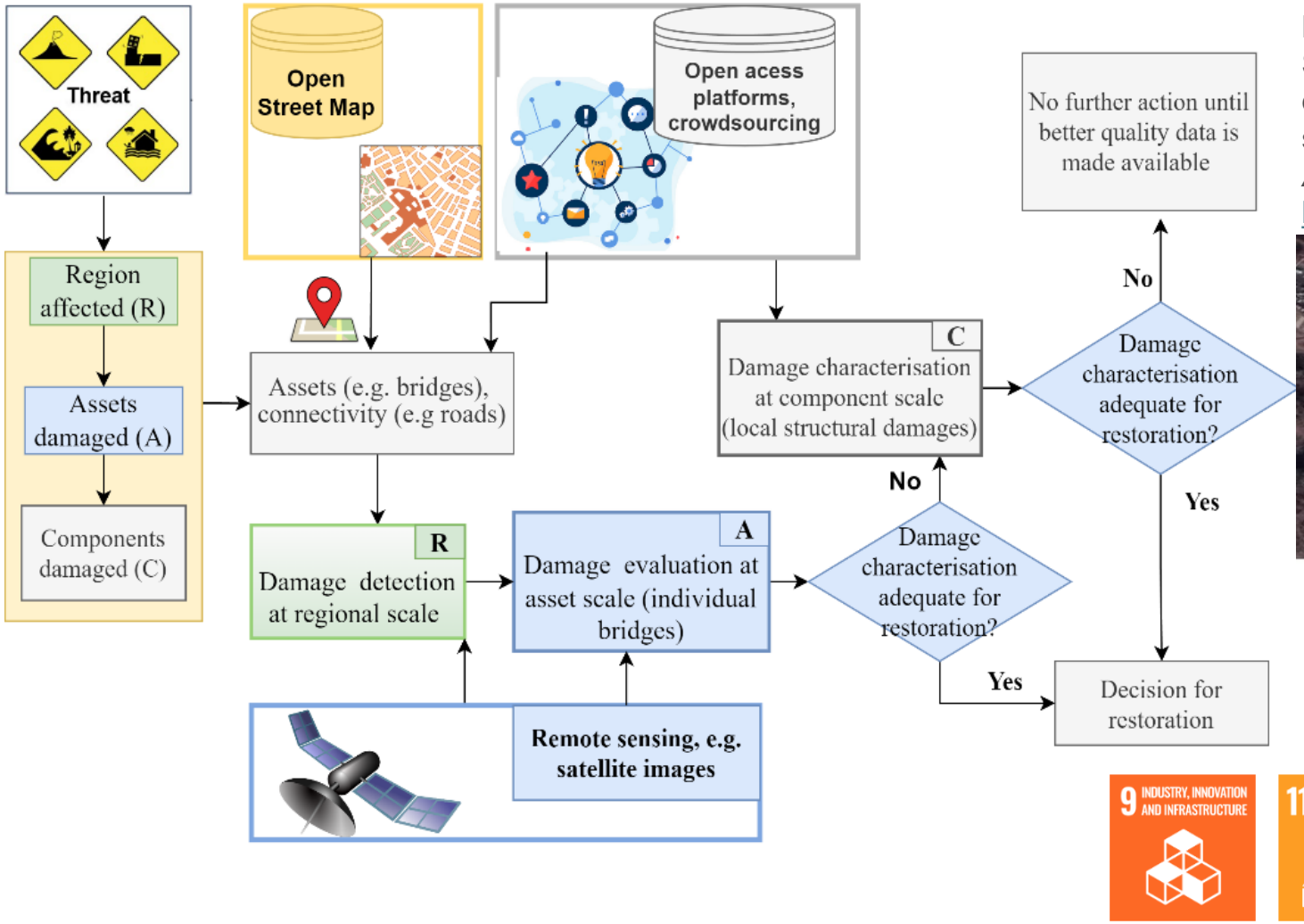
Research-Based Strategies for Post-Conflict Infrastructure Resilience and Recovery

Rapid post-disaster infrastructure damage characterisation

bridgeUkraine - for a sustainable and resilient future



Kopiika, N., Karavias, A., Krassakis, P., Ye, Z., Ninic, J., Shakhovska, N., Argyroudis, S., Mitoulis, S. A. (2025). Rapid post-disaster infrastructure damage characterisation using remote sensing and deep learning technologies: A tiered approach. *Automation in Construction*, 170, 105955. http://dx.doi.org/10.1016/j.autcon.2024.105955

Follow this research:

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

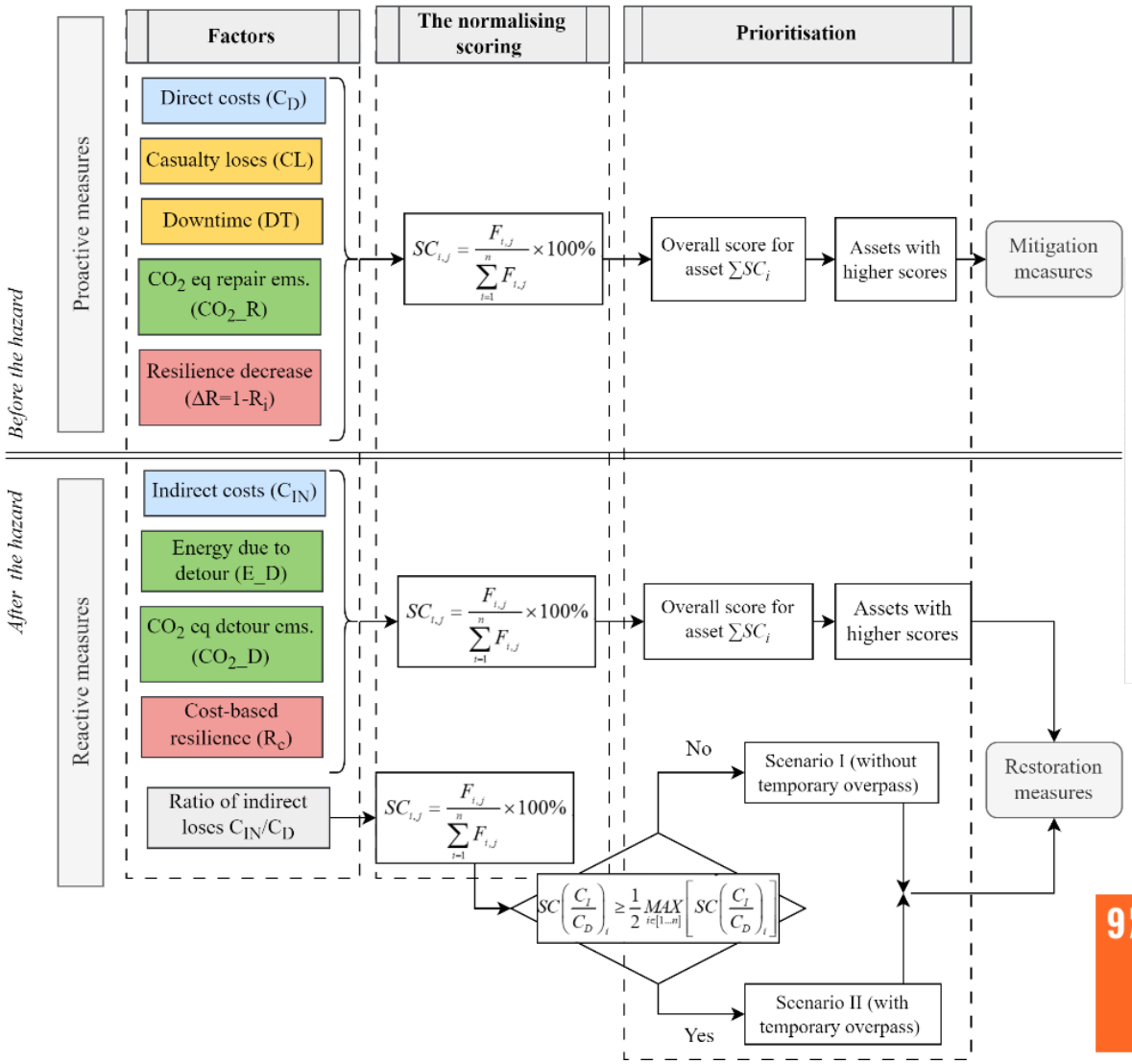
11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

We present a multi-scale tiered approach, which enables automated damage characterisation, achieved using digital technologies across regional to component scales: using Sentinel-1 SAR images, crowdsourced data, and high-resolution images for deep learning. The holistic methodology enhances the reliability of damage characterisation at various scales, automates and accelerates decision-making, facilitating more efficient restoration and adaptation efforts and ultimately enhancing infrastructure resilience.

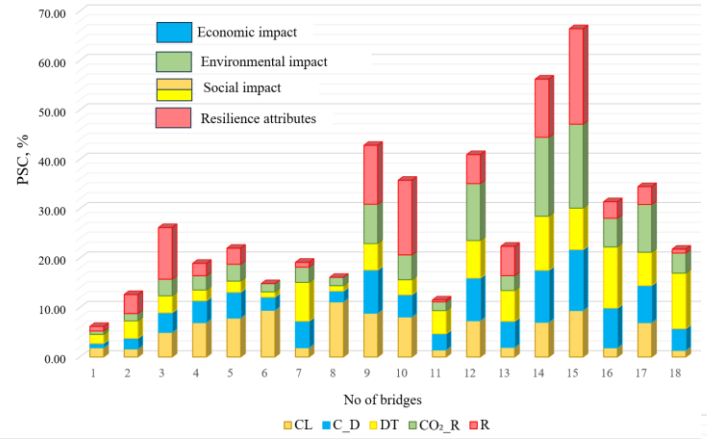
Sustainability and resilience-driven prioritisation for recovery

bridgeUkraine - for a sustainable and resilient future

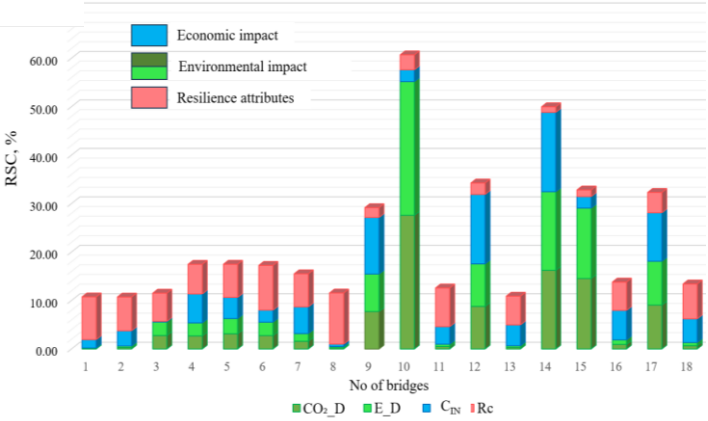


Factor	Label
Economic impact	
Environmental impact	
Social impact	
Resilience	

Kopiika, N., Di Bari, R., Argyroudis, S., Ninic, J., & Mitoulis, S. A. (2025). Sustainability and resilience-driven prioritisation for restoring critical infrastructure after major disasters and conflict. *Transportation Research Part D: Transport and Environment,* 104592. http://dx.doi.org/10.1016/j.trd.2025.104592



Follow this research:



This research introduces a novel framework for planning the recovery of bridge portfolios in conflict-affected regions, using a scoring system that incorporates integrated resilience and sustainability metrics. The method provides novel insights for guiding strategic investment allocation for infrastructure recovery that balances proactive and reactive measures in conflict zones.

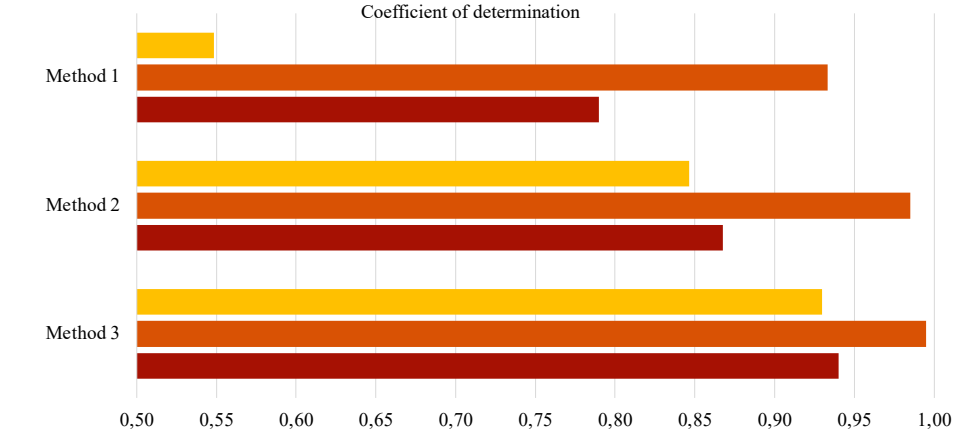
Non-Destructive Bridge Damage State Identification

bridgeUkraine - for a sustainable and resilient future

Problems from the AI perspective:

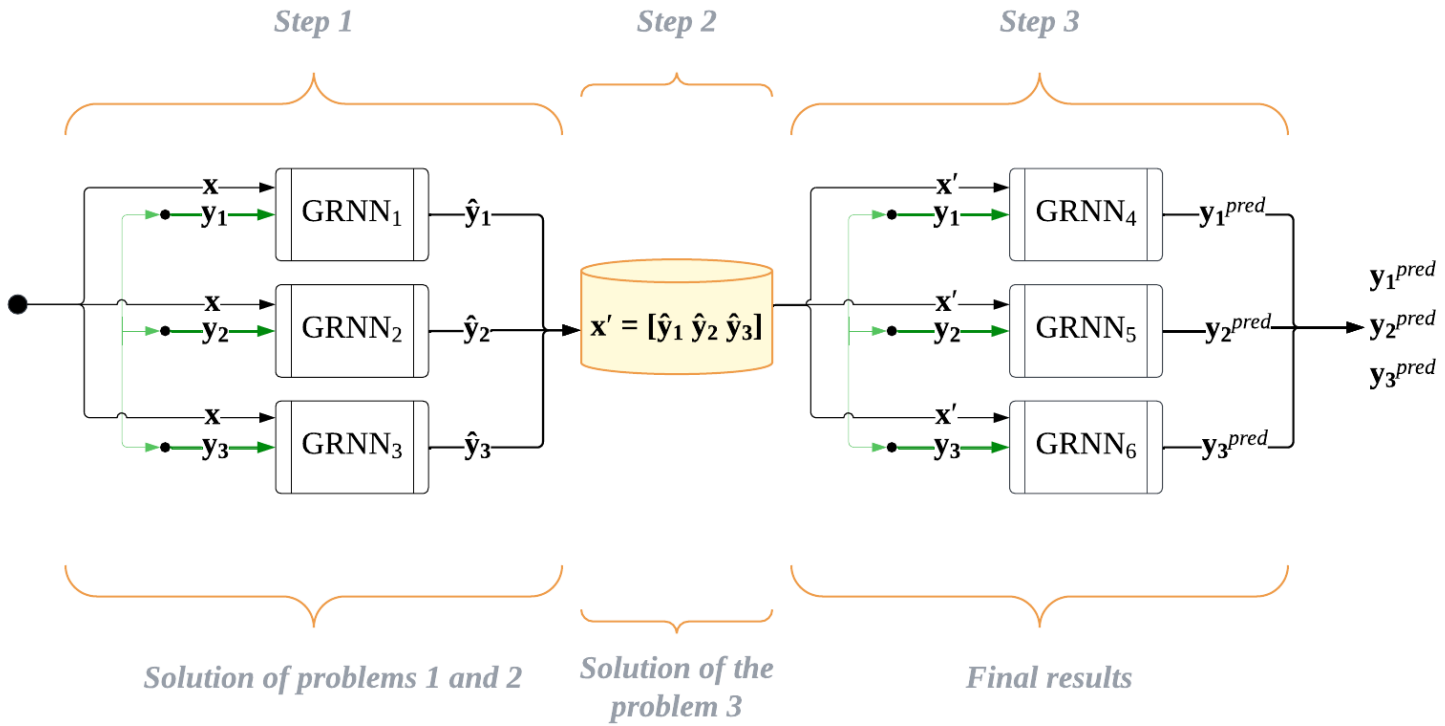
- Extremely short dataset
- Prediction of 3 outputs based on the same inputs.
- 3 desired outputs are interconnected.

Results



	Method 3	Method 2	Method 1
R2 for Zone 3	0,93	0,85	0,55
R2 for Zone 2	0,995	0,99	0,93
R2 for Zone 1	0,94	0,87	0,79

Proposed solution: A GRNN-based Cascade Ensemble Model



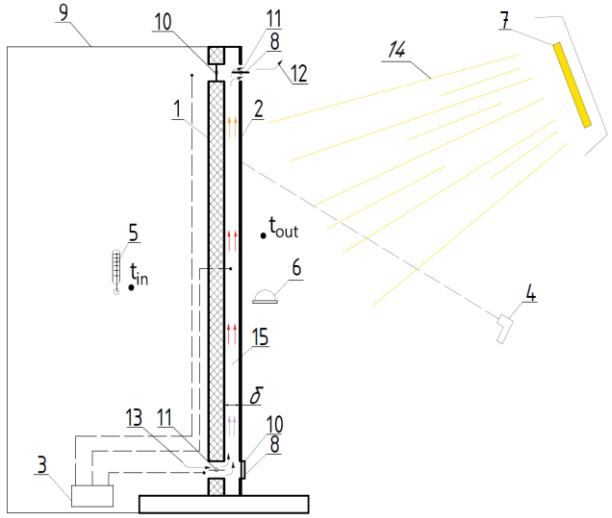
Method 1: Kazantzi AK, Moutsianos S, Bakalis K, Mitoulis SA. Cause-agnostic bridge damage state identification utilising machine learning, *Engineering Structures*, 320:118887; 2024.

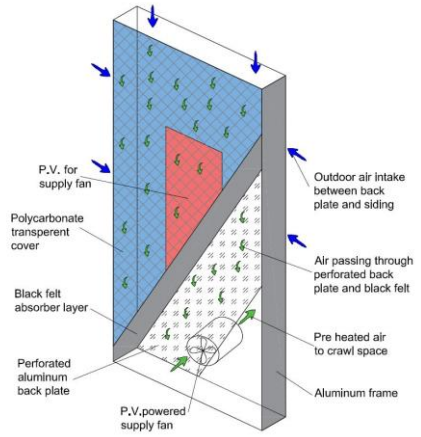
Method 2: Izonin I, Kazantzi A, Tkachenko R, Mitoulis SA. GRNN-based Cascade Ensemble Model for Non-Destructive Damage State Identification: Small Data Approach. *Engineering with Computers*; 2024a.

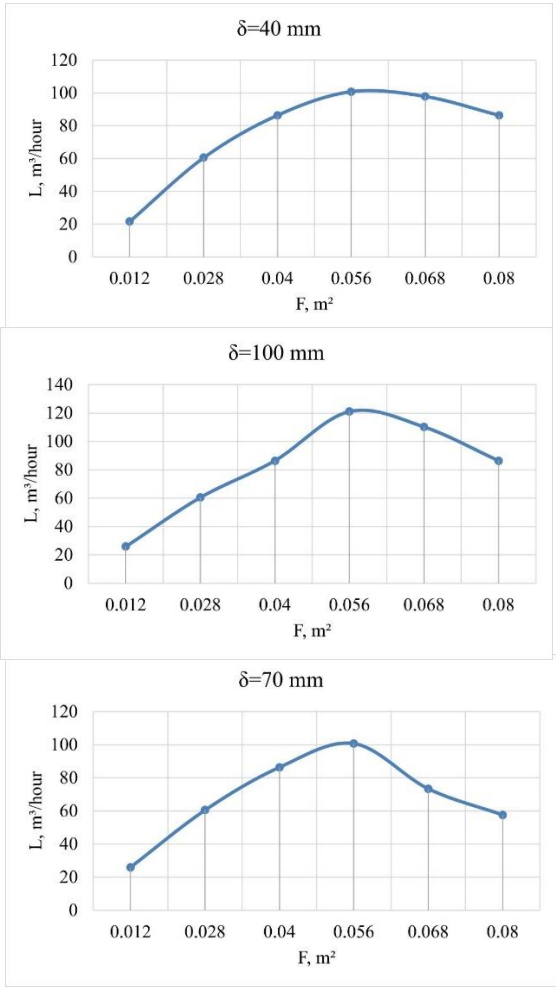
Method 3: Izonin I, Nesterenko I, Kazantzi AK, Tkachenko R, Muzyka R, Mitoulis SA. Enhanced ANN-based ensemble method for bridge damage characterization using limited dataset, *Scientific Reports*, 14:24395; 2024b.

Passive ventilation of residential buildings using the trombe wall

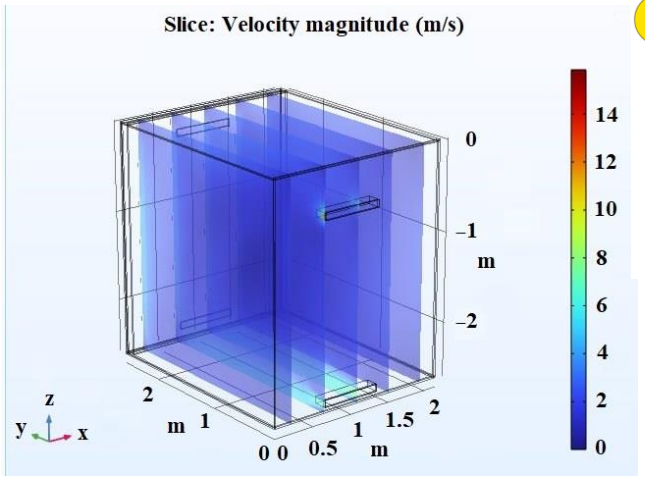
bridgeUkraine - for a sustainable and resilient future

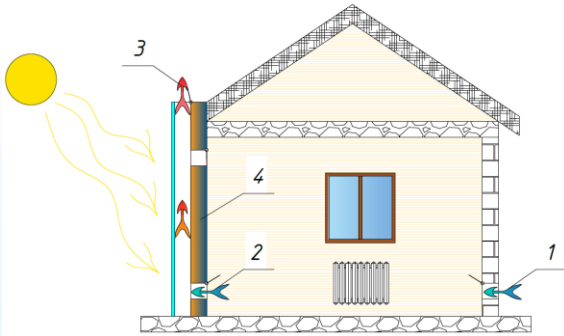






Myroniuk, K., Furdas, Y., Zhelykh, V., Adamski, M., Gumen, O., Savin, V., & Mitoulis, S. (2024). Passive Ventilation of Residential Buildings Using the Trombe Wall. *Buildings*, 14(10), 3154 *https://doi.org/10.3390/buildings14103154*

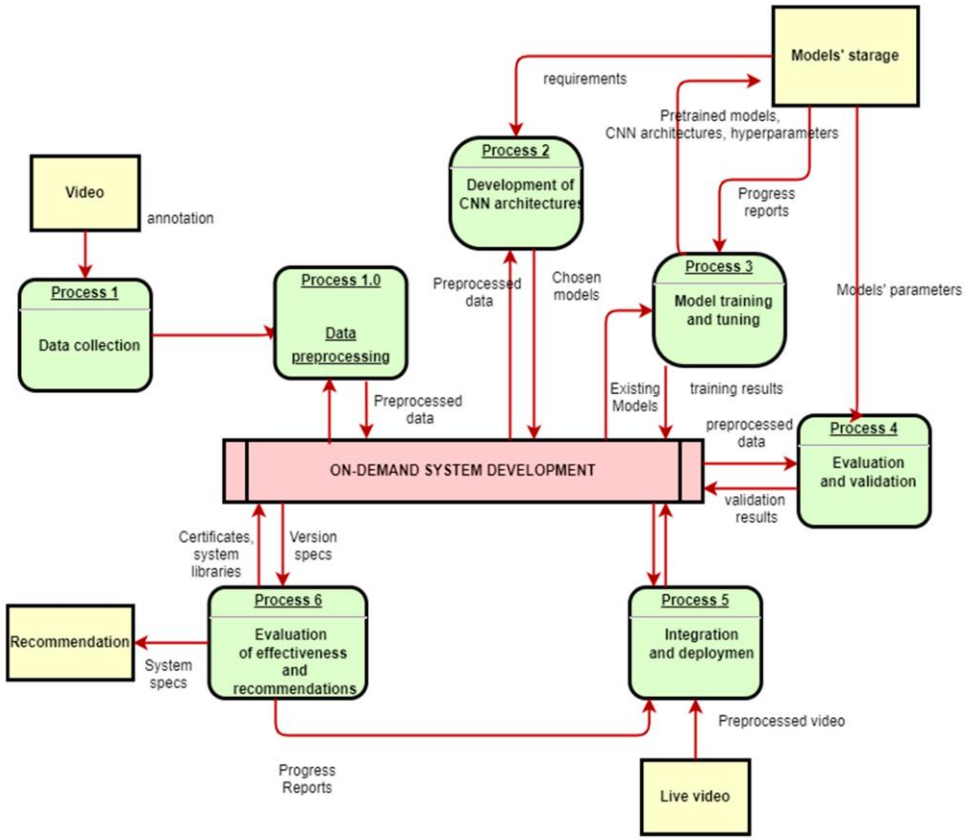




This study presents an innovative Trombe wall design for modular residential buildings, utilizing a black-painted metal sheet as a solar absorber and structural element. Experimental results confirm its effectiveness in facilitating passive ventilation, achieving air exchange rates from 1.5 h^{-1} to 7.1 h^{-1}. The optimal ventilation grille area is 2.5–3% of the wall's surface, ensuring efficient natural convection. While conducted under controlled conditions, the findings highlight the potential for energy savings. Future research will focus on real-world testing, climate adaptability, and integration with other passive technologies to enhance energy efficiency in modular housing.

Real-Time Monitoring of Road Networks for Pavement Damage Detection Based on Preprocessing and Neural Networks

bridgeUkraine - for a sustainable and resilient future

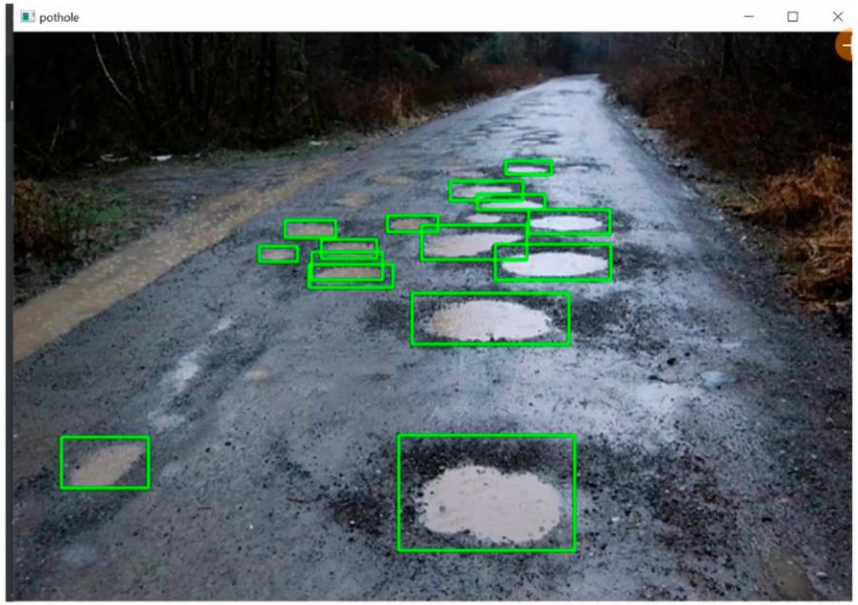


The flowchart of the proposed methodology

image before preprocessing

image after preprocessing

Shakhovska N, Yakovyna V, Mysak M, Mitoulis SA, Argyroudis S, Syerov Y. (2024). Real-Time Monitoring of Road Networks for Pavement Damage Detection Based on Preprocessing and Neural Networks. *Big Data and Cognitive Computing*, 8(10), 136. https://doi.org/10.3390/bdcc8100136



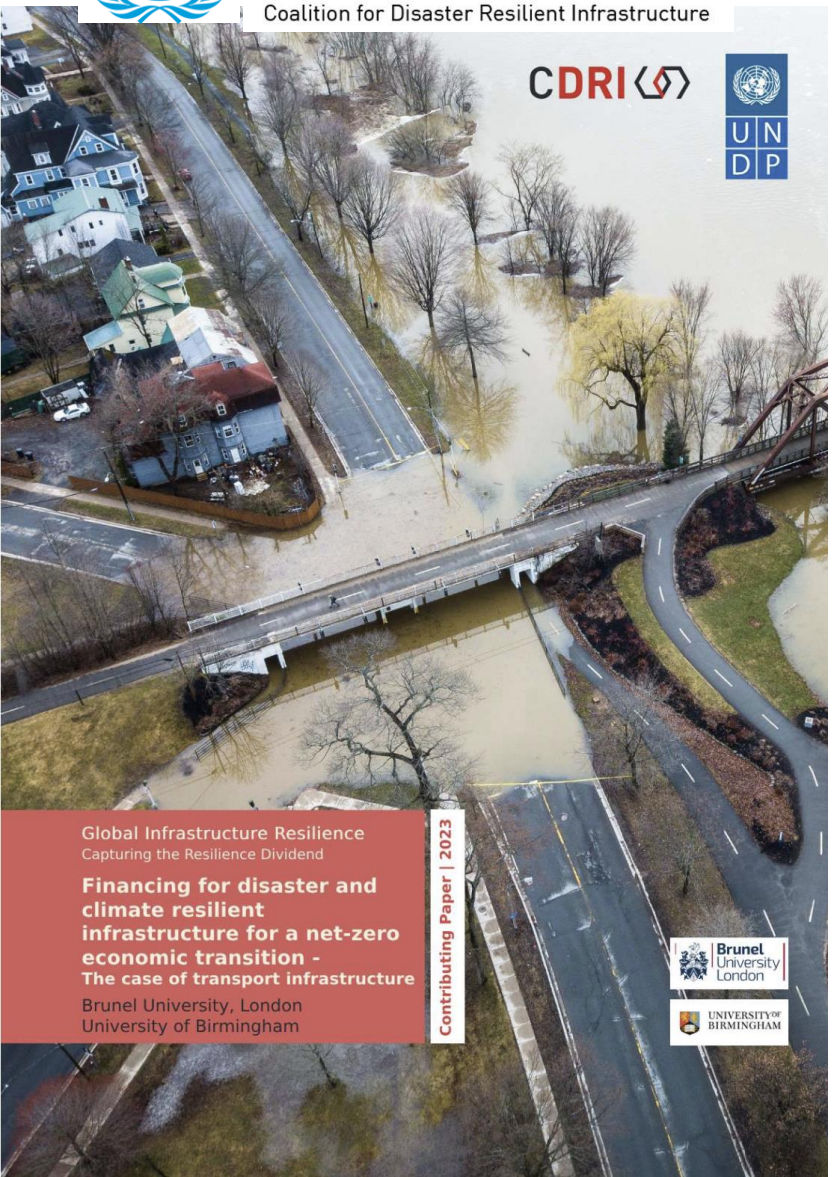
An example of multiple potholes on the road after rain in real-time

A novel multi-initialization model for recognizing road surface damage, e.g. potholes and cracks, on video using convolutional neural networks (CNNs) in real-time for fast damage recognition. The results obtained can enhance the safety and efficiency of road pavement and, hence, its traffic quality and contribute to decision-making for the maintenance and restoration of road infrastructure.

Financing for disaster and climate resilient infrastructure for a net-zero economic transition

bridgeUkraine - for a sustainable and resilient future

CDRI Coalition for Disaster Resilient Infrastructure



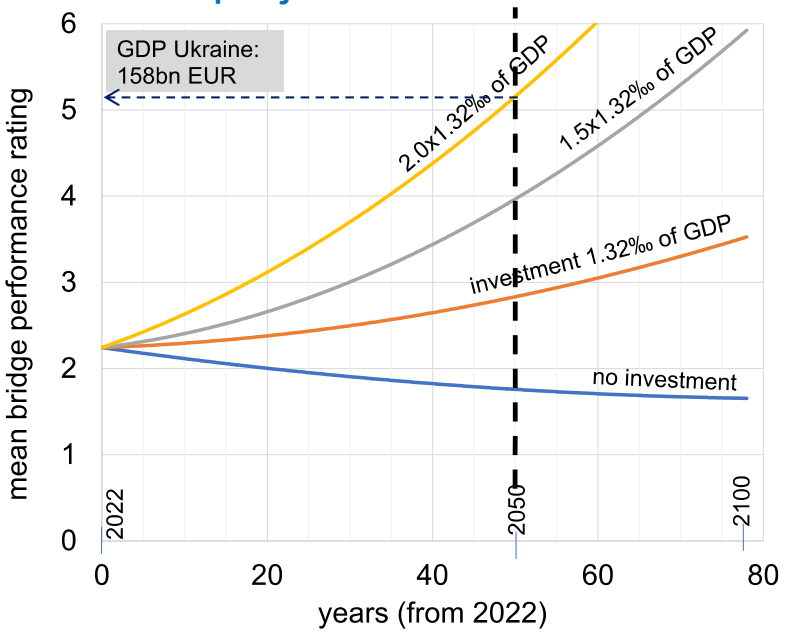
Global Flagship Report on Disaster and Climate Resilient Infrastructure

The report released in 2023 at G20

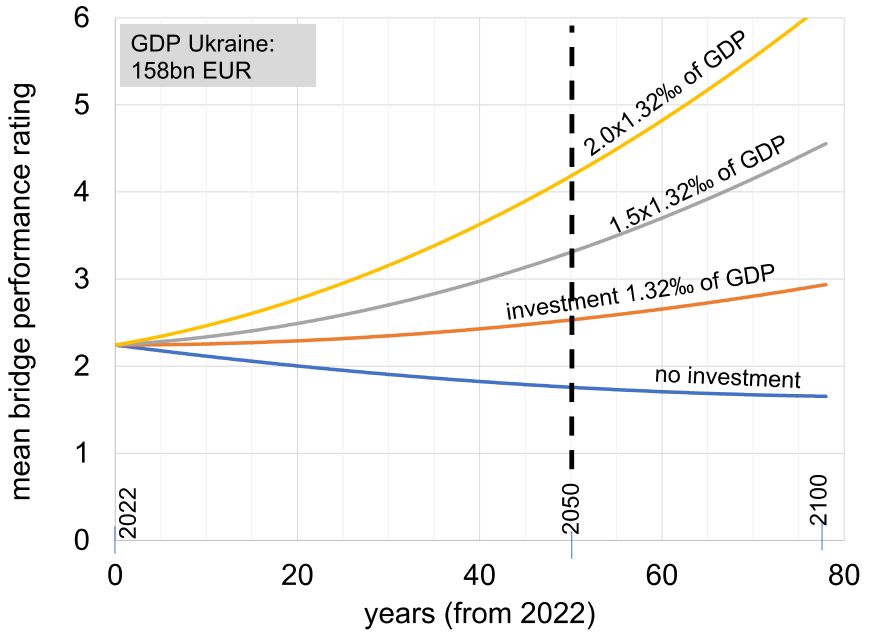
Dr Stergios Aristoteles Mitoulis, University of Birmingham, UK

Dr Sotirios A Argyroudis, Brunel University London, UK

- Quantify the trade-offs and synergies between climate resilience and sustainability in infrastructure adaptation
- Financing of transport infrastructure adaptation in Ukraine considering climate projections and correlation to GDP



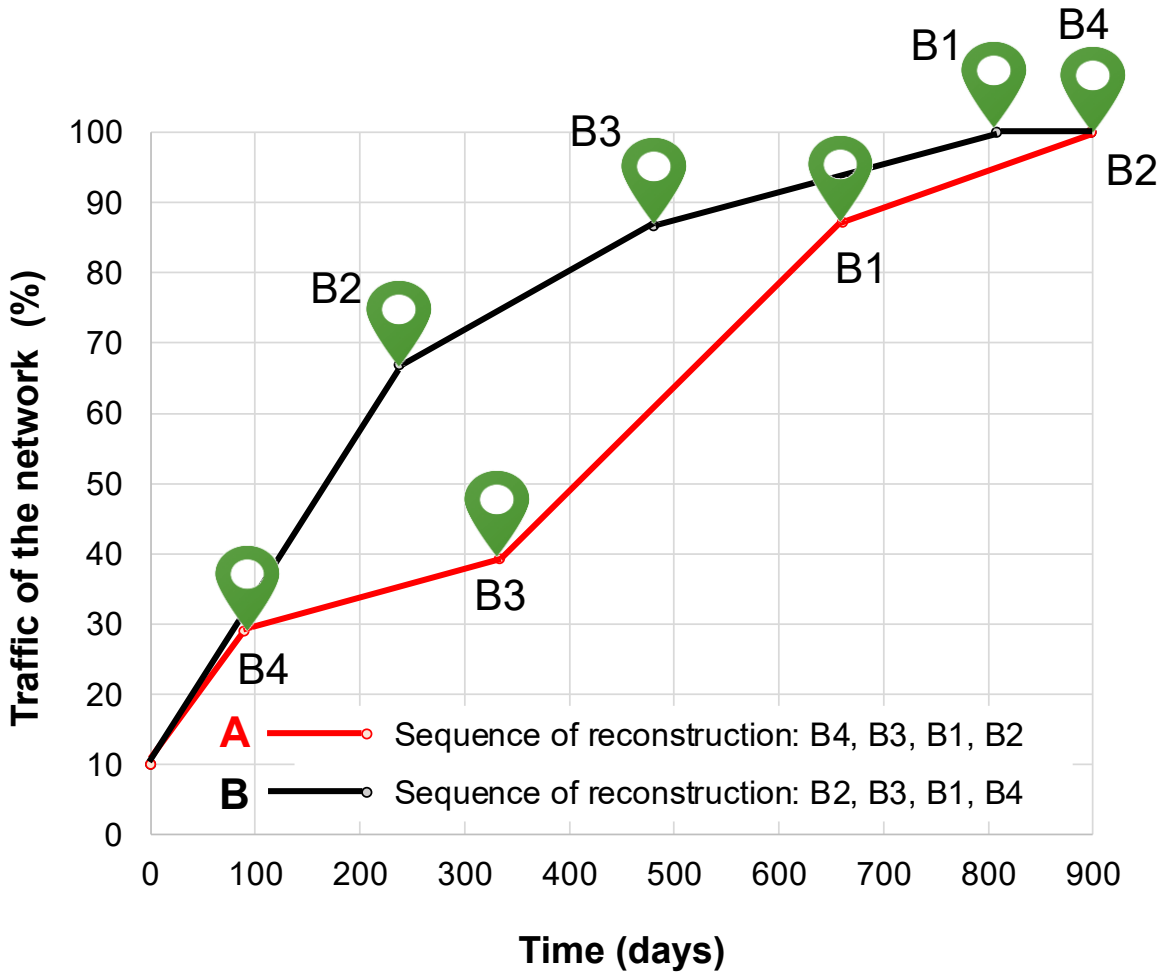
adaptation by conventional strategies



adaptation by sustainable strategies

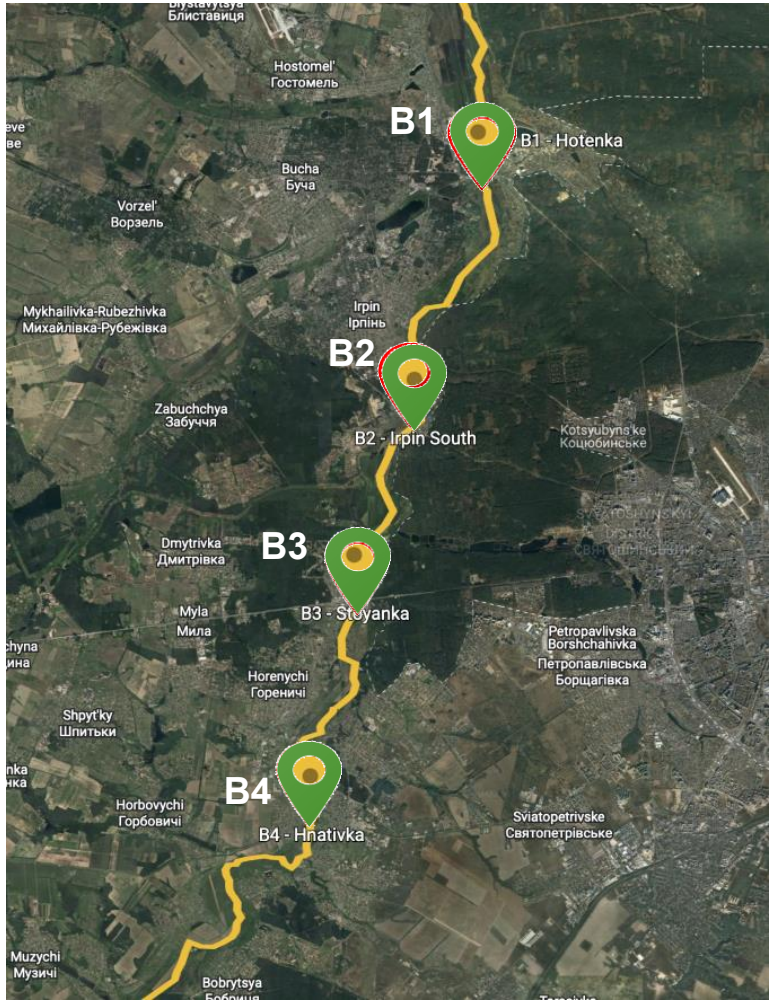
Science-based infrastructure reconstruction framework

bridgeUkraine - for a sustainable and resilient future



- 15-20% better traffic performance for the same investment ($) if reconstruction strategy **B** is adopted instead of **A**
- for limited investment ($) this framework can save 30% of cost and increase 30-35% the network traffic performance
- prioritisation reduces the cost due to traffic detours by 60%

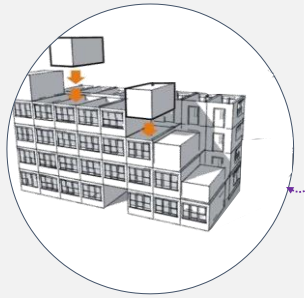
Mitoulis SA, Argyroudis S et al. (2023) Conflict resilience framework for critical infrastructure peacebuilding. *Sustainable Cities and Society,* https://doi.org/10.1016/j.scs.2023.104405



damaged / closed bridge

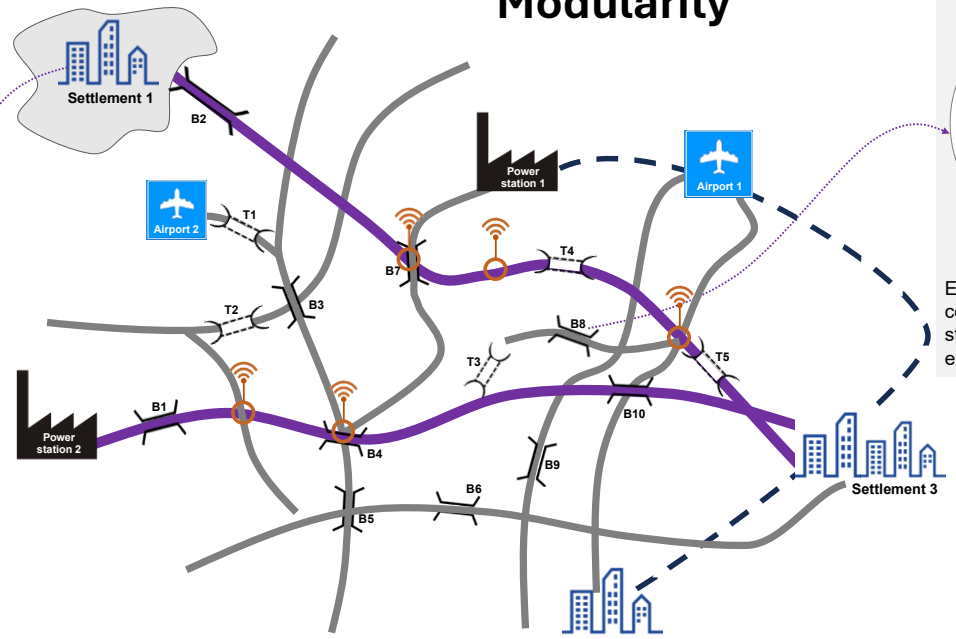
reconstructed / open bridge

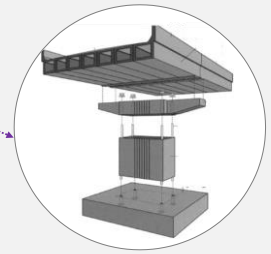
Resilience-based recovery



Example of a modular building: units of modular buildings for quick and low-cost construction. Utilization of digital identity of modular units and digital models (Digital Twin, BIM).

Modularity

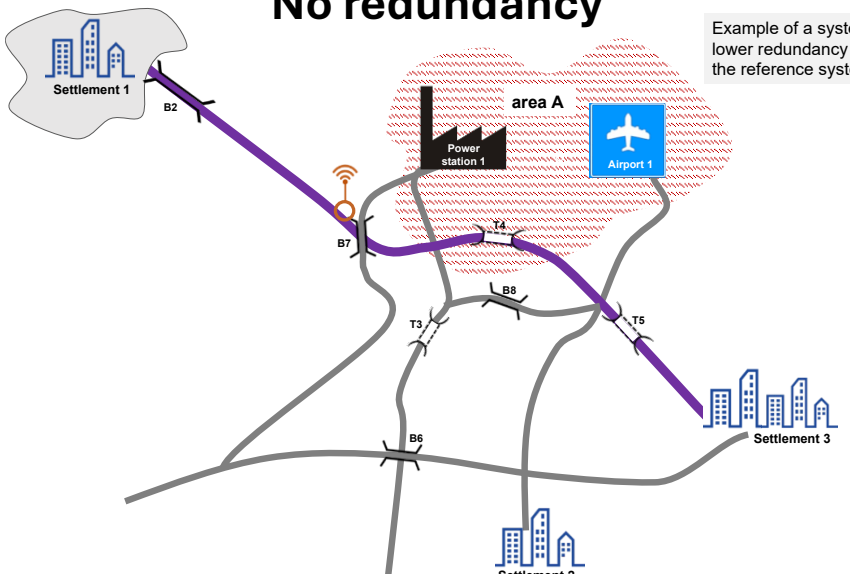




Example of a modular bridge: components of modular structures stored for quick updates and extensions

Threat-Agnostic Resilience: Framing and Application for Critical Infrastructure
https://arxiv.org/pdf/2501.01318

No redundancy



Example of a system that has lower redundancy compared to the reference system.

Redundancy & Distributedness