

# ENHANCING TRANSPORT RESILIENCE THROUGH ANALYTICAL FRAMEWORKS

**Dr. Jasper Verschuur, Delft University of Technology**

Date: 15-04-2025



On behalf of:

# Background

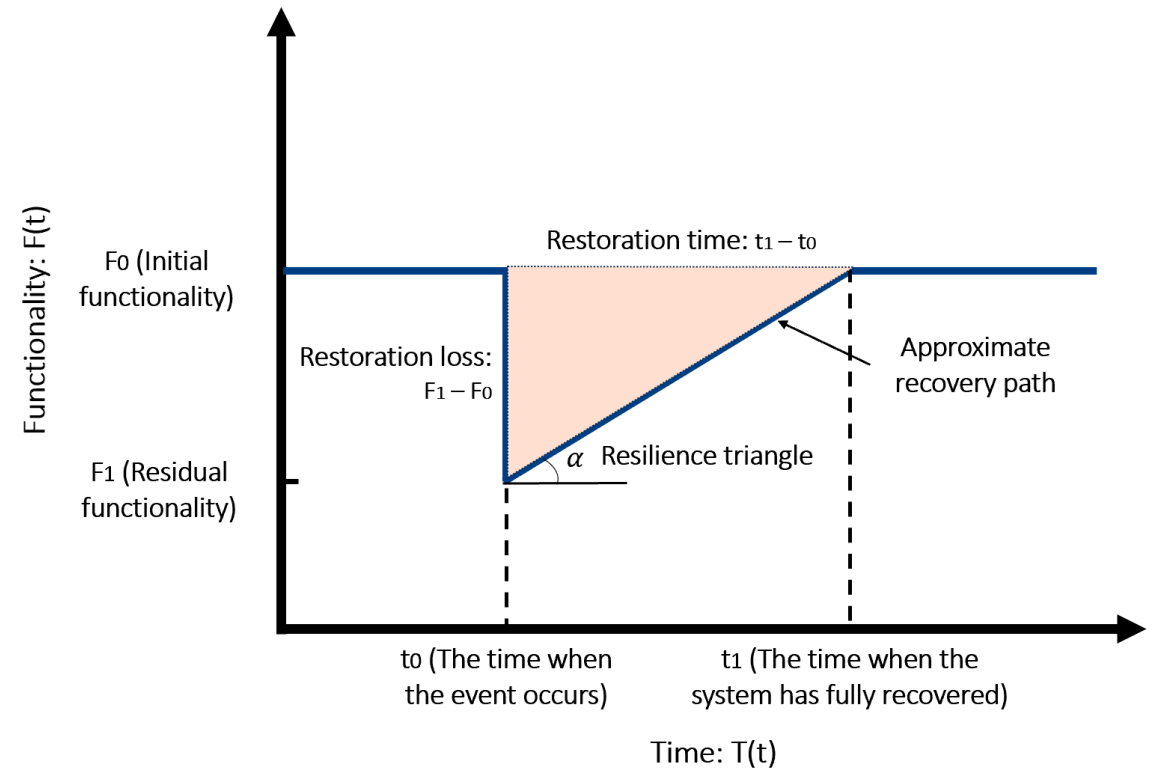
1. **Transport Resilience: “the ability to cope with, recover from, and adapt to external shocks and stressor to the transport system”**

2. **4R framework of Bruneau et al. (2003):**

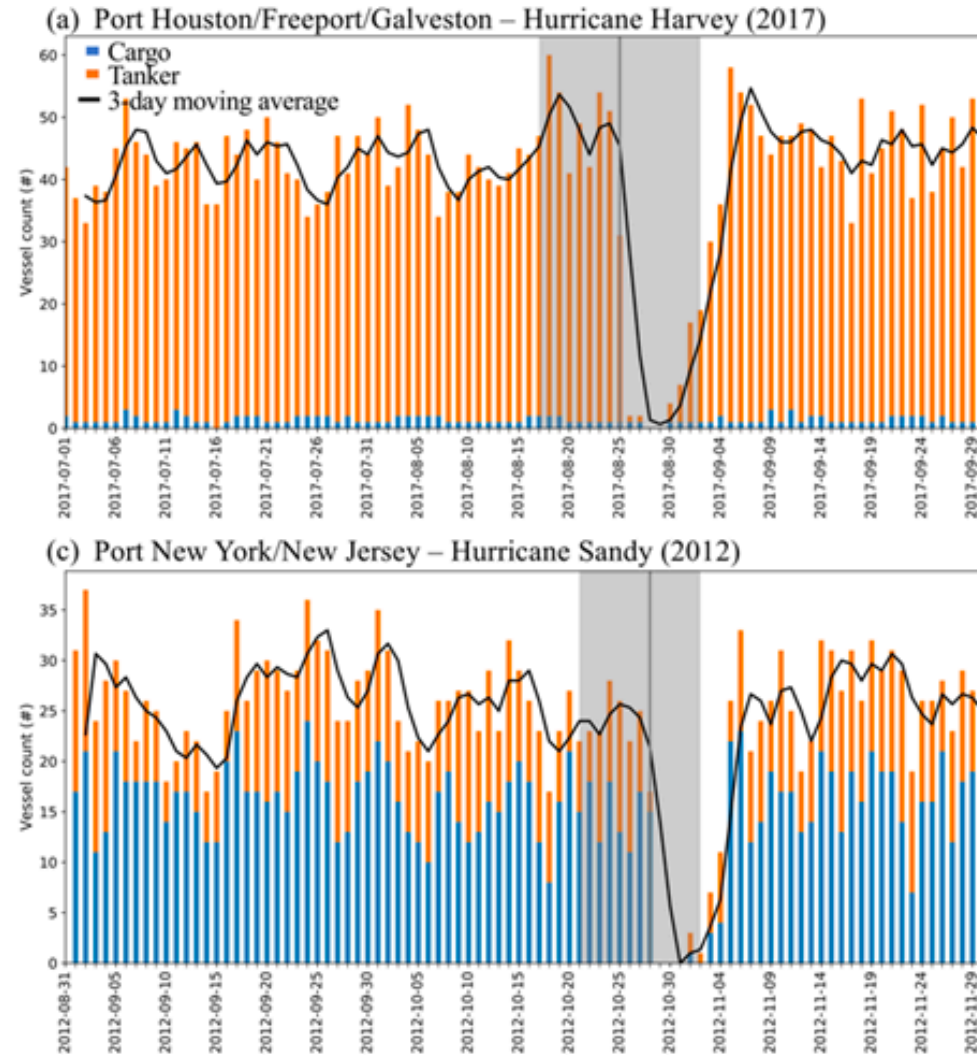
- Robustness (absorptive capacity)
- Redundancy (degree of substitutability)
- Resourcefulness (availability of materials, workers, resources)
- Rapidity (speed of recovery)

3. **‘Resilience triangle’**

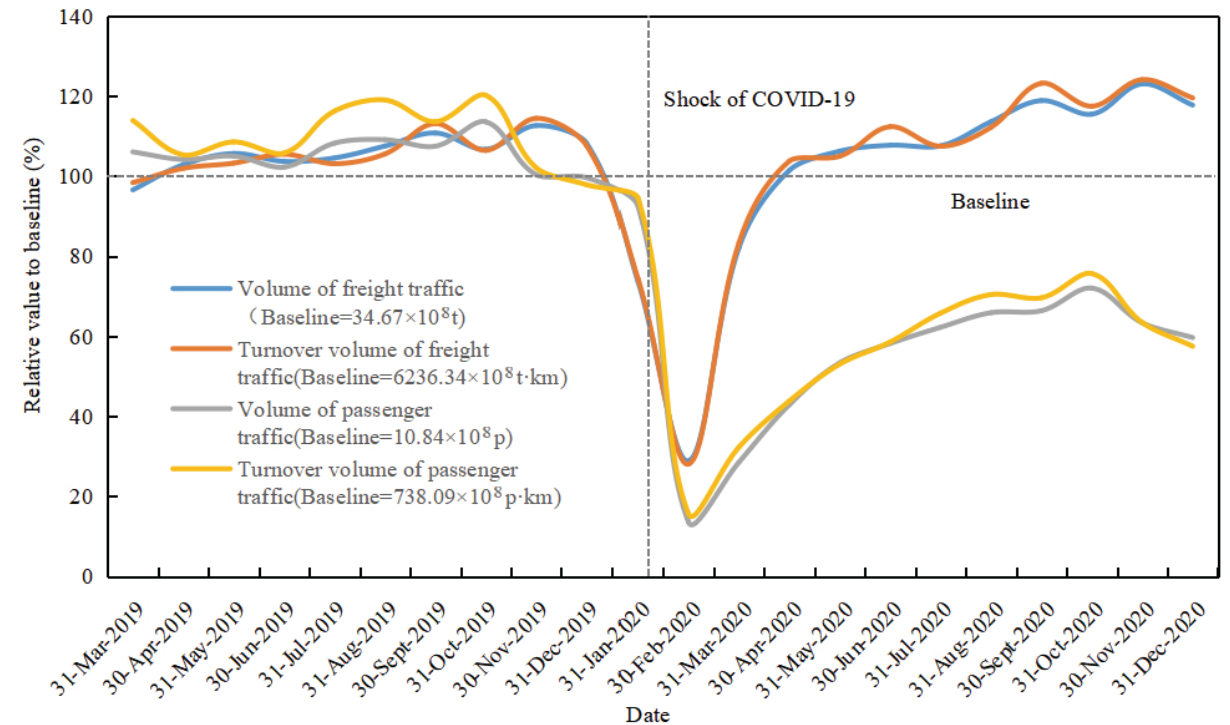
4. **Interactions of physical infrastructure and networks, logistics, and organisations**



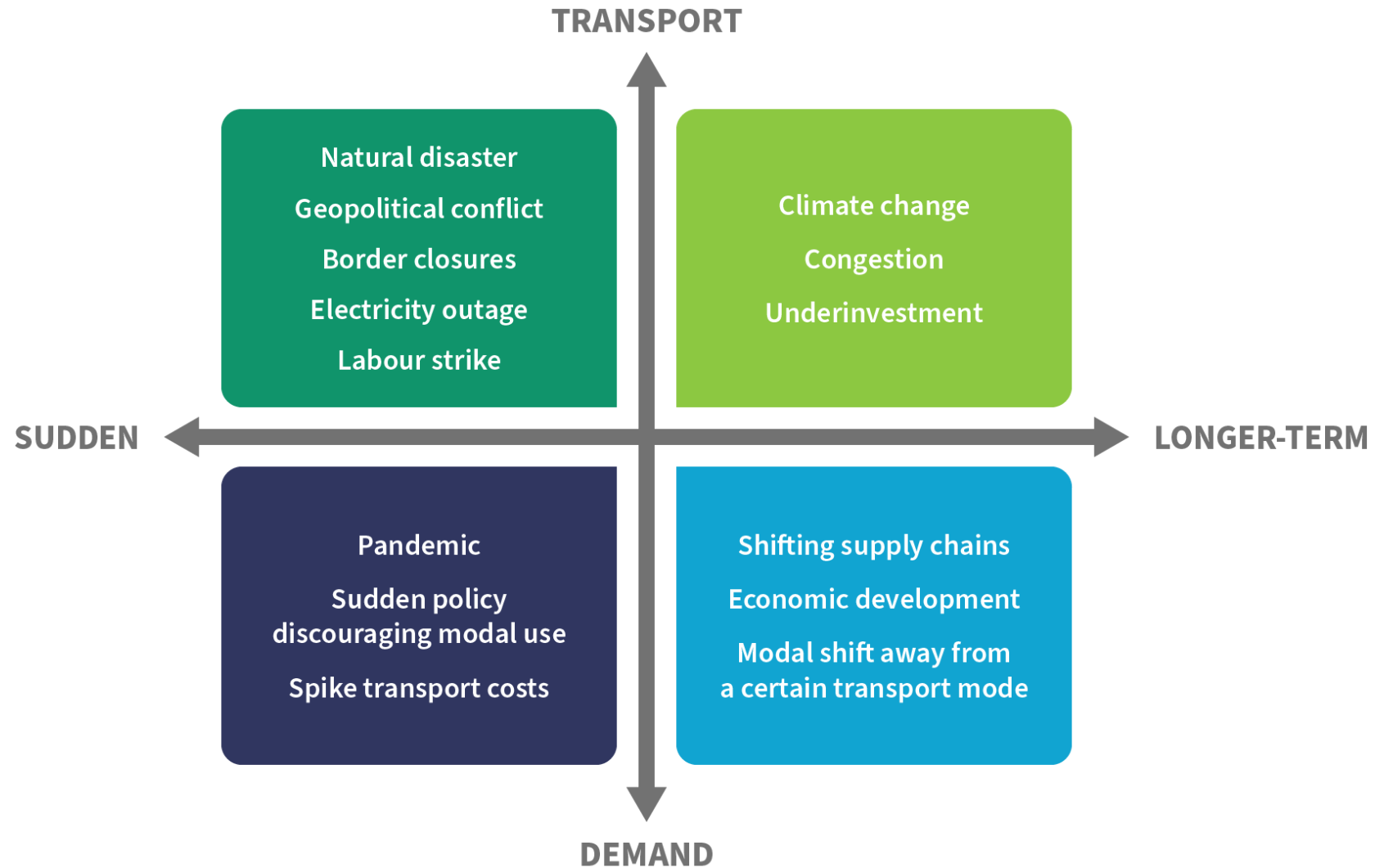
# Resilience in practice



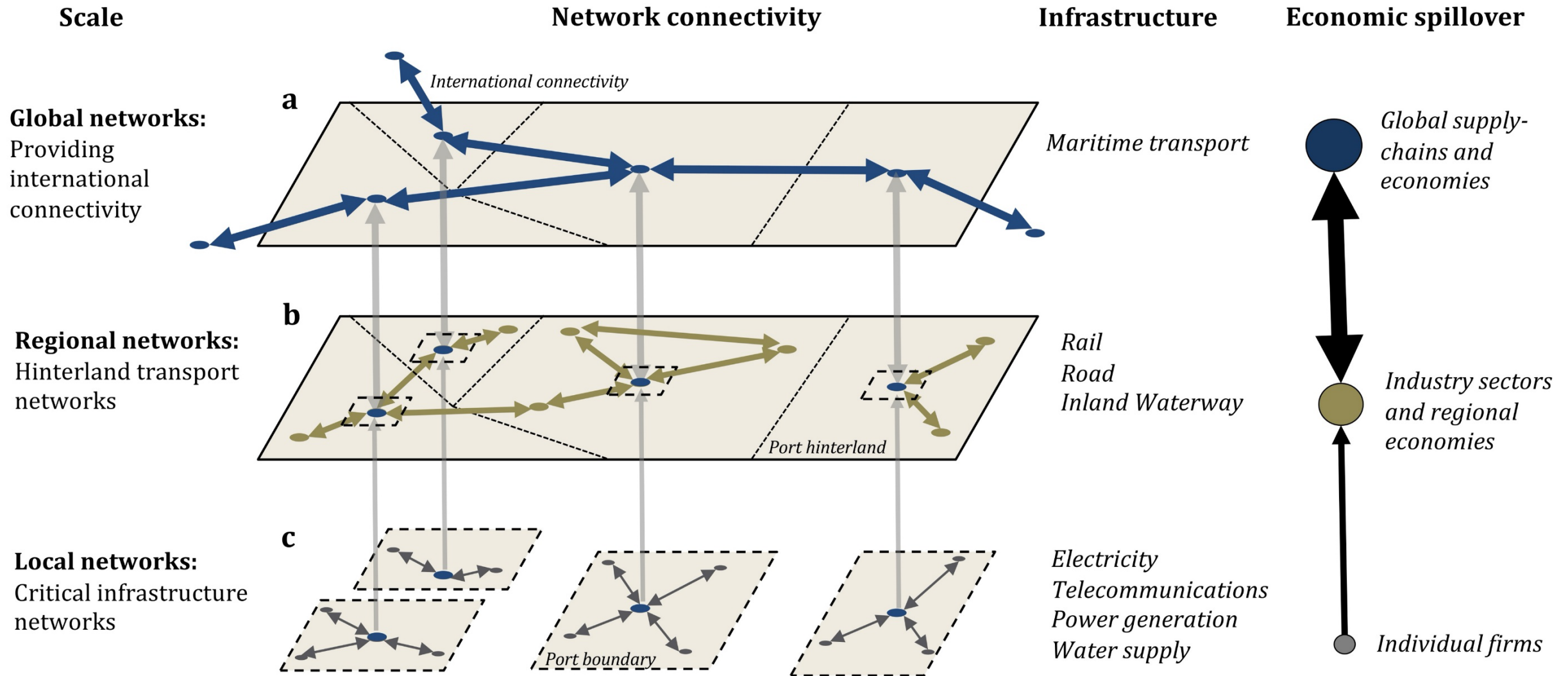
## Resilience curves road transport China during COVID-19



# Resilient to what?

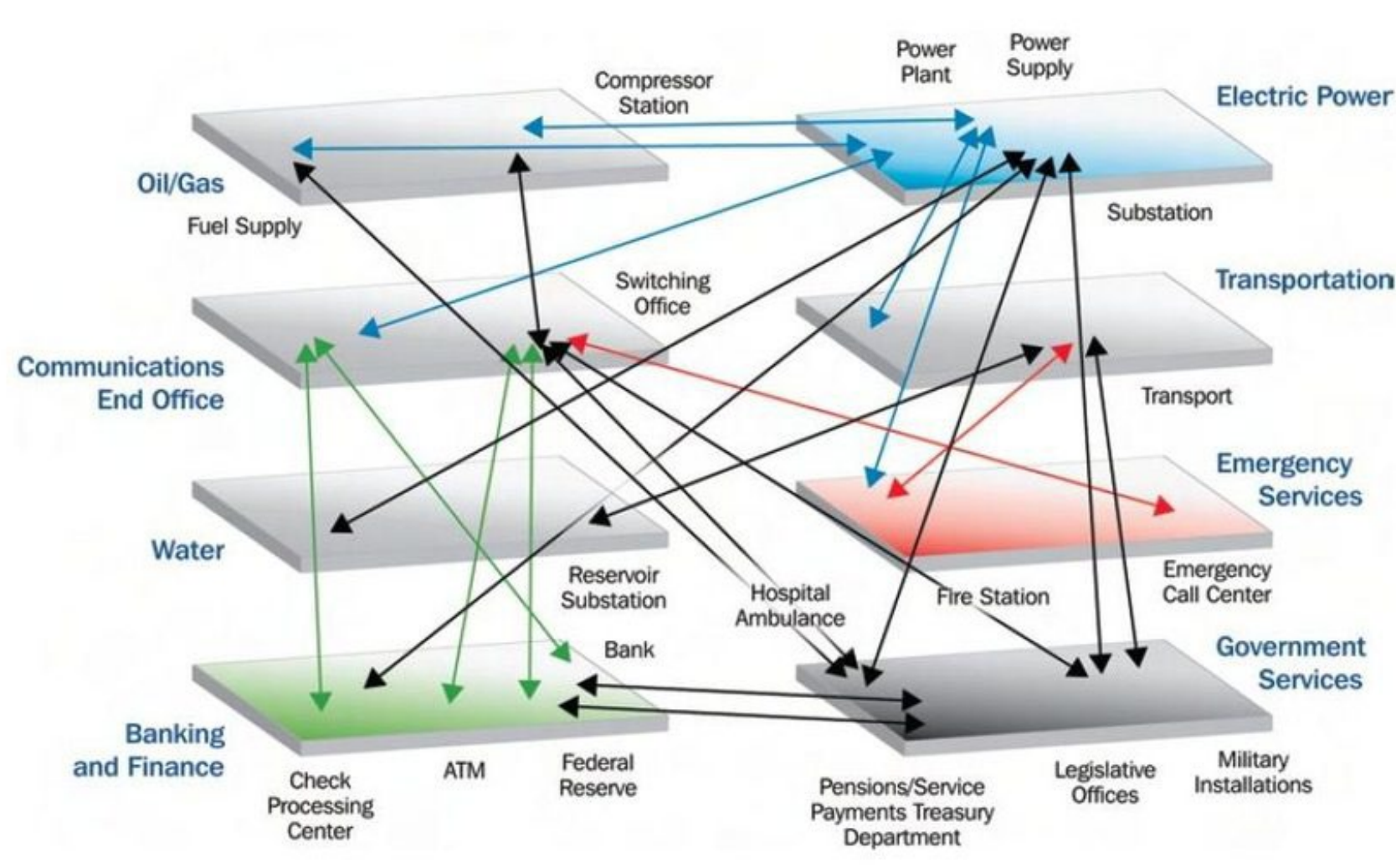


# Resilience across different scales

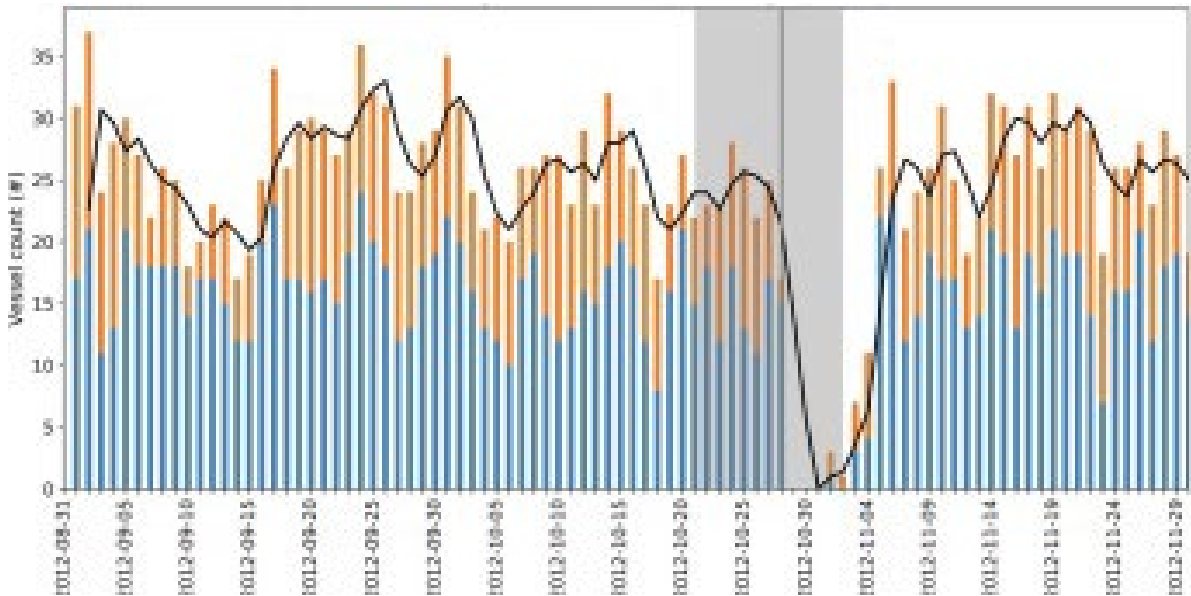




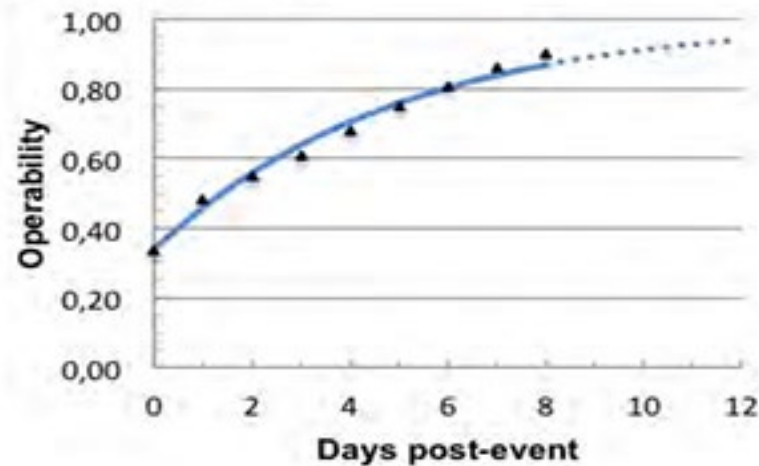
# Local critical infrastructure



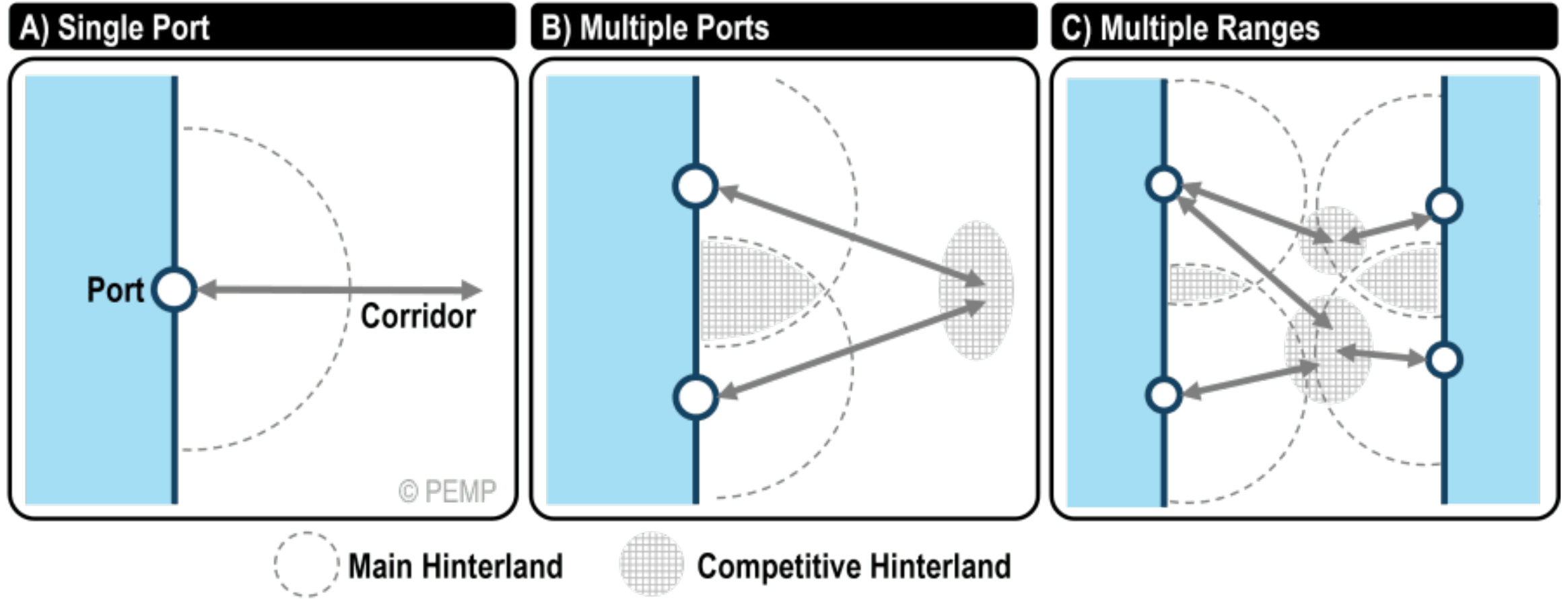
# Example Hurricane Sandy (2012)



**Power recovery**  
State of New Jersey



# Regional transport corridors

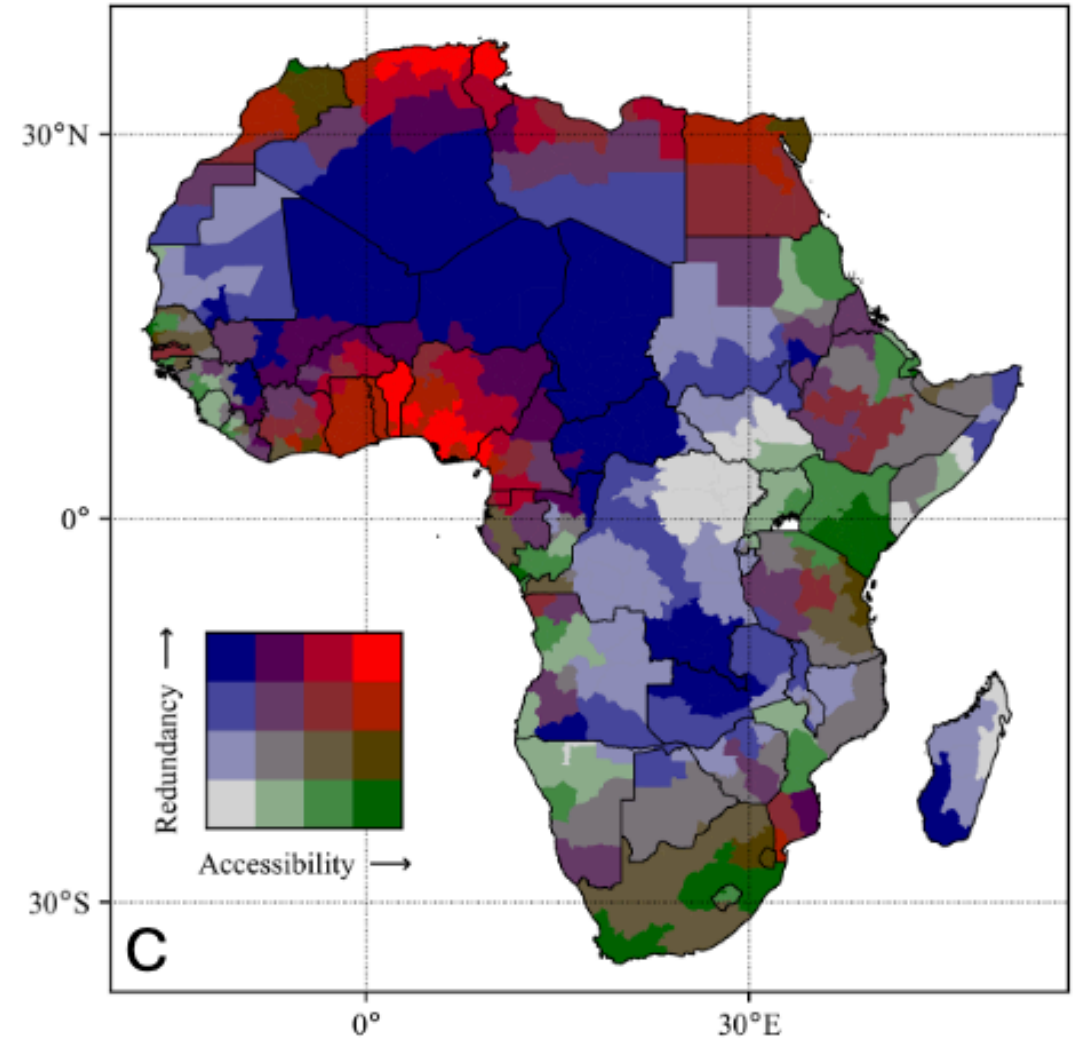
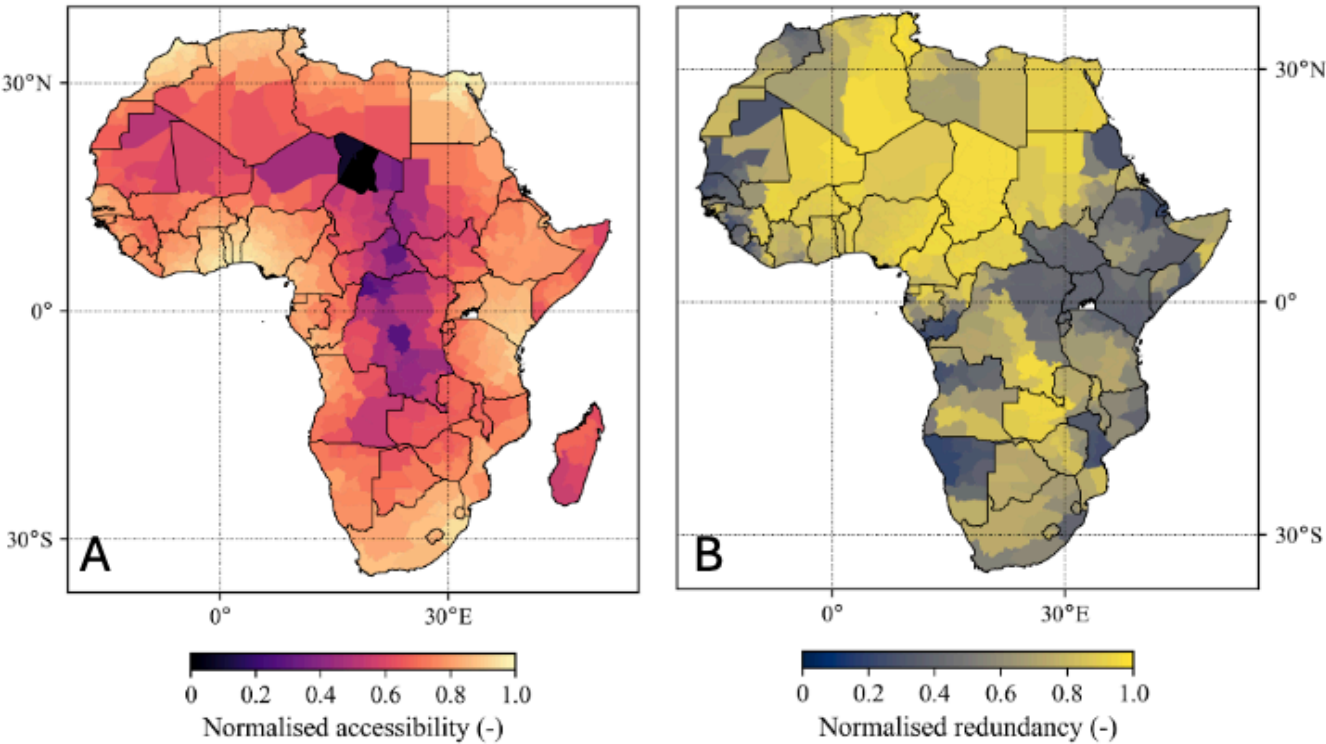


Source: Notteboom, Pallis and Rodrigue (2022)



# Example port-hinterland corridors Africa

Accessibility and redundancy of African **container** ports



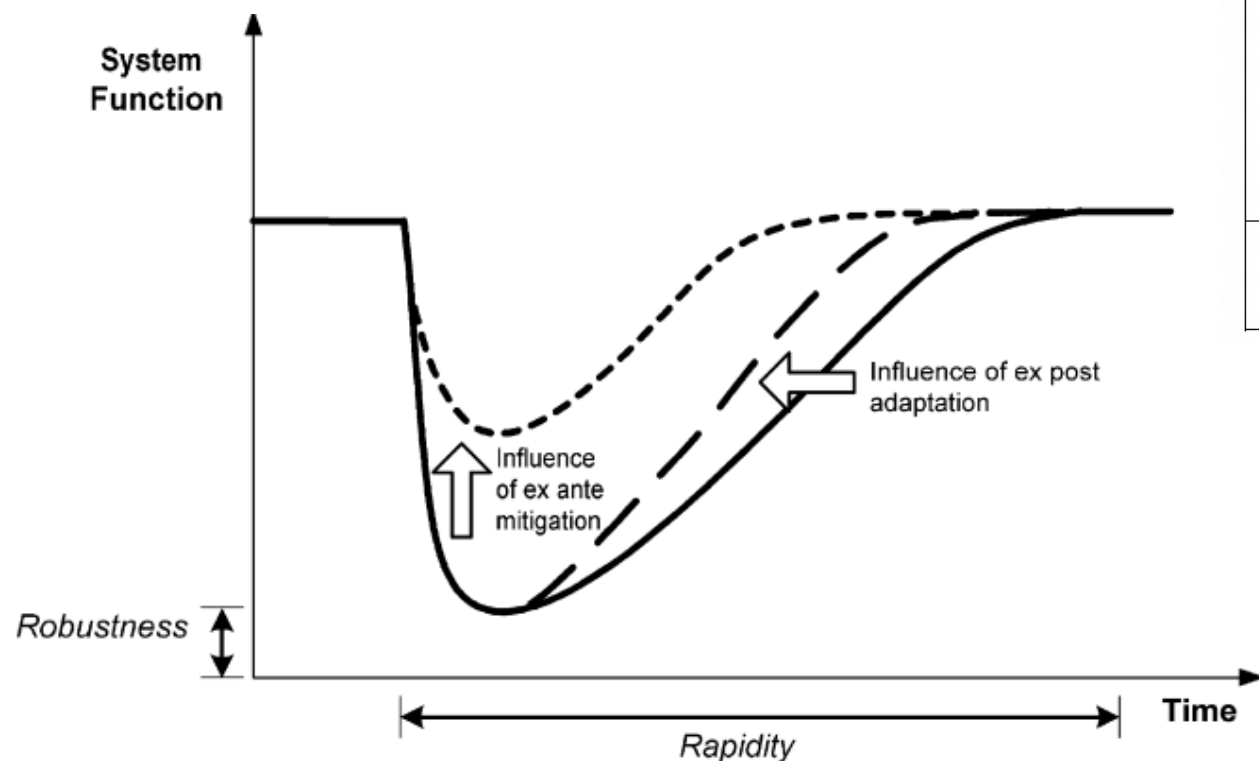
Source: Verschuur and Tavasszy (under review)

# IMPROVING THE RESILIENCE OF FREIGHT TRANSPORT



# Variety of strategies to improve resilience

Source: McDaniels et al. (2008)

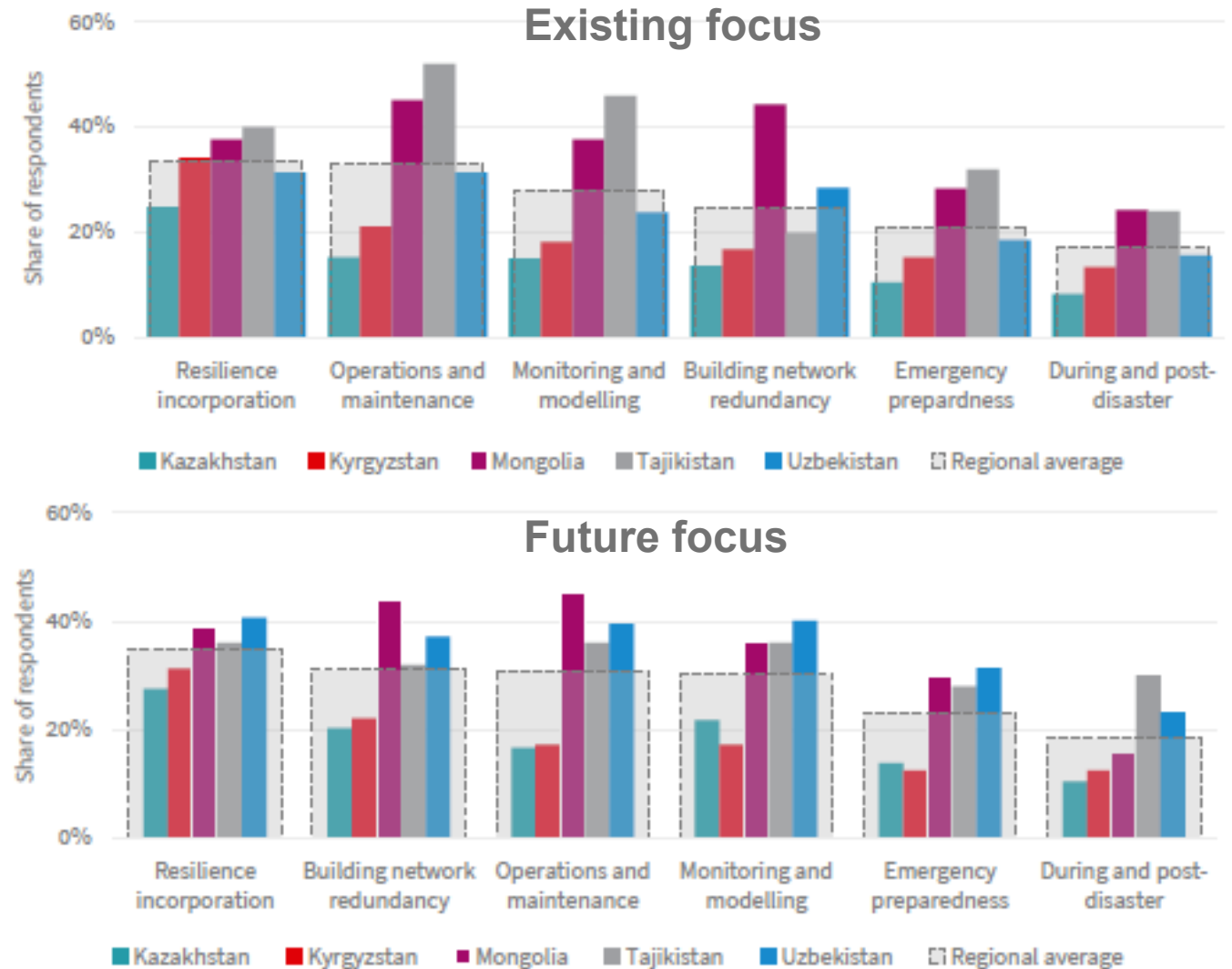


Type of measure	What does it aim to do?	Examples of measures
Coping capacity	Increase resistance of infrastructure to disruptions Protect critical infrastructure	Infrastructure investment (e.g. in drainage, permeable road surfaces, earthquake-proof construction, and increased pumping capacity in tunnels) Investment in elevated roads, runways, dikes, seawalls and bridges Prioritising maintenance of "critical networks"
Redundancy	Add links to create more alternative routes Provide buffers for crucial inputs (including electricity, workers and equipment)	Infrastructure investment planning Prioritising redundancy budgets for infrastructure managers

Type of measure	What does it focus on?	Examples of measures
Response	Planning, institutional and legal frameworks Training Optimising existing infrastructure	Contingency plans and timetables User communication plans Information systems for rescue workers Legal and contractual frameworks Support tools on which responses to prioritise Lane reversal and shoulder use (on roads)
Recovery	Clearing obstacles New transport equilibria New societal equilibria (e.g. teleworking, inventories, sourcing)	Plans and resources for clearing debris and conducting urgent repairs Relocation of roads, railways, runways and ports Policies on framework conditions (e.g. labour, trade facilitation, foreign direct investment)

# Variety of strategies to improve resilience

**Resilience strategies can differ depending on local factors** (types of challenges, budget, expertise, institutional)





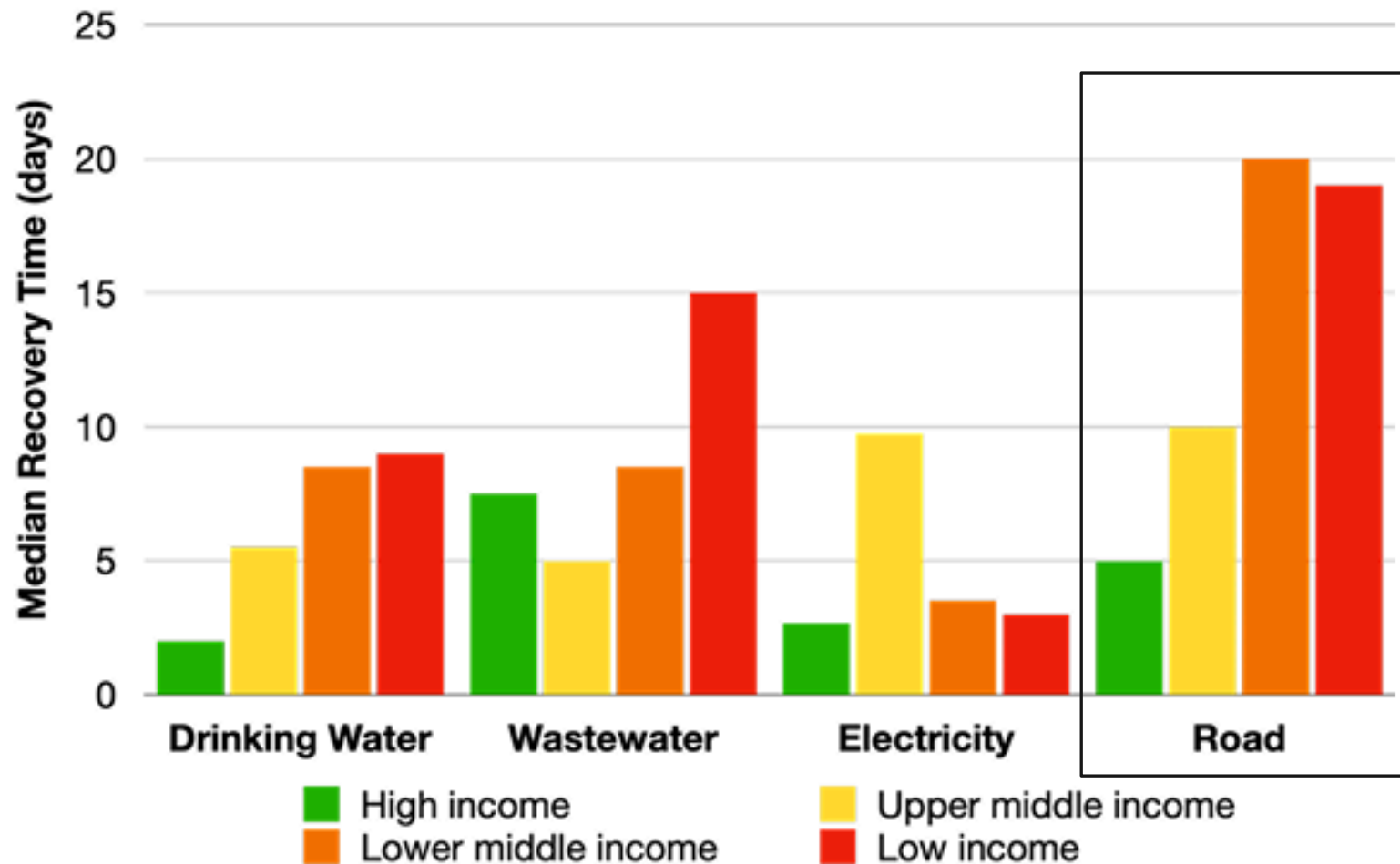
# THE NEED FOR NEW STATISTICS



# Resilience benchmarking?

## Resilience relatively new concept in transport

- First efforts to operationalise resilience indicators
- Important to first understand “resilience to what”
- Can be benchmark resilience?



Source: CDRI Global Infrastructure Resilience Survey (2023)



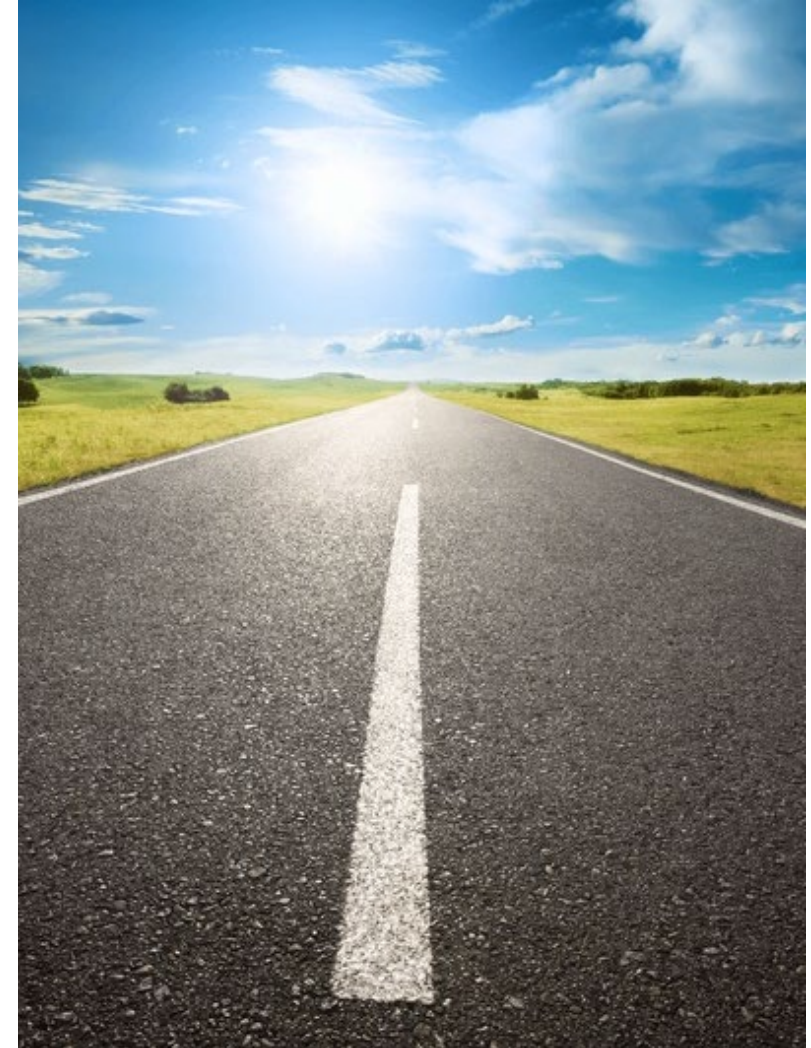
# Conclusions and call for “resilience statistics”

## 1. Completely in the dark in terms of:

- Evidence of system performance during past disruptions
- Do cascading impacts occur to other modes/regions/firms?
- Improvements of resilience over time (what works?)
- Is resilience being planned for? If so, how?

## 2. Need for new type of statistics to improve risk and resilience modelling

- Quantitative modelling is being hampered by lack of data → **statistics offices can plan a key role**



# ENHANCING TRANSPORT RESILIENCE THROUGH ANALYTICAL FRAMEWORKS

**Dr. Jasper Verschuur, Delft University of Technology**

Email: [j.verschuur@tudelft.nl](mailto:j.verschuur@tudelft.nl)



On behalf of: