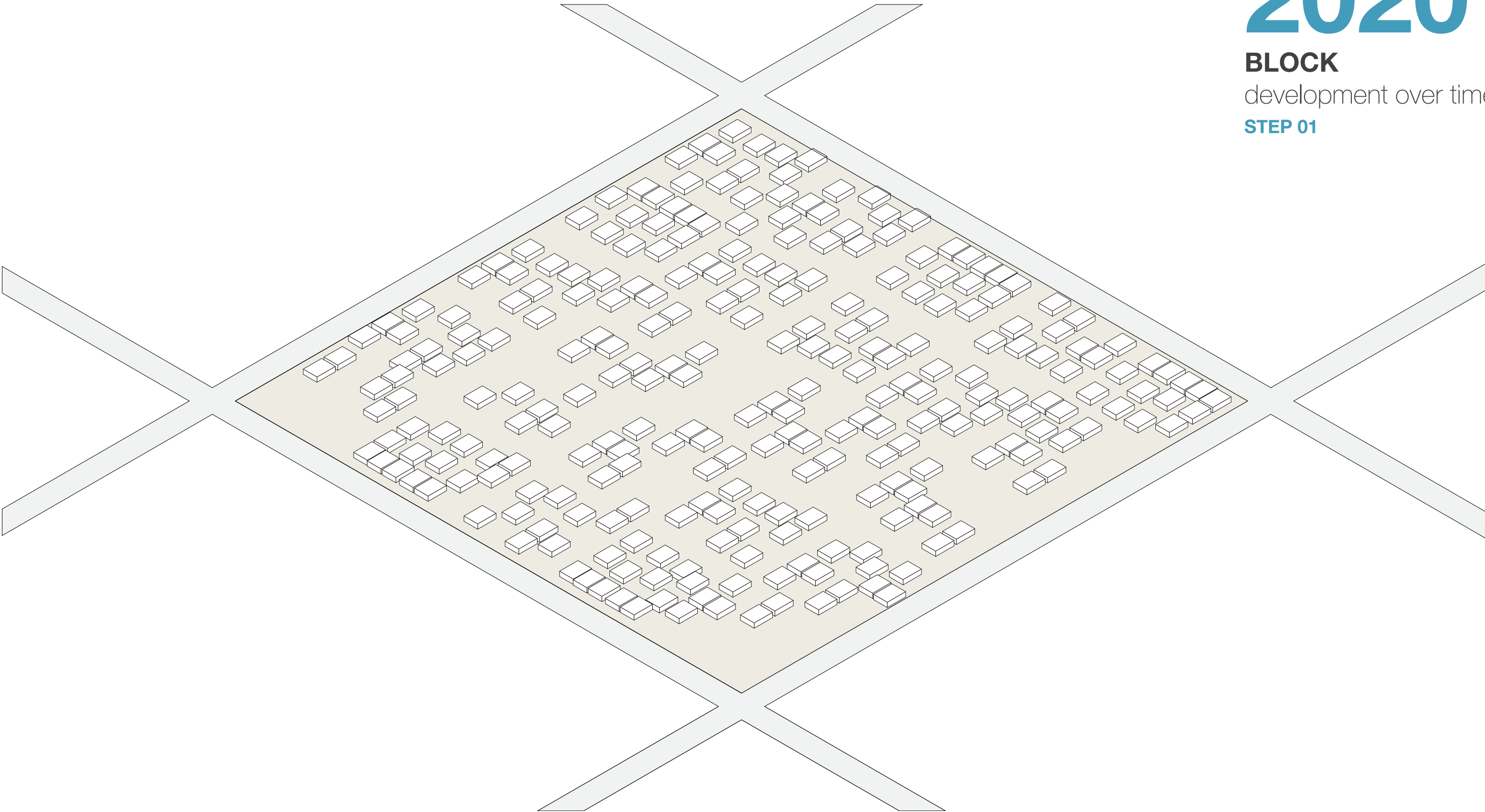
- AVERAGE PLOT SIZE SETTLEMENTS
- => SMALLEST POSSIBLE GRID SIZE



CONCEPT & APPROACH

2020

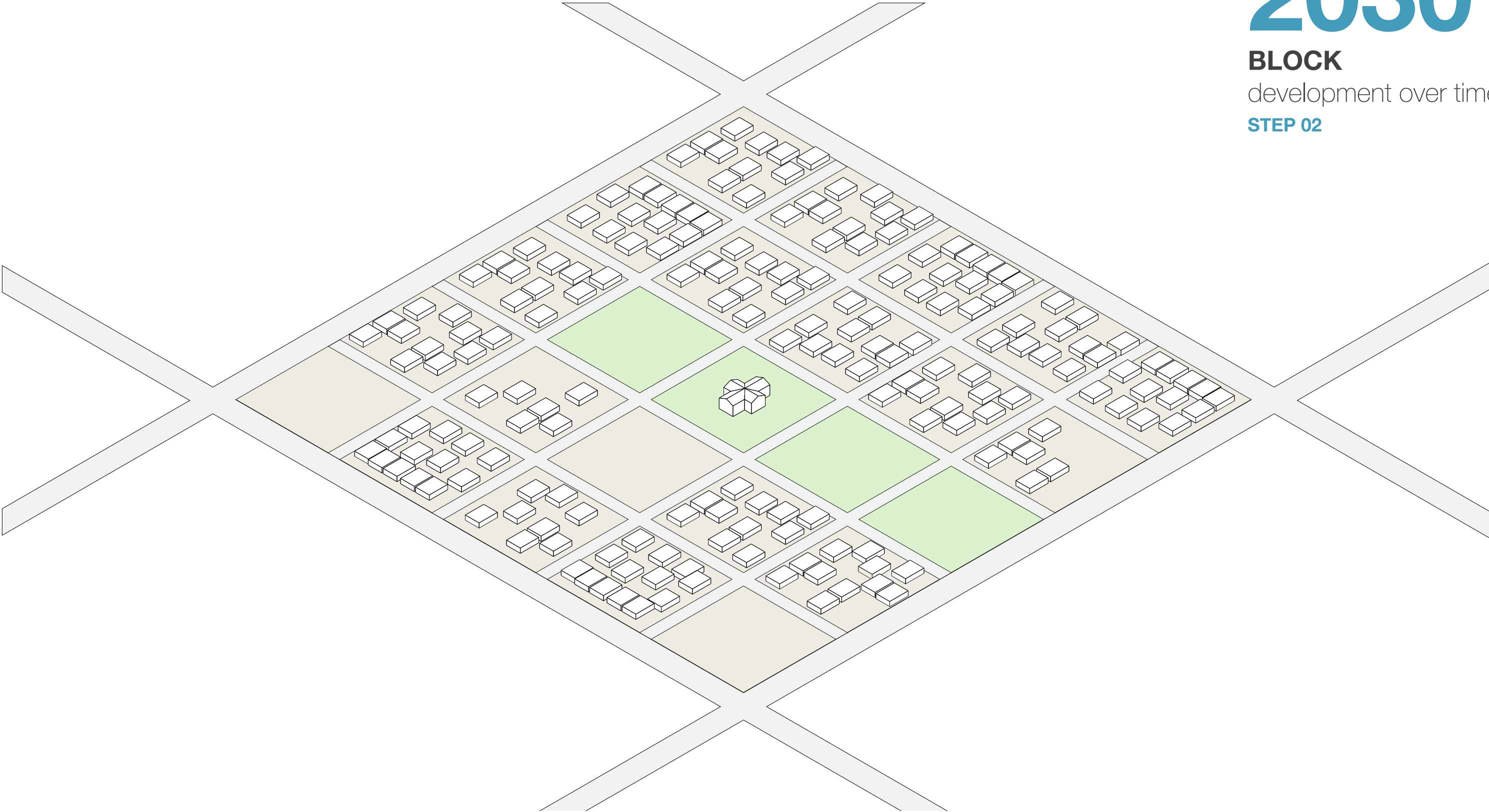
BLOCK  
development over time  
STEP 01



CONCEPT & APPROACH

2030

BLOCK  
development over time  
STEP 02

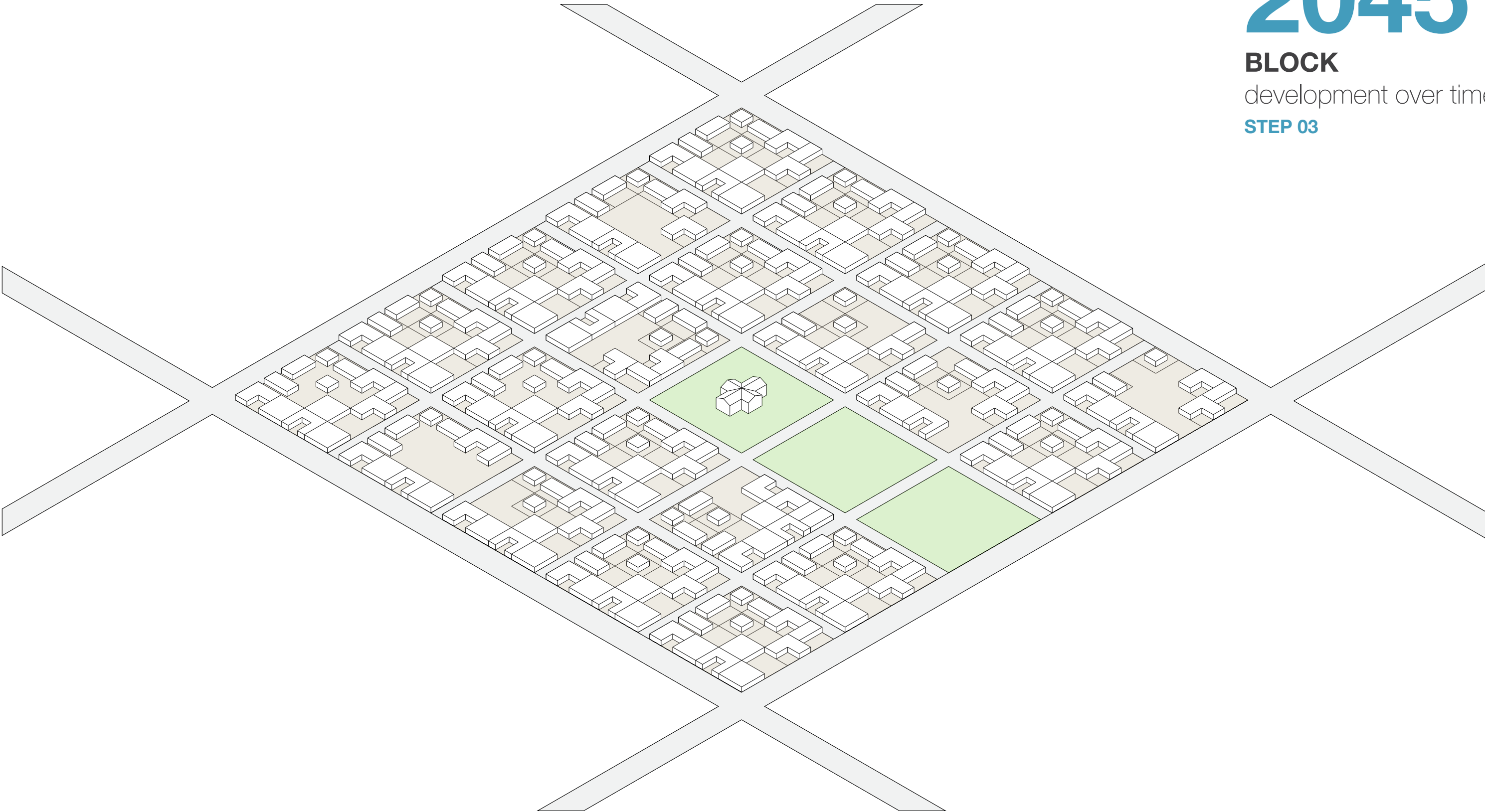




CONCEPT & APPROACH

2045

BLOCK  
development over time  
STEP 03



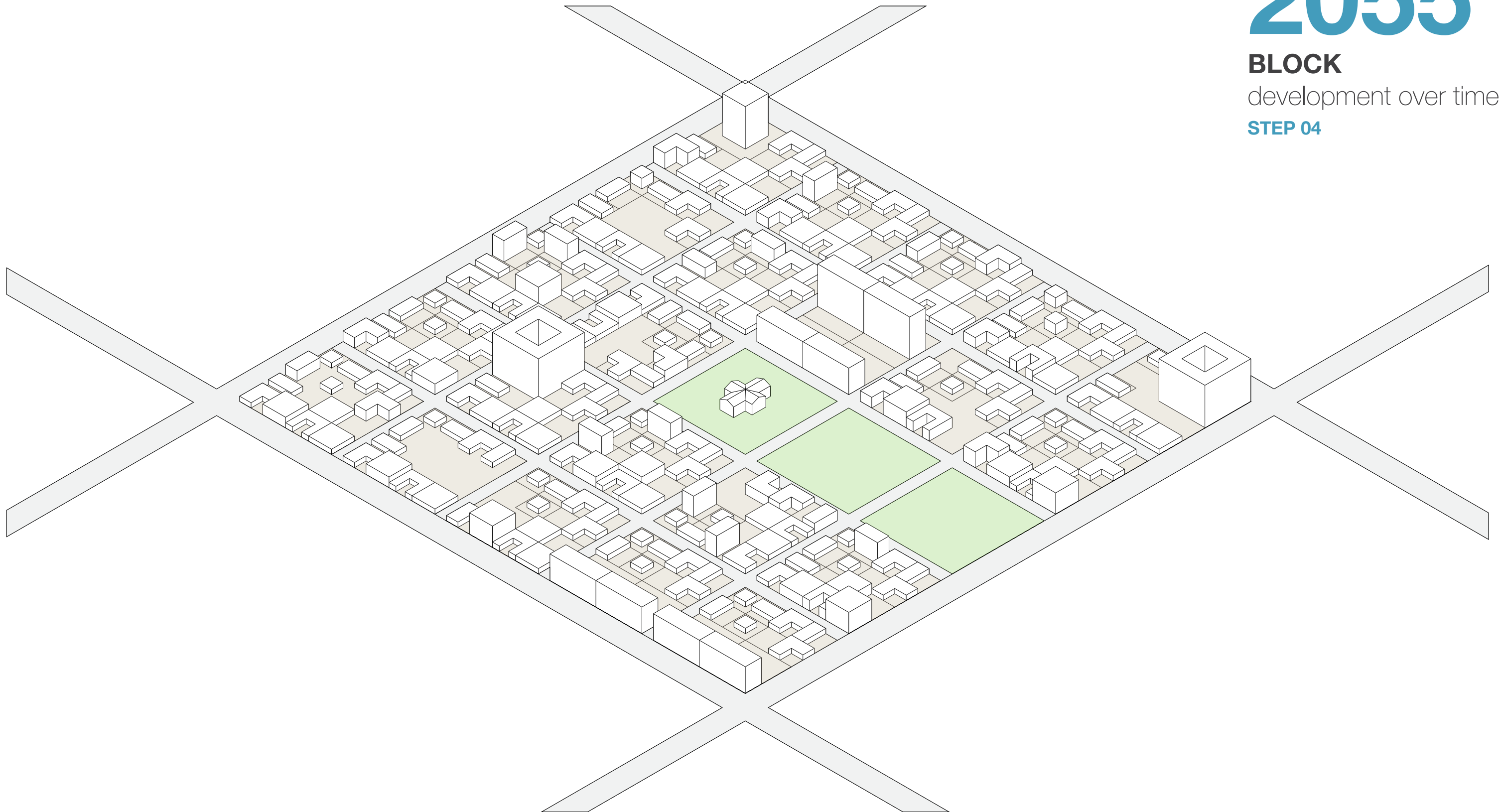
# CONCEPT & APPROACH

# 2055

**BLOCK**

development over time

STEP 04





# CONCEPT & APPROACH

## RULES

### Public Space

- at least **15%** public space

### Diversity

- at least **30%** public/commercial use in groundfloor in each district
- max. **5%** single-use blocks in each district
- more than **5** different typologies/functions in each neighbourhood
- less than **15%** plots should be over 1600 sqm

### Green space

- at least **5%** public green/**10%** total

### Shadows

- each residential/office unit must have at least **2 hours** sunlight per day

### Density

- the density should reach **10,000 – 20,000** people per squarekilometer
- at least 30% of the buildings must be min. **4 storeys**
- block courtyards must be reachable by vehicles

### Social Mix

- **20 – 50%** should be low-cost-housing

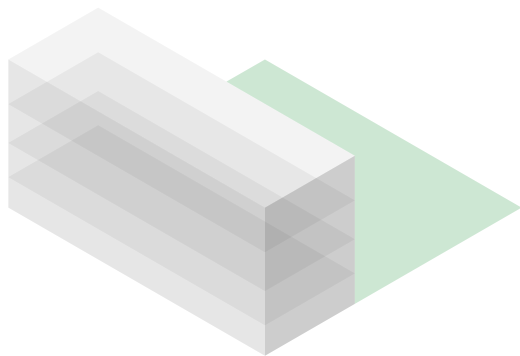
### Public Transport

- in max. **15-minutes** walking distance should be a public transport connection

**Source:** Rogier van den Berg, *UN Habitat Urban Planning and Design Lab, 'Urban Africa' Conference, Rotterdam (2015)*

# CONCEPT & APPROACH

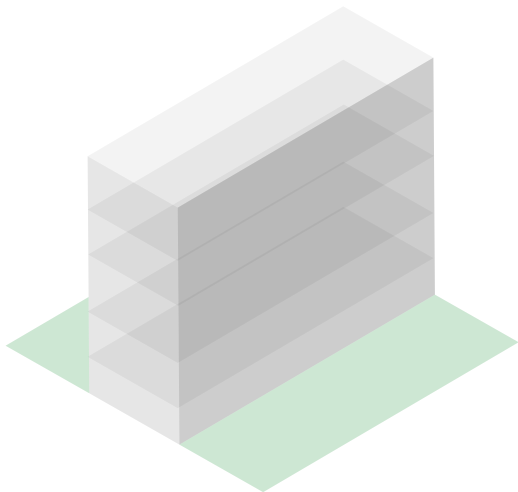
## Special Typologies



### BLOCK SIDE

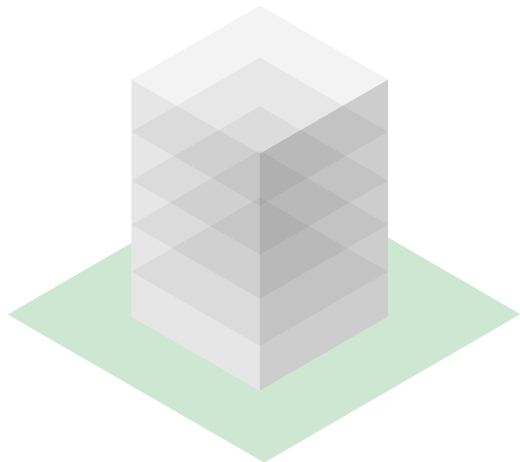
PLOT	40 x 40 m
DIMENSION	40 x 14 m
AREA	2800 sqm
INHABITANTS	100
FAR <sup>1</sup>	1.75
SOI <sup>2</sup>	0.35
STOREYS	5
FUNCTION	residential, commercial

1 FAR = Floor Area Ration  
2 SOI = Site Occupancy Index



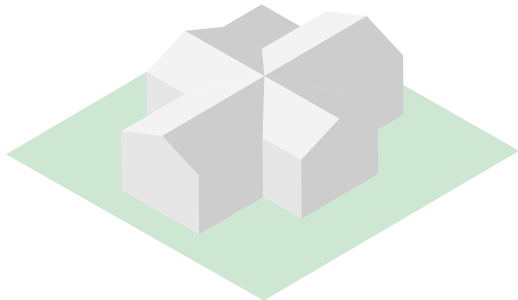
### BLOCK CENTER

PLOT	40 x 40 m
DIMENSION	40 x 14 m
AREA	4480 sqm
INHABITANTS	180
FAR	2.8
SOI	0.35
STOREYS	8
FUNCTION	residential, commercial



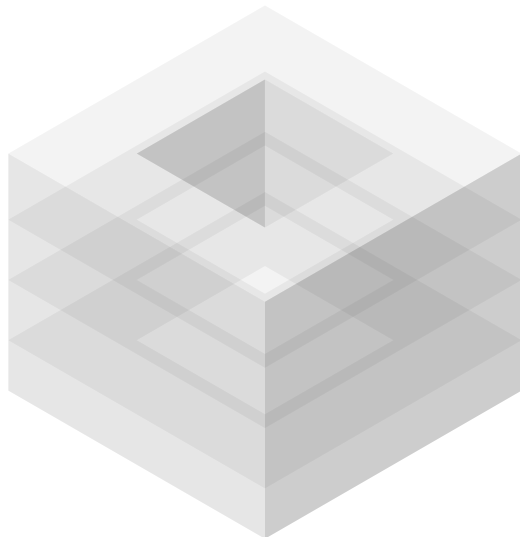
### HIGH RISE

PLOT	40 x 40 m
DIMENSION	20 x 20 m
AREA	3200 sqm
INHABITANTS	130
FAR	2
SOI	0.25
STOREYS	8
FUNCTION	residential, commercial



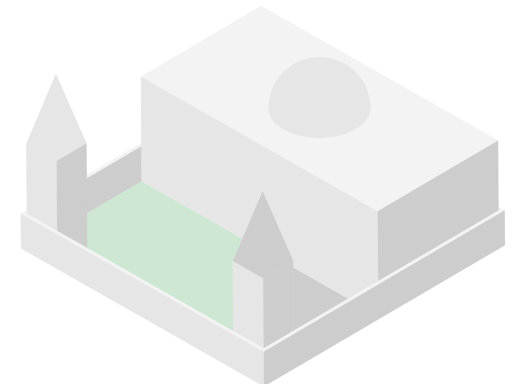
### CHURCH

PLOT	40 x 40 m
DIMENSION	32 x 32 m
AREA	528 sqm
INHABITANTS	0
FAR	0.33
SOI	0.33
STOREYS	1
FUNCTION	religion, community



### COURTYARD BLOCK

PLOT	40 x 40 m
DIMENSION	40 x 40 m
AREA	9600 sqm
INHABITANTS	380
FAR	6
SOI	1.3
STOREYS	8
FUNCTION	residential, commercial



### MOSQUE

PLOT	40 x 40 m
DIMENSION	40 x 40 m
AREA	670 sqm
INHABITANTS	0
FAR	0.42
SOI	0.42
STOREYS	1
FUNCTION	religion, community

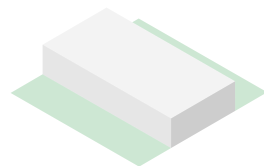
# CONCEPT & APPROACH

## Typologies 1 storey



### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	200 sqm
INHABITANTS	10
FAR	0.5
SOI	0.5
STOREYS	1
FUNCTION	residential, commercial



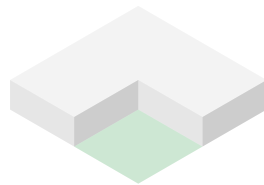
### BLOCK CENTER

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	200 sqm
INHABITANTS	10
FAR	0.5
SOI	0.5
STOREYS	1
FUNCTION	residential, commercial



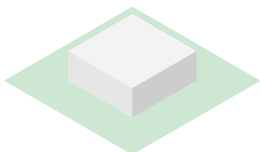
### FULL BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	400 sqm
INHABITANTS	0
FAR	1
SOI	1
STOREYS	1
FUNCTION	commercial, industry, public



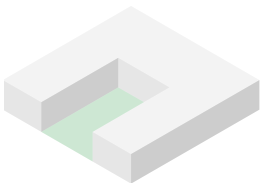
### L-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	300 sqm
INHABITANTS	0
FAR	0.75
SOI	0.75
STOREYS	1
FUNCTION	commercial, industry, public



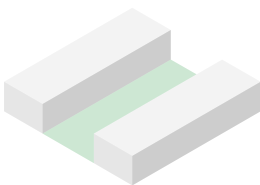
### SINGLE UNIT

PLOT	20 x 20 m
DIMENSION	10 x 10 m
AREA	100 sqm
INHABITANTS	5
FAR	0.25
SOI	0.25
STOREYS	1
FUNCTION	residential, commercial



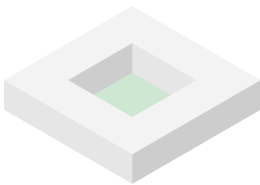
### U-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	308 sqm
INHABITANTS	15
FAR	0.77
SOI	0.77
STOREYS	1
FUNCTION	residential, commercial



### PARALLEL BLOCKS

PLOT	20 x 20 m
DIMENSION	(2x) 20 x 6 m
AREA	240 sqm
INHABITANTS	8
FAR	0.6
SOI	0.6
STOREYS	1
FUNCTION	residential, commercial



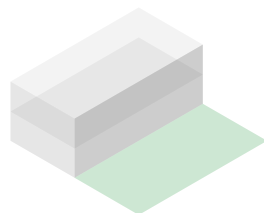
### COURTYARD

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	364 sqm
INHABITANTS	10
FAR	0.91
SOI	0.91
STOREYS	1
FUNCTION	residential, commercial, office



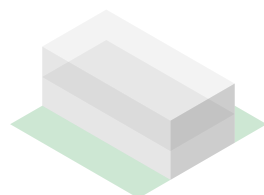
# CONCEPT & APPROACH

## Typologies 2 storeys



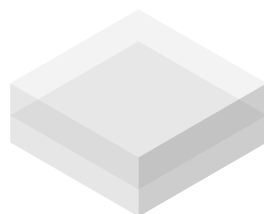
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	400 sqm
INHABITANTS	20
FAR	1
SOI	0.5
STOREYS	2
FUNCTION	residential, commercial



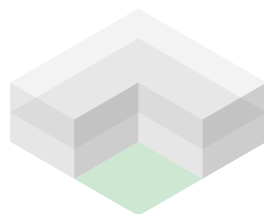
### BLOCK CENTER

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	400 sqm
INHABITANTS	20
FAR	1
SOI	0.5
STOREYS	2
FUNCTION	residential, commercial



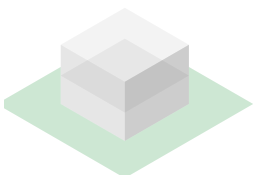
### FULL BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	400 sqm
INHABITANTS	0
FAR	2
SOI	1
STOREYS	2
FUNCTION	commercial, industry, public



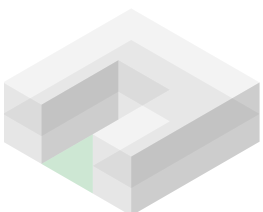
### L-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	600 sqm
INHABITANTS	0
FAR	1.5
SOI	0.75
STOREYS	2
FUNCTION	commercial, industry, public



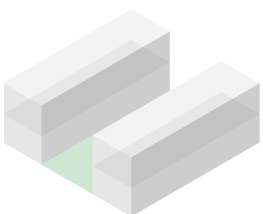
### SINGLE UNIT

PLOT	20 x 20 m
DIMENSION	10 x 10 m
AREA	200 sqm
INHABITANTS	10
FAR	0.5
SOI	0.25
STOREYS	2
FUNCTION	residential, commercial



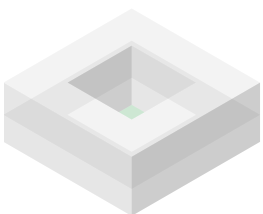
### U-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	616 sqm
INHABITANTS	30
FAR	1.44
SOI	0.77
STOREYS	2
FUNCTION	residential, commercial



### PARALLEL BLOCKS

PLOT	20 x 20 m
DIMENSION	(2x) 20 x 6 m
AREA	480 sqm
INHABITANTS	16
FAR	1.2
SOI	0.6
STOREYS	2
FUNCTION	residential, commercial

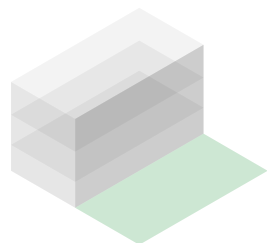


### COURTYARD

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	728 sqm
INHABITANTS	10
FAR	1.82
SOI	0.91
STOREYS	2
FUNCTION	residential, commercial, office

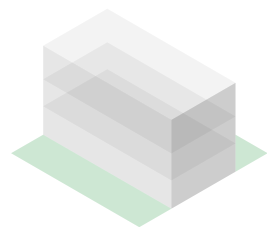
# CONCEPT & APPROACH

## Typologies 3 storeys



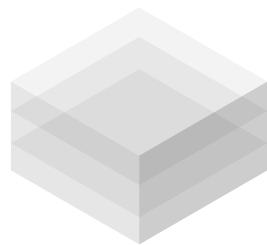
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	600 sqm
INHABITANTS	30
FAR	1.5
SOI	0.5
STOREYS	3
FUNCTION	residential, commercial



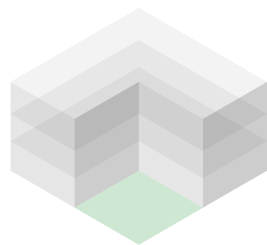
### BLOCK CENTER

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	600 sqm
INHABITANTS	30
FAR	1.5
SOI	0.5
STOREYS	3
FUNCTION	residential, commercial



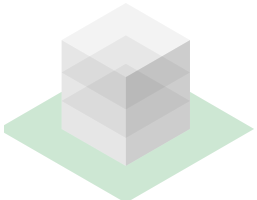
### FULL BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,200 sqm
INHABITANTS	0
FAR	3
SOI	1
STOREYS	3
FUNCTION	commercial, industry, public



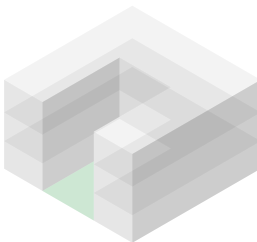
### L-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	900 sqm
INHABITANTS	0
FAR	2.25
SOI	0.75
STOREYS	3
FUNCTION	commercial, industry, public



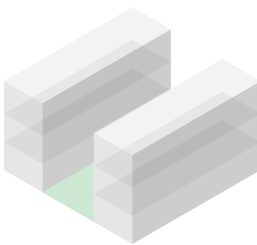
### SINGLE TOWER

PLOT	20 x 20 m
DIMENSION	10 x 10 m
AREA	300 sqm
INHABITANTS	15
FAR	0.75
SOI	0.25
STOREYS	3
FUNCTION	residential, commercial



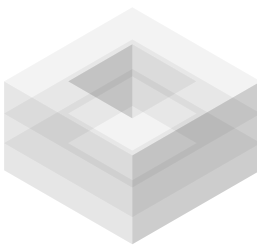
### U-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	924 sqm
INHABITANTS	45
FAR	2.31
SOI	0.77
STOREYS	3
FUNCTION	residential, commercial



### PARALLEL BLOCKS

PLOT	20 x 20 m
DIMENSION	(2x) 20 x 6 m
AREA	720 sqm
INHABITANTS	24
FAR	1.8
SOI	0.6
STOREYS	3
FUNCTION	residential, commercial

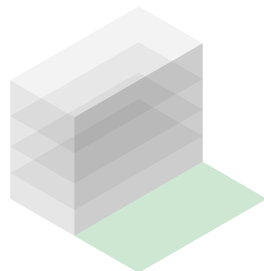


### COURTYARD

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,092 sqm
INHABITANTS	30
FAR	2.73
SOI	0.91
STOREYS	3
FUNCTION	residential, commercial, office

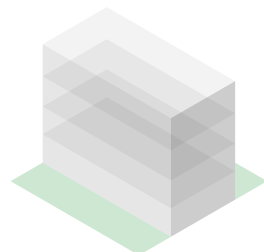
# CONCEPT & APPROACH

## Typologies 4 storeys



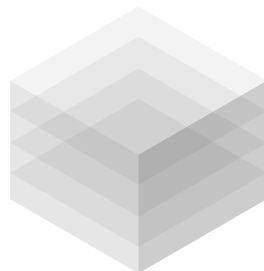
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	800 sqm
INHABITANTS	40
FAR	2
SOI	0.5
STOREYS	4
FUNCTION	residential, commercial



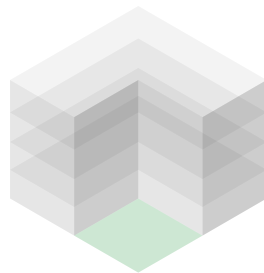
### BLOCK CENTER

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	800 sqm
INHABITANTS	40
FAR	2
SOI	0.5
STOREYS	4
FUNCTION	residential, commercial



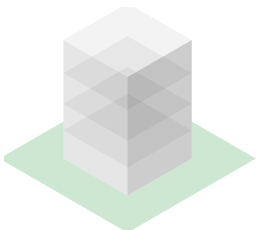
### FULL BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,600 sqm
INHABITANTS	0
FAR	4
SOI	1
STOREYS	4
FUNCTION	commercial, industry, public



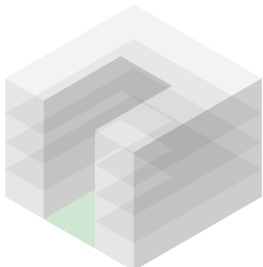
### L-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,200 sqm
INHABITANTS	0
FAR	3
SOI	0.75
STOREYS	4
FUNCTION	commercial, industry, public



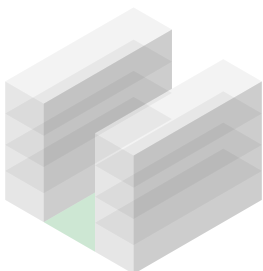
### SINGLE TOWER

PLOT	20 x 20 m
DIMENSION	10 x 10 m
AREA	400 sqm
INHABITANTS	20
FAR	1
SOI	0.25
STOREYS	4
FUNCTION	residential, commercial



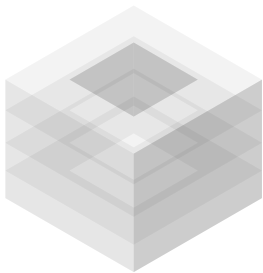
### U-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,224 sqm
INHABITANTS	60
FAR	3.08
SOI	0.77
STOREYS	4
FUNCTION	residential, commercial



### PARALLEL BLOCKS

PLOT	20 x 20 m
DIMENSION	(2x) 20 x 6 m
AREA	960 sqm
INHABITANTS	32
FAR	2.4
SOI	0.6
STOREYS	4
FUNCTION	residential, commercial



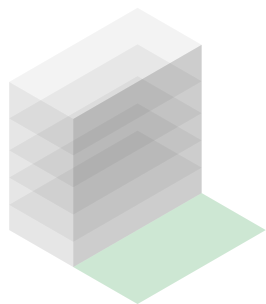
### COURTYARD

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,456 sqm
INHABITANTS	40
FAR	3.64
SOI	0.91
STOREYS	4
FUNCTION	residential, commercial, office



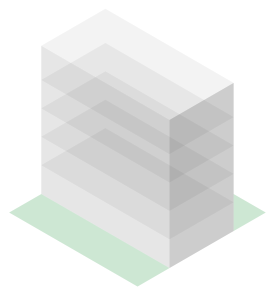
# CONCEPT & APPROACH

## Typologies 5 storeys



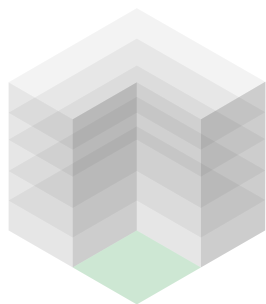
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,000 sqm
INHABITANTS	50
FAR	2.5
SOI	0.5
STOREYS	5
FUNCTION	residential, commercial



### BLOCK CENTER

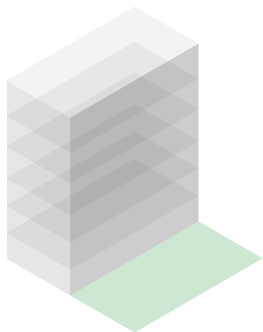
PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,000 sqm
INHABITANTS	50
FAR	2.5
SOI	0.5
STOREYS	5
FUNCTION	residential, commercial



### L-BLOCK

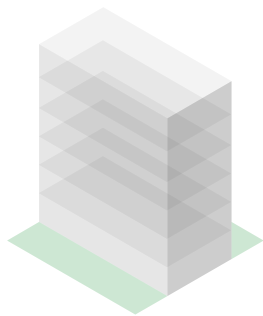
PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,500 sqm
INHABITANTS	0
FAR	3.75
SOI	0.75
STOREYS	5
FUNCTION	commercial, industry, public

## Typologies 6 storeys



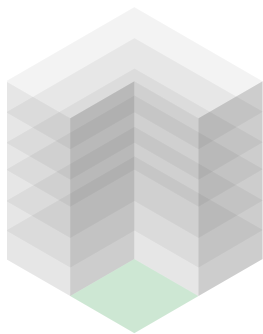
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,200 sqm
INHABITANTS	60
FAR	3
SOI	0.5
STOREYS	6
FUNCTION	residential, commercial



### BLOCK CENTER

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,200 sqm
INHABITANTS	60
FAR	3.5
SOI	0.5
STOREYS	6
FUNCTION	residential, commercial

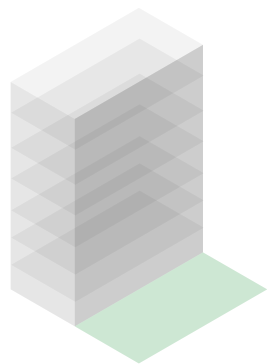


### L-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	1,800 sqm
INHABITANTS	0
FAR	4.5
SOI	0.75
STOREYS	6
FUNCTION	commercial, industry, public

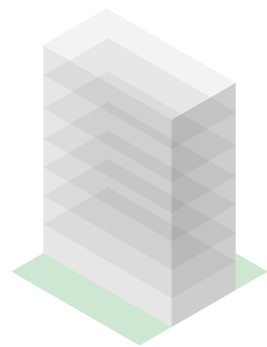
# CONCEPT & APPROACH

## Typologies 7 storeys



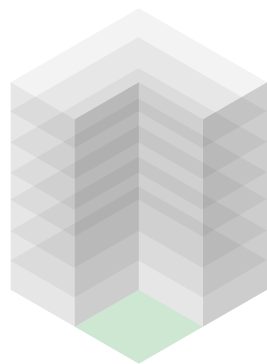
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,400 sqm
INHABITANTS	70
FAR	3.5
SOI	0.5
STOREYS	7
FUNCTION	residential, commercial



### BLOCK CENTER

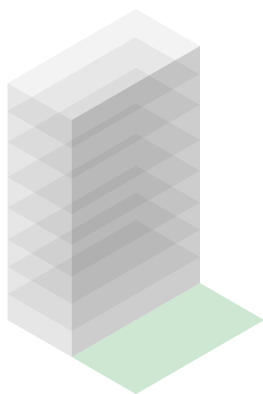
PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,400 sqm
INHABITANTS	70
FAR	3.5
SOI	0.5
STOREYS	7
FUNCTION	residential, commercial



### L-BLOCK

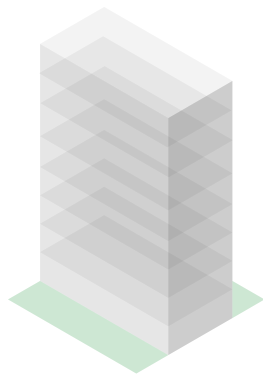
PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	2,100 sqm
INHABITANTS	0
FAR	5.25
SOI	0.75
STOREYS	7
FUNCTION	commercial, industry, public

## Typologies 8 storeys



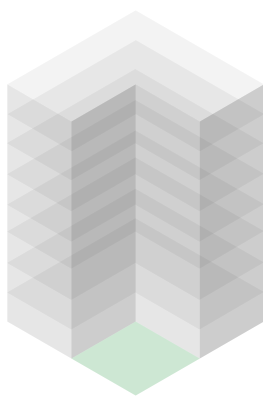
### BLOCK SIDE

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,600 sqm
INHABITANTS	80
FAR	4
SOI	0.5
STOREYS	8
FUNCTION	residential, commercial



### BLOCK CENTER

PLOT	20 x 20 m
DIMENSION	20 x 10 m
AREA	1,600 sqm
INHABITANTS	80
FAR	4
SOI	0.5
STOREYS	8
FUNCTION	residential, commercial



### L-BLOCK

PLOT	20 x 20 m
DIMENSION	20 x 20 m
AREA	2,400 sqm
INHABITANTS	0
FAR	6
SOI	0.75
STOREYS	8
FUNCTION	commercial, industry, public

# GENERATED CITY



Existing structure



**Source:** Ministry of Land, Housing and Urban Development, JICA (2010)



# GENERATED CITY

8 Million Inhabitants  
1.36 M new units  
644,000 new plots  
460,000 new buildings



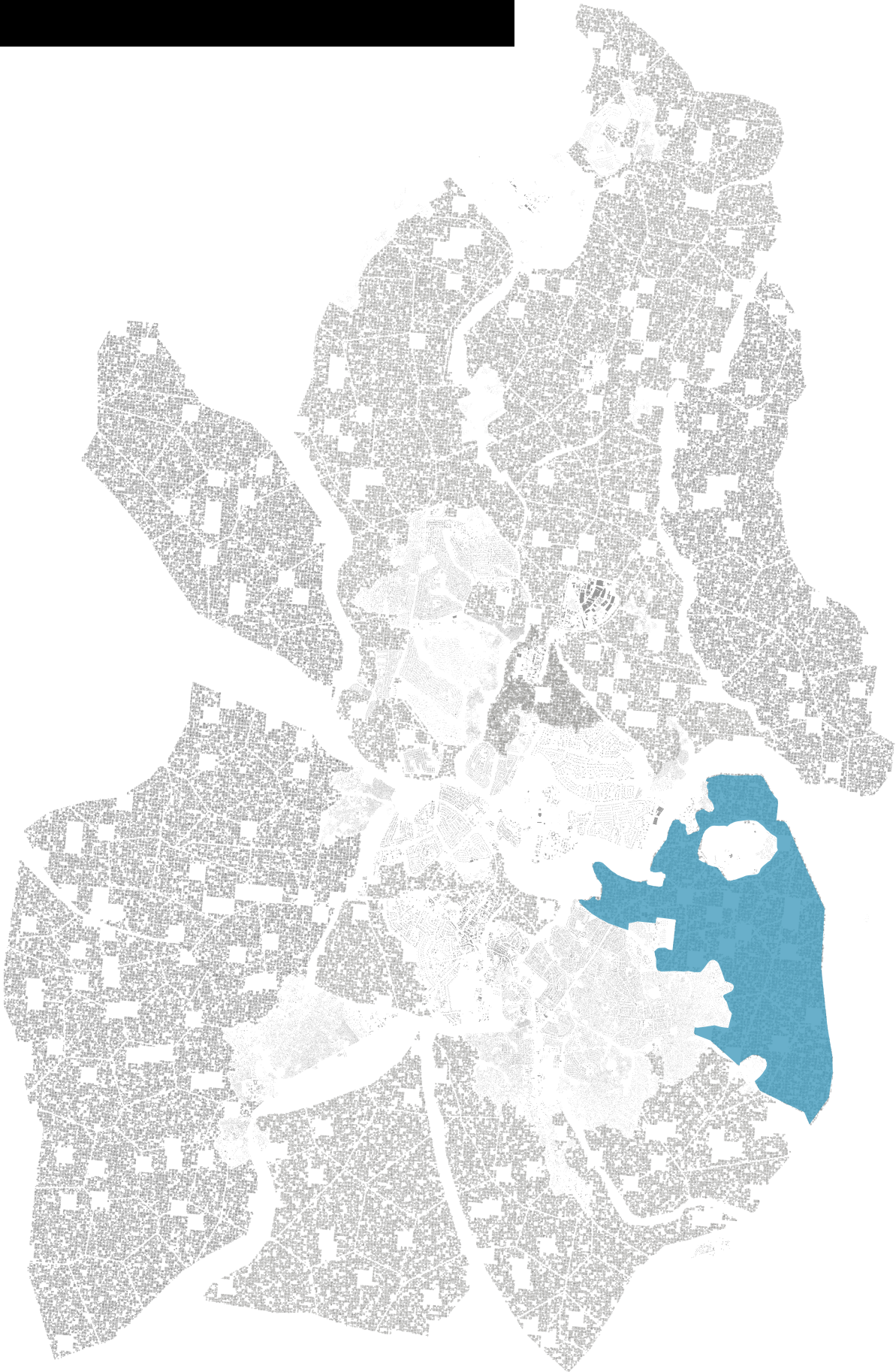
**Possible structure 2055**



**Source:** Ministry of Land, Housing and Urban Development, JICA (2010)



# GENERATED CITY



Detailed district



**Source:** Ministry of Land, Housing and Urban Development, JICA (2010)

# GENERATED CITY



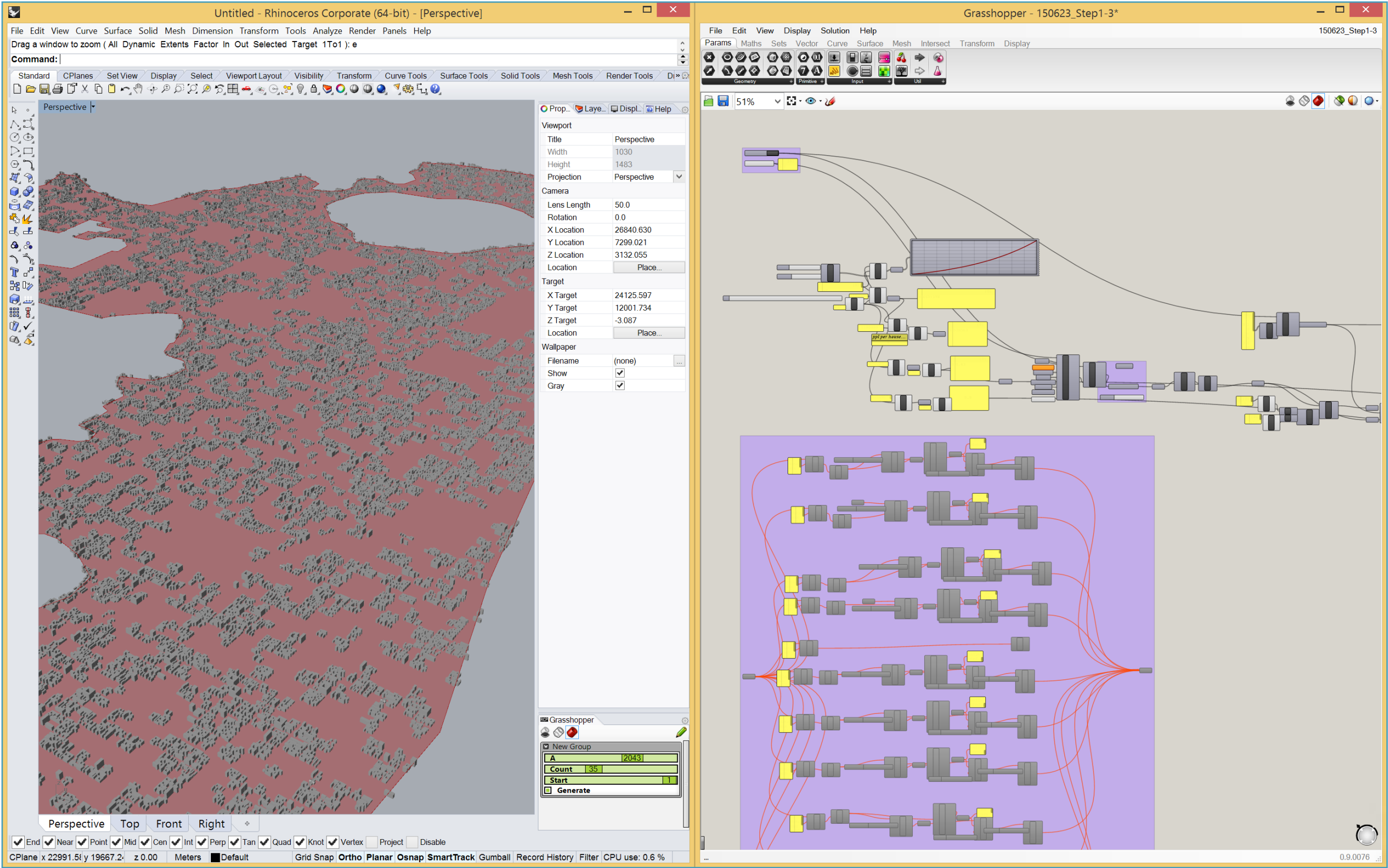
Detailed area 2055



Source: DigitalGlobe 2015

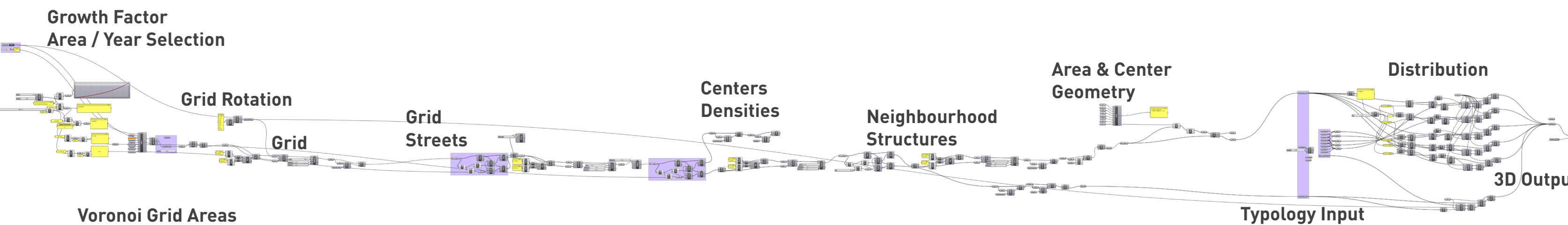


# FUNCTIONALITY OF RHINO & GH

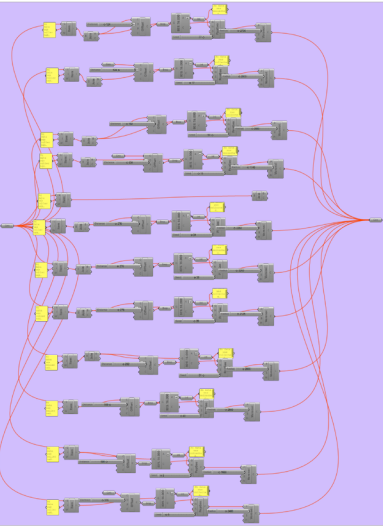




# FUNCTIONALITY OF RHINO & GH

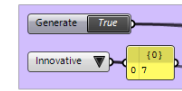


Voronoi Grid Areas

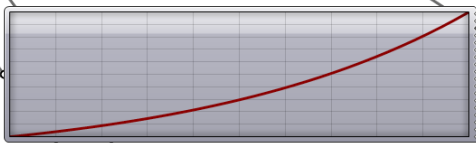


# FUNCTIONALITY OF RHINO & GH

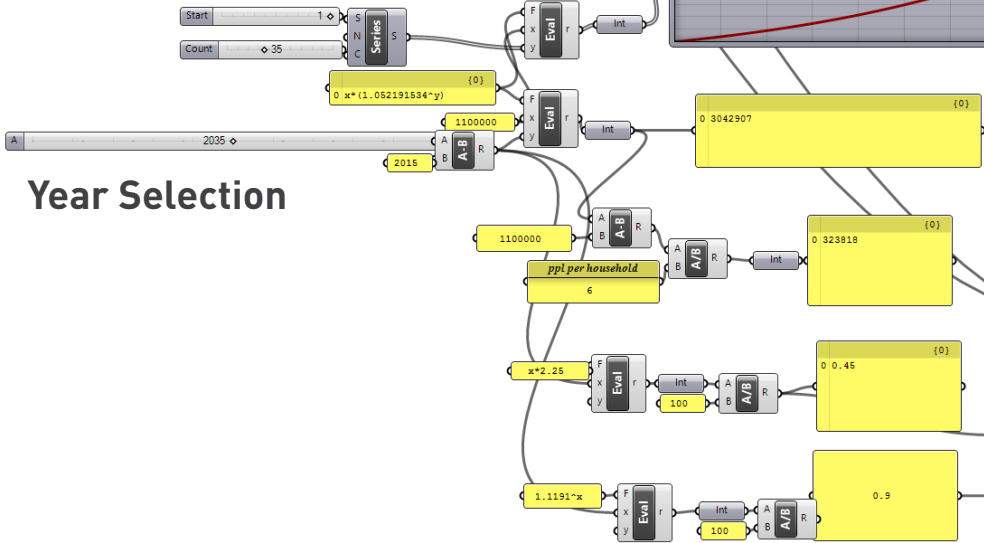
ON/OFF  
Area Selection



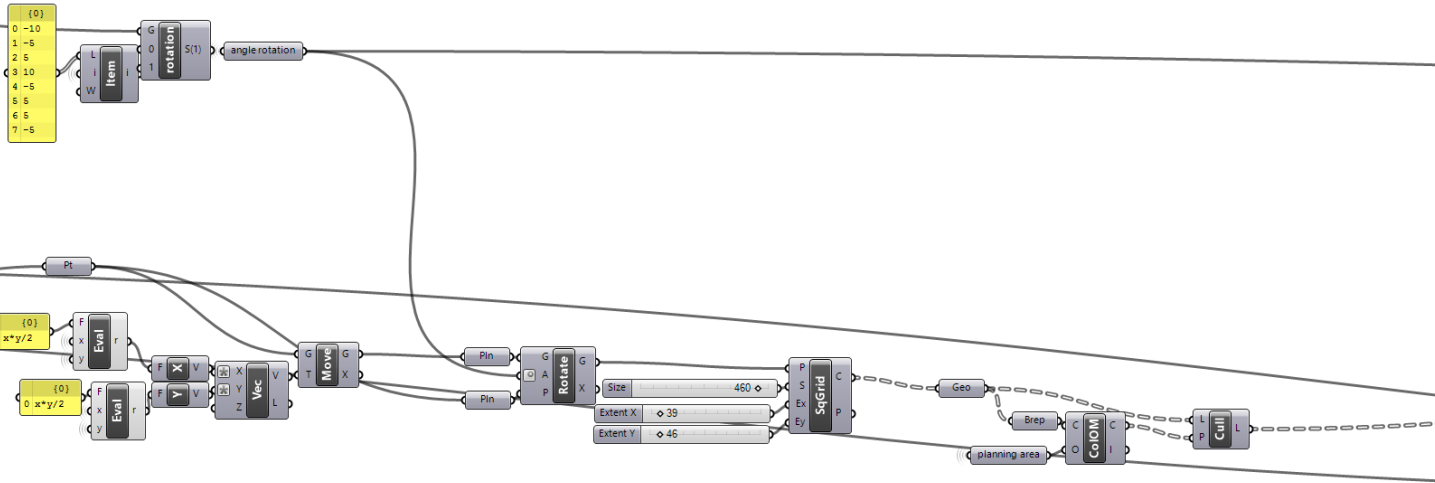
Population Growth



Year Selection

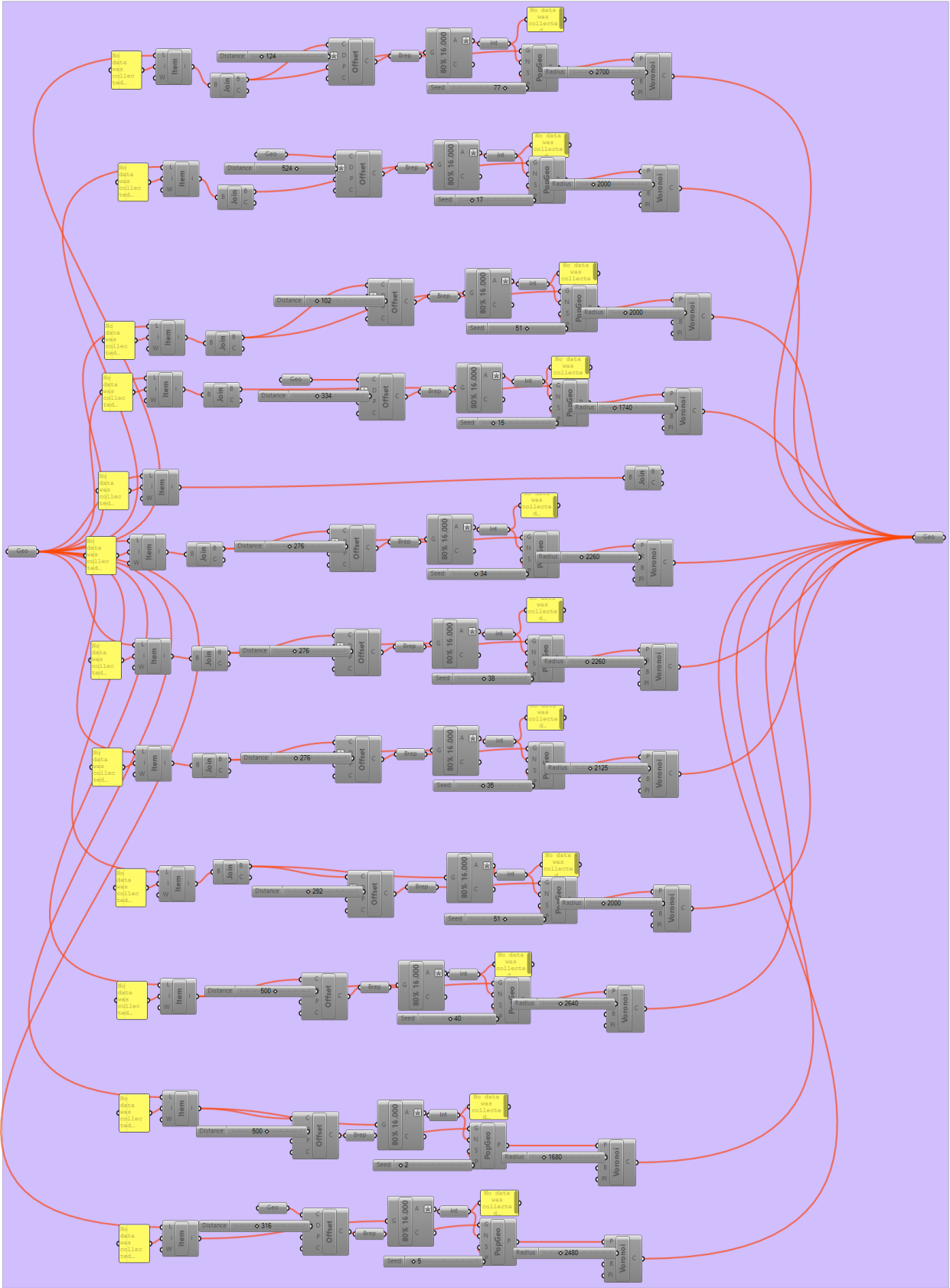


Grid Orientation & Dimension



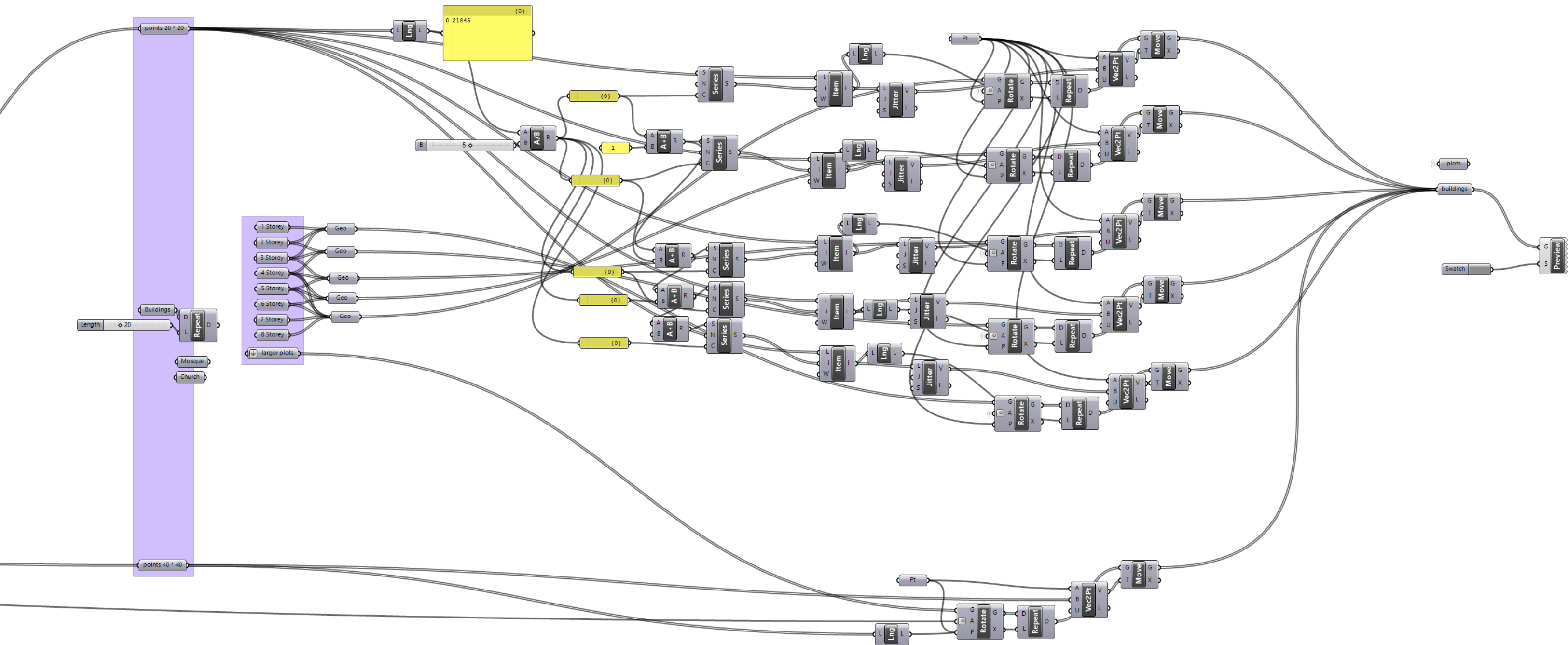
# FUNCTIONALITY OF RHINO & GH

8 Areas inported from Rhino



Voronoi Grids & Density towards Centres

# FUNCTIONALITY OF RHINO & GH





# CENTRAL FUNCTIONS

**Voronoi Grid for organic infrastructure**

**8 areas with different densities and typology combinations**

**changing typologies and heights towards area centers**

**exponentially growing population from centers**

**equally distributed special functions (churches, ...)**

**walk-ability through grid sizes and major infrastructure location**

# MAIN CHALLENGES

## **avoiding repetitive patterns**

(different parameter, changing rotation, preexisting green structures)

## **recreate human-made organic structures**

(voronoi grid, random factors, manual choice of different options & input,...)

---

## **time to generate content (full process >15 hours)**

(dividing area and process, small sample area, bootcamp (no virtual machine...))

## **rethinking space in mathematical formulas & shapes**

(center points instead of plots, lines instead of roads, different kind of vectors, lines, etc...)

## **influence / reduction due to standard program functions**

(every part must be planned and explainable, detailed rules, own formulas/scripts...)