



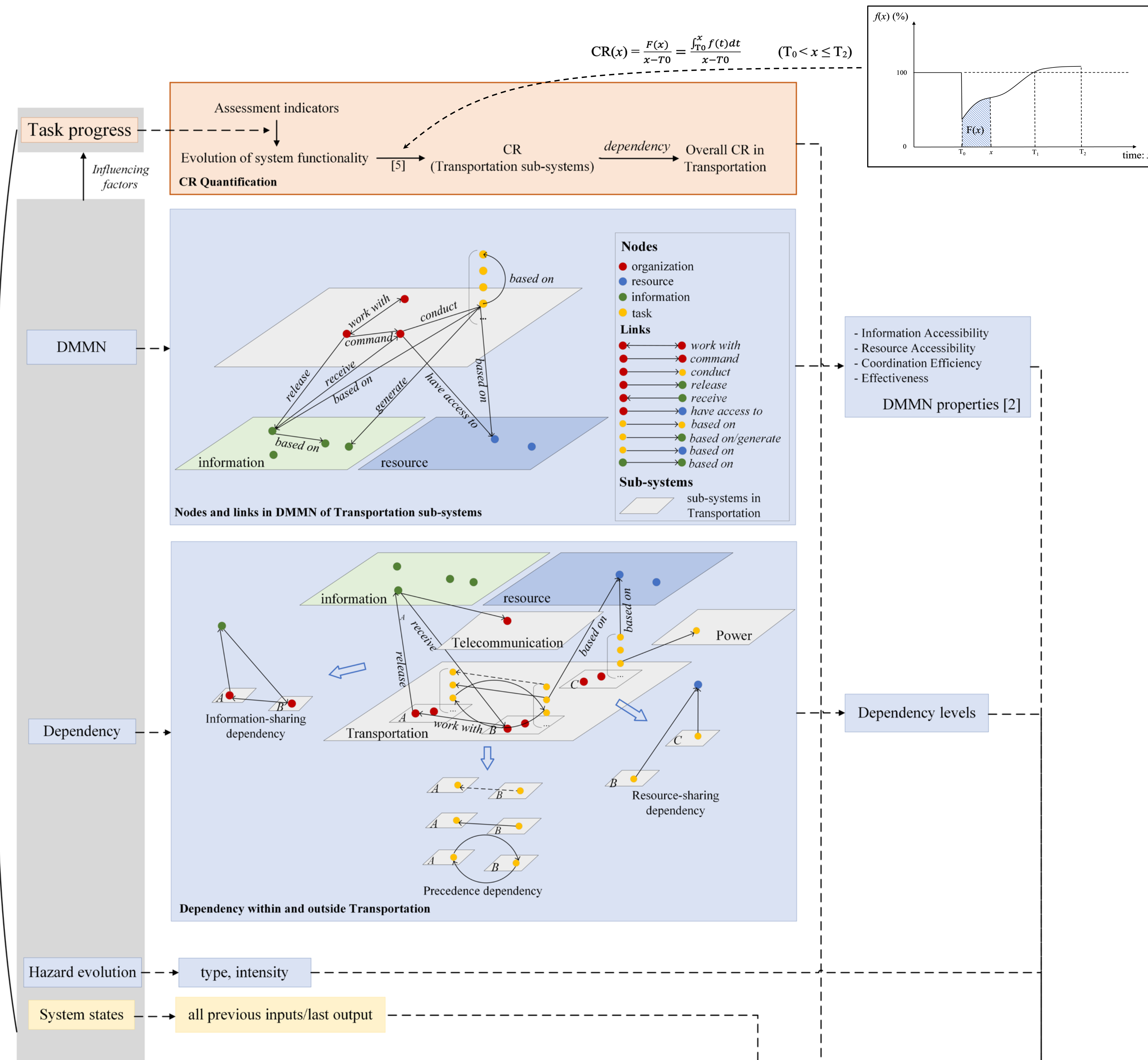
## 1 Introduction

- Disaster management (DM) is a process of coping with a disaster by coordinating organizations, organizing and directing resources, sharing information, and conducting disaster relief tasks, including four phases: mitigation, preparedness, response, and recovery<sup>[1]</sup>. Organizations, resources, information, tasks, and their links consist of the disaster management meta-network (DMMN)<sup>[2]</sup>.
- The transportation system includes several sub-systems (i.e., airport, highway, metro, bus, railway, taxis, and car-hailing vehicles). Dependency/interdependency exists between them, between them and other infrastructure systems, and between them and the external disaster environment<sup>[3]</sup>.
- Transportation resilience is an important component of community resilience (CR) and refers to the system's ability to resist disturbances and maintain transport functionality when being damaged, as well as the ability to quickly recover the transport functionality after appropriate measures are taken<sup>[4]</sup>. It changes over time during the disaster management process.
- However, there is a lack of empirical data and process-based approaches to assess the dynamic characteristics of CR and to understand what contributes to CR evolution during the disaster management process. This study selects the 7.20 heavy rainstorms that happened in Zhengzhou as a case study and focuses on the transportation system.

## 4 The components of DMMN in Transportation system

DM phases	Tasks
Mitigation	<ul style="list-style-type: none"> <li>establish emergency management procedures and policies</li> <li>determine and adhere to design codes and standards</li> <li>emergency drills and trainings.</li> </ul>
Preparedness	<ul style="list-style-type: none"> <li>risk assessment</li> <li>issue notices and establish command and control structures</li> <li>supporting logistics for response and recovery</li> <li>take emergency countermeasures in advance</li> </ul>
Emergency	<ul style="list-style-type: none"> <li>hold meetings and issue emergency notices or plans</li> <li>rescue, evacuate, and transfer people</li> <li>guarantee emergency rescue vehicles or flights</li> <li>roads, vehicles and facilities emergency repair</li> <li>on-site guidance</li> <li>raise and allocate disaster relief funds</li> </ul>
Recovery	<ul style="list-style-type: none"> <li>loss survey</li> <li>release restoration and reconstruction plans</li> <li>heavily damaged roads, vehicles and equipment repair</li> <li>risk survey</li> <li>Post-disaster recovery and reconstruction projects</li> <li>trial runs, safety assessment and resume operation of transportation systems</li> <li>transport supplies to support the resumption of work and production</li> <li>raise funds and allocate subsidies.</li> <li>On-site inspection and guidance</li> <li>Reflection and reform of disaster management abilities</li> </ul>
Aims	Resources
Restore system functionality	emergency maintenance personnel, vehicles and equipment (e.g., loaders, excavators, water pumps, generators, steel girder bridges)
Facilitate disaster relief	vehicles (e.g., bus, taxi, car-hailing vehicles, trucks) for transferring people and transport relief materials. loans, funds and donations. daily necessities for serving affected people and rescue personnel.
Organizations	Roles
Government departments	Decision-making, guidance, and supervision
State-owned enterprises	Control systems operation and maintenance
Private enterprises	A supplementary especially in emergency, e.g., car-hailing vehicles companies: people transferring, logistics companies: relief supplies transportation
Public institutions	Participated in disaster management in some cases, e.g., projects quality inspection
Civil society organizations	A supplementary especially in emergency, e.g., rescue team: roads emergency repair
Information	
Various notices, plans, announcements, and work requirements	
Latest situation of disaster damage and response or recovery tasks progress	

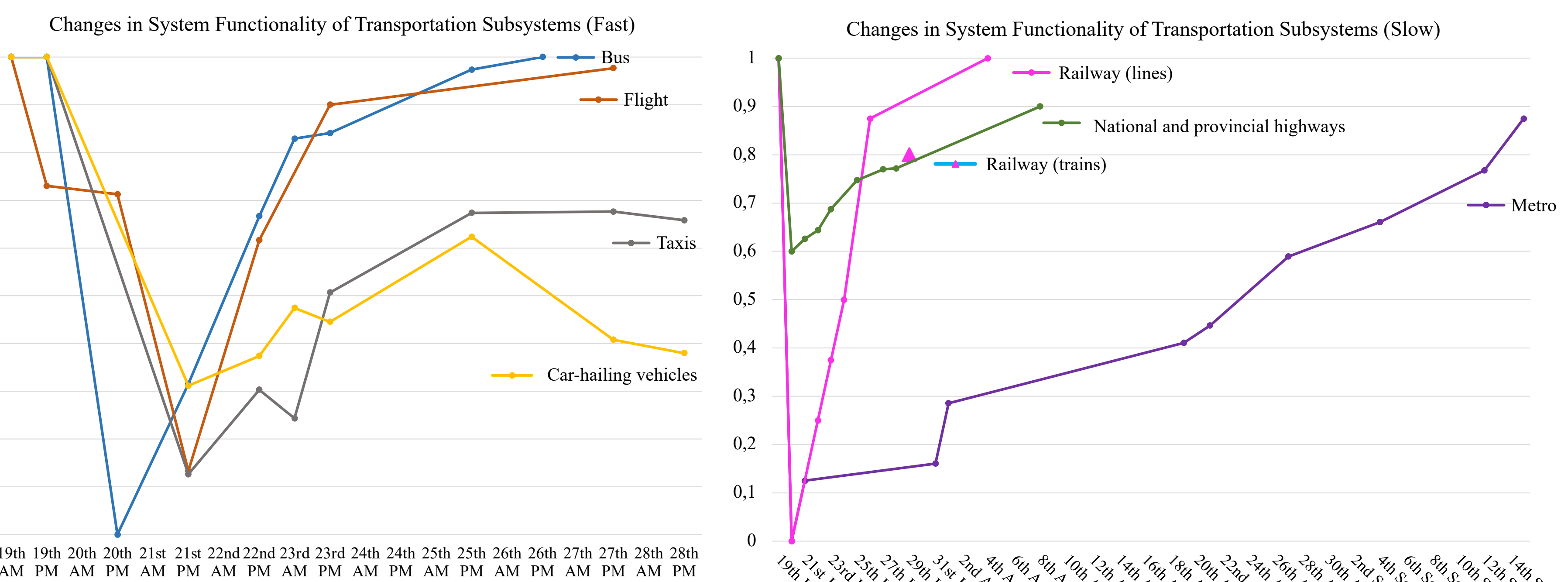
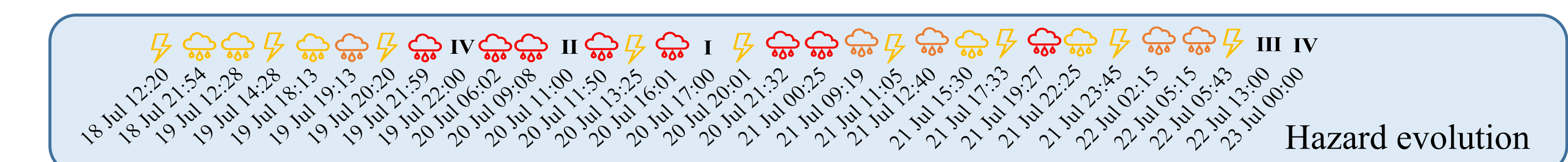
## 2 Research strategy



## 3 Assessment indicators of Transportation resilience

Sub-systems	Assessment indicators of system functionality
Airport	-The number of flights average before disaster, canceled or delayed, and resumed per day.
Highway	-The number of national and provincial highways, rural highways, and expressway lines in total, damaged and restored. -The number of damaged places in total and repaired.
Metro	-The number of metro lines in total, shuttled down, under maintenance, no-load operation, safety assessment, and resumed operation.
Bus	-The number of bus lines in total, stopped, resumed.
Railway	- The number of railway lines in total, stopped and restored. - Percentage of trains that have resumed operation.
Taxis or car-hailing vehicles	-Percentage of vehicles in operation
Sub-systems	Assessment indicators of disaster relief contribution
Airport	The number of emergency rescue flights or missions be guaranteed
Airport, bus, railway, taxis and car-hailing vehicles	The number of people be transferred.
Railway	The quantity of production and living materials and epidemic prevention materials be transported.
Expressway	Times of road rescue, Number of rescue vehicles that are guaranteed to pass, Times of serving rescue personnel and affected people
Dangerous goods transport enterprise	Times of dangerous good transport vehicles were dispatched
Assessment indicators of adaptive ability	
The completion degree of post-disaster reconstruction projects and actions (e.g., risk survey) — System vulnerability	
The completeness of disaster management plans and whether they are adapted to the new situation — Disaster management ability	

## 5 Preliminary results



## 6 Reference

[1] Federal Emergency Management Agency, 1996. *Guide for All-Hazard Emergency Operations Planning*.  
 [2] Fan, C., Zhang, C., & Mostafavi, A. (2018). Meta-Network Framework for Analyzing Disaster Management System-of-Systems. 2018 13th Annual Conference on System of Systems Engineering (SoSE), 372–378.  
 [3] Sun, W., Bocchini, P., & Davison, B. D., 2020. *Model for Estimating the Impact of Interdependencies on System Recovery*. Journal of Infrastructure Systems, 26(3), 04020031.  
 [4] Tian, T., Liang, Y., Peng, Z., Cheng, Y., & Chen, K. (2023). Assessing the dynamic resilience of Urban Rail Transit Networks during their evolution using a ridership-weighted network. PLOS ONE, 18(9), e0291639.  
 [5] Tierney, K., & Bruneau, M, 2007. *Conceptualizing and Measuring Resilience*.