

Vulnerability of Road Network to Rainstorms in London and surrounding regions

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Rainstorm impact modelling

Rain precipitation



Speed reduction



(1) The rainstorm limits drivers' visibility and makes the roads slippery, requiring drivers to decrease their speed to ensure safety.

The focus of existing studies

Waterlogging



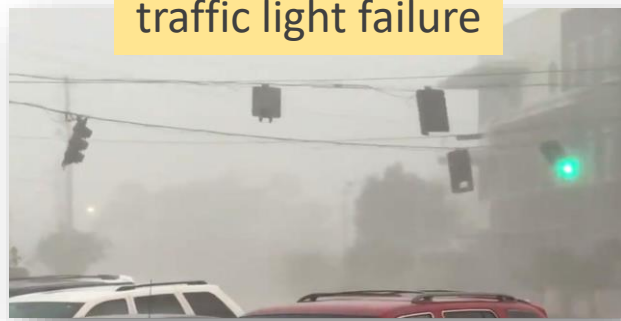
Speed reduction



Road closure

(2) The waterlogging caused by rainstorms makes vehicles navigate slowly through waterlogged areas. When the depth of the waterlogging is above 30 cm, vehicles cannot pass it.

traffic light failure

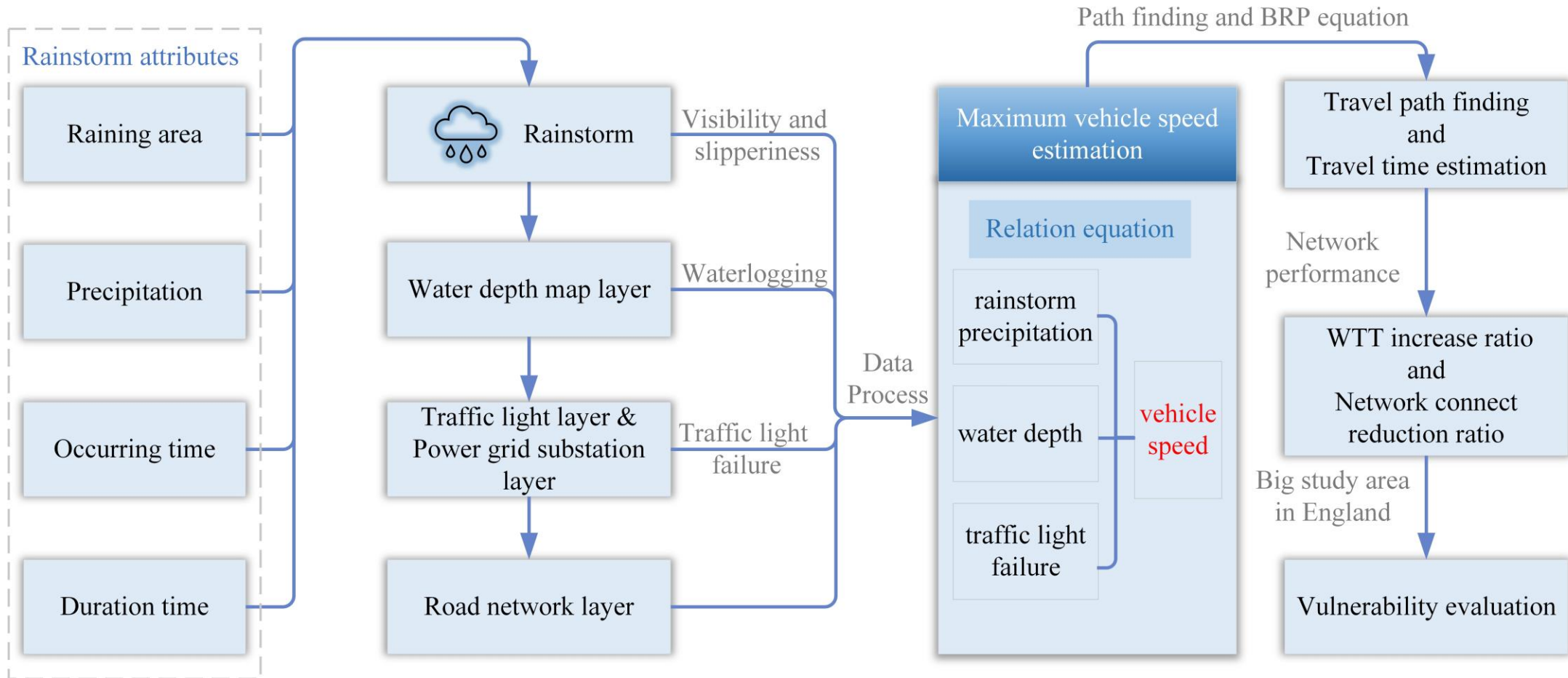


Speed reduction



(3) The rainstorm may cause the failure of the traffic light power supply, resulting in congestion, which also reduces vehicle speed and road capacity.

Research flow

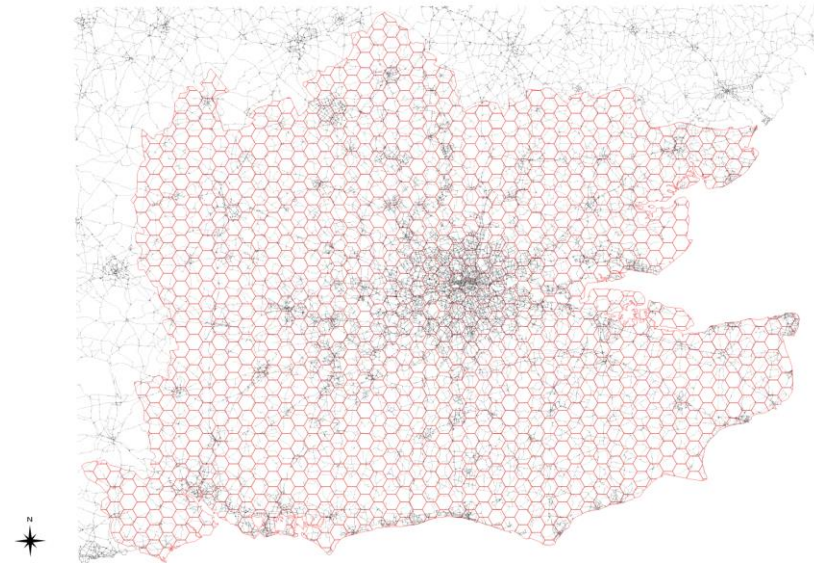
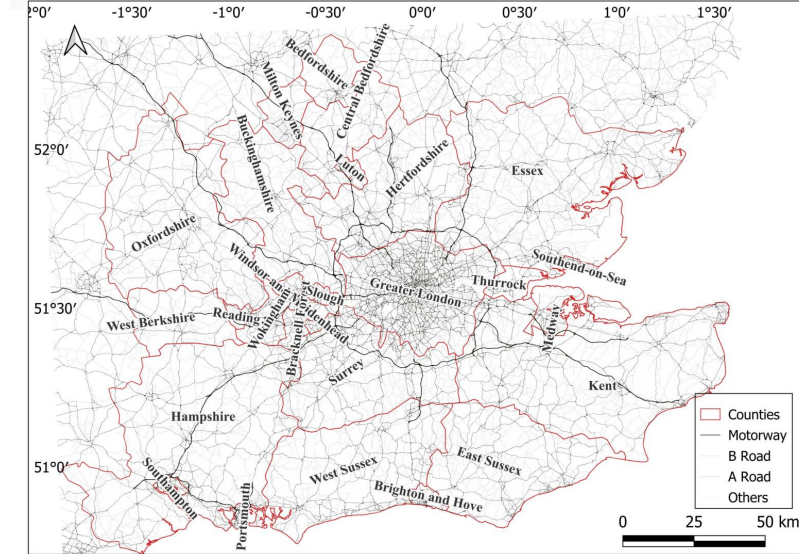


Research area

- The road network in the London and its surrounded regions.
- The research area encompasses 26 counties, and covers 26,837 km².
- The road network comprises 219,772 nodes and 242,906 edges.
- The study area is partitioned into 1,375 traffic zones using 5km-diameter hexagons.
- Network vulnerability is measured by the trip time and connection states among those traffic zones.



FUTURE ROADS



The data used for research

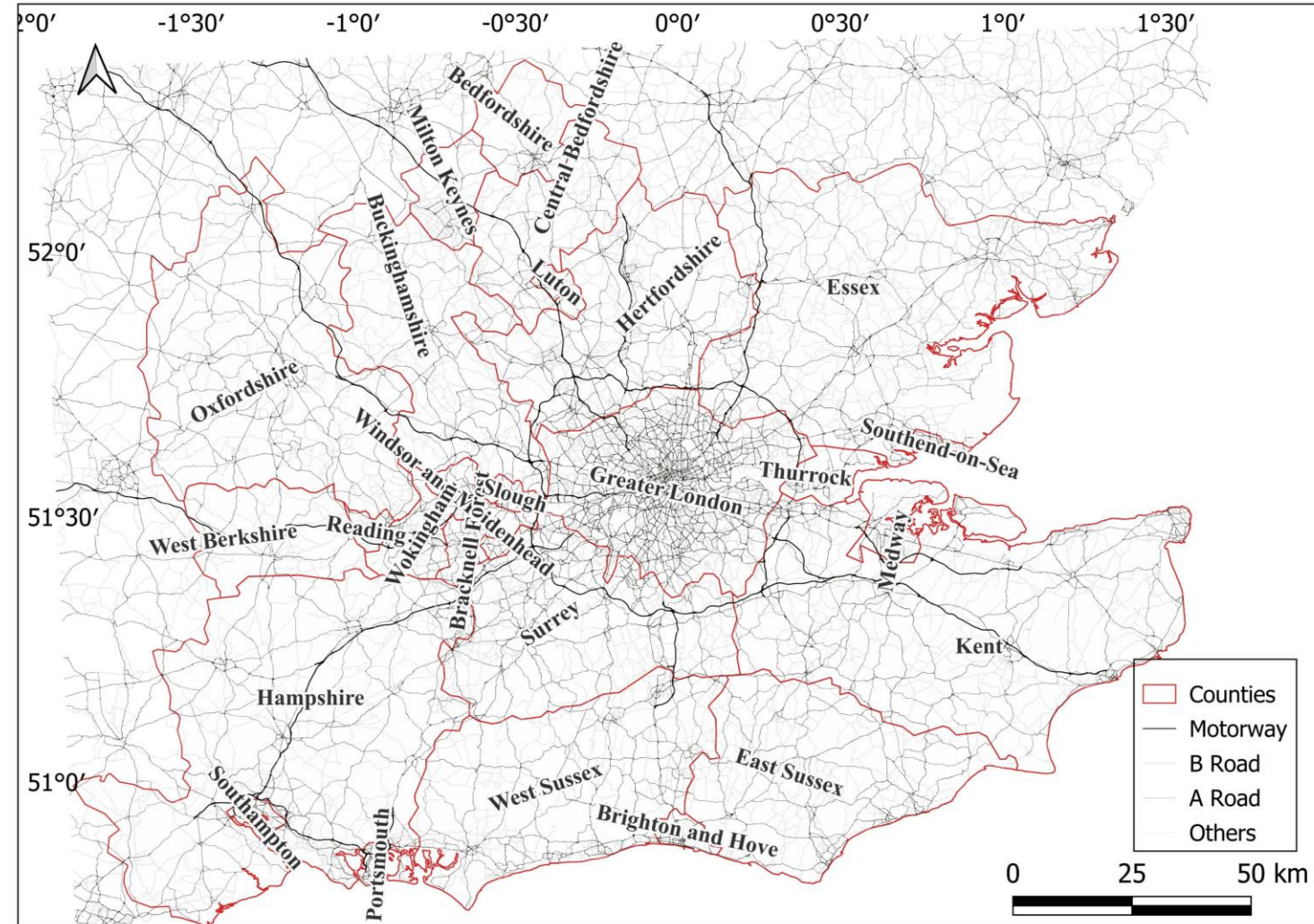
Data	Resolution	Attributes and unite	Data source
waterlogging depth map after a rainstorm occurring with return periods of 1 in 30, 1 in 100, and 1 in 1000 years	2m	Water depth (mm)	Environment Agency
Digital terrain elevation	2m (vertical accuracy 15 cm)	Elevation in each grid (mm)	Environment Agency
Digital surface elevation	2m (vertical accuracy 15 cm)	Elevation in each grid (mm)	Environment Agency
Location of power substation	N/A	Search for OSM nodes and polygons with tag "power"= "substation"	Open Street Map
Traffic light		Search for OSM nodes and polygons with tag "highway"= "traffic_signals"	Open Street Map
Road network	5-10m	Capacity () and free-flow speed (km/h) of each segment, traffic flow (vehicles/h)	Open Street Map
traffic accounting data	Hourly	The counting of vehicles per hour	Depart for Transport
POI		The building types, numbers, and locations	Ordnance Survey
Population in local authority area	N/A	Population and population density in local authority area of UK	Office for National Statistics

Rainstorm scenarios

Scenarios: the rainfall events (1 in 30 years, 1 in 100 years and 1 in 100 years) within these local Gov areas over one hour.

The waterlogging depth map following the rainstorm is overlaid onto the road network map using QGIS. (sample water depth for road segments and power supply facilities)

The precipitation rates for rainstorms with return periods of 1 in 30, 1 in 100, and 1 in 1000 years are 30 mm/h, 42 mm/h, and 65 mm/h, respectively.



Result

Relation between network attributes in rainstorm region and its vulnerability

- Network vulnerability is significantly positively correlated with the total distance of roads, POIs, and the population in the rainstorm area, with a p-value less than 0.05.
- Rainstorms covering large areas may not cause a high network vulnerability, but rainstorms occurring in an area with high POI, population, and long road distances are likely to have a significant impact on the network vulnerability.

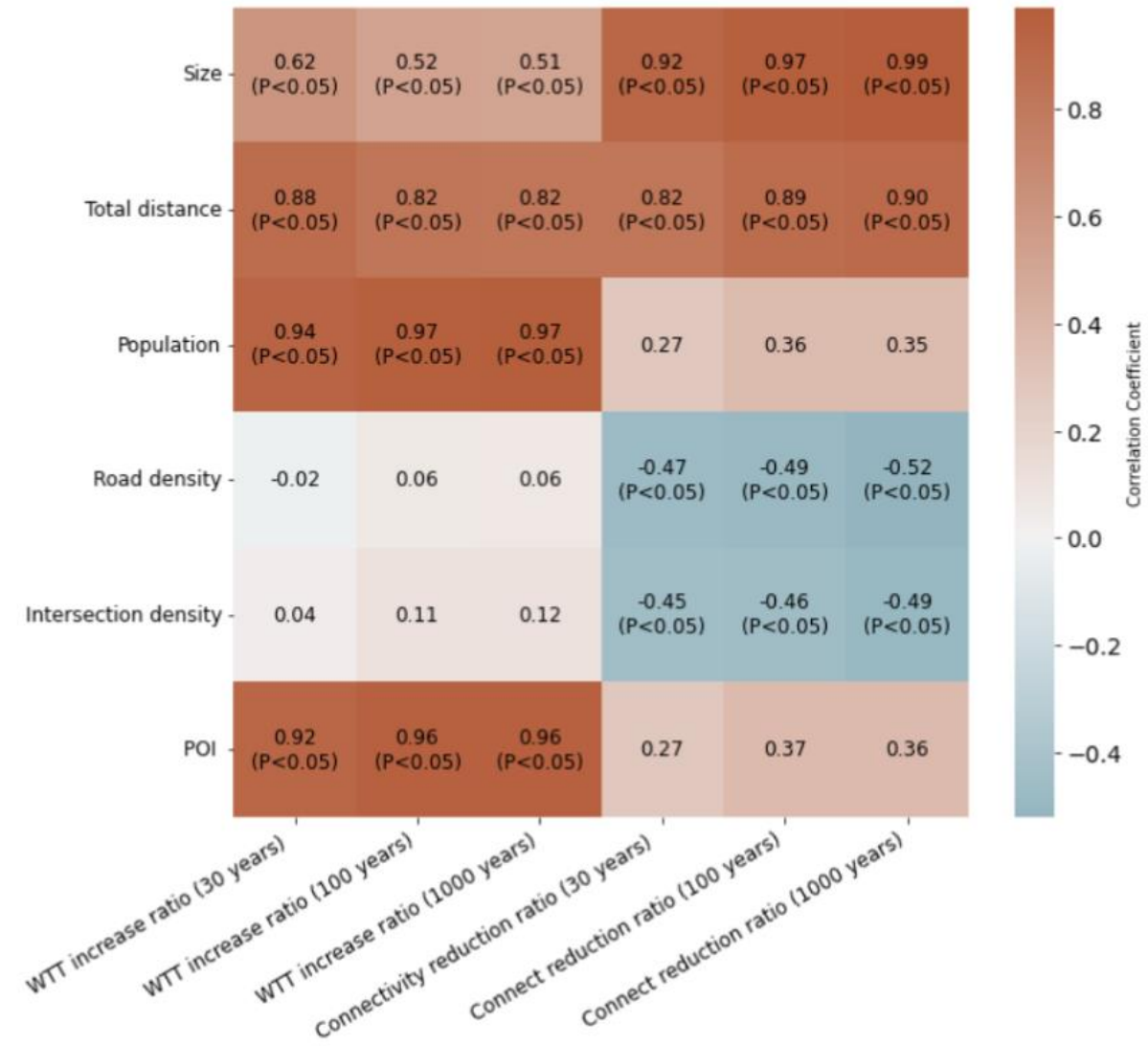
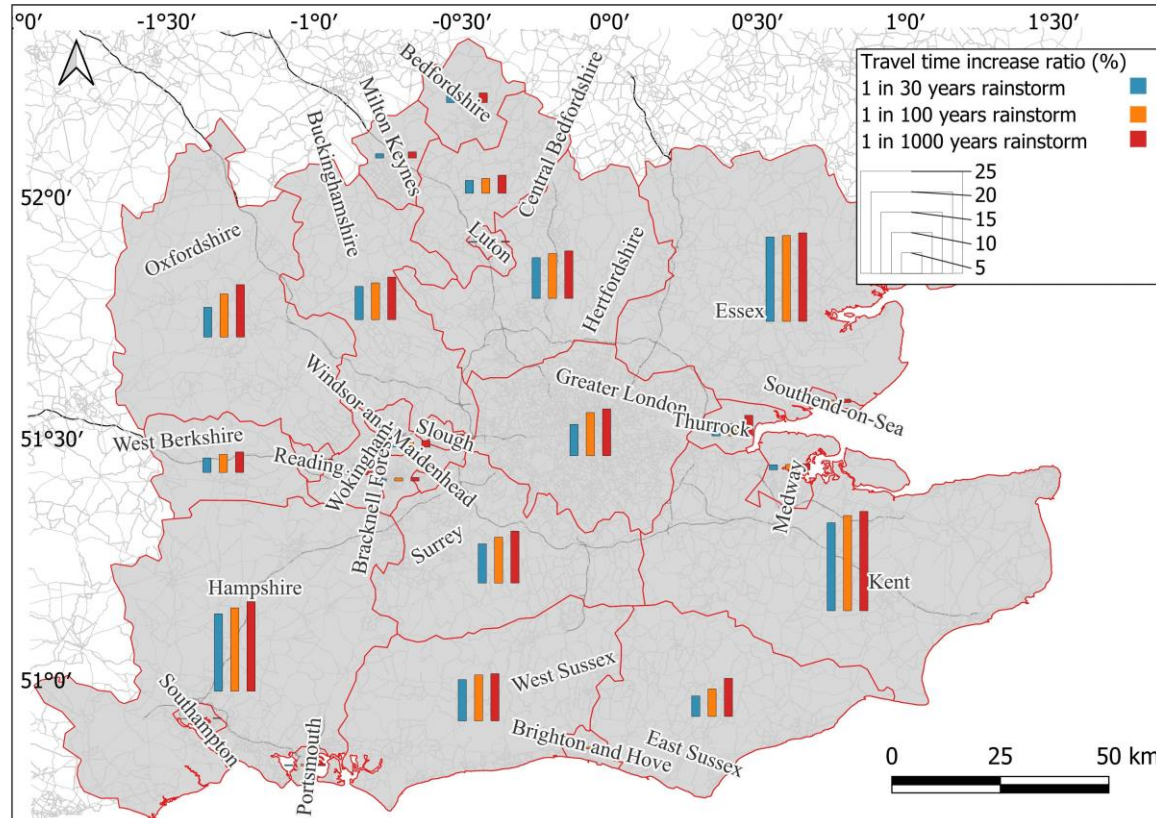


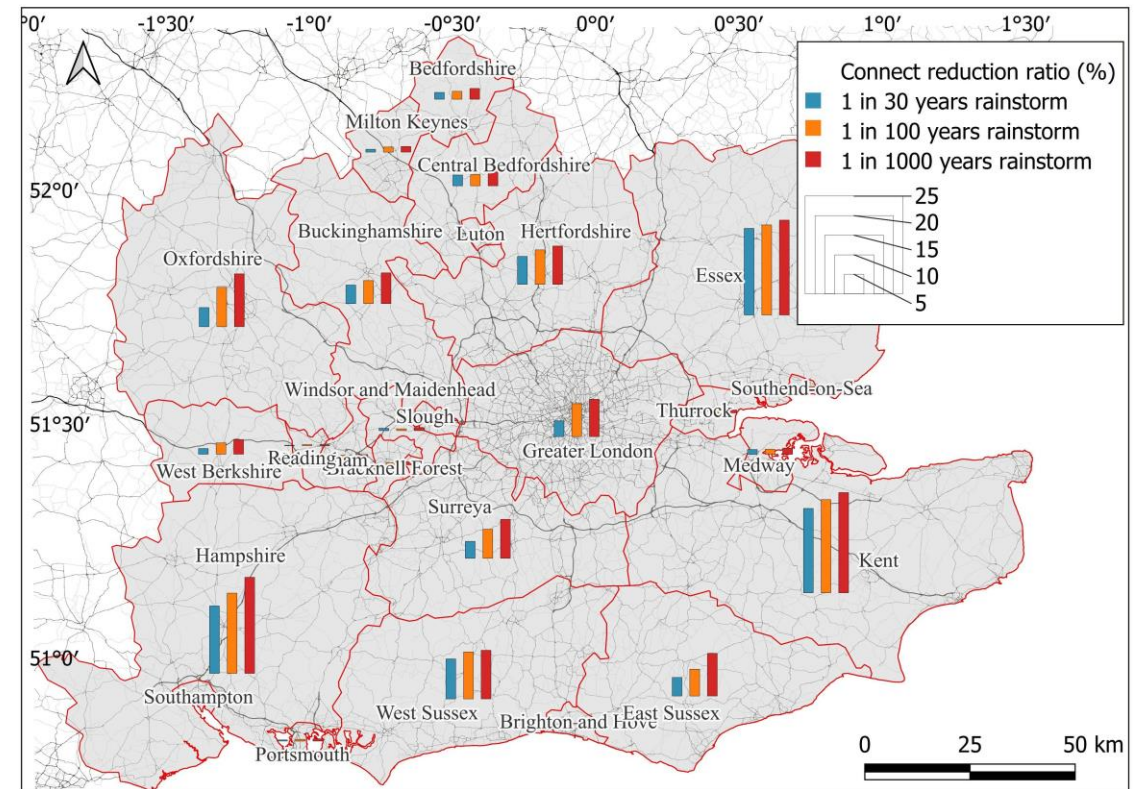
FIGURE 6 Correlation between the attributes of rainstorm regions and the network vulnerability after rainstorm.

Network vulnerability after a rainstorm covers local government areas

Rainstorm in Hampshire, Kent and Essex causes high travel time increase and high connect reduction.



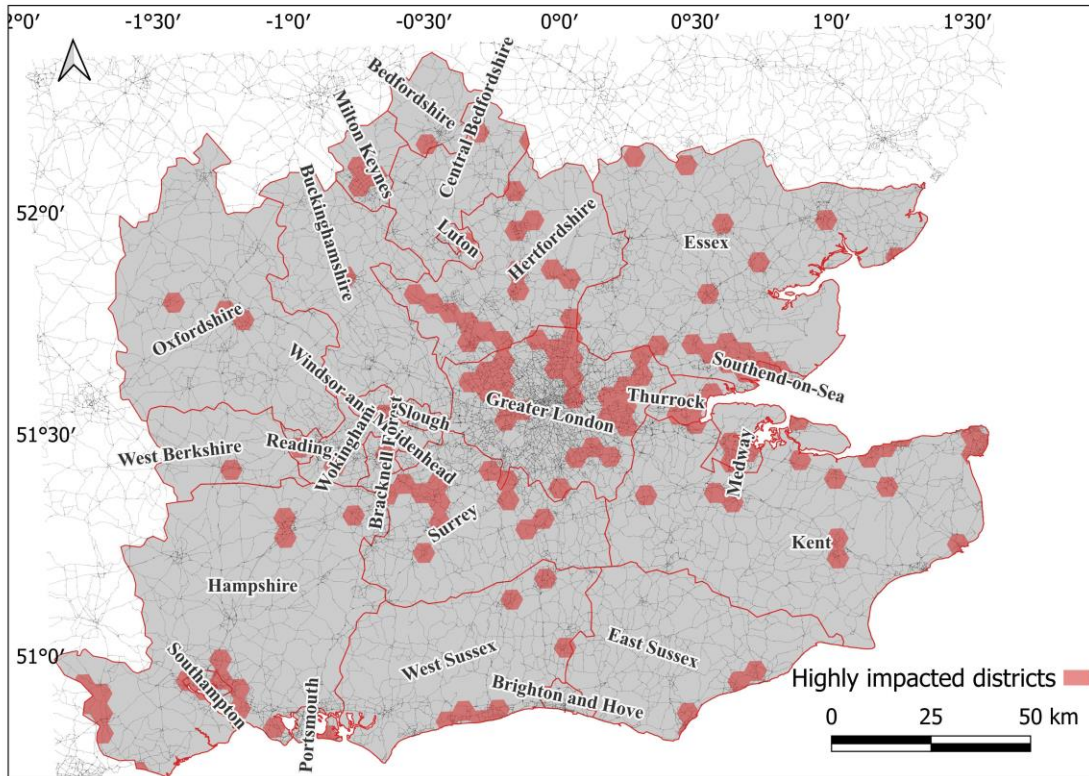
Travel time increase ratio during rainstorm



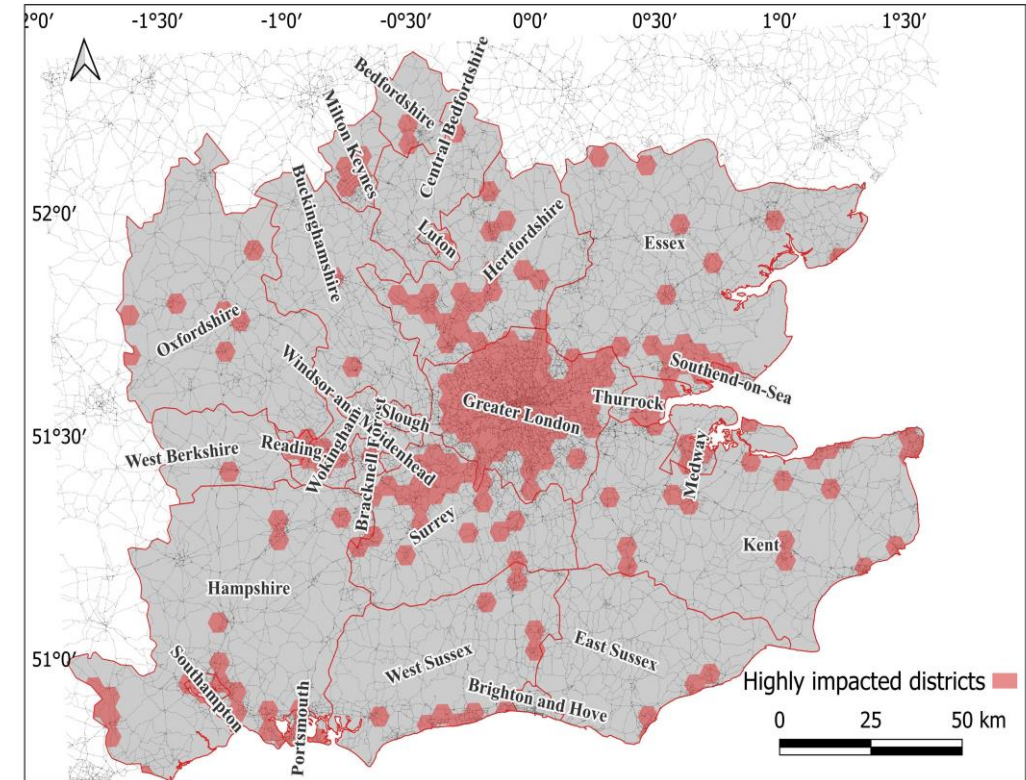
OD connect reduction ratio during rainstorm

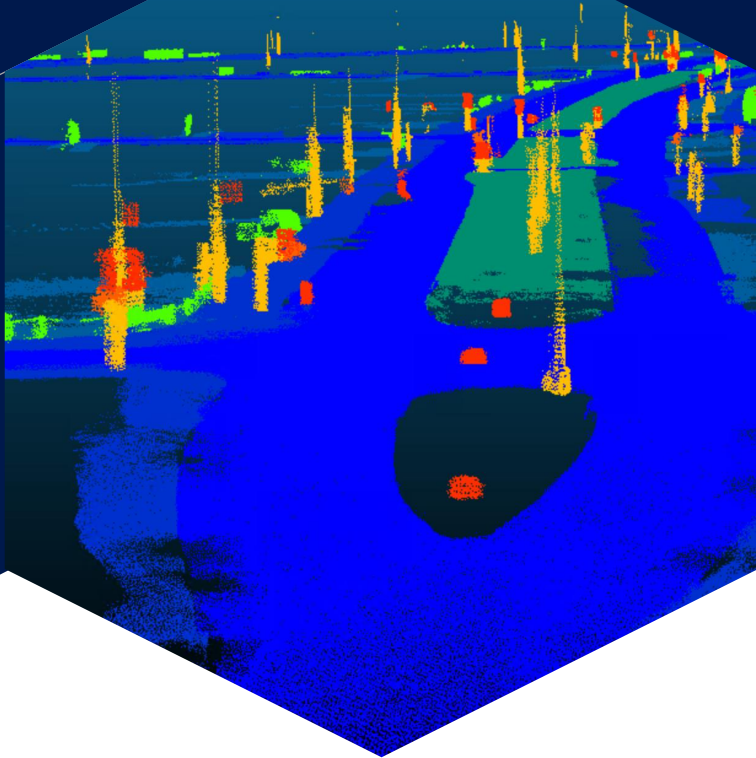
Traffic zones with **poor accessibility** and **high population** during floods considering the worst case

1 in 30 years event



1 in 100 years event





Thank you



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