

Accessibility, Capability Loss, and Territorial Resilience: Evidence from the Central Italy Earthquakes

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Natural hazards are exogenous events, but disasters are socially and politically produced phenomena, as a hazard becomes a disaster when pre-existing vulnerabilities amplify its impacts (Cutter, 2021; Wisner et al., 2003). Critical infrastructures, including transport networks and service facilities such as hospitals and schools, underpin essential services, and their accessibility shapes individual and community capabilities (Smith et al., 2012). When disrupted, they isolate homes, workplaces, hospitals, and other key destinations, disproportionately affecting already vulnerable populations and reinforcing existing inequalities (Anderson et al., 2022). Infrastructures are key mechanisms through which unequal life chances are reproduced across space (Graham & Marvin, 2001; Sawyer et al., 2021; Deitz & Meehan, 2019). From this perspective, disruptions do not merely damage assets; they reconfigure who can reach and effectively use essential services, and they often amplify existing inequalities. Bringing these insights together, a capability-based approach to resilience treats critical infrastructures as spatial resources whose contribution to resilience depends on the conversion environments through which different people can translate service provision into real freedoms.

Amartya Sen's famine research remains an important precursor to capability-based resilience thinking because it demonstrates that extreme deprivation is often produced by social and institutional conditions rather than by absolute scarcity (Sen, 1977). Challenging the food availability decline thesis, Sen argued that starvation typically occurs not because food is absent, but because people lack the entitlements necessary to command food through legal, economic, or social means, even when sufficient food exists within a country (Sen, 1977, 1981). This entitlement-based perspective foregrounds ethical and political questions that are obscured when disasters are treated as purely natural events, highlighting how poverty, vulnerability, and unequal ownership structures shape exposure to crisis. Building on Capability Approach, this study reconceptualizes resilience not as system recovery, but as the preservation of substantive freedoms.

Recent studies have begun to operationalize this perspective, particularly in transport and accessibility research. Sangeeta et al., (2025) for example, develop a capability-based framework for assessing transport network resilience under flood scenarios by linking accessibility loss to socio-economic vulnerability, demonstrating that resilience losses are spatially uneven and intensify under future climate scenarios. Sarma et al., (2025) synthesize capability-oriented approaches in wellbeing-focused transport assessment and emphasize that transport systems matter because they expand freedoms and opportunities rather than merely provide functional connectivity; in this view, conversion factors such as health, safety, social inclusion, and accessibility shape how transport resources translate into wellbeing outcomes. Similarly, Boakye et al., (2022) examine how disruptions to transportation infrastructure during hazards translate into losses of essential capabilities such as mobility, health, and shelter.

However, much of the disaster resilience literature continues to evaluate infrastructures primarily in terms of system performance, robustness, and recovery speed (Meerow et al., 2016; Ouyang, 2014). Infrastructure resilience frameworks often conceptualize "capabilities" as organizational or

technical capacities of systems rather than as the substantive freedoms of people affected by disruption (Linkov et al., 2022). This framing tends to treat users as passive demand and disruption as a temporary deviation from normality, overlooking how unequal baseline conditions shape who can convert infrastructure services into meaningful opportunities. As a result, resilience assessments may identify a network as “recovered” even while some groups remain effectively excluded from healthcare, education, employment, and administrative services due to persistent accessibility constraints. Accordingly, we ask: To what extent do disaster-induced disruptions to critical infrastructure translate into accessibility-mediated capability loss, and how does this capability loss help explain uneven post-disaster depopulation?

Empirically, the study focuses on the 2016-2017 Central Italy earthquake sequence, which affected four regions characterized by inner, mountainous areas with historically low service provision and accessibility. The earthquakes led to significant and lasting depopulation, particularly among working-age populations, intensifying territorial inequalities (Dottori, 2024). These conditions make the case particularly suitable for examining accessibility-mediated capability loss. Using post-earthquake building-level survey data from the Italian Civil Protection Department (DaDo database), Copernicus Emergency Management Service (EMS) damage grading maps (European Union, 2016), and using mobility data, we model earthquake-induced disruptions to critical infrastructure. Accessibility to essential services is computed before and after the earthquakes. The resulting accessibility decline is calculated as the increase in network travel time caused by infrastructure damage and road disruptions. This change is combined with a social vulnerability index to operationalize capability loss as the interaction between pre-existing vulnerability and accessibility reduction. We then examine the relationship between estimated capability loss and subsequent depopulation patterns.

We expect to find that (i) capability loss concentrates in already peripheral locations where modest network disruptions produce large increases in travel time (because of limited route redundancy), (ii) the strongest depopulation occurs not simply where physical damage is greatest, but where accessibility losses compound existing vulnerability (older populations, lower incomes, limited car access, fewer local services), and (iii) capability loss provides additional explanatory power beyond damage intensity alone in predicting which communities experience lasting population decline; especially among working-age residents who are most sensitive to constraints on employment access, schooling, childcare, and healthcare.

By linking infrastructure disruption, changes in network-based accessibility, and following demographic dynamics, the study contributes to regional science debates on uneven development and territorial resilience. It shows how disasters do not only damage physical assets, but reshape the spatial distribution of opportunities by altering access to essential services. Rather than conceptualizing resilience as the technical recovery of infrastructure systems, the paper advances a capability-based measure of territorial resilience grounded in differentiated access to healthcare, education, and other critical facilities. This approach makes it possible to assess how infrastructure shocks interact with pre-existing social vulnerability and to identify which territories retain meaningful opportunities and which experience a cumulative loss of capabilities. In doing so, the study provides a spatially explicit framework for understanding how disasters can reinforce or deepen regional inequalities over time.

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