







### 3.1 Factors Considered in the Modeling Process

The model considers the following factors: (1) The initial state of the system, represented by the vector  $x_i(0)$ . (2) The input variables, including precipitation  $P_i(t)$  and the initial water content  $W_i(0)$ . (3) The system parameters, such as the decay rate  $DR_i(P_i(t))$  and the initial water content  $W_i(0)$ . (4) The system dynamics, which are governed by the differential equations (1) and (2). (5) The system output, which is the water content  $W_i(t)$  over time.

### 3.2 Mechanisms of the Proposed Model

The proposed model is based on the following mechanisms: (1) The initial state of the system, represented by the vector  $x_i(0)$ . (2) The input variables, including precipitation  $P_i(t)$  and the initial water content  $W_i(0)$ . (3) The system parameters, such as the decay rate  $DR_i(P_i(t))$  and the initial water content  $W_i(0)$ . (4) The system dynamics, which are governed by the differential equations (1) and (2). (5) The system output, which is the water content  $W_i(t)$  over time.

#### 3.2.1 System Status

In this section, we describe the system status. The system is represented by the vector  $x_i(t)$  at time  $t$ . The system parameters are  $W_i(t)$ ,  $G_i(t)$ ,  $R_i(t)$ , and  $P_i(t)$ . The system dynamics are governed by the differential equations (1) and (2). The system output is the water content  $W_i(t)$  over time.

$$x_i(t+1) = \begin{cases} 0, & W_i(t) \geq B \\ [G_i(t) + R_i(t)] * (1 - DR_i(P_i(t))), & W_i(t) < B. \end{cases} \quad (1)$$

Figure 1 shows the system status. The system is represented by the vector  $x_i(t)$  at time  $t$ . The system parameters are  $W_i(t)$ ,  $G_i(t)$ ,  $R_i(t)$ , and  $P_i(t)$ . The system dynamics are governed by the differential equations (1) and (2). The system output is the water content  $W_i(t)$  over time.

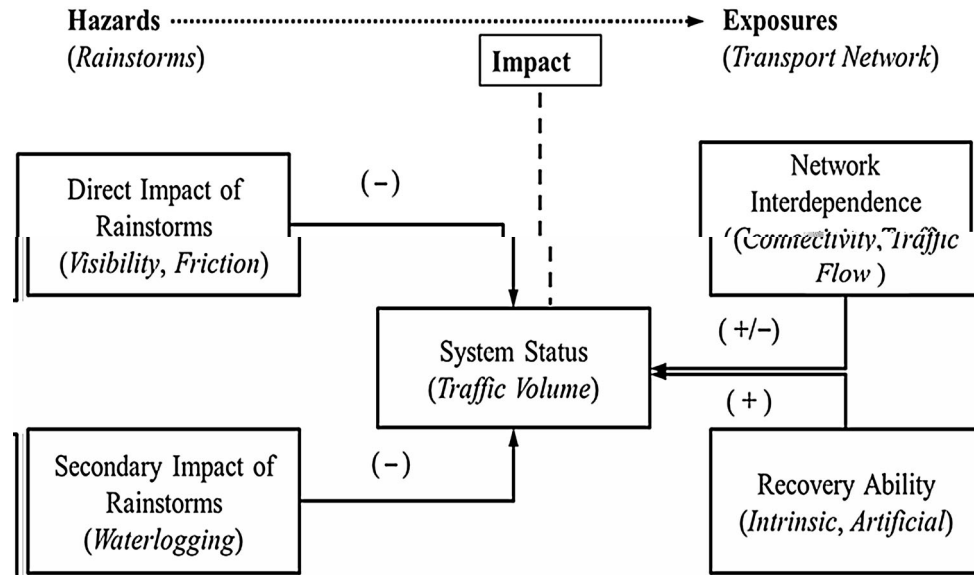
#### 3.2.2 Direct Impact of Precipitation on Transport Networks

The direct impact of precipitation on transport networks is described by the differential equation (1). The system parameters are  $W_i(t)$ ,  $G_i(t)$ ,  $R_i(t)$ , and  $P_i(t)$ . The system dynamics are governed by the differential equation (1). The system output is the water content  $W_i(t)$  over time.

#### 3.2.3 Secondary Impact of Precipitation on Transport Networks

The secondary impact of precipitation on transport networks is described by the differential equation (2). The system parameters are  $W_i(t)$ ,  $G_i(t)$ ,  $R_i(t)$ , and  $P_i(t)$ . The system dynamics are governed by the differential equation (2). The system output is the water content  $W_i(t)$  over time.

**Fig. 2** Framework of the impact of rainstorms on the transport network.



### 3.2.4 Interdependency Between Cities

Traffic volume in a city is influenced by various factors, including the origin-destination (OD) pairs and the network structure (Haller et al., 2007). One key indicator of a city's economic activity is its Gross Domestic Product (GDP), which is closely related to the traffic volume. The interdependency between cities is modeled by the traffic volume  $x_j(t)$  in city  $j$ , which is influenced by the traffic volume  $x_i(t)$  in city  $i$ .

$$G_i(t) = \sum_{j=1}^N Q_{ji}(t), \quad (3.1)$$

$$Q_{ji}(t) = x_j(t) * \frac{A_i * K_{ji}}{\sum_{l=1}^N \frac{A_i * K_{jl}}{(t_{ji})^2}}. \quad (3.2)$$

According to Eq. 3.1,  $N$  is the number of cities,  $i, j$  are the cities,  $t_{ji}$  is the travel time from city  $i$  to city  $j$ ,  $A_i$  is the area of city  $i$ , and  $K_{ji}$  is the connectivity between city  $i$  and city  $j$ .

### 3.2.5 Recovery Ability

Traffic volume in a city is influenced by various factors, including the origin-destination (OD) pairs and the network structure (Haller et al., 2007). One key indicator of a city's economic activity is its Gross Domestic Product (GDP), which is closely related to the traffic volume. The interdependency between cities is modeled by the traffic volume  $x_j(t)$  in city  $j$ , which is influenced by the traffic volume  $x_i(t)$  in city  $i$ . The recovery ability of a city is modeled by the recovery ability  $R_i(t)$ , which is influenced by the traffic volume  $x_i(t)$  and the recovery ability  $RE_i$ .

$$R_i(t) = r * PO_i(t) * RE_i \left(1 - \frac{x_i(t)}{MAX_i}\right), \quad (4.1)$$



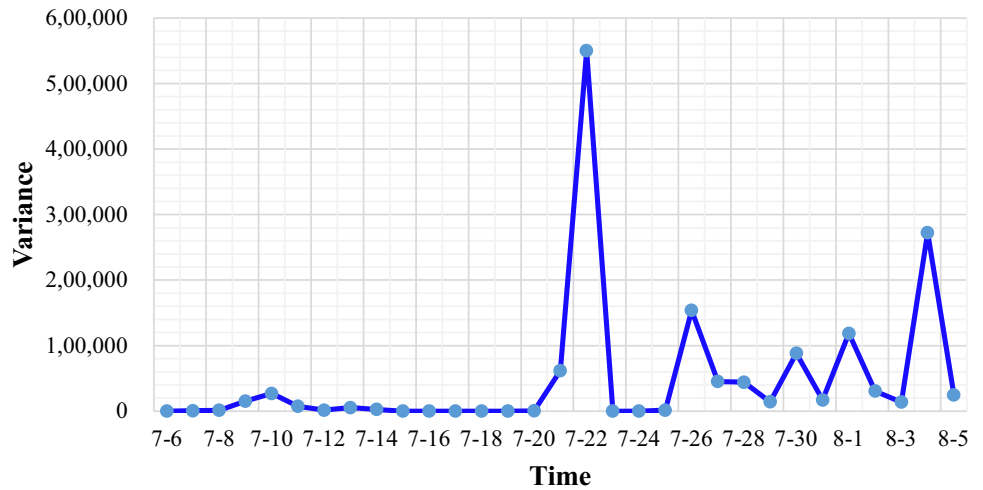








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### 7 Conclusion

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