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Socio-Hydrological Modelling of Cooperation and Conflict in the Transboundary Lancang-Mekong River

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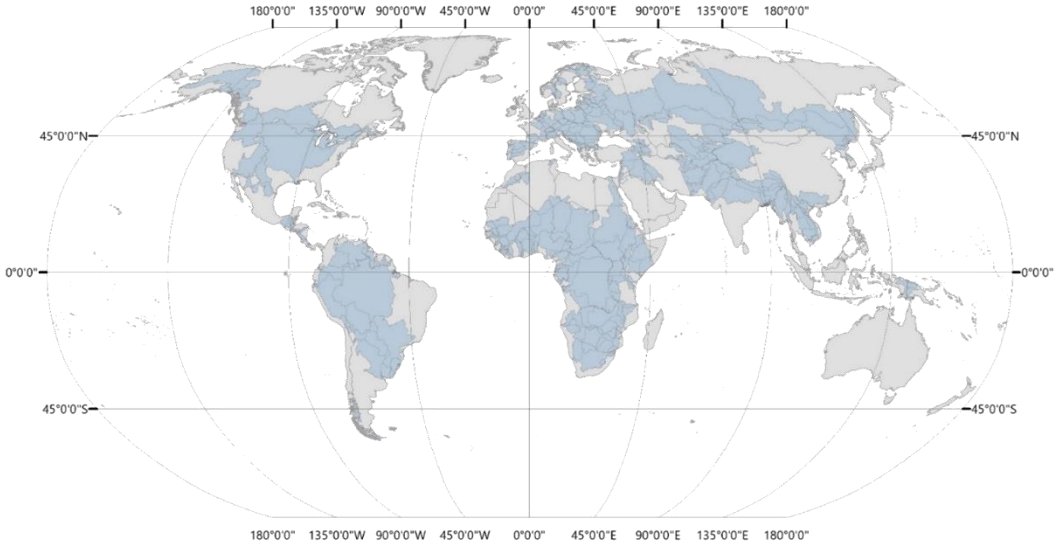
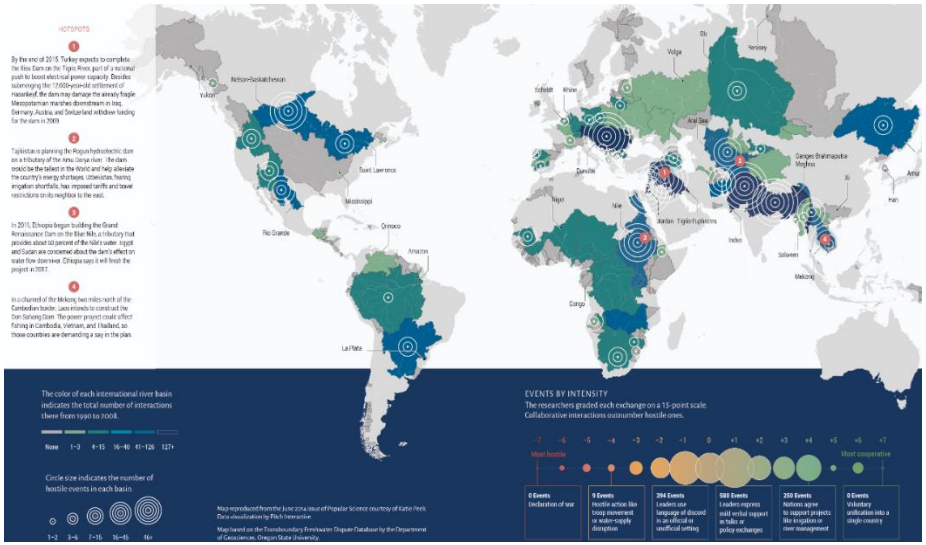
1. Transboundary Water Management

- Importance
  - ✓ Over 300 transboundary rivers
  - ✓ 150 countries
  - ✓ 40% of the population and land areas (UNEP 2016).
  - ✓ Global water security, food security, energy security and ecosystem security
- Complexity
  - ✓ Different uses of countries with sovereignty.
  - ✓ Cooperation limited by riparian relations and institutional limitations (Wolf, Natharius et al. 1999)
  - ✓ Difficult to achieve cooperation, conflicts even occur.



Global Transboundary rivers

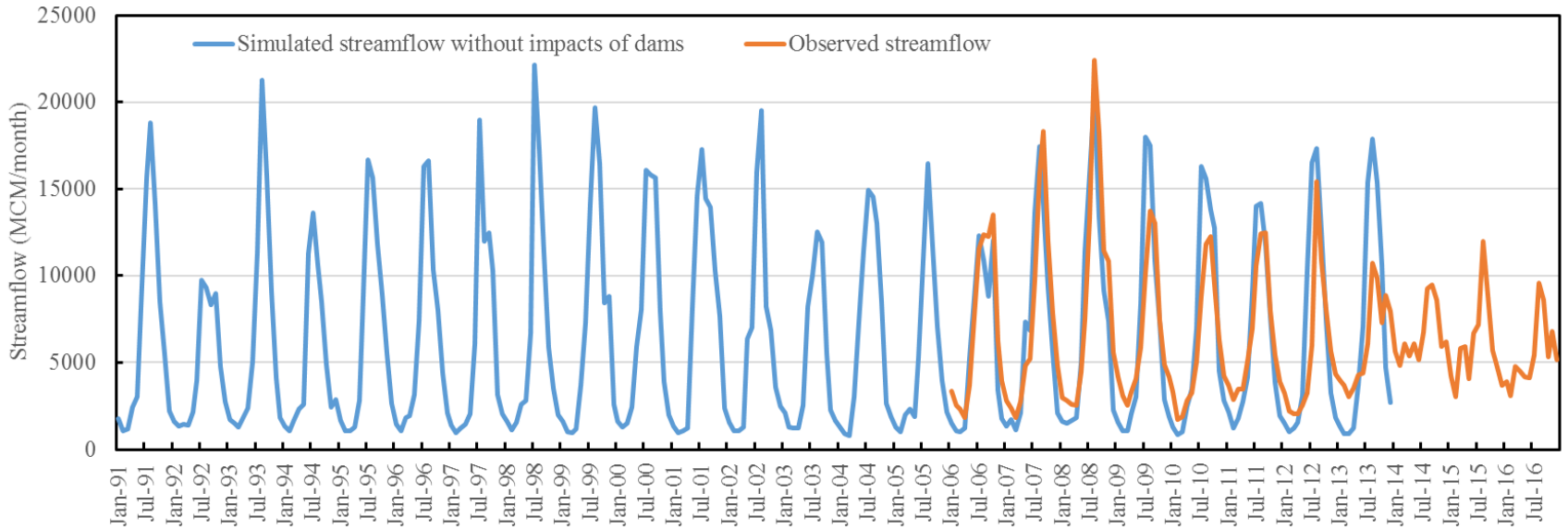


Global Transboundary Water Events Hotspots Map

2. Lancang-Mekong River Basin

- Geography
  - ✓ Total drainage area:773,231 km²
  - ✓ Population in basin: 70 million
- Economic Benefits
  - ✓ China: Hydropower
  - ✓ Laos: Hydropower
  - ✓ Thailand: Irrigation
  - ✓ Cambodia: Fishery
  - ✓ Vietnam: Irrigation, Salinity, Floods
- Cooperation
  - ✓ Mekong River Commission since 1995
  - ✓ Major dam operations since 2010
  - ✓ Lancang-Mekong Cooperation Mechanism since 2015

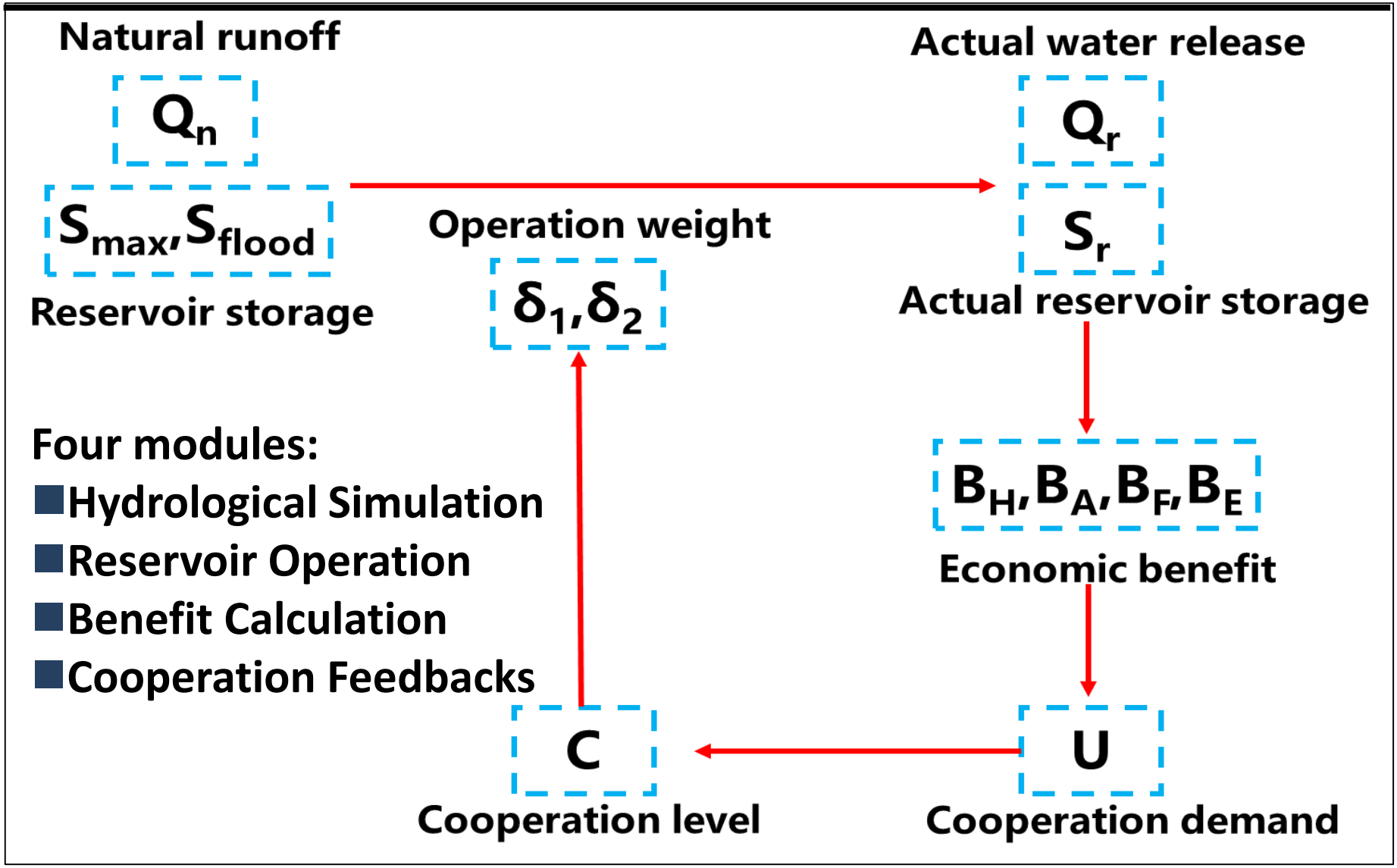
3. Phenomena



Construction and operation of mainstream hydropower dams in upstream countries change the seasonality of downstream discharge. Downstream countries expressed their concerns (i.e., cooperation demand), and the upstream countries changed the way to regulate reservoirs (i.e., cooperation level) according to direct economic benefits and indirect political benefits. The adaptation of upstream countries drives the evolution of the socio-hydrological system.

- ✓ Cooperation demand: reflected by the media sentiment analysis results
- ✓ Cooperation level: no cooperation and full cooperation

4. Model Framework



5. Cooperation feedbacks

Cooperation Demand

$$U = \left(\varepsilon_{Ad} \times \frac{A_{dmax} - A_d}{A_{dmax}} + \varepsilon_{Fd} \times \frac{F_{dmax} - F_d}{F_{dmax}} + \varepsilon_{Ed} \times \frac{E_{dmax} - E_d}{E_{dmax}}\right)$$

Cooperation Level

$$\frac{dC}{dt} = s\left[\frac{e^{\beta \times (U \times P_d + (\varepsilon_H \times \frac{H_u}{H_{umax}}) \times P_u)}}{e^{\beta \times (U \times P_d + (\varepsilon_H \times \frac{H_u}{H_{umax}}) \times P_u)} + e^{\beta \times (\varepsilon_H \times \frac{\widetilde{H_u}}{H_{umax}}) \times P_u}} - C\right]$$

Weights for cooperation

$$\delta_{up} = 1 - C$$

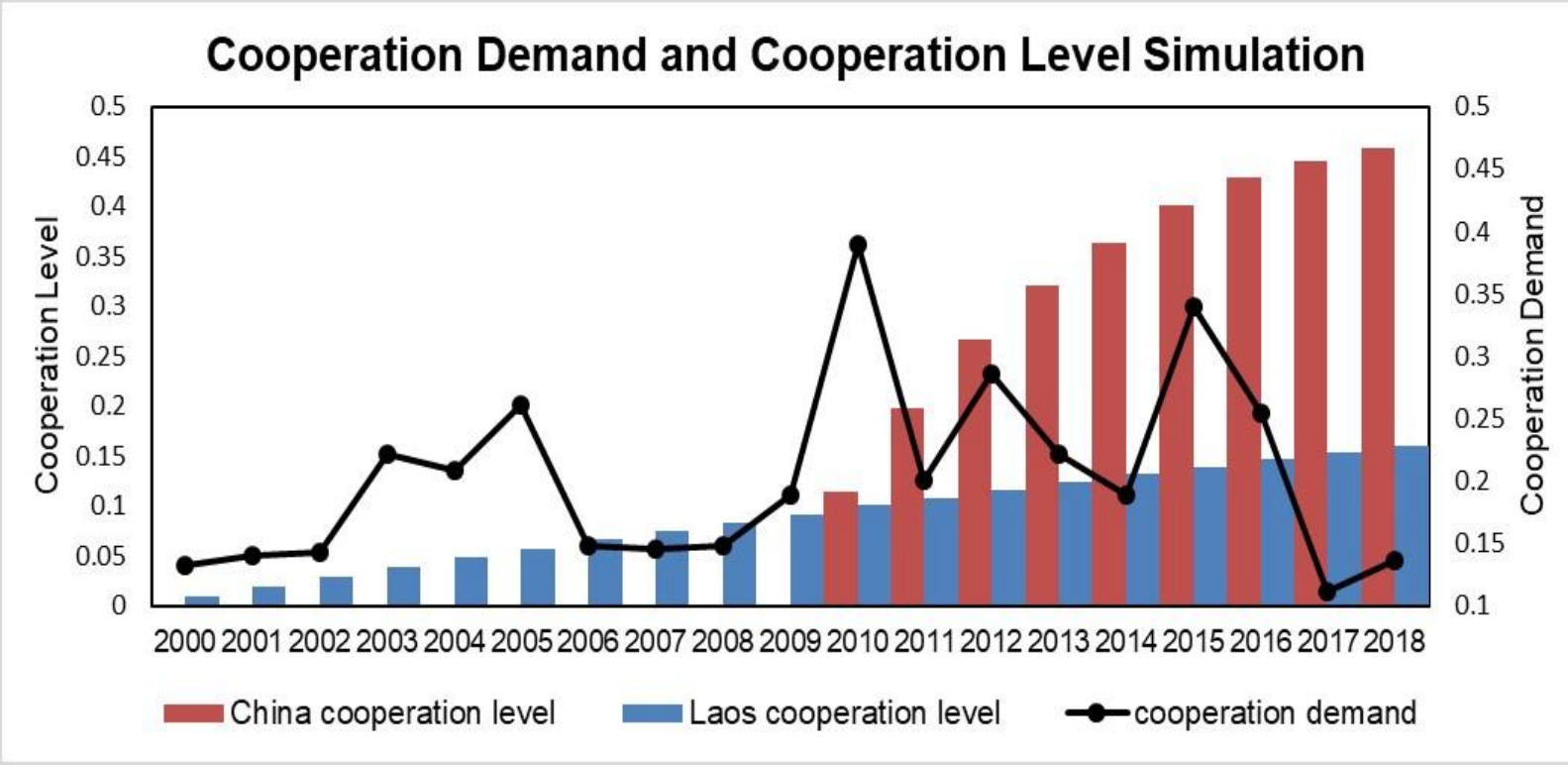
$$\delta_{down} = C$$

$$\Pr = \frac{e^{\beta \times B_c}}{e^{\beta \times B_c} + e^{\beta \times B_n}}$$

Logit Dynamics (McFadden D., 1981)

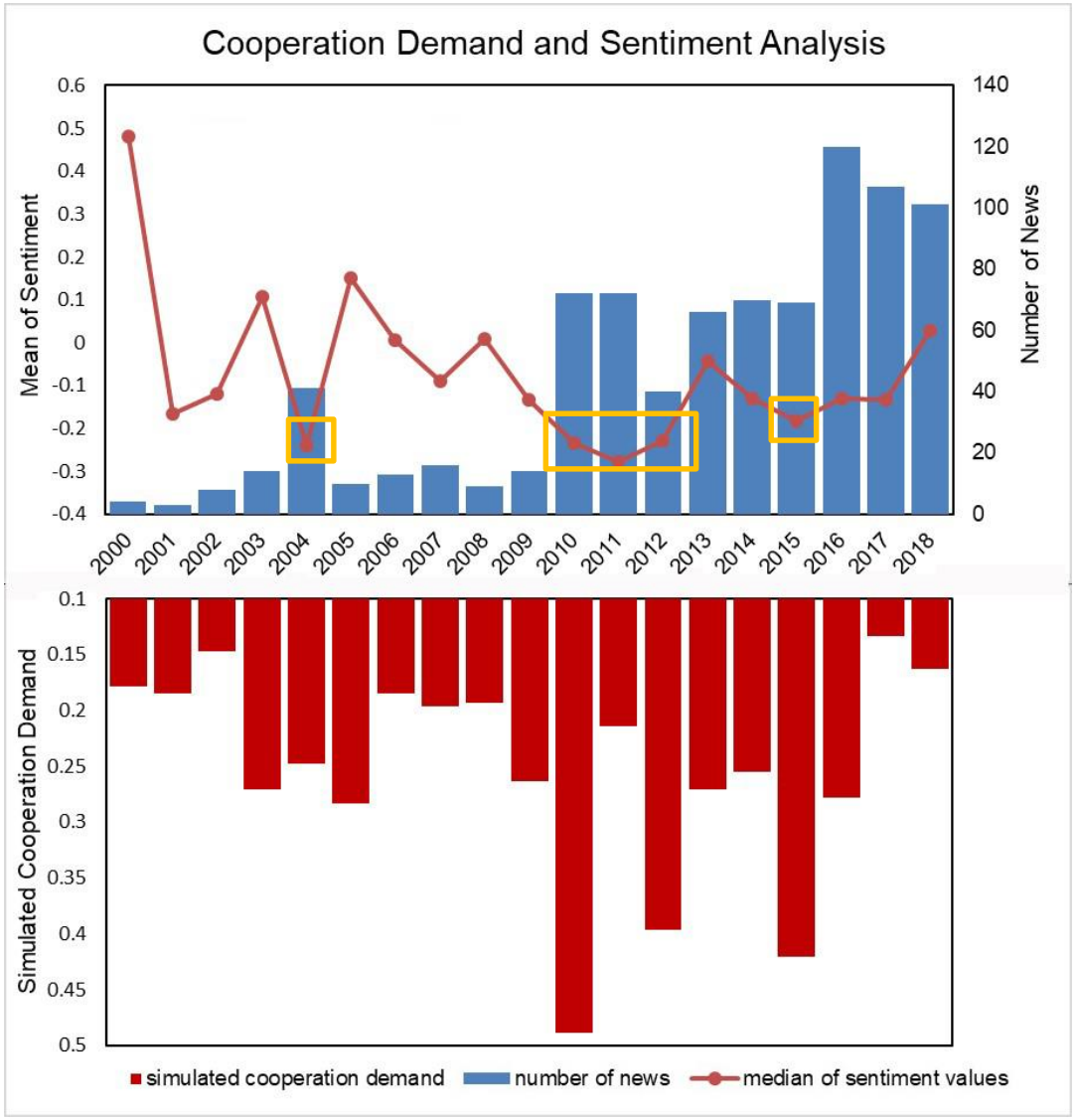
- **Used to calculate the rate of individuals in a group to cooperate or the possibility to cooperate**
- **Used in researches in environmental economics**
- **Here cooperation level indicate to what extent the upstream countries manage water with consideration of downstream benefits, the weight to determine final water release**

6. Cooperation simulation and news sentiment analysis



Simulation of cooperation demand of downstream and cooperation level of China and Laos

7. Cooperation simulation and news sentiment analysis



- Cooperation demand simulation for Thailand
- Collection of English news in Thailand since 2010, 4600 pieces
- 900+ selected for analysis
- Sentiment analysis and value assignment for each piece of news, positive/negative
- Simulated cooperation demand reached to peaks in 2204,2010-2012, and 2015
- Simulations are consistent with events and sentiment analysis results

8. Summary

- Cooperation: a dominated pattern emerging from dynamics of TR human-water system.
- The model can simulate cooperation dynamics in transboundary rivers in a reasonable manner.
- Sensitivity analysis of factors (e.g., political, institutional, etc.) based on model could offer implications in water management.
- Scenario analysis based on model could help future projections in evolutions of transboundary river human-water system.