

# *Spatial Signatures*

*Dynamic classification of  
the built environment*

Dani Arribas-Bel

[\[@darribas\]](#)

Martin Fleischmann

[\[@martinfleis\]](#)

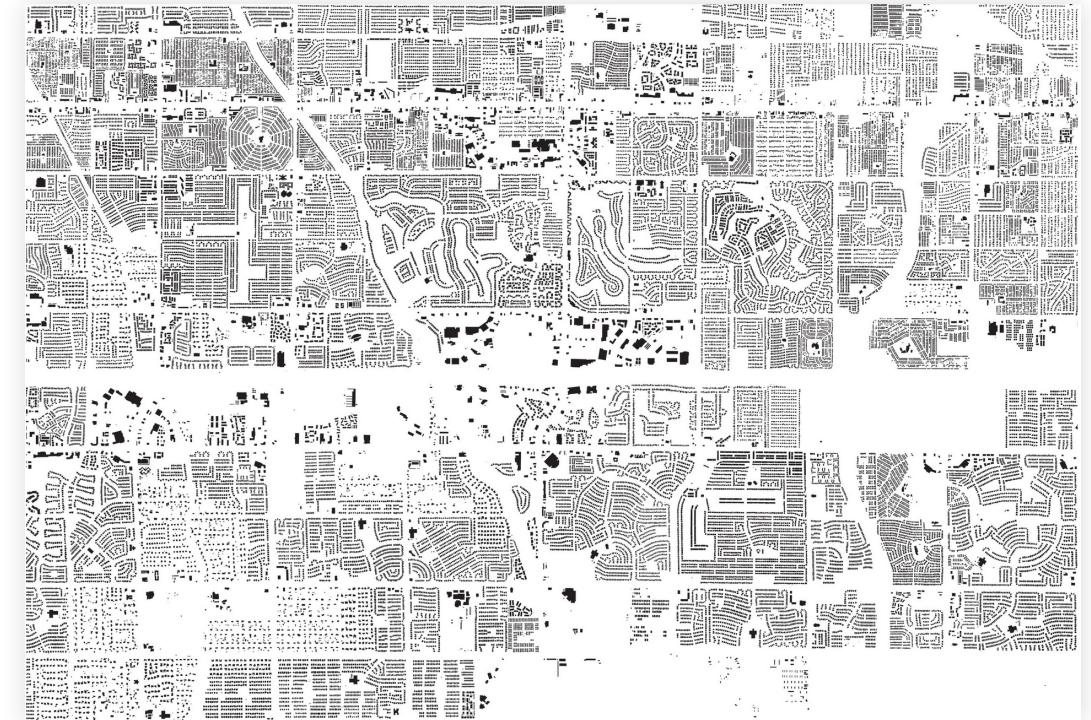
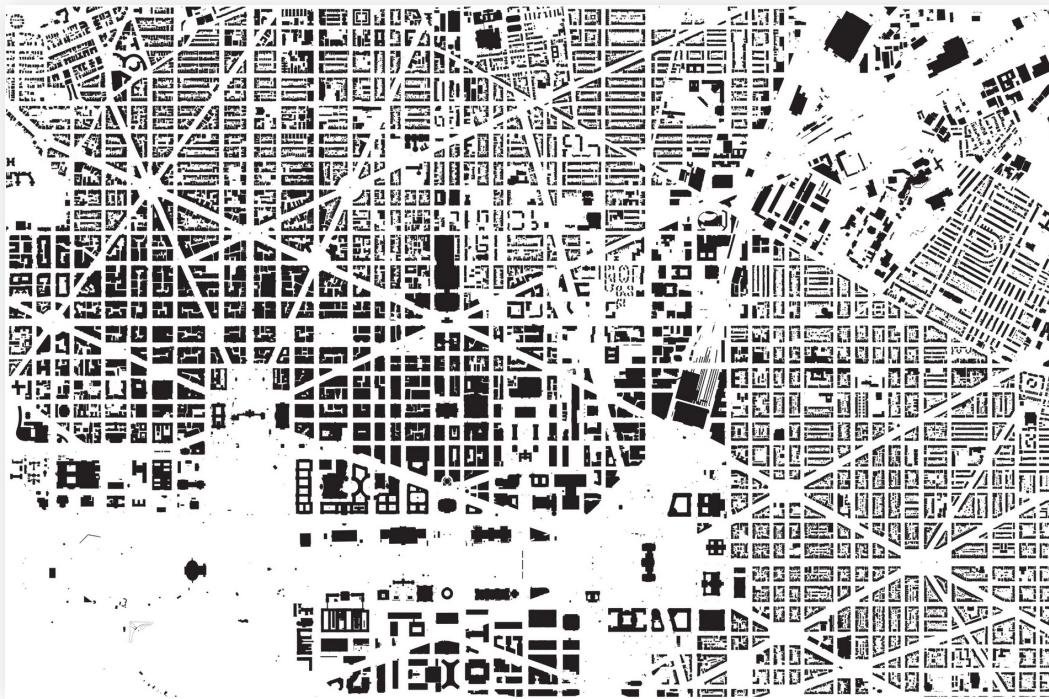


The  
Alan Turing  
Institute



Geographic  
Data Science  
Lab

# How we arrange “stuff” in cities matters...



Source: *A map of every building in America* (New York Times)

... it matters *a lot*

Journal of Urban Economics 111 (2019) 93–107  
Contents lists available at ScienceDirect  
Journal of Urban Economics journal homepage: [www.elsevier.com/locate/jue](http://www.elsevier.com/locate/jue)

The economic effects of density: A synthesis<sup>☆</sup>  
Gabriel M. Ahlfeldt<sup>a,1,\*</sup>, Elisabetta Pietrostefani<sup>b</sup>  
<sup>a</sup>London School of Economics and Political Sciences (LSE) and Centre for Economic Policy Research (CEPR), Houghton Street, London WC2A 2AE, United Kingdom  
<sup>b</sup>London School of Economics and Political Sciences (LSE), Houghton Street, London WC2A 2AE, United Kingdom

Cities in Bad Shape: Urban Geometry in India - American Economic Association — Mozilla Firefox

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## Cities in Bad Shape: Urban Geometry in India

Mariaflavia Harari

AMERICAN ECONOMIC REVIEW  
VOL. 110, NO. 8, AUGUST 2020  
(pp. 2377-2421)

ARTICLE  
pubs.acs.org/est

## Environmental Science & Technology

Effects of Income and Urban Form on Urban NO<sub>2</sub>: Global Evidence from Satellites  
Matthew J. Bechle,<sup>†</sup> Dylan B. Millet,<sup>†,‡</sup> and Julian D. Marshall<sup>\*,†</sup>  
<sup>†</sup>Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota 55455, United States  
<sup>‡</sup>Department of Soil, Water, and Climate, University of Minnesota, Minneapolis, Minnesota 55455, United States

Living with beauty: report of the Building Better, Building Beautiful Commission

Independent report on how to promote and increase the use of high-quality design for new build homes and neighbourhoods.

From: Ministry of Housing, Communities & Local Government  
Published: 30 January 2020

Applies to: England

Related content  
[Creating space for beauty: interim report of the Building Better, Building Beautiful Commission](#)

## Rethinking Urban Sprawl MOVING TOWARDS SUSTAINABLE CITIES



OECD

## NEW URBAN AGENDA

H | III | UN

# Urban Form

*What does it look like?*

“Physical structure and appearance of cities”

# What do we talk about...

... when we talk about urban morphology?

buildings

streets

plots

open  
spaces

**How can we describe it...  
... numerically?**

# Urban morphometrics

“quantitative analysis of urban form”

All about measuring.

# Measuring

dimension

intensity

shape

connectivity

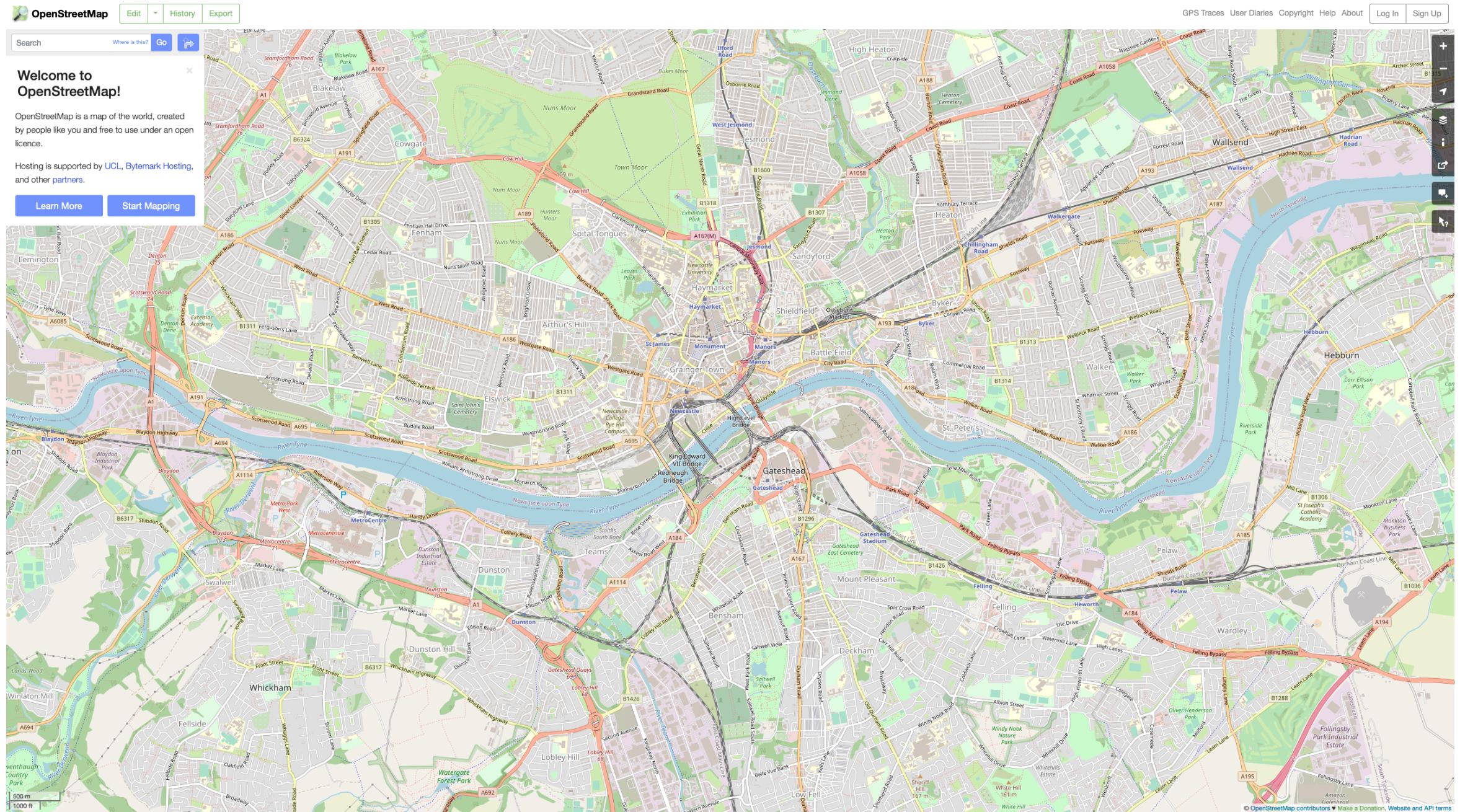
spatial  
distribution

diversity

# Why?

Because we (finally) can!

# Data



# Tools

OSMnx

PySAL

foot

momepy

momepy

Urban Morphology Measuring Toolkit

[momepy.org](http://momepy.org)

# Few examples

... before we move on.

3.83, 15.81  
15.81, 34.28  
34.28, 74.87  
74.87, 172.93  
172.93, 398.09

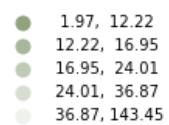


longest axis length  
dimension

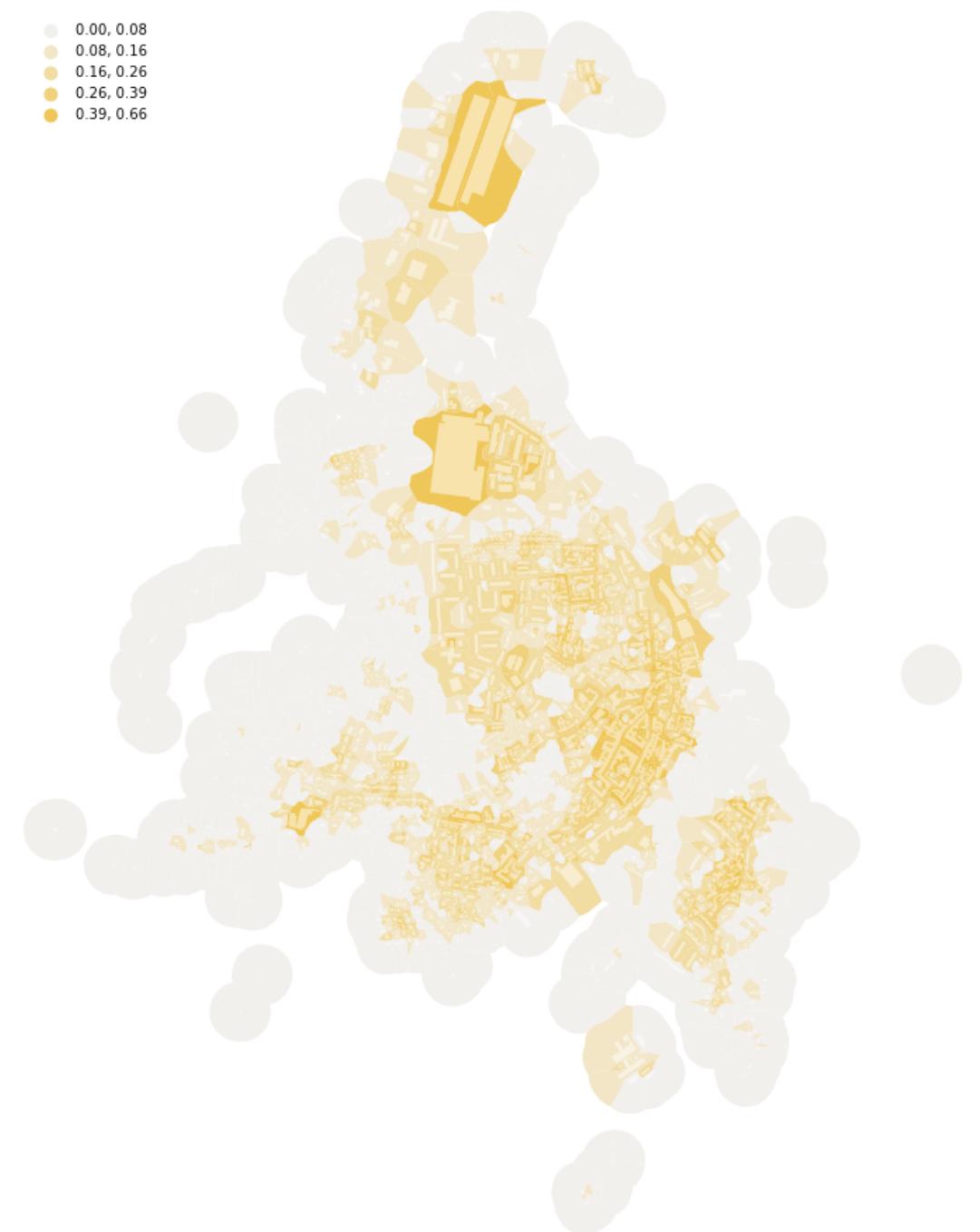
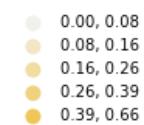
0.43, 0.72  
0.72, 0.83  
0.83, 0.91  
0.91, 0.97  
0.97, 1.12



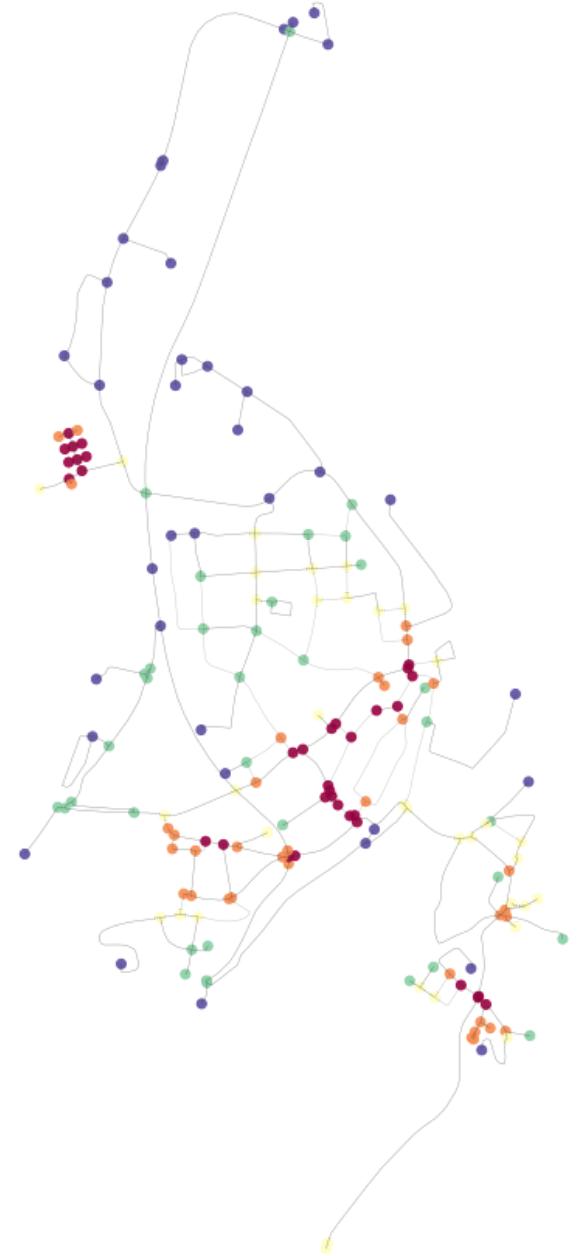
equivalent rectangular index  
shape



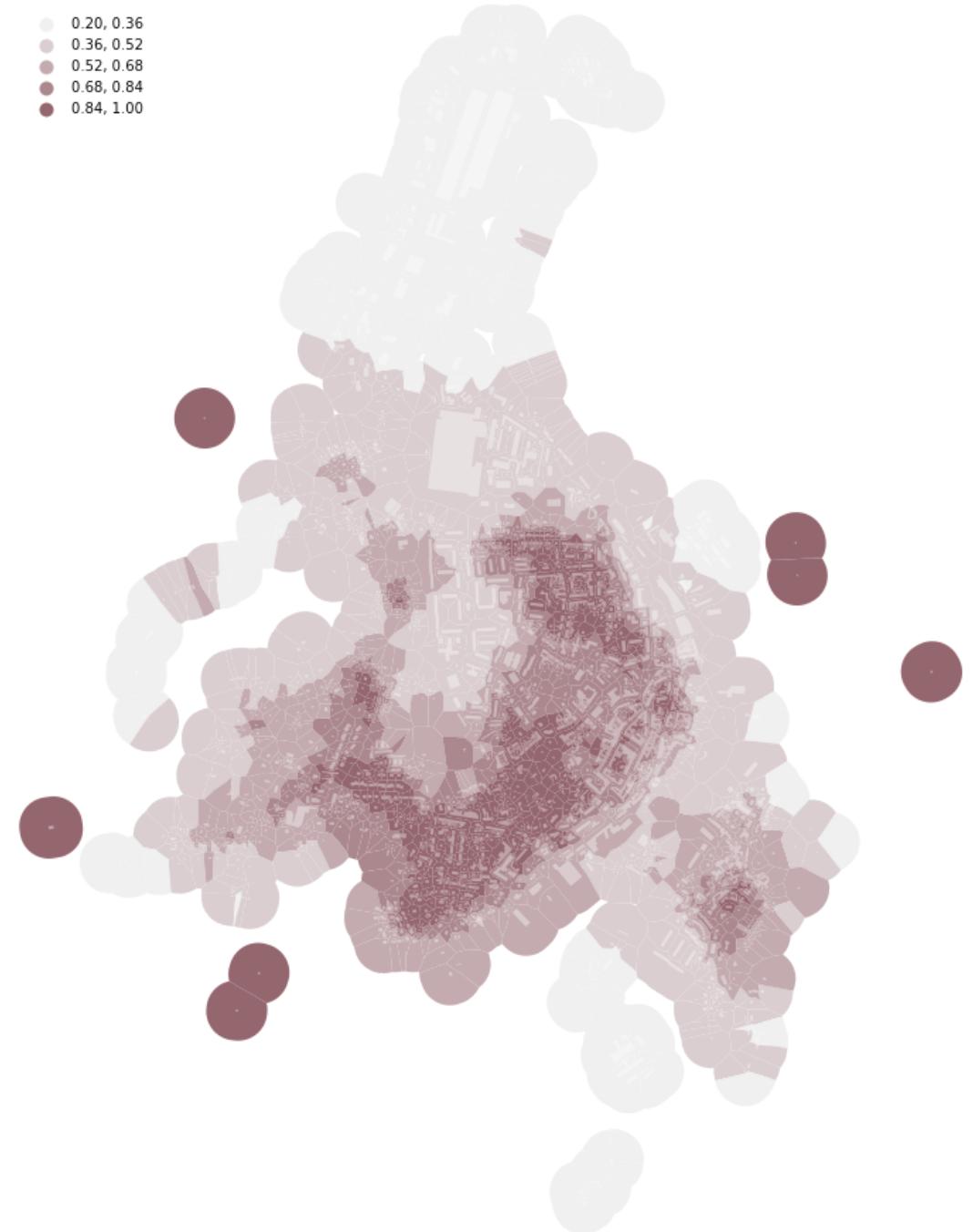
distance to neighbours  
spatial distribution



covered area ratio  
intensity



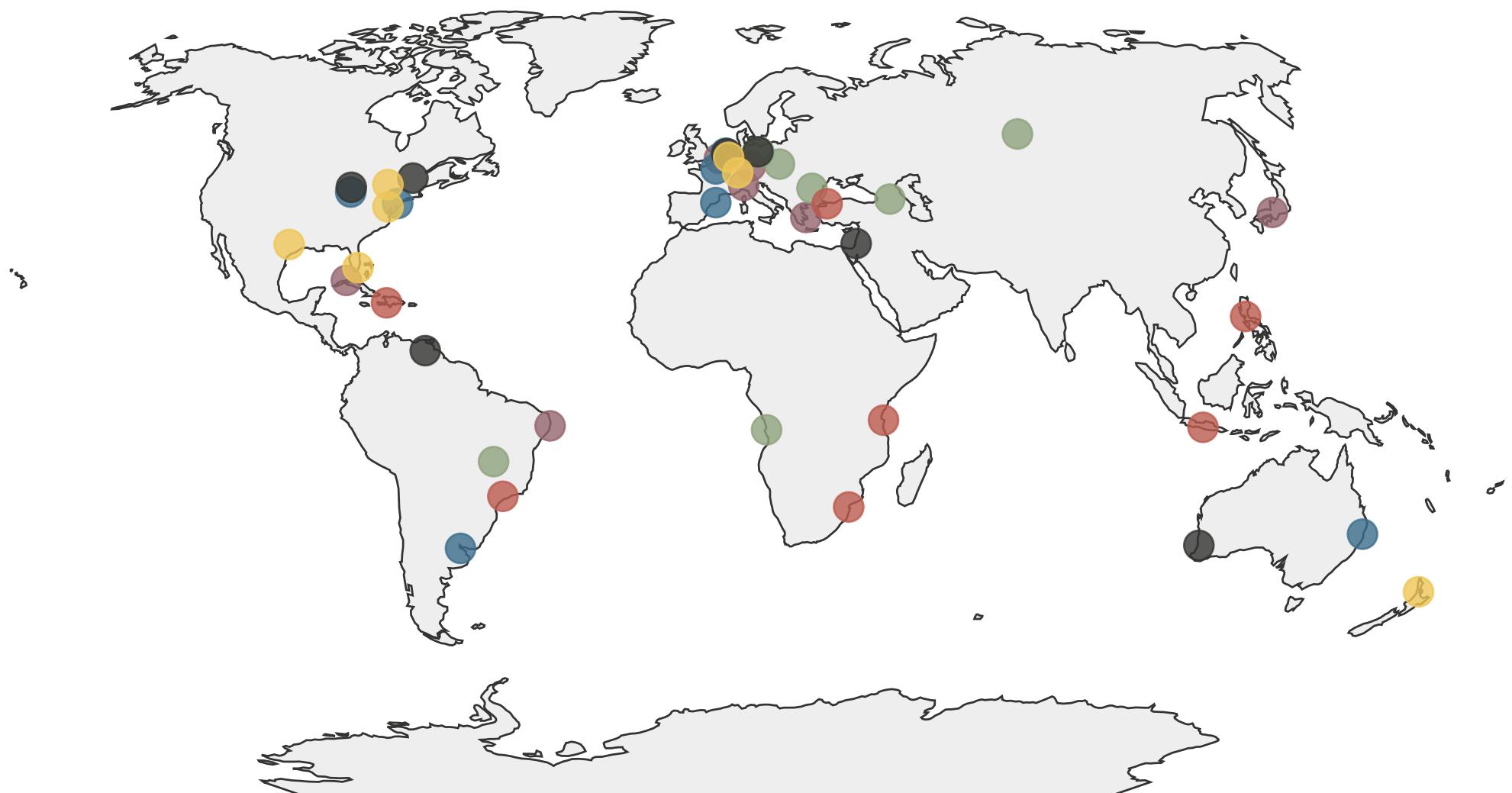
closeness centrality  
connectivity



Simpson's diversity of tessellation area  
diversity

# Evolution of urban patterns

# 42 places, 6 historical periods



# 400 m buffer

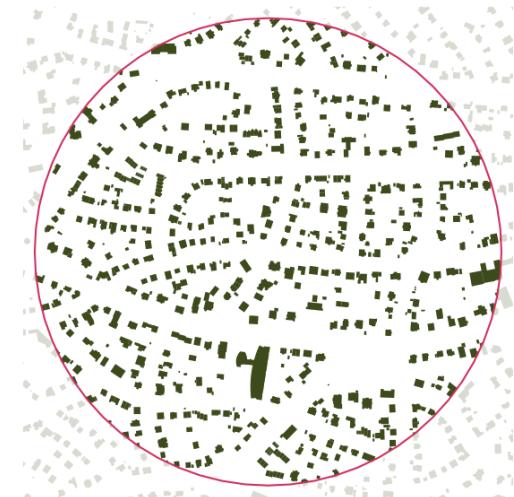
Kyoto  
(pre-industrial)



Chicago  
(industrial)



Frohnau  
(garden city)



Brasilia  
(modernist)



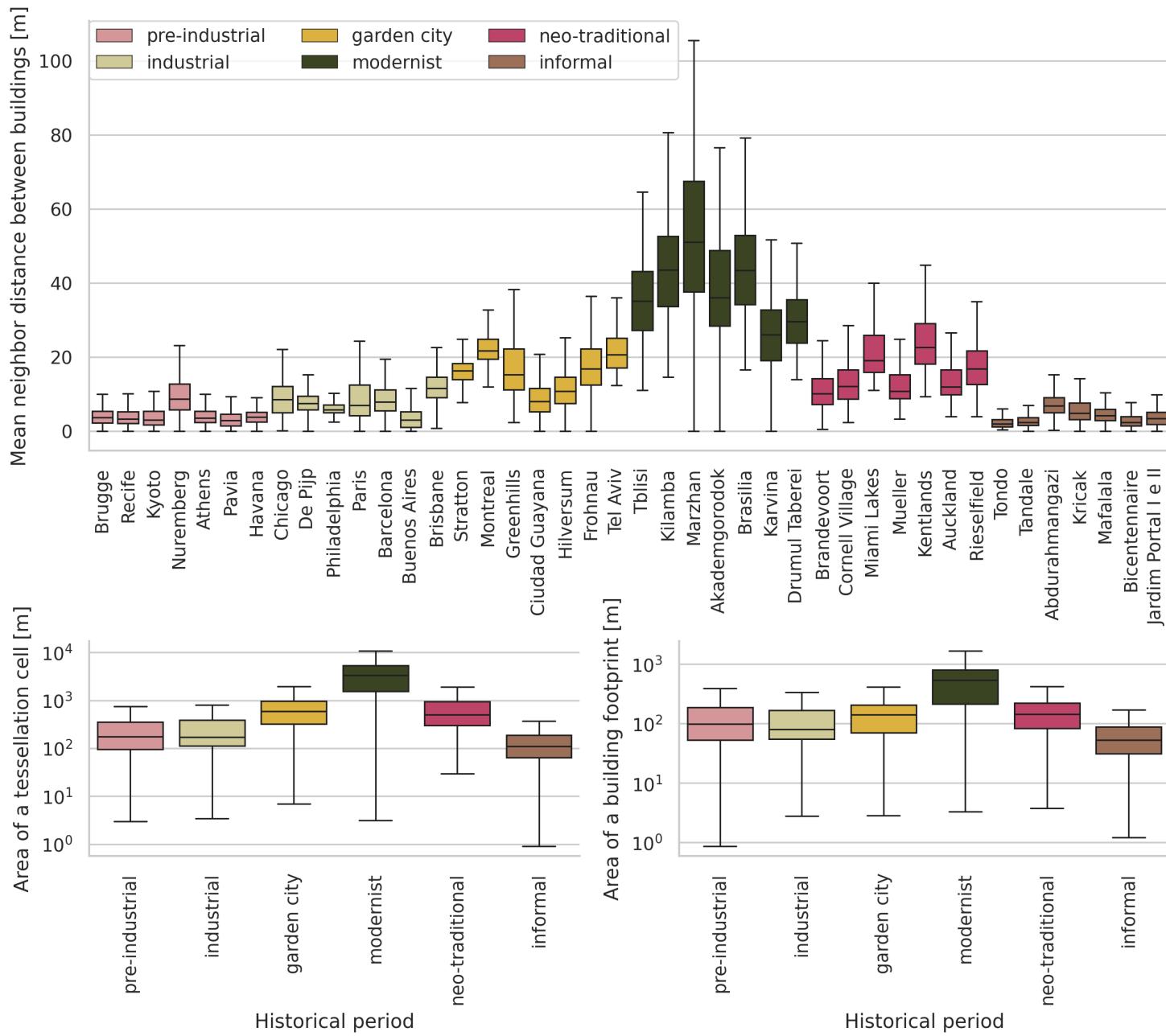
Miami Lakes  
(neo-traditional)



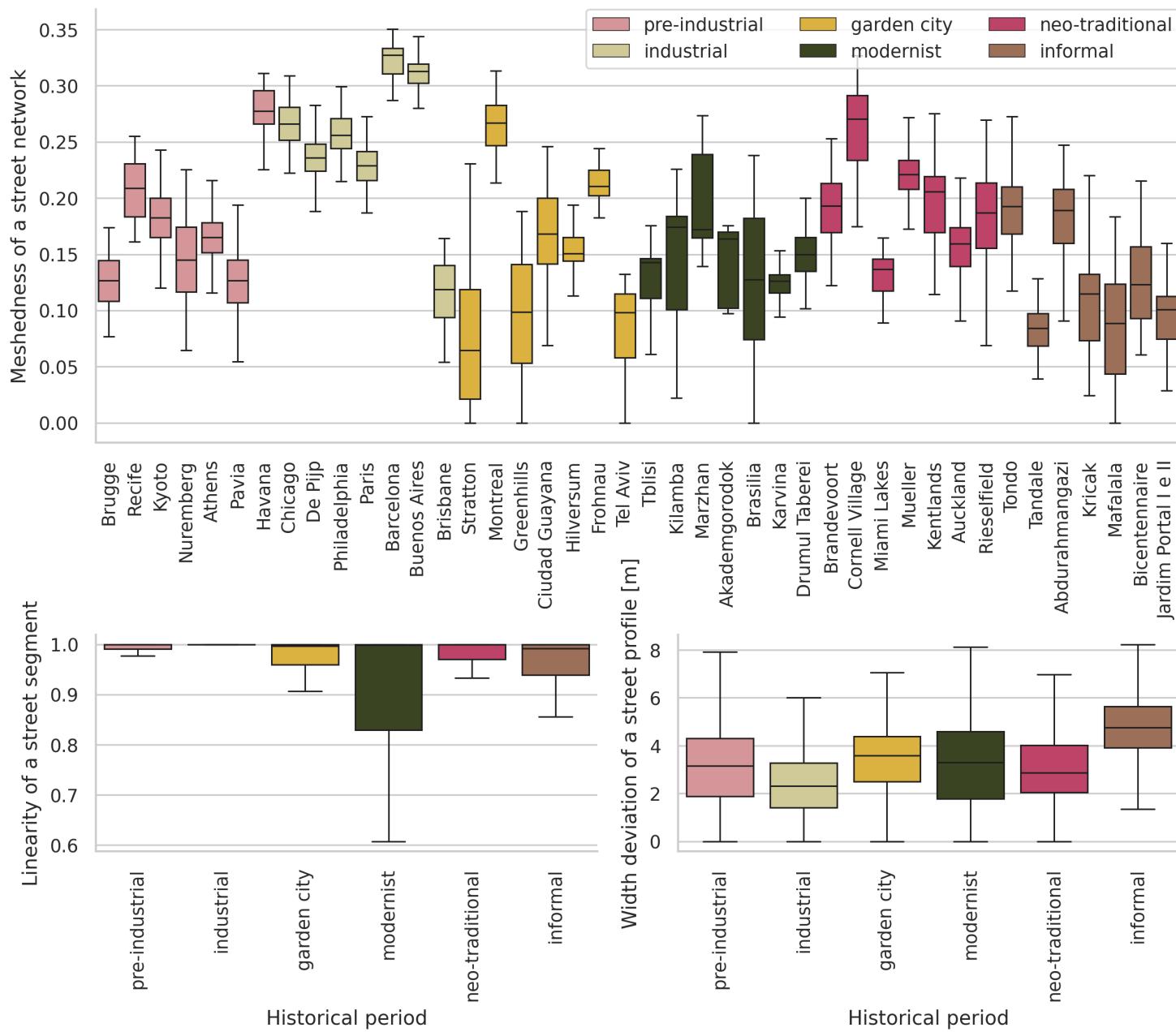
Tandale  
(informal)



# Scale peaked in modernism



# We forgot how to make a grid



# Classification

# Spatial Signatures

*A characterisation of space based on form and function  
designed to understand urban environments*

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# Form

*What does it look like?*

“Physical structure and appearance of cities”

Qualitative, quant. case studies, morphometrics,  
remotely sensed

# Function

*What is it used for?*

“Activities that take place within an environment”

Geography, Economics, Sociology, Environmental Sciences, Transport studies...

# Form & Function

- Richer picture
- Topography, history, technology, cultural values...
- More robust representations

# Opportunities

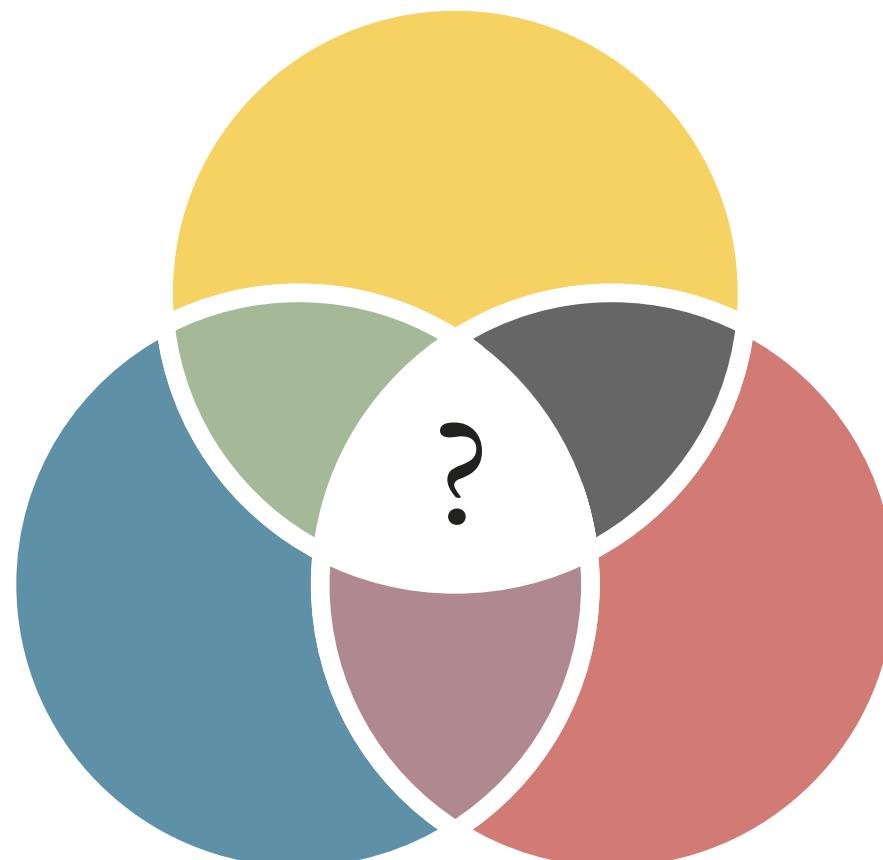
We don't have good ways of measuring form & function in cities

# Opportunities

detailed

scalable

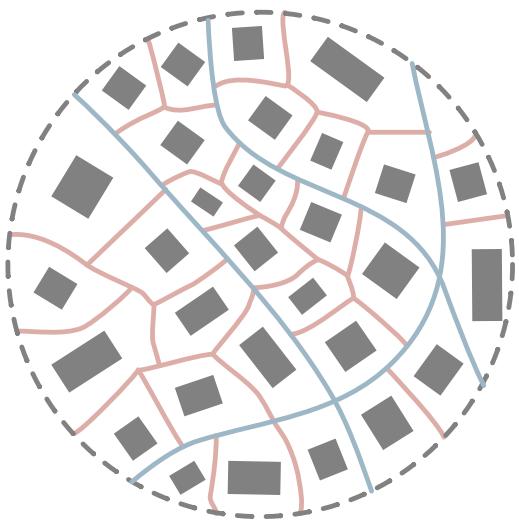
consistent



# Opportunities

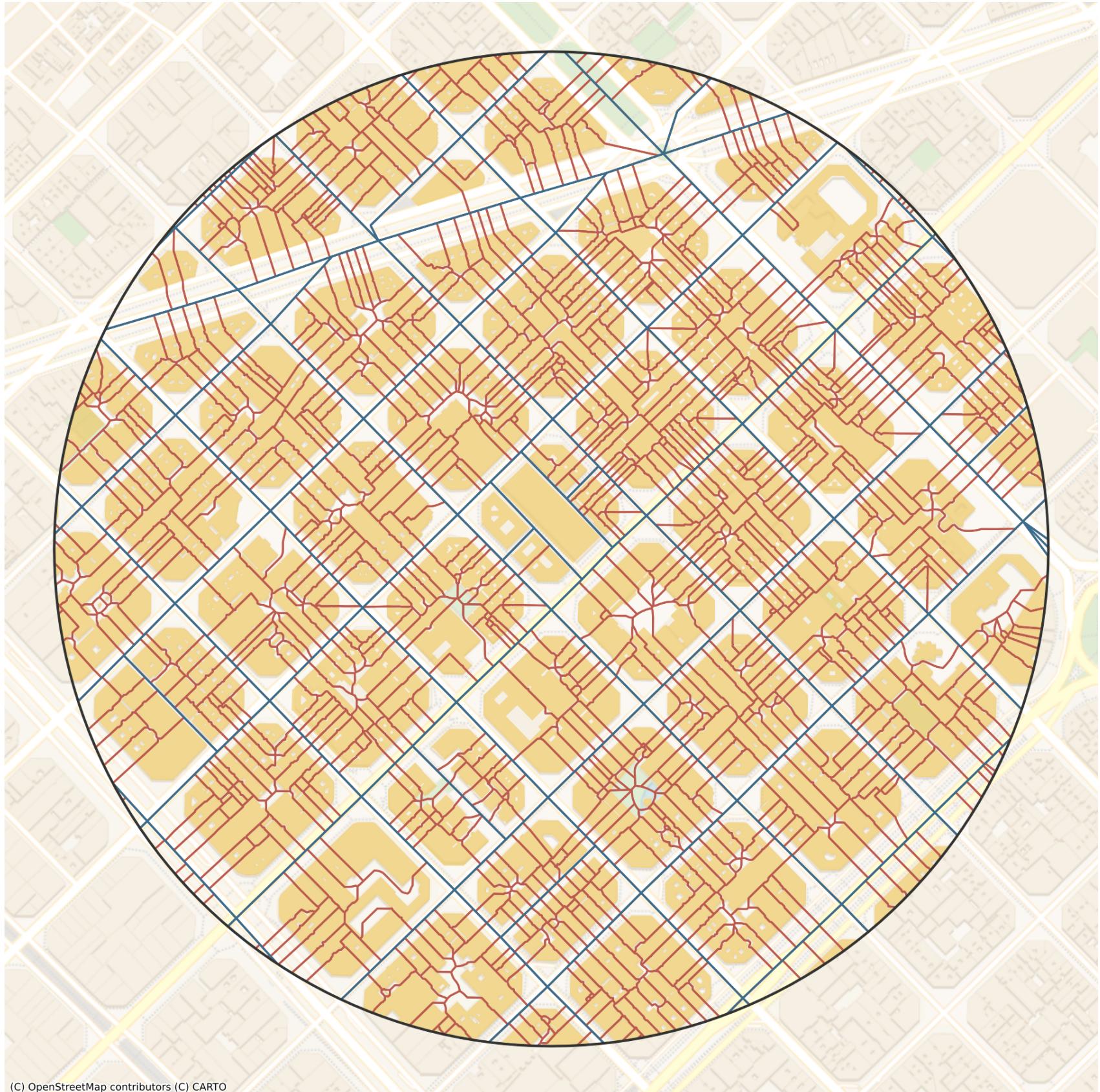
- Fragmented understanding
- Physical classification - ??? - Geodemographics

Enclosed  
Tessellation

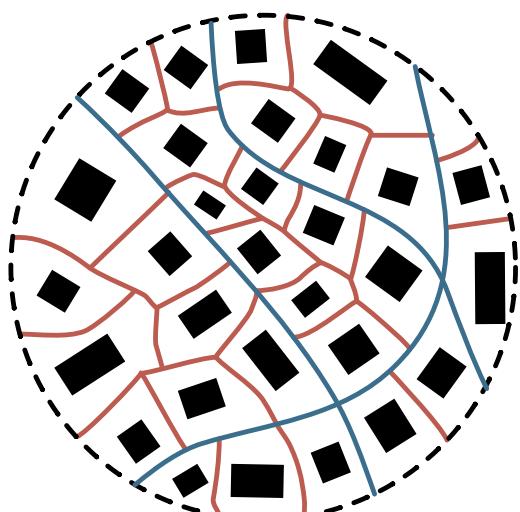


Embedding  
*form & function*

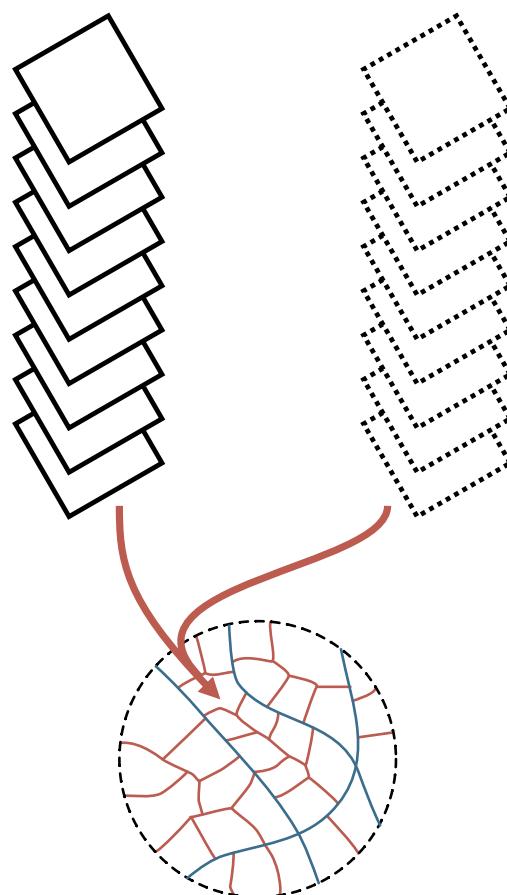
Spatial  
Signatures



Enclosed  
Tessellation



Embedding  
*form & function*



Spatial  
Signatures

# Characters

## Form

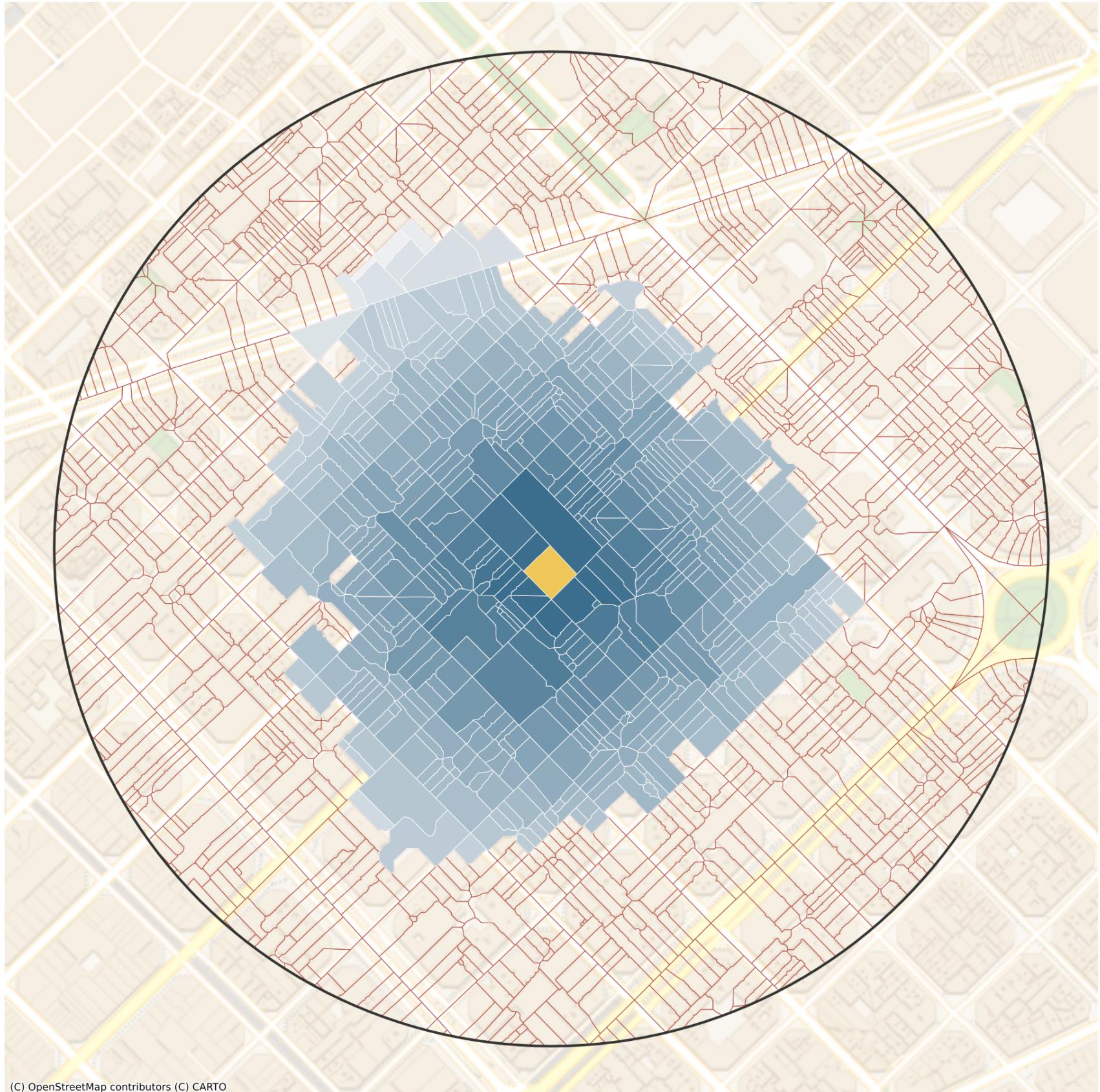
- Building
- ET cell
- Street segment
- Cell context
- ...

## Function

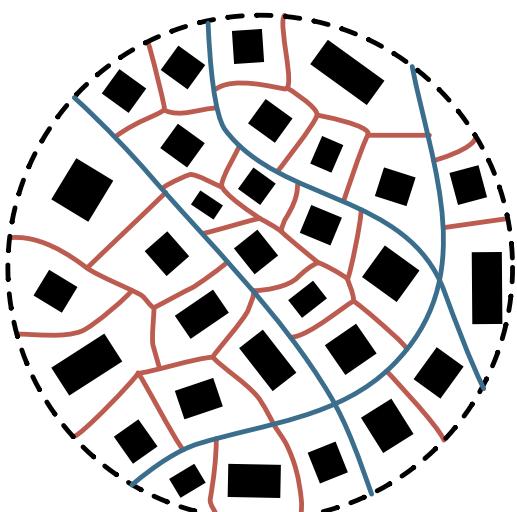
- Population
- Land use/cover
- Access to uses
- Activity densities
- ...

# Context

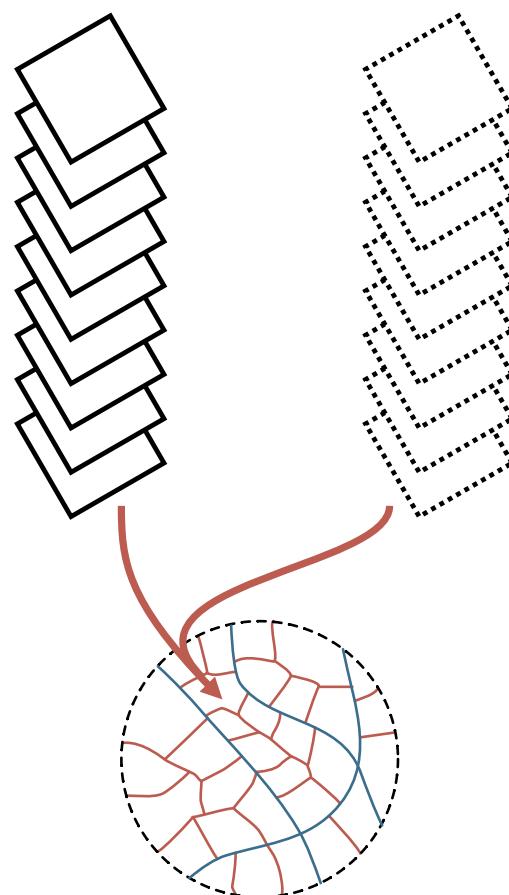
Every piece of information is considered within its  
spatial context



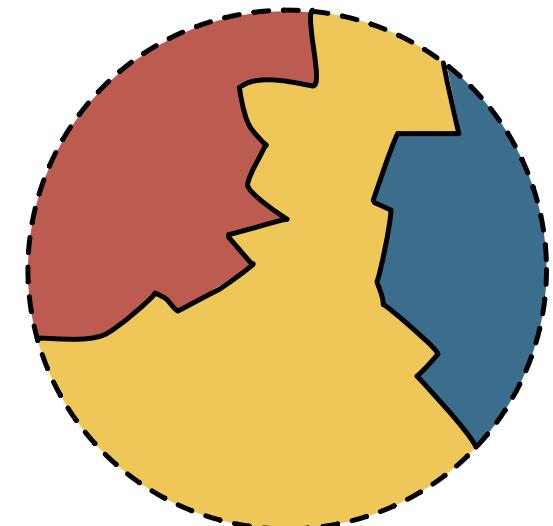
Enclosed  
Tessellation



Embedding  
*form & function*



Spatial  
Signatures



# Benefits

- Data-driven & (multidiscipline) theory-informed
- Granular & scalable
- Flexible deployment

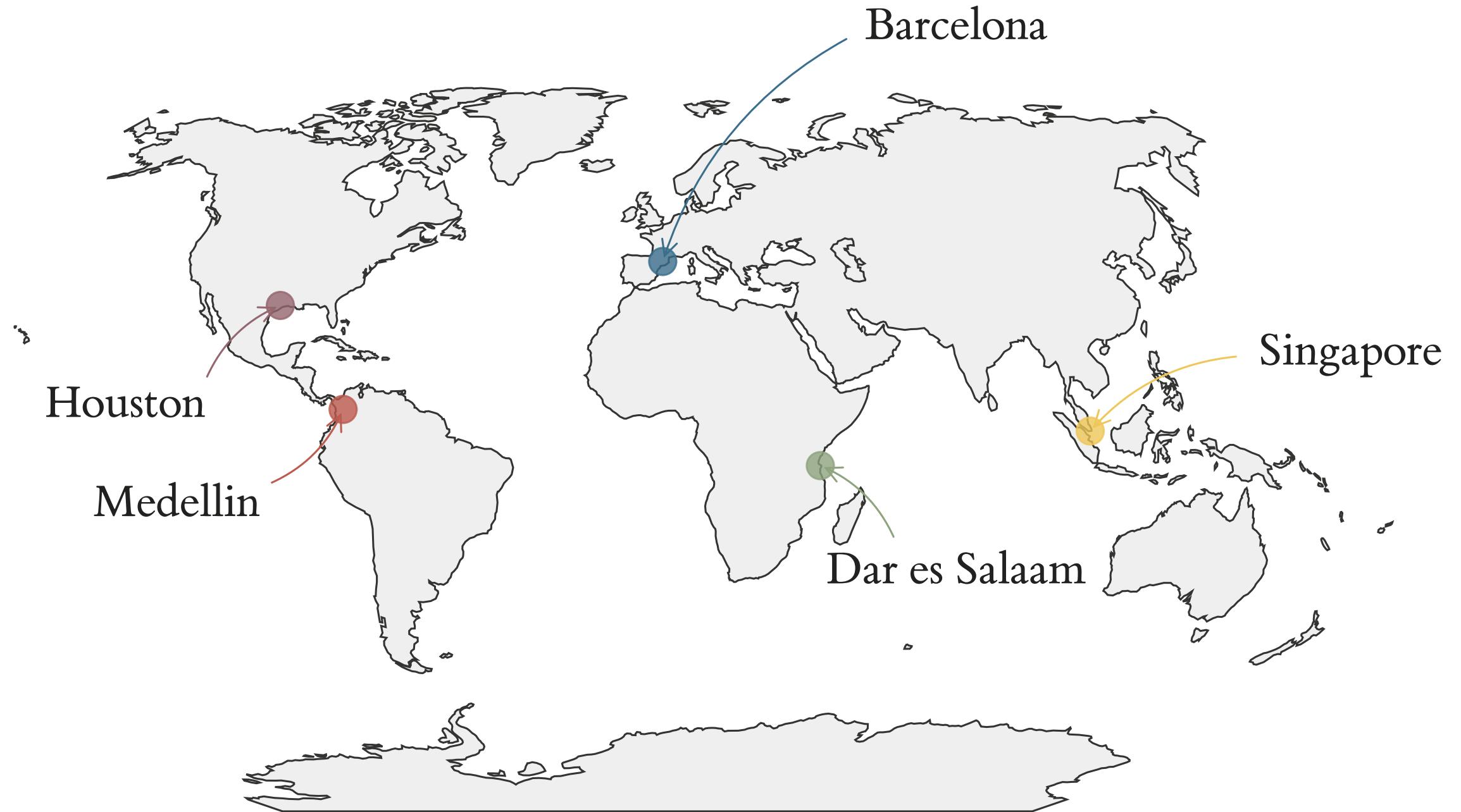
# Illustration

# The Setup

Five *different* cities

- Historical environments
- Geography & culture
- Data landscapes

# The Cities



# The Data

## Form

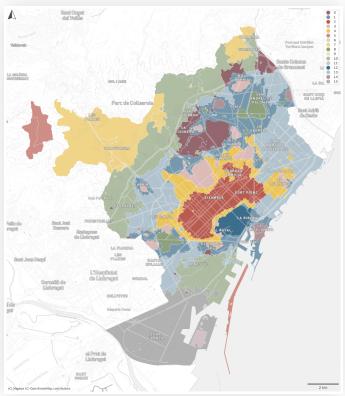
- Local open data
- OpenStreetMap
- Satellite-derived

## Function

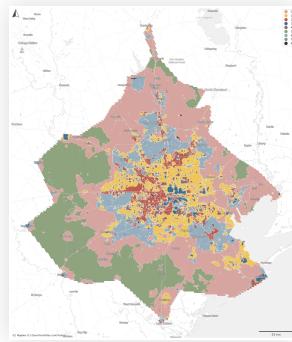
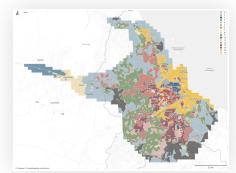
- Local open data
- Land use/cover
- Global grids
- Nightlights

Clustered with K-Means + clustergram

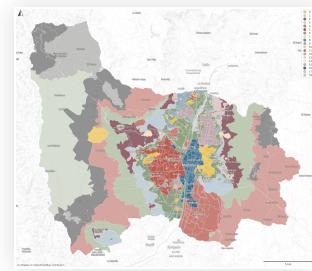
# The Signatures



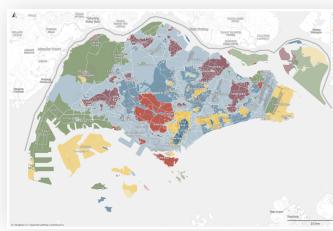
Barcelona  
Dar es  
Salaam



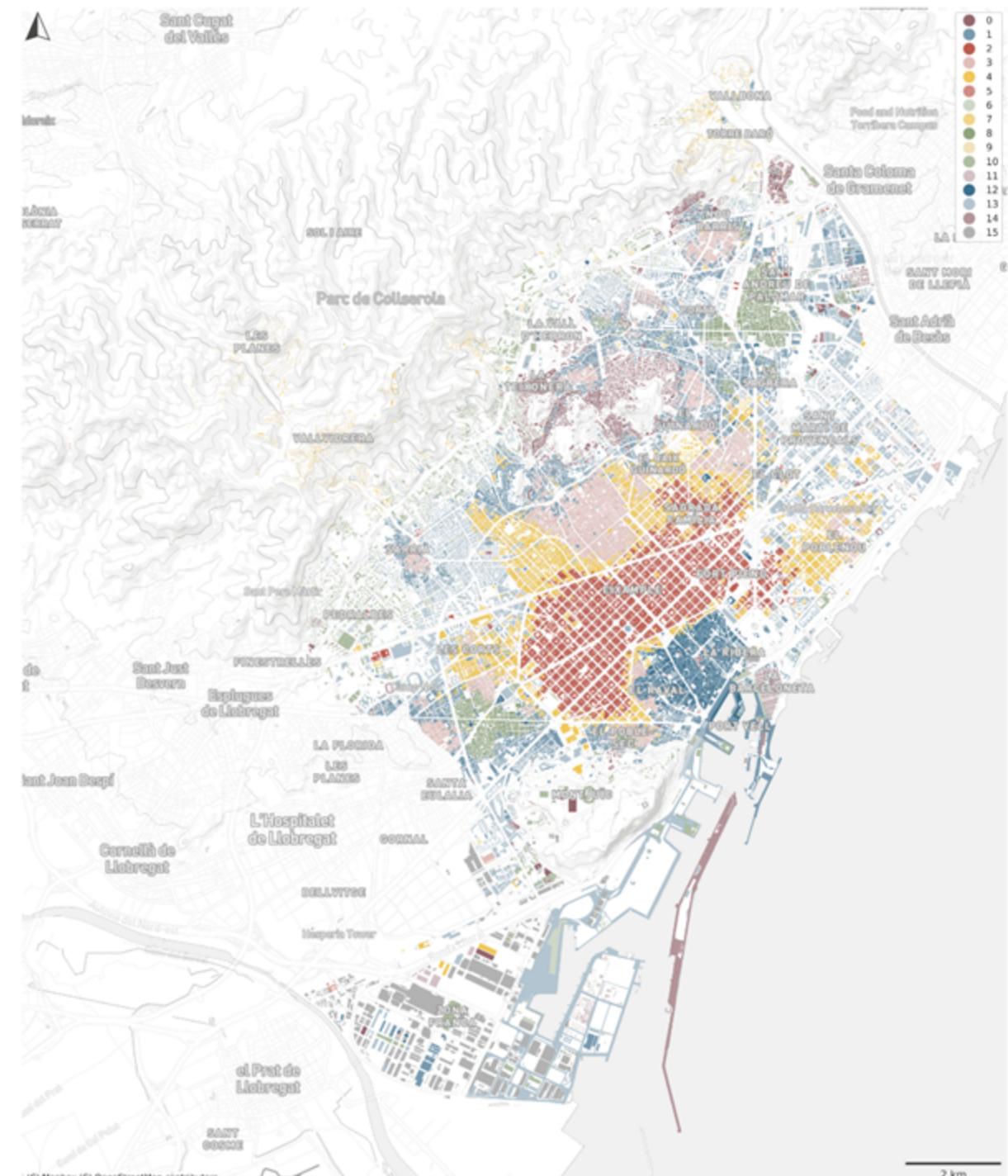
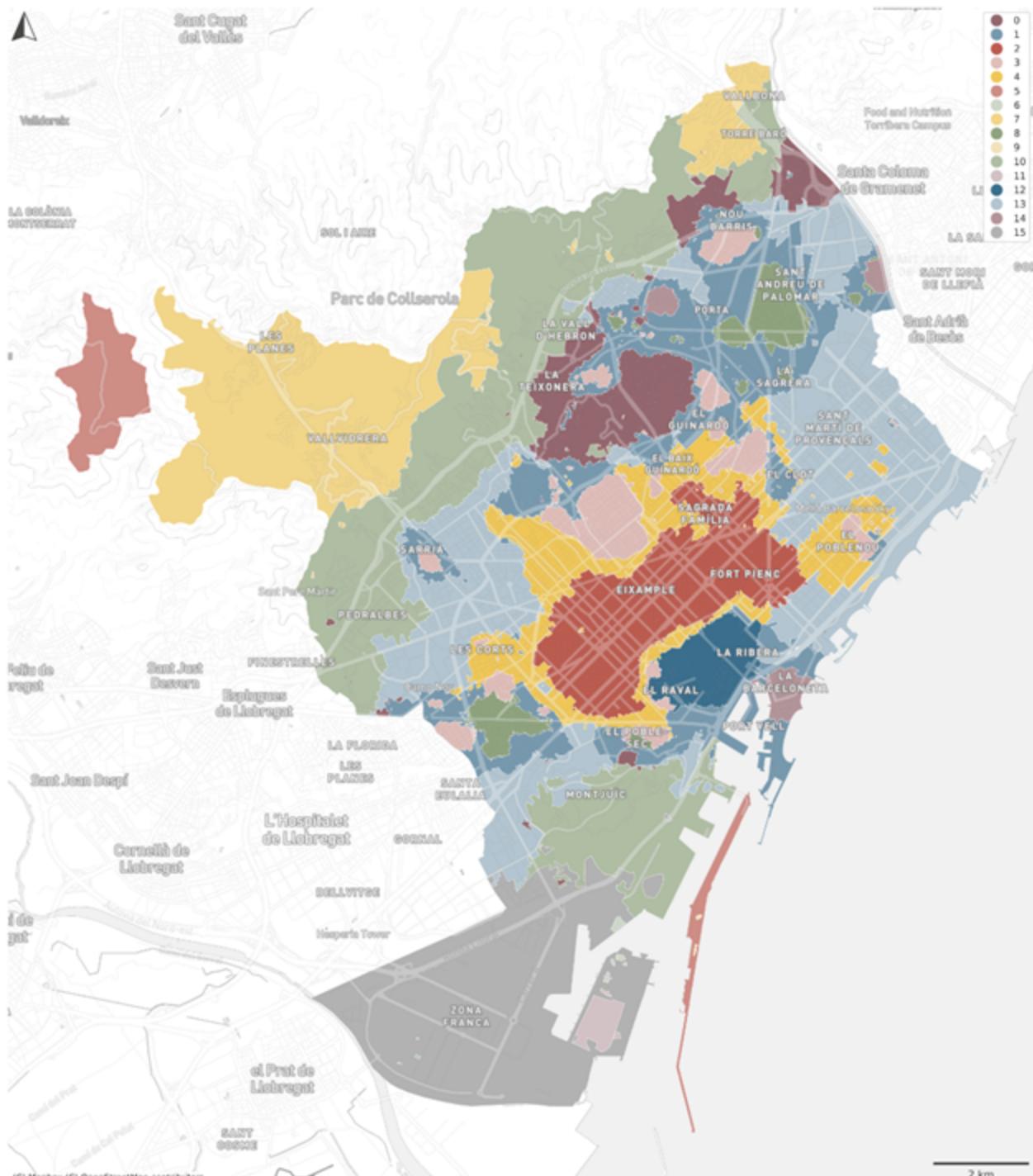
Houston



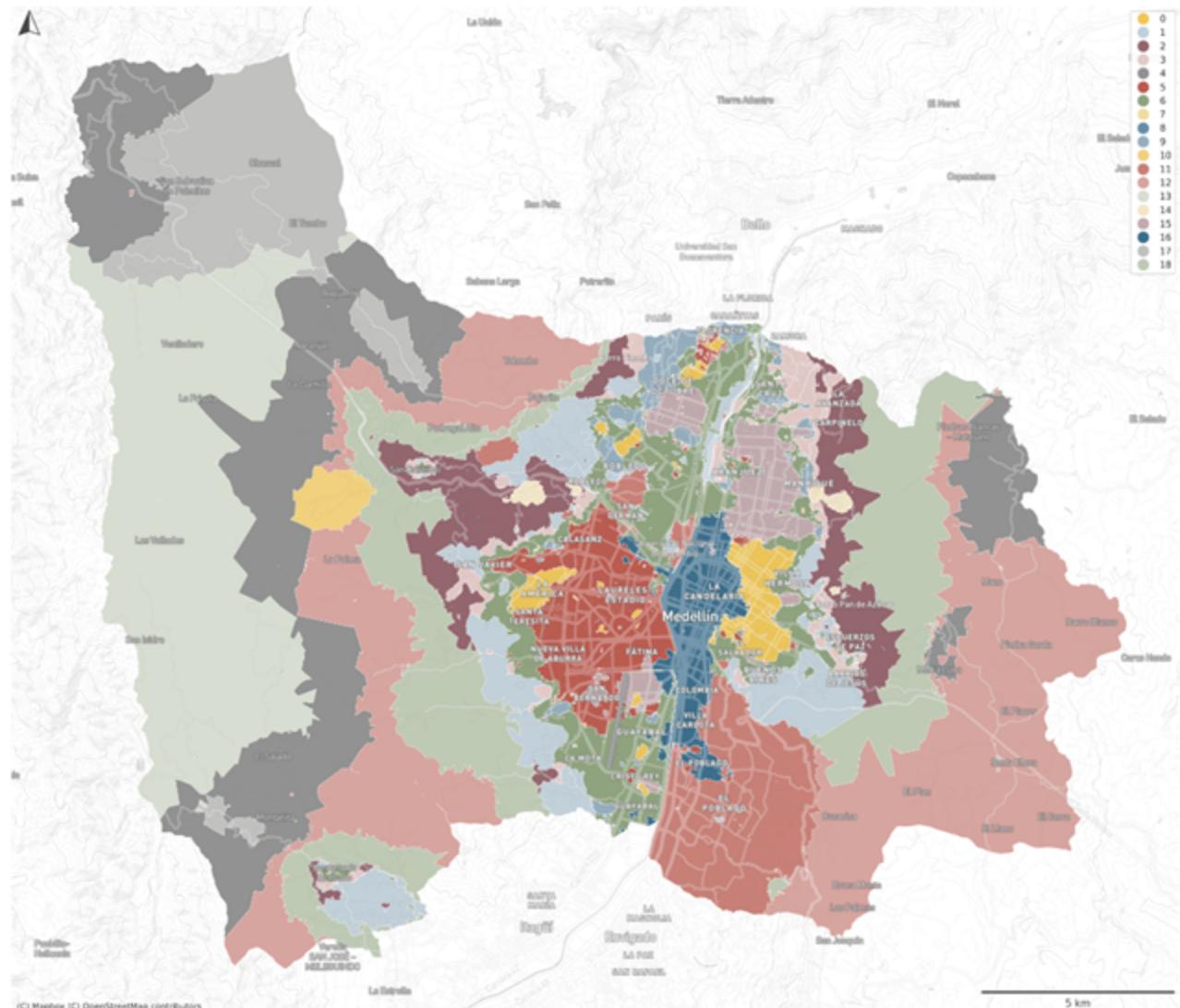
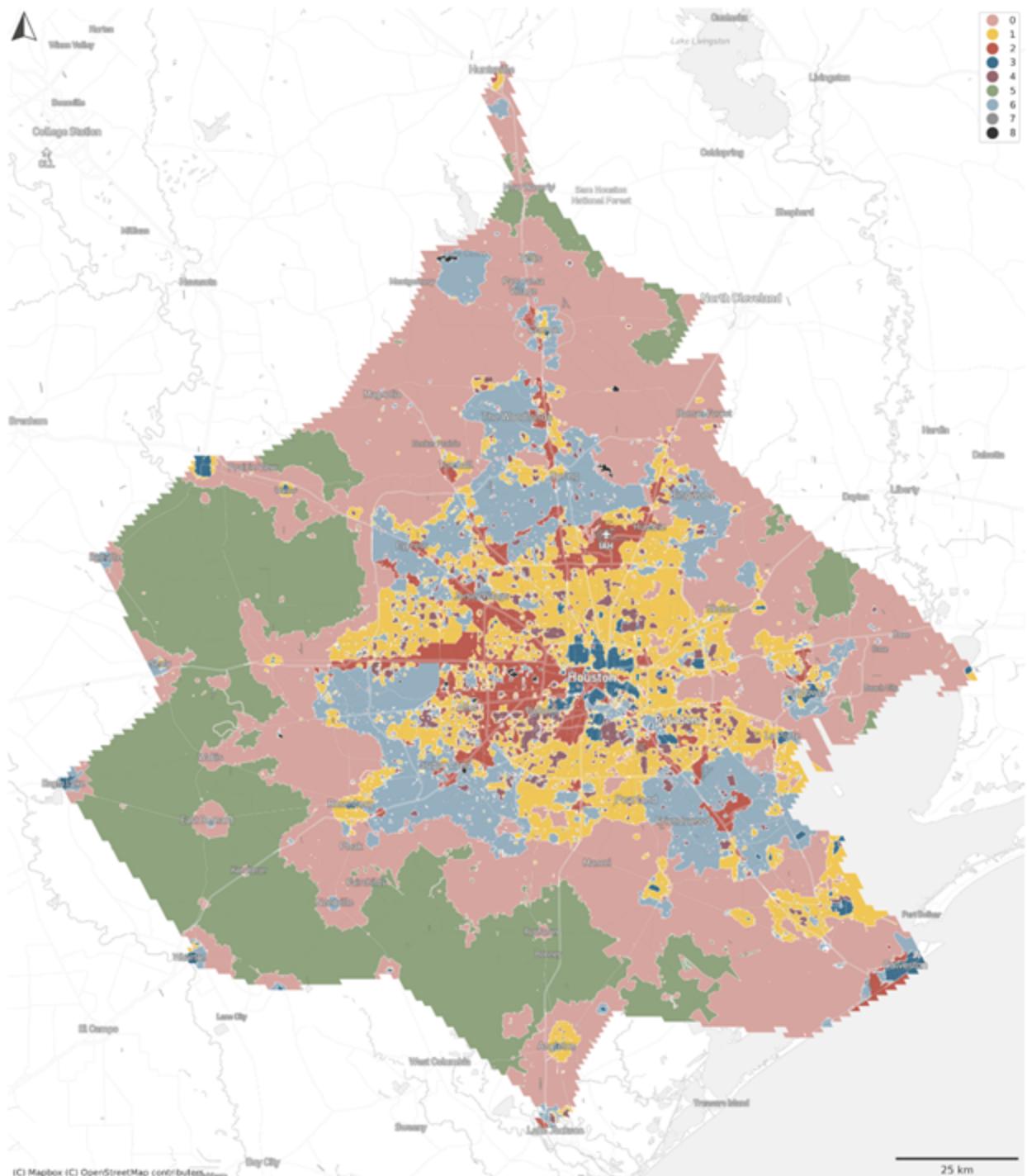
Medellin



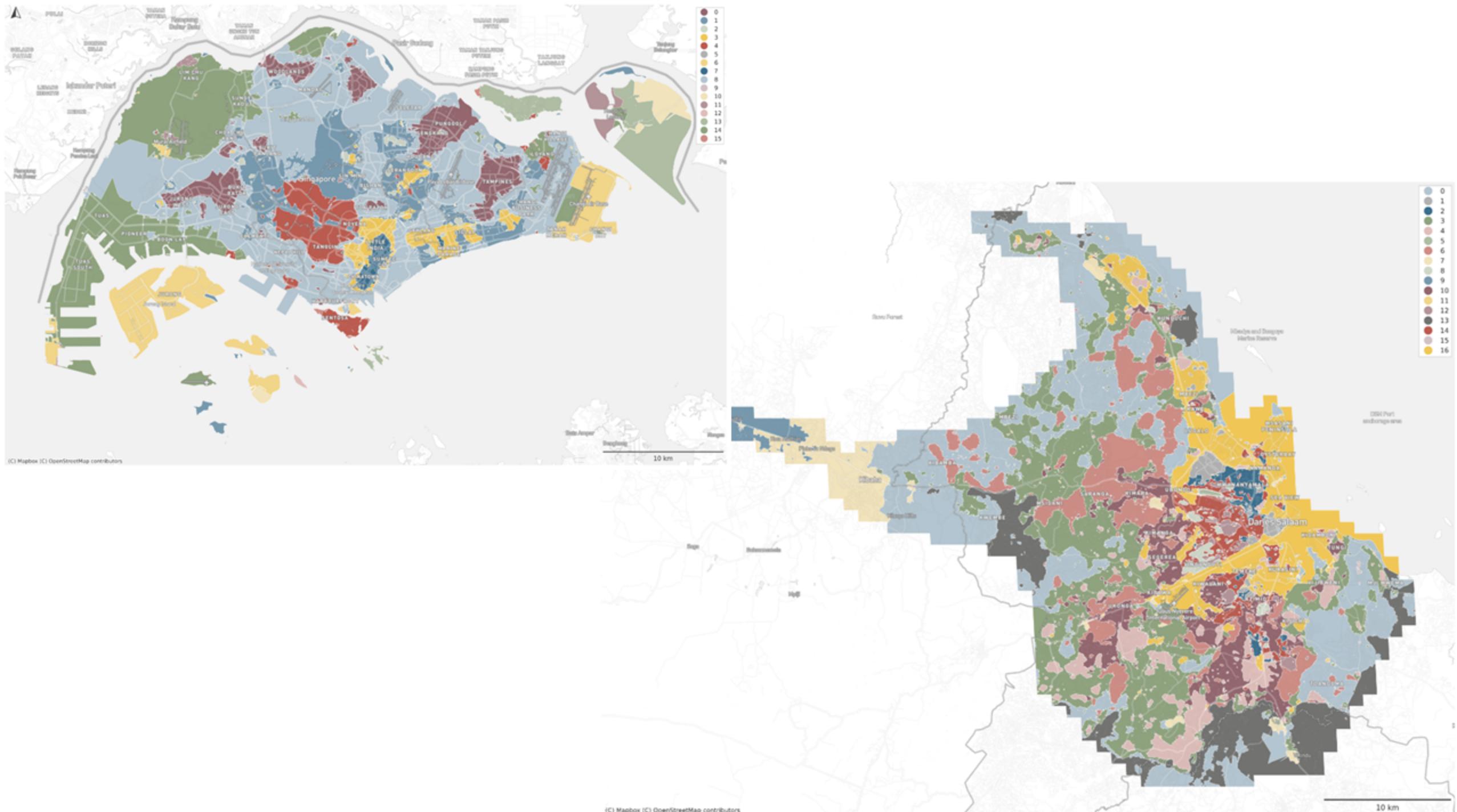
Singapore



Barcelona



Houston | Medellin



Singapore | Dar es Salaam

# To take away

1. Urban *form* and *function* matter
2. Spatial Signatures: F&F for cities, in detail, at scale
3. Good measurement → better understanding

# *Spatial Signatures*

*Dynamic classification of  
the built environment*

Dani Arribas-Bel

[@darribas]

Martin Fleischmann

[@martinfleis]



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