**Table S1. Recent research on interdependent critical infrastructures**

Meanings of the abbreviations and acronyms in Table S1:

- Temporal scale: ST = short-term; LT = long-term
- Types of impacts: T = Technical; O = organizational; E = economic; S = societal.
- Granularities of measurement of infrastructure performance (MIP): B = binary; Ca = categorial; C = continuous
- Methods: IIM = inoperability input-output method; ER = empirical research; ABM = agent-based model; SD = system dynamics, BN = Bayesian network; OT = operational techniques; Network=Topology-based network
- Interdependency: G = geographical; T: Temporal; F=functional; L = logical; P = physical; C = cyber. F, L, P, and C all belong to status intedepnency in the manuscript.

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mohamed (2019) | 2019 | Power Grid<br>ICT Network<br>E-Mobility | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | General Failure | V | Network | P |
| 2 | Kong *et al*. (2019) | 2019 | Electric<br>Gas<br>Oil | Hurricane<br>Flood | Ex-ante<br>Ex-post | MESO | Static | Region | T | Node, link, network related indicators | B | Resilience | R | Network | P |
| 3 | Goldbeck *et al.* (2019) | 2019 | Metro<br>Electricity power | Flood | Ex-post | MESO | ST | City | T | Demand and Supply | C | Resilience | R | Flow-based network<br>PBM | P |
| 4 | Loggins *et al*. (2019) | 2019 | Civil infrastructures<br>Social infrastructures | General | Ex-post | MESO | Static | County | T | Node, link, network related indicators | B | Restoration | R | OT<br>Network | P |
| 5 | Fang & Zio (2019) | 2019 | Power<br>Gas | Typhoon | Ex-ante<br>Ex-post | MESO | Static | Region | T | Node, link, network related indicators | B | Resilience | R | OT<br>Network | P |
| 6 | Almoghathawi & Barker (2019) | 2019 | Power<br>Water | General | Ex-ante<br>Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Resilience | V | Network | P |
| 7 | Beyza *et al*. (2019) | 2019 | Power<br>Gas | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Resilience | V | Network | P |
| 8 | Klein & Klein (2019) | 2019 | 11 CIs | General | Ex-ante<br>Ex-post | MACRO | LT | N/A | E | Sectors' outputs | C | Operability | V | IIM | L |
| 9 | Almoghathawi *et al*. (2019) | 2019 | Power<br>Water | General | Ex-ante<br>Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Resilience | V | Network | P |

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Zhou *et al.* (2018) | 2019 | Water<br>Power<br>Gas | General | Ex-ante | MESO | Static | City | T | Node status-based network characteristics | B | Robustness | R | Network | F, G |
| 11 | Yang *et al.* (2019) | 2019 | Drainage pipe<br>Transit | Rainfall | Ex-ante | MACRO | ST | Community | T | Drainage pipe capacity<br>Traffic speed<br>…… | C | Vulnerability | R | PBM | G, T |
| 12 | Thompson *et al.* (2019) | 2019 | Power<br>Water | Climate Change | Ex-ante | MESO | LT | Region | T | Unmet demand<br>Cost<br>…… | Ca, C | Capacity | V | ABM | P, T |
| 13 | Khalid & Ali (2019) | 2019 | 23 CIs | Flooding | Ex-post | MACRO | LT | Nation | E | Sector inoperability | C | Operability | R | IIM | L |
| 14 | Tariverdi *et al.* (2019) | 2019 | Health Care Network<br>Power<br>Water<br>Transportation | General | Ex-ante<br>Ex-post | MESO | ST | City | T, O | Patients served<br>Capacity of power water and transportation | C | Resilience | V | OT | F, G |
| 15 | Danziger *et al.* (2019) | 2019 | Power grid<br>Telecommunication | General | Ex-ante | MESO | Static | N/A | T | Nodes remained or removed | B | Robustness | V | Network | P, G |
| 16 | Attary *et al.* (2019) | 2019 | Power<br>Building | Hurricane | Ex-ante | MESO | ST | Community | T, S | Power loss<br>Buildings have power or not | Ca | Damage | R | ER | P |
| 17 | Lin *et al.* (2019) | 2019 | Telecommunication<br>Electricity | General | Ex-ante | MACRO<br>MESO | LT | City | T | Failed node in telecommunication network and electrical grid | B | Loss | R | IIM<br>Network | L, P |
| 18 | Applegate & Tien (2019) | 2019 | Power<br>Water supply | General | Ex-ante | MESO | Static | City | T | Node status<br>Failure probability<br>Network Minimum Link Set | C, B | Vulnerability | R | Bayesian network | P<br>G |
| 19 | Monsalve & Carlos de la Llera (2019) | 2019 | Gas<br>Power<br>Water | Earthquake | Ex-post | MICRO | ST | Nation | T | Capacity of each system | C | Restoration | R | ER | General |
| 20 | Dong *et al.* (2019) | 2019 | General | General | Ex-ante | MESO | Static | N/A | T | Node status | B | Vulnerability | V | Network | P, G |
| 21 | Wang *et al.* (2018) | 2018 | Power<br>Gas | General | Ex-ante | MESO | Static | City | T | Node status<br>Node capacity (e.g., betweenness) | B | Vulnerability | R | Network | P |

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | Zeraati *et al.* (2018) | 2018 | Power<br>Cyber | General | Ex-ante | MACRO | Static | N/A | T | The delayed response of the disconnected components<br>…… | C | Vulnerability | R | OT | P, C, G |
| 23 | Galbusera *et al.* (2018) | 2018 | Electricity<br>Port | Earthquake | Ex-ante<br>Ex-post | MESO | LT | Community | T | Node status with threshold | B | Resilience<br>Recovery<br>Serviceability | R | Network | P |
| 24 | Alinizzi *et al.* (2018) | 2018 | Pavement<br>Underground utilities | General | Ex-ante | MESO | LT | N/A | T | Cost<br>Treatment service<br>Life | C | Preparedness | V | OT | G |
| 25 | He *et al.* (2018) | 2018 | Power<br>Gas | General | Ex-ante | MACRO | ST | N/A | T | Gas consumption<br>Electric energy consumption | C | Vulnerability | V | OT | P |
| 26 | Dong *et al.* (2018) | 2018 | General | General | Ex-ante | MESO | Static | N/A | T | Node status | B | Vulnerability | V | Network | General |
| 27 | Zhao *et al.* (2018) | 2018 | Water supply<br>Electric power<br>Natural gas<br>Oil transportation<br>Telecommunication | General | Ex-ante | MESO | Static | City | T | Node degree<br>Flow<br>Page rank | B | Criticality | R | Network | P |
| 28 | Xian & Jeong (2018) | 2018 | Electricity<br>Water<br>Telecommunication | Hurricane | Ex-ante<br>Ex-post | MACRO | LT | City | T | Node, link, network related indicators | C | Damage<br>Recovery | R | IIM<br>Network | P, L |
| 29 | Seppanen *et al.* (2018) | 2018 | General | Winter Storm | Ex-ante | MICRO | Static | N/A | G | N.A. | B | Vulnerability | V | ER | General |
| 30 | Lam & Tai (2018) | 2018 | 8 CIs | General | Ex-ante | MICRO | Static | N/A | T | System status with fuzzy | B | Vulnerability | V | Network | General |
| 31 | Hempel *et al.* (2018) | 2018 | Power<br>Transportation | Blackout | Ex-ante<br>Ex-post | MESO | ST, LT | General | T, O | Node, link, network related indicators | B | Criticality | V | ER | General |
| 32 | Rueda *et al.* (2018) | 2018 | Power | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B, C | Robustness | V | Network | P<br>G |
| 33 | Mo *et al.* (2018) | 2018 | Water<br>Energy | Future Changes | Ex-ante | MESO | LT | City | S | Demands and supply | C | Resilience<br>Sustainability | V | ABM<br>SD | L, T |
| 34 | Mao & Li (2018) | 2018 | Electric power<br>Telecommunication<br>Water supply | Typhoon | Ex-ante | MESO | Static | City | T | Node, link, network related indicators | B | Impact<br>Resilience | R | Network | P |
| 35 | Tsavdaroglou *et al.* (2018) | 2018 | 7 CIs | Extreme Climatic Events | Ex-ante<br>Ex-post | MESO | Static | Nation | T, O | Time to recover<br>Exposure to hazard | C | Risk<br>Vulnerability | R | ER | P |
| 36 | Zhang *et al.* (2018b) | 2018 | Electricity<br>Water | General | Ex-post | MESO | ST | N/A | T | Node, link, network related indicators | B, C | Restoration | V | Network | P |
| 37 | Antenucci & Sansavini (2018) | 2018 | Electric<br>Gas | Demand surge | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B, C | Adequacy<br>Security | V | Network | P |

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | Lu *et al*. (2018) | 2018 | Water<br>Electricity | General | Ex-ante | MESO | Static | Community | T | Water capacity<br>Electricity capacity | C | Vulnerability | R | Network | P |
| 39 | Rocco *et al*. (2018) | 2018 | Community<br>Electric power | General | Ex-post | MESO | ST | N/A | T | Node status | B, C | Recovery | V | OT<br>Network | P |
| 40 | Liu *et al*. (2018) | 2018 | General | General | Ex-ante | MESO | Static | N/A | T | Node status preserved with the probability | B, C | Percolation | V | Network | General |
| 41 | Zhang *et al*. (2018a) | 2018 | General | General | Ex-post | MACRO | LT | Nation | E | Inoperability<br>Restoration capacity<br>Amount of resources<br>…… | C | Restoration | R | IIM | L |
| 42 | Duan *et al*. (2018) | 2018 | Communications<br>Power | General | Ex-post | MESO | ST | N/A | T | Node, link, network related indicators | B, C | Reliability | V | Network | P, C |
| 43 | Chen *et al*. (2018) | 2018 | Communications<br>Power | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B, C | Robustness<br>Redundancy | V | Network | P |
| 44 | Banerjee *et al*. (2018) | 2018 | Power<br>Communication | General | Ex-ante | MESO | Static | Nation | T | Node, link, network related indicators | B | Robustness | R | Network | P |
| 45 | Johansen & Tien (2018) | 2018 | Power<br>Water<br>Gas | General | Ex-ante<br>Ex-post | MESO | Static | County | T | Failure probabilities for each component | B | Repair. | R | Bayesian network | G |
| 46 | Korkali *et al*. (2017) | 2017 | Communications<br>Smart grid | General | Ex-ante | MESO | Static | Nation | T | Node status | B, C | Risk | R | Network | P |
| 47 | Zimmerman *et al*. (2017) | 2017 | Electric Power<br>Transportation<br>Water Supply | Extreme Weather | Ex-ante<br>Ex-post | MESO | ST | Nation | G | Infrastructure capacity<br>Demands<br>Supplies | C | Resilience | R | ER | P, G, L |
| 48 | Portante *et al*. (2017) | 2017 | Electricity<br>Gas | Pipe Breaks | Ex-ante | MESO | Static | Nation | T | Node, link, network related indicators<br>Total supply<br>Total demand | B, C | Interdependency | R | ER | P |
| 49 | Bloomfield *et al*. (2017) | 2017 | Electricity<br>Telecommunication | General | Ex-ante | MESO | ST | City | T | Node, link, network related indicators | C | Risk | R | Network | P |
| 50 | Heracleous *et al*. (2017) | 2017 | Water<br>Telecommunication<br>Power | General | Ex-ante | MACRO | ST | N/A | T | Water capacity | B, Ca, C | Interdependency | V | PBM | P, C, L,T |
| 51 | Faust *et al*. (2017) | 2017 | Portable water<br>Wastewater<br>Stormwater | Urban Decline | Ex-ante | MESO | LT | City | S | Water demand<br>Utility revenues<br>…… | C | Preparedness | V | SD<br>ABM | P, T |
| 52 | Alirezaei *et al*. (2017) | 2017 | Road<br>Economy | Climate Change | Ex-ante | MACRO | LT | Global | S, T | Air temperature<br>Infrastructure condition<br>Ocean temperature | Ca, C | Interdependency | R | SD | L, T |

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | Cheng (2017) | 2017 | General | Geo-Disasters | Ex-ante | MICRO | Static | City | G | Node, link, network related indicators | Ca | Interdependency | V | ER | P |
| 54 | Nan & Sansavini (2017) | 2017 | Sub-system in power | General | Ex-ante<br>Ex-post | MESO | ST | Nation | T | Power demand and served<br>…… | B, C | Resilience | R | Network | P, T |
| 55 | Dong & Frangopol (2017) | 2017 | Healthcare<br>Bridge | Earthquake | Ex-ante | MESO | ST | Region | T | Hospital functional level | Ca, C | Damage<br>Functionality | R | Indicator-based metrics | G |
| 56 | Min (2017) | 2017 | General | General | Ex-ante<br>Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Resilience | V | Network | P |
| 57 | Tian *et al.* (2017) | 2017 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Cascading Failures | V | Network | P |
| 58 | Hong *et al.* (2017) | 2017 | General | General | Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Recovery | V | Network | P, G |
| 59 | Yan *et al.* (2017) | 2017 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Vulnerability | V | Network | P |
| 60 | Yuan *et al.* (2017) | 2017 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Cascading Failures | V | Network | P |
| 61 | Korkali *et al.* (2017) | 2017 | Electricity<br>Telecommunication | General failures | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Cascading Failures | V | Network | P |
| 62 | Rueda & Calle (2017) | 2017 | Power<br>Telecommunication | Targeted attacks | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Reliability | V | Network | P |
| 63 | Peng & Poudineh (2016) | 2016 | Electricity<br>Gas | General | Ex-ante | MACRO | LT | Nation | T, S | Gas power supply<br>Gas production | C | Capacity | R | SD | L, T |
| 64 | Krishnamurthy *et al.* (2016) | 2016 | Power<br>Telecommunication | Earthquake | Ex-post | MICRO | ST | City | G | Power outages<br>Mobile outages | C | Restoration | R | ER | P |
| 65 | Kelly *et al.* (2016) | 2016 | 9 CIs | General | Ex-ante | MACRO | LT | UK | E | Sector output | C | Vulnerability | R | IIM | L |
| 66 | Reed *et al.* (2016) | 2016 | Power<br>Telecommunication | Weather-Related Hazards | Ex-post | MICRO | ST | N/A | T, S | Customers affected | C | Resilience | R | ER | P |
| 67 | Rahnamay-Naeini & Hayat (2016) | 2016 | Electric<br>Cyber | General | Ex-ante | MESO | ST | N/A | G | Number of failures<br>Probability | C | Risk | V | ER | P |
| 68 | Omega *et al.* (2016) | 2016 | General | Supply change | Ex-ante | MACRO | LT | Community | E | Sector output | C | Risk | R | IIM | L |
| 69 | Yazdani & Azizi (2016) | 2016 | Water supply<br>Gas<br>Drainage<br>Electricity<br>Telecommunication<br>Transportation | General | Ex-post | MICRO | ST | Community | T | Pattern description | B | Restoration | R | ER | P, G |

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | Sharkey *et al.* (2016) | 2016 | General | Hurricane | Ex-post | MICRO | ST | Region | S, O, T | Pattern description | B | Restoration | R | ER | P, G |
| 71 | Haraguchi & Kim (2016) | 2016 | Electricity<br>Transportation<br>Health care<br>Building<br>…… | Hurricane | Ex-ante | MICRO | ST | City | T | Pattern description | B | Damage | R | ER | G |
| 72 | Tri-Dung *et al.* (2016) | 2016 | Water supply<br>Biomass production<br>Refineries | General | Ex-ante<br>Ex-post | MICRO | LT | N/A | T | Long-term functionality | C | Resiliency<br>Sustainability | V | ER<br>Indicator-based metrics | P |
| 73 | MacKenzie *et al*. (2016) | 2016 | Tourism<br>Real estate<br>Petro | Oil leakage | Ex-post | MICRO | ST | Nation | E | Sector output | C | Recovery | V | OT | L |
| 74 | Liu *et al*. (2016) | 2016 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Redundancy | V | Network | P |
| 75 | Ouyang (2016) | 2016 | Power<br>Gas | Spatially localized attacks | Ex-ante | MESO | Static | Harris County | T | Node, link, network related indicators | B | Performance Metrics | R | Network | P, G |
| 76 | L.Zhang *et al.* (2016) | 2016 | Power<br>Transportation | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Reliability | V | Network | P, G |
| 77 | Hong *et al.* (2016) | 2016 | General | General | Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Failure<br>Restoration | V | Network | P, G |
| 78 | Gonzalez *et al.* (2016) | 2016 | Gas<br>Water | Earthquake | Ex-post | MESO | Static | County | T | Node, link, network related indicators | B | Restoration | R | Network | P, G |
| 79 | Y. Zhang *et al.* (2016) | 2016 | Power<br>Water | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Vulnerability | V | Network | P |
| 80 | Wu *et al.* (2016) | 2016 | Power<br>Oil | Terrorist attacks | Ex-ante | MESO | Static | County | T | Node, link, network related indicators | B | Failures | R | Network | P, G |
| 81 | Pant *et al.* (2016) | 2016 | Railway<br>Electricity<br>Telecommunication<br>Natural Gas<br>Liquid/Solid fuels<br>Water | Random component failures | Ex-ante | MESO | Static | Nation | T | Node, link, network related indicators | B | Vulnerability | R | Network | P |
| 82 | Loggins & Wallace (2015) | 2015 | Power<br>Water<br>Hospital<br>Fire<br>…… | Hurricane | Ex-ante | MESO | Static | County | T | Power outage Water outage Waste outage<br>…… | B, Ca | Damage | R | ER | P |
| 83 | Yang *et al.* (2015) | 2015 | Gas<br>Power | General | Ex-ante | MICRO | LT | Nation | E | Power transmission limits<br>Gas pipeline flow<br>…… | C | Effects | V | ER | L |

| No. | Sources | Year | Interdependent infrastructures | Background events | Oriented process | Abstraction Level | Temporal scale | Spatial scale | Types of impacts | Measurement of infrastructure performance | Granularities of MIP | Ultimate Outcomes | Case | Methods | Interdependency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84 | Chopra & Khanna (2015) | 2015 | General | General | Ex-ante | MACRO | LT | Nation | E | Inoperability | C | Preparedness | R | ER<br>IIM | L |
| 85 | Thomas *et al.* (2015) | 2015 | Power<br>Telecommunication<br>Transportation<br>Wastewater | General | Ex-post | MESO | Static | County | T | Supply Nodes<br>Demand Nodes | B, C | Restoration | V | Network | P, G |
| 86 | Ntalampiras *et al.* (2015) | 2015 | Power<br>Telecommunication | General | Ex-post | MESO | ST | N/A | T | Voltage<br>…… | B, C | Diagnosis | V | Hmm | P, T |
| 87 | Xu *et al.* (2015) | 2015 | Transportation<br>Gas | General | Ex-post | MACRO | LT | Nation | E | Sector output | C | Restoration | V | IIM | L |
| 88 | Hwang *et al.* (2015) | 2015 | General | Earthquake | Ex-post | MESO | LT | City | T | Damage ratio<br>Shortage of transport service<br>…… | C | Recovery | R | SD | P, L, T |
| 89 | Shekhtman *et al.* (2015) | 2015 | Electricity,<br>Telecommunication | General | Ex-ante<br>Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Resilience | R | Network | P |
| 90 | Hong *et al.* (2015) | 2015 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Failure Cascade | V | Network | G |
| 91 | Chen *et al.* (2015) | 2015 | General | Extreme events | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Failures | V | Network | G |
| 92 | Z. Dong *et al.* (2015) | 2015 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Robustness | V | Network | G |
| 93 | Chen *et al.* (2015) | 2015 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Control | V | Network | G |
| 94 | R. Li *et al.* (2015) | 2015 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Vulnerability | V | Network | P |
| 95 | Ouyang & Wang (2015) | 2015 | Electricity<br>Gas | Hurricane | Ex-post | MESO | Static | N/A | T | Node, link, network related indicators | B | Restoration | V | Network | P |
| 96 | Sharkey *et al.* (2015) | 2015 | Power<br>Telecommunication<br>Transportation<br>Wastewater | General | Ex-post | MESO | Static | County | T | Node, link, network related indicators | B, C | Restoration | V | Network | P, G |
| 97 | G. Dong *et al.* (2015) | 2015 | General | General | Ex-ante | MESO | Static | N/A | T | Node, link, network related indicators | B | Robustness | V | Network | G |

**Table S2. Existing literature on integrating data-driven methods and physics-based approaches**

| No | Authors | Field | Ways of integration | | | | Reasons | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | For improvement | | For necessities | |
| | | | I-1 | I-2 | I-3 | I-4 | RI-1 | RI-2 | RI-3 | RI-4 |
| 1 | (Liang *et al.*, 2019) | Water Quantity and Quality | | √ | | | | √ | | |
| 2 | (Hanachi *et al.*, 2019) | Tool wear prediction | | | √ | | √ | | | |
| 3 | (Ren *et al.*, 2019) | Petroleum industry | √ | | | | √ | | | |
| 4 | (Wang *et al.*, 2019) | Manufacturing | | √ | | | | | √ | |
| 5 | Zhou *et al.* (2019) | Interdependent infrastructure (Water & Transport) | | | | √ | | | √ | √ |
| 6 | (Koponen *et al.*, 2018) | Electricity Power | | √ | √ | | | √ | | |
| 7 | (Rahman *et al.*, 2018) | Computing(Incompressible Flow Solvers) | √ | √ | | | | √ | | |
| 8 | (Giha *et al.*, 2018) | Hydrology | √ | | | | | √ | | |
| 9 | (Subramaniyan *et al.*, 2018) | Environment (PV Module Degradation) | √ | √ | | | | √ | √ | |
| 10 | (Kaneko *et al.*, 2018) | Petroleum industry (Offshore drilling) | | √ | √ | | √ | √ | √ | |
| 11 | (He, 2018) | Electricity Power(Battery) | √ | | | | | √ | | |
| 12 | (Das & Samuel, 2018) | General | √ | | | | √ | | | |
| 13 | (Guo *et al.*, 2017) | Petroleum industry (Waterflooding) | √ | | | | | | | |
| 14 | (Zhou *et al.*, 2017) | Building (HAVC Systems) | √ | | | | | √ | | |
| 15 | (Hegde *et al.*, 2017) | Petroleum industry (drilling, rate of penetration) | √ | | | | √ | √ | | |
| 16 | (Mount *et al.*, 2017) | Hydrology | | | | | | √ | √ | |
| 17 | (Mahdi *et al.*, 2017) | Hydrology | √ | | | | | √ | | |
| 18 | (Byram *et al.*, 2017) | Computing(image reconstruction) | √ | | | | √ | | | |
| 19 | (Christelis & Mantoglou, 2017) | Petroleum industry | √ | | | | √ | √ | | |
| 20 | (Artun, 2017) | Petroleum industry (waterflooded reservoirs) | √ | | | | | √ | | |
| 21 | (Vaghefi *et al.*, 2016) | Building (HAVC Systems) | | | √ | | | √ | | |
| 22 | (Shahidi, 2016) | Building (structure) | √ | | | | | √ | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | (An *et al.*, 2015) | General (Condition based maintenance) | ✓ | | | | | ✓ | | |
| 24 | (Klie, 2015) | General (Industry Production) | ✓ | | | | | ✓ | | |
| 25 | (Li *et al.*, 2015) | Manufacturing (Predict condition of components) | | | | | | | | |
| 26 | (Chen *et al.*, 2014) | Electricity Power | ✓ | | | | | ✓ | | |
| 27 | (Hofleitner, 2013) | Transportation | ✓ | | | | | ✓ | | |
| 28 | (Xie *et al.*, 2012) | Electricity Power | ✓ | ✓ | | | ✓ | ✓ | | |
| 29 | (Ji *et al.*, 2012) | Hydrology (Flood) | ✓ | | | | | ✓ | ✓ | |
| 30 | (Pendse *et al.*, 2012) | Weather (Rainfall) | | ✓ | | | | ✓ | | |
| 31 | (Ki Ooi *et al.*, 2005) | Agriculture (Irrigation channels) | ✓ | | ✓ | | | | | ✓ |

As the 31 publications have specific scenarios, it is arduous to compare the pros and cons of DDMs and PBMs, but general motivations on why these researchers integrate DDMs and PBMs could be summarized. The motivations can be divided into two categories, namely “reasons for improvements” (RI) and “reasons for necessities” (RN).  More specifically, they include (i) RI-1: to improve the efficiency and performance in order to save time and cost. For example, physics-based methods are high cost dramatically with the increase of system complexity; the process of data collection also may be too time-consuming to be abandoned. (ii) RI-2: to improve the accuracy and reliability through the ensemble of two types of methods, For example, data-driven methods are usually complained due to that it lack mature theory as the foundation to provide results with enough reliability; cross-validation of the results from the two categories of methods could enhance the overall reliability. (iii) RN-1: to make up the lack of data. Available and accessible data is so-limited compared with the complex infrastructure system in real world, but data-driven methods normally demands huge data with enough information density. (iv) RN-2: to make up the lack of physical knowledge. Although great efforts have been paid to investigate the physical operations of critical infrastructures, there are not all infrastructures’ failure mechanisms fully understood, and exiting physical knowledge cannot effectively simulate their failure processes.

According to the reasons, there are several typical ways to realize the integration of these DDMs and PBMs including: (i) I-1: Data-driven methods generate parameters for physics-based methods, corresponding to RI-1 or RN-2; (ii) I-2: Utilizing results from physics-based methods to training Data-driven methods, corresponding to RN-1; (iii) I-3: Compare/Validate the results of data-driven methods and physics-based methods from each other, corresponding to RI-2; (iv) I-4:  Applying DDM or PBM respectively for different infrastructure systems or sub-systems, mainly corresponding to RN-1 and RN-2. The former three integration ways (i.e., I-1, I-2, and I-3) focus on a single system, but the last one (i.e. I-4) is at a system of system level, which is also the integration type in our proposed framework.

**Table S3: Detailed text-mining process of extracting the failure pattern of water pipe bursts in Hong Kong**

| (i) Data collection |
|---|
| Using 'water pipe burst' and 'water main burst' as the keywords for searching, 2,731 news articles reporting water pipe bursts between 01.01. 2000 and 31.12.2018 were retrieved from Wise News – the largest news repository in Great China containing almost all newspapers published in Hong Kong. Information embedded in these news articles can be used as raw empirical records to monitor the development and performance of a city's urban infrastructures (Bigger *et al.*, 2009; Chang *et al.*, 2009; Luiijf *et al.*, 2009; McDaniels *et al.*, 2007; McDaniels *et al.*, 2015; Sharkey *et al.*, 2015; Van Eeten *et al.*, 2011). They additionally play an unseen filtration role in ignoring insignificant issues and focusing on key events. |
| **(ii) Data cleansing** |
| The collected news articles need to be cleansed for subsequent analysis. In this study, the articles were cleansed by following the principles of 'Authority', 'Accuracy', and 'Uniqueness' (Chapman, 2005). 'Accuracy' mainly refers to amending garbled texts and removing items with missing values; the resulted texts were encoded with UTF-8 scheme and 69 null items were ruled out. 'Authority' means that only trusted and authoritative newspapers were included as our data sources; there were only 16 of the 31 newspapers included, leading to that 47 news articles were excluded. 'Uniqueness' refers to deleting repeating news articles; this resulted in 152 news articles being removed. 'Uniqueness' also includes combining news reports on the same event. To do this, the degrees of similarity of the news were calculated with the TF-IDF algorithm and SimHash algorithm. After applying these principles in the data cleansing step, 1028 cleaned news sets – regarded as 1028 water pipe bursts – were obtained for further data mining. |
| **(iii) Domain knowledge preparation** |
| General natural language processing (NLP) tools for livelihood scenarios cannot be applied directly to extract infrastructure interdependency and failure patterns from cleansed news articles. In order to apply the tools to a vertical field users need to prepare domain knowledge components first, such as 'keywords for searching' (Kryvasheyeu *et al.*, 2016), 'index words' (Yuan & Liu, 2018) or 'trigger words' (Li *et al.*, 2018). In our current research, four domain knowledge components are prepared to help derive target infrastructure insights. Corresponding to the target information, hotspot areas, high-incidence time, and potential consequences of water pipe bursts, the components are listed in Table belwo consisting of: (i) Hong Kong Location Dictionary containing more than 5000 roads covering the whole city, which is collected from Commercial Map API; (ii) Regular expression of time, such as 'a certain number'+'o'clock'+'today/yesterday'; (iii) Trigger words of pipe bursts, such as 'burst', 'erupt', 'happen', 'explode', and 'break'; and (iv) Damage words regarding the consequences, such as 'close', 'wade', 'sunk', 'collapse', 'subside', 'congestion', 'jam', and 'slow' suggested by Yuan and Liu (2018). The basic rules are determined based on existing research and expertise, and they are iteratively updated according to the performance in step v (i.e., verification). |

Table of Domain knowledge components prepared and target information extracted

| No. | Target feature information | Domain knowledge components | Target information extracted | Mining rules |
|---|---|---|---|---|
| 1 | Hot areas | Hong Kong location dictionary | Location of water pipe bursts | • Could be null<br>• One news normally has one affected road. When it happened in interaction, both roads will be regarded as affected roads.<br>• Location in the title are prior to the location in the text<br>• Location closer to the article beginning has higher priority |

| | | | | |
|---|---|---|---|---|
| 2 | High-incidence time | Regular expression of time & Trigger words | Time of water pipe bursts | • Could be null<br>• Time and trigger words should appear in a short sentence. For example, in the sentence that 'a water pipe burst *happened* (trigger words) at *eight o'clock yesterday morning* (time)', 'happened' is a trigger word, and 'eight o'clock yesterday morning' is the time, then this time will be regarded as the bursting time of the water pipe failure.<br>• Time closer to the article beginning has higher priority |
| 3 | Potential consequences on road transport system | Affected infrastructures &Corresponding damage word list | Consequences of water pipe bursts | • Could be null<br>• Using road transport as an example, the affected infrastructures words include 'road', 'vehicles', 'streets' and so on; damage words include 'closure', 'wade', 'collapsed' (Table S4). |

Note: Specific contents of domain knowledge components are accessible in **Table S4**.

**(iv) Feature selection and extraction**

Three categories of target information are automatically extracted from the news. To realize the automatic process, a Python application was developed using the cross-platform integrated development environment PyCharm from JetBrains. The program was written based on a series of open libraries, including the *Scrapy* for web-crawler, *Jieba* and *NLTK* for keyword extraction, *NumPy* for scientific calculation, *OpenCC* for mixed language processing, and *pyExcelerator* and *PyMySQL* for data storage. The Python source code of the application together with a series of dependent packages has been uploaded to GitHub repository; all researchers can check out the source code for academic use and further enhancement.

**(v) Verification of extracted information**

To test the completeness and correctness of information extracted, 'Accuracy' is introduced to check the performance of the domain knowledge components (Yuan & Liu, 2018); it is defined as the ratio of the number of news from which information is correctly extracted to the total number of sample news articles. In current study, 100 out of the 1,028 news sets (at a 90% confidence level) were randomly selected; the selected news sets were manually labeled with the incidents' location, time, and consequence for comparison with the results extracted automatically. For this study, the text-mining accuracy of burst location, burst time, and consequence are respectively 92%, 90%, and 95%, which confirm the effectiveness of the domain knowledge components and mining rules prepared. Should the accuracy be unsatisfactory, it is necessary to adjust the domain knowledge components according to the errors occurred in the sample news articles. The information extracted (i.e. burst location, burst time, and consequence ) in each news set as well as the verification details are presented in next Appendix.

**Table S4. Raw data, intermediate products, and results of the text-mining approach**

| Associated steps of the text-mining in Appendix III | Name of Sheets in the Excel | Description of the contents |
|---|---|---|
| (i) Data collection | 1. News collected | • 2731 News articles on water pipe bursts<br>• Title<br>• Contents<br>• News Date<br>• Newspapers<br>• Is the content null?<br>• Hash value of the contents.<br>• Is the newspaper source authoritative?<br>• …… |
| (ii) Data cleansing | 2. News cleansed | • 2454 remained news and corresponding 1028 news sets reporting the pipe burst incidents |
| (iii) Domain knowledge preparation | 3.Domain knowledge components | • Streets/Roads<br>• Regular expression for automatically extracting pipe burst time<br>• Trigger words of burst time<br>• consequences on road transport system<br>• Trigger words of road transport system |
| (iv) Information extraction | 4.All information extracted | • Affected roads in each news articles<br>• Bursting time<br>• Consequence on road transport system |
| (v) Verification of extracted information | 5.Verification | • Are the 'Locations' identified true or false?<br>• Are the 'Burst time' identified true or false?<br>• Are the 'consequences' identified true or false? |
| Text-mining Results | 6.Results_burst location | • Statistical data of bursting locations for ArcGIS visualization |
| | 6. Results_ burst time | • Statistical data of bursting time for ArcGIS visualization |
| | 6. Results_ consequence | • Statistical data of consequences observed on road transport system for |

The Excel file is accessible in "[https://github.com/0AnonymousSite0/Integrating-Data-Driven-and-Physics-Based-Approaches](https://github.com/0AnonymousSite0/Integrating-Data-Driven-and-Physics-Based-Approaches)". Here, Table S4 is Specification of the contents contained in the Excel file.

**Table S5. Experts who help explains the text-mining results of water pipe bursts**

| No. | Identify | Experience on infrastructure management |
|---|---|---|
| 1 | Staff in Water Supplies Department | >5 years |
| 2 | Member of Advisory Committee on Water Supplies | >10 years |
| 3 | Professor in University of Hong Kong (Infrastructure management direction) | >15 years |
| 4 | Staff in Transport Department | >5 years |
| 5 | Assistant Professor in University of Hong Kong (Water managment direction) | >5 years |

**Table S6. Values and sources of each paramters in the traffic simulation model**

The Excel file is accessible in the supplemental material or in "https://github.com/0AnonymousSite0/Integrating-Data-Driven-and-Physics-Based-Approaches".

**Table S7. Calibration of the traffic model under normal scenario**

The Excel file is accessible in the supplemental material or in "https://github.com/0AnonymousSite0/Integrating-Data-Driven-and-Physics-Based-Approaches".

**Table S8. Results of the traffic flow simulation**

The Excel file is accessible in the supplemental material or in "https://github.com/0AnonymousSite0/Integrating-Data-Driven-and-Physics-Based-Approaches".

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