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HelpAge International

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KING'S College LONDON

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NERC SCIENCE OF THE ENVIRONMENT

SHARPER

Seasonal health and resilience for ageing urban populations and environments

London / New York / Shanghai

Introduction

1 2

Climate change impacts, continued urbanisation, and an ageing population are critical trends for the future of global cities.

Most climate change impacts in cities will be felt through the increase of extreme weather events such as heatwaves and floods. Heatwaves such the ones experienced in London over the last two decades (for example those in 2003, 2006, 2011 and 2013) and hurricanes like Sandy which caused significant damage in New York City in 2012 are projected to occur more often and be more intense.

People living in cities currently represent 54% of the total world population compared to 34% in 1960.

Alongside this continued urbanisation, the world population is ageing rapidly. People aged 65 and older are expected to make up 22% of the total world population by 2050. The number of people aged 80 and older will also quadruple by 2050. These combined trends mean that more people will be exposed and vulnerable to climate change impacts in cities in the future.

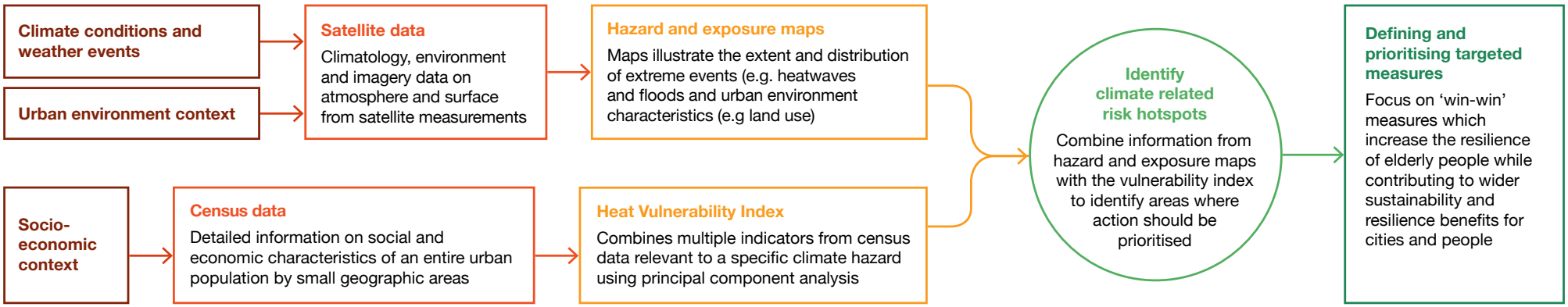
This report focusses on how these global trends are affecting London, New York and Shanghai. It addresses the exposure and vulnerability of the ageing populations in cities to extreme weather events.

Exposure and vulnerability are assessed using a range of spatial, temporal and socio-economic data about climate related hazards, city characteristics and people. Satellite data has been used to illustrate the spatial pattern of weather and climate impacts in each city, while a novel approach based on census data has been used to produce a Heat Vulnerability Index to generate vulnerability maps for London and New York.

A range of measures have been identified to reduce the vulnerability of elderly people through informing policy and practice relevant to creating healthy and resilient cities. The use of hazard, exposure and vulnerability maps helps to identify areas where measures should be prioritised. We suggest that 'win-win' measures which increase the resilience of elderly people while contributing to wider sustainability and resilience benefits for cities and people are prioritised where possible.

This report is the result of a collaboration between Arup, University College London, King's College London, ClimateUK, HelpAge International and Satellite Applications Catapult.

Methodology



The approach followed relies primarily on freely available climate, environmental and socio-economic data. 'At cost' data has only been obtained to further illustrate the before and after context of Hurricane Sandy in New York City using Synthetic Aperture Radar (SAR) from Airbus.

Socio-economic data has been used in the development of a heat vulnerability index of London, whilst maps representing current climate and weather related hazards have been derived using satellite data. Information on the urban environment (e.g. land use, green areas and water bodies) based on both satellite data and OpenStreetMap data is used to provide an insight on current and past changes to the urban form of cities. These multiple layers of information are combined to identify climate related risk hotspots which can then be used to prioritise 'win-win' measures to reduce risks and increase resilience.

Climate and urban environment

Extreme high temperature

Land surface temperature data has been used to illustrate how temperatures vary across a city during a heatwave event and an average summer day due to the Urban Heat Island effect.

Data from MODIS has allowed the assessment of long term averages of temperatures while Landsat enables the study of heatwave events at a higher spatial resolution.

Floods

The most significant flood event to affect one of the three case study cities was Hurricane Sandy. Satellite imagery provides an insight on the extent of the damage caused by Sandy.

'Post-Sandy' data available from the Federal Emergency Management Agency Modelling Task Force (FEMA-MOTF) has been used in combination with pre- and post-event data from Synthetic Aperture Radar (SAR) from Airbus.

Land cover

Satellite imagery allows the classification of land use in a city. It can provide an overview of the green and water bodies spaces in comparison to built up areas as well as the urbanisation trends.

The CORINE land cover classification has been used to classify the Landsat data in this study.

City characteristics

Information on the number and location of health centres, pharmacies, community centres, parks and other city characteristics provide an insight into the access vulnerable populations might have to critical amenities during an extreme weather event.

The collaborative project OpenStreetMap provides open data for a large number of city characteristics.

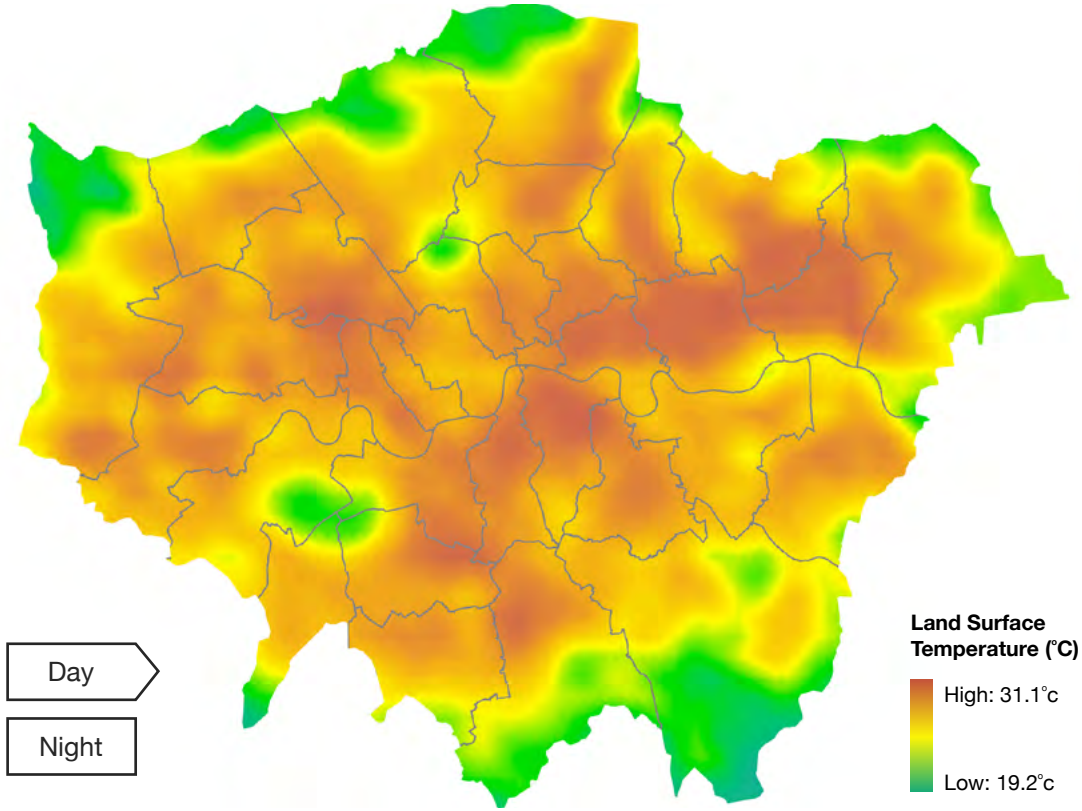
Extreme weather events

London - High temperatures

Land surface temperature maps of heatwave events illustrate the significance of the Urban Heat Island effect and the cooling effect of medium and large scale green spaces and water bodies during the day.

The cooling effects of green areas in the city are depicted in maps of day and night temperatures during a heatwave and for an average summer day. Green spaces and water bodies in a city play an important cooling role during heatwave events when the difference between day and night temperatures are considerably smaller than for an average summer day.

See the Reducing urban heat risk report for more visualisations of high temperatures in London.



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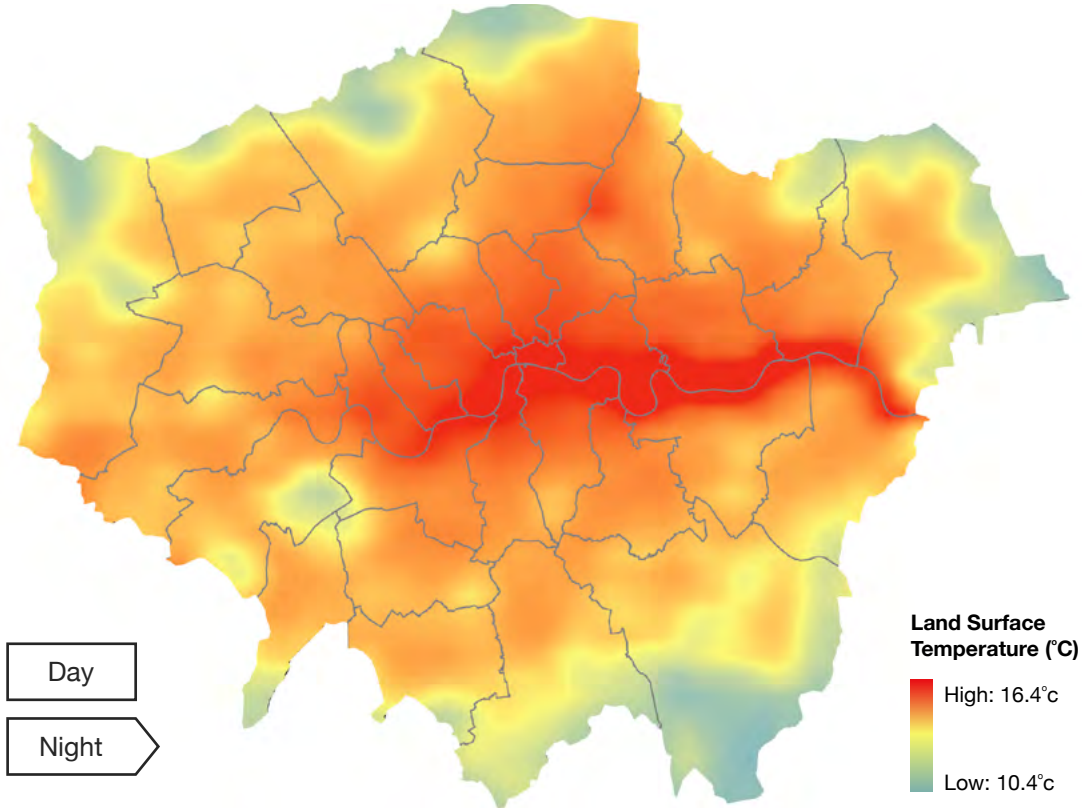

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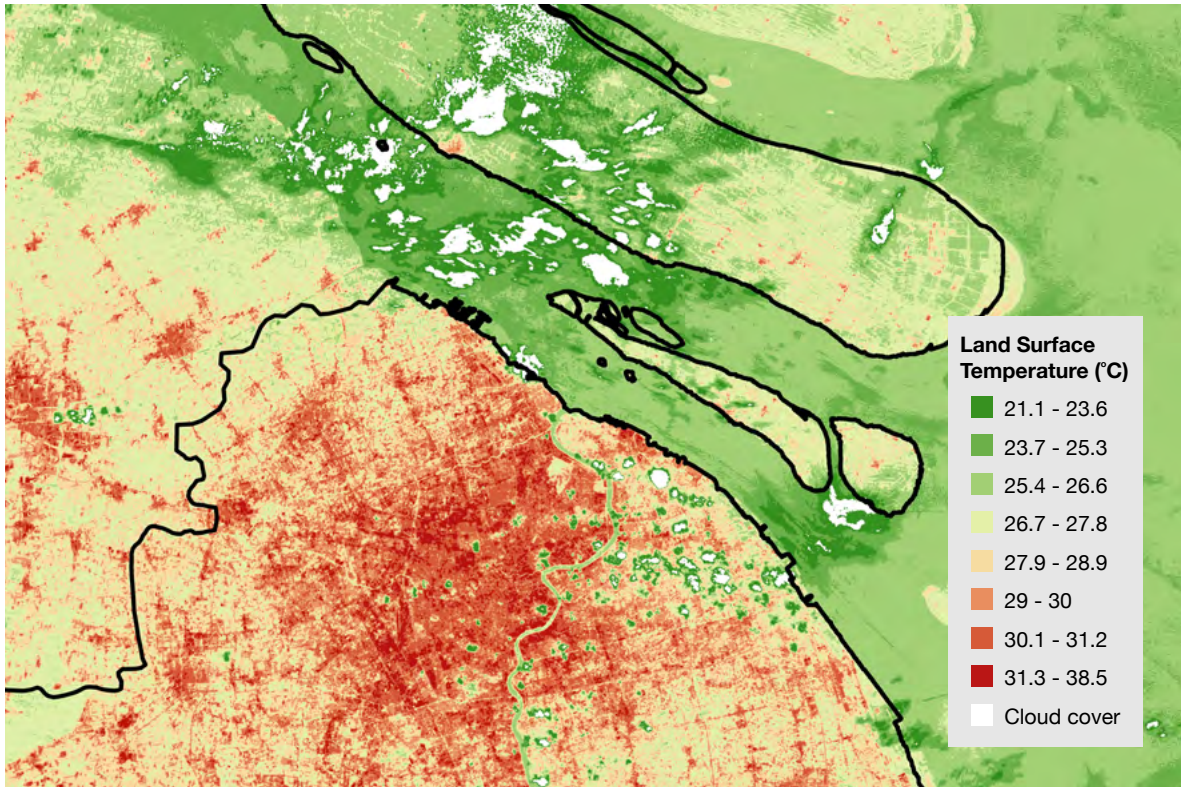
Extreme weather events

Shanghai - High temperatures

The urbanisation trend in Shanghai is clearly reflected in the visualisation of past heatwaves. The number of 'hotspots' in the city during the 2013 heatwave is considerably larger than during the 2003 heatwave. This increase corresponds to the agricultural or forested areas which have been converted to urban areas over the ten year period.



Heatwave 2003 | Heatwave 2013

Extreme weather events

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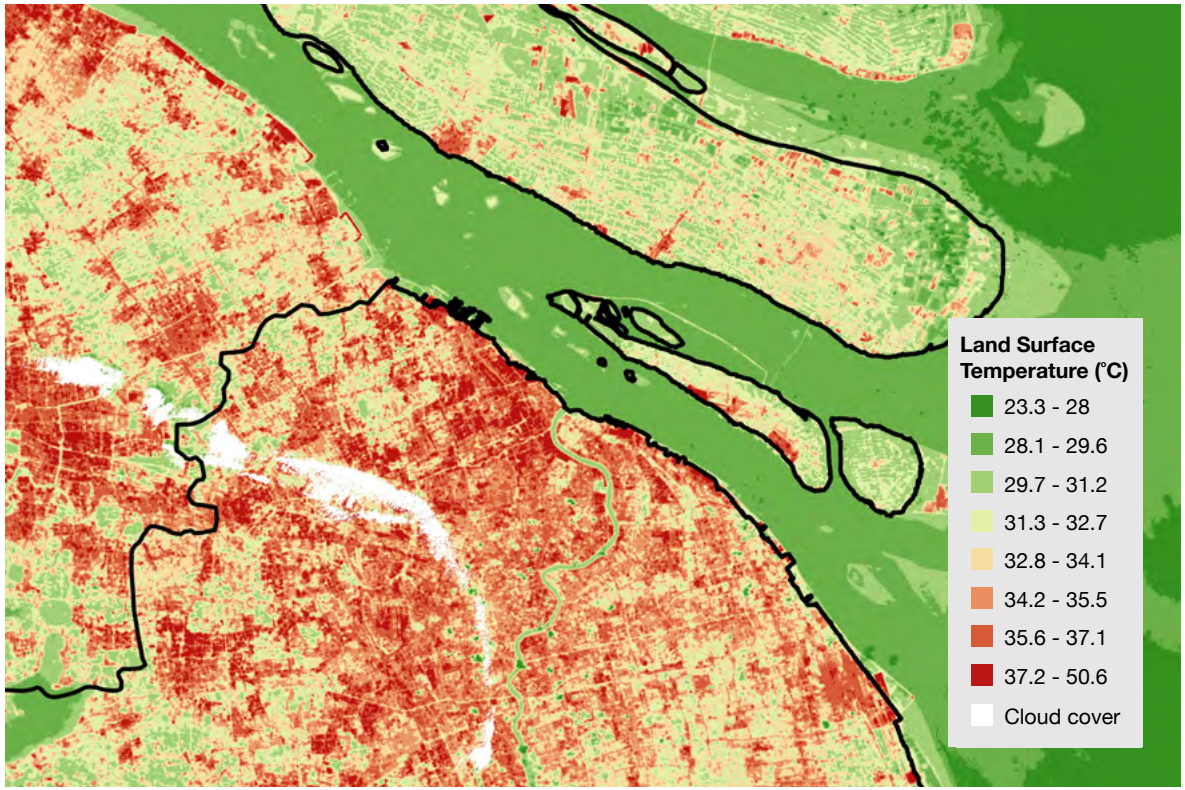


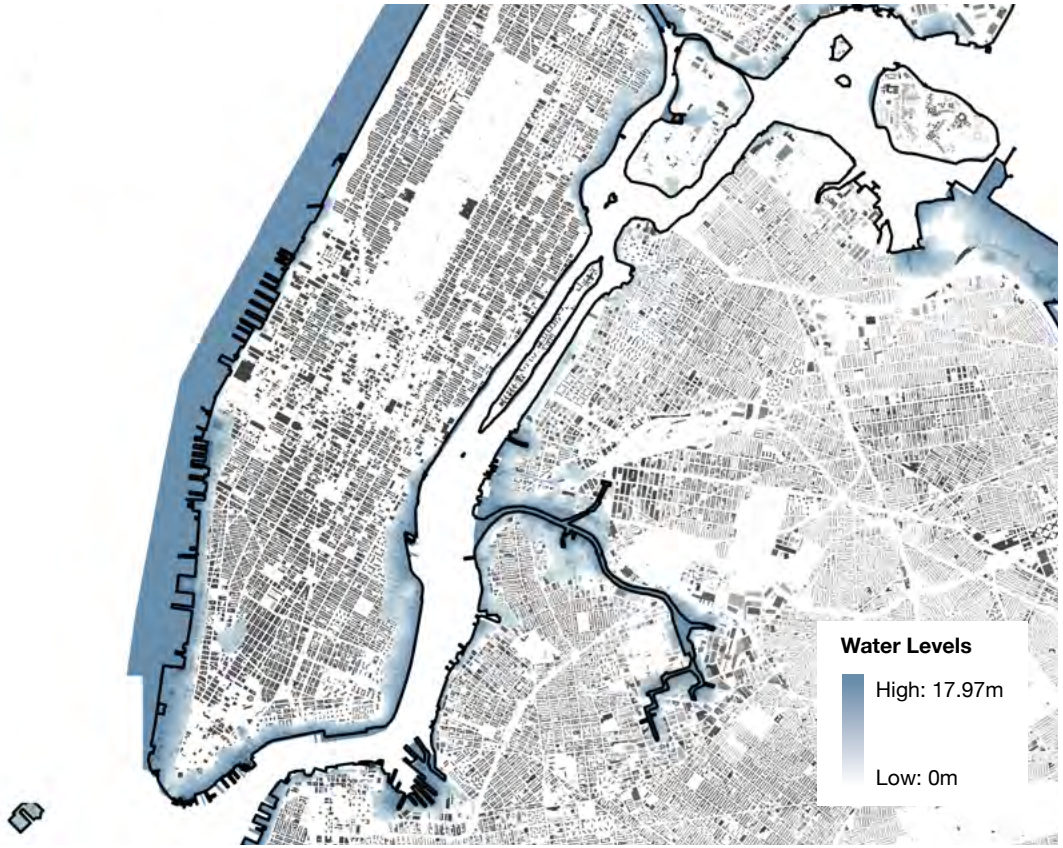
Heatwave 2003 **Heatwave 2013**

Extreme weather events

New York - Floods

Hurricane Sandy caused more damage and affected more lives than any previous storm in New York. Almost 90,000 buildings were located in the inundation zone and 6,500 patients were evacuated from nursing homes and hospitals*.

The map of the post event flood extent shows the buildings in lower Manhattan, Brooklyn and Queens which were affected by the hurricane.

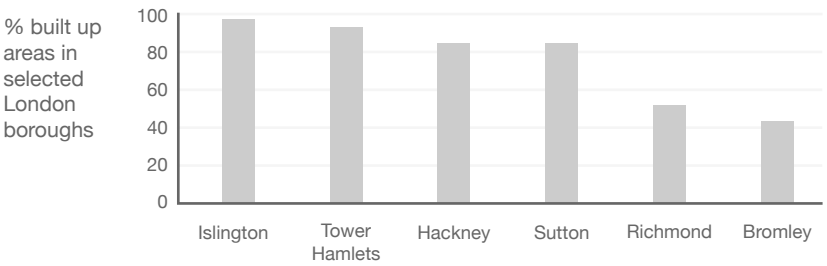


* The Impact of Hurricane Sandy

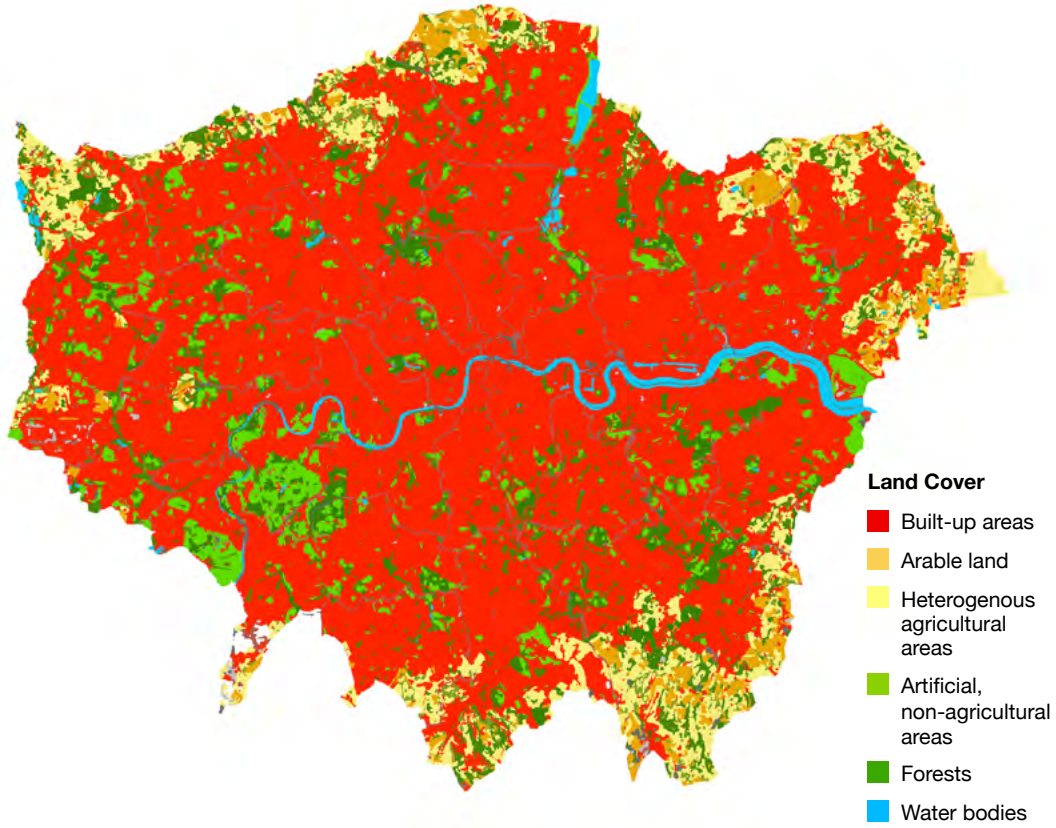
Land cover

London

The percentage of green areas, water bodies and agricultural land represents around 31% of London's surface area with the remaining 69% comprised by built up areas. These percentages vary considerably depending on the borough.



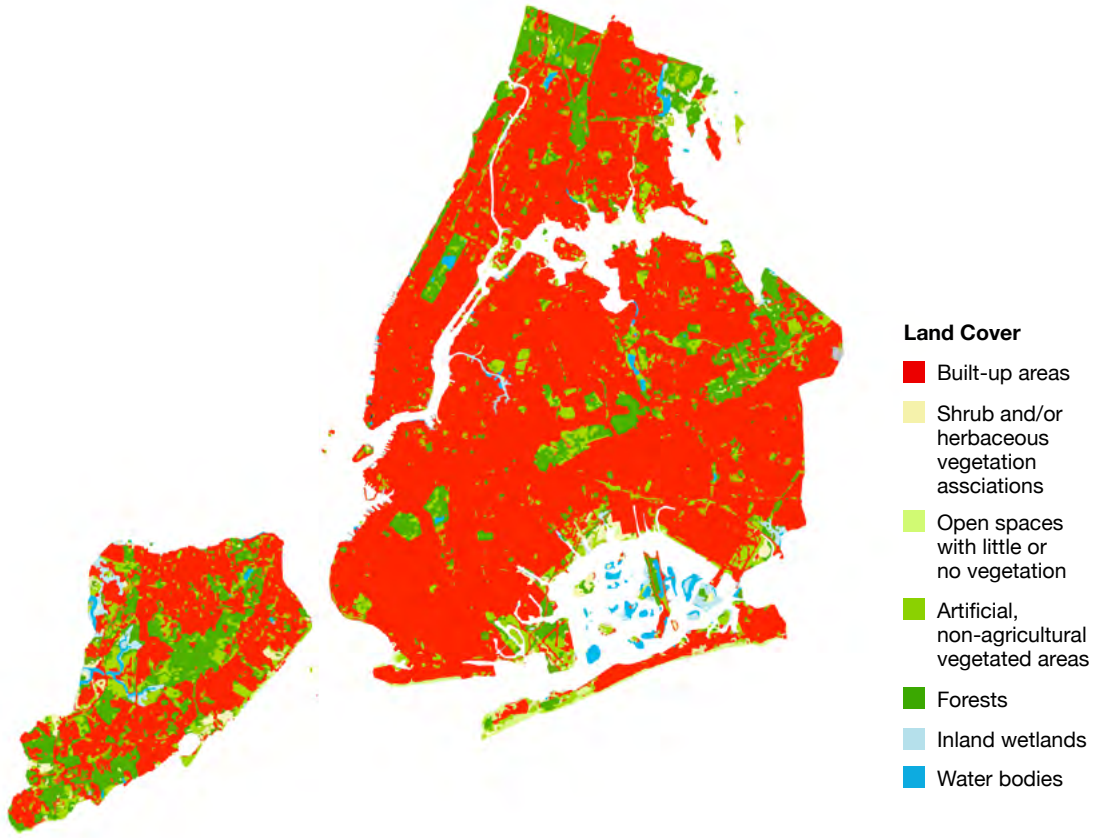
London's land cover has not changed significantly from 2000 to 2015. The increase in green areas and water bodies during this period is less than 2%.



Land cover

New York

Similar to London, the percentage of green areas and water bodies represents approximately 26% of New York City's total surface while built up areas represent 74%.



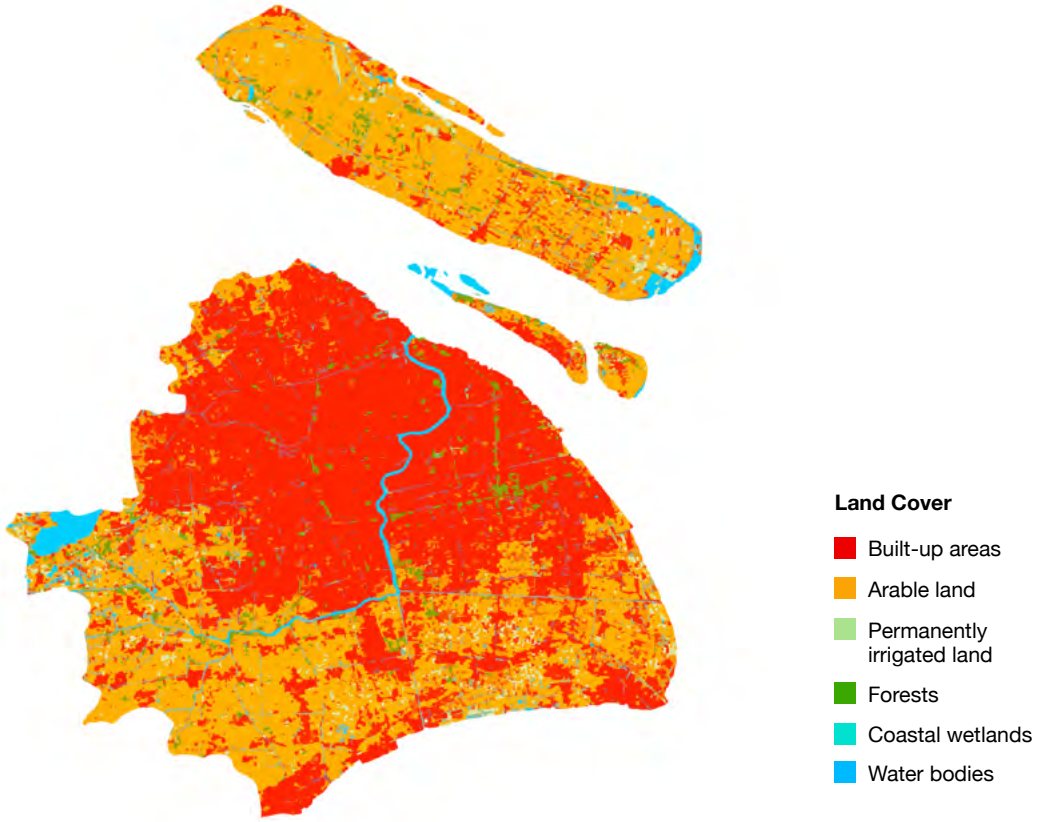
Land cover

Shanghai

The urbanisation trend in Shanghai is very clear from the land use changes over time. The urban area has almost doubled from 2000 to 2015, while agricultural land, forest and wetlands areas have decreased significantly.

Shanghai in 2000

Shanghai in 2005



Socio-economic context

Vulnerability

Human vulnerability refers to the degree to which individuals or households are susceptible to or unable to cope with a hazard. Low vulnerability enables individuals and households to achieve a standard of living which goes beyond mere survival and allows them to deal with unforeseen circumstances. Source: City Resilience Index and Resilient Cities Series.

Census data

Census data provides an insight into the socio-economic characteristics of a population within relatively small geographical areas. Census data for different countries and cities include different indicators which may or may not be directly comparable. Some countries and cities make their census data publicly available for general information, research and commercial use, others do not.

Heat Vulnerability Index (HVI)

The Heat Vulnerability Index (HVI) for London is estimated using an updated version of the approach developed by Wolf and McGregor (2013). This approach is based on a Principal Component Analysis (PCA) of socio-economic indicators available from census data. These indicators have been selected to reflect factors considered to be important determinants for heat risk as identified in the literature review for this project. Some heat risk factors are not covered by census data, therefore in those cases proxies of these categories are used (for example, use of 'no central heating' from census data as a proxy for low housing quality and low thermal comfort in winter as well as summer).

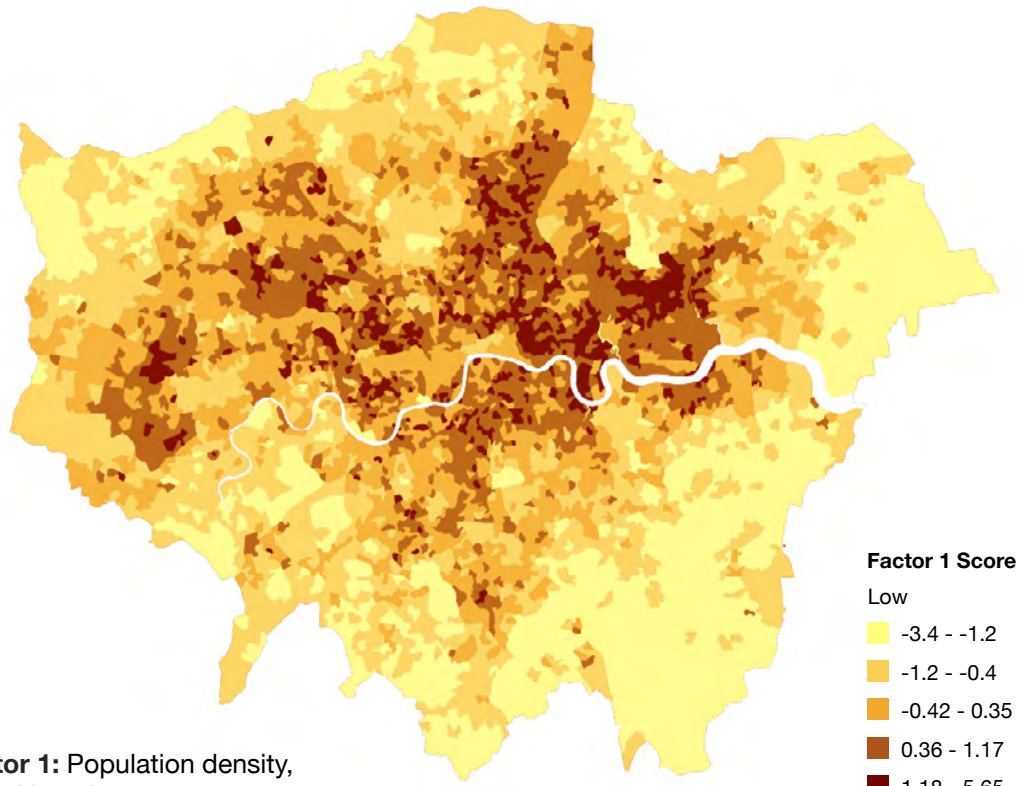
The PCA approach views vulnerability as a latent characteristic rather than a directly measurable one. Based on the data it identifies inherent risk factor groups which are then combined into the HVI*.

*Further information to be provided in a document still in preparation at the time of publication

Heat Vulnerability Index - London

The HVI for London is based on seven indicators obtained in the resolution of Lower Super Output Area (LSOA). Using the PCA statistical method, three principal components or factors are identified, which are then combined to form the HVI. Factor 1 plays the most important role in defining the HVI followed by Factor 2 and 3.

- Factor 1: Population density, rented housing, no person speaking English
- Factor 2: Bad and very bad health, households with one single person being over 65, day to day activities limited significantly
- Factor 3: No central heating



Factor 1: Population density, rented housing, no person speaking English

Factor 1 | Factor 2 | Factor 3 | HVI

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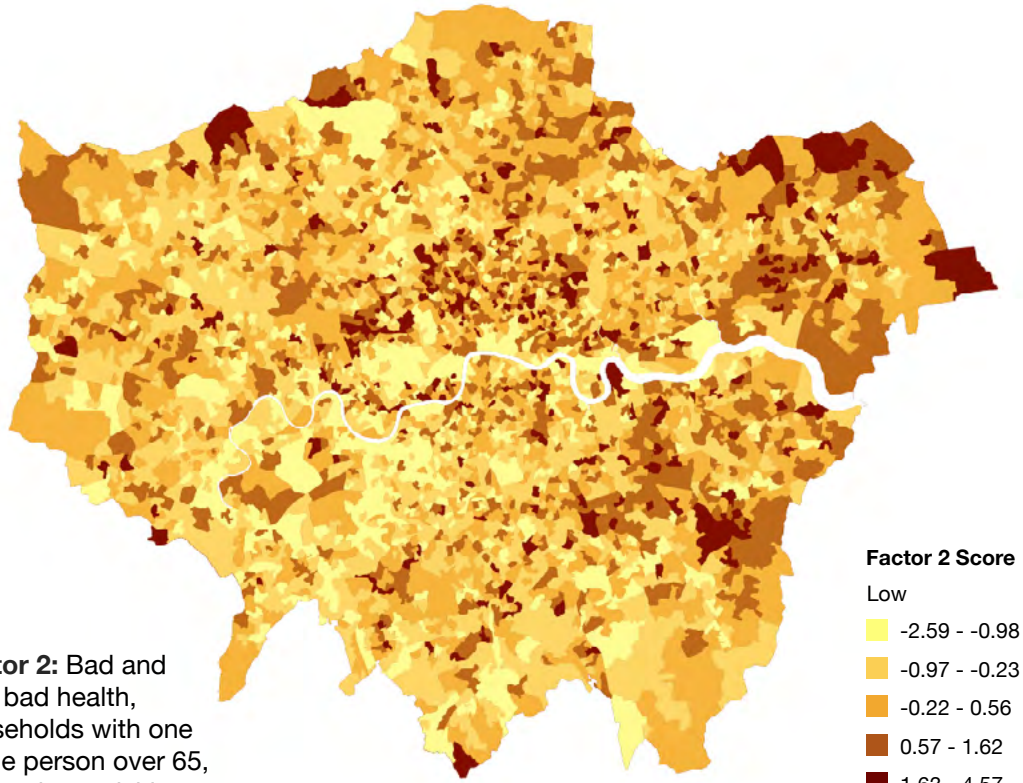

Factor 2: Bad and very bad health, households with one single person over 65, day to day activities limited significantly

Factor 1 | **Factor 2** | Factor 3 | HVI

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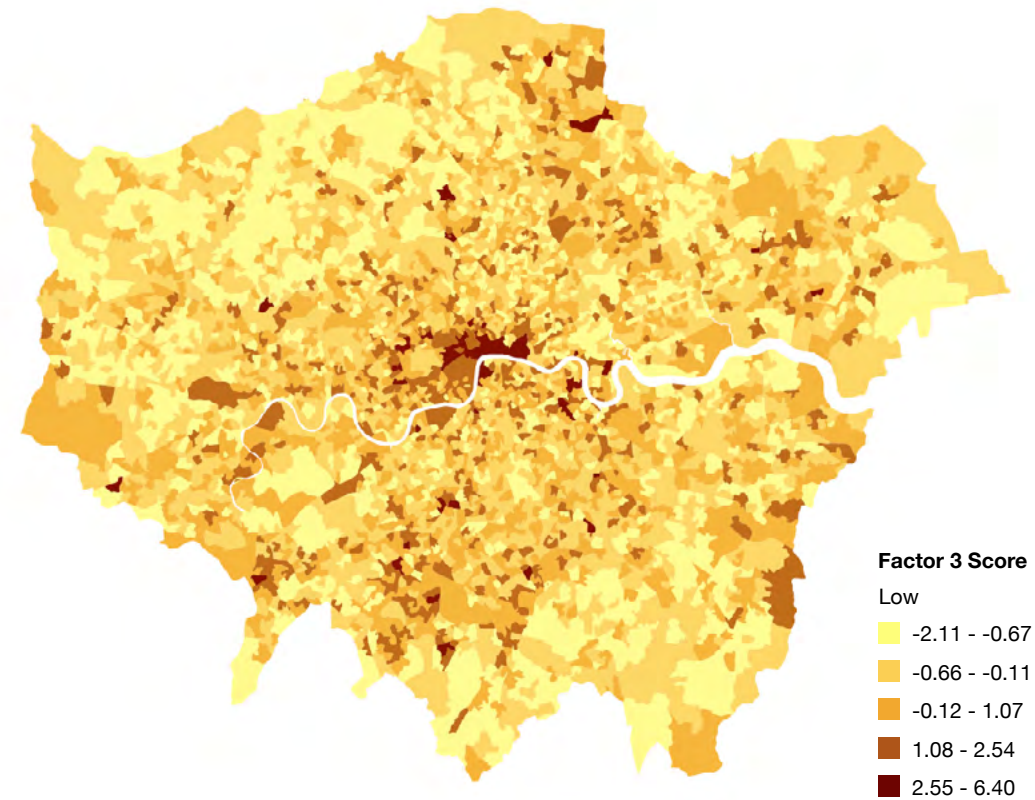
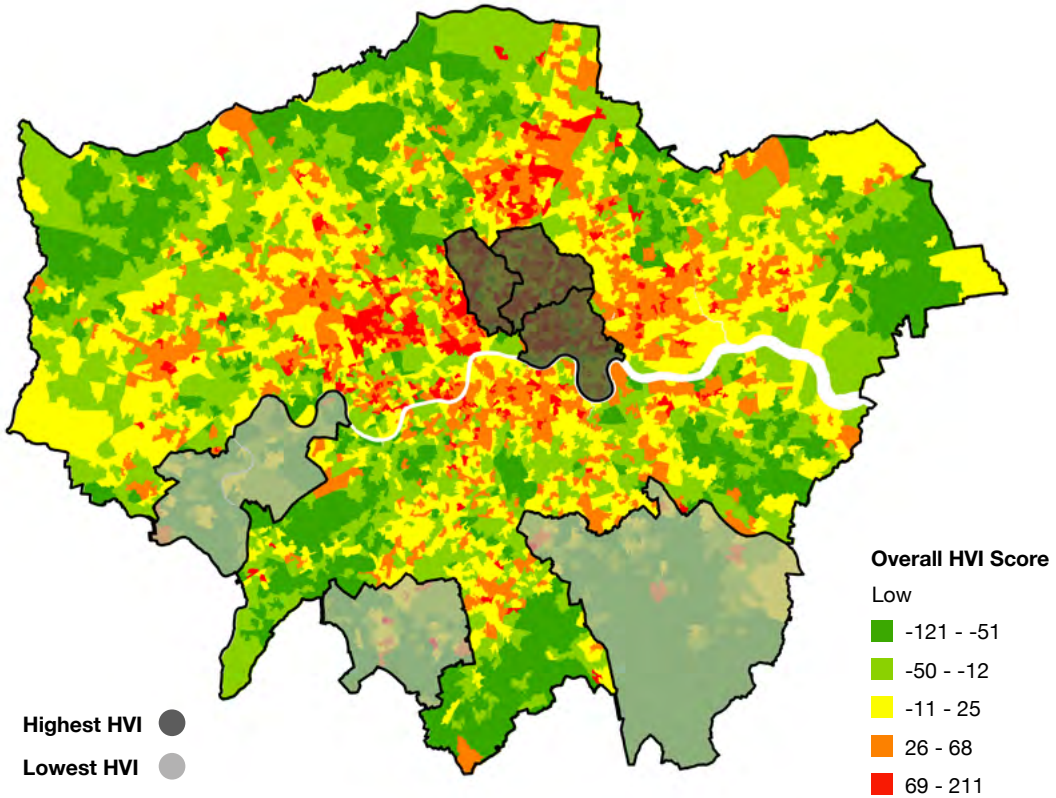


Factor 3: No central heating

Factor 1 | Factor 2 | **Factor 3** | HVI

Heat Vulnerability Index - London

Based on these factors, the highest vulnerability values are found in the London Boroughs of Hackney, Islington and Tower Hamlets while the lowest values are found in Bromley, Richmond upon Thames and Sutton. Overall, more highly vulnerable people live in central and north east London (except for the City of London).

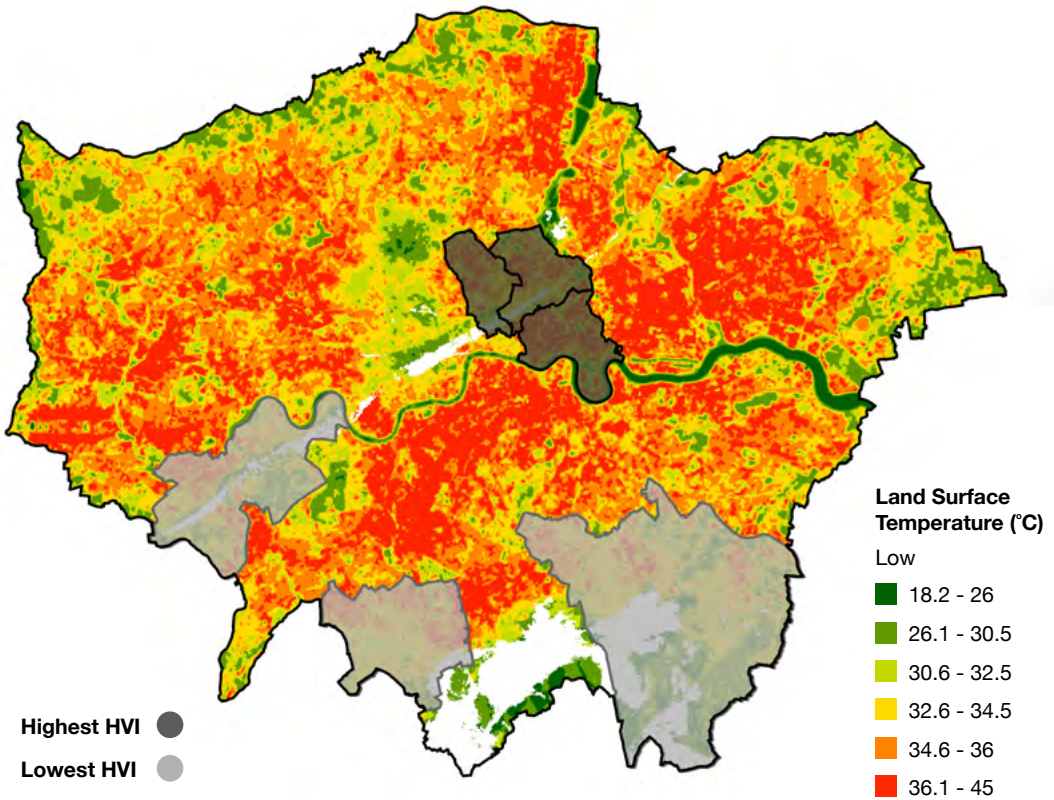


Factor 1 | Factor 2 | Factor 3 | **HVI**

Map overlays

Climate related risk 'hotspots' are areas within cities where measures to reduce risks and increase resilience should be prioritised due to the fact they are most affected by climate impacts and extreme weather events (for example heatwaves and floods) and have a high percentage of vulnerable people. These areas can be identified by combining information related to climate hazards, exposure and vulnerability. For example, the London Boroughs of Hackney and Islington have a high HVI level, are highly built up and reached very high temperatures during the heatwave in 2013.

These maps illustrate the different data sources that might be combined to identify climate related risk 'hotspots'.



*White areas represent cloud cover at time of satellite image.

Heatwave | Land cover | HVI | Health

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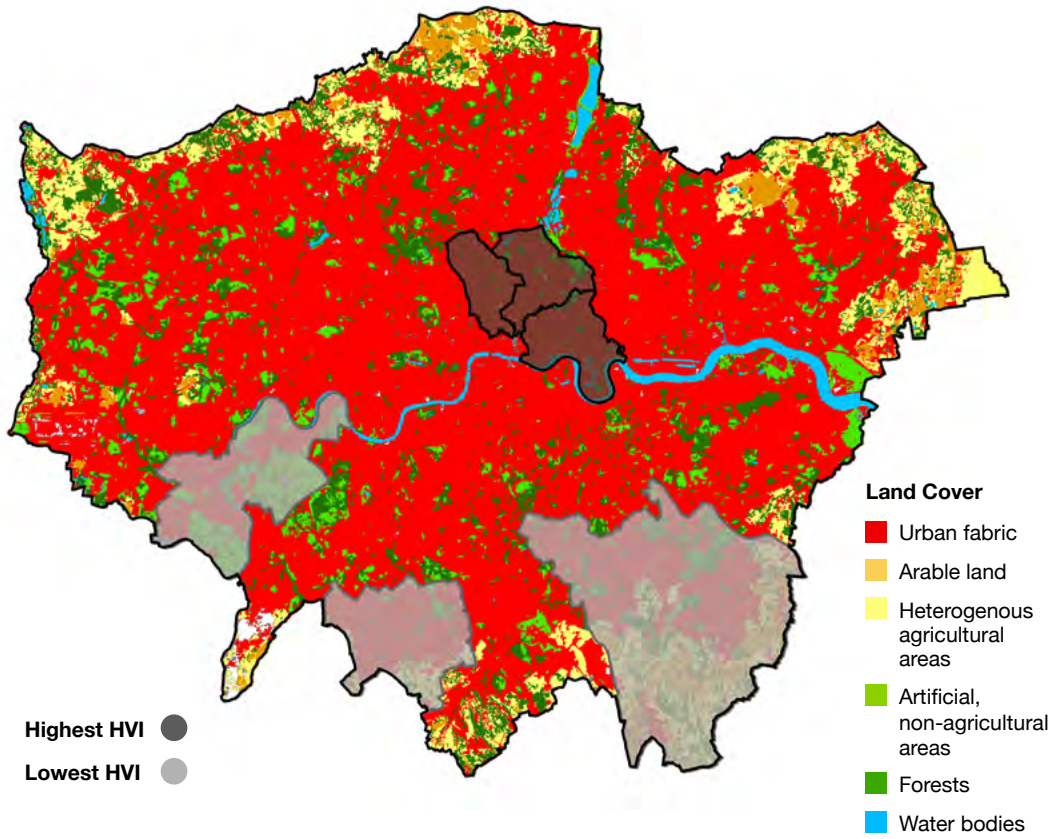

Heatwave | **Land cover** | HVI | Health

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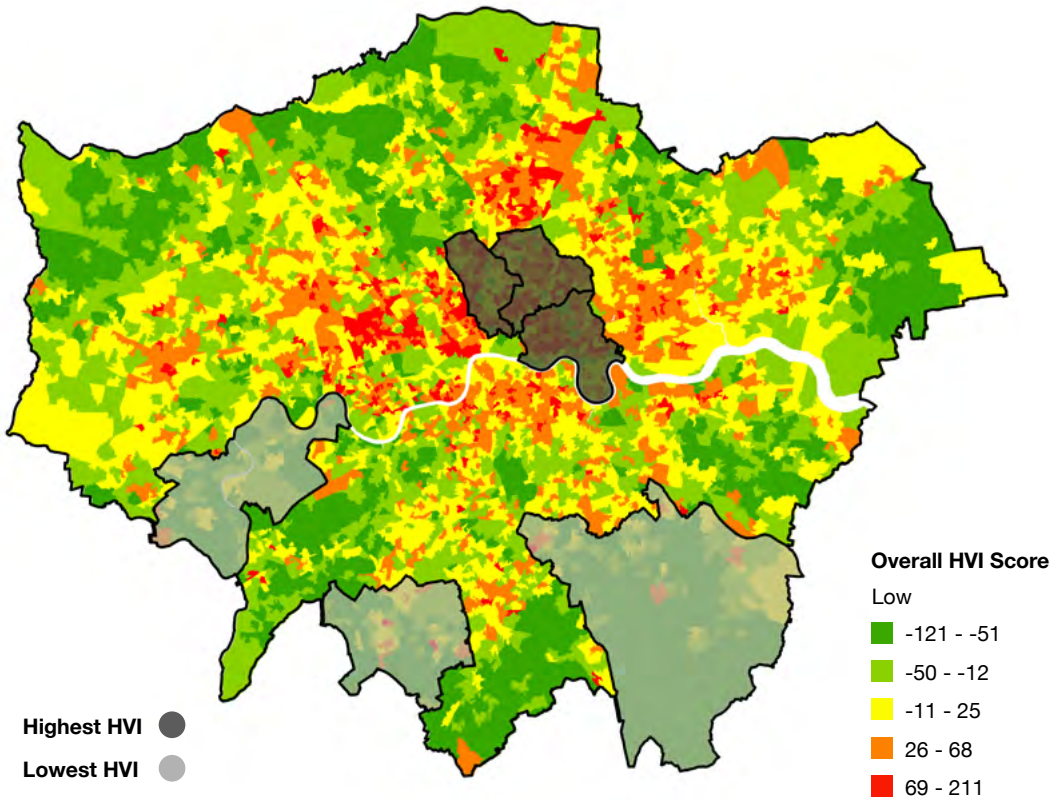

Heatwave | Land cover | **HVI** | Health

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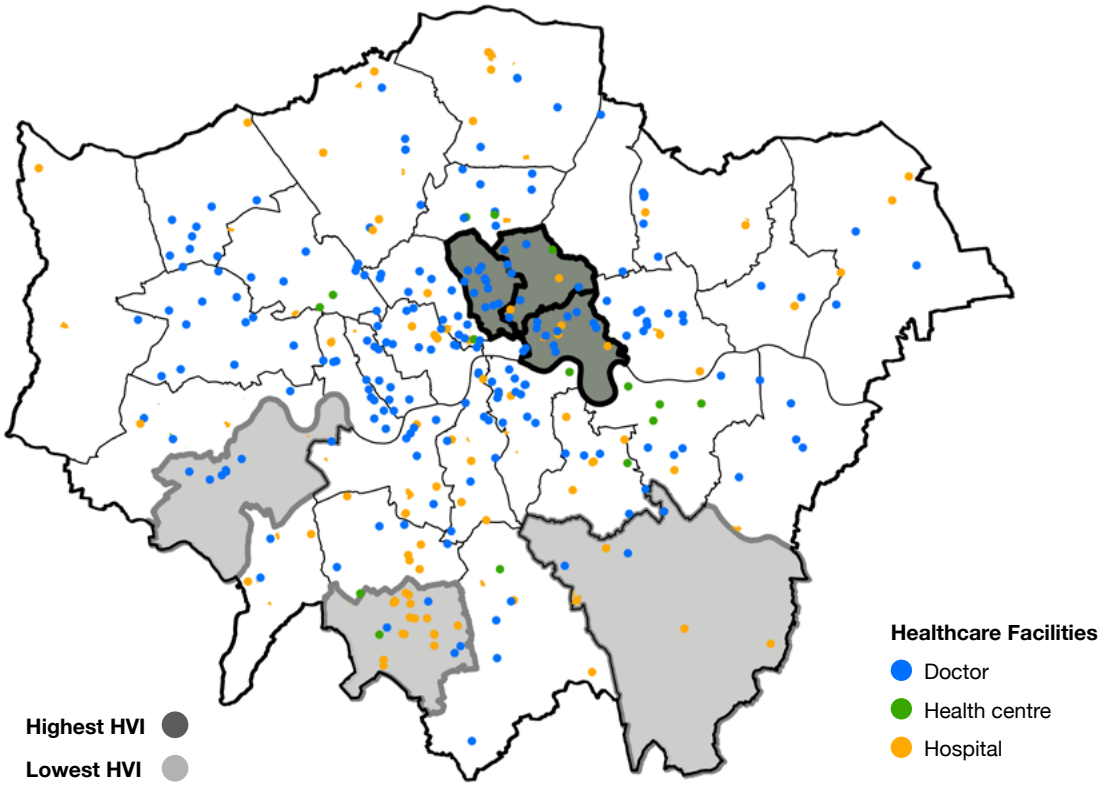


Heatwave | Land cover | HVI | **Health**

Win-win measures

There are a wide range of potential measures which can increase the resilience of elderly urban populations to climate impacts and extreme weather events. Of these measures, it is the 'win-win' measures which need to be prioritised as they contribute to wider sustainability and resilience benefits for cities and people. These win-win measures can be categorised as strategic or operational and physical or social.

Strategic measures involve long term planning with larger investments of time and resources before extreme weather events occur.

Operational measures involve short term reactive effort during extreme weather events.

Physical measures involve a change, intervention or improvement to the urban environment.

Social measures involve policies and practices relating to awareness raising, communication and behaviour change.

Win-win measures

① ② ③

Example of measures*	Category	Who is responsible and/or able to influence implementation?**	
		London	New York
Draw upon the fact that elderly people have many years of knowledge, skills and wisdom, which can be used in the development of resilience plans.	Strategic and social	Mayors, Local Authorities, Age UK, Public Health England	Mayor's Office of Recovery and Resiliency, City Council, Community Boards, Department for the Ageing, Department for Health and Mental Hygiene **(Group 1)**
Ensure that there are social services and public health programmes which enable elderly people to access energy, food, water, sanitation and medicines during and after extreme weather events.	Strategic and social	Mayors, Local Authorities, Local Resilience Forums, Age UK	As Group 1 plus New York City (NYC) Housing Authority and places of worship
Develop age-inclusive climate risk assessments and action plans which include awareness raising and environmental improvements.	Strategic and social	Mayors, Local Authorities, Environment Agency	As Group 1 plus NYC Department of City Planning's Resilient Neighbourhoods and New York State Governor's Office of Storm Recovery
Creation of green and blue spaces and infrastructure. Aim to transform as many urban areas from 'grey' surfaces to green, and impermeable surfaces to permeable.	Strategic and physical	Mayors, planners and developers, Local Authorities	As Group 1 plus NYC Department of Environmental Protection (DEP), Department Of Transport, NYC Parks and Recreation
Implement local scale measures such as shading of streets and external spaces through tree planting and structures, as well as sustainable urban drainage systems.	Strategic and physical	Mayors, planners and developers, Local Authorities	Mayor's Office of Recovery and Resiliency, Mayor's Office of Sustainability, City Council, Community Boards, Planners and Developers, NYC Department of City Planning, NYC DEP, NYC Parks and Recreation **(Group 2)**

Win-win measures

① ② ③

Example of measures*	Category	Who is responsible and/or able to influence implementation?**	
		London	New York
Take a 'design for future climate' approach to new building and infrastructure projects and major retrofits which take climate change uncertainties and socio-economic trends such as population growth and technological needs into account.	Strategic and physical	Planners and developers, Mayors, Local Authorities	As Group 2 plus NYC Digital, NYC Housing Authority (NYCHA), NYC Housing, Planning and Development and NYC Department of Buildings
Enhance existing heatwave and flood risk warning systems to ensure reliable and suitable communication channels to reach all urban populations including the most vulnerable people.	Operational and social	Mayors, Met Office, Environment Agency, Public Health England, Age UK	Mayor's Office of Recovery and Resiliency, City Council, Community Boards, Department for the Ageing, Department for Health and Mental Hygiene, NYCHA, NYC Digital, New York State Governor's Office of Storm Recovery, NYPD, NYC Fire Department **(Group 3)**
Resource and staff an extreme weather telephone or email hotline and provide social and public health visits and checks for the most vulnerable people.	Operational and social	Mayors, Local Authorities, ITC companies and providers, Age UK	As Group 3 plus FEMA, Project Hope, Salvation Army, NYC Police Department, NYC Fire Department

*This list is drawn from a longer list of measures

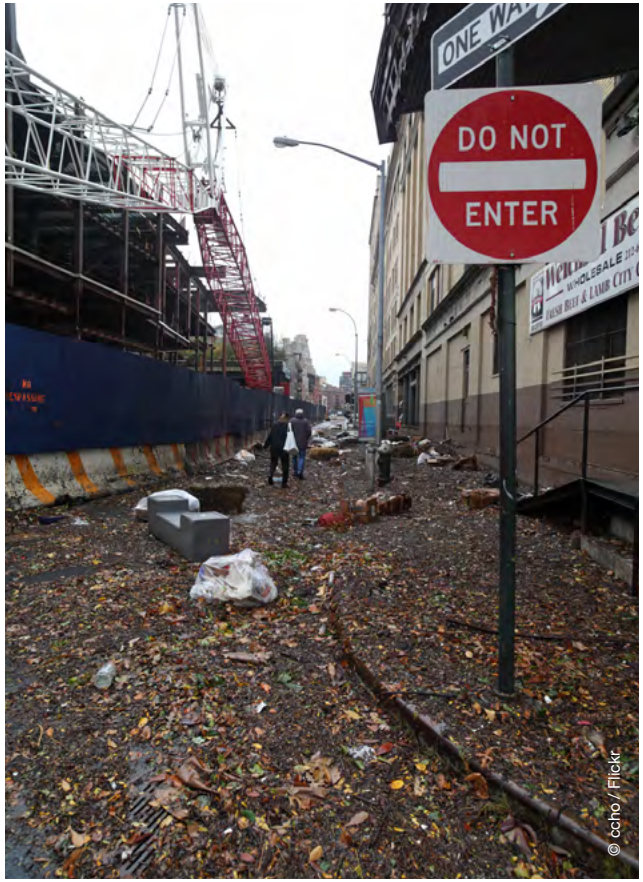
**Further research is needed to identify key stakeholders who are responsible and/or can influence the implementation of win-win measures for Shanghai

Key messages

Climate change impacts combined with population growth and an ageing population, are increasing the exposure and vulnerability of cities and people to extreme weather events.

In global cities like London and New York, a significant proportion of vulnerable populations live in areas which are most affected by extreme weather events such as heatwaves and floods. Methods which combine and draw upon several sources of data information are required to obtain a comprehensive understanding of current and future risks in these cities. These methods can be applied to other cities around the world, including Shanghai.

Action is needed by decision makers and planning and design professionals to implement ‘win-win’ measures which increase the resilience of vulnerable populations, such as elderly people, and contribute to wider sustainability and resilience priorities in cities.



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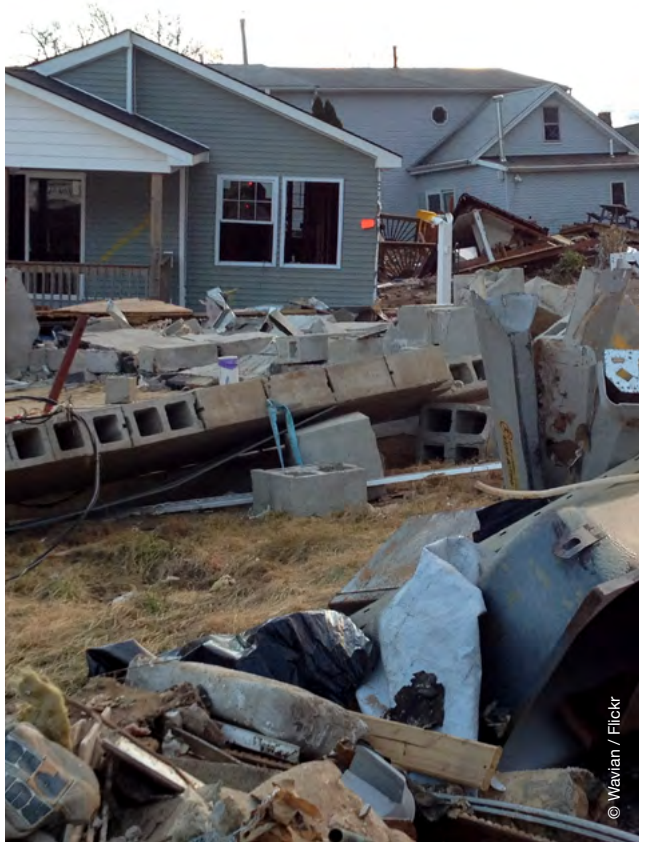
Further work

This project has highlighted the value of developing a methodology for assessing exposure and vulnerability of ageing populations in cities to climate impacts based on a diverse evidence base of past and current extreme weather events as well as past and current physical and socio-economic city characteristics. Future work should incorporate in the methodology projections for future climate and extreme weather events, and projections for socio-economic changes.

As a result of applying this methodology to London and New York, strategic and operational 'win-win' measures can be effectively targeted to the most exposed areas and vulnerable people in cities.

We suggest other global cities, including Shanghai, consider and develop this approach further.



Glossary

Landsat

The Landsat Program is the flagship Earth Observation Satellite Program led by NASA and the United States Geological Survey. Data from the multispectral Landsat-7 and Landsat-8 was utilised for this project. Comprising of 11 bands ranging between 15m and 100m resolution, the Landsat 8 TIRS instrument has two Thermal bands with 100m resolution. Using these it is possible to infer Normalised Surface Temperature by applying algorithms to convert radiance to temperature in Kelvin, and then Celsius.

MODIS

The Moderate Resolution Imaging Spectroradiometer is an instrument on-board NASA's Aqua and Terra Satellites. MODIS captures data on a daily basis in 36 spectral bands. These data cover wavelengths from 0.4 µm to 14.4 µm at varying spatial resolutions (2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km). MODIS data can be used to infer surface temperature. These daily observations give a clear indication of the temporal trend in surface temperature both during the day and night which are useful long term time series analysis.

Synthetic Aperture Radar (SAR)

SAR is an active remote sensing technique which utilises radio frequencies of the electromagnetic spectrum from 1cm to 1m wavelength. Space borne SAR is utilised to image the Earth in both 2D and 3D, by measuring surface roughness characteristics through the interaction of the radar signal with the Earth's surface, and also for creating Digital Elevation Models. SAR is particularly useful for urban and flooding applications, as well as geological applications such as monitoring earthquakes and volcanoes.

FEMA-MOTF

The FEMA Modeling Task Force (MOTF) is a group of modelling and risk analyst experts from FEMA Regions VIII (Denver) and IV (Atlanta) that may be activated by the FEMA National Response Coordination Centre (NRCC) for Level 1 events in support of disaster response operations. The group consists of individuals with experience in multi-hazard loss modelling and impact assessments, including earthquakes, hurricanes, riverine and coastal floods (surges, tsunamis), winter storms and others.

Go to website

CORINE

The CORINE (Co-ORdinated INformation on the Environment) dataseries was established by the European Community (EC) as a means of compiling geo-spatial environmental information in a standardised and comparable manner across the European continent. The Corine Land Cover is a standardised classification nomenclature for assigning land cover classes based on satellite data.

< Back to Climate and urban environment

Relevant projects

University of Manchester, Joseph Rowntree Foundation, the Environment Agency, JBA Consulting, Centre for Sustainable Energy and Climate UK information tool 'Climate Just'

Adaptation and Resilience in the Context of Change (ARCC) Network

Zero Carbon Hub 'Tackling Overheating in Buildings' project

National Institute for Health Research Health Protection Research Unit in Environmental Change and Health

100 Resilient Cities

Arup and The Rockefeller Foundation 'City Resilience Index'

Asian Cities Climate Change Resilience Network (ACCCRN)

Natural Resources Defense Council 'City Resilience Toolkit'

U.S. Climate Resilience Toolkit

Public Health England, Duke Global Health Institute and the Australian National University 'International Consortium for Urban Environmental Health & Sustainability', Healthy-POLIS

London Climate Change Partnership – The business case: incorporating adaptation measures in retrofits and A checklist for retrofits

London Climate Change Partnership – Your social housing in a changing climate

Want to know more?

Polly Turton and Dr Maria Sunyer Pinya are climate change adaptation and resilience specialists based in Arup's Advanced Technology and Research team in London. If you would like to know more about the work that has gone into the SHARPER project, or are interested in how the data and the approaches we have used could be applied to your city, please get in contact with us.

Polly Turton,
Associate, Arup
polly.turton@arup.com

Dr. Maria Sunyer Pinya,
Consultant, Arup
maria.sunyer-pinya@arup.com