Satellite Data for Environment

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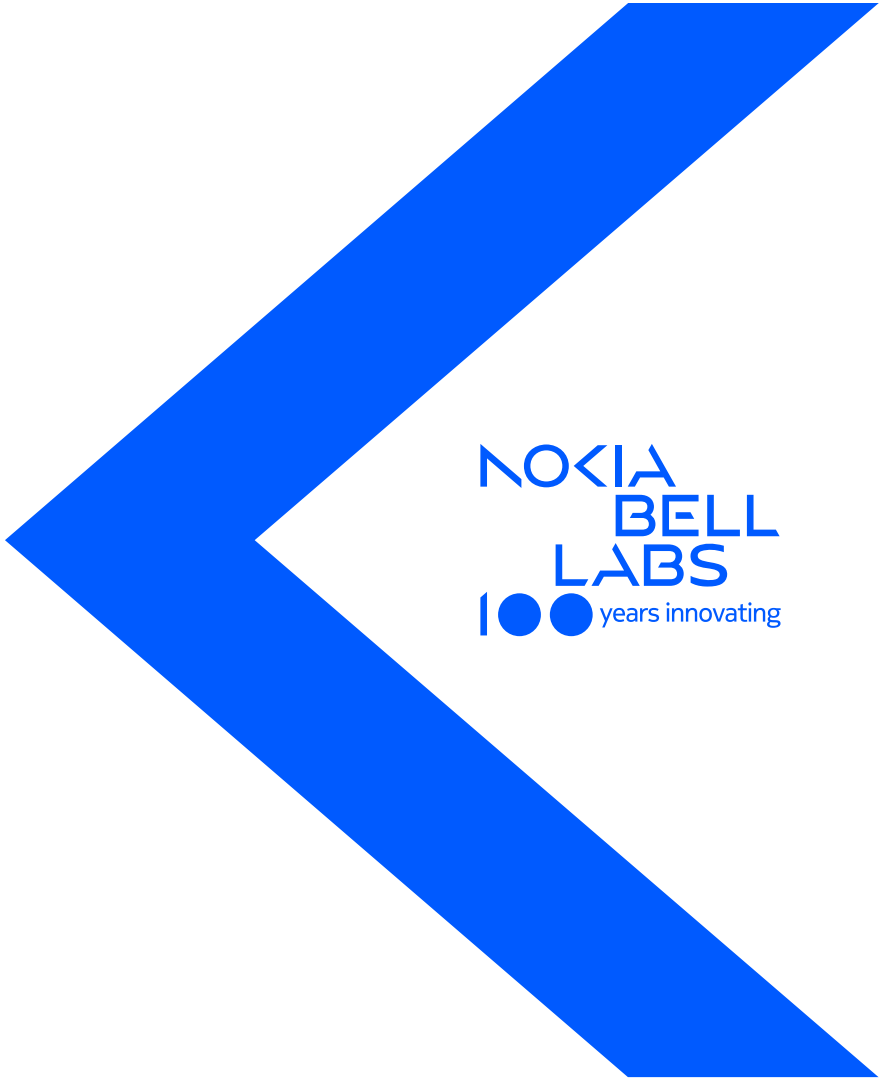


1 Urban Vitality

2 Environmental Indicators for Health

3 Greenery and Health

1 Urban Vitality

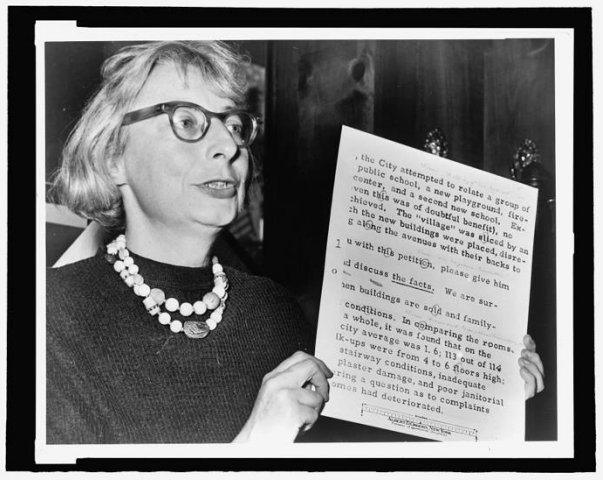
Predicting Urban Vitality with Open Satellite Data

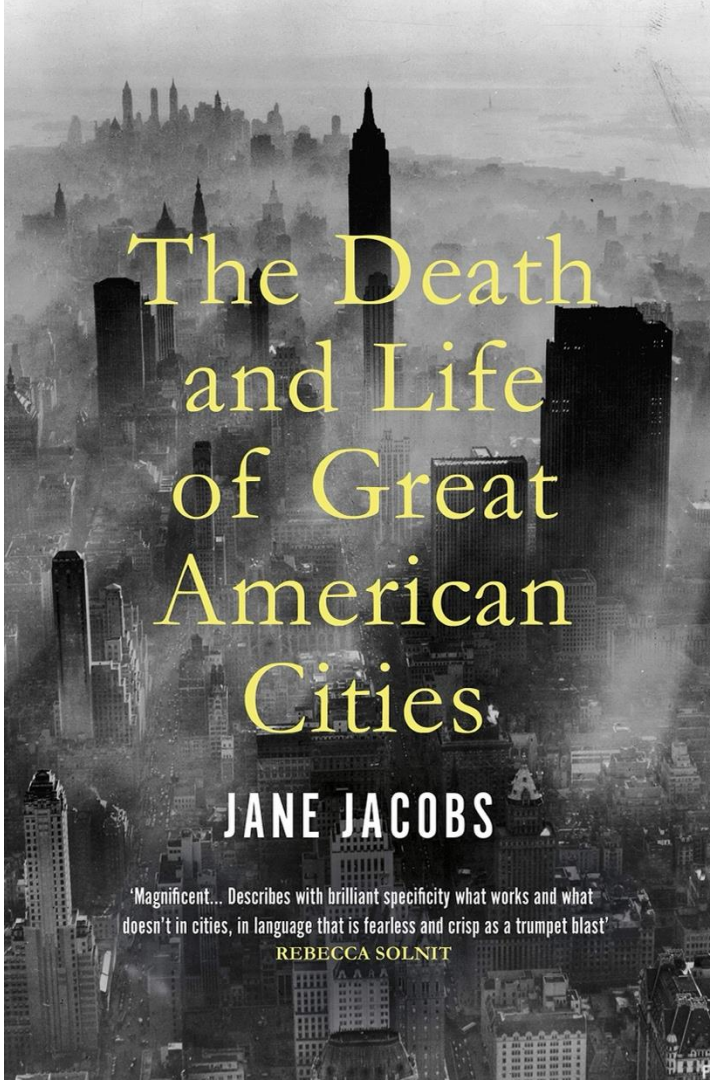
Jane Jacobs Theory Empirically Validated

Jane Jacobs Urban Vitality Theory

Theorized 4 conditions for the promotion of life in cities:

1. diversity of land use,
2. small block sizes,
3. concentration of people, and
4. mix of economic activities.





Jane Jacobs Theory in Practice

1

Seoul

The Household Travel Survey

New Address Information Database, Seoul Land Use Information Database, Nationwide Firm Statistics Survey, Population and Housing Census, Korea Transport Database

Hyungun Sung, Sugie Lee, and SangHyun Cheon. 2015. Operationalizing Jane Jacobs's urban design theory: Empirical verification from the great city of Seoul, Korea. Journal of Planning Education and Research 35, 2 (2015), 117–130.

2

Italian cities

Mobile phone Internet density

OpenStreetMap, Census Data, Land Use, Infrastructures, Foursquare

Marco De Nadai, Jacopo Staiano, Roberto Larcher, Nicu Sebe, Daniele Quercia, and Bruno Lepri. 2016. The death and life of great Italian cities: a mobile phone data perspective. In Proceedings of the International conference on World Wide Web (WWW). ACM, 413–423.

3

Italian cities (our work)

Mobile phone Internet density

Sentinel-2 imagery

Šćepanović, Sanja, et al. "Jane Jacobs in the Sky: Predicting Urban Vitality with Open Satellite Data." Proceedings of the ACM on Human-Computer Interaction 5.CSCW1 (2021): 1-25.

Our Approach

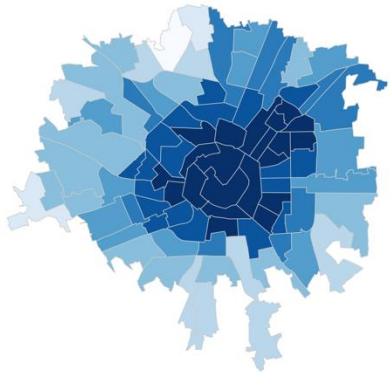
Quantify 2 out of the 4 conditions for the promotion of life in cities:

1. diversity of land use,
2. small block sizes,
3. concentration of people,
4. mix of economic activities,

Or vitality directly from satellite imagery (Sentinel-2).

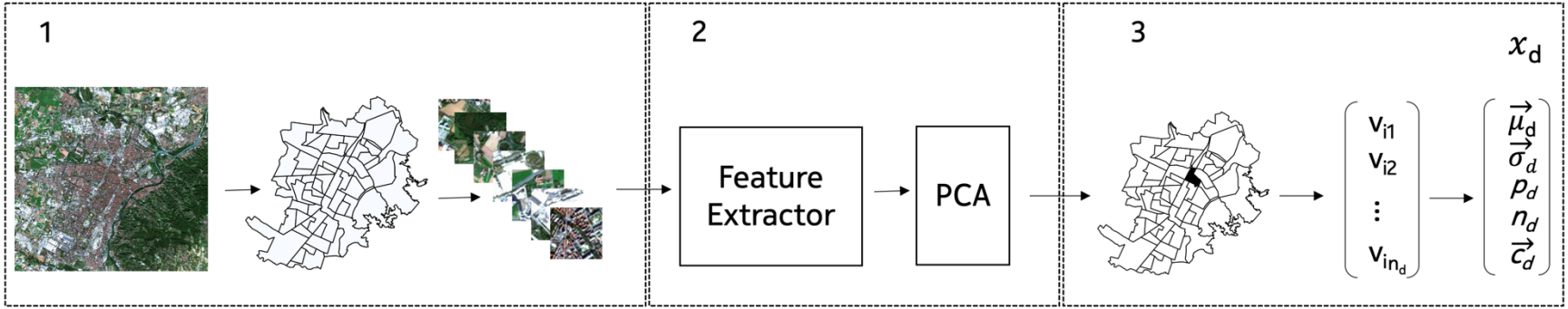
Data

City	#Districts (N_c)	Mean Area (in km^2)	Mean Population
Milan	85	1.72	14,551
Bologna	23	3.34	15,918
Florence	21	2.89	16,633
Palermo	43	2.01	15,075
Turin	56	2.00	15,543
Rome	146	3.24	17,123



Land Use		μ	σ	**Small Blocks**		μ	σ
Land use mix		0.733	0.201	Block size		9.618	0.459
Building height		0.689	0.216	Intersection density		10^{-4}	10^{-4}
Small parks		0.004	0.003	Anisotropicity		0.385	0.042
Vitality		μ	σ				
Activity density		0.006	0.005				

Framework

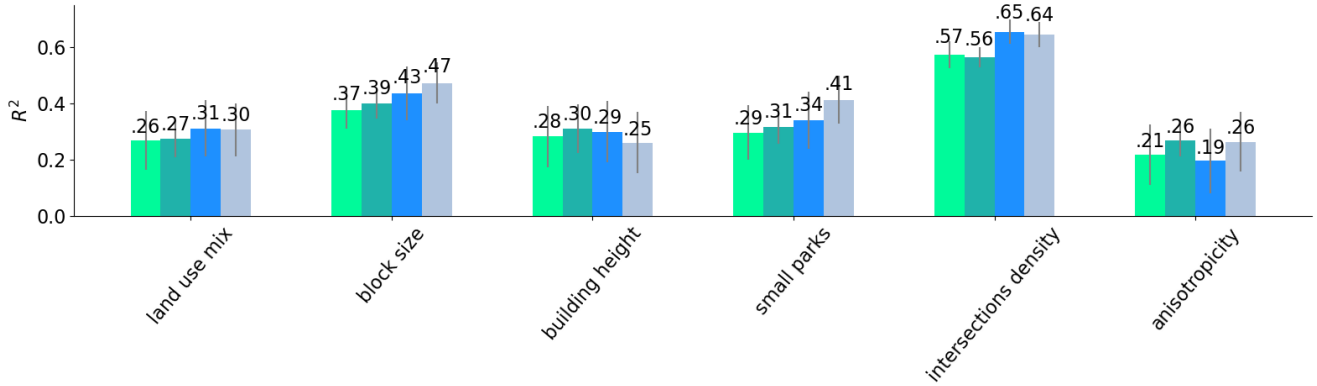


Step 1: extract small images (imagelets) from satellite imagery

Step 2: extract visual features from these imagelets with deep learning methods

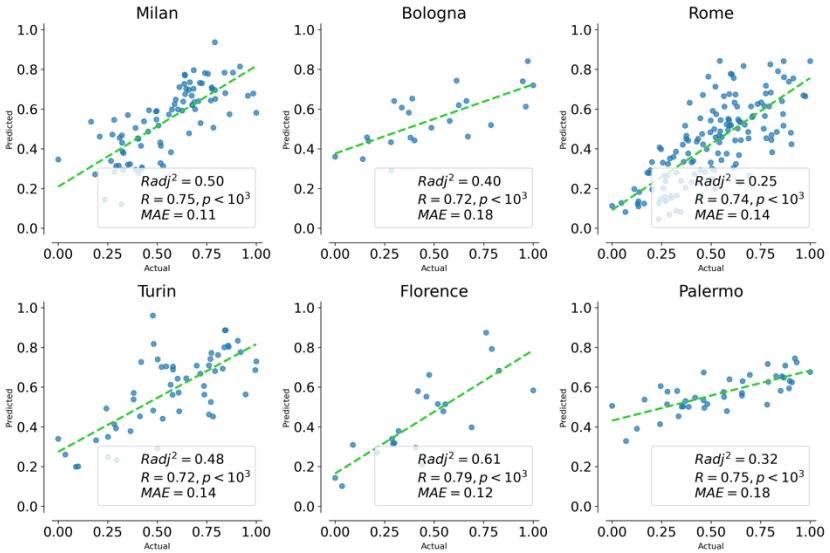
Step 3: combine these features into district-level feature vectors

Results: Predicting Vitality Conditions



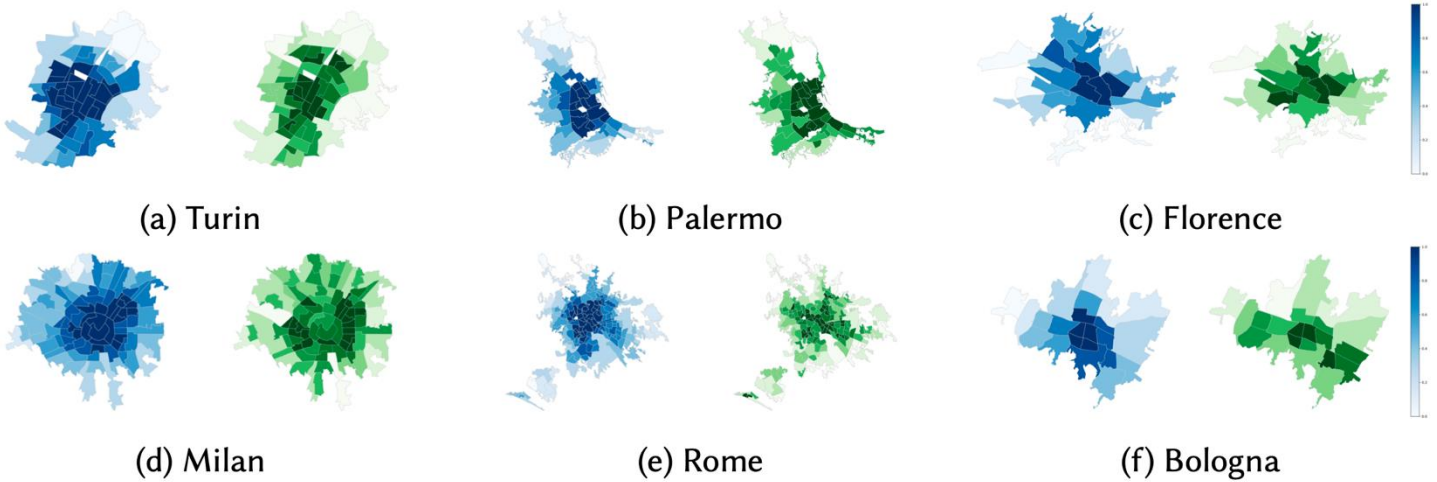
Regression scores for predicting different vitality conditions from satellite features.

Results: leave-one-city-out



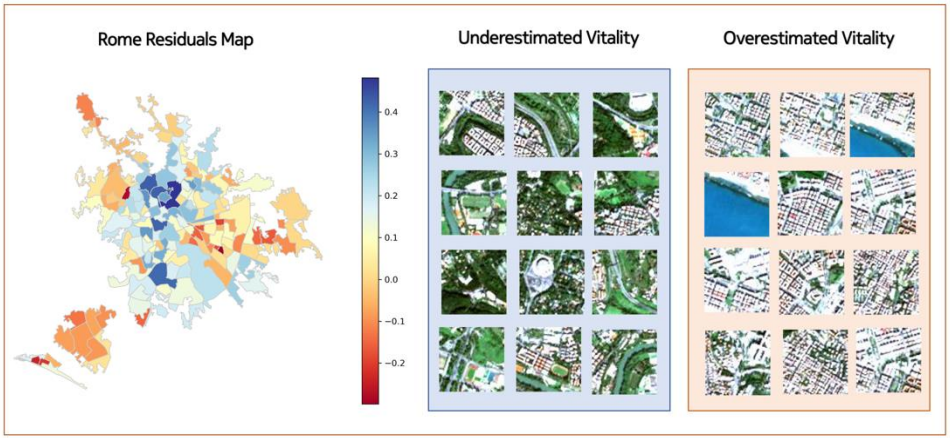
Regression scores for predicting vitality directly from satellite features on an unseen city.

Results: leave-one-city-out



Maps of the true (blue) and predicted (green) urban vitality levels.

Factors Affecting Vitality Prediction



underestimated vitality levels in areas with large parks, rivers, highways, and stadiums

overestimated vitality levels in areas with high density of buildings and near the sea

Satellite Data for Urban Vitality

Practical Implications

Satellite Data in City Dashboards

Guidelines for Urban Measurement from Satellite Data

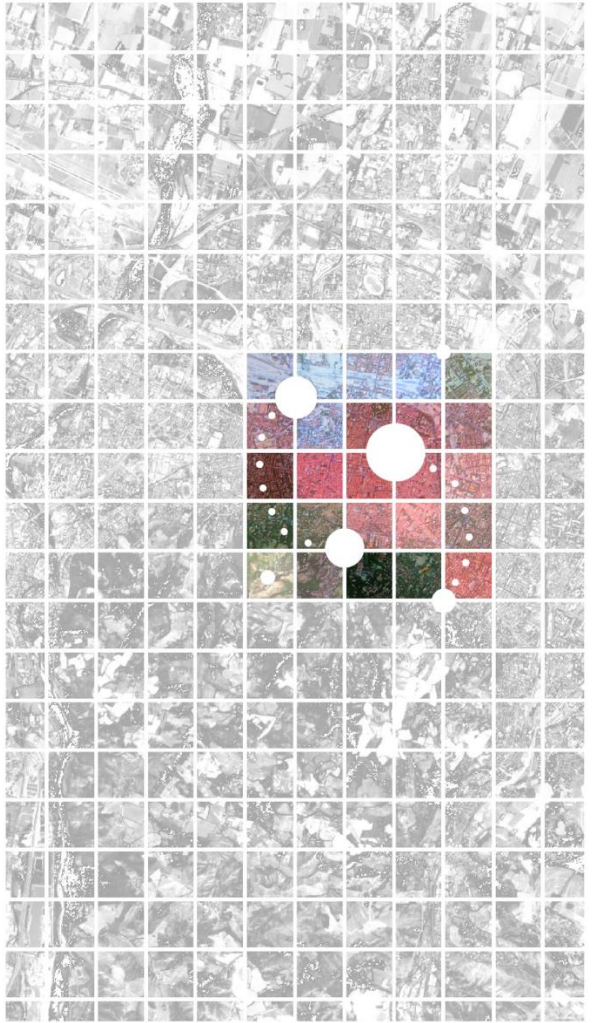
Digital Earth

Theoretical Implications

If scaled across the world, could help to uncover subtleties in how vitality is expressed across different natural and cultural environments and extend the theory

Interactive Visualisation

http://social-dynamics.net/vitality



by Edyta P. Bogucka

2 Environmental Indicators for Health

MEDSAT

A Public Health Dataset for England Featuring Medical Prescriptions and Satellite Imagery

Environment Impacts Health

MEDSAT enables public health research

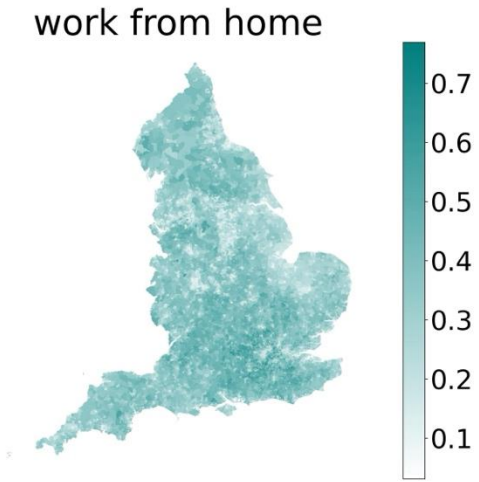
A novel readily available real-world dataset for the entire England

- **all** the NHS **prescriptions**
- for **all** 33K Lower Layer Super Output Areas (**LSOAs**), each <18km^2
- **pre-COVID** (2019) and first **COVID-year** (2020)

MEDSAT Structure

Which features are available for each small area?

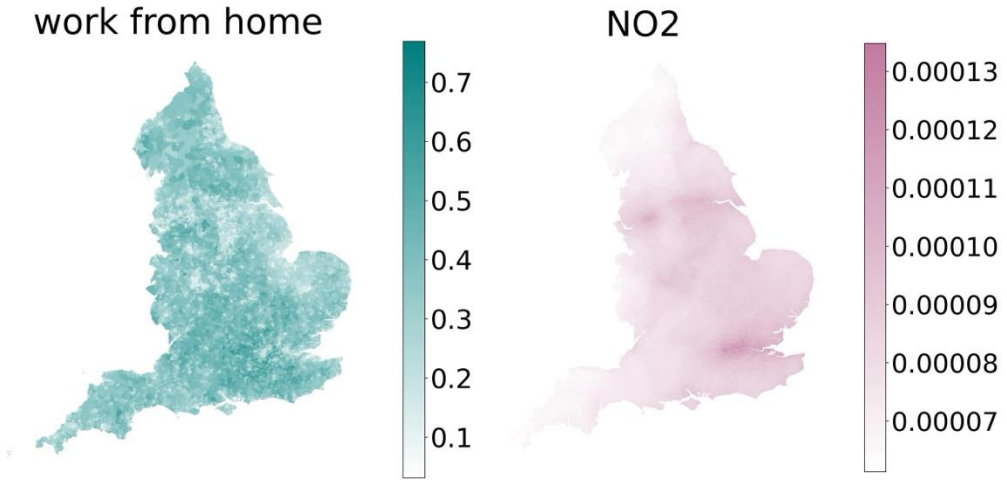
- 100+ sociodemographic



MEDSAT Structure

Which features are available for each small area?

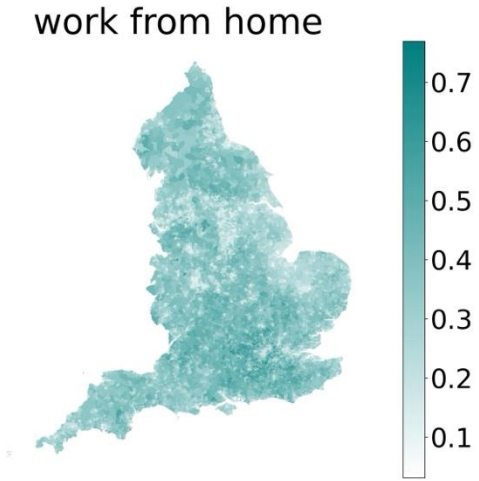
- 100+ sociodemographic
- 40+ environmental

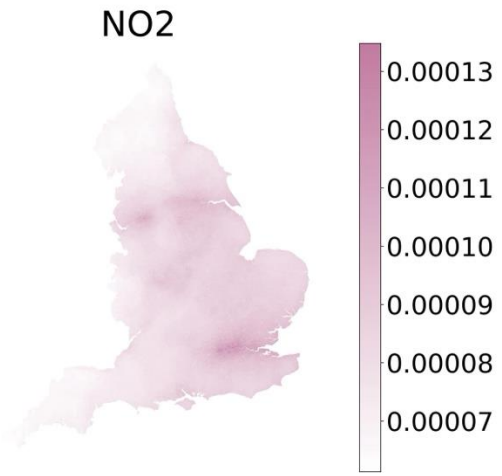


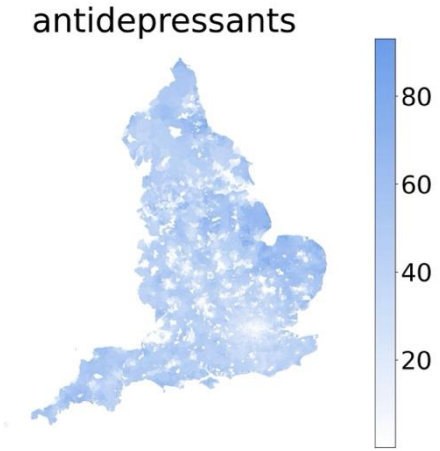
MEDSAT Structure

Which features are available for each small area?

- 100+ sociodemographic
- 40+ environmental
- 7 medical outcomes



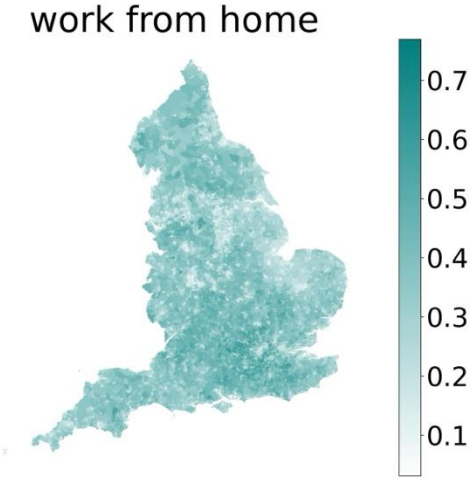


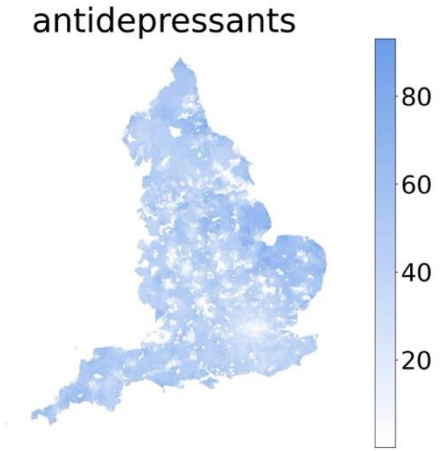


MEDSAT Structure

Which features are available for each small area?

- 100+ sociodemographic
- 40+ environmental
- 7 medical outcomes
- 8 seasonal satellite images



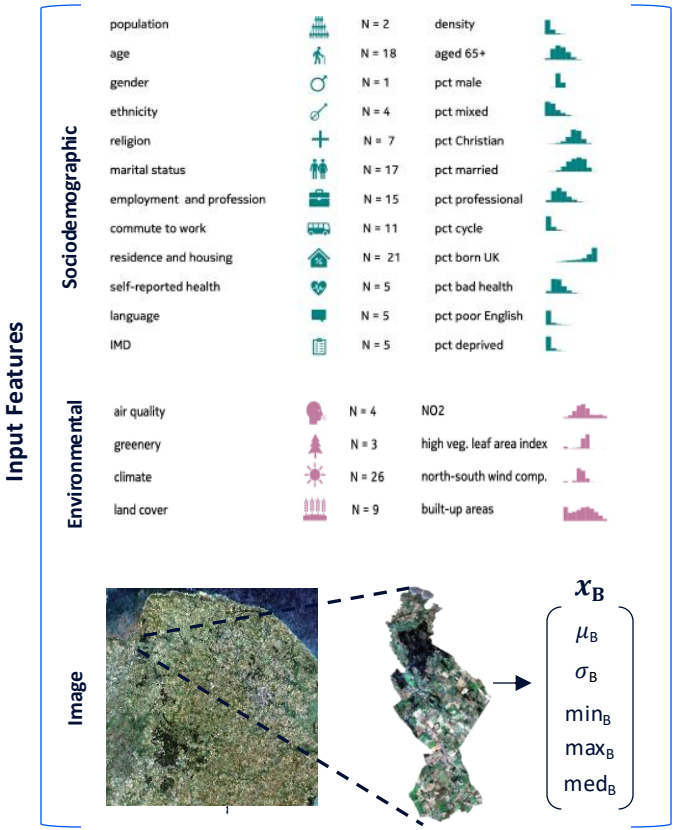


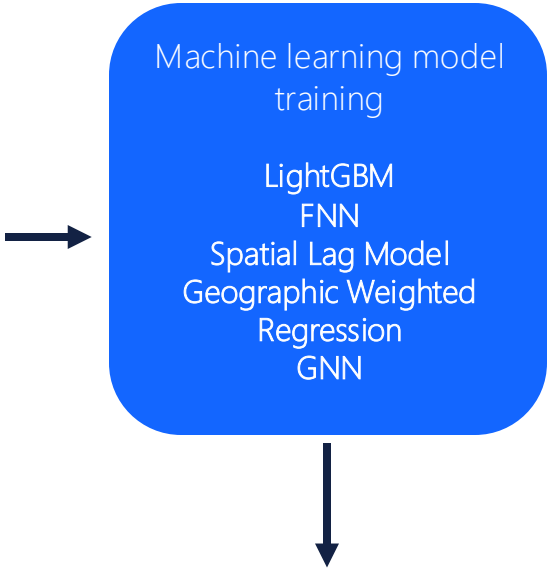
Sentinel-2 imagery

How MEDSAT Supports Public and Population Health?

Preliminary Insights

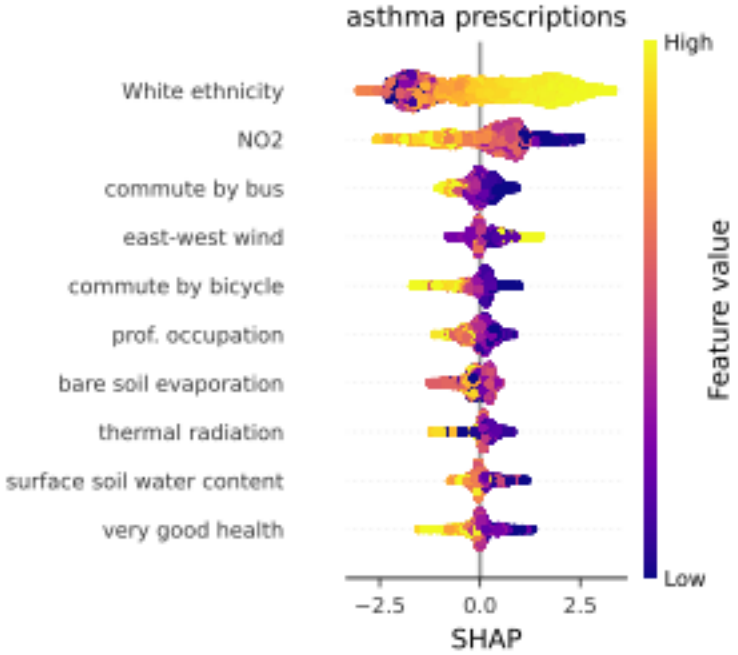
Machine Learning Pipeline for Extracting Health Insights

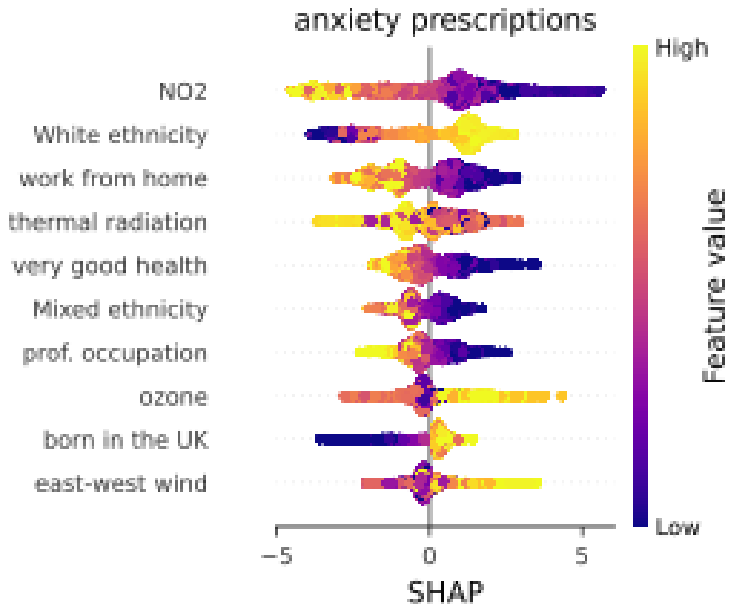




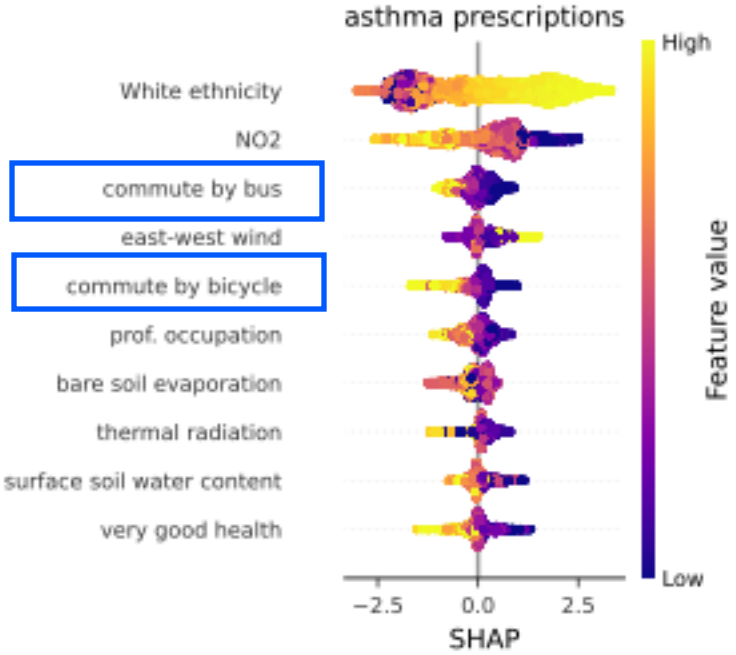
NOKIA BELL LABS

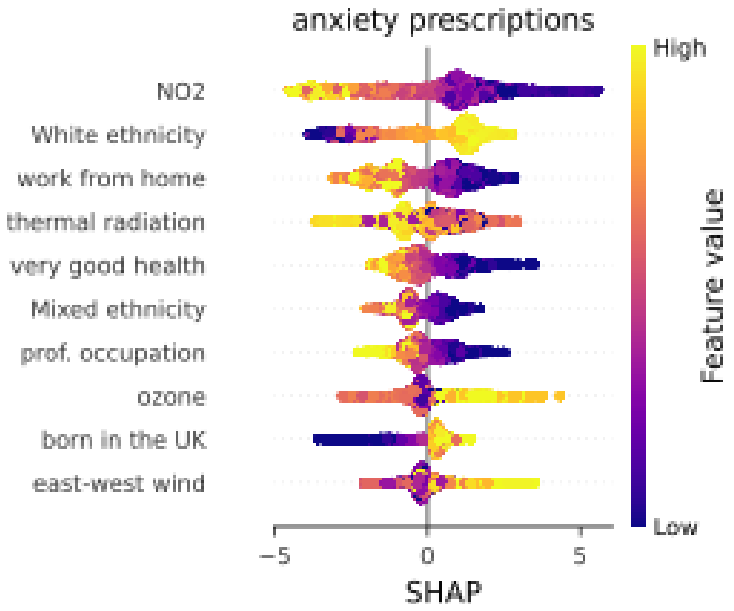
SHAP Values Reveal Important Health Indicators





SHAP Values Reveal Important Health Indicators





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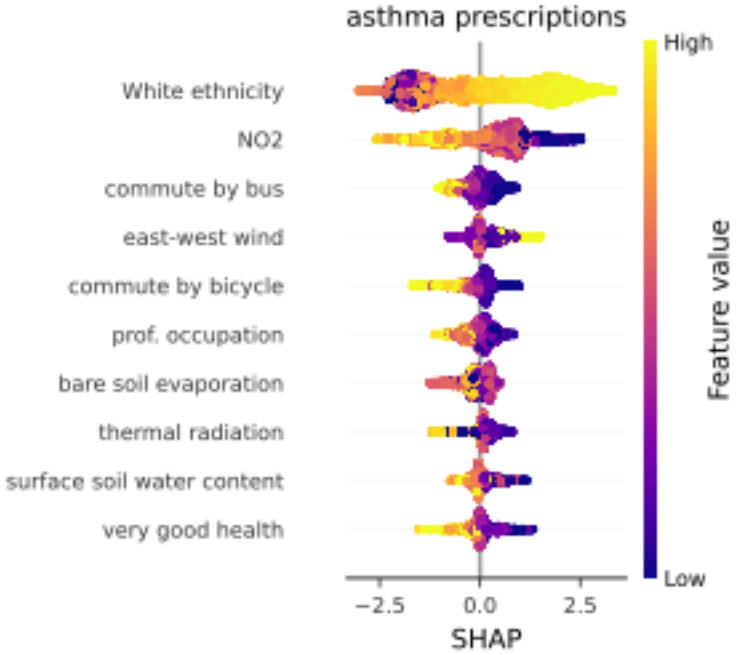
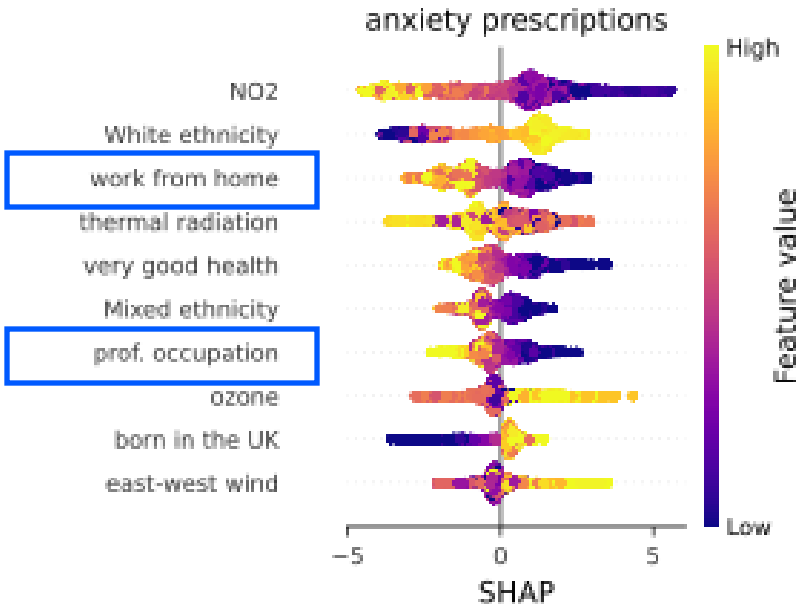
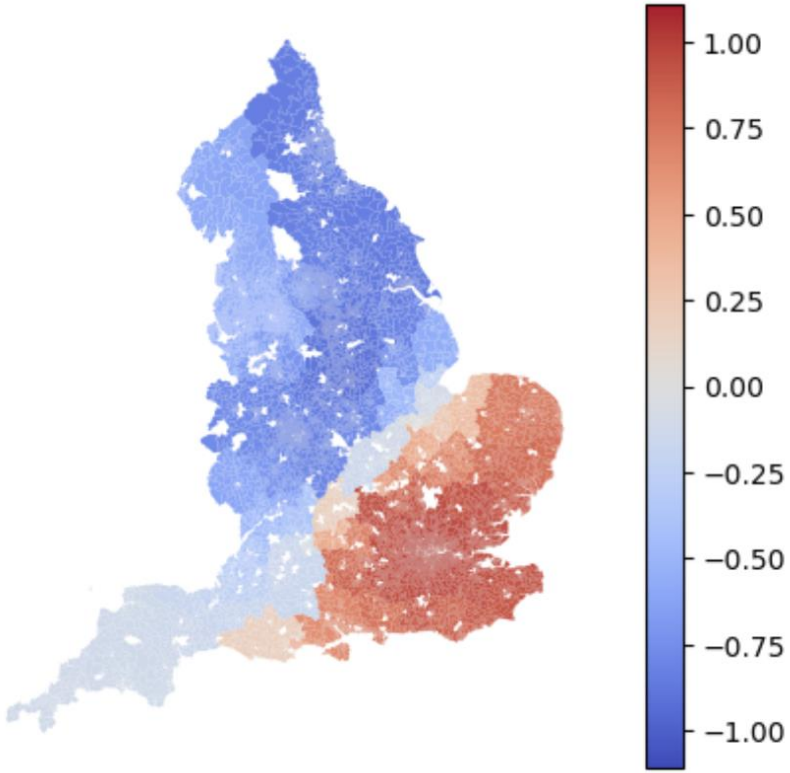




Solar Radiation Is a Crucial Predictor of Anxiety Prescriptions

but Very Dependent on Region



MEDSAT Enables Public and Population Health Research

- Empowers the development of innovative machine learning approaches for health modelling
- Facilitates novel discoveries in public health

3 Greenery and Health

Vitamin N: Benefits of Different Forms of Public Greenery for Urban Health

NDVI, WHO, or Natural England targets assess urban greenery

but yield inconsistent findings

Some studies have reported that urban greenery is

- is associated with better health
- others have found no correlation,
- others have even found a worse health.

Our Proposal for Spatial Greenery Classification

Public Greenery Classification:

1) on-road: visible and accessible during on-road activities
2) off-road: predominantly found in public parks and gardens

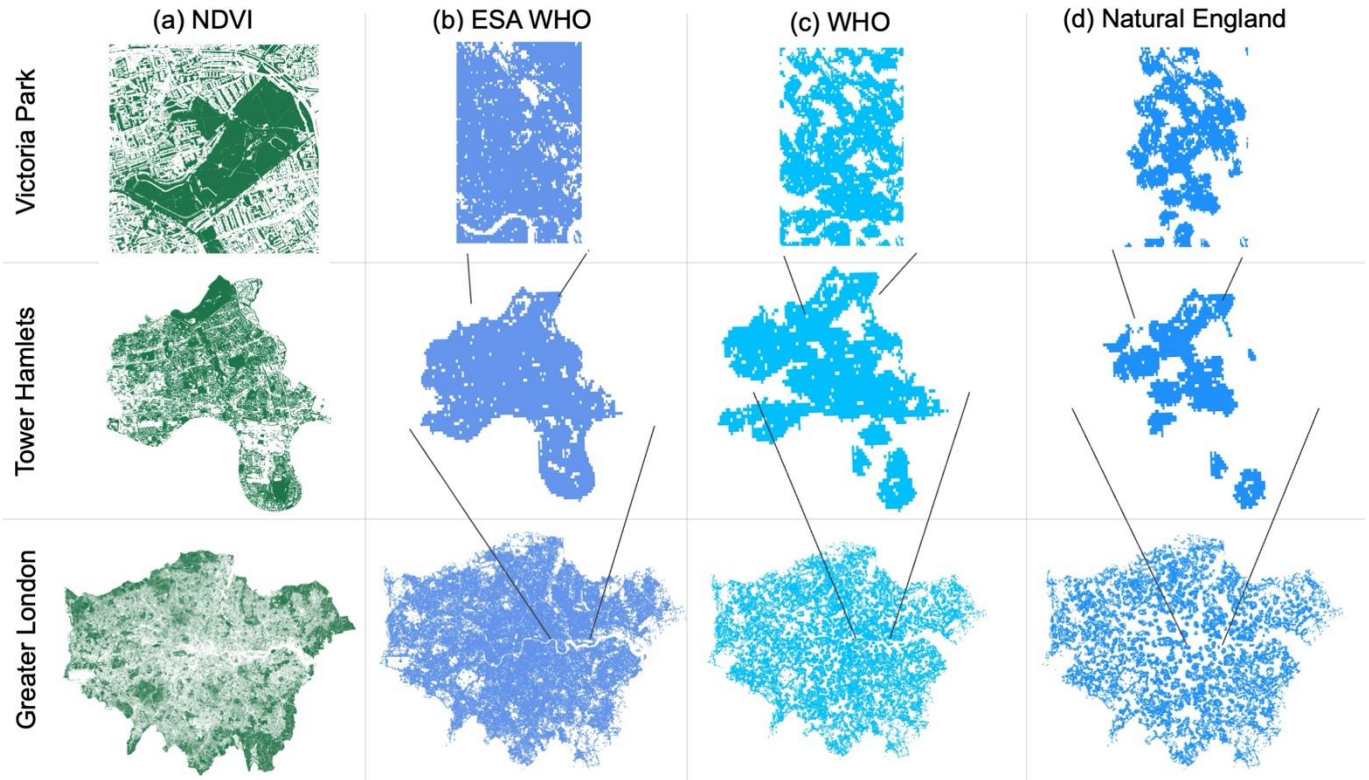
Total: consists of these two public greenery types, and the rest of private (inaccessible) greenery found mainly in private gardens

Study Area

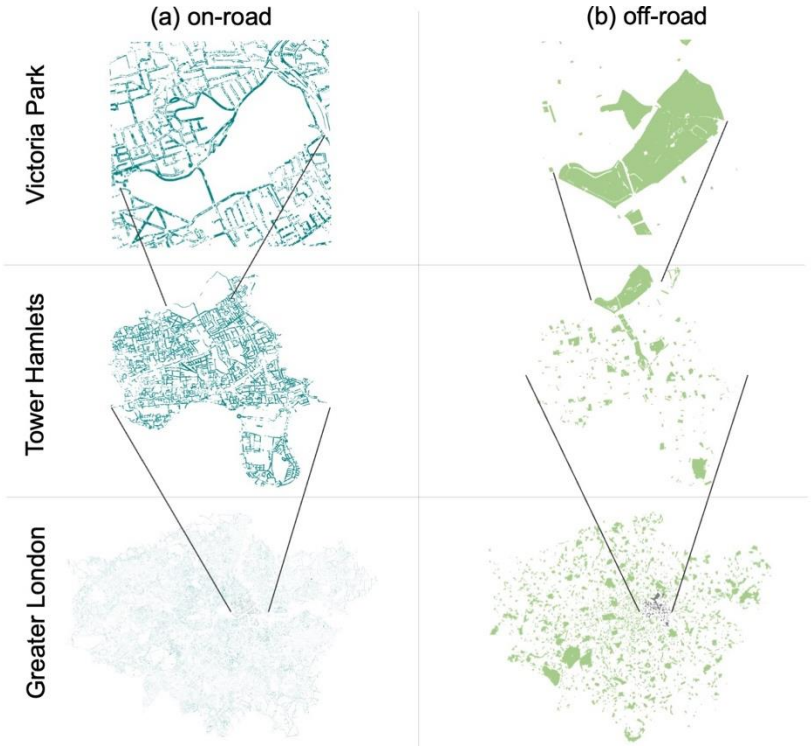
Greater London

NDVI. Source: high-resolution aerial map London Green Cover.

Official Greenery Measures



Our Proposed Measures



Spatial distributions of greenery

Zoom-in to Victoria Park

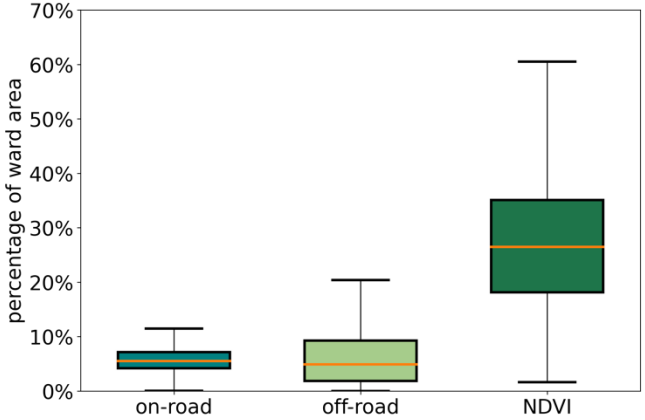
(a) satellite

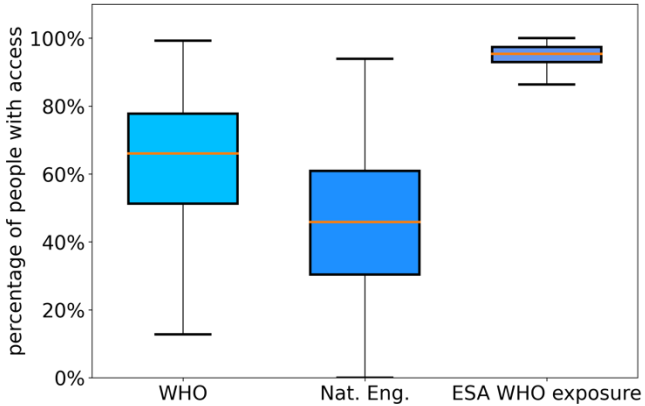
(b) NDVI

(c) off-road + on-road

The NDVI quantifies all visible greenery uniformly from the satellite perspective. In contrast, our two greenery types effectively capture the diversity of greenery, considering its location, function, and accessibility.

Percentage of greenery across wards





Predicting Medical Prescriptions while Controlling for Greenery

Propensity Score Matching Model

Official Greenery

	diabetes	hypertension	asthma	depression	anxiety	opioids	total
NDVI	1.18%	1.99%	0.86%	0.91%	0.19%	-0.79%	**1.90%**
ESA WHO	-0.49%	-0.91%	0.83%	-0.75%	-1.99%	-0.73%	-0.93%
WHO	**1.70%**	2.39%	2.68%	**3.08%**	**3.11%**	**3.23%**	1.40%
Nat. Eng.	**2.45%**	**2.13%**	**2.29%**	**2.09%**	1.81%	1.49%	**1.78%**

Significant causal ATEs ($p < 0.01$) are bolded.

Our Greenery

	diabetes	hypertension	asthma	depression	anxiety	opioids	total
on-road	**-3.01%**	**-3.68%**	**-2.32%**	**-2.59%**	**-2.92%**	**-3.18%**	**-0.90%**
off-road	0.17%	1.66%	-1.56%	-2.10%	-0.84%	-0.47%	-1.26%

Significant causal ATEs ($p < 0.01$) are bolded.

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Vitamin N: Benefits of Different Forms of Public Greenery for Urban Health

Practical Implications

Street-visible greenery may **promote walking** and **encourage social interactions**.

It can mitigate harmful effects of **pollution and noise,** providing **restorative benefits** against chronic stressors during daily commutes.

Less frequent daily exposure to parks might dilute the positive health effects of available greenery.

Theoretical Implications

This evidence emphasizes the need for more nuanced investigations into the **multifaceted relationships between urban greenery and health outcomes**.

Thanks to my Collaborators










Sagar Joglekar
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Ke Zhou
Ivica Obadic
Xiaoxiang Zhu
Ishaan Maitra
Alice Battiston
Crhistiano Nattero


NOKIA
BELL
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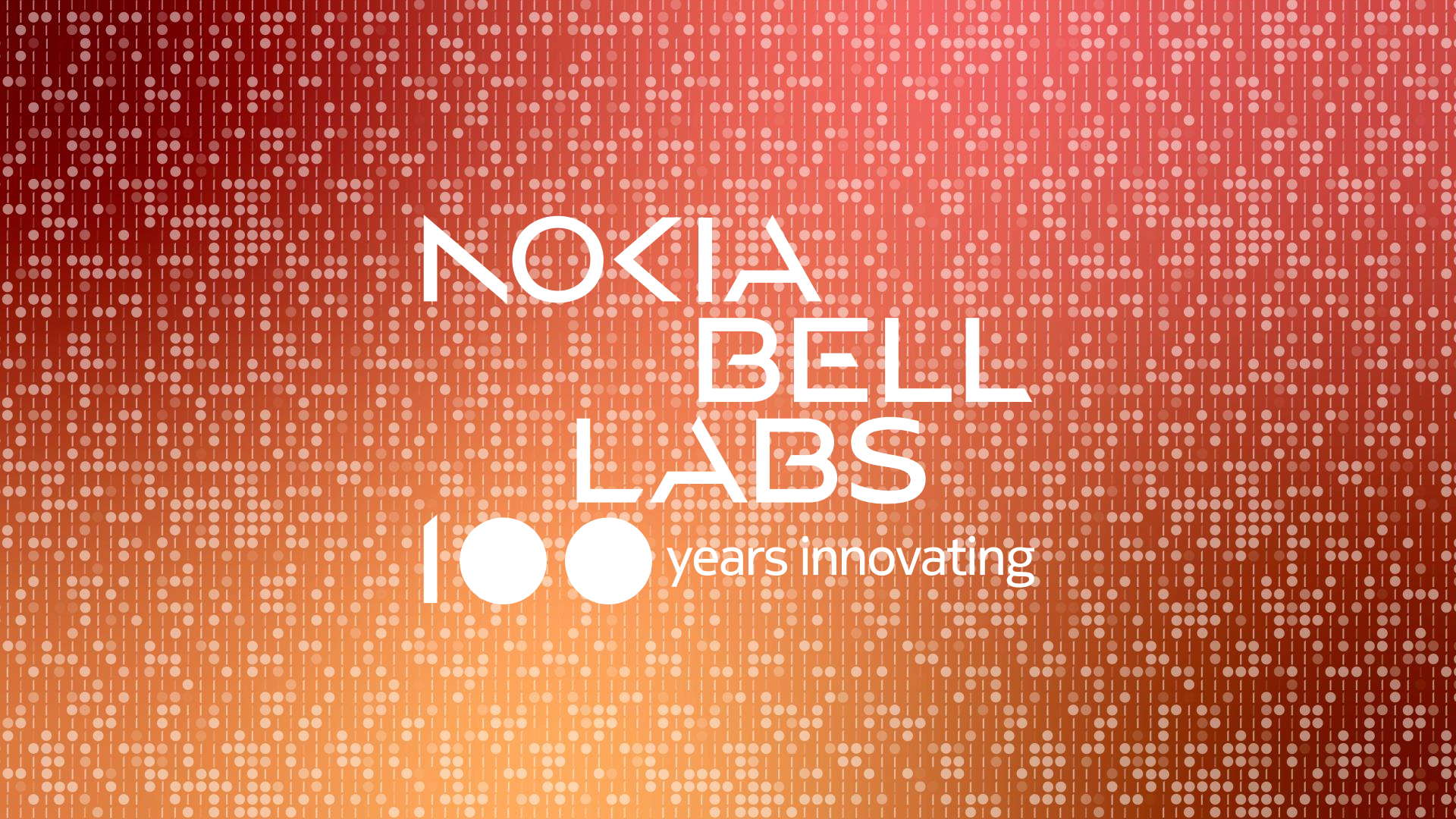
100 years innovating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