CASE STUDY

The STORMS project: surging towards more resilient buried infrastructure

Dr Xilin Xia: Assistant Professor in Resilience Engineering, University of Birmingham

Introduction

The UK's buried infrastructure network covers an estimated 4 million kilometres and includes water and gas pipelines, electricity and telecoms cables, and sewer structures.

These underground structures carry essential services and are at risk from increasing weather extremes caused by climate change. Flooding erodes soil and tarmac surfaces and can expose the pipes to the elements. Wet and dry cycles weaken the soil and compromise the integrity of the pipelines.

The STORMS (Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks) project has developed a weather-related risk assessment framework. The work will increase resilience to weather-related risks, including analysing soil structure changes and damage calculations for buried pipes. This will inform national guidance and planning, to increase resilience at network and national scale

What would you identify as the main impact of this work?

"STORMS provides a very robust and quantitative set of models and datasets, creating important evidence for planners. It provides hitherto unattainable insights. It could become an essential tool for companies to understand their risk across their own network and ultimately across multiple regions, as well as having significant potential to influence national policy," Dr Xilin Xia.

In terms of national policy, the outputs from the STORMS project could fill in a critical gap of evidence about climate risk to buried infrastructure such as the national and regional natural gas networks for the Climate Change Risk Assessment (CCRA). The UK Government publishes the CCRA every five years, as required by the 2008 Climate Change Act, to assess the risks to the UK from climate change. The fourth CCRA is due to be published in 2027.

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Key challenges that STORMS aims to solve

Currently, there is a lack of comprehensive research that applies to regional or national scale buried infrastructure, and the risks from climate change.

By enhancing decision-making capabilities among infrastructure operators and utility companies, STORMS aims to reduce service disruptions, leading to cost savings, and increased resilience of infrastructure systems in the face of meteorological shocks and climate change.

The approach

STORMS combines scientifically rigorous and practical tools to model climate risk to pipelines at regional and national scale. It combines data on soil properties, climate projections, flooding and soil moisture changes with mechanistic modelling of the structural integrity of the pipes.

The principle can also be applied internationally, using the same methodology and inserting region-specific data.

Benefits

Dr Xilin Xia, Assistant Professor in Resilience Engineering, University of Birmingham, emphasises, ***"DAFNI as an independent trusted research platform was ideal for making data available to stakeholders and for linking different organisations' data together. The team could test methods locally and then scale them up using the DAFNI HPC platform."***

What did DAFNI allow you to do that you couldn't have achieved otherwise?

The team appreciated the many opportunities to increase the visibility of the STORMS project and engage with a wider community of academics and industry.

These provided plenty of occasions for the STORMS team to engage with new organisations and collaborations.

The main outputs from the STORMS project available on DAFNI are:

- Rainfall scenarios derived from the climate projections
- Soil information datasets such as SPMM which have been processed and uploaded to DAFNI with other complementary data
- A hydrodynamic model which can simulate both floods and entrainment of ground surface (SynxFlow)
- A climate risk assessment model for pipes

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How could this work benefit society as a whole?

"STORMS has raised public awareness of buried infrastructure resilience to climate threats, and promoted interest in sustainability and safety in infrastructure planning. If climate risk is managed well within the buried infrastructure sector, it will mean better and more reliable functioning of telecoms, gas, electricity, water and sewerage for the population, with less disruption to essential services and more economic operations," Dr Xilin Xia.

Direct public engagement with the STORMS project includes a University of Birmingham showcase for students, parents and the general public during open days, as well as giving seminars at other universities and research centres in the UK and abroad, such as the University of Cambridge, Imperial College London, RWTH Aachen, UK Centre for Ecology & Hydrology and the University of Sao Paolo. The project has contributed to raising awareness among the public and local communities about the risks associated with underground pipe infrastructure, particularly in the context of climate change.

How do you anticipate other researchers, policymakers and stakeholders using this work?

Collaborations are already well underway with projects and organisations including:

- **The EPSRC project Uncertainty Quantification for Flood Modelling (UQ4FM)**
  Developed a codebase used to generate the rainfall scenarios in collaboration with UQ4FM (PI Prof Lindsey Beevers, University of Edinburgh) which had a similar demand for scenario generation.
- **Flood Hydrology Improvements Programme (FHIP)**
  Attendees at the Extreme Rainfall workshop (October 2024) workshop included representatives from EA, SEPA, NRW, JBA, Bristol University, Newcastle University.

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- **DAFNI conferences 2023 and 2024 and project showcases**
  The project and results were presented at the annual DAFNI conferences in 2023 and 2024 with over 100 attendees for each of the conference, and received interests from a broad audience including researchers, industry and policy makers.
- **Infrastructure Operators Adaptation Forum**
  Dr Xilin Xia has been attending the Infrastructure Operators Adaptation Forum (IOAF), which is a quarterly meeting bringing together asset owners, regulators (e.g., Ofgem, Ofwat, EA, and the CCC) and researchers with around 100 regular attendees.
- **Interest from Humber Industry Cluster – Humber Net-Zero Engagement**
  The STORMS demonstrator was also showcased to the academic lead of the Humber Industrial Cluster funded through the UKRI Industrial Decarbonisation Challenge. There is significant interest in the risks to buried pipe infrastructure, particularly due to its potential for reuse in transporting hydrogen, which could play a key role in achieving industrial net-zero goals.
- **Presentation at Digital Subsurface Symposium organised by DSIT**
  Professor Nicole Metje made a presentation on Quantum Detecting in the Subsurface at the Digital Subsurface Symposium in Newcastle in March 2025. The STORMS project was part of the presentation, highlighting climate resilience as a potential use case for new sensing technologies.

STORMS has built and strengthened links with stakeholders in the utility sector, including Cadent Gas, Thames Water, Northumbrian Water and LSBUD (Line Search Before You Dig). Other organisations, including Anglian Water, AtkinsRéalis, National Grid, National Highway, Transport for London and Wales and West Utility are in early-stage discussions or have attended project workshops.

Engagement and outreach activities have ensured strong connections with significant projects and initiatives like the National Underground Asset Register (NUAR), Model for Underground Data Definition and Integration (MUDDI) Standards Working Group, and NERC's JASMIN computing platform, enabling greater data integration and potential for future projects.

Dr Adam Griffin spoke about STORMS to the hydrological community at the British Hydrological Society National Symposium in September 2024.

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The future

The STORMS team continues to engage with industry. Given the sensitive nature of the datasets, DAFNI's role as an independent trusted research platform is key.

Future plans include soliciting feedback from stakeholders and further improving the methodology, moving towards a high-level national scale risk assessment that's critical for government policy and planning.

If you are interested in collaborating, contact: x.xia.1@bham.ac.uk

Who's involved?

The STORMS project brings together a large team of experts from academia.

Principal Investigator: **Dr Xilin Xia**, Assistant Professor in Resilience Engineering, University of Birmingham.

Co-Investigators from University of Birmingham: **Professor Nicole Metje**; **Professor David Hannah; Dr Asaad Faramarzi**, **Dr Soroosh Sharifi**. Researchers: **Dr Nikolaos Reppas**, Research Fellow (currently Assistant Professor at the University of Warwick); and **Dr Qian Li**, Research Fellow at University of Birmingham.

UK Centre for Ecology & Hydrology (UKCEH)
Co-I: **Dr Steven Cole**
Co-I: **Mr Bob Moore**
Co-I: **Dr Adam Rich-Griffin**
Co-I: **Dr Alison Kay**
British Geological Survey
Co-I: **Dr Andrew Hughes**

When did the project start and finish?

The project ran from October 2023 to March 2025.

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