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Where England's Cities Are Growing: Evidence from Big Building Footprint Data and Explainable AI

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Detecting construction, demolition, and regeneration using building footprint data in England

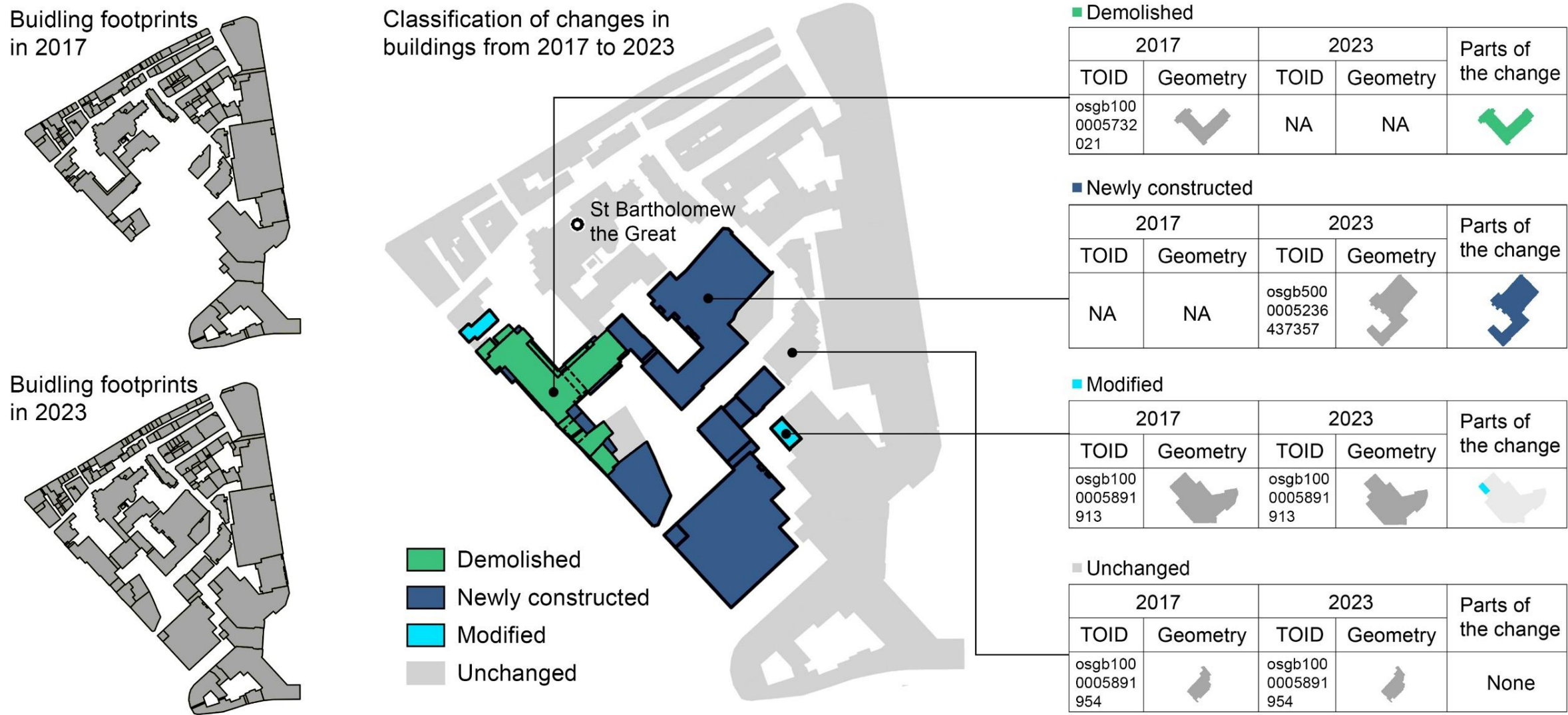
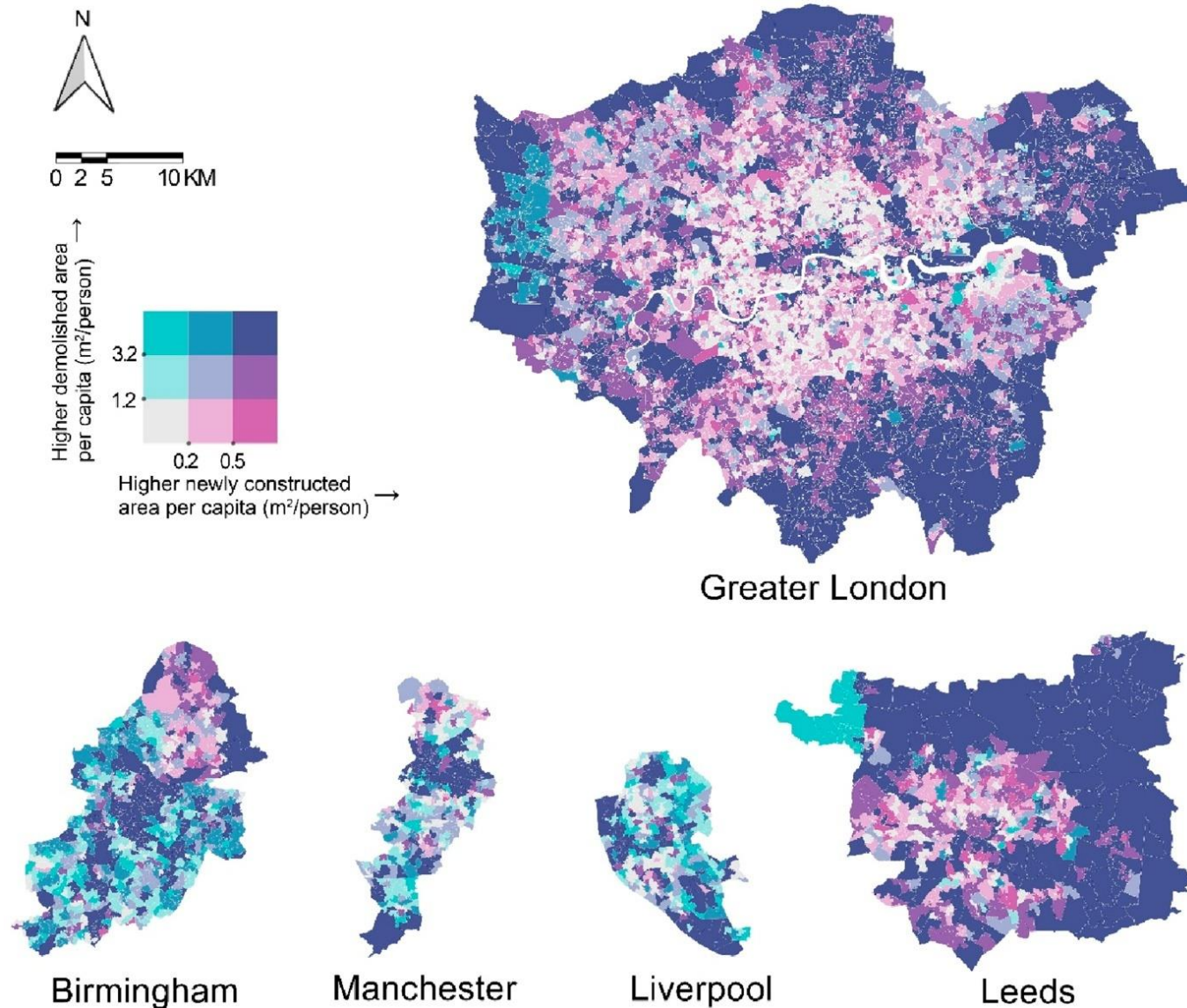


Fig. An example of building classification and change extraction.

Different Cities, Different Urban Change Patterns



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Fig. Construction and demolition patterns of England's five major cities by Lower Layer Super Output Area (LSOA) and Local Authority District (LAD), 2017–2023.

Urban Development Extent in England

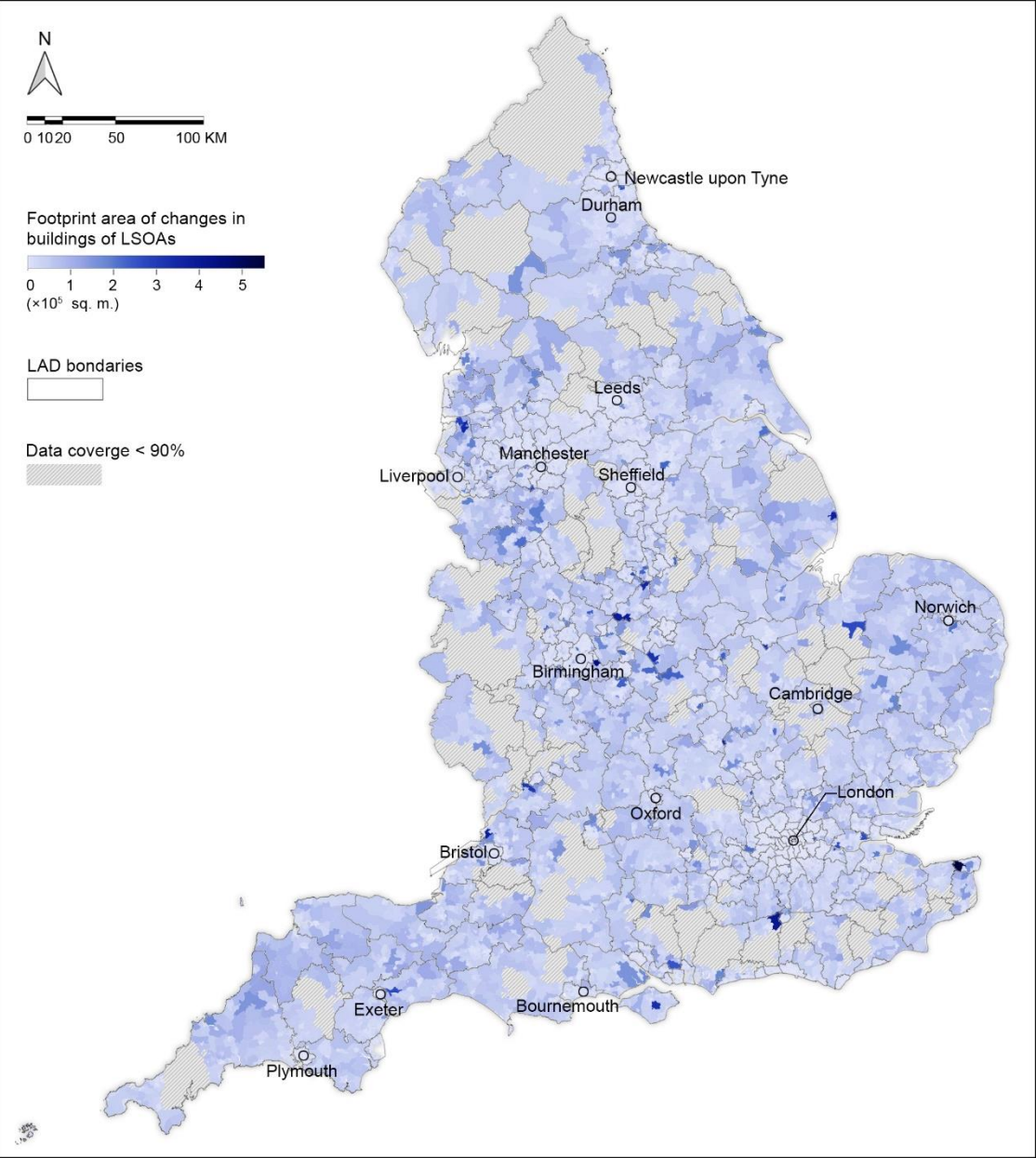


Table. Urban development ranking for major cities in England, 2017-2023

Ranking	LADs	Area of the LADs (km ²)	Population	Population density (person /km ²)	Footprint area of changes in buildings (km ²)
1	Birmingham	267.79	1144919	4275.42	8.68
2	Cheshire East	1166.36	398772	341.90	6.88
3	East Riding of Yorkshire	2491.79	342215	137.34	5.37
4	Leeds	551.71	811953	1471.71	4.94
5	Central Bedfordshire	715.67	294252	411.16	4.13
6	Bournemouth, Christchurch and Poole	173.93	400196	2300.87	3.94
7	Liverpool	133.53	486088	3640.19	3.49
8	Kirklees	408.55	433216	1060.37	3.22
9	Enfield	82.19	329984	4014.88	3.11
10	Croydon	86.49	390719	4517.57	3.02

Include only LADs with a population exceeding 250,000 and with a coverage over 90% by both the 2017 and 2023 datasets.

Fig. Urban development extent in England by LSOA, 2017-2023

Modelling urban development with Explainable AI

Table. The names, descriptions, and statistical information of the variables

Variables		Descriptions	Mean	Std
Dependent variable	<u>change_area_log</u>	Natural logarithm of the footprint area of changes in buildings between 2017 and 2023 (m ²).	9.04	1.21
	<u>population_dens</u>	Mid-2012 estimated population density (excluding prisoners) (person/km ²)	4459.69	4336.74
Independent variables	<u>Asian_proportion</u>	Proportion of the Asian-ethnic population in 2011	7.60%	13.01%
	<u>Black_proportion</u>	Proportion of the Black-ethnic population in 2011	3.44%	6.77%
	<u>Mixed_proportion</u>	Proportion of the -ethnic population in 2011	2.25%	1.93%
	<u>IMD_score</u>	IMD score for 2015 (higher scores correspond to more deprived areas)	22.04	15.75
	<u>IMD_std</u>	Standard deviation of 2015 IMD scores of all LSOAs within its first and second order neighbors	10.40	4.55
	<u>BNG_E</u>	Easting geographical coordinate in the British National Grid reference system	456365.92	82725.09
	<u>BNG_N</u>	Northing geographical coordinate in the British National Grid reference system	277112.31	126708.37

Table. Out-of-sample model accuracy assessment

Models	R ²
<u>XGBoost</u>	0.691
<u>LightGBM</u>	0.691
<u>CatBoost</u>	0.672
Random Forest	0.658

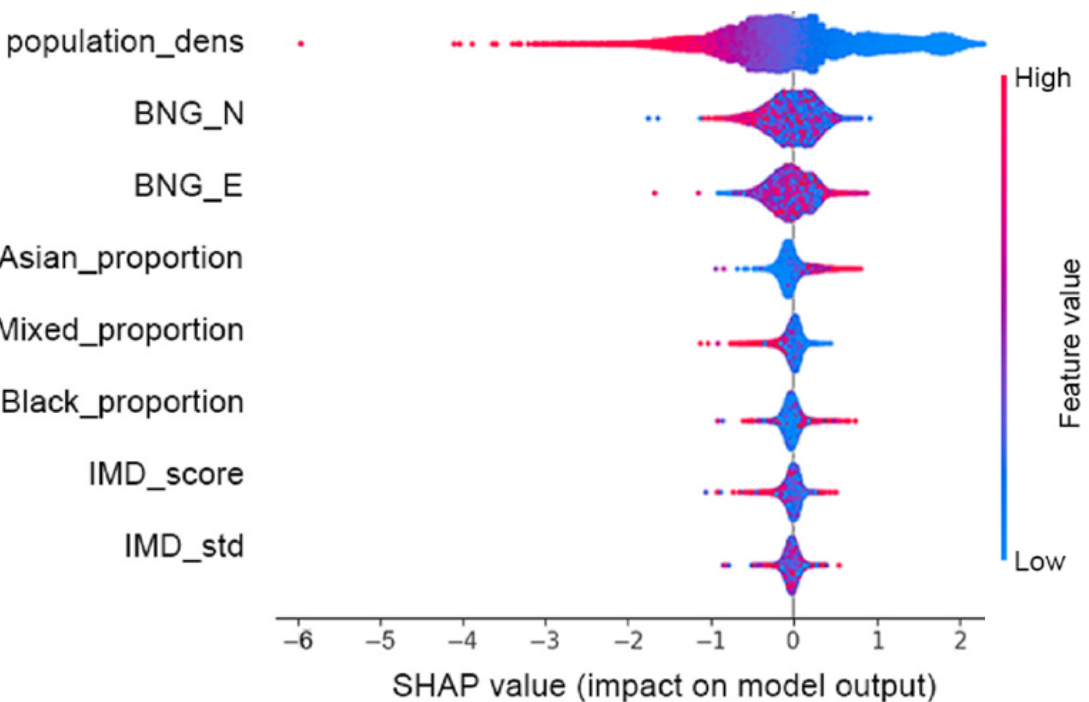
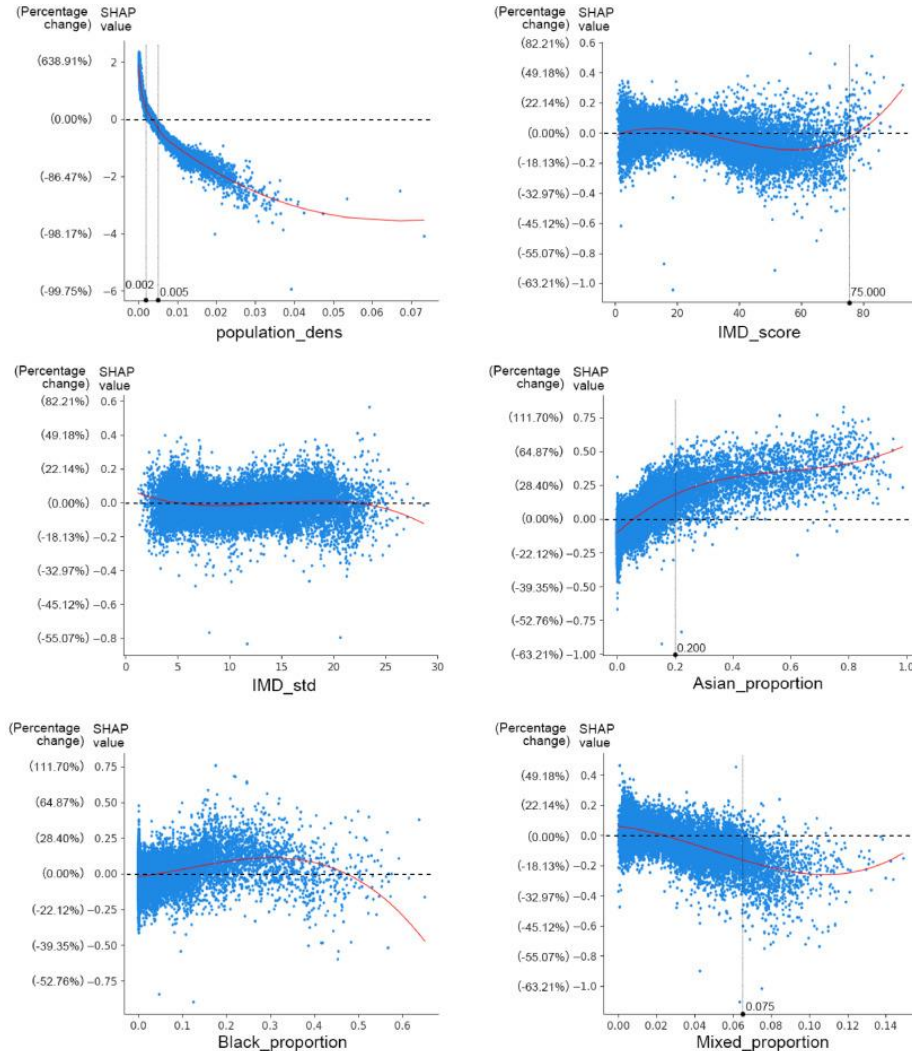


Fig. SHAP values for each feature

SHAP Findings



Note: Percentage change represents the impact of each feature on the predicted footprint area changes compared to the baseline. SHAP values, calculated based on the natural logarithm of these area changes, are transformed back to the original scale using the exponential function and expressed as a percentage. The formula for this transformation is: $\text{Percentage change} = (e^{\text{SHAP value}} - 1) \times 100\%$

Fig. SHAP dependence plots for demographic and socio-economic features

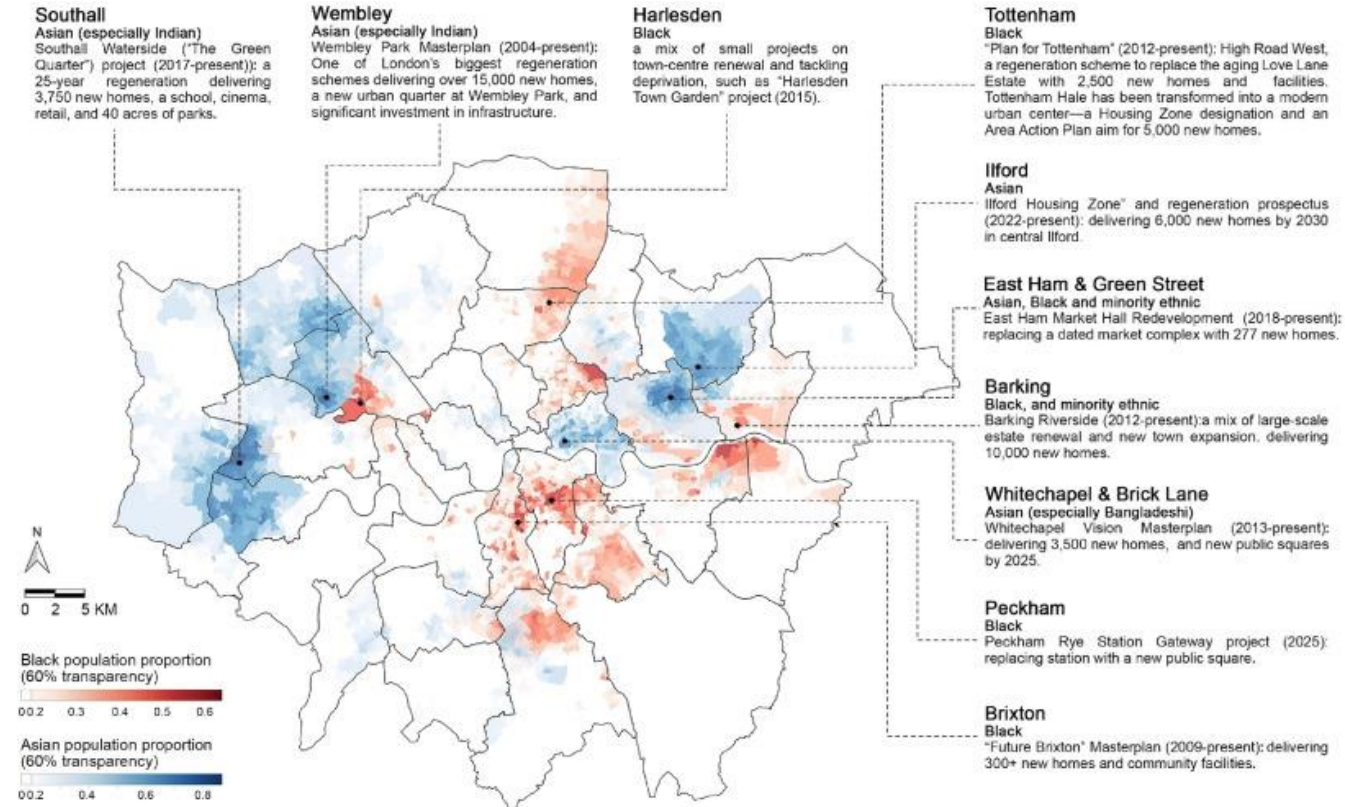


Fig. The spatial distribution of Asian and Black populations in Greater London, alongside ten well-known minority ethnic enclaves and their recent urban development projects.

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Thank you

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