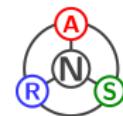


# Typology-informed solutions for sustainable infrastructure systems

Jimi Oke



Networks for Accessibility, Resilience and  
Sustainability Laboratory (NARS Lab)  
Department of Civil and Environmental Engineering  
University of Massachusetts Amherst



4th International Conference on Access Management  
July 24, 2024

# Academic journey

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BA (2010)

Physics, Music

Williams College, MA



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(2010–12)

Mathematics,  
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EngineeringMassachusetts Institute  
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Professor  
(2019–date)Civil and Environmental  
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Massachusetts Amherst

# Geographic trajectory

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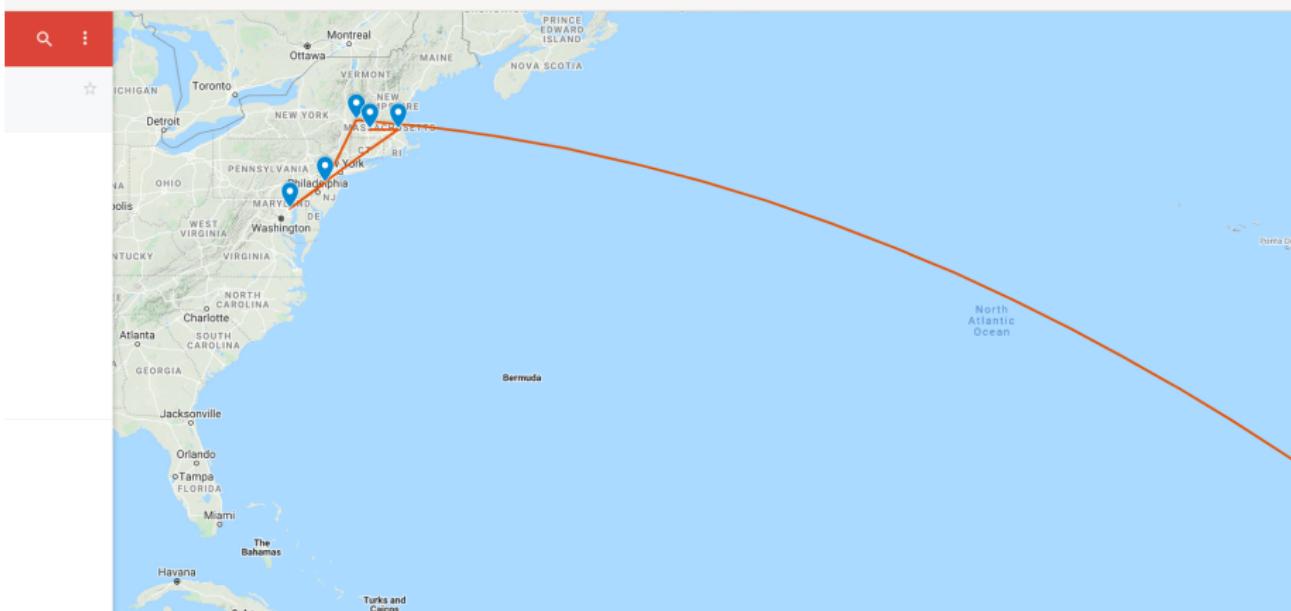
Ibadan, Nigeria → Harare, Zimbabwe → Williamstown, MA

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Ibadan, Nigeria → Harare, Zimbabwe → Williamstown, MA → Pennington, NJ →  
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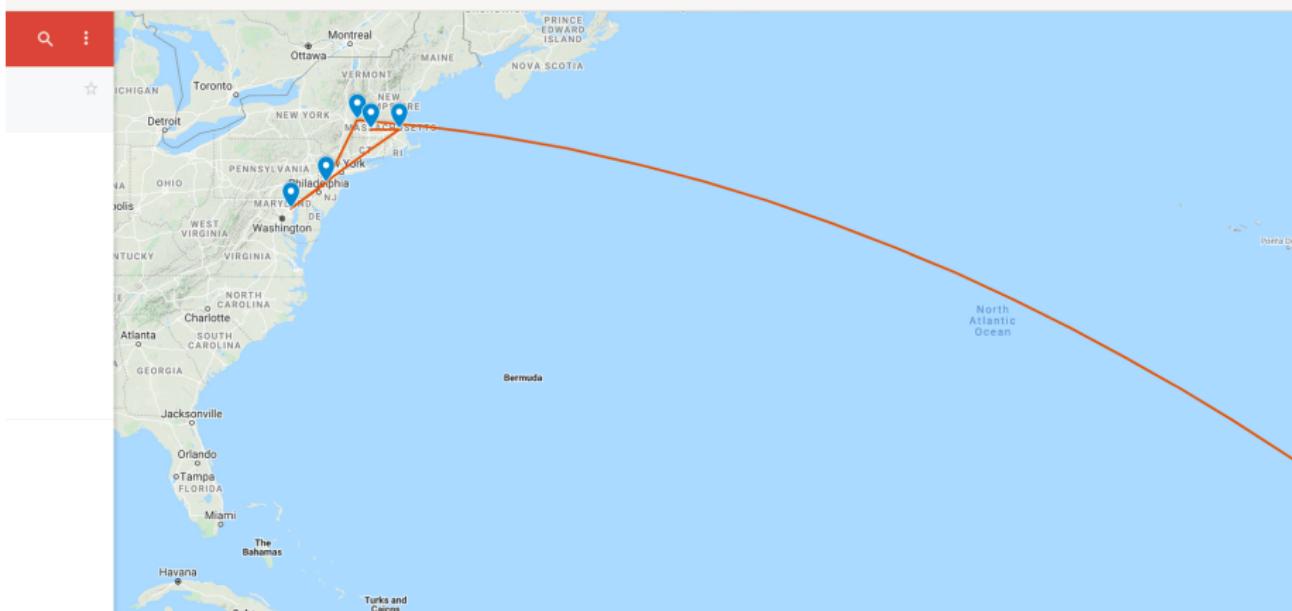
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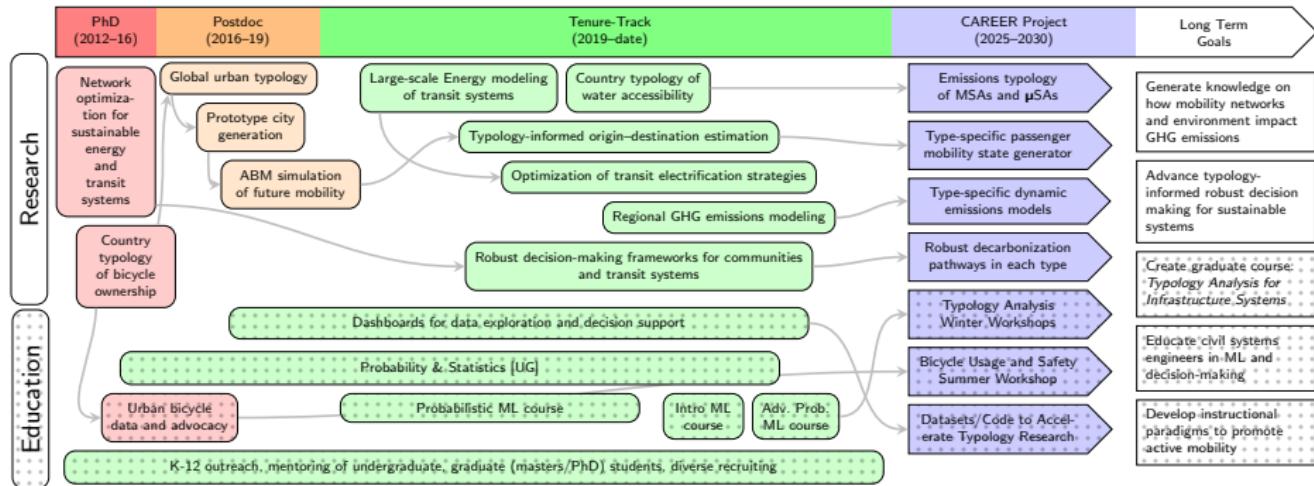


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# Career path



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Networks for Accessibility, Resilience and Sustainability (NARS) Lab

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- Advance sustainable and zero-emissions infrastructure systems
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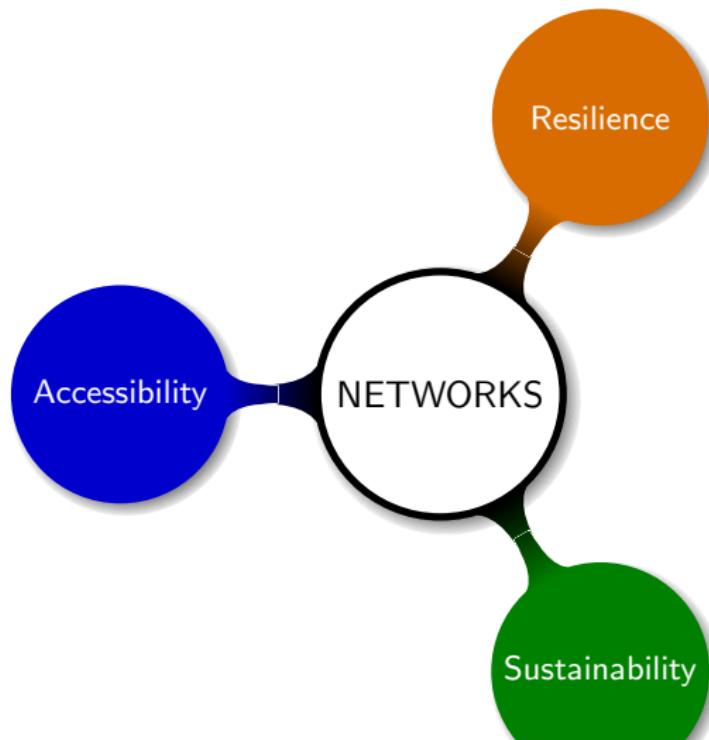
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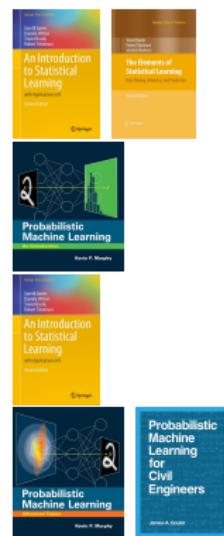
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4

## Graduate (new)

- Big Data and Machine Learning for Engineers (Spring 2020, '21, '22)
- Probabilistic Machine Learning (Spring 2023)
- Machine Learning Foundations and Applications (Fall 2023)
- Advanced Probabilistic Machine Learning (Spring 2024)



# Team

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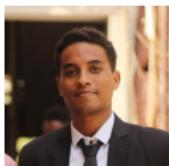
**Current members** (status; date joined):

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## Current members (status; date joined):



Zhuo Han  
MS/PhD; Winter '20



Mohammed Abdalazeem  
MS/PhD; Winter '21



Mahsa Arabi  
PhD; Summer '21



Peiyao Zhao  
PhD; Fall '23



Jimi Oke  
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Geehan Altayb  
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## Alumni

Atanas Apostolov (MS '24); Vivian Rost-Nasshan (NSF REU '23); Alexa Weinman (BS '23); Hichul Chung (BS '22)

# Typology analysis

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# Typology analysis

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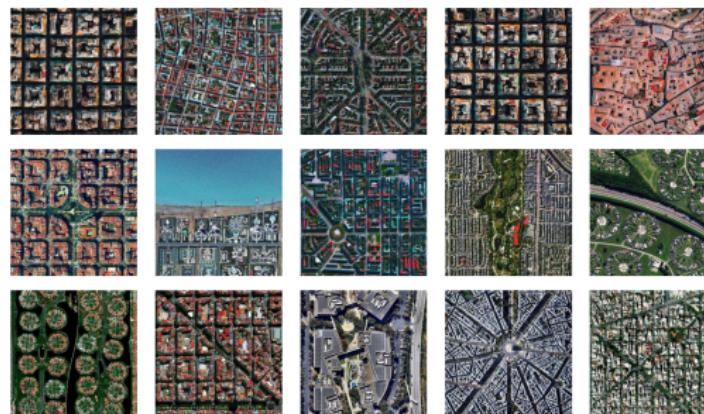
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Source: Arch Daily *Types of Urban Blocks* 2023

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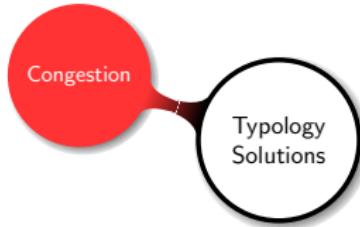
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Midtown New York; Source: Clifford 2024

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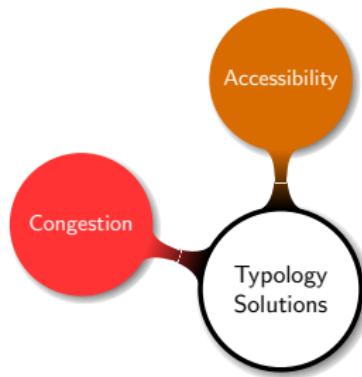
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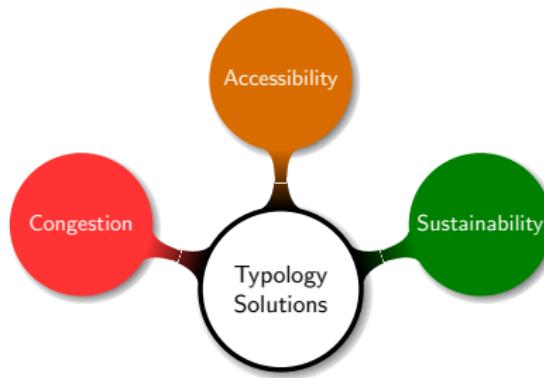
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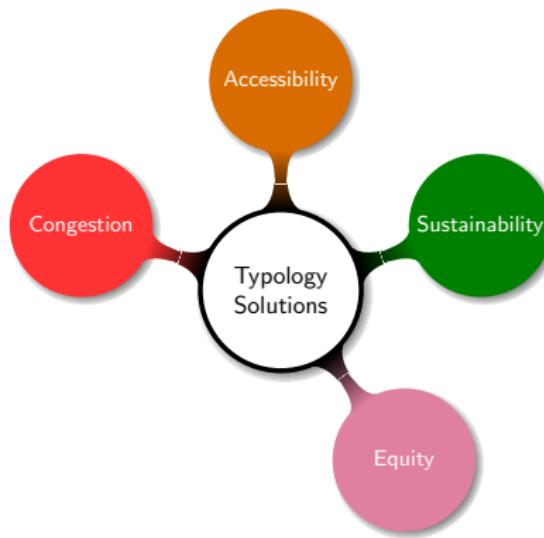
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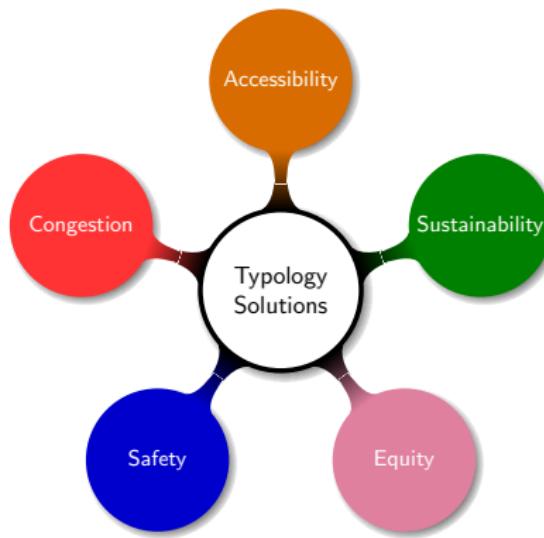
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# Outline

① Introduction

② Background

③ Global urban typology

④ Road safety

⑤ Outlook

# Urban typology for sustainable mobility

<sup>5</sup>IEA 2017

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(a)

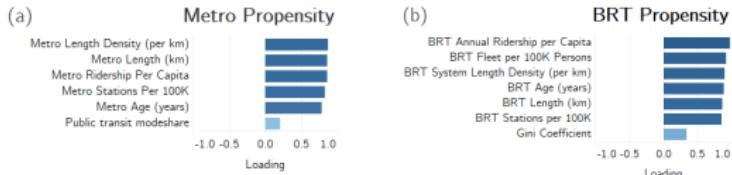
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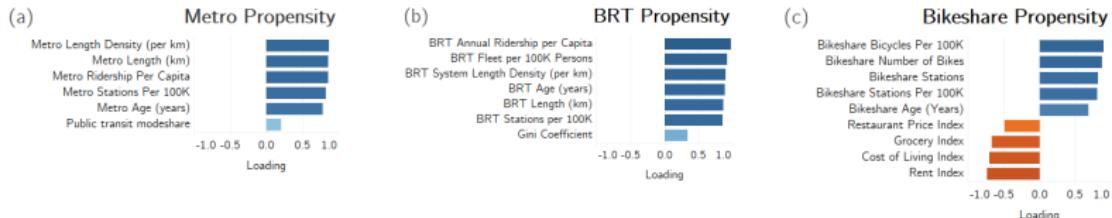
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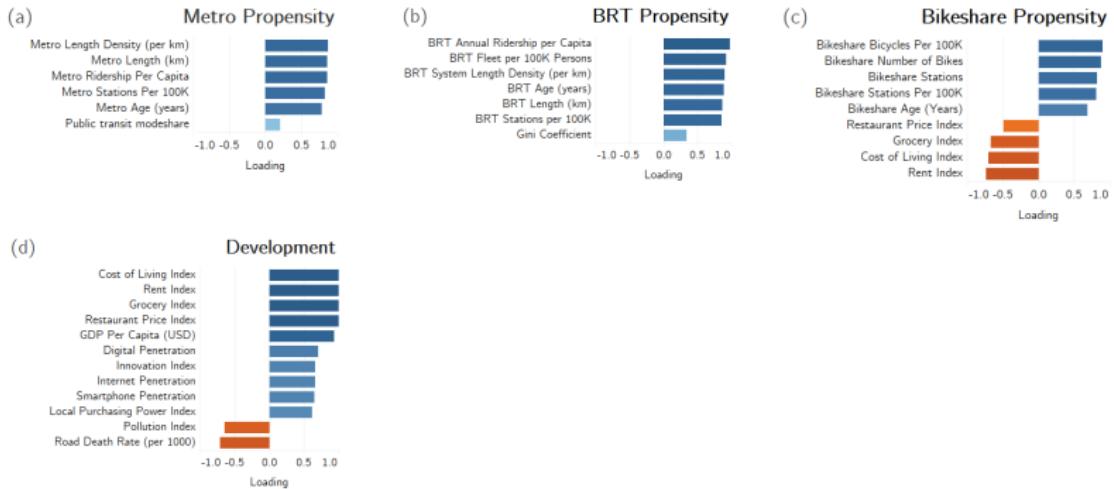
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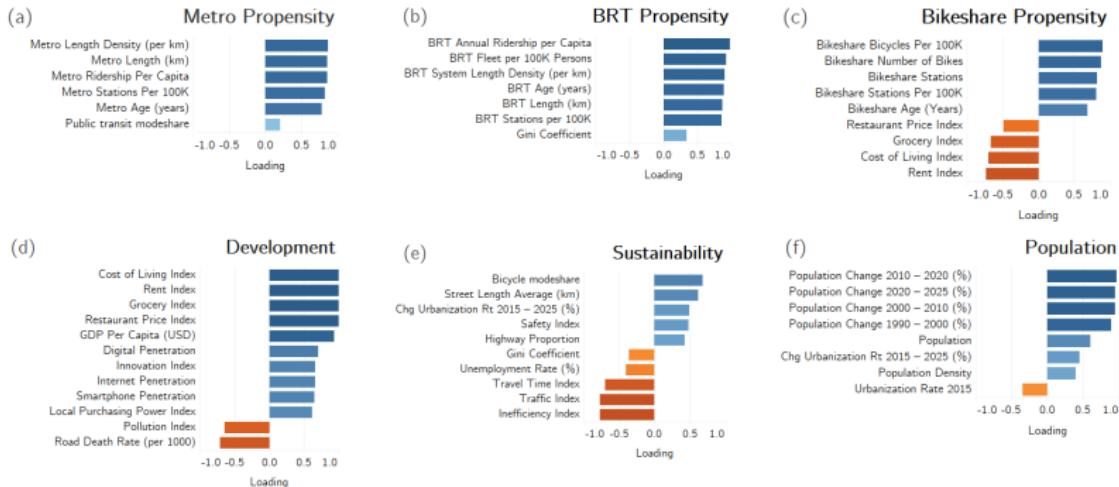
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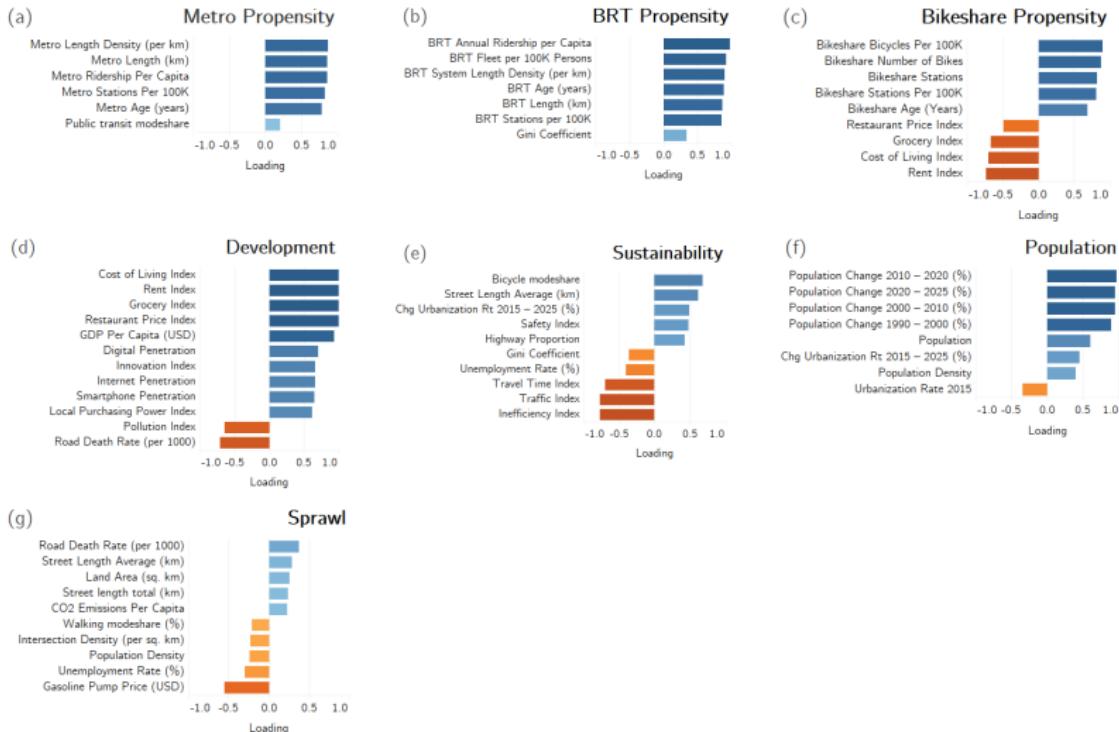
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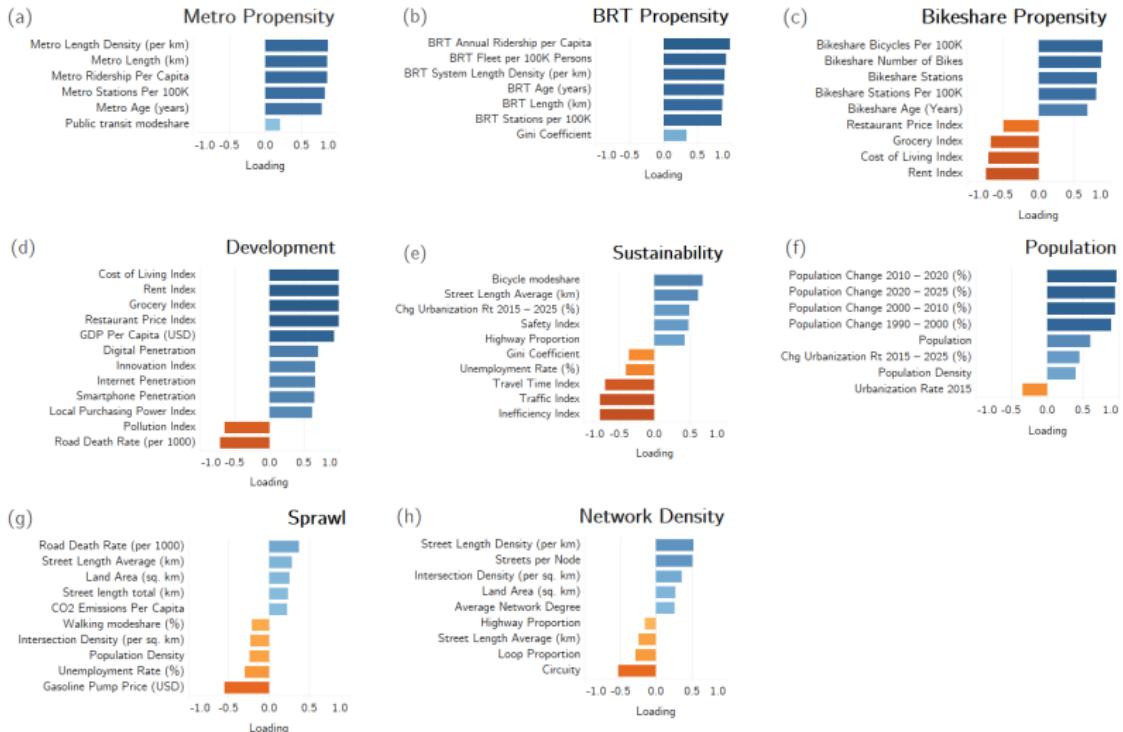
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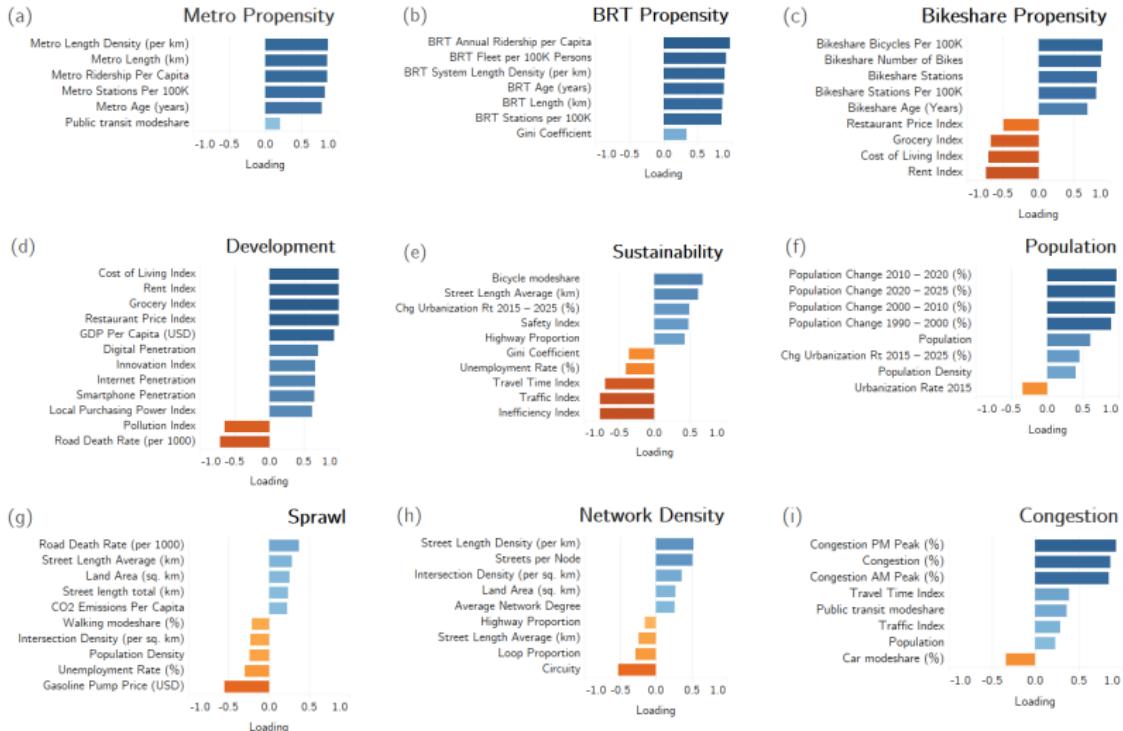
331 cities, 64 variables<sup>8</sup>: mode choice, form, socioeconomic, environment



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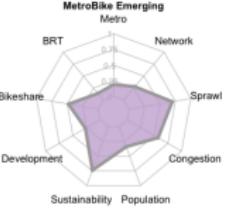
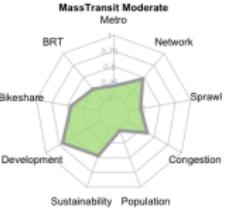
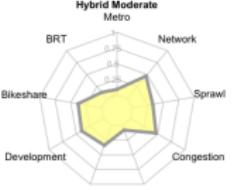
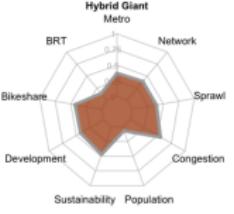
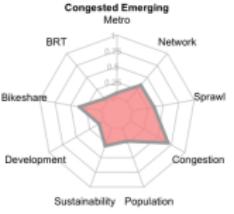
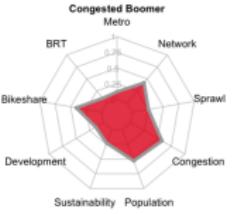
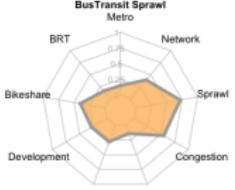
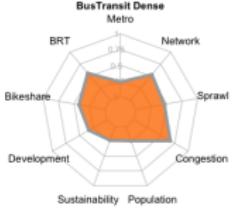
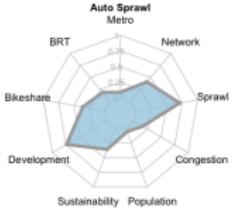
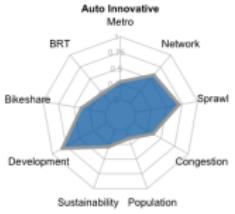
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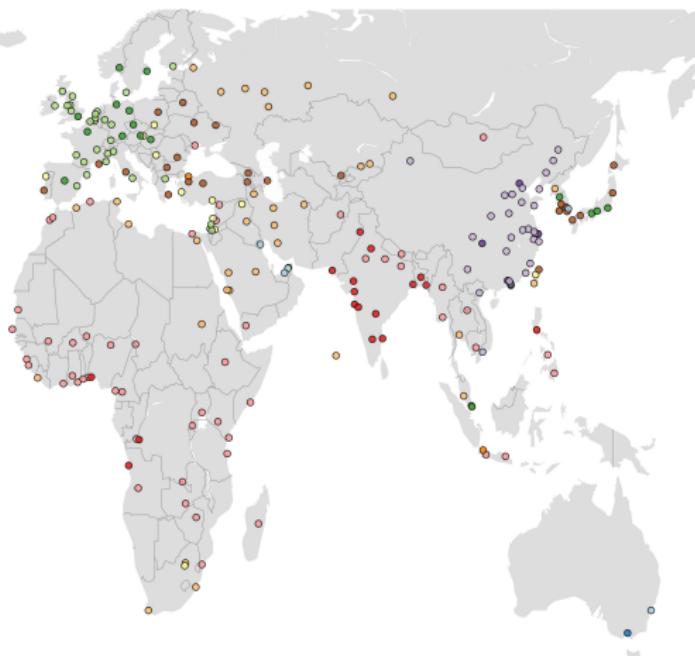
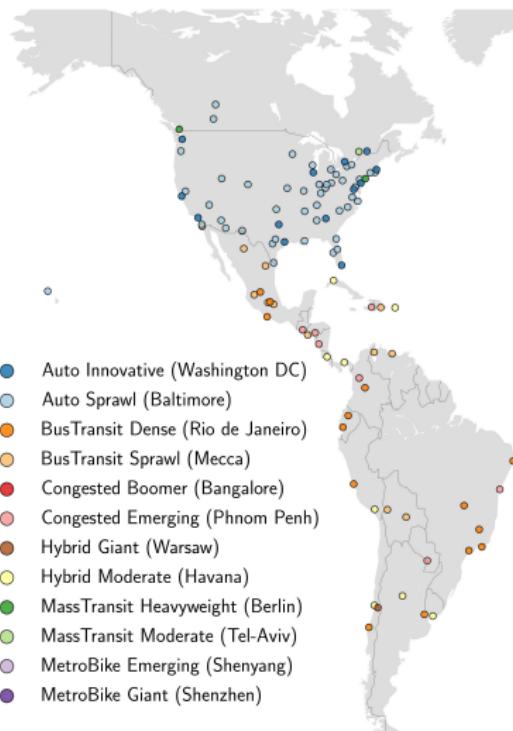
# 12 urban types discovered



# Typology map<sup>9</sup>

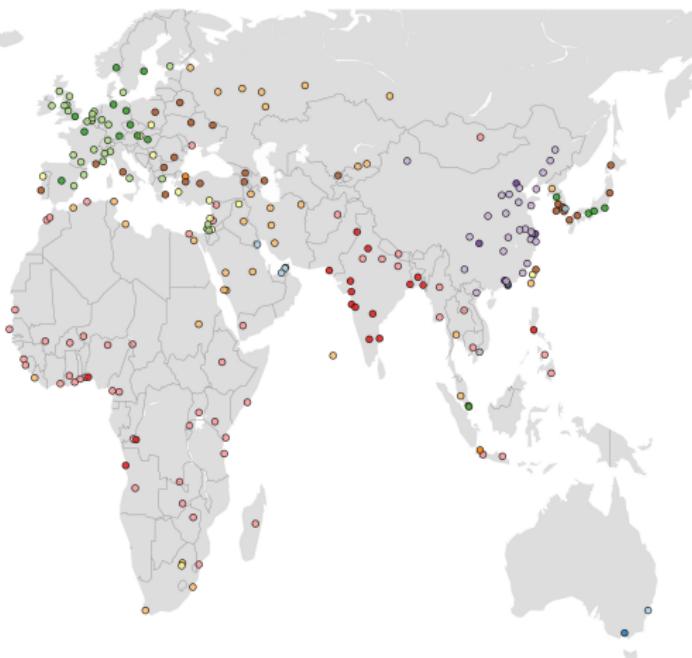
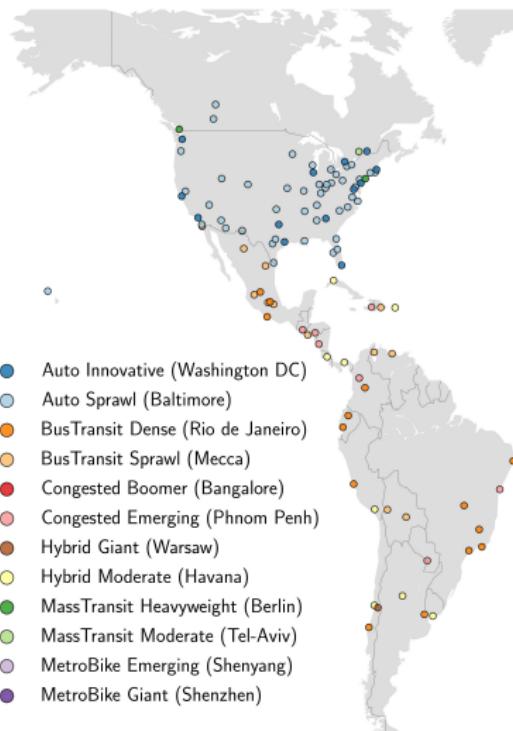
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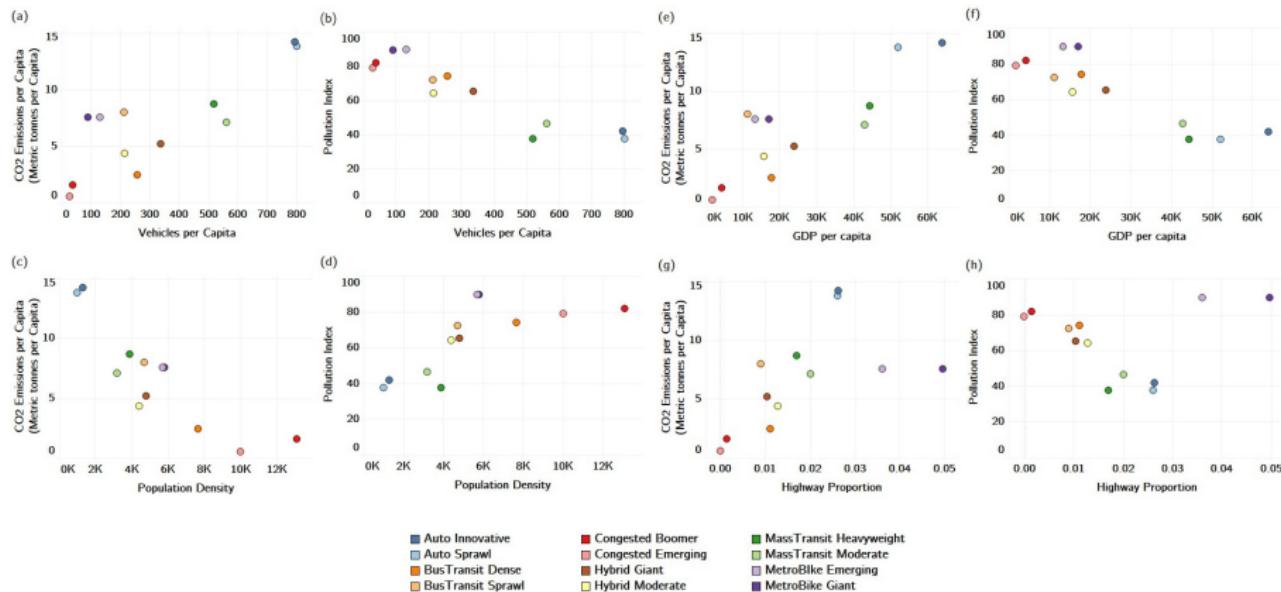
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# Application: evaluating autonomous mobility impacts

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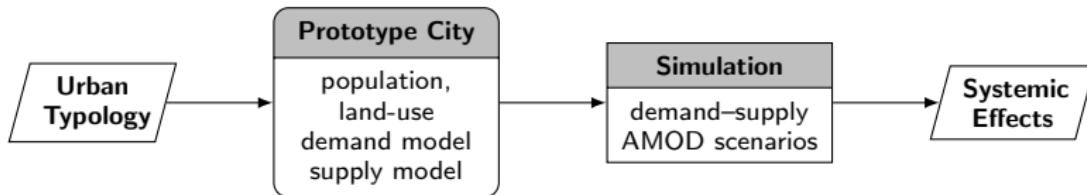
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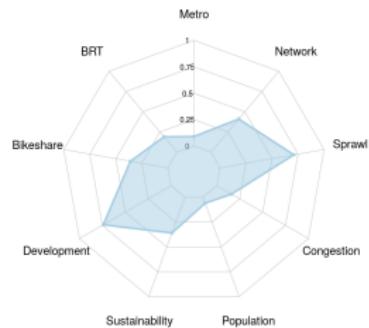
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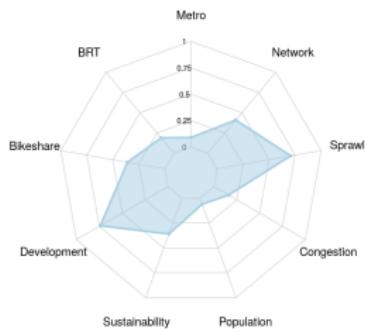
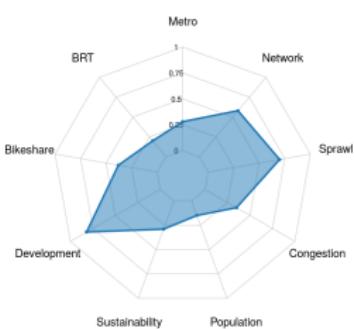
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# A tale of three prototype cities

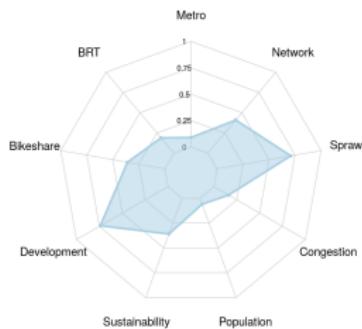
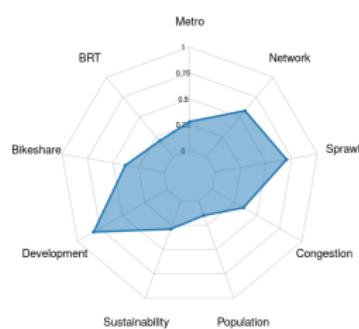
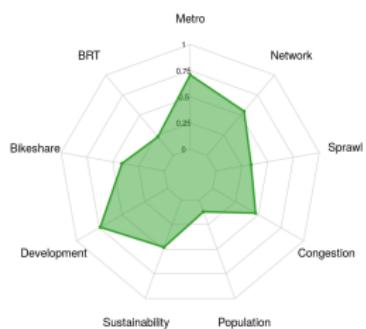
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**Auto Sprawl**

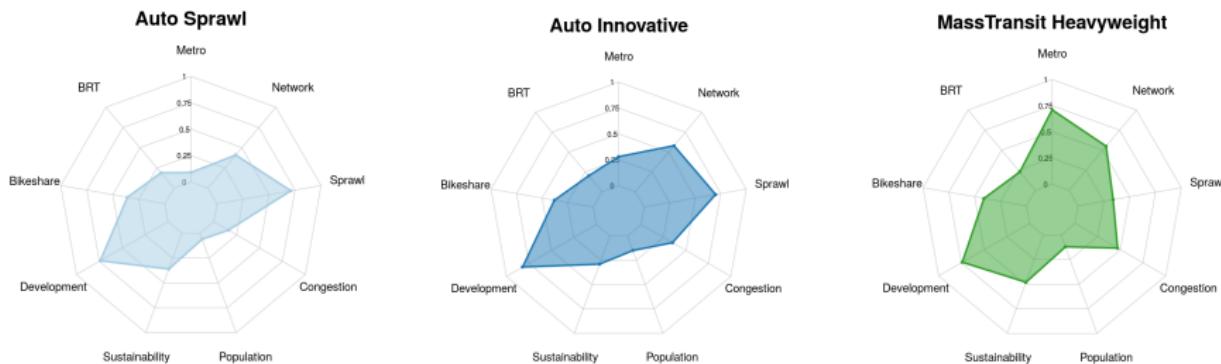
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**Auto Sprawl****Auto Innovative**

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**Auto Sprawl****Auto Innovative****MassTransit Heavyweight**

# A tale of three prototype cities



Characteristics	Auto Sprawl (AS)	Auto Innovative (AI)	Mass Transit Heavyweight (MH)
Car mode share (%)	86	79	32
Mass Transit mode share (%)	3.5	11	37
Walk mode share (%)	3.3	3.3	23
Population density (1000/km <sup>2</sup> )	1.0	1.3	3.9
CO <sub>2</sub> emissions p.c. (mtCO <sub>2</sub> e/yr)	16	15	10
Examples	Baltimore, Tampa, Kuwait City	Boston, Chicago, Wash. DC	Berlin, Madrid, Seoul

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# Global roadway safety outlook<sup>13</sup>

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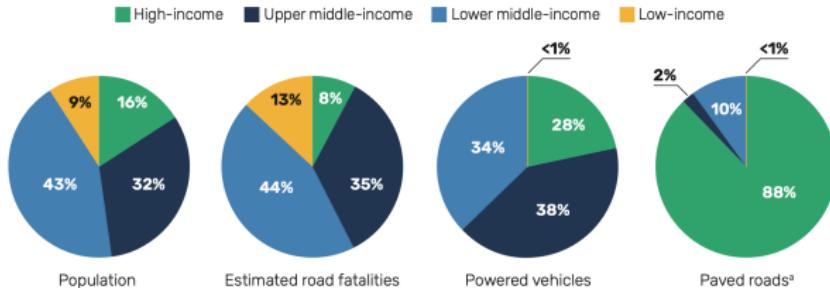
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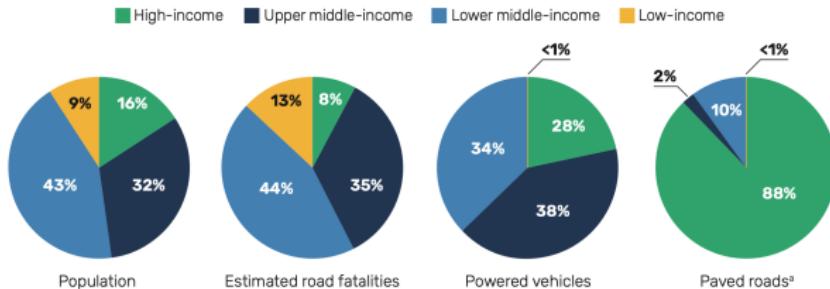
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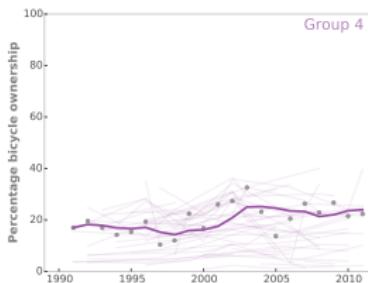
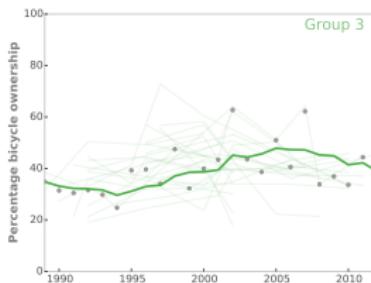
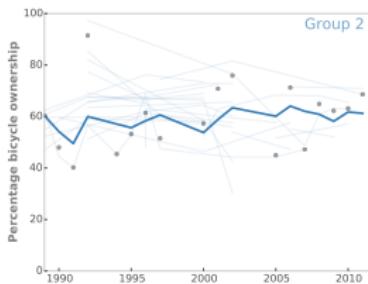
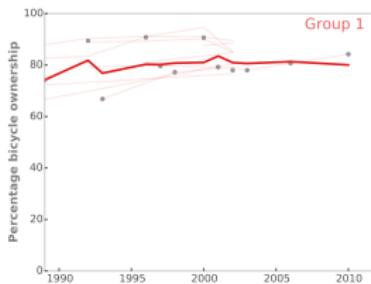
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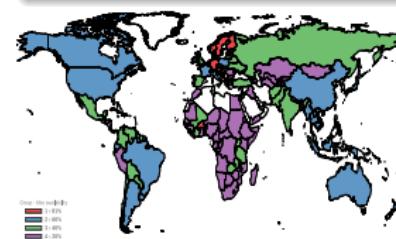
# Bicycle ownership trends

Pattern discovery from survey data in 150 countries spanning 30 years<sup>14,15</sup>



## Key findings

- > 580 million bicycles owned by households around the world
- Global household ownership declined by 50% since 1985



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# Vulnerable road users in the US

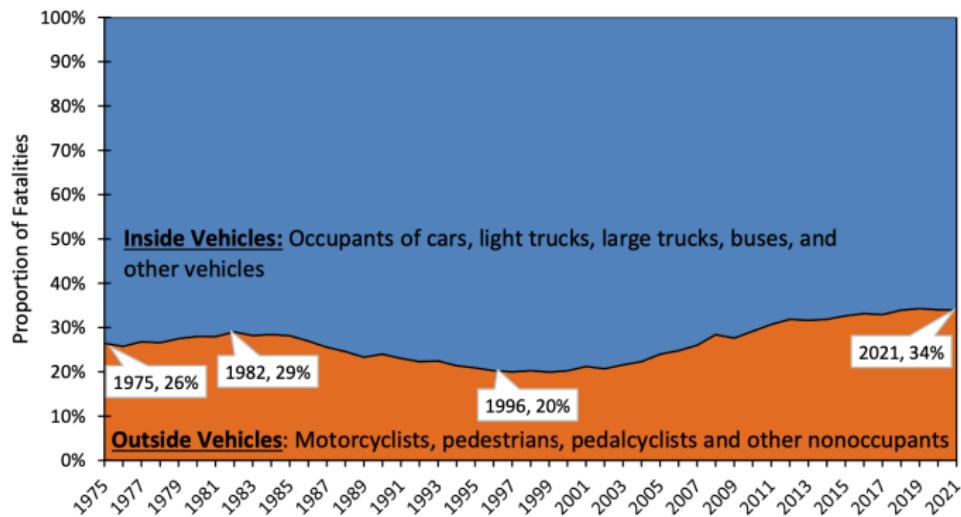
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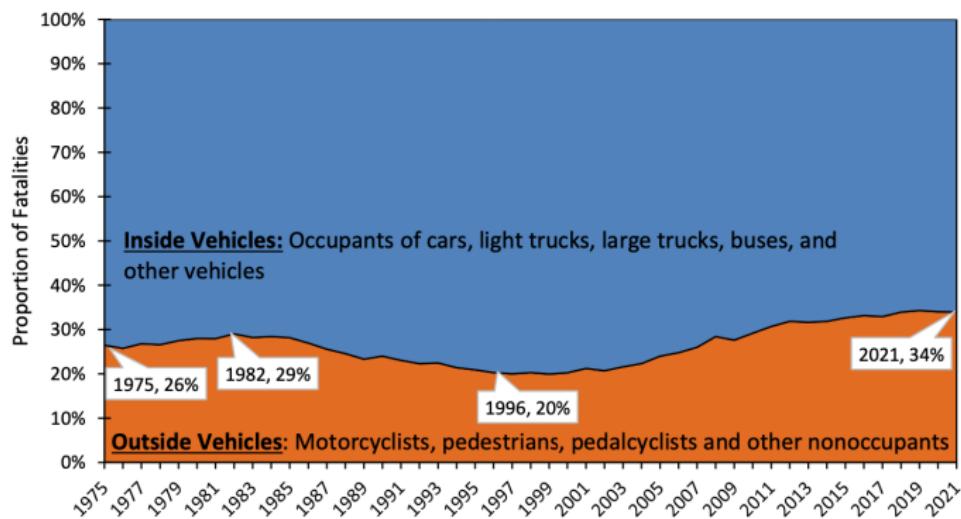
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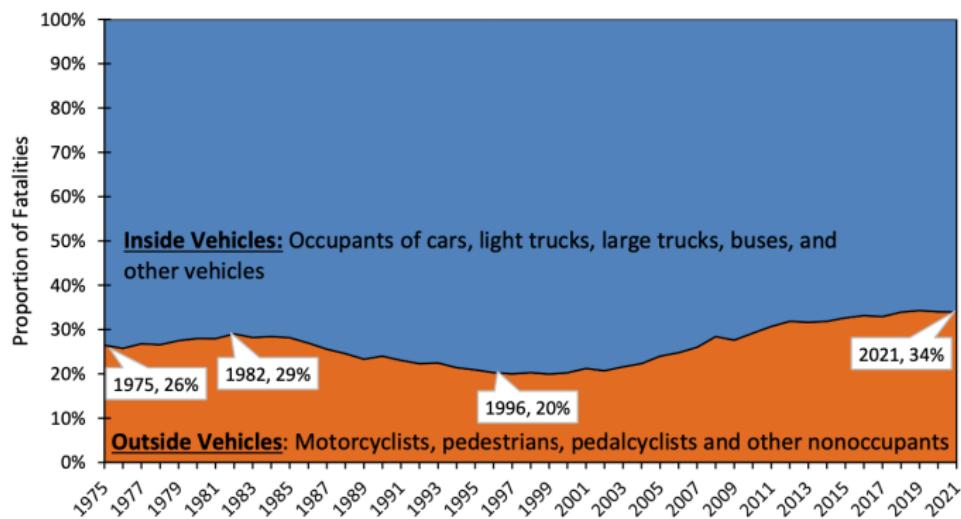


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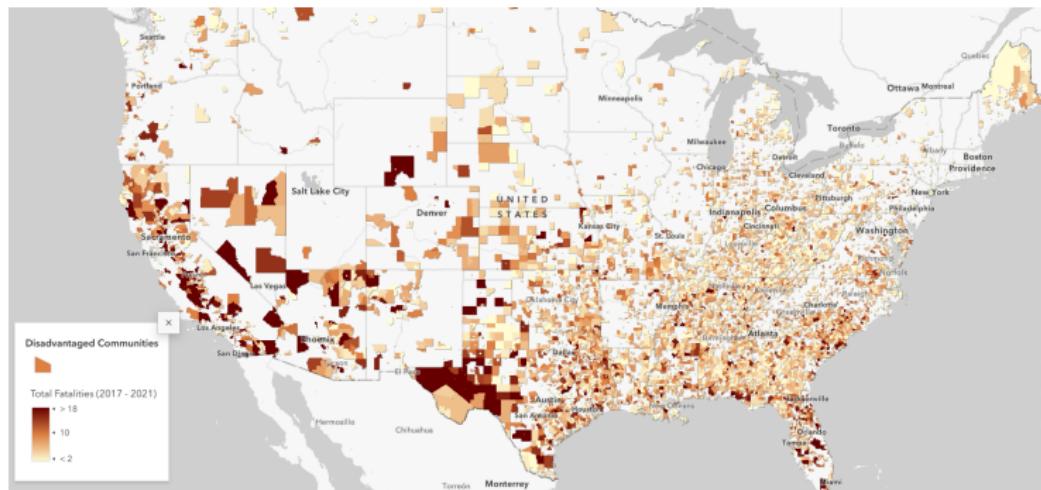


Image source: USDOT *Roadway safety problem* <https://www.transportation.gov/NRSS/SafetyProblem>

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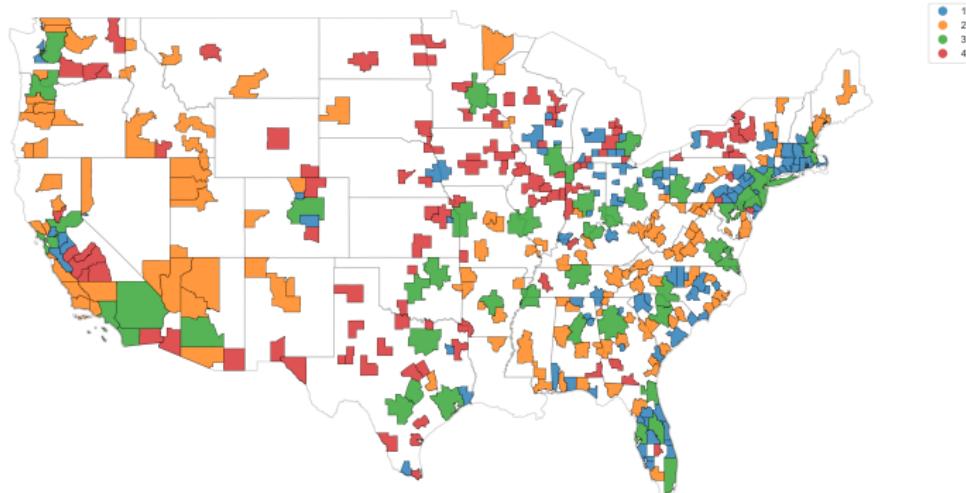
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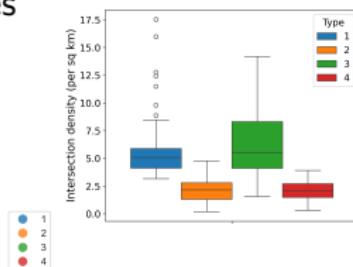
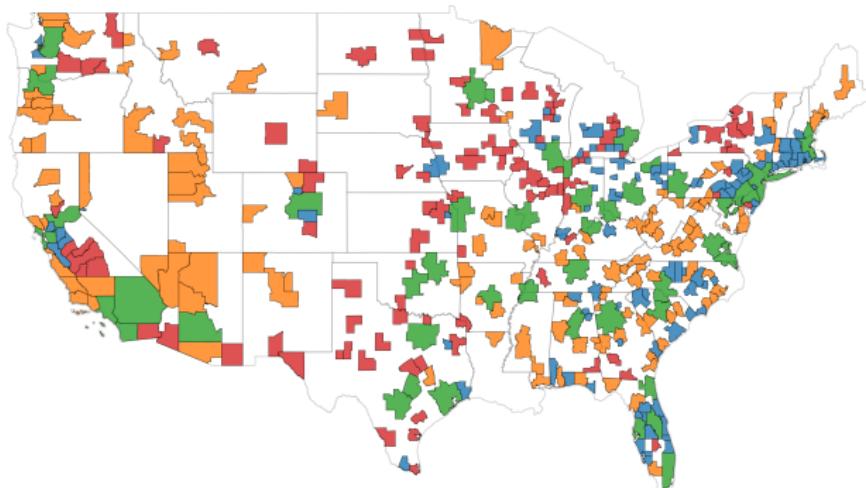
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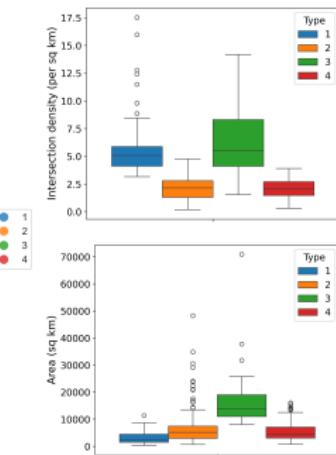
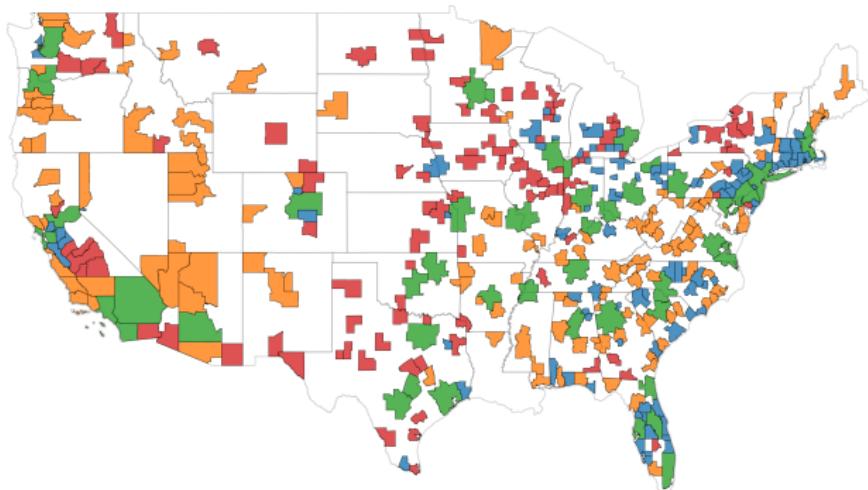
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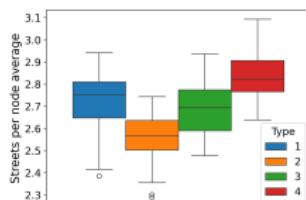
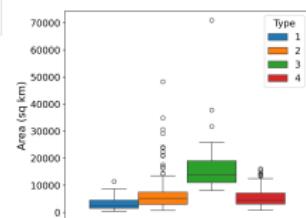
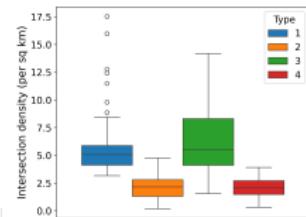
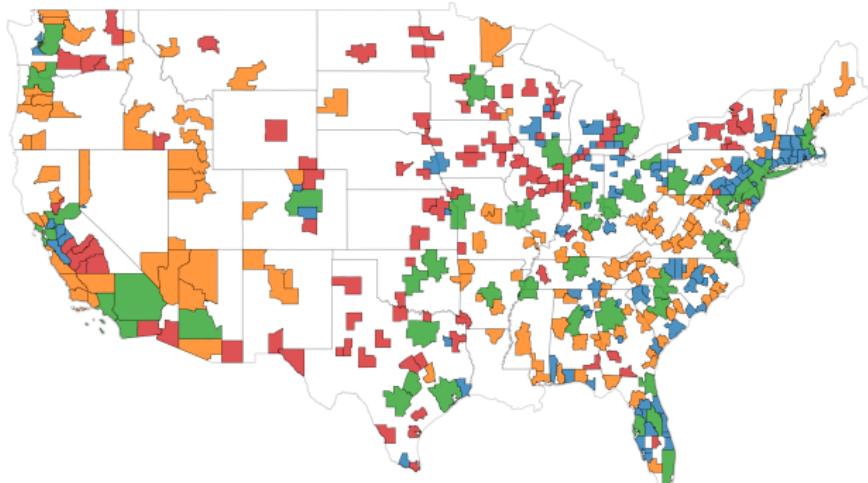
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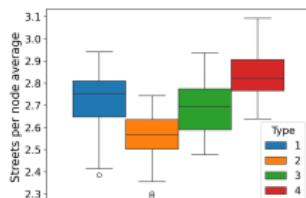
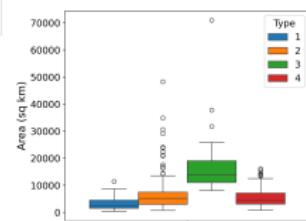
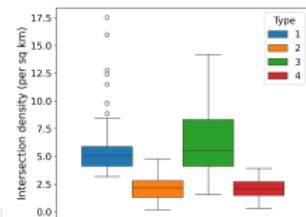
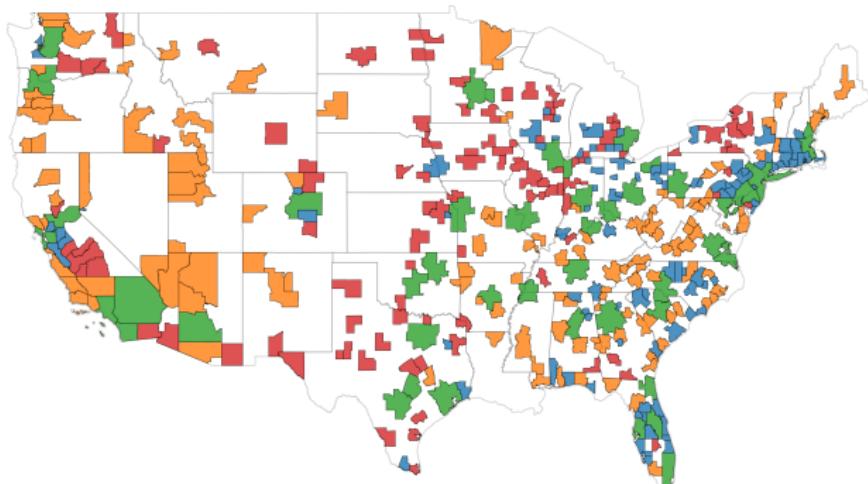
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- Potential applications: explain congestion patterns, analyze crashes

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## Emerging areas

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## Emerging areas

- Decarbonization/electrification
- Fairness (Artificial Intelligence)
- Micromobility

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Thank You

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# Factor analysis

## Model

$$\mathbf{y}^* = \boldsymbol{\nu} + \boldsymbol{\Lambda}\boldsymbol{\eta} + \boldsymbol{\varepsilon} \quad (1)$$

$\mathbf{y}^*$  vector of  $J$  normal response variables

$\boldsymbol{\nu}$  vector of variable means

where:  $\boldsymbol{\Lambda}$   $J \times P$  matrix of factor loadings (or weights);  
 $P$  is number of factors

$\boldsymbol{\eta}$   $P \times 1$  vector of variable scores on each factor

$\boldsymbol{\varepsilon}$   $J \times 1$  vector of independent error terms

# Hierarchical agglomerative clustering methods

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Iteratively group cities by pairing **closest** based on defined metric

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Iteratively group cities by pairing **closest** based on defined metric

Selected method: Ward

- Distance between two clusters  $U, V$  (merging cost):

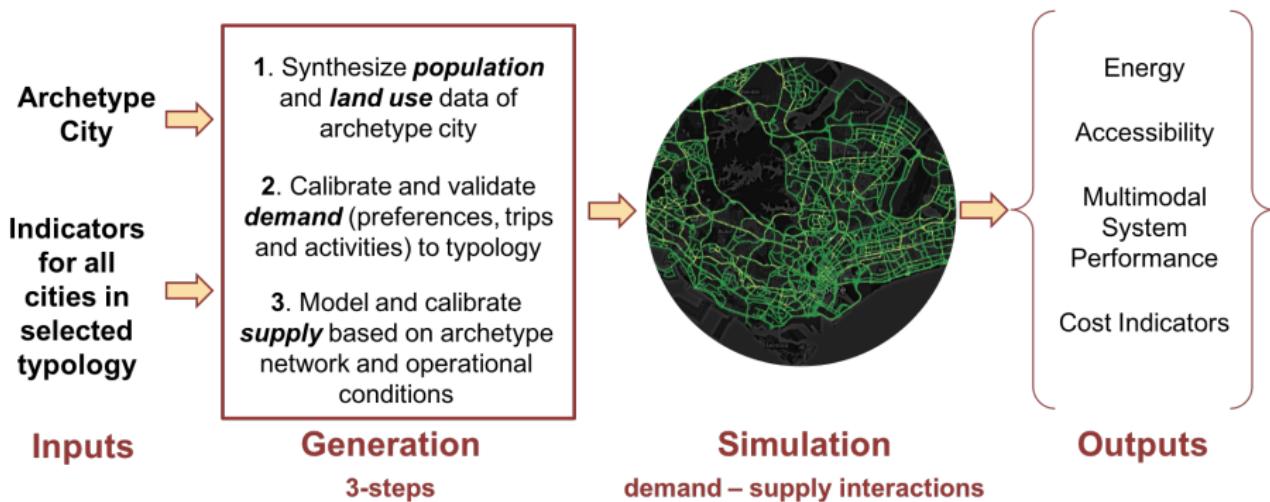
$$\begin{aligned} D(U, V) &= SSE_{UV} - (SSE_U + SSE_V) \\ &= \frac{|u| \cdot |v|}{|u| + |v|} \|\bar{u}_i - \bar{v}_j\|^2 \end{aligned} \tag{2}$$

$SSE$ : sum of squared errors

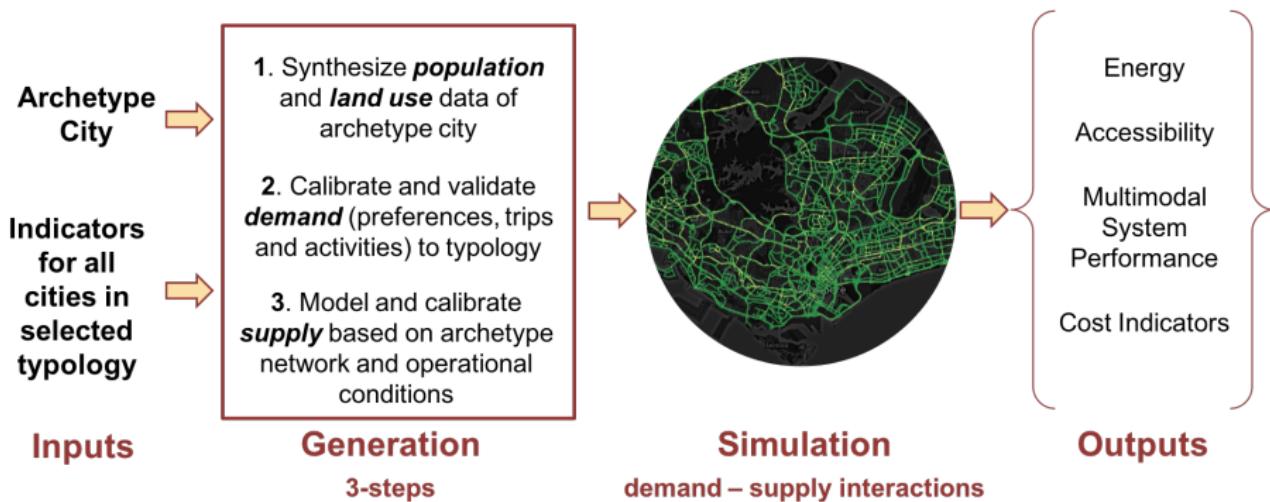
- Optimal number of clusters: 13 (merging cost curve; dendrogram)

# Prototype city generation overview

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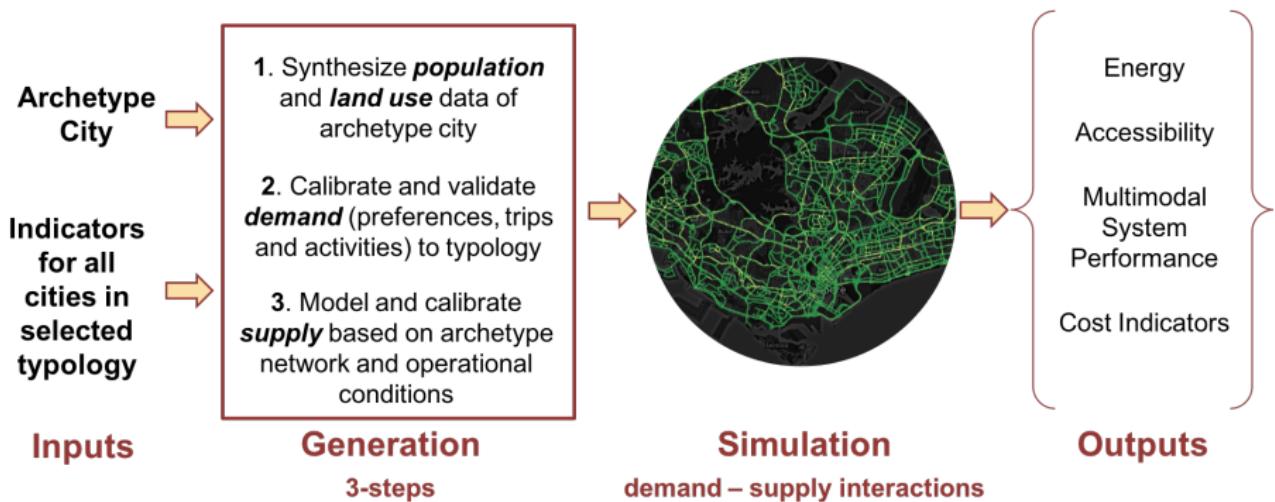


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## Approach

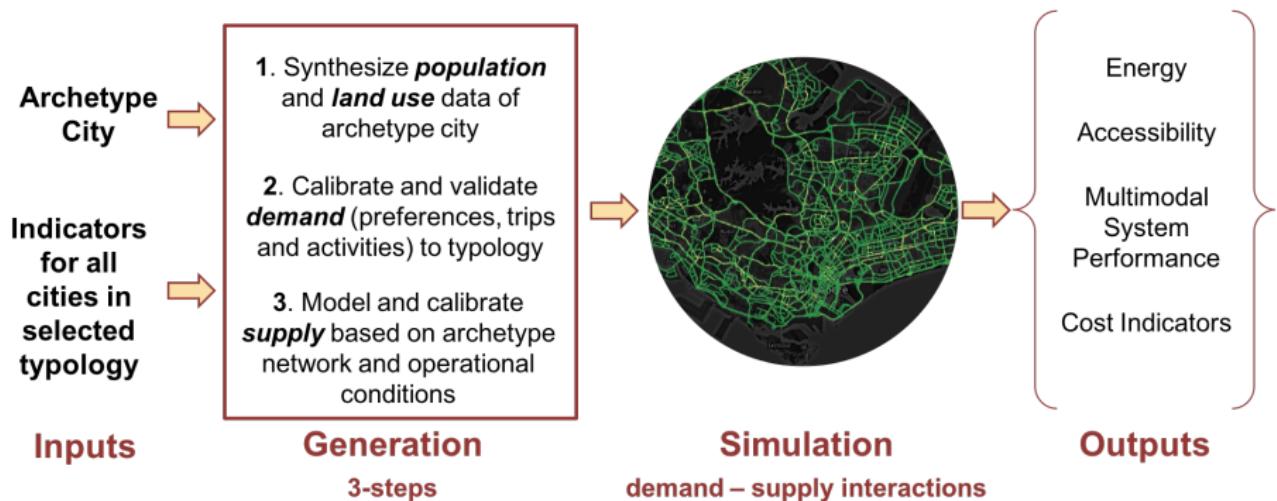
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## Approach

Generate representative prototype city for urban typology:

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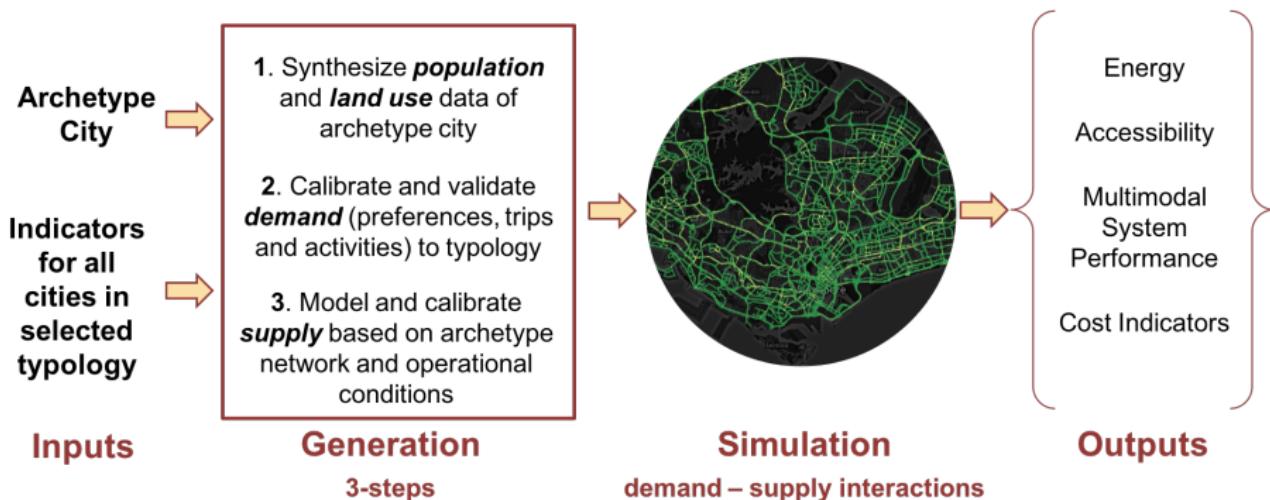


## Approach

Generate representative prototype city for urban typology:

- Population and land-use synthesis

# Prototype city generation overview

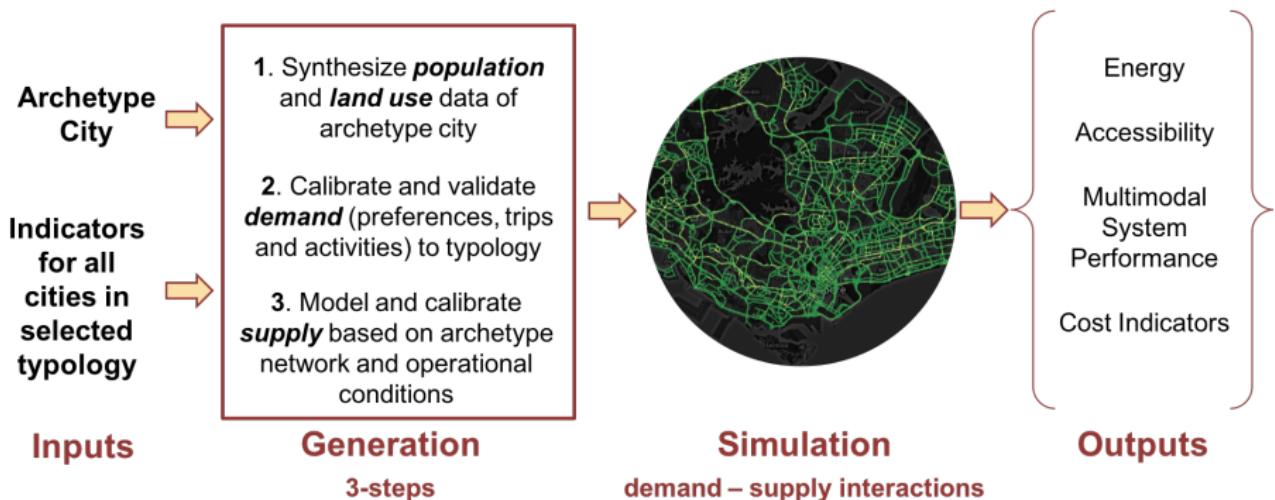


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Generate representative prototype city for urban typology:

- Population and land-use synthesis
- Demand modeling and calibration

# Prototype city generation overview

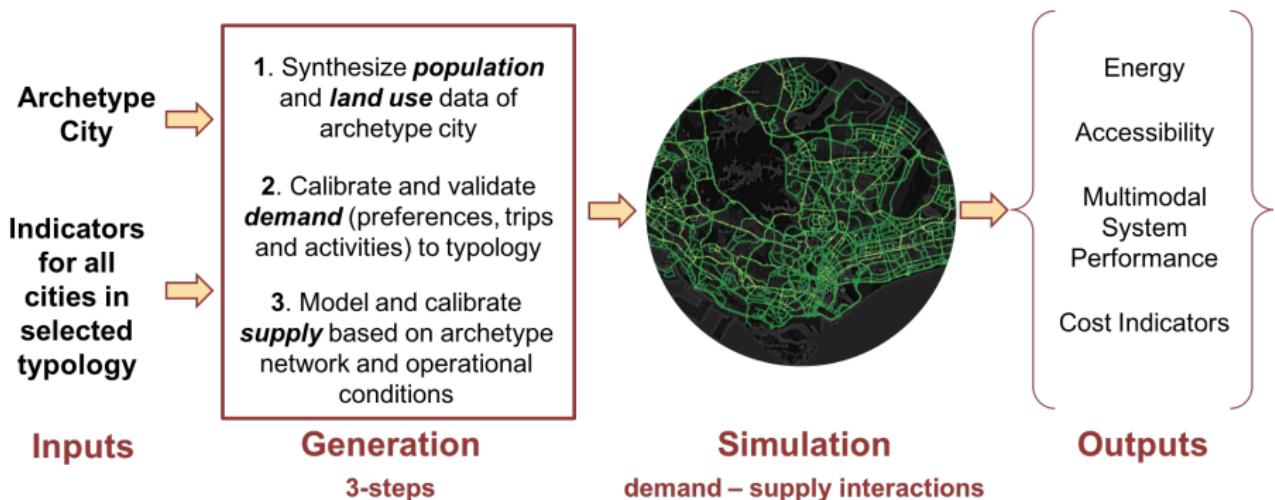


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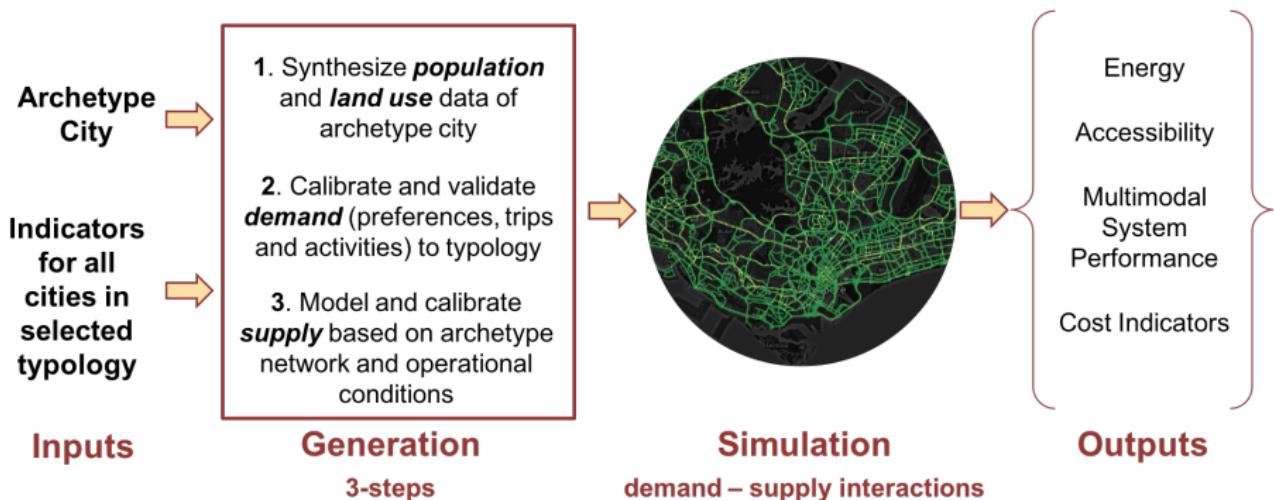


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Generate representative prototype city for urban typology:

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Perform agent-based simulations to analyze mobility scenarios

# Scenarios

- Base Case

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- existing on-demand services; mass transit and private modes

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## On-demand powertrain assumptions

- MoD fleet: hybrid-electric vehicles
- AMOD fleet: battery-electric vehicles

# Mesoscopic simulator: SimMobility Mid-term

