

Assessing the Social and Economic Impacts of Climate-Related Transport Disruption in the North of England

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Background and Motivation

Transport systems across the North of England are increasingly affected by climate-related hazards such as flooding, heat, extreme weather, ground instability and coastal erosion. These disruptions can limit access to essential services, reduce mobility, and disproportionately affect communities. This project integrates TfN's climate-risk assessments with socio-economic data to highlight communities most likely to experience transport-related impacts and to support evidence-based decision-making.

Data and Methods

The study combines climate-risk scores for road and rail infrastructure (covering 17 hazards under current and future scenarios) with socio-economic indicators for 9,680 LSOAs. All datasets were cleaned, standardised and merged to a consistent geography using official lookup tables.

Exposure was calculated by linking each LSOA's population-weighted centroid to nearby assets within 250m, 500m and 1km buffers. Metrics include average hazard score, nearest-asset score, asset count and distance to the closest asset. Hazard scores were normalised per hazard to ensure comparability. Sensitivity was derived from 14 socio-economic indicators, including IMD, car ownership, age structure, health, income, and GVA, which were normalised and combined using both equal-weighted and PCA-weighted approaches. Vulnerability was then calculated by combining exposure and sensitivity for both current and future periods.

Spatial patterns were examined using Moran's I, LISA and Getis-Ord Gi* hotspot analysis, applied with both Queen contiguity and KNN spatial weights. Hazard change was calculated by comparing current and forecast climate-risk scores across all hazards and buffer distances. Transport layers, including local road networks, strategic roads, train stations, bus/coach stations and the rail network, were intersected with vulnerability hotspots to identify where high-risk infrastructure overlaps with sensitive communities. An economic importance index was developed using economic activity, employment, GVA and travel-to-work flows.

Key Findings

Climate-hazard trends show clear shifts: cold-related risks decrease across much of the region, while heat, extreme weather, drought and flooding increase, with flood and coastal erosion rising sharply but locally. Although the equal-weighted composite vulnerability shows a small overall decline, this largely reflects a reduction in cold risk. When examined by individual hazard, new pockets of higher risk emerge, particularly for heat and flooding, highlighting the importance of analysing hazards

separately rather than relying solely on composite scores.

Vulnerability is strongly clustered in space. Moran's I values range from 0.67 to 0.82 across all variants and spatial weight definitions, indicating consistent spatial patterns. Hotspots appear in major urban areas, particularly West Yorkshire (Leeds and Bradford), and in several coastal communities. Equal-weighted vulnerability shows slightly stronger clustering than PCA-weighted vulnerability.

Socio-economic sensitivity is driven primarily by demographic structure. Vulnerability hotspots have substantially older populations compared with the rest of the region, while IMD and income differ only marginally. This suggests that demographic composition, rather than deprivation, is the main factor shaping sensitivity to transport disruption.

Economic importance and vulnerability are only weakly related ($r \approx 0.15-0.17$). Economically significant routes are not systematically more vulnerable. However, nodal transport infrastructure (train stations, bus/coach stops, and the strategic (NoHAM) road network) overlaps with vulnerability hotspots substantially more than the general local road network, indicating that resilience investment may be most effective when focused on key interchange points and strategic roads rather than spread uniformly across all roads.

Value of the research

This project provides a robust, scalable framework for assessing climate-related transport vulnerability across the North of England. By integrating hazard exposure, socio-economic sensitivity and economic importance, it identifies communities where climate-related disruption may have the greatest social impact. The findings highlight the role of demographic structure in shaping vulnerability, the presence of strong spatial clustering and the importance of focusing resilience investment on critical transport nodes. The methodology is reproducible and adaptable, supporting TfN's long-term planning and future climate-risk assessments.

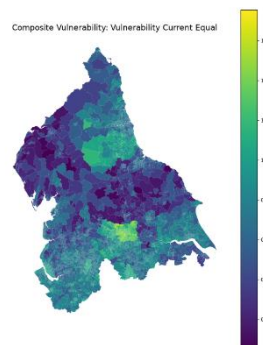


Figure 1: Composite Vulnerability Map (current, equal). The highest vulnerability is concentrated in West Yorkshire and coastal communities.

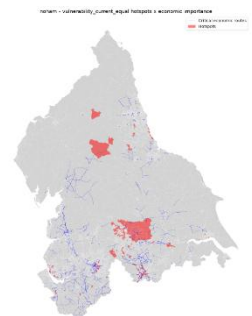


Figure 2: Transport Overlay Map (NoHAM x Hotspots). Critical NoHAM routes intersect vulnerability hotspots, highlighting where climate-related disruption may have the greatest transport impact.