

Coastal Flooding on Transportation Infrastructures: A Systematic Review of Patterns, Impacts, and Methodologies

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1 Background

- Critical transportation infrastructure—essential for economic activity and societal function—faces increasingly severe risks from coastal flooding intensified by sea-level rise, changing storm patterns, and coastal development.
- Although the vulnerability of these infrastructures is widely recognized, understanding their failure requires analyzing complex, systemic mechanisms.
- Despite robust research on coastal hazards, existing literature remains fragmented across disciplines, often analyzing flood drivers in isolation rather than addressing the complex, compound nature of systemic failure of transportation sector.

2 Research Objectives

- Address the critical research gap by synthesizing and structuring the rapidly expanding but fragmented field of coastal flooding impacts on transportation.
- Systematically examine the literature through four interconnected themes: hazard patterns, infrastructure vulnerability, multifaceted impacts, and assessment methodologies.
- Identify major research deficiencies to provide a foundational resource that informs more integrated and resilient transportation planning.

3.1 Methodology

- The review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
- A comprehensive search was conducted across Google Scholar, Web of Science, and Scopus, targeting English-language publications from 2000 to 2025.
- Screened 3,073 records down to 83 distinct studies via a multi-stage consensus process.
- Synthesized findings via a framework linking flood drivers directly to infrastructure vulnerability, impacts, and methodologies.

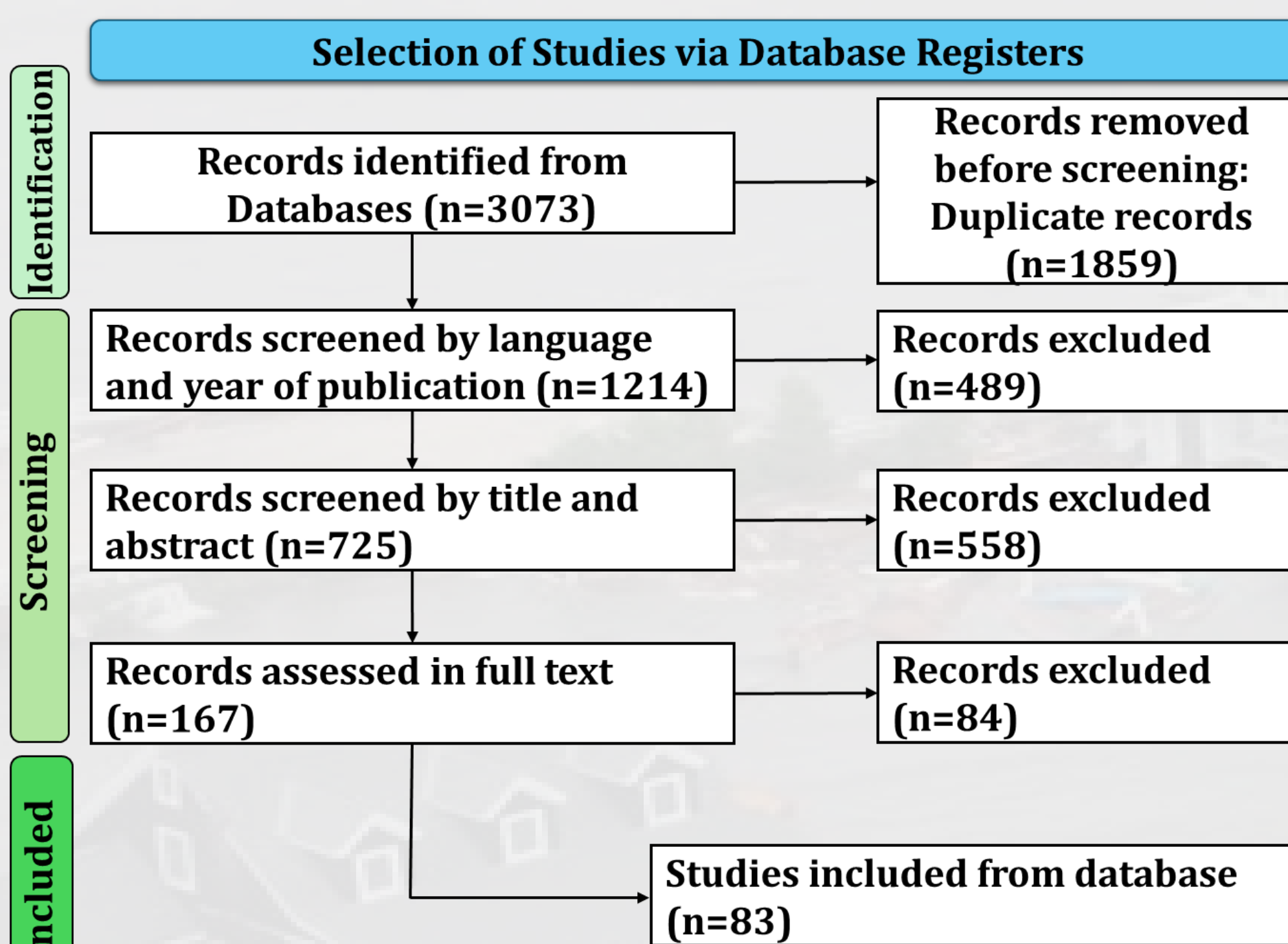


Figure 1. Flow Chart of the Selection Process

Table 1: Search Keywords

Search Concept	Keywords
Hazard	"Coastal flood*", "Urban flood*", "Climate change", "Sea level rise", "Extreme Rainfall"
Infra-structure	"Transportation", "Transport infrastructure", "Road*", "Rail*", "Port*", "Airport**"
Impact	"Vulnerability", "Impact", "Risk"
Logic	(Concept 1) AND/OR (Concept 2) AND/OR (Concept 3)

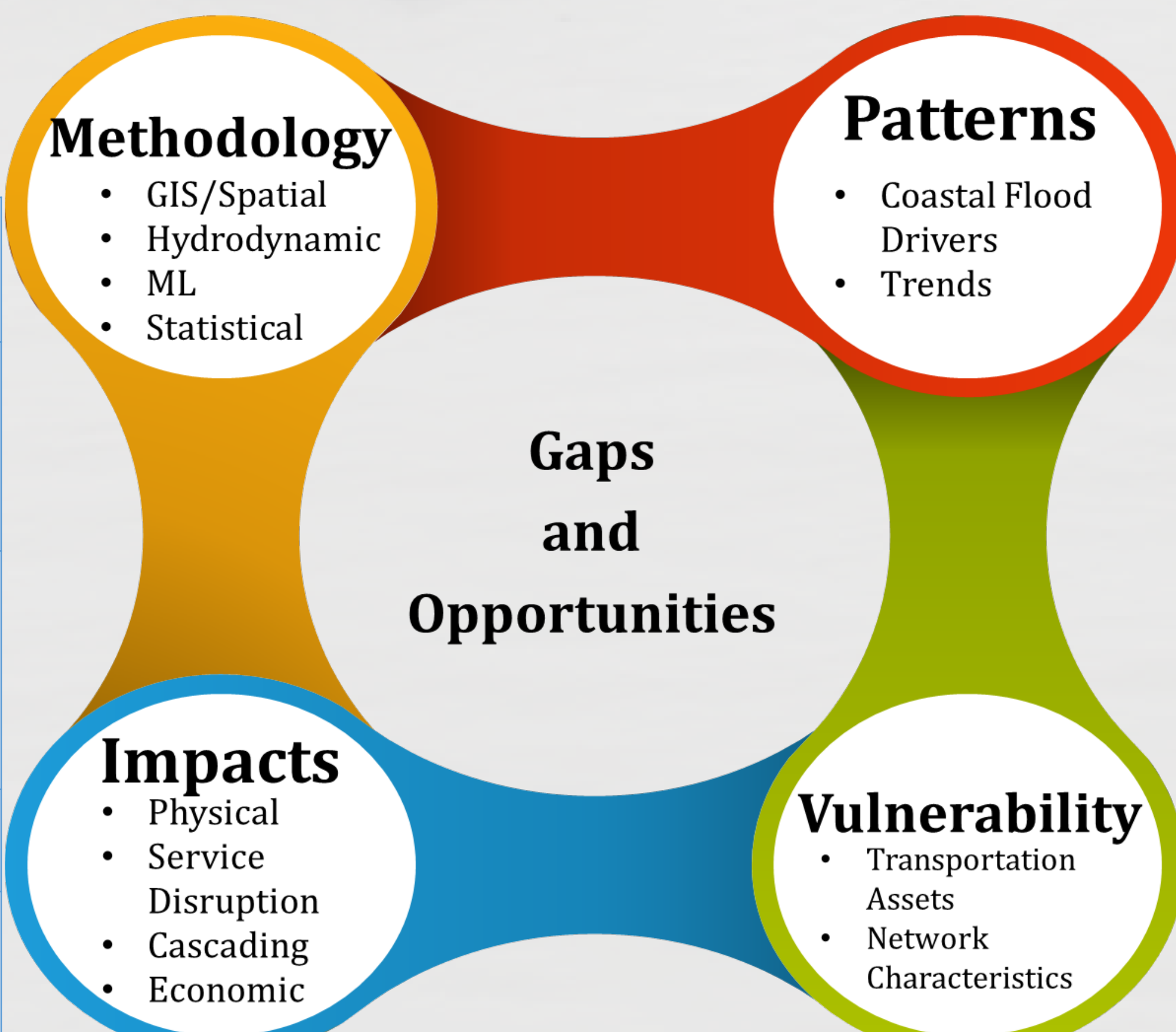


Figure 2. Conceptual Framework Demonstrating the Five Components of the Study

3.2 Bibliometric Analysis

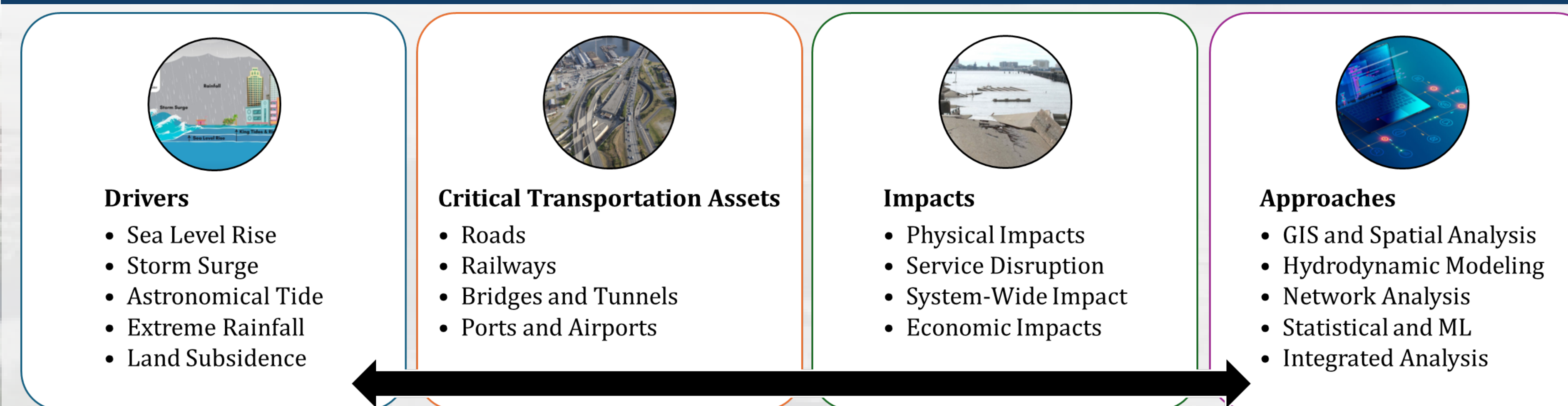


Figure 3. Overview of the Study

- Compound Shift:** Post-2015 connection densification reflects a paradigm shift from single-driver assessments to complex Compound Hazard analysis.
- Modal Bias:** Literature is overwhelmingly road-centric, leaving critical nodes like Ports, Airports, and Rail fragmented and underrepresented.
- Dominant Drivers:** "Storm Surge" and "Tidal" remain central hubs, though "Compound" drivers have gained significant linkage strength.
- Methodological Anchor:** "GIS/Spatial" analysis serves as the primary vulnerability assessment tool, bridging diverse flood drivers and infrastructure assets.
- Emerging Techniques:** Machine Learning (ML) node indicate a growing evolution toward data-driven, non-deterministic risk assessment frameworks.

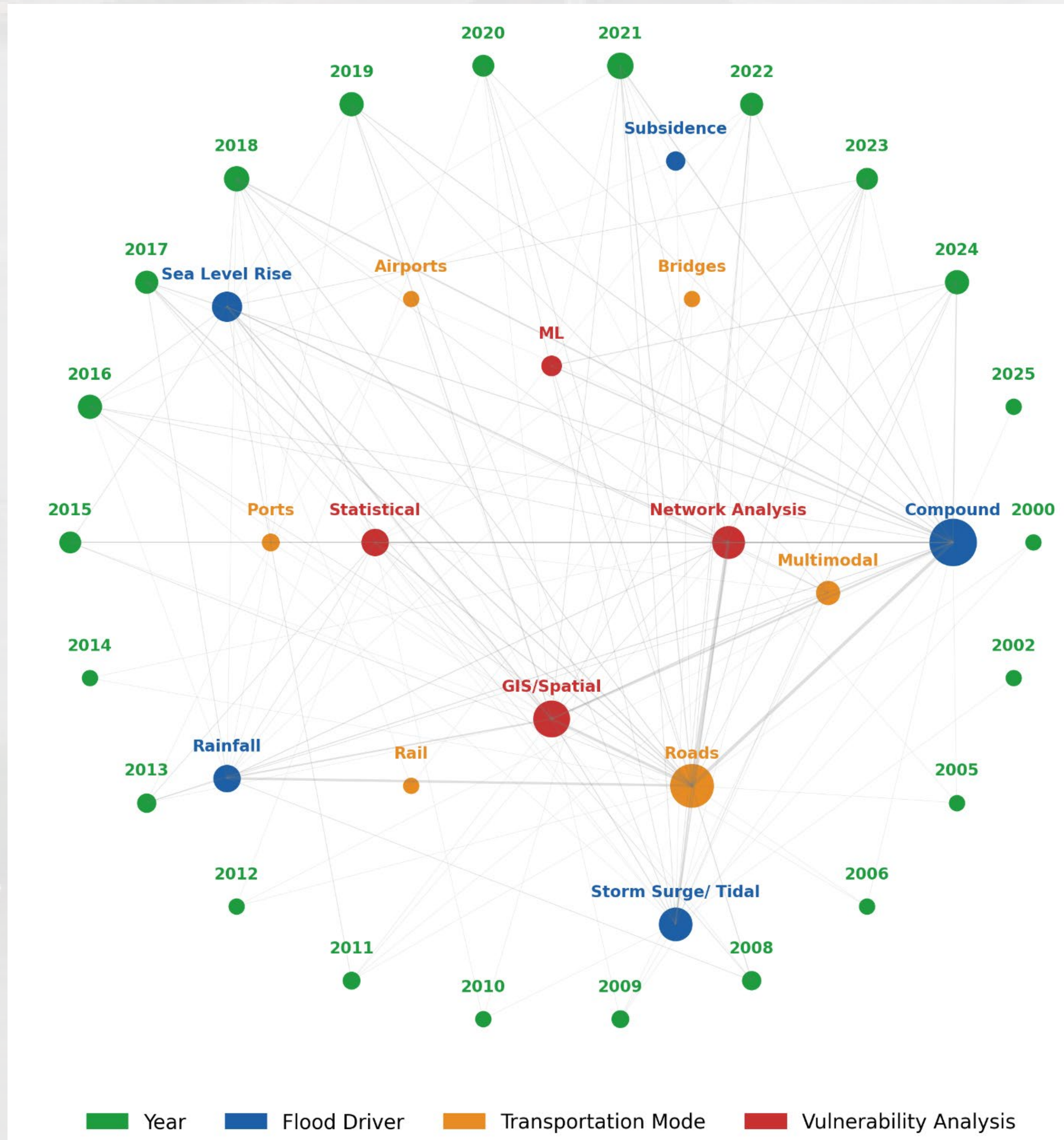
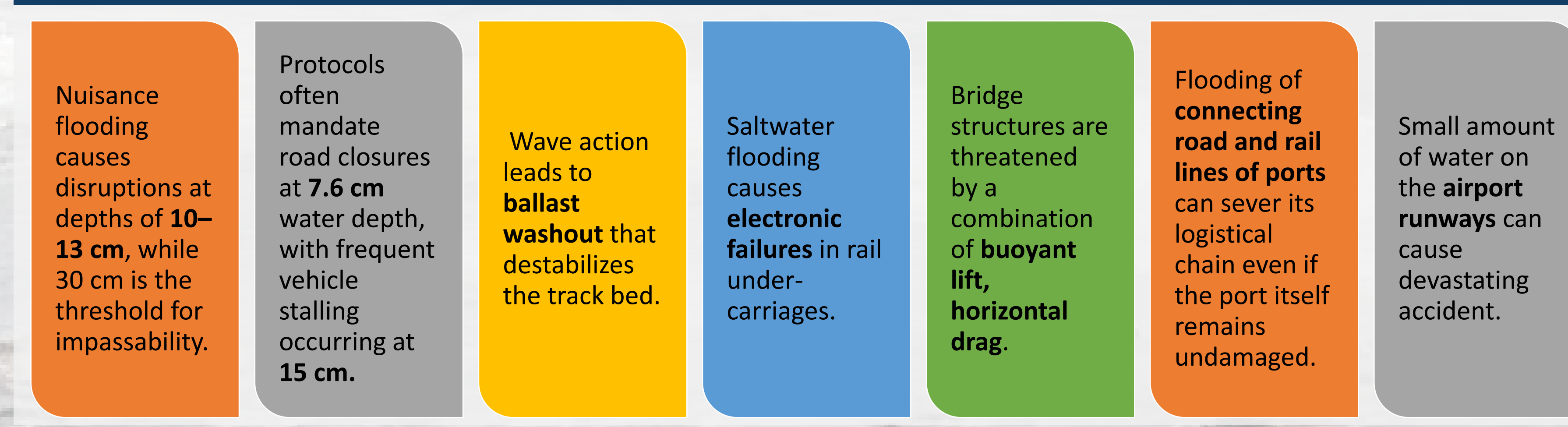


Figure 4. Network Diagram Showing the Interconnectivity among Publication Year, Flood Driver, Transportation Mode, and Vulnerability Analysis

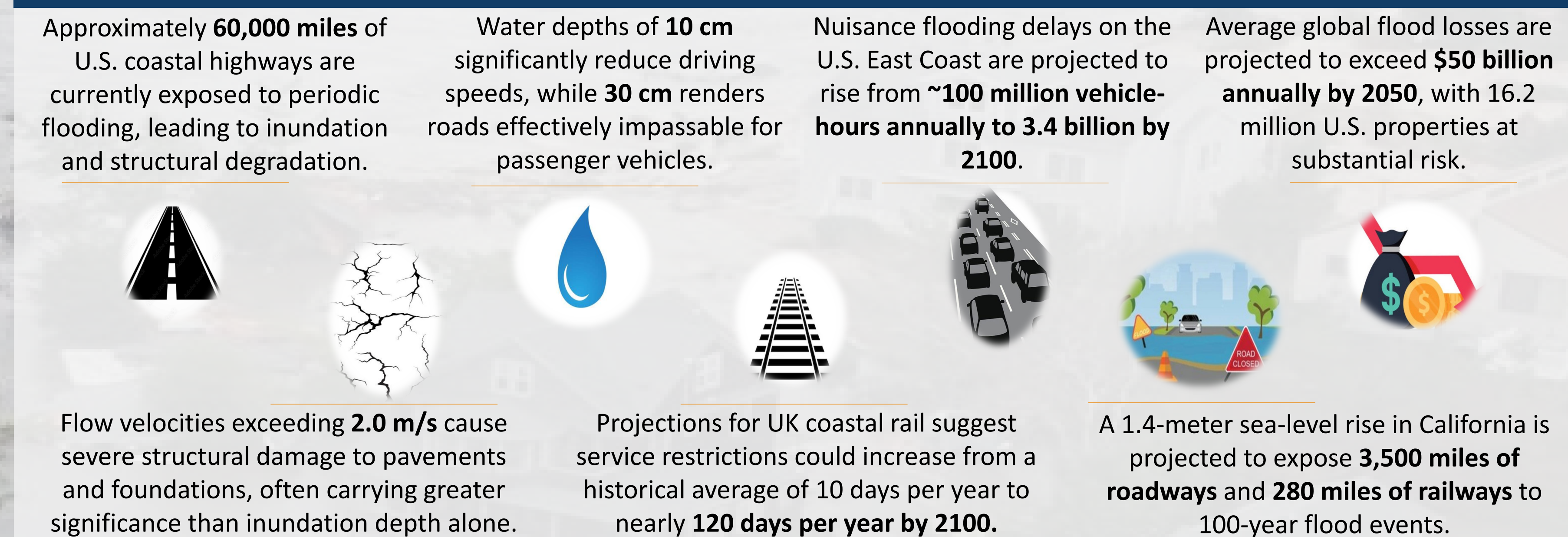
4.1 Patterns of Coastal Flooding Hazards

- Coastal flood risk is shifting from isolated incidents to "compound events" driven by synergistic oceanic, atmospheric, and hydrological interactions.
- Global Mean Sea Level rise increased from 1.2–1.9 mm/yr (historical) to ~3.3 mm/yr today, potentially reaching 16 mm/yr by 2100.
- Land subsidence accelerates Relative Sea Level Rise up to 10x, exposing 15.6 million people to 0.5m of sinking.
- Current 100-year floods are projected to become annual or decadal events by 2050 at most global tide gauges.
- High-tide flooding is projected to occur nearly daily along the U.S. East Coast by the 2060s.


4.2 Vulnerability and Exposure of Transportation Infrastructure



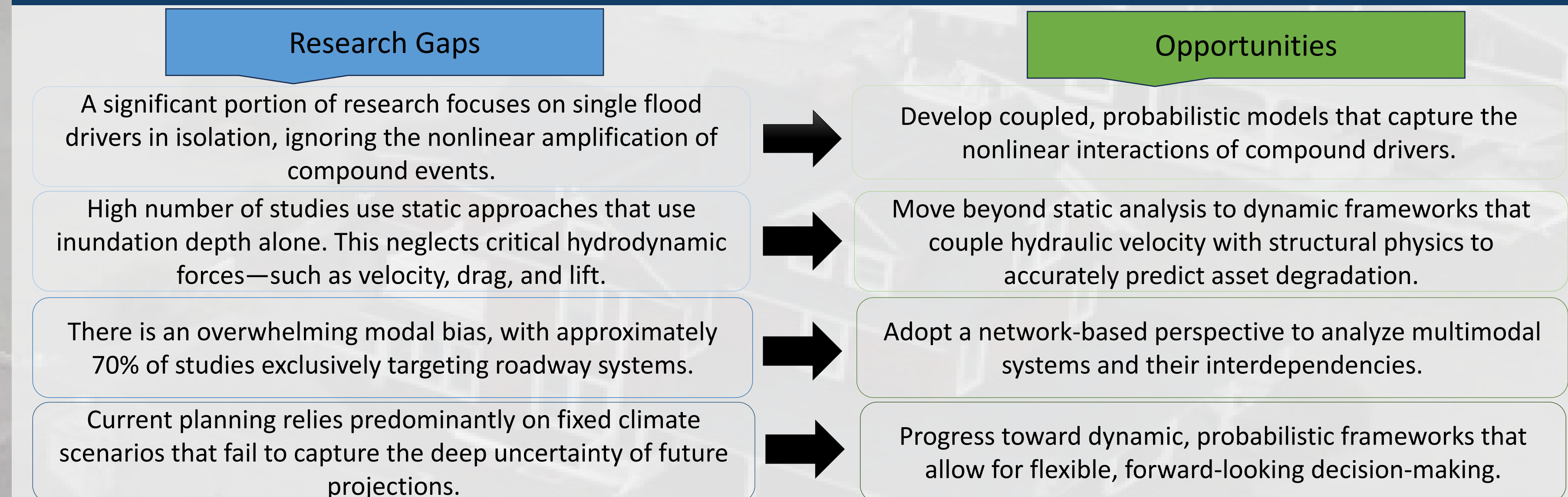
4.3 Impacts of Coastal Flooding on Transportation Systems



4.4 Approaches for Assessing Coastal Flood Risk

Methodology	Description	References
GIS & Spatial Analysis	Overlays flood hazard layers with asset inventories to identify "at-risk" infrastructure. Uses Multi-Criteria Decision Analysis (MCDA) to weight vulnerability factors.	Scan Here 
Hydrologic & Hydrodynamic	Solves shallow water equations to simulate flood depth, velocity, and duration. Progressed from static 1D to coupled 1D-2D models.	
Network & Accessibility	Quantifies functional degradation. Uses graph theory to measure reduced mobility, lost trips, and critical node failure.	
Statistical & Machine Learning	Manages deep uncertainty and compound driver dependence. Uses ML for rapid hazard mapping in data-scarce regions.	
Integrated Frameworks	Couple multiple approaches to capture cascading failures across sectors.	

5 Research Gaps and Opportunities



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