RESEARCH BRIEF

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Stanford WOODS INSTITUTE for the ENVIRONMENT

Urban Traffic Resilience and Coastal Flooding

Disruptions from sea level rise and coastal flooding events have significant indirect impacts on urban traffic networks.

Background

Almost half of the world's population currently lives in cities and that number is projected to rise significantly in the near future. This rapid urbanization is contributing to increased flood risk due to the growing concentration of people and resources in cities and the clustering of cities along coastlines. These urban shifts also result in more complex and interconnected systems on which people depend such as transportation networks. Disruptions to urban traffic networks from flooding or other natural disasters can have serious socioeconomic consequences. In fact, what are defined as indirect impacts from these types of events, such as commute-related employee absences and travel time delays, could ultimately outweigh the more direct physical damages to roads and infrastructure caused by severe flooding.

The Intergovernmental Panel on Climate Change has recognized the growing importance of indirect impacts when evaluating natural hazards and the challenges faced in quantifying them due to variable socioeconomic factors, cultural contexts, and uncertainties around human behaviors. This brief is based on Stanford research which examined traffic networks in the San Francisco Bay Area (SF Bay Area) as a case study to quantify the indirect impacts of sea level rise and intensifying coastal flood events on urban systems.

POINTS FOR POLICY MAKERS

▶ **Flood-related travel time delays extend far beyond the areas of inundation.** While the physical damage to buildings and infrastructure is constrained to the areas of inundation, travel time delays propagate through the road network and extend far inland to cities such as Santa Rosa, which would unlikely see any coastal flood waters on roads. The extensive nature of flood-related traffic disruption also highlights the need for a coordinated regional response to coastal flooding and sea level rise.

▶ **Sprawl and pre-existing vulnerabilities in the traffic system may exacerbate flood-related travel time delays.** The rise in housing prices near urban centers and the availability of highways have contributed to an increase in urban sprawl and have resulted in heavy congestion and long travel times on major traffic routes. Potential flooding of routes near the SF Bay shoreline may amplify this issue, particularly travel from regions with lower housing prices to more expensive urban centers offering greater employment.

▶ **The characteristics of a traffic system, i.e. the availability of alternate routes, can play a larger role in the magnitude of indirect impacts from flooding and hazards than the exposure to the hazard itself.** Communities that lack sufficient alternate routes to offset road closures, even with overall low coastal flood risk, are potentially more vulnerable to delays than those with higher risk factors but more efficient local road networks. Although flood maps indicate that Sonoma County will experience relatively low levels of flooding over the next few decades, the lack of sufficient alternate routes will result in high travel time delays throughout the region.

▶ **Integrating a traffic model with flood maps can help planners to quantify how flood exposure, regional commute patterns, and characteristics of the road network affect traffic resilience**. Increasing resilience – or the ability of the traffic system to mitigate travel time delays resulting from road closures – will be necessary to avoid cascading socioeconomic consequences likely to be worsened by sea level rise.

Similar to many other regions across the country, the SF Bay Area has dense urban development concentrated along its coastline and heavily congested traffic grids. Currently, even relatively minor instances of coastal flooding have the potential to inundate major traffic corridors and increase already lengthy commute times. For coastal flooding events, two types of traffic disruptions were identified: *impassable commutes* where the origin, destination or critical road connections are flooded and impede driving; and *travel time delays* resulting from the congestion caused by commuters rerouting to avoid flooded roads. Flood-related travel time delays spread throughout the region regardless of the actual proximity to a flood zone.

In the near future, global climate change will continue to increase the likelihood of extreme coastal flooding, particularly in low-lying areas. Integrating a traffic model with flood maps can help planners to quantify how flood exposure, regional commute patterns and characteristics of the road network affect traffic resilience. Increasing resilience – or the ability of the traffic system to mitigate travel time delays resulting from road closures – will be necessary to avoid cascading socioeconomic consequences, such as loss of wages and business disruption, likely to be worsened by sea level rise.

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This brief is based on the article **"When Floods Hit the Road: Resilience to Flood-related Traffic Disruption in the San Francisco Bay Area and Beyond"** published in the journal *Science Advances*.

FOR MORE INFORMATION

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