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Preliminary study on evaluation indicators for urban engineering system sustainability

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Research Background

- China’s urbanization has entered a mid-to-late stage
- High-density engineering projects form systems coupled to geotechnical environment
- Strong spatiotemporal coupling amplifies the systemic vulnerability of megacities



Schematic diagram of urban engineering system



Disaster mismanagement



Carbon emission imbalance



Pollution disorder

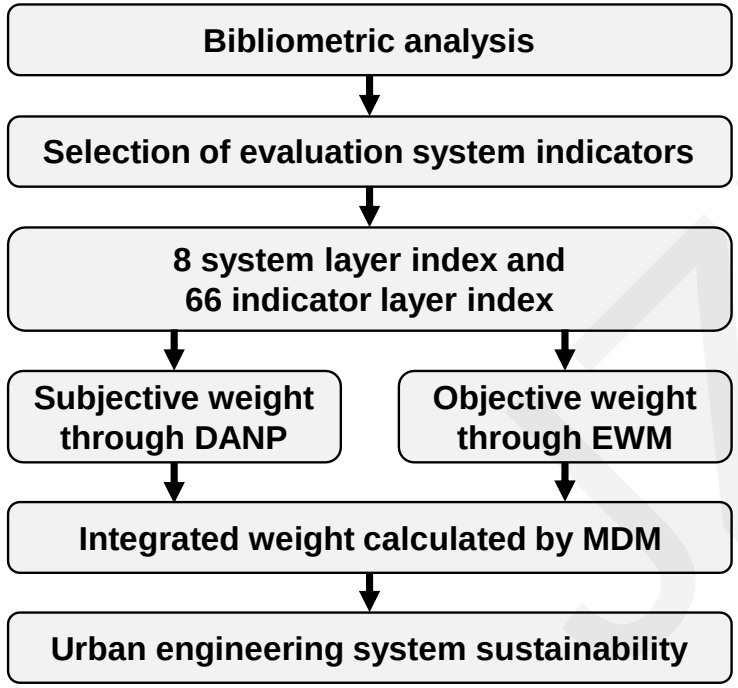
Literature Review

- Current evaluation system only covers certain types of engineering subsystems
- Current evaluation system fail to comprehensively consider performance coupling and feedback mechanisms between different dimensions
- Limitations of current evaluation frameworks and methods
  - Qualitative analysis is highly subjective and difficult to verify as statistically significant
  - Quantitative analysis demands much stricter and deeper verification methods
  - There is no unified method for quantifying urban engineering system sustainability in terms of statistical indicators
  - Since existing evaluation frameworks have mainly been established in developed countries, some of these indicators fail to integrate with the setting in China

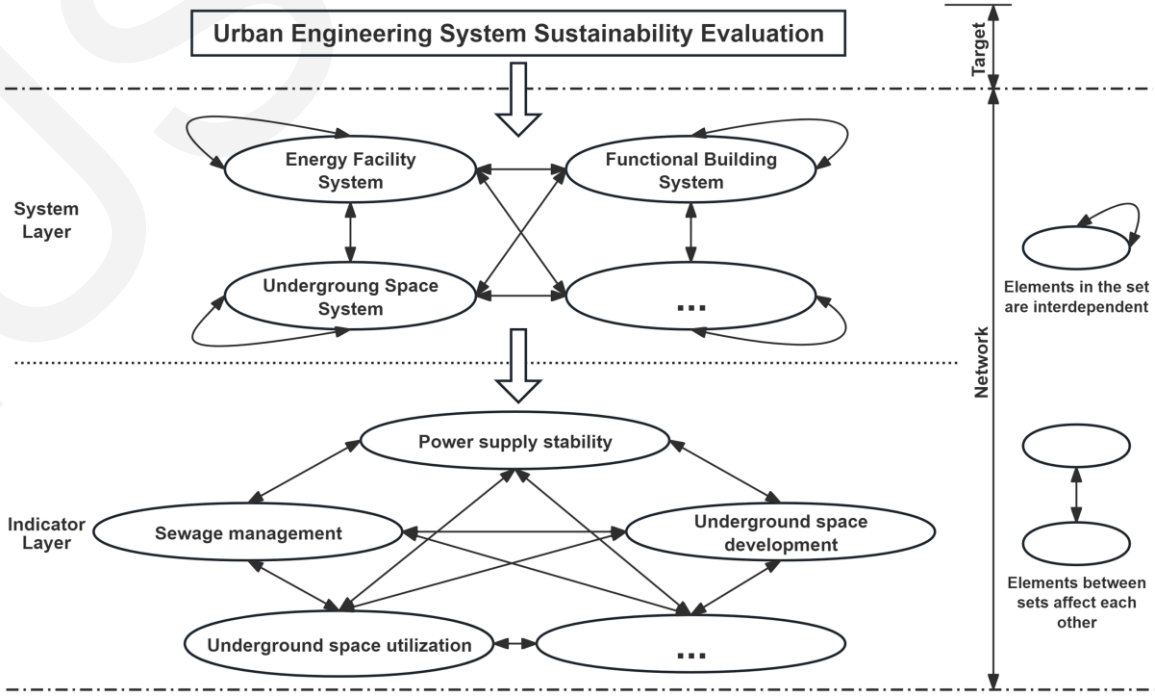
There is still a lack of a comprehensive evaluation system covering various subsystems and different dimensions

Methodology

- Indicators were selected across resilience, low-carbon, and ecological dimensions
- Integrated weights were determined by combining DANP-based subjective weights and entropy-based objective weights via the Maximizing Deviation Method
- The system demonstrates high reliability (Cronbach's α = 0.8811)



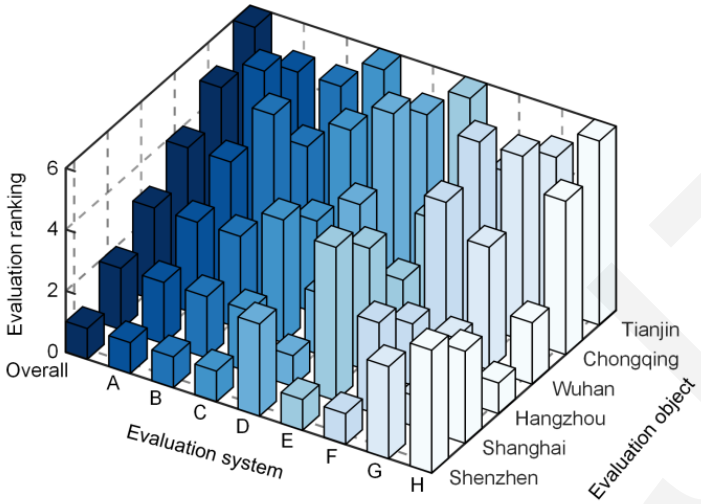
Flowchart of the methodology



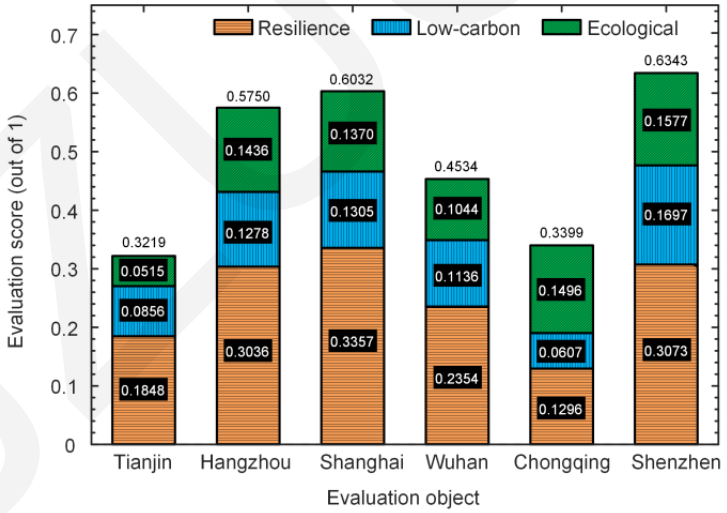
Network hierarchy of DANP

Empirical Analysis

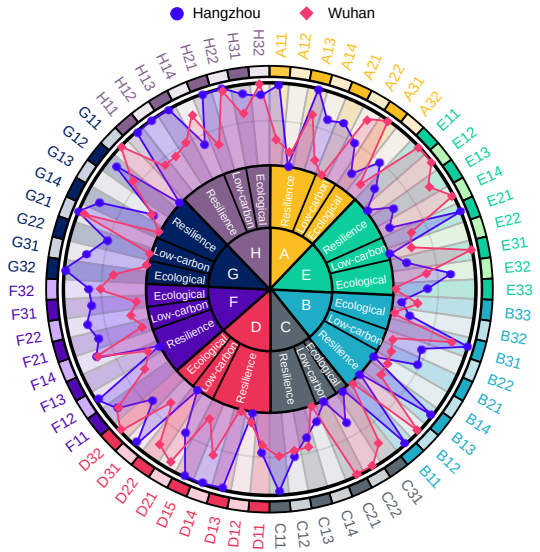
- Empirical analysis is conducted across six megacities to validate the evaluation index
- **Geological disaster forecast accuracy** and **Mobile communication assurance** are the most critical indicators affecting urban engineering system sustainability
- Significant imbalance was observed in the overall scores of the selected megacities
- Performance imbalance was found across different dimensions within the same city



Evaluation results ranking the different subsystems



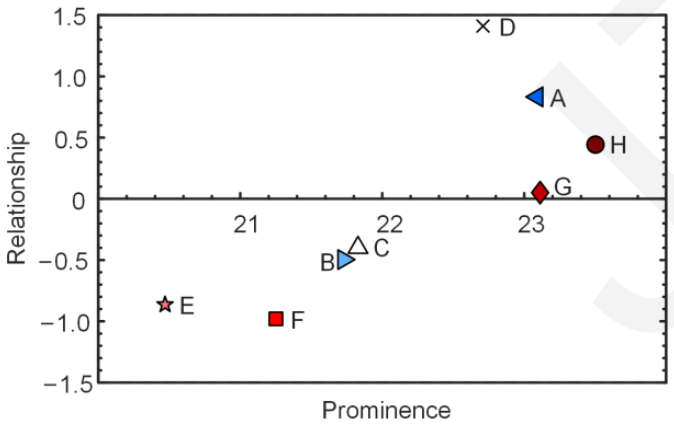
Evaluation scores across different dimensions



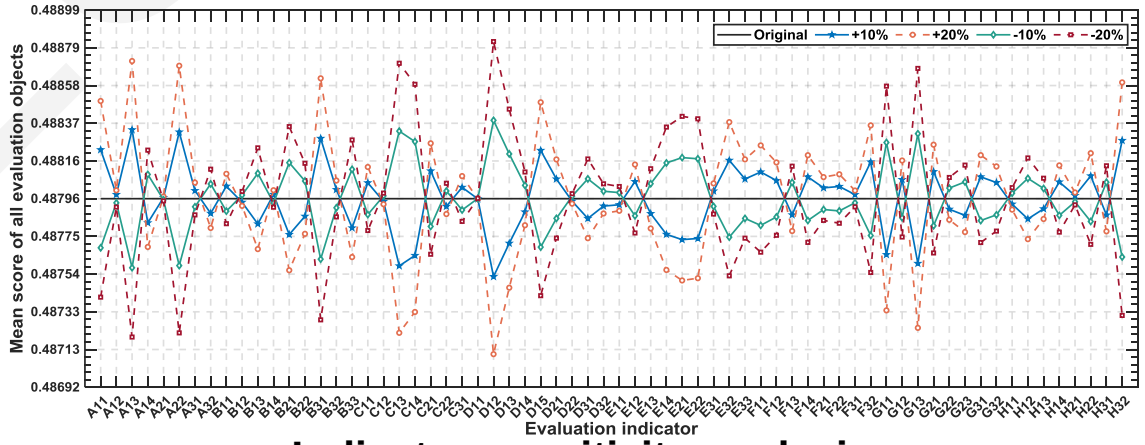
Indicator scores of Hangzhou and Wuhan

Conclusions

- The proposed evaluation indicator system effectively quantified the sustainability of urban engineering systems in each evaluated city. Notably, geological disaster forecast accuracy and mobile communication assurance were identified as the most critical indicators influencing urban engineering system sustainability
- Significant imbalances were also observed in the comprehensive scores of the selected megacities. Shenzhen and Shanghai achieved the highest scores (0.6343 and 0.6032), while Chongqing and Tianjin had the lowest (0.3399 and 0.3219). Moreover, substantial variations in performance across different dimensions were observed within the same city, indicating intra-city disparities



Relation map of subsystems



Indicator sensitivity analysis