London Climate Risk

A Spatial Analysis of Climate Risk Across Greater London: Methodology Report

2024 Update

This report was prepared for the Greater London Authority by

Bloomberg Associates

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I. Introduction

Background

The data produced for this project is the result of an ongoing partnership between the GLA and Bloomberg Associates to support sustainability initiatives across the city of London. To help the GLA target its resources to communities with the highest climate risks, Bloomberg Associates has produced a series of citywide maps overlaying key metrics to identify areas within London that are most exposed to climate impacts with high concentrations of vulnerable populations. Metrics were identified through research and collaboration between the GLA and Bloomberg Associates, referencing past studies and projects on the subject of climate risk.

Bloomberg Associates (BA) is the philanthropic consulting arm of Bloomberg Philanthropies that works side by side with client cities to improve the quality of life for residents. The organization typically works alongside its client cities for 2-4 years, taking a strategic, collaborative and results-oriented approach to make cities strong, safer, more equitable and efficient.

Climate-related impacts will not affect all communities equally. As the COVID-19 pandemic has exposed the health inequalities that place a heavier burden on marginalized groups, climate impacts such as heatwaves and floods will disproportionately harm exposed and vulnerable communities. Assessing the spatial distribution of risk factors across cities can help support informed decisions to help vulnerable populations through the allocation of resources.

In 2022, Bloomberg Associates updated London's climate risk maps to include additional data layers at a finer geographic scale (LSOA boundaries). These maps were built upon earlier maps using the Transport for London (TfL) hexagonal grid.

Then, in 2024, the risk maps were further modernized by updating many of the data layers to pull from 2021 census data rather than 2011. The map interface remains largely the same in a functional sense, allowing users to compare individual data layers to three indices of risk: overall climate risk, heat risk, and flood risk. This means that users can continue to investigate specific metrics at the LSOA level to see which factors might be driving risk throughout the city.

The climate risk maps show three primary risks:

- Overall risk overlays 12 metrics: % of people considered income deprived, mean PM2.5 concentration, mean NO2 concentration, % of area with surface water flood risk, % of area with blue/green land cover, % of area with a lack of access to public open space, % of people under age 5, % of people over age 75, % of people not proficient in English, % of people in social housing, % of people identifying as BAME, mean air temperature.
- Flood risk overlays 9 metrics: % of people considered income deprived, % of area with surface water flood risk, % of area with blue/green land cover, % of area with a lack of access to public open space, % of people under age 5, % of people over age 75, % of people not proficient in English, % of people in social housing, % of people identifying as BAME.
- Heat risk overlays 11 metrics: % of people considered income deprived, % of area under tree canopy cover, mean PM2.5 concentration, mean NO2 concentration, % of area with a lack of access to public open space, % of people under age 5, % of people over age 75, % of people not proficient in English, % of people in social housing, % of people identifying as BAME, mean air temperature.

II. Data and Technology

These maps were produced using datasets available in tabular, vector, and raster format. 13 metrics were analyzed in this study, including six climate vulnerability metrics and seven climate exposure metrics. To visualize the climate vulnerability metrics, population data from the 2021 Census and 2019 mid-year population estimates were used. Population data tables were downloaded, cleaned, and joined to corresponding vector geographies using GIS software. To visualize the exposure metrics, both raster and vector datasets were used. All metrics were re-aggregated to the LSOA census tract level before use as input layers to produce this set of final Risk maps.

Details on the data sources' geographies, data formats, and temporal years are listed below (additional information and citations can be found in the Appendix of this document). All spatial analysis for this project was conducted using ArcGIS Pro Desktop.

Vulnerability Metrics	Data Source	Geography	Data Type	Temporal Year
% of people under age 5	ONS (NOMIS website)	LSOA	Tabular	2021
% of people over age 75	ONS (NOMIS website)	LSOA	Tabular	2021
% of people not proficient in English	ONS (NOMIS website)	LSOA	Tabular	2021
% of people in social housing	ONS (NOMIS website)	LSOA	Tabular	2021
% of people identifying as Black, Asian, or Minority Ethnic (BAME)	ONS (NOMIS website)	LSOA	Tabular	2021
% of people considered income deprived	English Indices of Multiple Deprivation (MHCLG)	LSOA	Tabular	2019

Exposure Metrics	Data Source	Geography	Data Type	Temporal Year
Mean air temperature	ARUP AMS	-	Raster	2018 - 2022
% of area under tree canopy cover	Breadboard Labs / GLA	LSOA	Vector	2013
% of area with a lack of access to public open space	Green Infrastructure Focus Map (GiGL data)	LSOA	Vector	2016
mean PM2.5 (air pollutant) concentration	GLA and TFL Air Quality	-	Raster	2016
mean NO2 (air pollutant) concentration	GLA and TFL Air Quality	-	Raster	2016
% of area with surface water flood risk	Environment Agency	-	Vector	2013
% of area with blue/green land cover	GLA	-	Vector	2016

III. Methodology

The methodology used to produce this series of maps can understood in three phases:

1. Gathering data
2. Preparing input layers
3. Producing decision maps

1. Gathering data

Both publicly available and privately licensed data were used for this project. Bloomberg Associates aimed to secure the smallest-scale, most up-to-date datasets available for each of the 13 metrics, all of which needed to span the whole of Greater London. The GLA aided in securing these datasets, and metrics were finalized based on the data that was available.

2. Preparing input layers

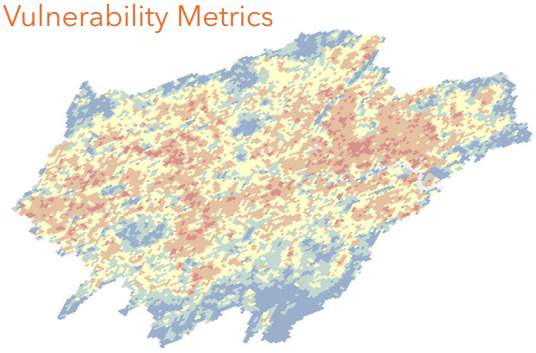
Upon obtaining all 13 datasets, each metric was prepared to be used as an input layer to create three final "decision maps": the Overall Climate Risk map, the Flood Risk map, and the Heat Risk map. Using ArcGIS Pro, metrics were mapped to their respective small-scale georgraphies or visualized in their original vector or raster format before re-aggregating them to the LSOA level. The diagrams on the following pages outline the steps taken to re-aggregate data.

3. Producing decision maps

Map Algebra was used to combine the input metric layers to produce the final series of pan-London Climate Risk Maps. After rasterizing each metric vector layer, the values of the rasters were reclassified into five quintiles, each of which was reassigned with a value of 1 - 5 (1 indicating the lowest exposure or vulnerability grouping of values, 5 indicating the highest exposure or vulnerability grouping of values). In the final maps, each LSOA has a resultant "risk score" created by the addition of these reclassified input layers.

Different combinations of the 13 metrics were used to create the three final decision maps. The final maps display Overall Climate Risk, Flood Risk, and Heat Risk across London. The maps available on the London DataStore utilize a gradient symbology, stretching a gradient of color across the risk score values.

Vulnerability Metrics



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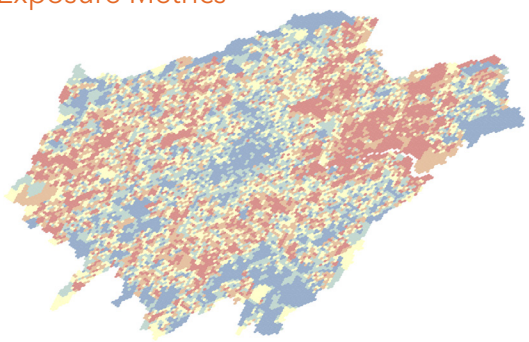
Exposure Metrics



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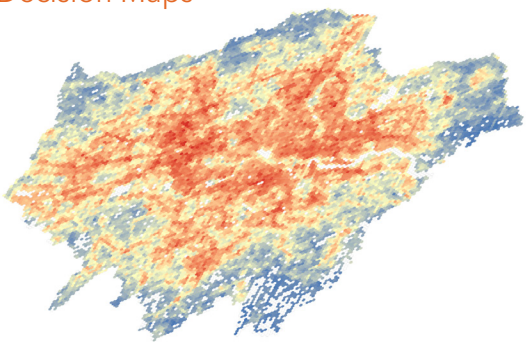
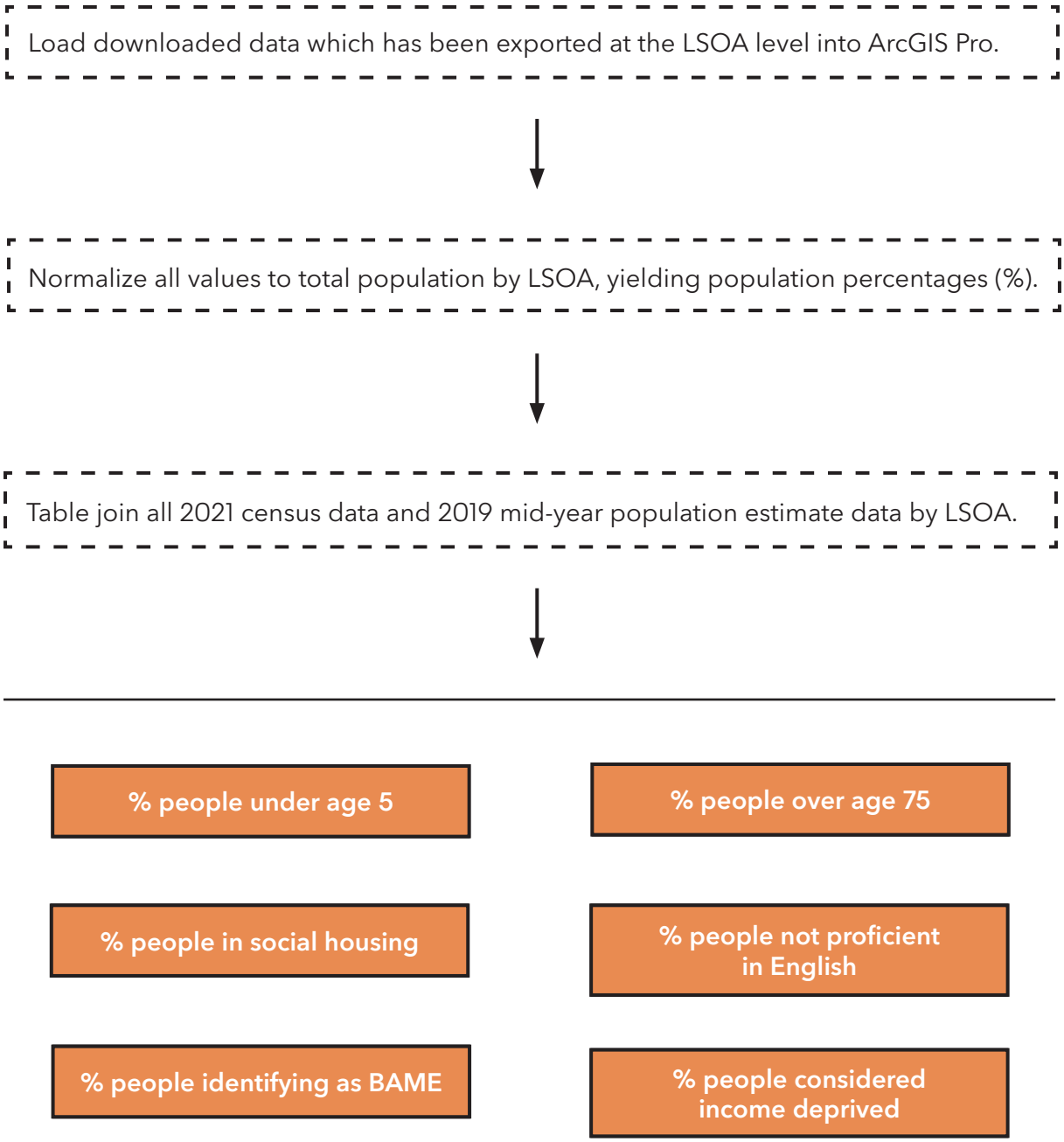
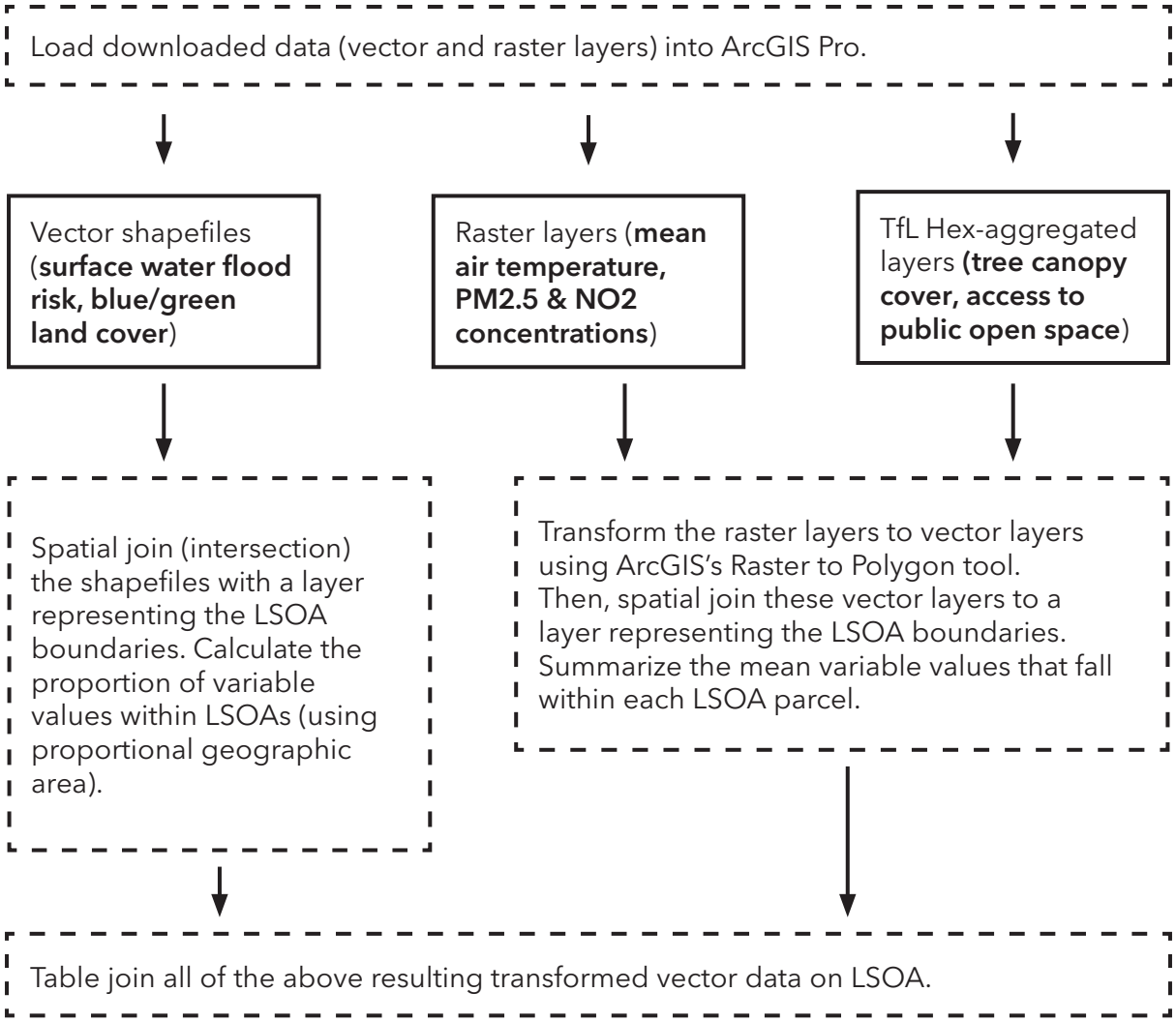
Decision Maps



Preparing Vulnerability Metrics

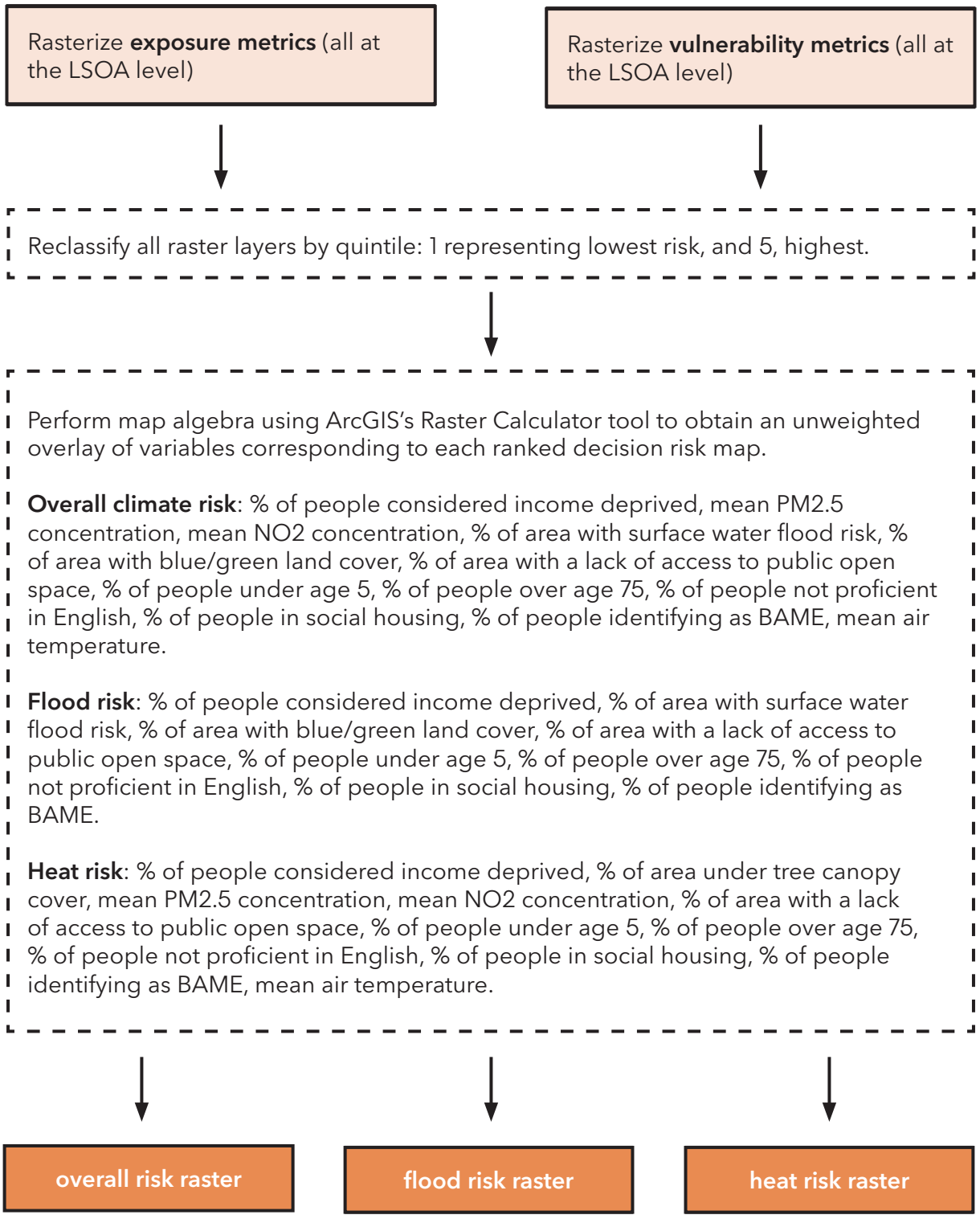


Preparing Exposure Metrics



- mean air temperature
- % of area under tree canopy cover
- % of area with a lack of access to public open space
- % of area with surface water flood risk
- mean PM2.5 concentration
- mean NO2 concentration
- % area with blue/ green land cover

Creating Decision Maps



Metric Overview + Metadata

METRIC CREATION: % of people under age 5	
Metric Category	Vulnerability Metric
What is measured	The percentage of the population under the age of 5
Unit of measurement	Count (percentage calculated by summarizing population counts under age 5 and dividing by total population count)
Method for LSOA Aggregation	• No spatial aggregation - exported at LSOA level • Added new field in imported shapefile: • Und5_per: divided the number of people under the age of 5 by the total population per LSOA to calculate the decimal estimated percentage; multiplied by 100 to calculate the **estimated percentage of individuals under the age of 5 living within the estimated total population**
DATA SOURCES	
Source	2021 Census
Citation	Office for National Statistics (2021). 2021 Census - Population Estimates. Office for National Statistics. Dataset. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationandhouseholdestimatesenglandandwalescensus2021
Data type	Tabular
Geographic resolution	LSOA - Greater London
Year of publication	2021

METRIC CREATION: % of people over age 75	
Metric Category	Vulnerability Metric
What is measured	The percentage of the population over the age of 75
Unit of measurement	Count (percentage calculated by summarizing population counts over age 75 and dividing by total population count)
Method for LSOA Aggregation	• No spatial aggregation - exported at LSOA level • Added new field in imported shapefile: • Over75_per: divided the number of people over the age of 75 by the total population per LSOA to calculate the decimal estimated percentage; multiplied by 100 to calculate the **estimated percentage of individuals over the age of 75 living within the estimated total population**
DATA SOURCES	
Source	2021 Census
Citation	Office for National Statistics (2021). 2021 Census - Population Estimates. Office for National Statistics. Dataset. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationandhouseholdestimatesenglandandwalescensus2021
Data type	Tabular
Geographic resolution	LSOA - Greater London
Year of publication	2021

METRIC CREATION: % of people not proficient in English	
Metric Category What is measured Unit of measurement	Vulnerability Metric The percentage of the population unable to speak English well or at all. Count (percentage calculated by summarizing population counts of those unable to speak English well or at all and dividing by total population count)
Method for LSOA Aggregation	• No spatial aggregation - exported at LSOA level • Added new field in imported shapefile: • EST_EngPer: divided the number of individuals with a lack of English profiency by the total population per LSOA to calculate the decimal estimated percentage; multiplied by 100 to calculate the **estimated percentage of individuals that do not speak English well or do not speak English at all living within the estimated total population**
DATA SOURCES	
Source Citation	2021 Census Office for National Statistics (2021). 2021 Census - Proficiency in English. Office for National Statistics. Dataset. Available from: https://www.ons.gov.uk/datasets/TS029/editions/2021/versions/2
Data type Geographic resolution Year of publication	Tabular LSOA - Greater London 2021

METRIC CREATION: % of people identifying as Black, Asian, or Minority Ethnic (BAME)	
Metric Category What is measured Unit of measurement	Vulnerability Metric The percentage of the population identifying as BAME Count (percentage calculated by summarizing population counts of those identified as BAME and dividing by total population count)
Method for LSOA Aggregation	• BAME is defined by the London Authority (https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/bame) is "all ethnic groups except white ethnic groups". The metric is calculated as such, summing across the various population tallies across ethnic groups according to the 2021 census • No spatial aggregation - exported at LSOA level • Added new field in imported shapefile: • BAME_per: divided the number of BAME individuals by the total individuals per LSOA to calculate the decimal estimated percentage; multiplied by 100 to calculate the **estimated percentage of individuals identifying as BAME within the estimated total population**
DATA SOURCES	
Source Citation	2021 Census Office for National Statistics (2021). 2021 Census - Ethnic group, England and Wales. Office for National Statistics. Dataset. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/ethnicity/bulletins/ethnicgroupenglandandwales/census2021
Data type Geographic resolution Year of publication	Tabular LSOA - Greater London 2021

METRIC CREATION: % of people in social housing	
Metric Category What is measured Unit of measurement	Vulnerability Metric The percentage of households categorized as social renters Household Count (percentage calculated by summarizing household categorized as social renters and dividing by total household count)
Method for LSOA Aggregation	• No spatial aggregation - exported at LSOA level • Added new field in imported shapefile: • EST_SocRen: divided the number of social renting households by the total number of households per LSOA to calculate the decimal estimated percentage; multiplied by 100 to calculate the **estimated percentage of households categorized as social rented within the estimated total households**
DATA SOURCES	
Source Citation	2021 Census Office for National Statistics (2021). 2021 Census - Tenure - Households. Office for National Statistics. Dataset. Available from: https://www.ons.gov.uk/datasets/TS054/editions/2021/versions/4
Data type Geographic resolution Year of publication	Tabular LSOA - Greater London 2021

METRIC CREATION: % of people considered income deprived	
Metric Category What is measured Unit of measurement	Vulnerability Metric The percentage of the population identified as Income Deprived. Person Count (percentage calculated by dividing income deprivation count by total population count)
Method for LSOA Aggregation	• Income deprivation data provided in table format at the LSOA level • Data joined to 2021 LSOA-level total population data • Added new field in joined layer: • IncDep_per: divided the number of income deprived individuals by the total individuals per LSOA to calculate the decimal estimated percentage; multiplied by 100 to calculate the **estimated percentage of income deprived individuals living within the estimated total population**
DATA SOURCES	
Source Citation	English Indices of Multiple Deprivation (MHCLG) Ministry of Housing, Communities & Local Government (2019). Indices of Deprivation. Greater London Authority. Dataset. Available from: https://data.london.gov.uk/dataset/indices-of-deprivation
Data type Geographic resolution Year of publication Temporal Resolution	Tabular LSOA - Greater London 2019 2015

METRIC CREATION: Mean air temperature	
Metric Category	Exposure Metric
What is measured	The average air temperature at the surface, per LSOA.
Unit of measurement	Degrees Celsius
Dataset Aggregated to LSOA	Dataset is vectorized; resultant feature class visualizes the **2018-2022 average air temperature (summertime, daytime LST)**
DATA SOURCES	
Source	ARUP AMS
Citation	The High Resolution Air Temperature at the Surface information layer for Greater London was produced by ARUP as part of the dataset: Properties Vulnerable to Heat Impact Report (London City Hall) and provided by the Greater London Authority
Data Type	Raster
Year of publication	2024
Temporal Resolution	2018 - 2022 (summer months)

METRIC CREATION: % of area under tree canopy cover	
Metric Category	Exposure Metric
What is measured	Tree canopy cover for the Greater London area
Unit of measurement	The geographic cover of tree canopy represented as density across London
Dataset Aggregated to LSOA	Dataset class visualizes the **proportion of an LSOA covered by tree canopy**
DATA SOURCES	
Sources	Curio (Breadboard Labs Limited) / GLA
Citation	Breadboard Labs (2018). Curio Canopy - London Tree Canopy Cover. London DataStore. Dataset. Available from: https://data.london.gov.uk/dataset/curio-canopy
Data type	Vector
Year of publication	2015
Temporal Resolution	2013

METRIC CREATION: % of area with a lack of access to public open space	
Metric Category	Exposure Metric
What is measured	Percent of households in an Area of Deficiency (AoD) in Access to Public Open Space
Unit of measurement	Percent of households
Dataset Aggregated to LSOA	Dataset is aggregated to the LSOA level; resultant feature class visualizes the **proportion of households in an LSOA within an Area of Deficiency (AoD) in Access to Local and District Public Open Space**
DATA SOURCES	
Sources	GIGL CIC Area of Deficiency (AoD) in Access to Local and District Public Open Space and Ordnance Survey AddressBase Plus
URLs	GIGL CIC AoD data: https://www.gigl.org.uk/open-spaces/areas-of-deficiency-in-access-to-public-open-space/ OS AddressBase Plus data: https://www.ordnancesurvey.co.uk/business-and-government/products/addressbase-plus.html https://data.london.gov.uk/dataset/green-infrastructure-focus-map © Environment Agency copyright and/or database right 2015
License	Licensed by Greenspace Information for Greater London CIC and Ordnance Survey
Citation	Greenspace Information for Greater London CIC Crown Copyright and database right 2018. Ordnance Survey 100032216 GLA.
Data type	Vector
Year of publication	GiGL CIC Area of Deficiency (AoD) in Access to Local and District Public Open Space: 2016 OS AddressBase Plus: 2018
Temporal Resolution	2016
DATA NOTES	
An LSOA containing no address points is allocated no value and treated as 'no data', or -999. Within the Climate Risk Map series, these areas do not contribute to the risk overlays and are visualized without color.	

METRIC CREATION: Mean PM2.5 (air pollutant) concentration	
Metric Category	Exposure Metric
What is measured	The ground level concentrations of PM2.5 across Greater London
Unit of measurement	Micro gramme per cubic metre
Method for LSOA Aggregation	• Data provided in raster format at 20m grid resolution • Used Raster to Point tool to convert PM2.5 raster values to points • Spatial Joined points to LSOA, summarizing the mean point values, resulting in the mean PM2.5 values aggregated to LSOA
DATA SOURCES	
Source	GLA and TFL Air Quality
Citation	GLA and TFL Air Quality (2019). London Atmospheric Emission (LAEI) 2016. London DataStore. Dataset. Available from: https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory--laei--2016
Data type	Raster
Resolution	20m grid resolution
Year of publication	2020
Temporal Resolution	2016

METRIC CREATION: Mean NO2 (air pollutant) concentration	
Metric Category	Exposure Metric
What is measured	The ground level concentrations of NO2 across Greater London
Unit of measurement	Micro gramme per cubic metre
Method for LSOA Aggregation	• Data provided in raster format at 20m grid resolution • Used Raster to Point tool to convert PM2.5 raster values to points • Spatial Joined points to LSOA, summarizing the mean point values, resulting in the mean NO2 values aggregated to LSOA
DATA SOURCES	
Source	GLA and TFL Air Quality
Citation	GLA and TFL Air Quality (2019). London Atmospheric Emission (LAEI) 2016. London DataStore. Dataset. Available from: https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory--laei--2016
Data type	Raster
Resolution	20m grid resolution
Year of publication	2020
Temporal Resolution	2016

METRIC CREATION: % of area with surface water flood risk	
Metric Category What is measured Unit of measurement	Exposure Metric Percentage of LSOA (square metres) at risk of flooding from Surface Water Percentage of Area
Method for LSOA Aggregation	• Data provided in vector format, displaying Risk of Flooding from Surface Water Extent (RFSWE) (3.3 percent annual chance) • Merged and Dissolved vector layer to create a contiguous multi-part vector • Intersected RFSWE dataset with LSOA; Calculated areas of resultant polygons intersected with each LSOA • Spatial Joined intersected RFSWE feature class to LSOA • Replaced LSOA rows with "null" values in RFSWE area field with zero (values read as "null" when no RFSWE polygon area is present within an LSOA) • Calculated proportion of RFSWE area within LSOA (dividing RFSWE area by LSOA, multiplied by 100 to calculate percentage) • Resultant feature class visualized the **percentage of the LSOA that has 3.3 percent annual chance of Risk of Flooding from Surface Water**
DATA SOURCES	
Source Citation License	Environment Agency Department for Environment, Food & Rural Affairs (2011). Risk of Flooding from Surface Water Extent: 3.3 percent annual chance. Data.gov.uk. Dataset. Available from: https://environment.data.gov.uk/dataset/90d2ff8f-d465-11e4-8cb5-f0def148f590 © Environment Agency copyright and/or database right 2015
Data type Resolution Year of publication Temporal Resolution	Vector 20m grid resolution 2015 2013

METRIC CREATION: % of area with blue/green land cover	
Metric Category What is measured Unit of measurement	Exposure Metric Percentage of LSOA (square metres) covered by green/blue land cover Percentage of Area
Method for LSOA Aggregation	• Data provided in vector format, displaying Green/Blue land cover across London • Merged and Dissolved vector layer to create a contiguous multi-part vector • Intersected Green/Blue land cover dataset with LSOAs, maintaining land cover type; Calculated areas of resultant polygons intersected with each LSOA • Spatial Joined intersected Green/Blue land cover feature class to LSOA • Replaced LSOA rows with "null" values in RFSWE area field with zero (values read as "null" when no RFSWE polygon area is present within an LSOA) • Calculated proportion of Green/Blue land cover area within LSOAs (dividing Green/Blue land cover area by LSOA, multiplied by 100 to calculate percentage) • Resultant feature class visualizes the **percentage of each LSOA that consists of Green/Blue land cover**
DATA SOURCES	
Source Citation License	GLA Greater London Authority (2019). London Green and Blue Cover. Greater London Authority. Dataset. Available from: https://data.london.gov.uk/dataset/green-and-blue-cover © Environment Agency copyright and/or database right 2015
Data type Year of publication Temporal Resolution	Vector 2019 2016

IV. Outputs

The primary output for this project is a series of three pan-London climate risk maps, provided in raster format, with risk scores assigned to LSOAs across London. Each of the three maps (the overall climate risk map, the flood risk map, and the heat risk map) were created using a unique set of exposure and vulnerability metrics highlighting areas of higher and lower risk across London.

In addition to this metadata guide, a package of the original data tables used to create individual metric layers is available for download on the London DataStore (.xlx or .csv tables include all 13 variables aggregated to the LSOA level).

Symbology + Risk Scores

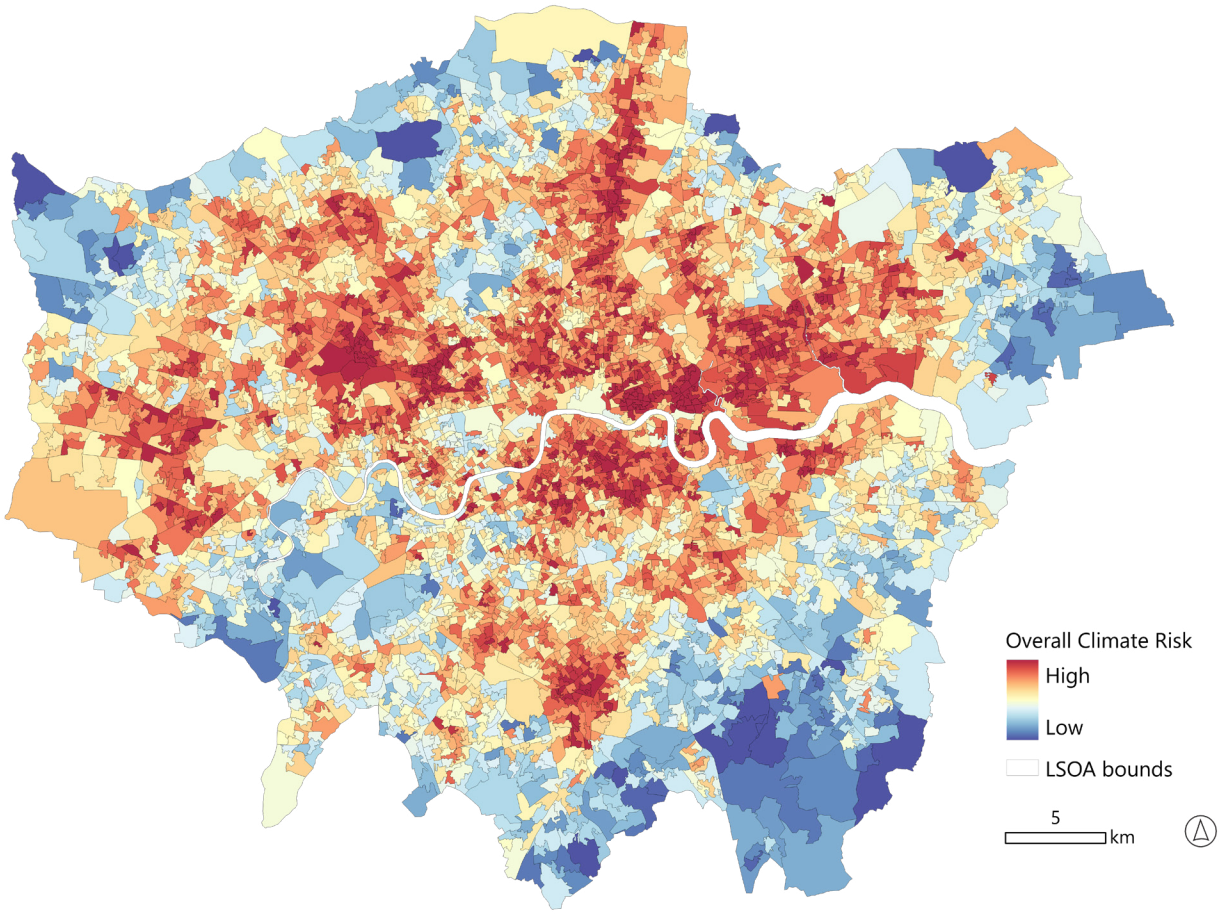
The symbology used for the climate risk maps highlights areas with "low" to "high" risk scores across London using a sliding color scale. All scores are relative to each other; blue LSOAs indicate areas with lower risk scores, and red LSOAs indicate areas with higher risk scores. The minimum and maximum scores vary for each map, as the set of metric input layers vary for each map.

It is important to note that these scores have not been normalized or manipulated to hold significant meaning on their own. It is not recommended that raw scores be displayed to the general public; when taken out of context, the scores hold little meaning.

Climate Risk Map Rasters

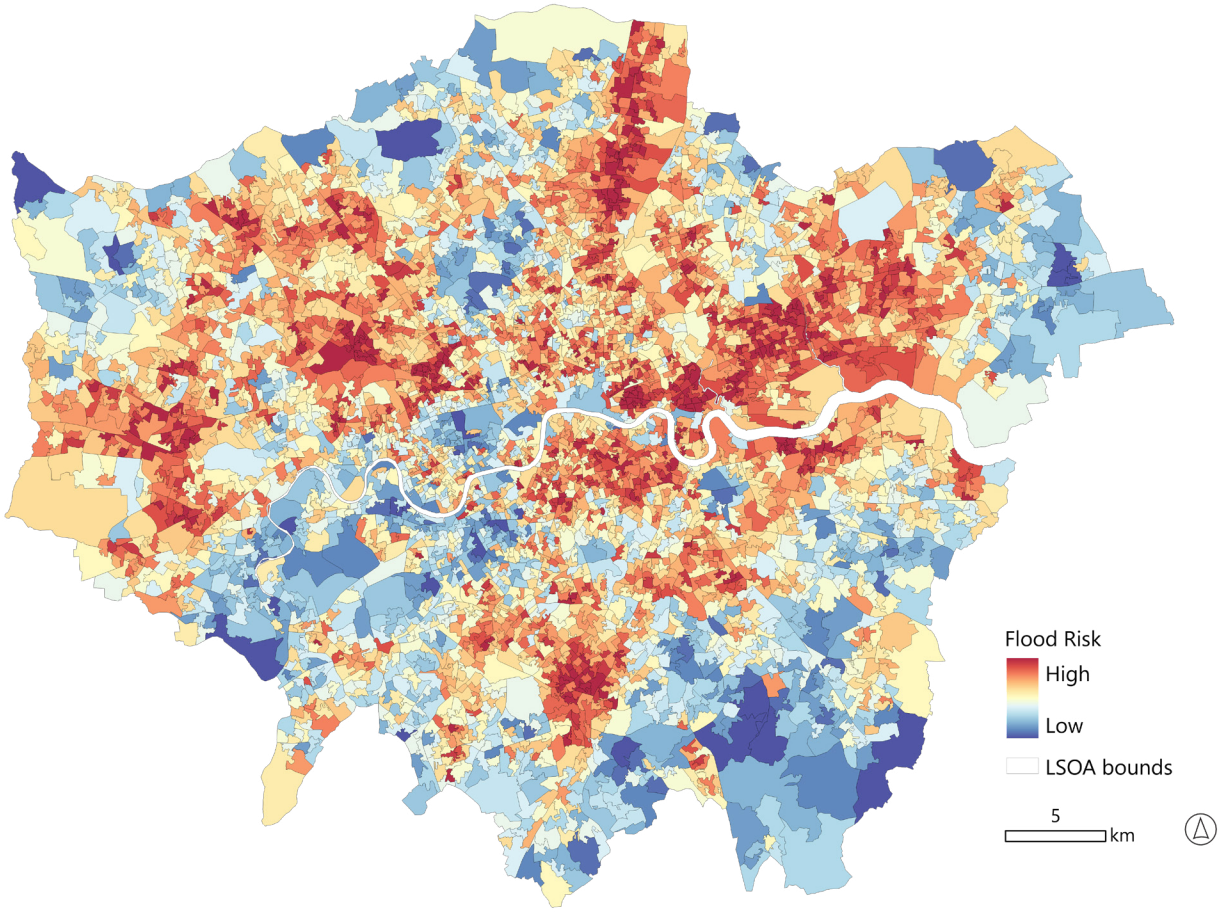
The following Climate Risk Maps are available for download in raster format on the London DataStore.

Overall Climate Risk Map



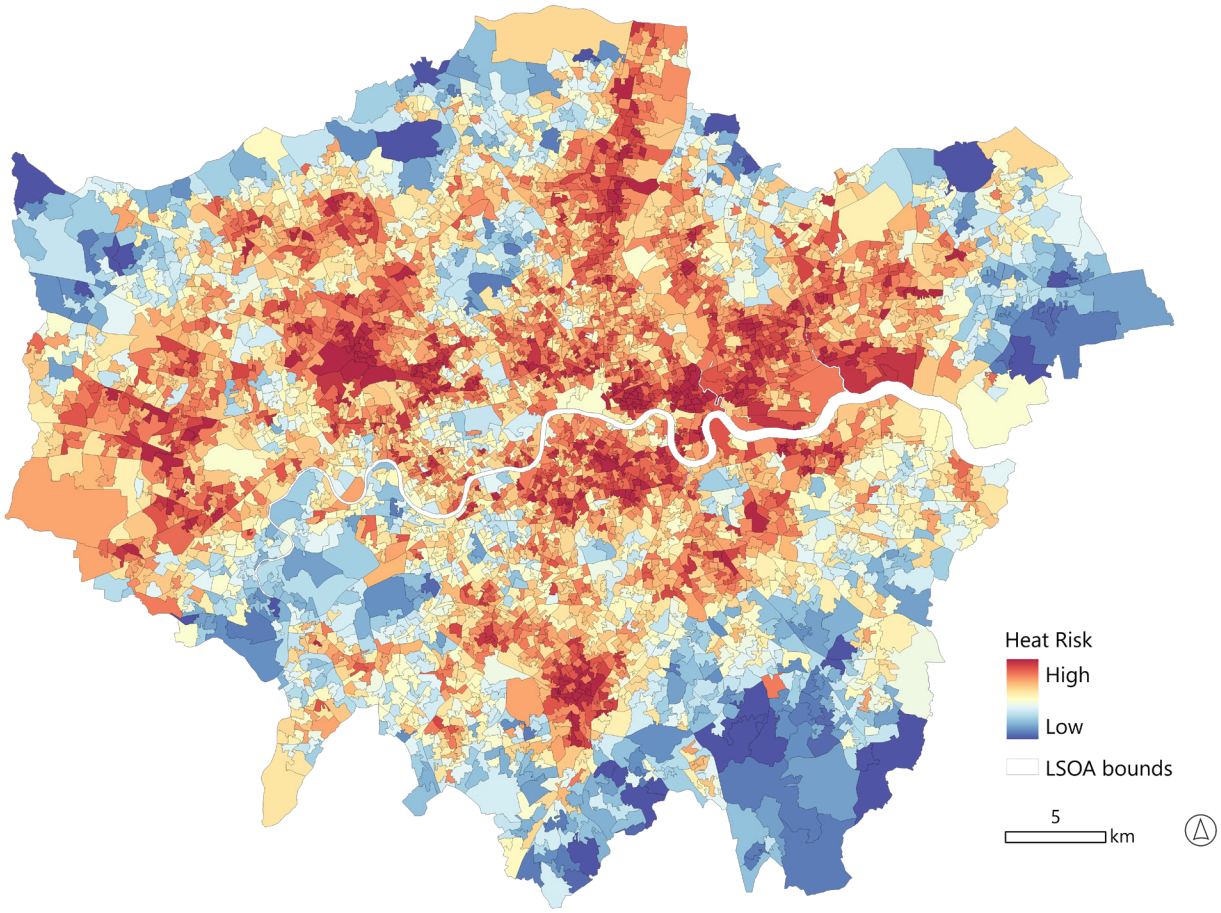
The **Overall Climate Risk map** was created using 12 of the 13 metrics:
% of people considered income deprived, mean PM2.5 concentration, mean NO2 concentration, % of area with surface water flood risk, % of area with blue/green land cover, % of area with a lack of access to public open space, % of people under age 5, % of people over age 75, % of people not proficient in English, % of people in social housing, % of people identifying as BAME, mean air temperature.

Flood Risk Map



The **Flood Risk map** was created using 9 of the 13 metrics:
% of people considered income deprived, % of area with surface water flood risk, % of area with blue/green land cover, % of area with a lack of access to public open space, % of people under age 5, % of people over age 75, % of people not proficient in English, % of people in social housing, % of people identifying as BAME.

Heat Risk Map



The **Heat Risk map** was created using 11 of the 13 metrics:
% of people considered income deprived, % of area under tree canopy cover, mean PM2.5 concentration, mean NO2 concentration, % of area with a lack of access to public open space, % of people under age 5, % of people over age 75, % of people not proficient in English, % of people in social housing, % of people identifying as BAME, mean air temperature.

V. Conclusion

Limitations of the Methodology

The methodology used for this study allows for the analysis of multiple metrics in combination with each other across London. However, it is not recommended that these London-wide maps be used for neighbourhood-level decision making, given the geospatial manipulation of datasets to assess climate risk at the citywide-scale.

Some degree of accuracy is always lost when manipulating spatial data from one geography to another. All datasets used in this study were converted to the TfL hexagonal grid from different statistical boundaries or other data types, with the exception of two datasets that were already aggregated to the hex. The uniform hex geography is larger than some geographic scales available for use, and re-aggregating datasets to this uniform geography inevitably reduces the small-scale accuracy of the analysis.

However, the methodology does not require all inputs to be aggregated to the same geography. The same study could be conducted using datasets aggregated to their original geographies. While this would increase the geospatial accuracy of the outputs, it would be more difficult to highlight and analyze trends at a citywide scale.

Future Uses of Data

The Climate Risk maps produced for this project are actively being used to inform new and ongoing initiatives by the GLA and individual boroughs aimed at addressing climate change and supporting climate resilience. While it is not recommended that these maps be used as sole determinants for project direction and implementation, they can serve as a supplementary reference when identifying priority areas for targeting resources. These maps are meant to serve as a first iteration of an evolving methodology for Climate Risk analysis in London.

VI. Appendix

METRIC	EVIDENCE SUPPORTING USE OF THIS VARIABLE
% of people under age 5	Research has shown that young children and babies face disproportionate health effects from climate-related impacts relative to many adults, as they are more biophysically susceptible to hazards (Vardoulakis & Heaviside, 2012). Young children are more likely to be affected by hot weather because their bodies create more heat energy, they sweat less, and dehydration affects them more quickly compared to healthy adults (Public Health England, 2014).
% of people over age 75	Conclusive evidence reveals that older people, particularly those over 75, consistently face more severe impacts as a result of heatwaves (Vardoulakis & Heaviside, 2012) (Hames et al., 2012). A range of characteristics increase their vulnerability, such as being socially isolated, being in ill-health, having lower personal mobility, living in certain types of housing, or having low income (Haq et al., 2008).
% of people not proficient in English	People who cannot read, write, and/or speak English or who are less proficient in English are more likely to have difficulty obtaining and using information and guidance provided to the general public (Lindley et al., 2011).
% of people identifying as Black, Asian, or Minority Ethnic (BAME)	Populations of non-white minority ethnicities according to research have been known to live in vulnerable areas more at risk of experiencing climate-related extreme weather, mobility challenges, and housing unaffordability.
% of people in social housing	Social housing tenants may encounter difficulties in preparing for and responding to flooding due to their living arrangements and because they are likely to have a low income. Tenants are often not allowed to make physical alterations to their properties, and leaseholders may be disinclined to make these alterations as they may not feel the additional expense is not worthwhile given that they do not own the property (Combined 'Info Sheets', 2018).
% of people considered income deprived	Poverty is an important determinant of how well people can prepare for, respond to, and recover from climate-related events. People on low incomes are more likely to have a lower adaptive capacity to heatwaves because they lack both the resources to act and the power to make changes . Additionally, low income households are less likely to have the capacity to fully prepare for floods (through insurance and property level measures. They are also more likely to be displaced as a result of flooding (Combined 'Info Sheets', 2018).

METRIC	EVIDENCE SUPPORTING USE OF THIS VARIABLE
Mean air temperature	Understanding air temperature, a measurement of the ambient temperature by the Earth's surface, can help to inform how hot or cold a specific location is relative to its surroundings. Elevated urban temperatures can have a direct impact on people's health and wellbeing. Research funded by the Department of Health in the UK indicates that over 7,000 people could die from the effects of urban heat waves per year by the 2050s (House of Commons, 2018). Elevated urban temperatures can also impact air and water quality, and demands for energy, with implications for carbon neutral targets, public health, strategic planning and city resilience (Nation-wide heat hazard, 2020). Compared to land surface temperature which was used in previous iterations of these maps, air temperature paints a more experientially representative picture of heat extremes.
% of area with surface water flood risk	'Pluvial' (rain-related) floods, which occur following short intense downpours, cannot be quickly enough evacuated by the drainage system or infiltrated to the ground, particularly in built-up urban areas. Pluvial floods often occur with little warning in areas not obviously prone to flooding, and they have recently been identified as the type most likely to increase in severity as a result of climate change. They are also the most difficult to manage because they are difficult to predict and it is challenging to provide adequate warning times (Houston et al., 2011).
Mean PM2.5 (air pollutant) concentration	A City Hall commissioned report estimated over 9,000 Londoners died prematurely from long-term exposure to air pollution in 2010. Two pollutants are of specific concern: particulate matter (PM10, PM2.5, and black carbon) and nitrogen dioxide (NO2). Particulate matter is damaging to health at any level and must be reduced (London Environment Strategy, 2018). Further, elevated air pollution levels and high temperatures have been associated with the increase in urban heat islands and air pollution in London, England (McMichael et al., 2003; Rooney, McMichael, Kovats, & Coleman, 1998).
Mean NO2 (air pollutant) concentration	In London, road transport and heating systems are the main sources of nitrous oxide (NOx) emissions. NOx is primarily made up of two pollutants: nitric oxide (NO) and nitrogen dioxide (NO2). NO2 is of most concern due to its impact on health. However, NO easily converts to NO2 in the air, so to reduce concentrations of NO2, it is essential to control emissions of NOx. London is failing to meet the legal limit for NO2 (London Environment Strategy, 2018).
% of area with blue/ green land cover, % of area under tree canopy cover	London's green and blue land cover - its parks, green spaces, trees, rivers, wetlands and green roofs – can reduce the impacts of climate change and help to store carbon. It can improve air quality and water quality. It can promote healthier lives, reduce car dependency and encourage more walking and cycling. It can improve biodiversity and ecological resilience (London Environment Strategy, 2018).
% of area with a lack of access to public open space	Some parts of London have more green spaces than others, but almost half of Londoners have poor access to parks. Councils now have less money to spend on maintaining parks, so their quality has declined in some places. Access to good quality green space and living in greener neighborhoods can have a big impact on people's health and quality of life, and on how attractive a place London is in which to live, visit and do business (London Environment Strategy, 2018).

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