



Mapping Accessibility, Perception and Equity globally

My Journey at MIT Media Lab City Science

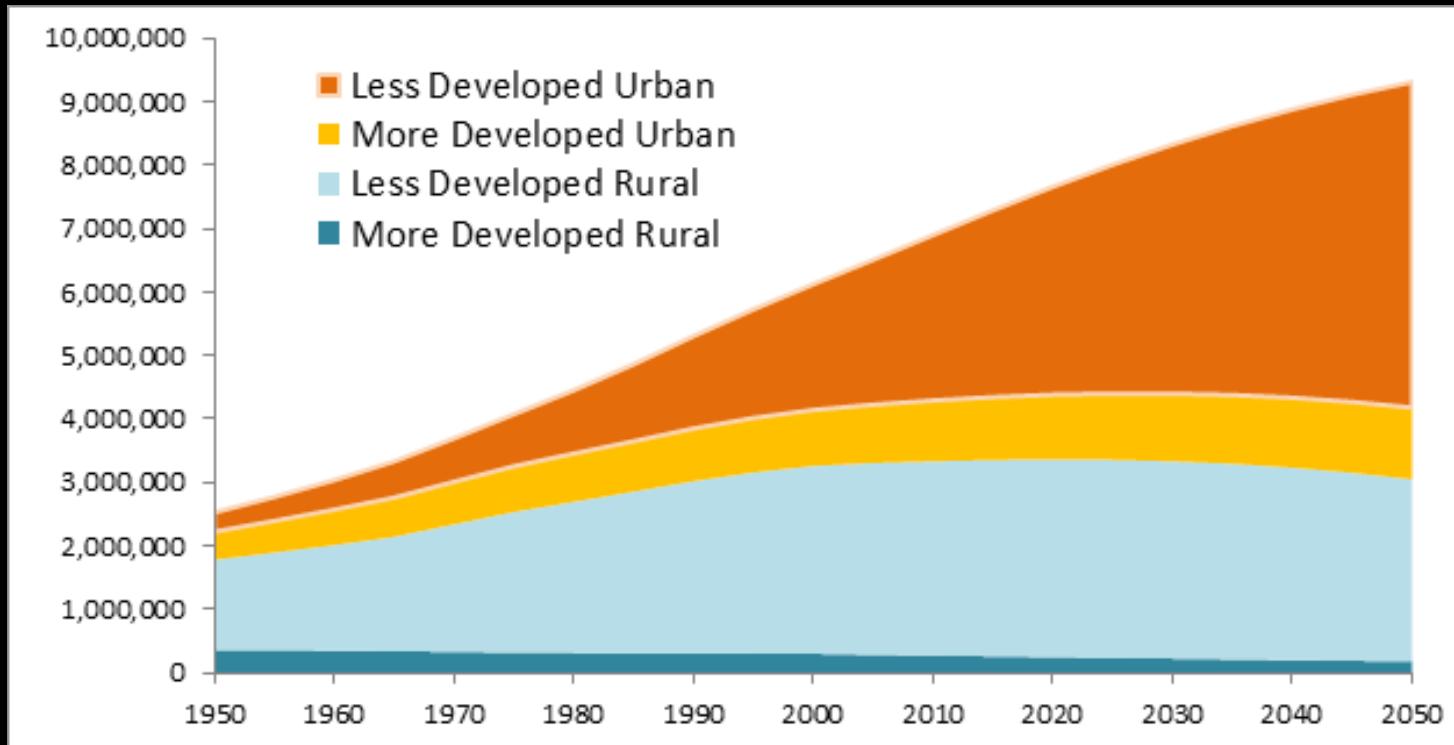
Miguel Ureña Pliego - Visiting Student - MIT Media Lab - City Science

About me



- Miguel Ureña Pliego
- MEng Civil Engineering at UPM (Spain)
- Visiting Student @ City Science (September 25 to March 2026)
- No drivers licence
(but licence to build roads)
- I like cats

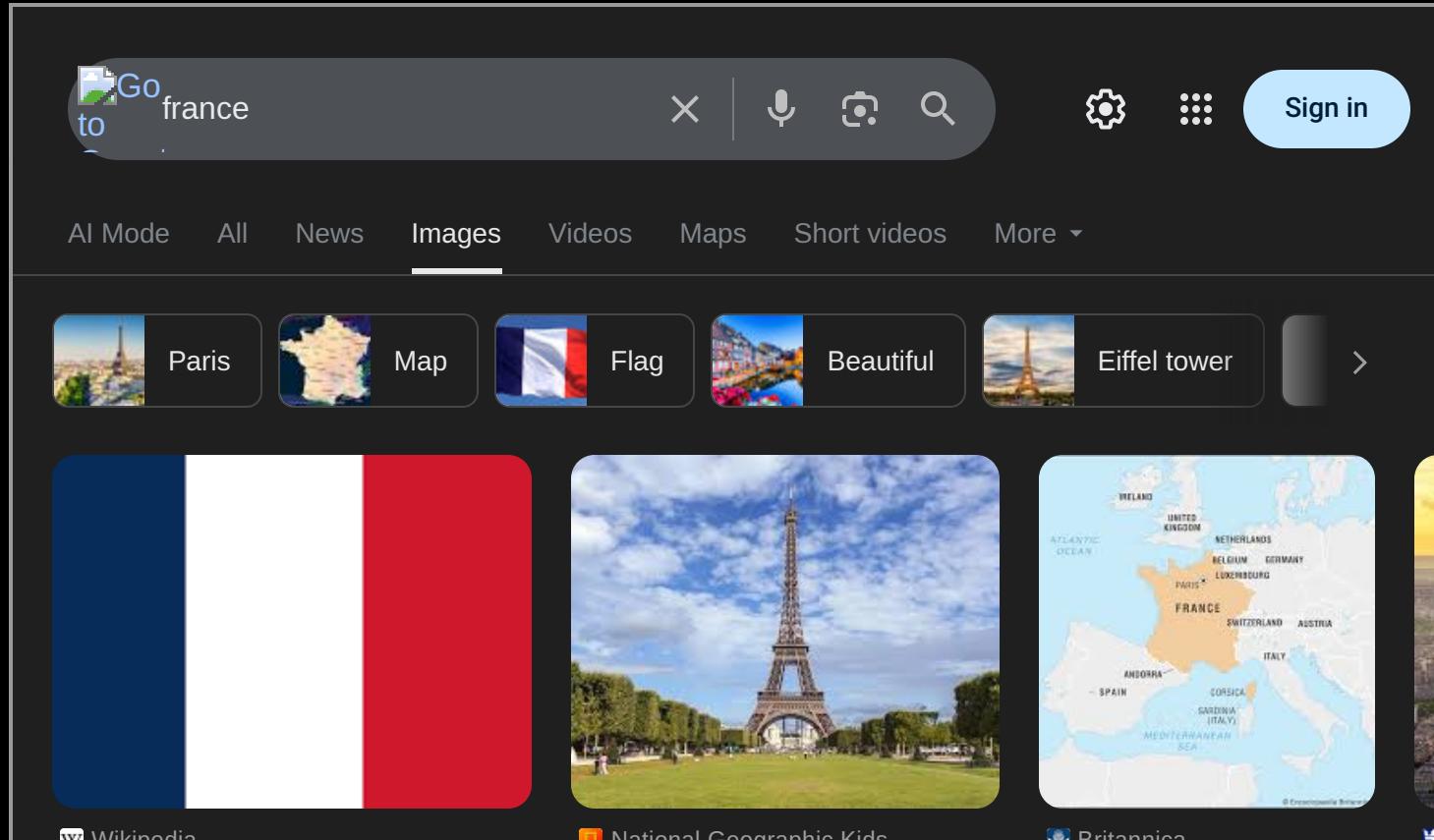
Cities are important



- Urban population growth
- Asia exploded
- Africa?



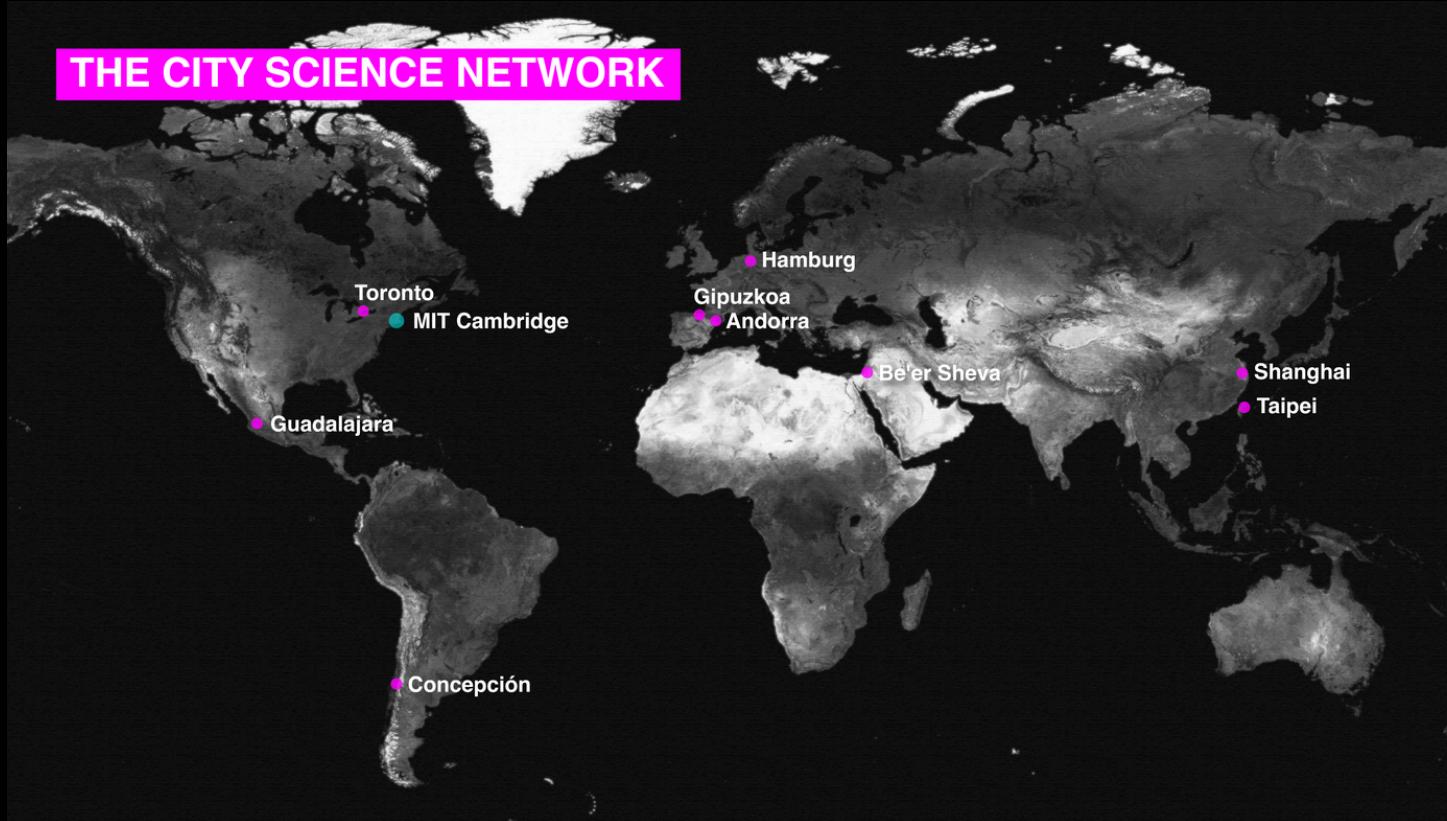
Cities are important



- Cities always had power and identity
- A world of cities beyond nation states...



The city science network



- MIT Media Lab City Science
- 10 city science labs
- Close relationship with local administration
- North/south America, Europe and Asia



What is accessibility?



- Good KPI for coverage
- Points of Interest (Pols) + Distance / Time
- Very related to the 15-min-city
- Access if you don't drive?
- Work with [Naroa Coretti](#)



But not every PoI is equally attractive...

- Transit stop:
Subway vs bus
 - Groceries:
Large chain vs small shop
- 
- $$\text{Accessibility} = \text{PoI quality} \times \text{Distance}$$



Motivation

The screenshot shows a news article from the website [elDiario.es](#). At the top, there is a navigation bar with various links: HOY HABLAMOS DE..., Acto Rufián, Jefe Policía Nacional, Fiscal general, DAO, Pocholos, Burka, Telefónica, ERE Iberia, Bad Bunny, Argentina, Borrasca Pedro, Gastos Renta 2025, Audiencias TV, Pensiones febrero, Vinicius, and Calendario. Below the navigation is a large, empty rectangular area labeled "PUBLICIDAD". The main content begins with the **elDiario.es** logo and a three-dot menu icon. A blue header bar contains the word "Aragón". The main headline reads: **Un informe destapa las graves carencias de Zaragoza en movilidad y apuesta por la línea 2 del tranvía para paliarlas**.



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Mapping accessibility globally

8

Accessibility to public transport

Accessibility = PoI quality \times Distance



The city science accessibility contest



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Mapping accessibility globally 10

Accessibility to public transport

- Pols - Stops

$$\text{Accessibility} = \overbrace{\text{PoI quality}}^{\text{Public Transport quality}} \times \text{Distance}$$



Accessibility to public transport

- Pols - Stops
- Stop quality

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \text{Distance}$$



Accessibility to public transport

- Pols - Stops
- Stop quality
- Normalization [0, 1]

$$\underbrace{\text{Accessibility}}_{[0,1]} = \overbrace{\underbrace{\text{headway}}_{[0,1]} \cdot \underbrace{\text{speed}}_{[0,1]} \cdot \underbrace{\text{mode}}_{[0,1]}}^{\text{public transport quality}} \times \underbrace{\text{distance}}_{[0,1]}$$

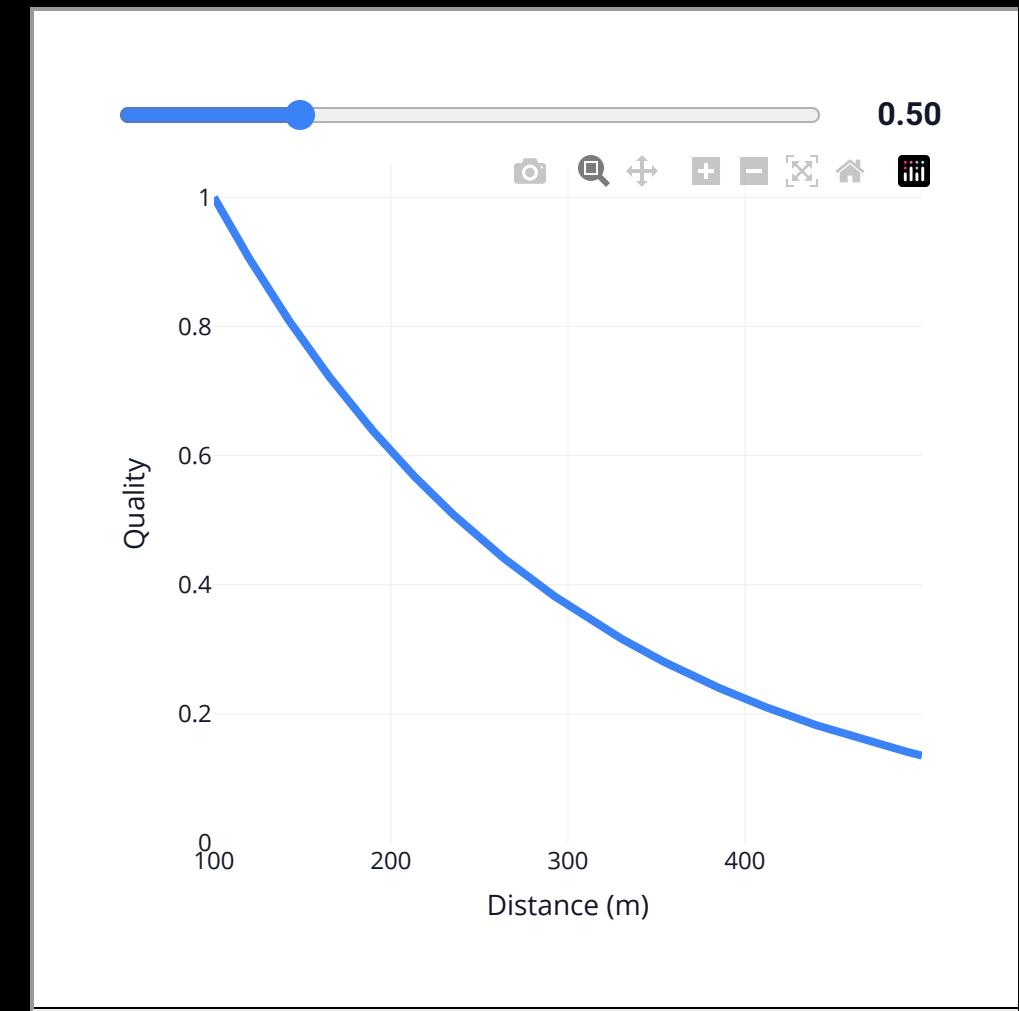


Quality functions

Distance → [0, 1]

Exponential decay function - Elasticity:

$$e = \frac{\% \text{ change in Demand} (\approx \text{ Quality})}{\% \text{ change in Distance}}$$



Accessibility to public transport

- Pols - Stops
- Stop quality



- Timetables

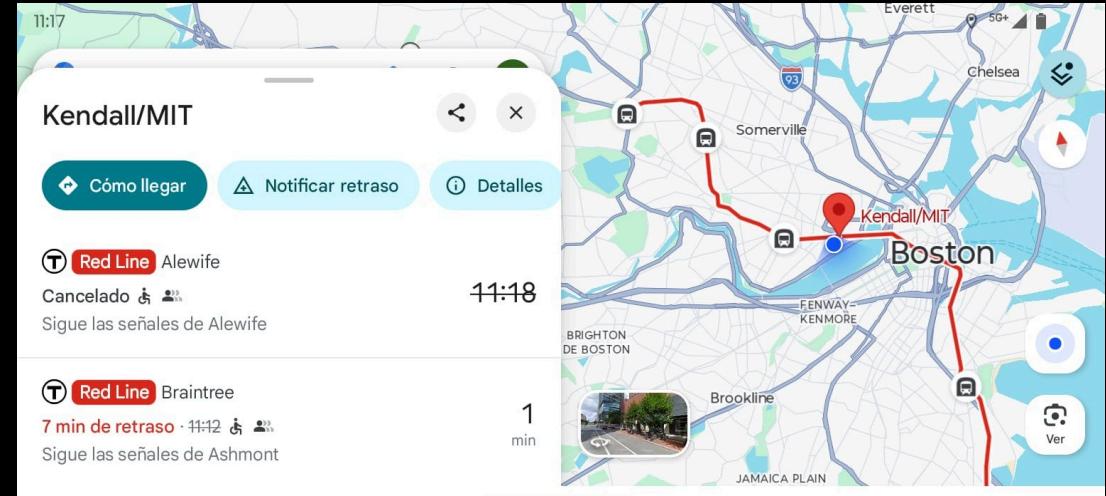
$$\text{Accessibility} = \underbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}_{\text{Public Transport quality}} \times \text{Distance}$$



Public transport timetables: GTFS

Global standard

- Mobility Database API
- Transitland API
- Local agencies (mandatory in the EU)



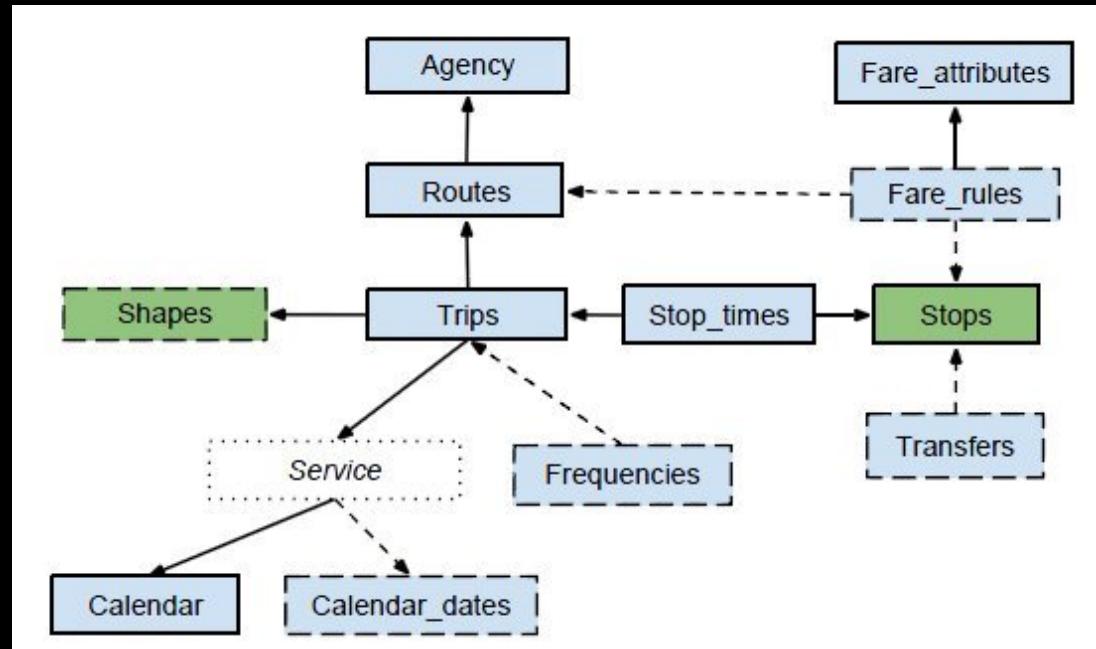
We all use it



Not that easy...

✓ GTFS → stop location

😢 GTFS → headway, speed, mode



GTFS file structure

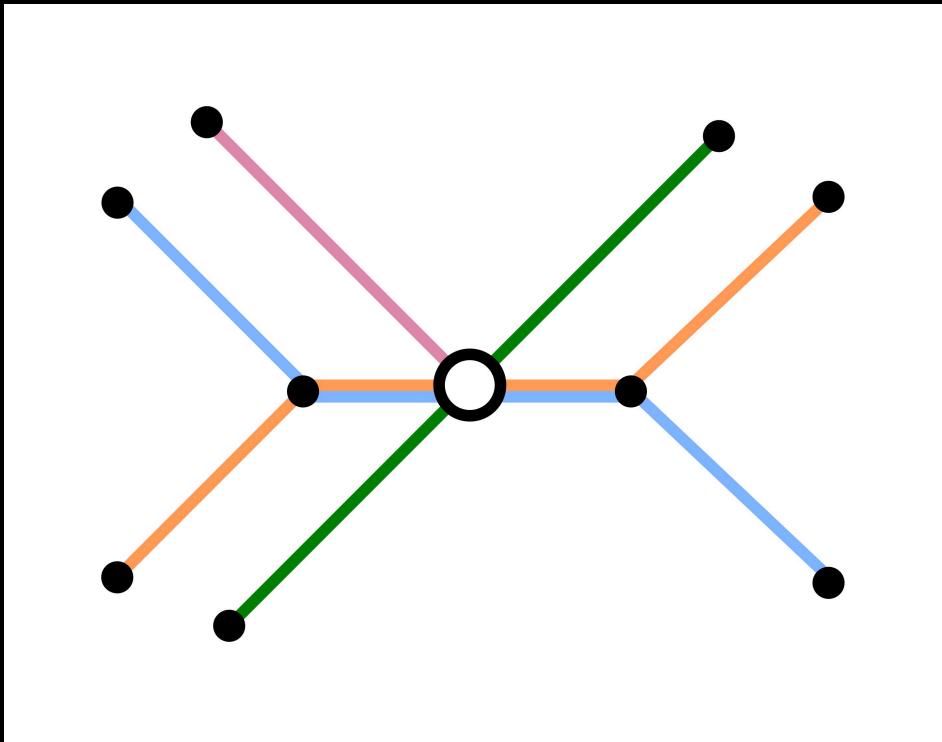


Stop quality

$$\text{Accessibility} = \overbrace{\text{headway}}^{\text{Public Transport quality}} \cdot \text{speed} \cdot \text{mode} \times \text{Distance}$$



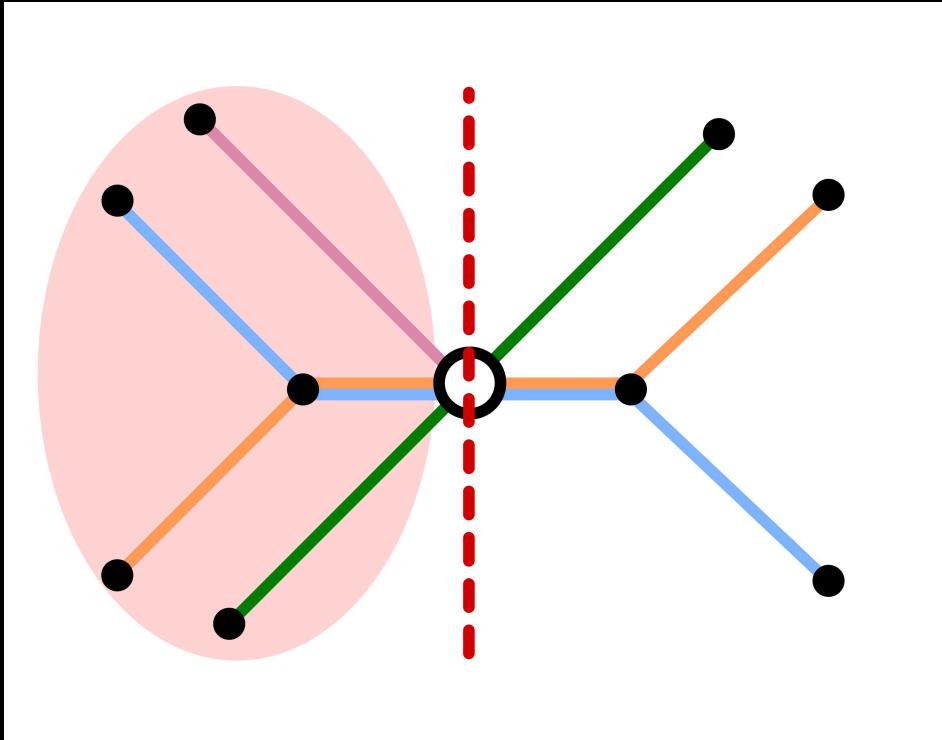
Headway



Contribution of multiple routes?



Headway

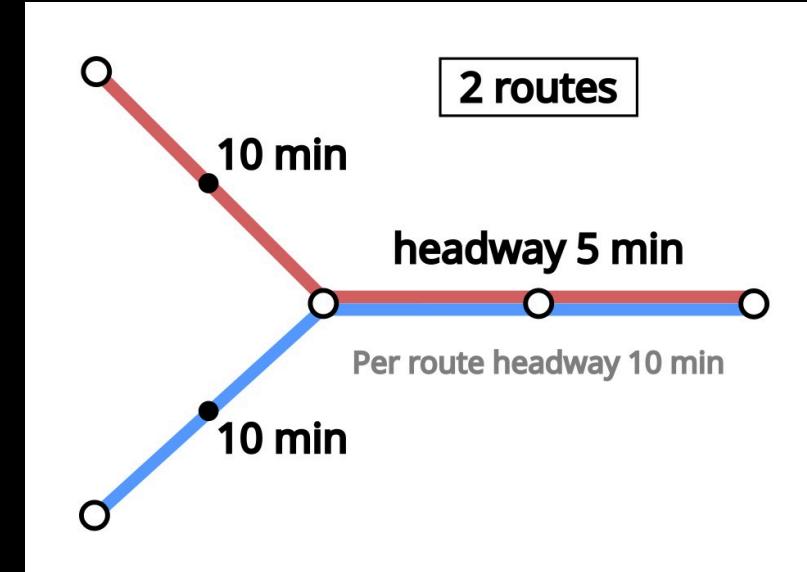
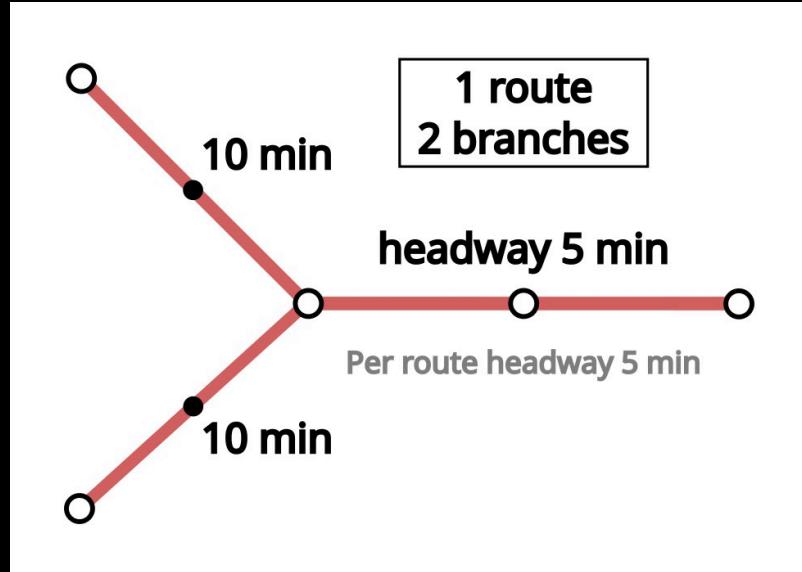


Harmonic mean

$$\text{HM} = 1 / \left[\text{mean} \left(\frac{1}{\text{headway}_i} \right) \right]$$



Headway: Trips and routes



The problem with the 'route' concept. Better use trips.



Headway

Elasticity:

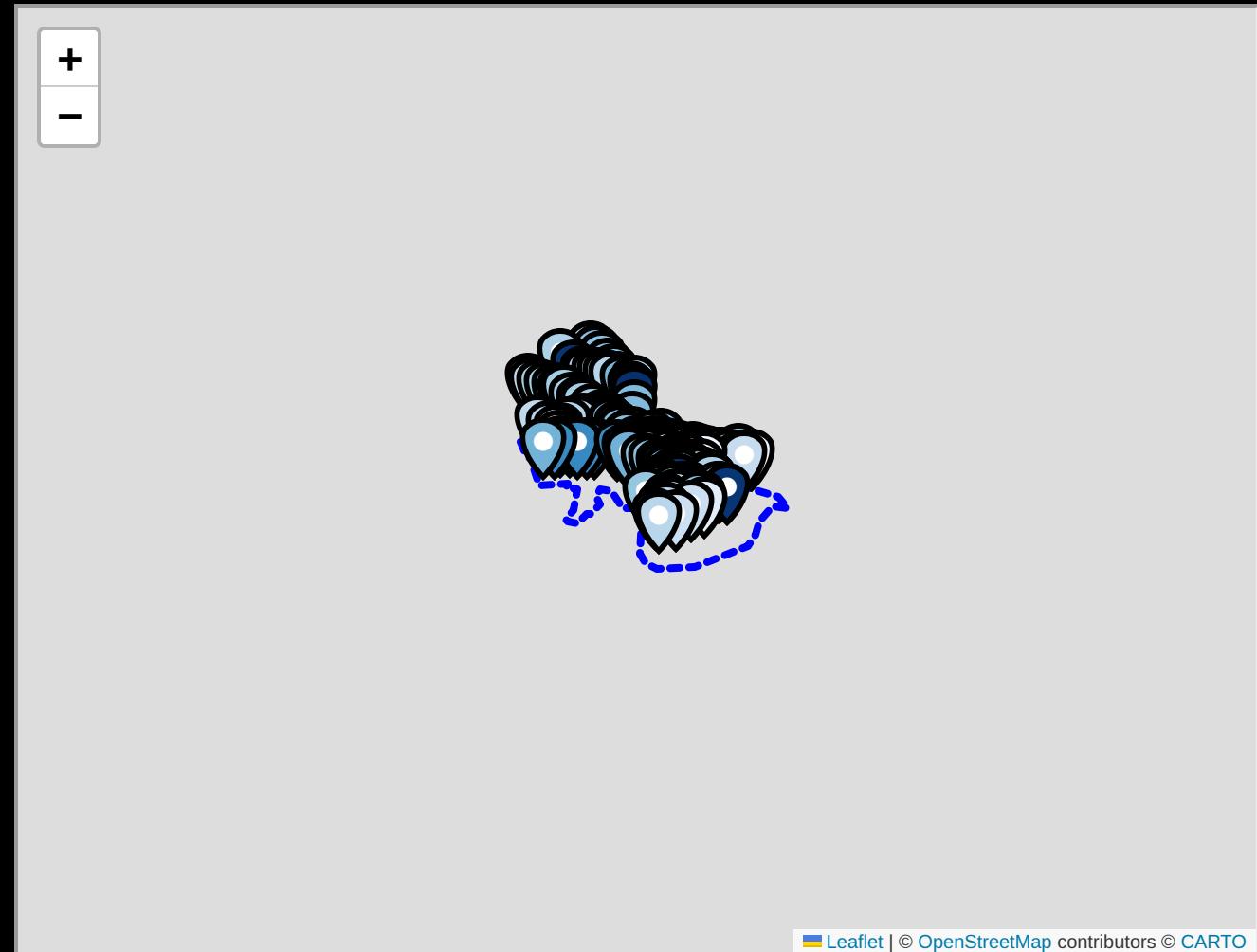
Theoretical value:

0.5 (Mohring's Law)

Empirical:

< 30 min: $e = 0.3$ to 0.5

> 60 min: $e = 0.6$ to 1



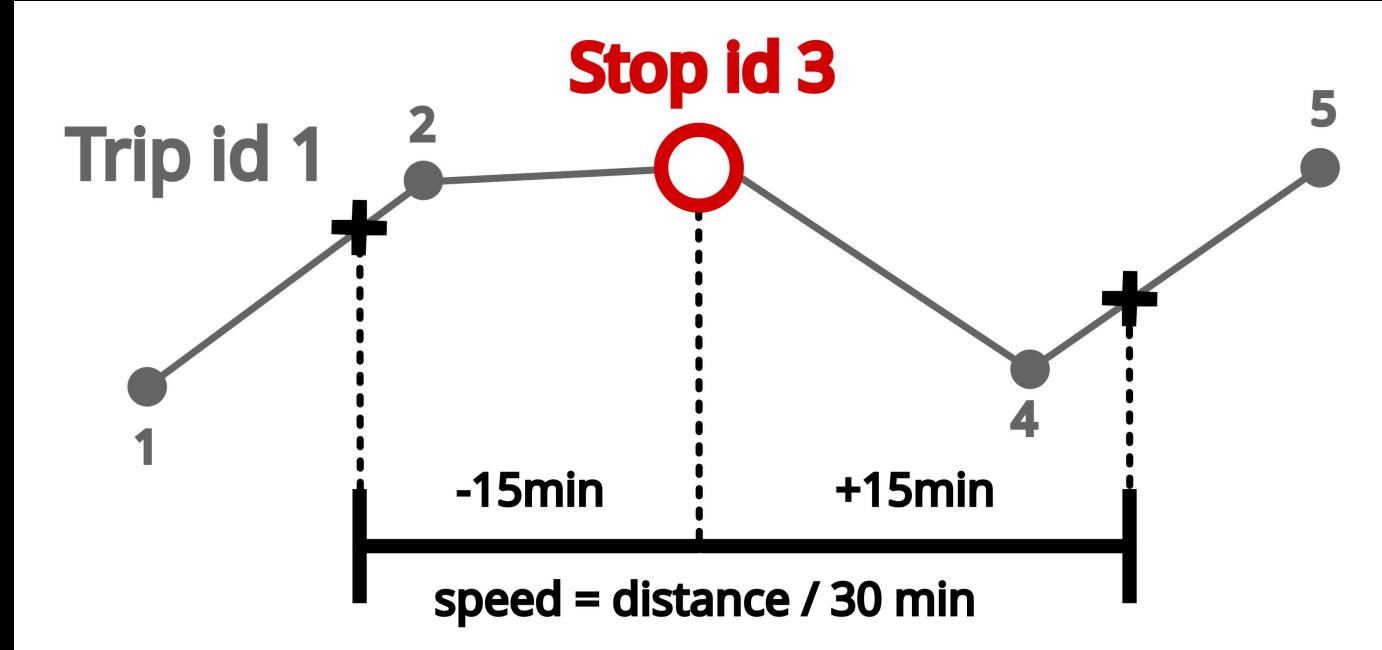
Stop quality

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \text{Distance}$$



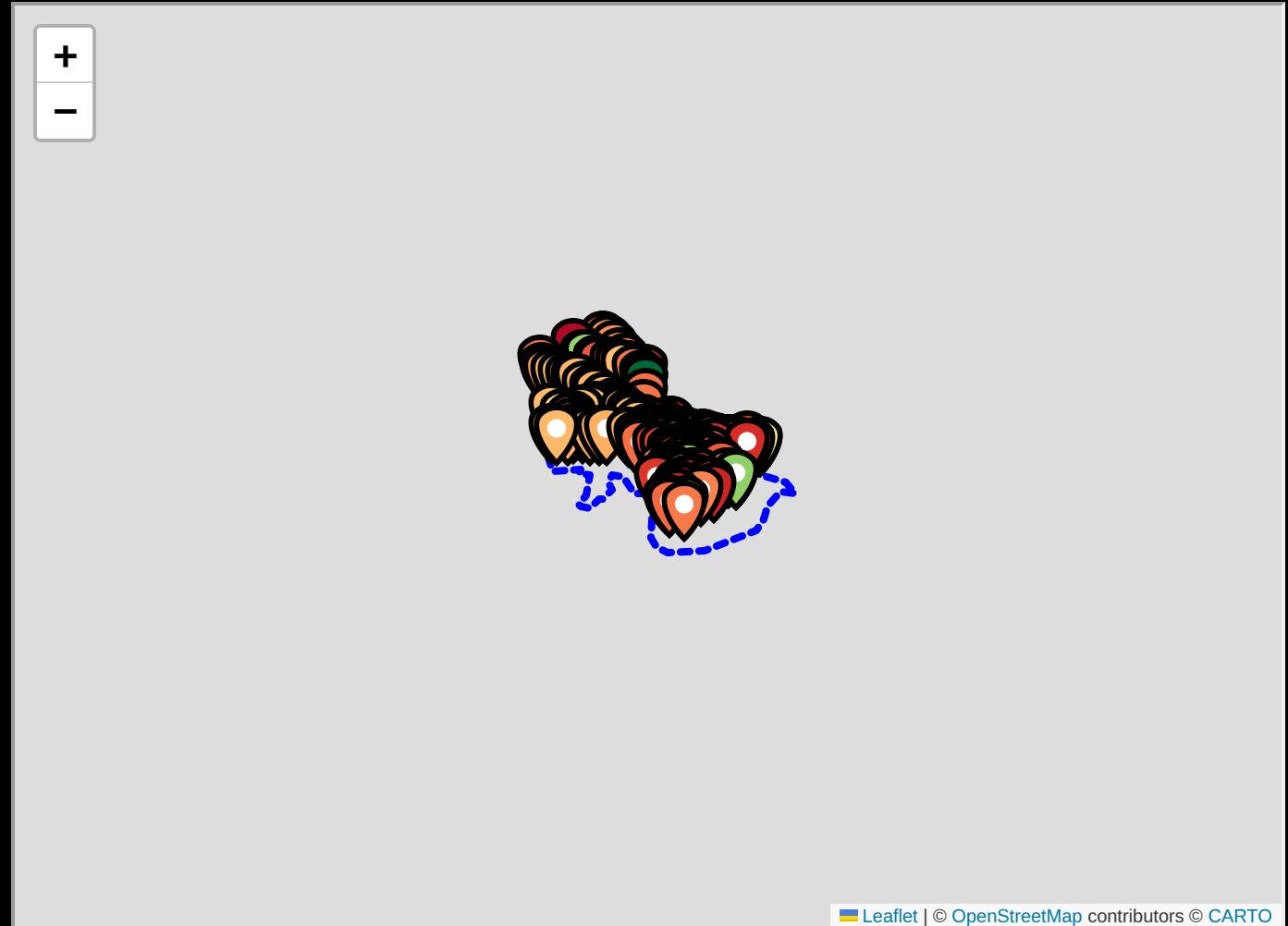
Speed

- Per trip and stop
- Measured ± 15 minutes around each stop
- Elasticity: $e = 0.1 - 0.4$ (smaller than headway)



Speed

- Per trip and stop
- Measured ± 15 minutes around each stop
- Elasticity: $e = 0.1 - 0.4$ (smaller than headway)



 Leaflet | © OpenStreetMap contributors © CARTO



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Mapping accessibility globally 25

Stop quality

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \text{Distance}$$



Mode

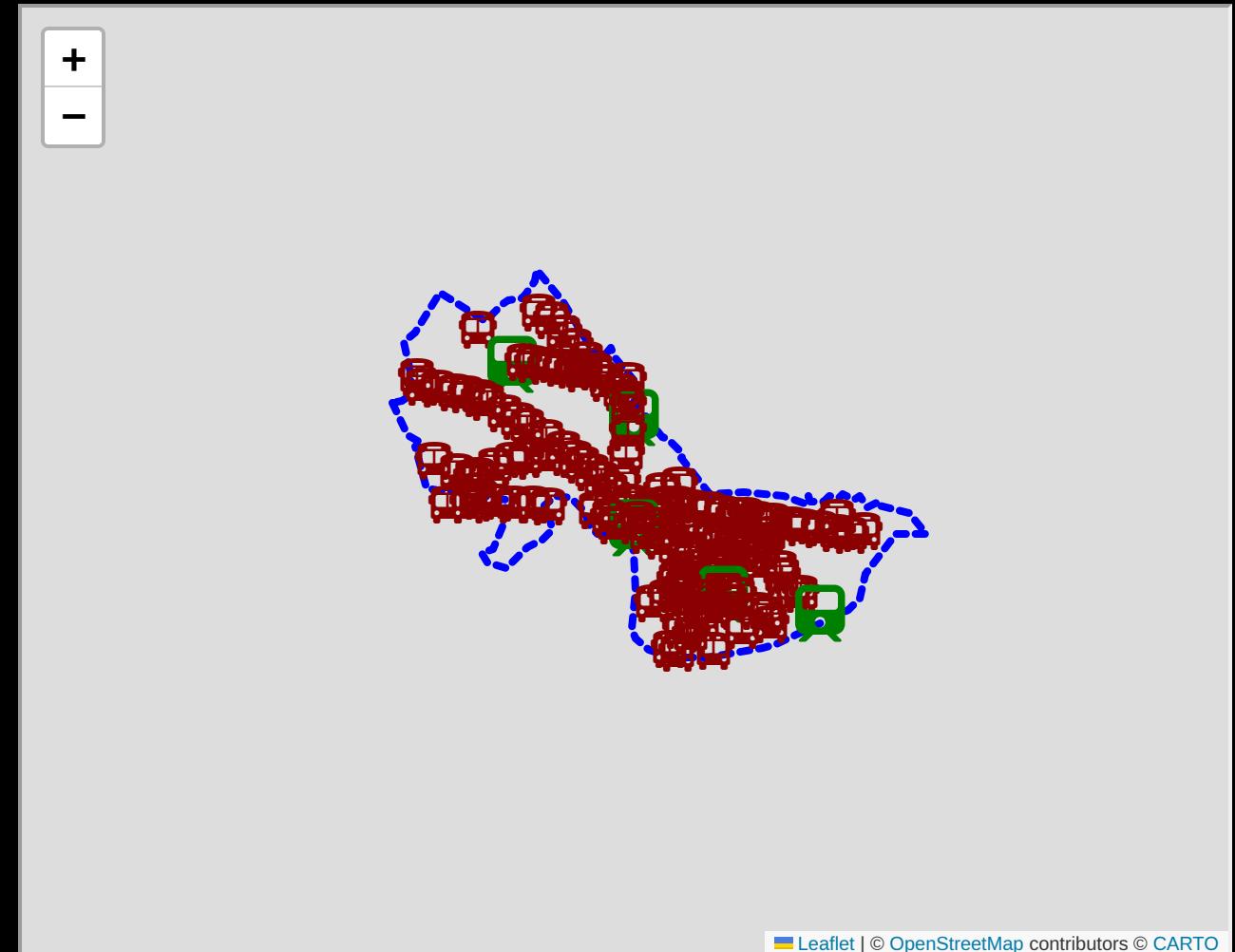
Values

- **Bus:** 0.5 – 0.9
- **LRT/BRT (tram):** 0.75 – 0.95
- **Subway/Train (rail):** 1

User comfort and capacity

route_type column in GTFS

No specific ID for BRT services



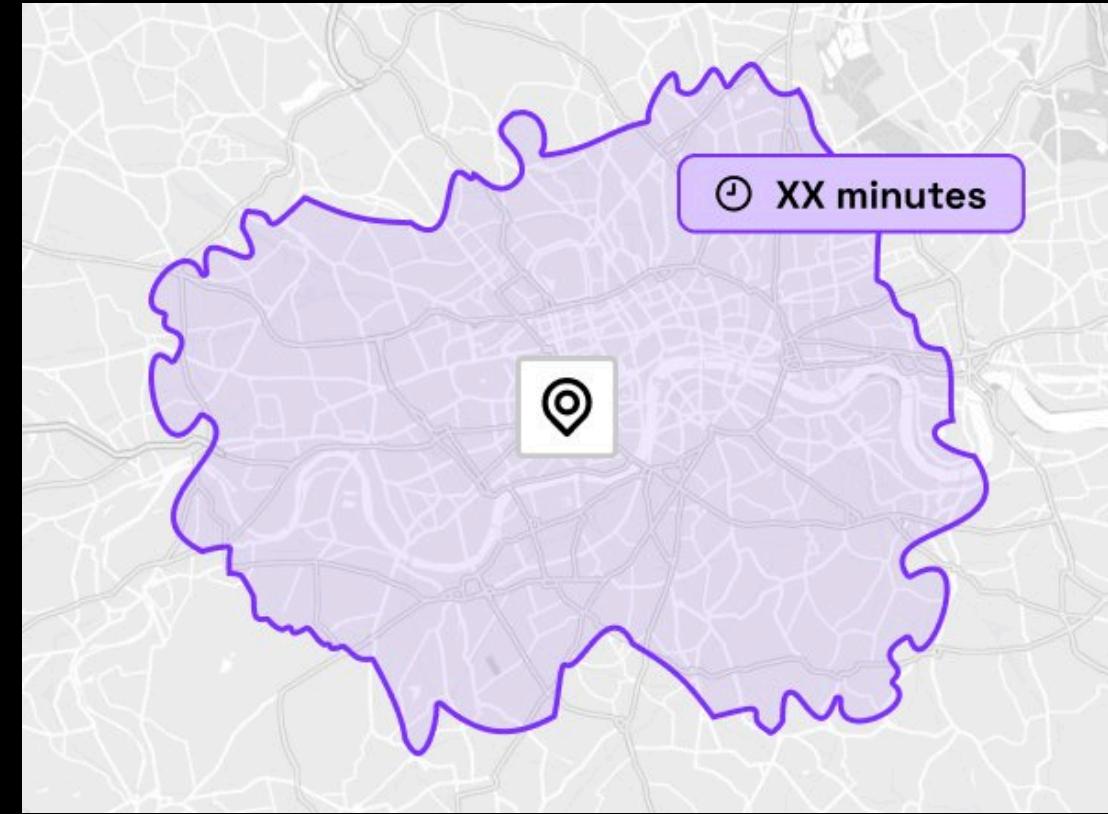
Accessibility

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \boxed{\text{Distance}}$$



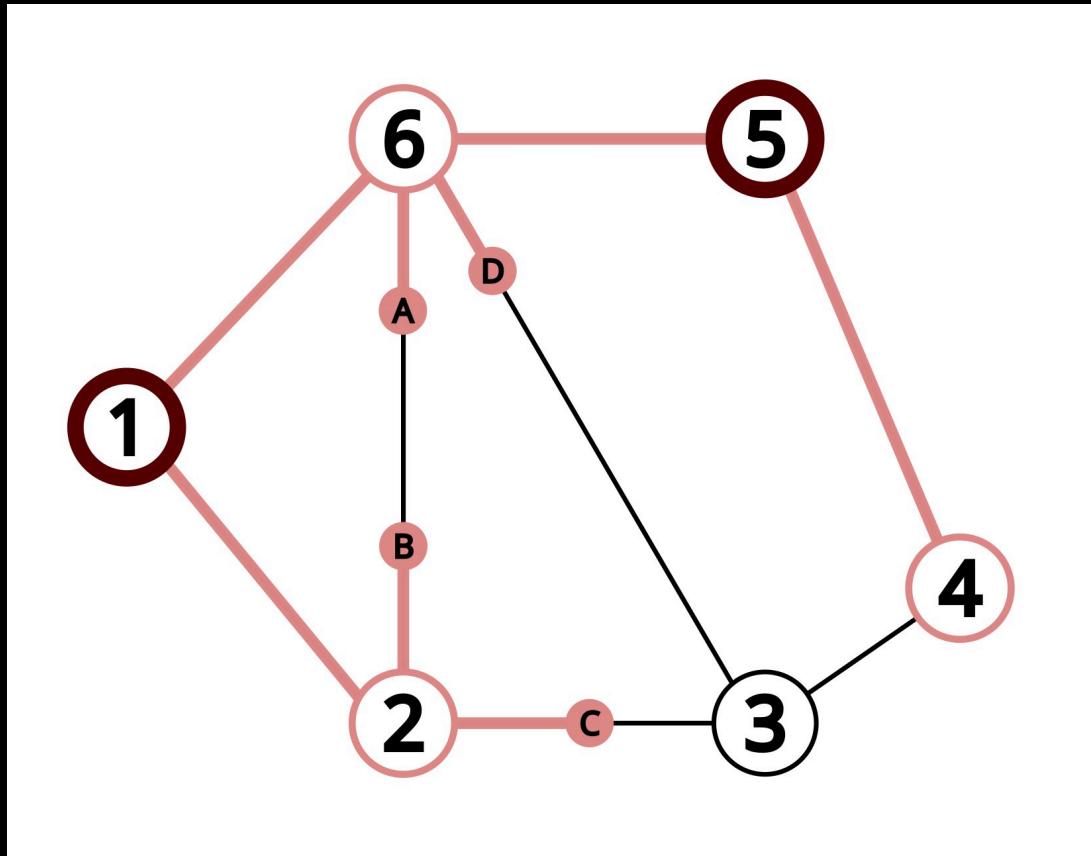
Distance/Time: Isochrones

- The area reachable in **X minutes** with a specific transport **mode** (public transport, walk, bike, car, etc.)
- Transport system graph
- For accessibility to public transport: walk isochrones
- Elasticity: $e = 0.1 - 0.4$ (smaller than headway)



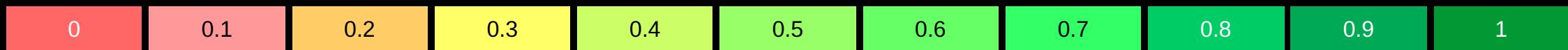
A bit of graph theory

- Transport system graph
(source: OpenStreetMap streets)
- Geo-multi-source **Dijkstra**
adds exact nodes at breakpoints
- Discrete distances
- Discrete stop qualities



Discretization

1. Choose discrete accessibility grades



2. Stop quality and distance are discretized automatically



An example result



Population/Census



- Global source: [WorldPop](#)
- Census data: Individual countries



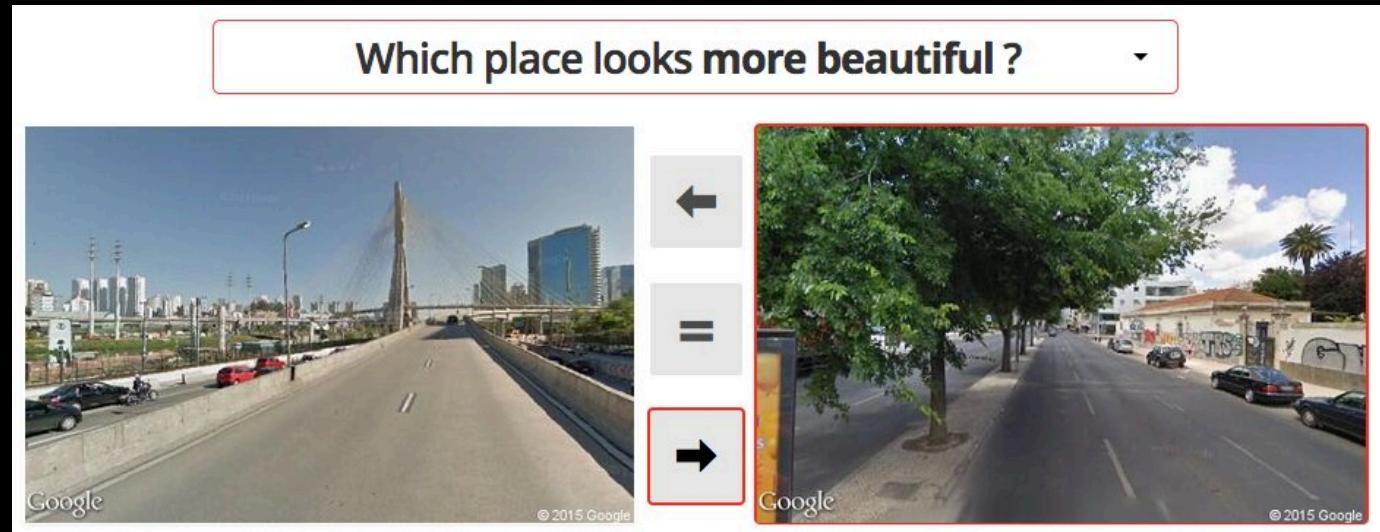
This idea is flexible!

- Park quality by its **area**



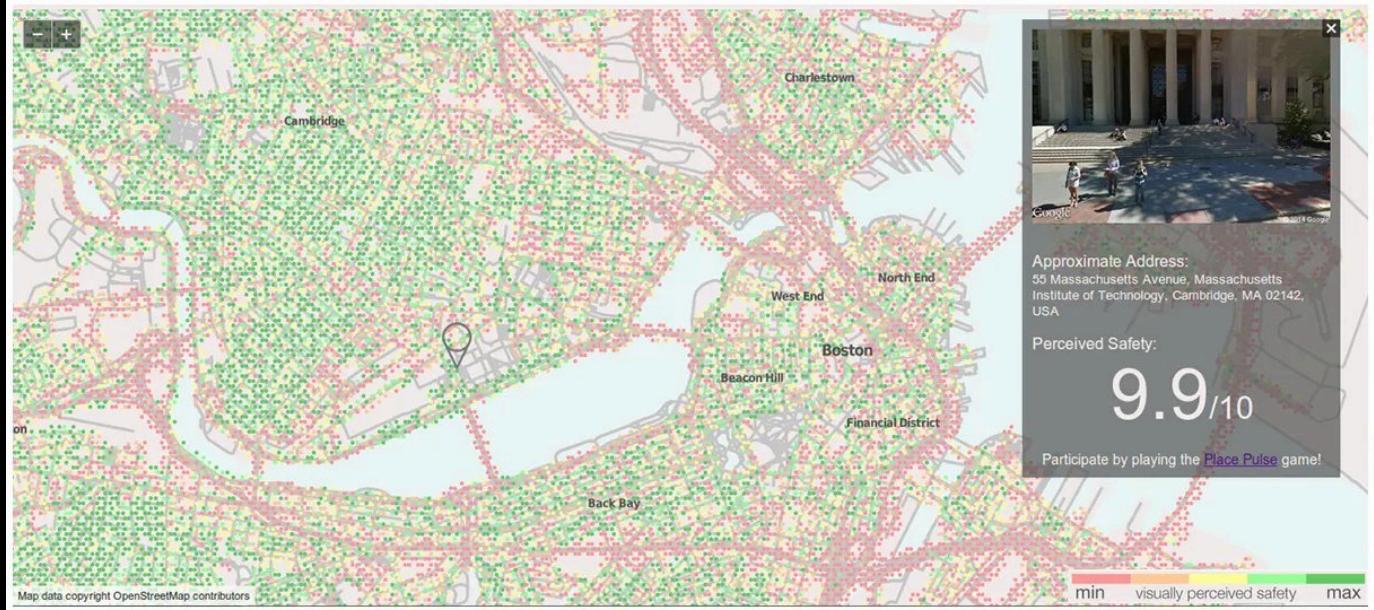
Introducing perception

- Work with [Leticia Izquierdo](#)
- Pairwise comparisons
- Image vision model
- Small sample size
- Different profiles
- Perceived distances



Introducing perception

- Work with [Leticia Izquierdo](#)
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Connecting with DUSP

- Coffee and transit
 - Speaker next Wednesday

🔍


[Log in](#)


Bi-Weekly Seminars • Beginning Wednesday September 10, 12:30pm

Fall

Term

2025 |

BiWeekly

Coffee

&

Transit

Seminars

September

Contact Name
Jim Aloisi

Contact Email
jaloisi@mit.edu

Location
9-415

Discipline
Mobility

Series
Mobility



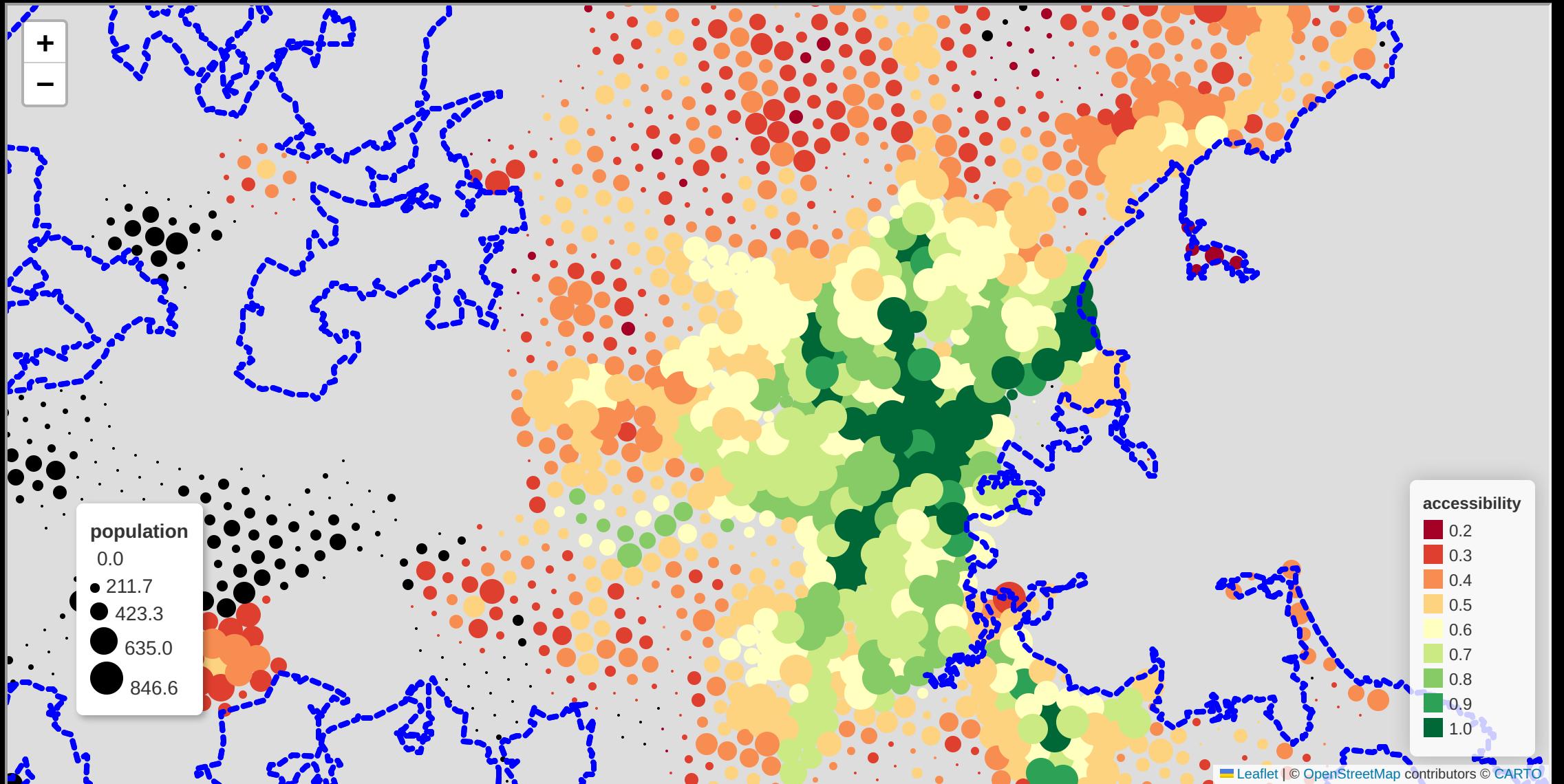
Connecting with DUSP

- City Science San Francisco:
 - Affordable housing
 - Erik Huntley: Who owns Massachusetts?



Results

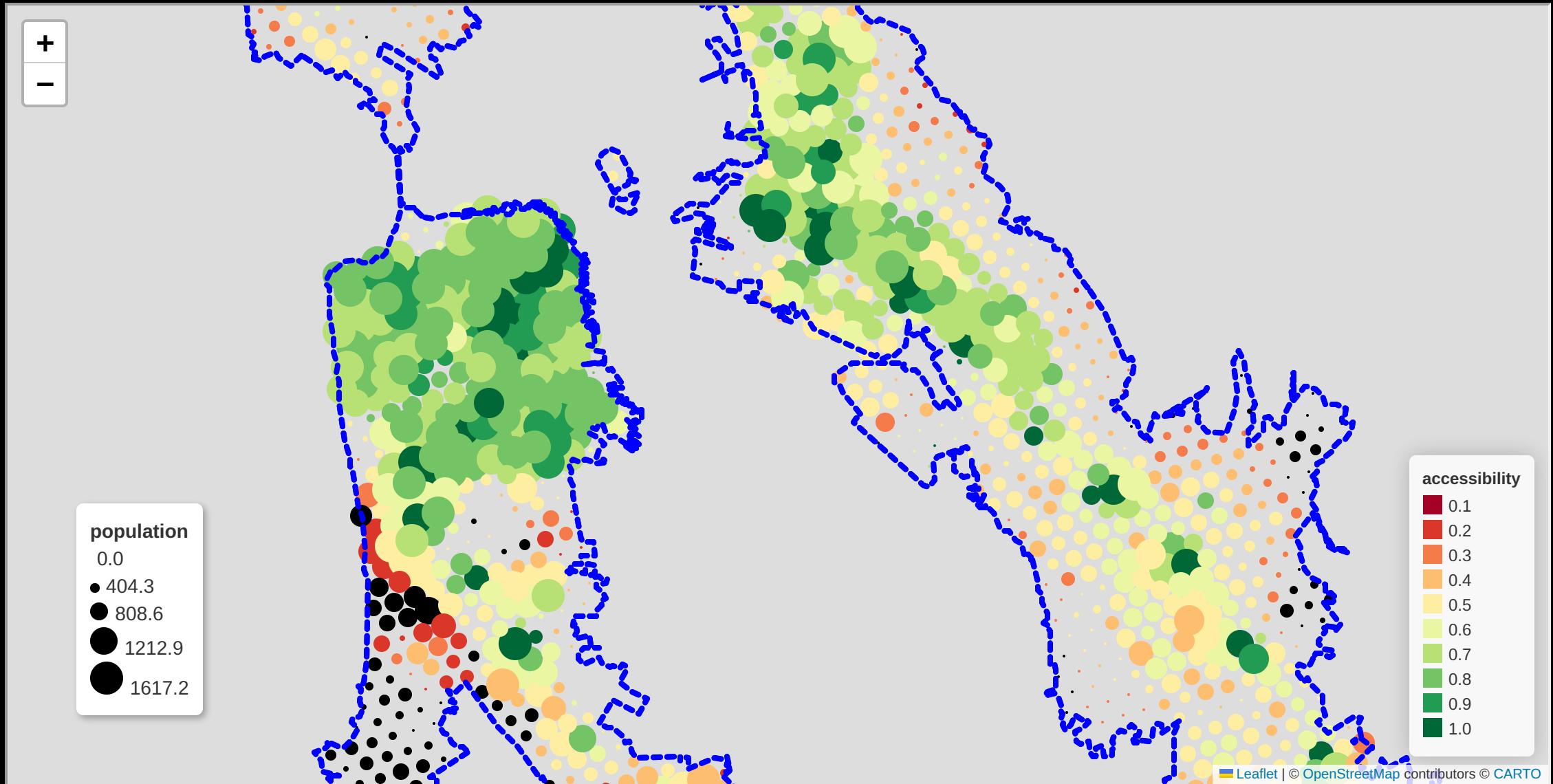




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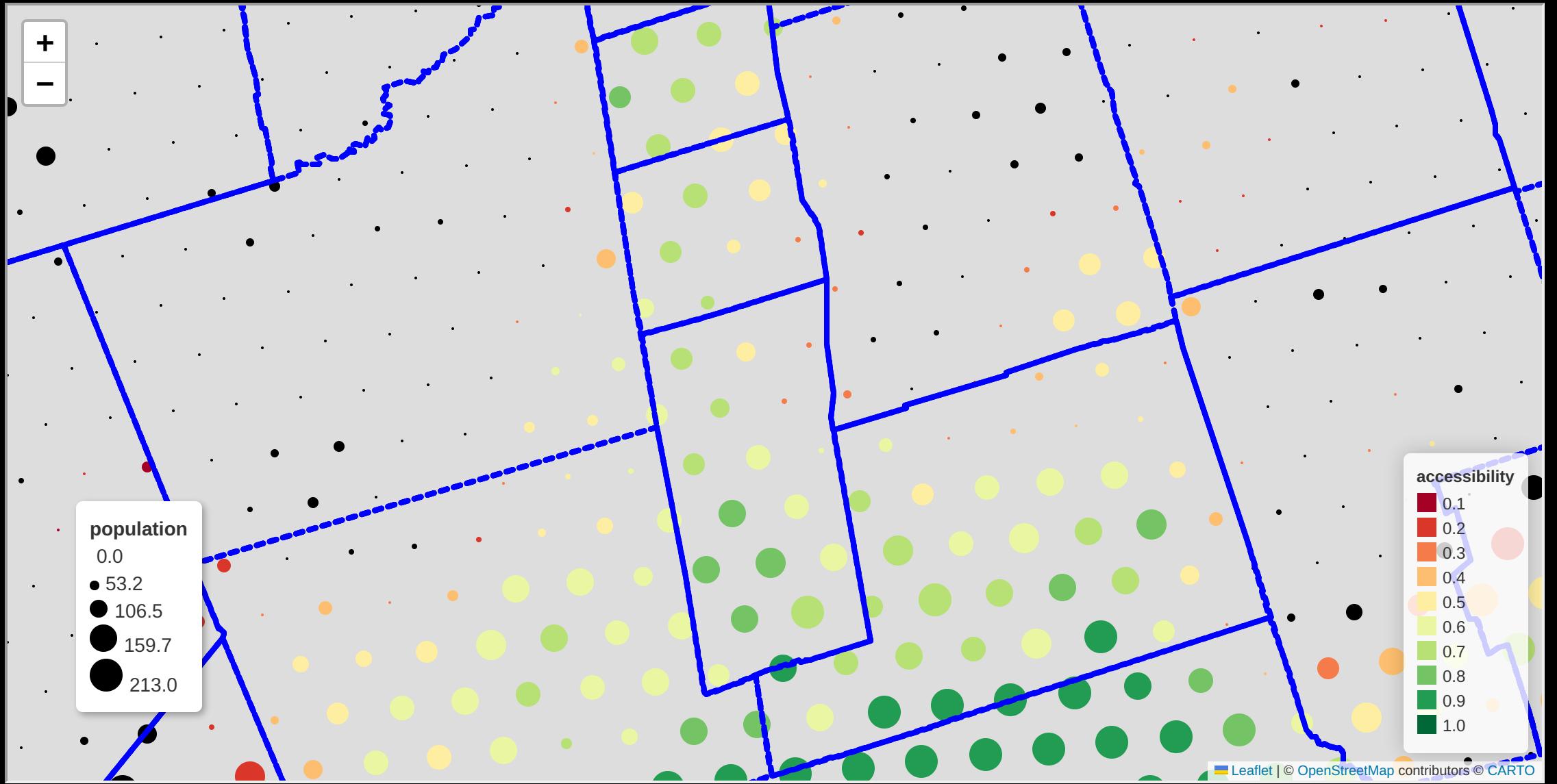
40



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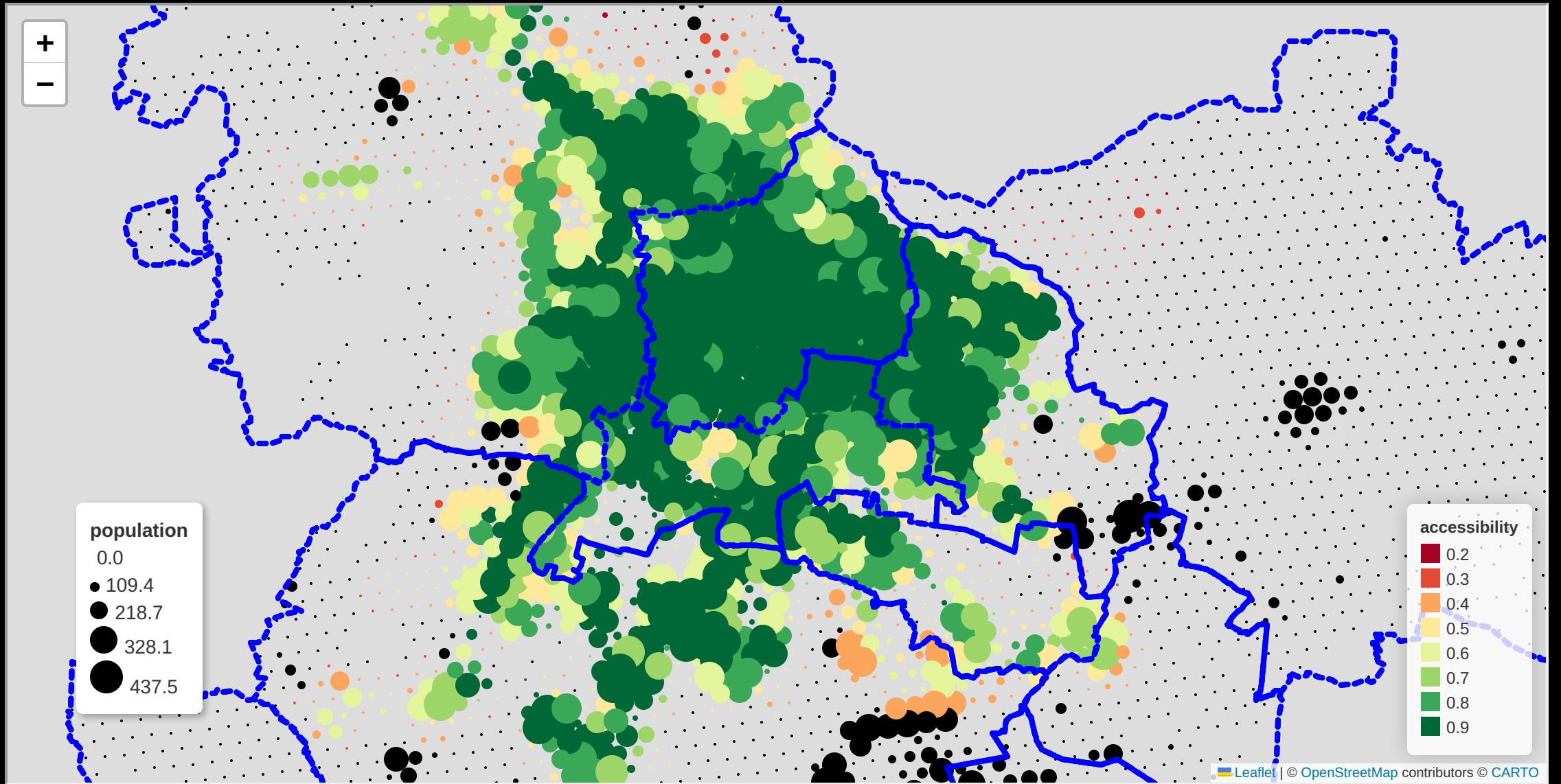
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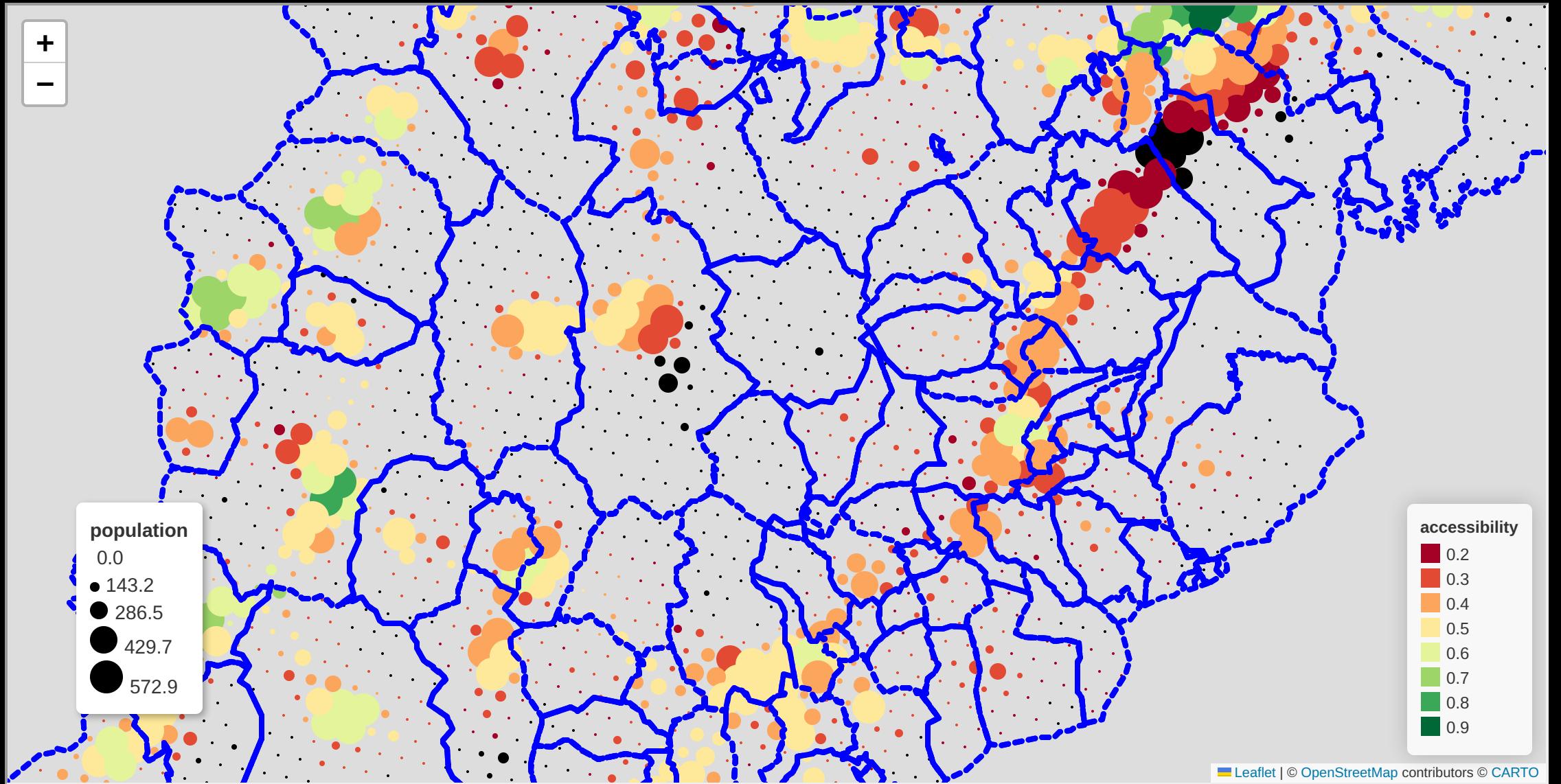
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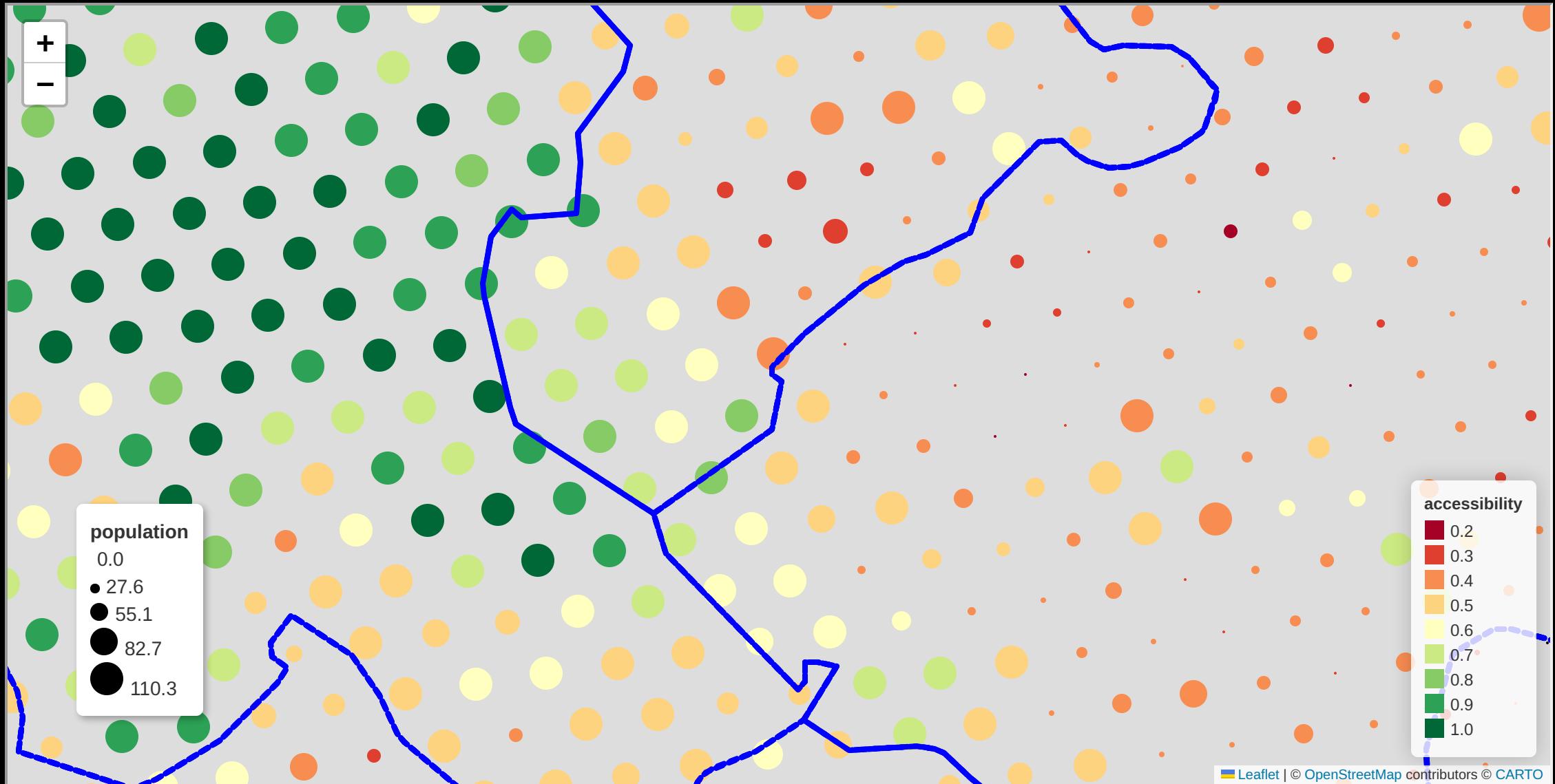
Mapping accessibility globally

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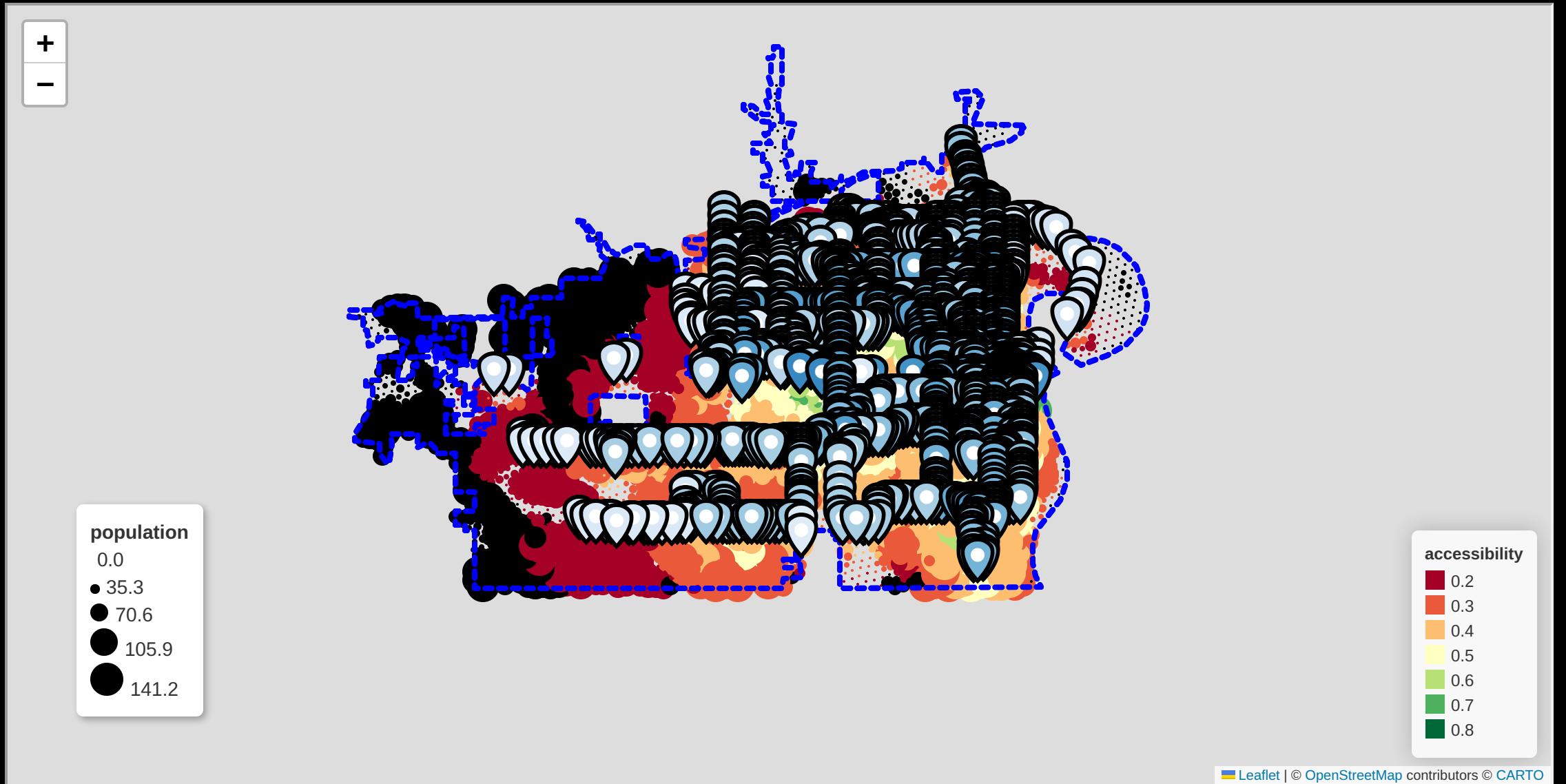
Mapping accessibility globally 44



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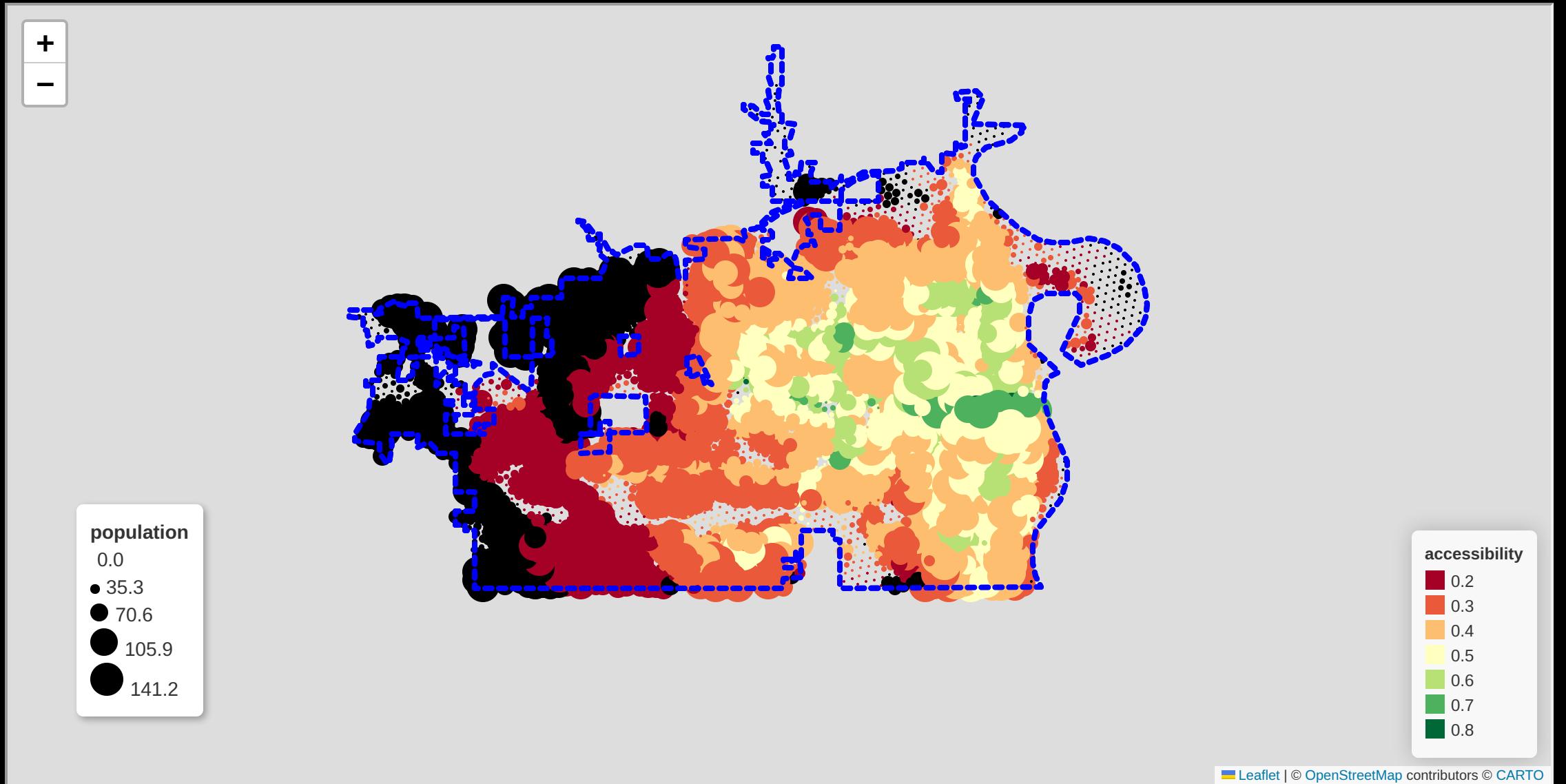
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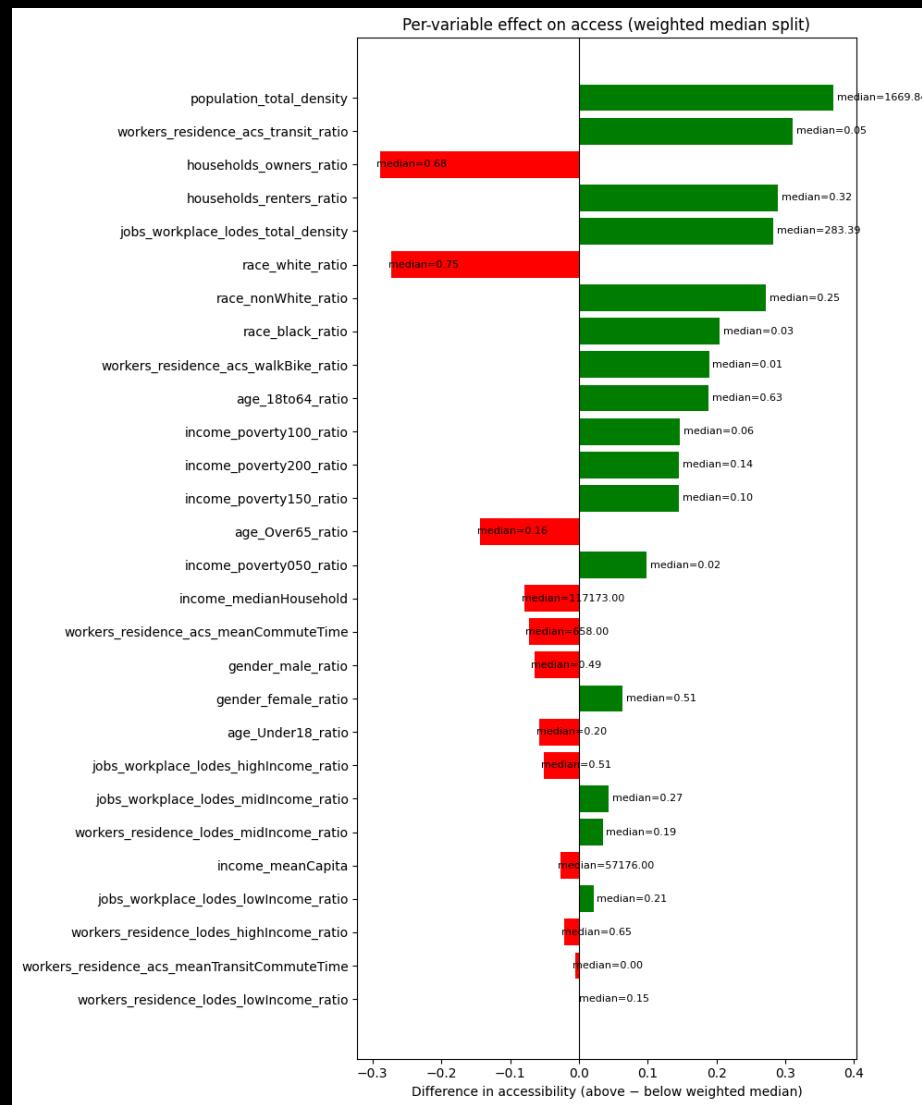
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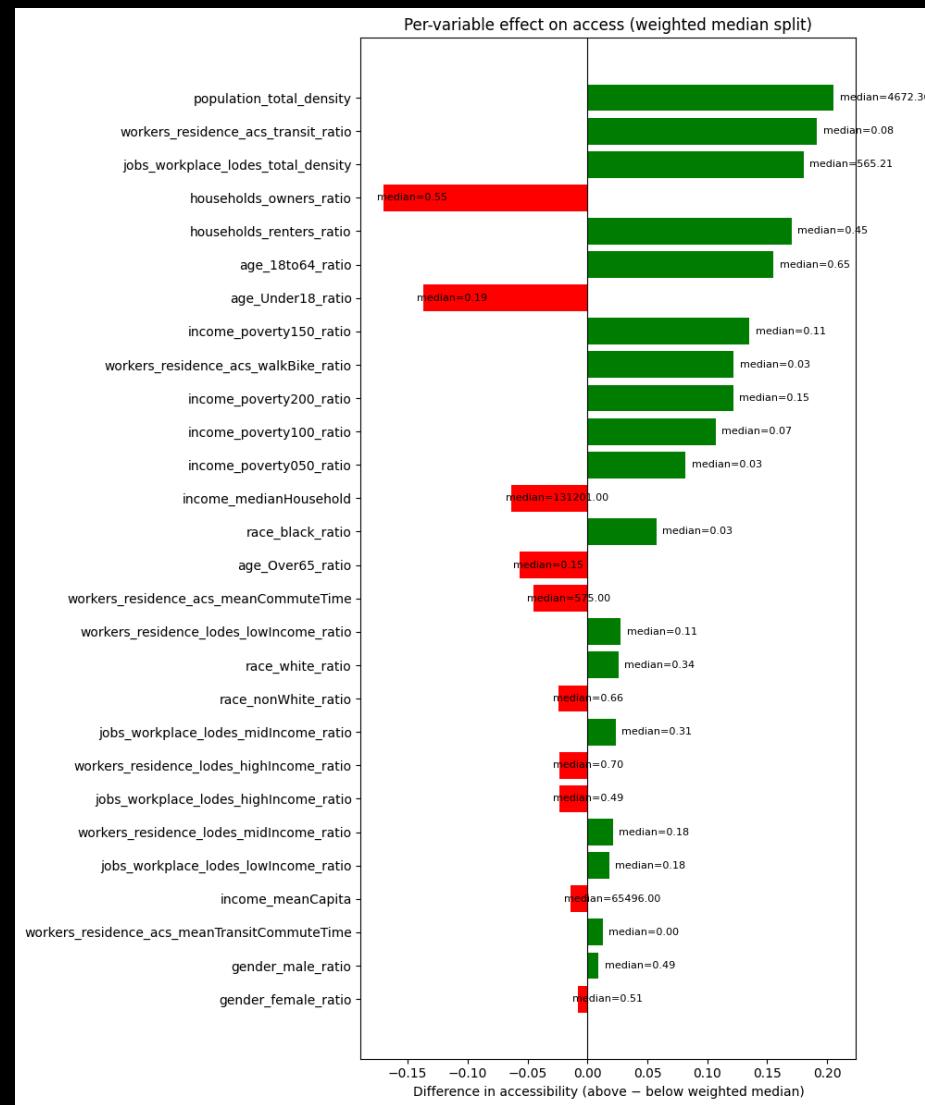
Equity

- Population density
- Home ownership
- Car ownership
- Race
- Income



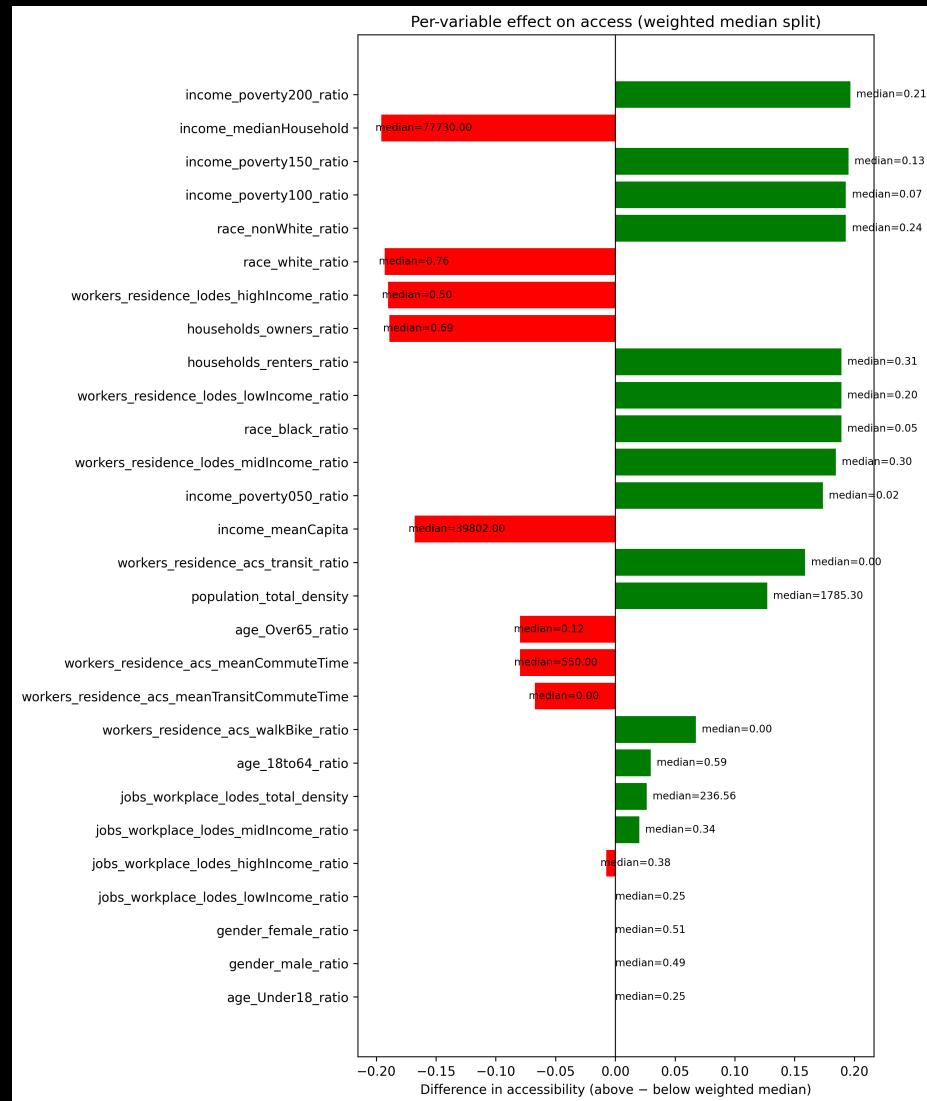
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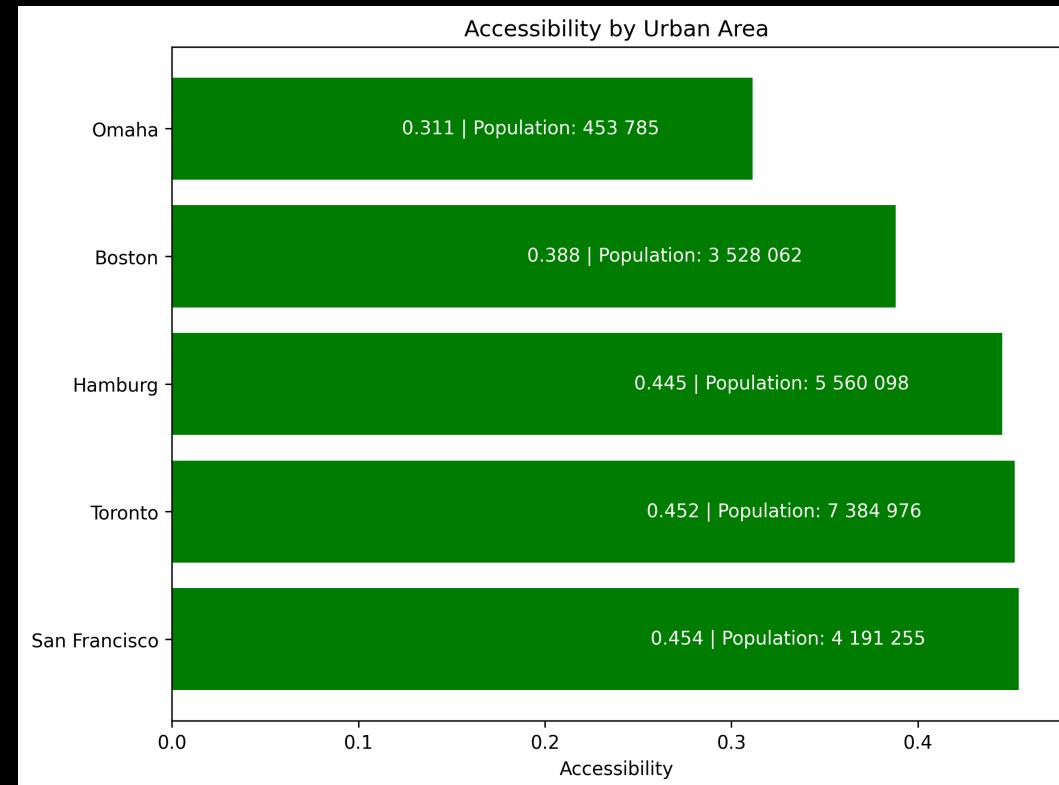
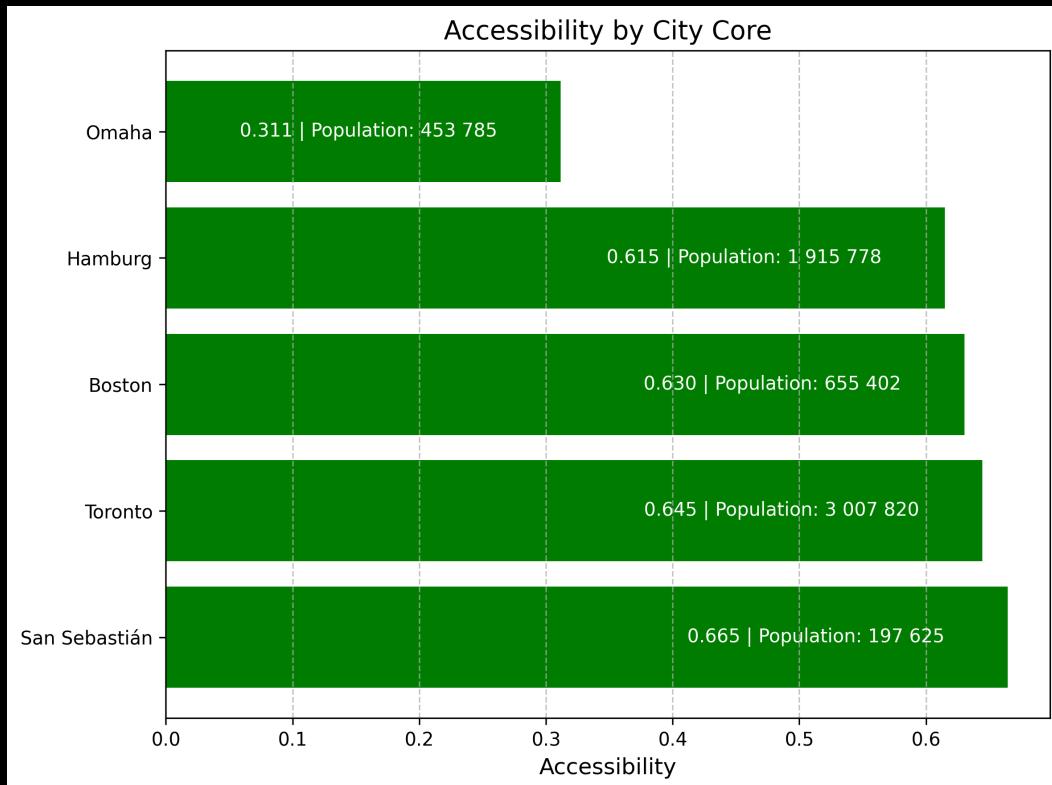


Equity

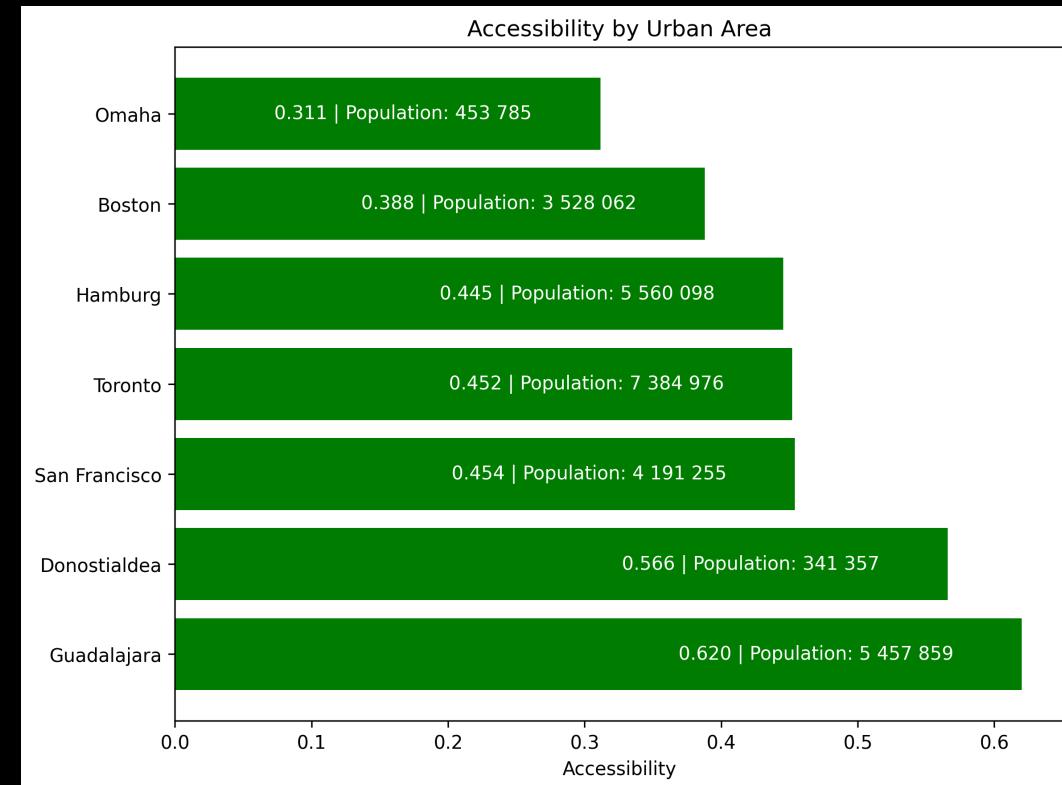
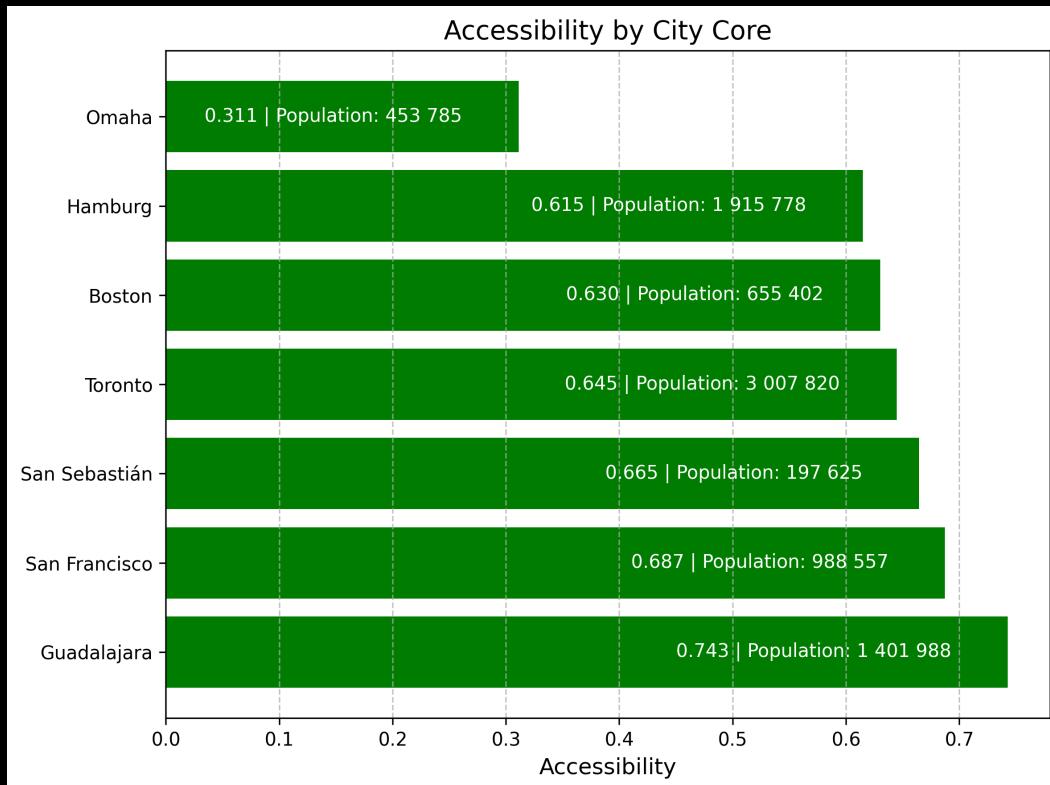
- Population density
- Home ownership
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- Income



Ranking: Bottom



Ranking: Top



Python packages

PyGTFSHandler

- Tutorial

Download GTFS and compute speed and headway

UrbanAccessAnalyzer

- Schools

Basic example and download of Polys from OpenStreetMap

- Parks

Simple tutorial introducing Pol quality

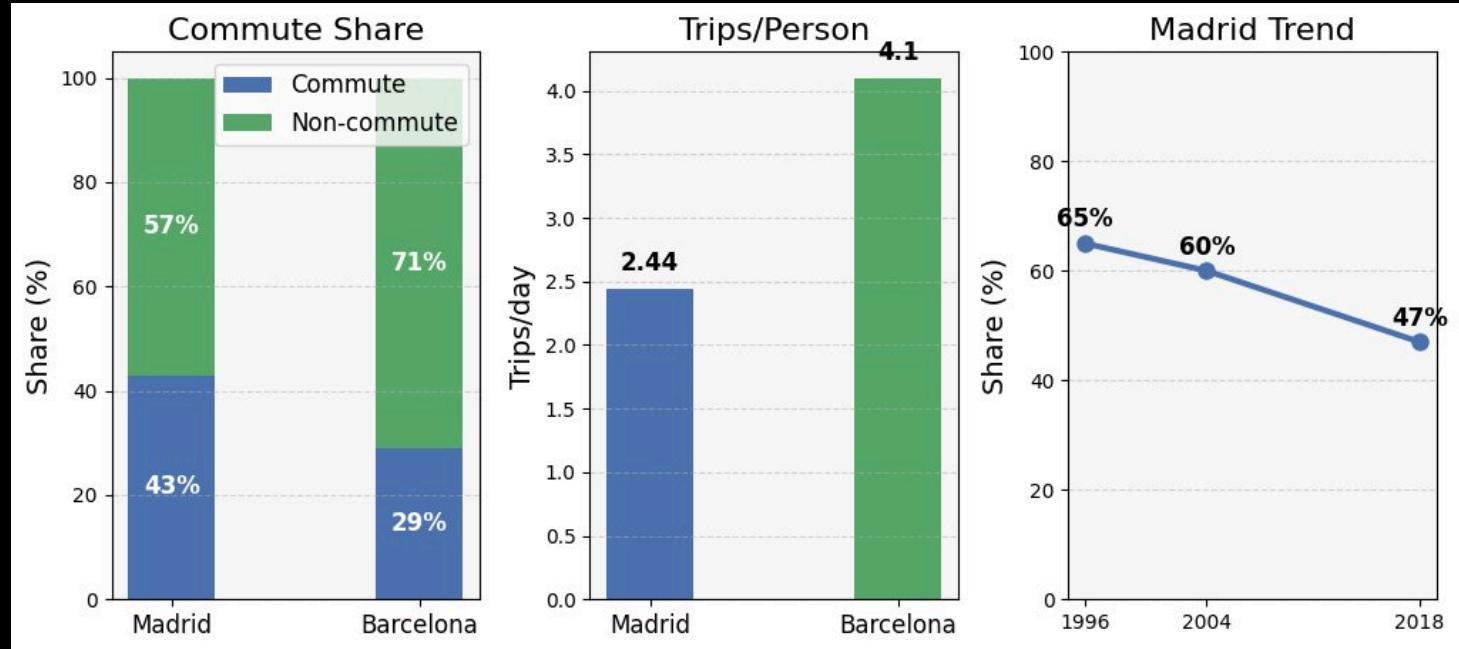
- Public Transport

Complete example of our accessibility to public transport indicator including isochrone computation and GTFS processing



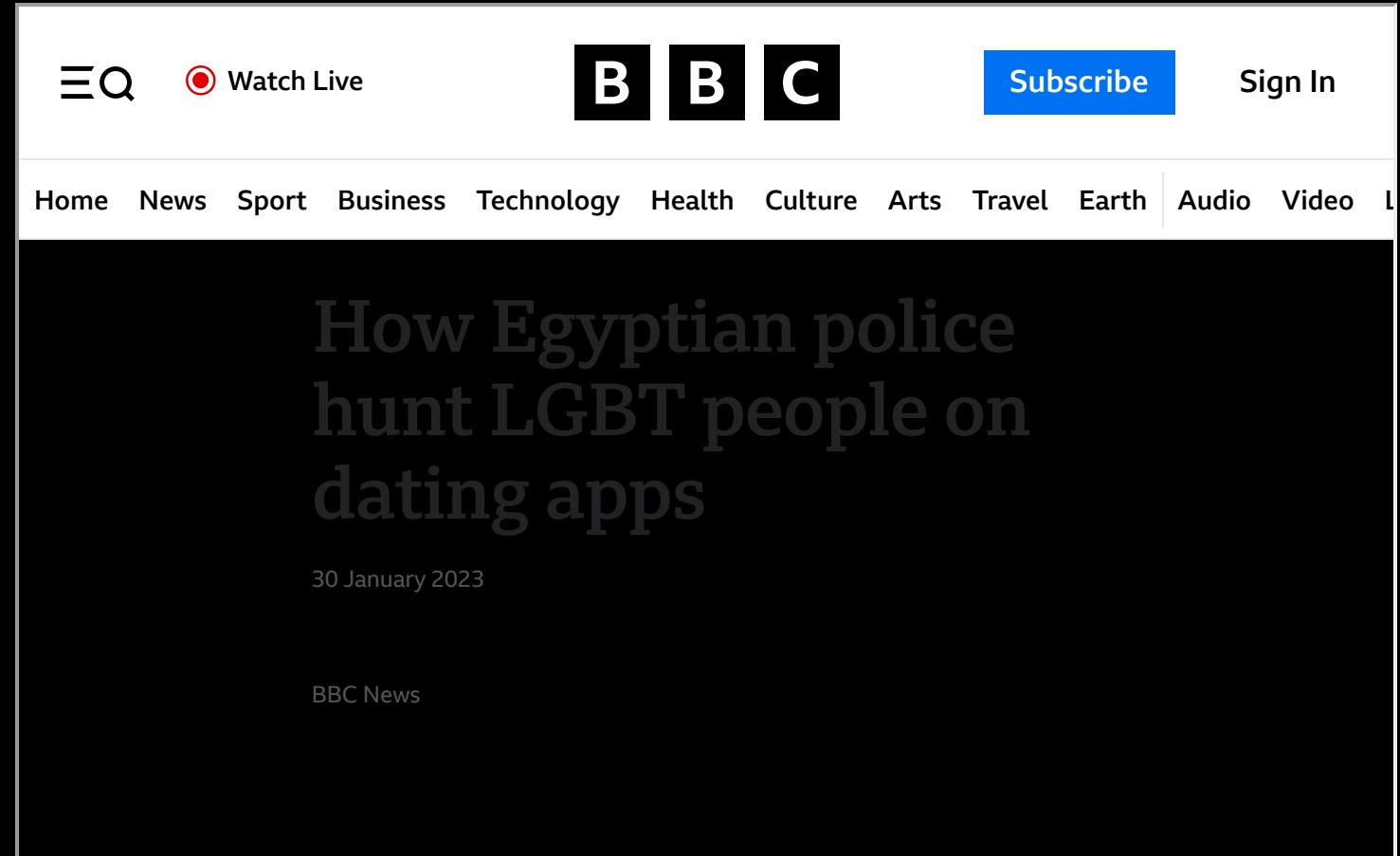
A good relationship with data?

- What data gets collected?
- Decision informed data



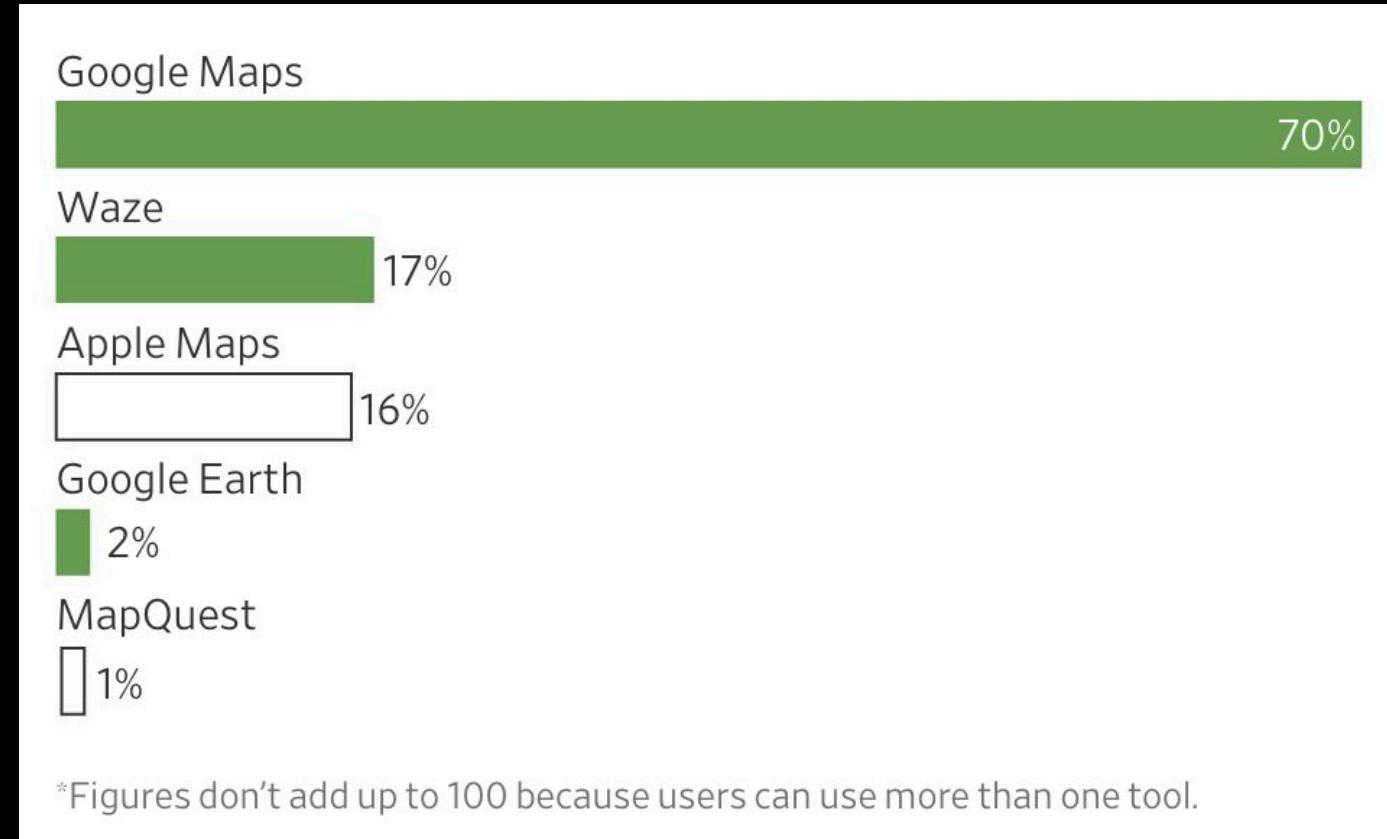
A good relationship with data?

- What data gets collected?
- Decision informed data
- What data should exist?



A good relationship with data?

- Data governance and monopolization
 - Google dominates
 - OpenStreetMap



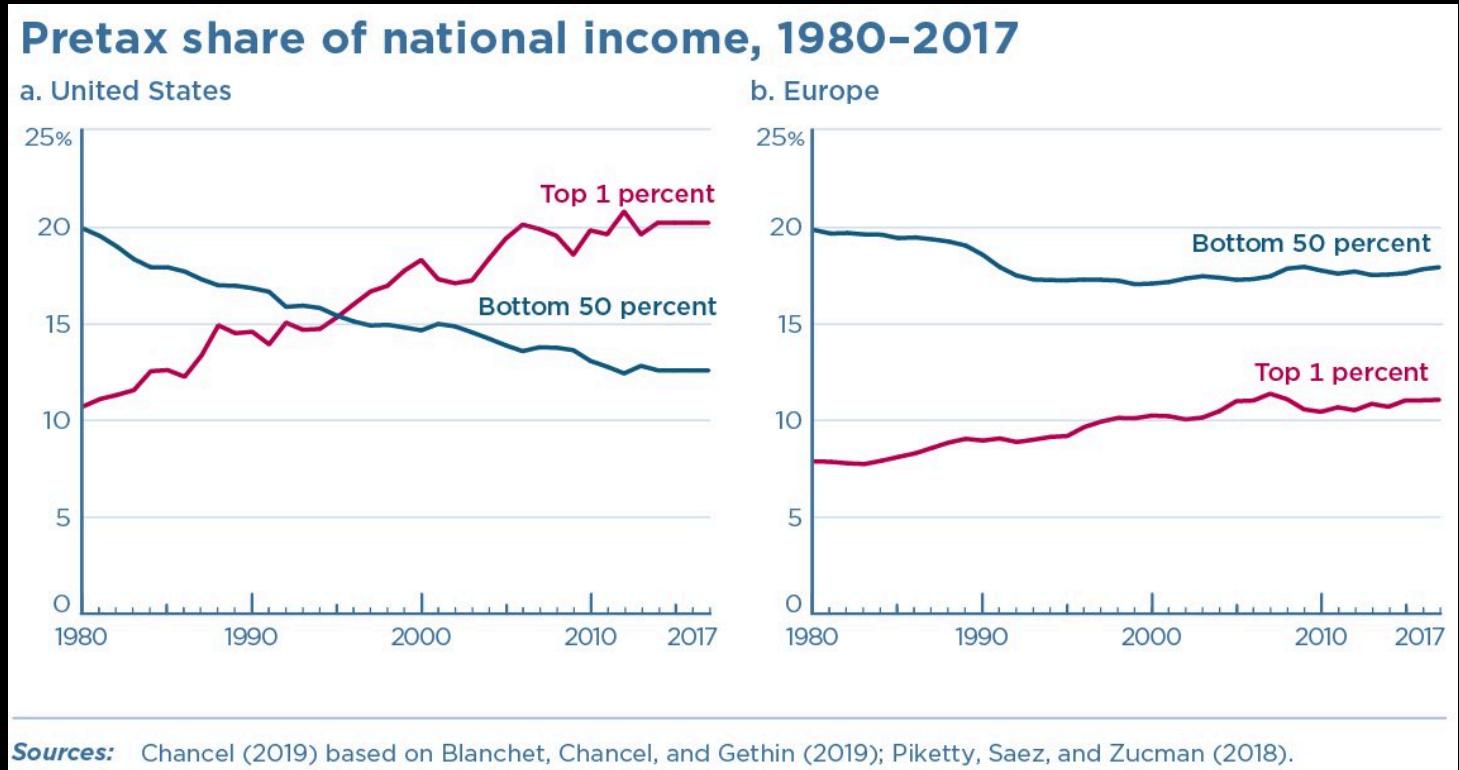
A good relationship with data?

- Who is looking?
- Data science is not objective!



Look up!

- Poverty does not just exist
- A system makes it happen
- Who profits?



How does the world change?



How does the world change?





Data as a pressure mechanism?





Questions?

Thank you!

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LinkedIn: [miguel-urena-pliego](#)