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DAFNI Conference 2025: Bridging the gap between Academia, Government and Industry

The Edge, Sheffield, UK

11th September 2025

L Harding (editor)

March 2026

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DAFNI CONFERENCE 2025

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

BRIDGING THE GAP

BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

DAFNI

Data & Analytics Facility for National Infrastructure

Professor Mathew Williams

Chief Scientific Adviser for Environment, Natural Resources and Agriculture at the Scottish Government

Professor Mathew Williams, spoke at a DAFNI Roadshow in Glasgow in autumn 2024 and said,

DAFNI can help us to bring together key datasets and metadata needed for decision making; drill down to capture adaptation resilience; move beyond research Digital Twins to drive Digital Twins that engage with decision makers; empower decision makers to use tools and be confident using them; and connect more broadly to natural resource decision making such as preparing for drought and flood planning with infrastructure adaptations.

Contents

Audience participation is welcomed throughout various points in the programme.

Version date 11 September 2025

Welcome

Welcome to the DAFNI Conference 2025! I am pleased to welcome you all to this year's conference venue located at the University of Sheffield, an apt location given our recent collaborations with the university, working with Dr Giuliano Punzo on harnessing quasi real-time data for improved transport outcomes and Professor Daniel Coca.

Our theme today is 'Bridging the Gap between Government, Academia and Industry' and it is vitally important that we keep abreast of the latest plans and developments. I am delighted to welcome our keynote speakers, who have a great breadth of expertise across our sub-themes of climate resilience, security and trusted research. Dr Juliet Mian and Sarah Hayes will bring insight and experience from their respective roles as Global Resilience Skills Leader at ARUP and Chair of the Data Sharing Working Group and Independent Consultant.

Our invited speakers are Oliver Tones from the Department for Science, Innovation and Technology will be showcasing research data access pilots, Holger Kessler will be presenting on the journey to NUAR and Paul Hickey from Ofwat and Jonny Wilson from the Environment Agency will be talking about national water resources modelling.

Further to last year's conference theme on 'Building A Secure and Resilient World', we will also be hearing from Dr Richard Kirkham, University of Manchester on SALIENT's Research and Coordination Hub, Rachael Steller and Karina Rodriguez, Climate Change Committee on assessing the resilience of UK infrastructure and Professor Nicholas Vasilakos,University of East Anglia on insights from our CrossEU project on climate extremes and income equality.

Our DAFNI-DINI (Data Infrastructure for National Infrastructure) showcase earlier this year highlighted the ever-increasing need for Trusted Research Environments and I am very pleased to welcome the members of our Trusted Research panel, Emily Jefferson from Health Data Research, Jason Feehily from the University of Nottingham, David Batho from Jisc,Tash Buckley from Cranfield University and Kathryn Dally from UK Research Integrity Office. Their combined knowledge and expertise will give depth and understanding to what is necessary for us to drive forward and push the DAFNI platform to be the best it can be.

There will also be the opportunity today to learn more about the outcomes of our 'Building and Secure and Resilient World' and Sandpit projects via our poster session, alongside networking and demonstrations.

DAFNI continues to develop and thrive, underpinned by the continuous dedication of our team and their unwavering commitment to computing excellence, in partnership with our wonderful user community. Today reflects the achievements of the past year and the body of research that addresses the increasingly complex scientific challenges that we face today.

I hope you have an enjoyable and informative day.

Brian

Dr Brian Matthews

DAFNI Leader

Dr Brian Matthews has over 30 years of experience in R&D development in computing, with a focus on tools, methods and standards for managing accessing research data from scientific experiments.

He took a leading role in the development of the data management infrastructure that supports the ISIS Neutron and Diamond Light Sources, and has worked extensively on European programmes on data infrastructures.

Brian leads the DAFNI team, developing data and modelling infrastructure to support research into national infrastructure, and is Co-Investigator on projects extending its use including #OpenCLIM and the UK Centre for Greening Finance and Investment initiative.

He is Co-Investigator and Technical Lead on the Physical Sciences Data Infrastructure (PSDI) Service, one of EPSRC's National Research Facilities.

DAFNI Strategy Board

Professor Asaad Faramarzi
University of Birmingham

Professor Liz Varga
University College London

Professor Daniel Coca
Newcastle University

Professor Michael Batty
University College London

Dr Giuliano Punzo
University of Sheffield

Professor Nik Lomax
University of Leeds

Professor Jim Hall
Oxford University

Professor Phil James
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Dr Juan Bicarregui
STFC

Professor Stephen Hallett
University of Cranfield

Professor Julien Harou
University of Manchester

Professor Theo Tryfonas
University of Bristol

DAFNI Team

Dr Brian Matthews
DAFNI Programme Lead

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Software Engineer

Akhil Dubakunta
Software Engineer

Akhil Maganti
Scientific Computing Graduate

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Project Co-Ordinator

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CReDO Security Architect

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User Liaison

Lewis Sampson
Research Software Engineer

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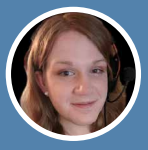

Rose Dickinson
Senior Software Engineer / Technical Lead

Saiful Khan
Senior Data Scientist

Sarah Byrne
Senior Software Engineer / Product Owner

Dr Server Kasap
DevOps Engineer

Teagan Zoldoske
Data Curation Officer

Tom Kirkham
Science Lead

Conference Chairs

CHAIR (Morning)

Giuliano Punzo

Director of Sheffield Urban Flows Observatory

Giuliano Punzo obtained an MEng in Aerospace Engineering at the University of Naples before getting his PhD in swarm engineering at the University of Strathclyde, Glasgow. With a core focus on distributed systems, Giuliano moved from aerospace to infrastructure and socio-technical systems, using modelling techniques in the areas of network science, control theory and game theory. Dr Punzo is a Lecturer at the University of Sheffield, director of the Sheffield Urban Flows Observatory, where he also leads the transport theme, and member of the DAFNI Strategy Board.

CHAIR (Afternoon)

Tom Kirkham

DAFNI Science Lead

My background is in distributed computing having worked in academic and industry roles since completing my PhD in 2008. My interests are in widening access to advanced computing infrastructure with an interest in data and model security, standardisation and reuse.

I have recently joined the DAFNI team rejoining STFC from Innovate UK where I was the Innovation Lead for Future Telecoms working with Industry and academia to deliver a 70m GBP UKRI investment funded by DSIT. I am keen to use my skills and experience to support the current and future development of the DAFNI community.

Conference Programme

Morning Programme

Chair: **Giuliano Punzo, Director of Sheffield Urban Flows Observatory**

09:00 **Arrival and breakfast networking**

09:30 **Welcome and introduction**

09:45 **Keynote presentation - Making good choices**
Juliet Mian, Arup

10:15 **DAFNI – Technical update**
Sarah Byrne, DAFNI Senior Software Engineer

10:35 **Networking break**

11:00 **SALIENT: Building a Secure and Resilient World: Research and Coordination Hub**
Dr Richard Kirkham, University of Manchester

11:20 **Assessing the resilience of infrastructure in the UK**
Rachael Steller and Karina Rodriguez Villafuerte, Climate Change Committee

11:40 **Climate Extremes and Income Inequality: First Glimpses of Econometric Evidence and Policy Insights from the CROSSEU Project**
Nicholas Vasilakos, University of East Anglia

12:00 **Networking lunch, poster session and demonstrations**

Afternoon Programme

Chair: **Tom Kirkham, DAFNI Science Lead, STFC**

13:30 — **Keynote presentation - Do it once and share it many times**
Sarah Hayes, Chair Data Sharing Working Group,
Independent Consultant

14:00 — **Learning to Fly: Research Data Access Pilots**
Oliver (Olly) Tones, Department for Science, Innovation
and Technology

14:20 — **DINI Project results and recommendations**
Catherine Jones and Elizabeth Newbold

14:40 — **Networking break**

15:05 — **Trusted Research Panel**
David Batho, JISC
Tash Buckley, Cranfield University
Kathryn Dally, UK Research Integrity Office (UKRIO)
Emily Jefferson, CTO Health Data Research UK, and Interim Director of DARE UK
Jason Feehily, University of Nottingham

15.55 — **From hackathon to legislation – the journey of NUAR**
Holger Kessler, AtkinsRéalis

16.15 — **National Water Resources Quality Modelling: From research to delivery**
Jonny Wilson, Environment Agency

16.35 — **Conference closing remarks**
Tom Kirkham, Science Lead, DAFNI

16.45 — **Close of Conference**

Keynote Speakers

Dr Juliet Mian

Director of Arup's Climate Services and Sustainability

Making good choices

This keynote will invite the audience to reflect on 'choices' as we plan, deliver, manage and operate the UK's infrastructure assets and networks. Safe, sustainable and resilient infrastructure is critical to enabling growth, enhancing wellbeing, and protecting lives and livelihoods. As we strive to make the best decisions for the future, we come up hard against the realities of budget constrained, deep uncertainties and the knowledge that past choices have had permanent, significant impacts on our planet, from climate change to species extinction. If 'do nothing' is not an option, how can academics, engineers, decision-makers and communities work together towards collective positive future outcomes?

Dr Juliet Mian

Juliet is an Arup Fellow, a Director of Arup's Climate Services and Sustainability portfolio and global leader of Resilience skills. She specialises in assessment and enhancement of the resilience of infrastructure systems to climate change and other shocks and stresses. She brings over 25 years' experience on a broad range of infrastructure projects both in the UK and internationally to helping clients on their resilience journeys – from understanding risk, to delivering adaptation actions ranging from policy updates to major capital projects.

She is Technical Director for a major Climate Adaptation Plan for a Middle East transportation owner and operator, and has been the Environment Agency Fens 2100+, leading an innovative system level approach towards adaptation decision making in a complex multi-stakeholder landscape. She was Director for the National Grid Climate Change Risk Assessment. She has developed leading reports including the Network Rail Weather Resilience and Climate Change Analysis. Internally at Arup, Juliet is leading their 'Future Climates' initiative to ensure that climate change is accounted for in all projects not only those that have a resilience and adaptation lens.

Dr Sarah Hayes

Chair Data Sharing Working Group,
Independent Consultant

Do it once and share it many times

This is the motto for the Digital Twin Hub Data Sharing Working Group. This Group consists of representatives across industry, academia and government and meets weekly to discuss challenges and solutions to sharing data across sectors. This keynote will cover how academia and industry are working together to share learnings and to progress the development of data sharing infrastructure to kickstart economic growth and to support the path to clean power. Find out how we can collaborate more to share data in a safe and secure way to improve the efficiency and resilience of infrastructure.

Dr Sarah Hayes

Sarah is Chair Data Sharing Working Group, Independent Consultant. She is a data and digitalisation expert and has worked across energy, ICT, water and transport sectors over the last 25 years. She was the lead author of Data for the public good, a report about the need to share infrastructure data, which was published by the UK's National Infrastructure Commission (NIC) in December 2017.

Sarah works as an independent consultant and has been involved in CReDo, the Climate Resilience Demonstrator project from its launch. Sarah chairs a weekly Data Sharing Working Group, comprising thought leaders and practitioners across the data sharing space, who discuss different data sharing initiatives and the requirements to advance the development of data sharing infrastructure.

Invited Speakers (morning)

Dr Richard Kirkham,

Principal investigator on Building a Secure And Resilient World, University of Manchester

SALIENT

Building a Secure And Resilient World: Research and Coordination Hub

Led by Dr Richard Kirkham from the Thomas Ashton Institute for Risk and Regulatory Research, SALIENT is a research hub dedicated to enhancing the UK's societal and economic resilience. It employs a human-centred systems-thinking approach to strengthen national resilience. The hub unites diverse stakeholders and organises funding calls to address various challenges, ensuring a secure future for the UK. By integrating diverse research disciplines, SALIENT develops innovative solutions for contemporary security issues, representing a significant step towards safeguarding the nation's stability and prosperity.

Professor Richard Kirkham

Richard is the Principal investigator on Building a Secure And Resilient World: Research and Coordination Hub (SALIENT), a Reader in Civil Engineering at UoM, Deputy Director of the Thomas Ashton Institute for Risk and Regulatory Research, and member of the senior leadership team in the Manchester Urban Institute. Richard's research on government major project delivery has attracted funding from ESRC and he provides expert advice to government on aspects of risk management in the context of major projects. He is also leading the Cabinet Office Science and Engineering Network workstream on 'knowledge transfer' having successfully completed an ESRC funded secondment into the Cabinet Office in 2016.

Rachael Steller,
Climate Change Committee

Karina Rodriguez Villafuerte,
Climate Change Committee

Assessing the resilience of infrastructure in the UK

Rachael and Karina will present the findings regarding infrastructure in the CCC's latest Adaptation Progress Report, and invite attendees to share their views regarding the upcoming Fourth Climate Change Risk Assessment in an interactive session.

Rachael Steller

Rachael is the Resilient Infrastructure Lead at the Climate Change Committee (CCC). She leads the team's analysis of the energy, ICT, water, transport, and waste sectors for Adaptation Progress Reports and the Fourth Climate Change Risk Assessment

Karina Rodriguez Villafuerte

Karina Rodriguez is a Resilient Infrastructure Analyst at the Climate Change Committee (CCC). She supports the team's analysis of the energy and ICT sectors for the Fourth Climate Change Risk Assessment.

Professor Nicholas Vasilakos,

University of East Anglia

CROSSEU

Climate Extremes and Income Inequality: First Glimpses of Econometric Evidence and Policy Insights from the CROSSEU Project

This talk introduces the Horizon Europe CROSSEU project, which investigates the socio-economic impacts of climate change across sectors and regions. Drawing on new findings from Vasilakos et al. (2025), a CROSSEU working paper that uses World Bank economic data for 145 countries and high-resolution climate data from Tyndall UEA, the talk explores the impact of different types of extreme weather events on within-country income distribution and inequality. By modelling the interaction between the frequency and intensity of such events (including heatwaves, coldwaves, icing days, hot days, and others), we find consistently regressive impacts on income distribution. The results underscore the need for climate adaptation policies that also address deep-rooted social and economic inequalities

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Professor Nicholas Vasilakos

Professor Nicholas Vasilakos is a Professor of Sustainable Business Economics and Public Policy at the University of East Anglia. His research explores the nexus of social justice, net zero and sustainable development. His work has been cited by major governmental and intergovernmental organisations, including the US Treasury, the World Bank, the United Nations, and the OECD. Nicholas has published extensively in leading economics and policy journals and was awarded the 2012 Campbell-Watkins Energy Journal Best Paper Award by the International Association of Energy Economics. Over his career, Nicholas has secured more than €20 million in research funding, with approximately half of it raised in the last ten years as both Principal Investigator and Co-Investigator. His current research on climate impacts is supported by the European Commission through CROSSEU (and SECLI-FIRM before it). Beyond academia, Nicholas has extensive experience collaborating with industry and government bodies to support evidence-based strategies and drive long-term sustainability initiatives at the regional and national levels.

Trusted Research Panel (afternoon)

David Batho

Director of Security

Jisc

David is Director of Security at Jisc, responsible for protecting the education sector from cyber-attacks. Involved in a substantial number of major cyber incidents in the sector over recent years, David is passionate about educating and improving the sector at all levels. With experience as a penetration tester and head of IT for several years in the education sector, David believes that cyber security is everyone's responsibility, and all have a role to play in protecting their organisations.

Tash Buckley,

Lecturer

Cranfield University

Tash Buckley is a Lecturer at Cranfield University and a former Research Analyst at the Royal United Services Institute. Her research areas include trusted research and disruptive and emerging technologies at the intersection of national security and policy. Tash's PhD research at Royal Holloway University of London, focuses on the transition from cyber security to cyber power within strategy and policy in the UK.

Kathryn Dally,

Director of Programmes

UK Research Integrity Office (UKRIO)

Kathryn Dally has recently joined the UK Research Integrity Office as Director of Programmes. Her role is focused on coordinating and delivering UKRIO's growing portfolio of projects and initiatives, in collaboration with key stakeholders.

Prior to this, for many years she worked at the University of Oxford as Research Integrity and Policy lead, and Head of the Research Ethics and Integrity Team, overseeing the University's research ethics committees, the development of integrity-related policy and acting as the University's principal research integrity adviser. She has been a member of various national and international networks (such as the Russell Group Research Integrity Forum and the League of European Research Universities' Research Integrity Policy Group).

Jason Feehily

Trusted Research team
University of Nottingham

Jason is Head of the Trusted Research team at the University of Nottingham. He has responsibility for the implementation and management of the Trusted Research guidance from NPSA and UKRI at the University. Trusted Research checks are conducted on all new international research and knowledge exchange projects. Strategic projects, which include specific technology themes and infrastructure development, are also reviewed by the team.

Emily Jefferson

Chief Technology Officer
Health Data Research UK
and Interim Director of DARE UK

Professor Emily Jefferson became the Chief Technology Officer (CTO) of Health Data Research in November 2022. She leads on the development and delivery of technology services to enable the provision of consistent and meaningful research access to health data, e.g. the Health Data Research Gateway. Emily has also been Interim Director of DARE UK, since January 2024.

Invited Speakers (afternoon)

Oliver Tones,

Head of Data Sharing and Technology,
Department for Science, Innovation and Technology

DSIT

Learning to Fly: Research Data Access Pilots

Olly will present and discuss the findings from the UKRI and DSIT "Research Data Cloud" pilots which ran between 2023 and March this year. Long before talk of a National Data Library surfaced, UKRI and DSIT worked together to tackle some of the known barriers around creating and sharing data across the research ecosystem. In partnership with the UKRI Digital Research Infrastructure programme, funding was awarded to 4 pilots each of which focused on an aspect of breaking down silos, bringing together discipline adjacent data, improving adoption of the FAIR principles, and standardising approaches to accessing sensitive data.

Oliver (Olly) Tones

Oliver Tones is Head of Data Sharing and Technology in the Department for Science, Innovation and Technology, where he leads policy teams on Data Licensing and Valuation and Researcher Access to Data. An experienced civil servant, his focus has always been on improving public services whether through Digital Trade, Frontier Technologies, or Data Access policy. He has a keen interest in ensuring public services deliver effectively for citizens and this zeal is now focused on improving public sector data access for the benefit of the economy and society, harnessing the opportunities which increased data access can bring to the UK.

Catherine Jones,
Energy Data Centre Lead

Elizabeth Newbold,
Open Science Theme Lead

DINI Project results and recommendations

Catherine Jones

Catherine Jones leads the Energy Data Centre within the Energy Research Unit, Technology Department, UKRI/STFC. She has a wide experience in providing information systems and services to the academic community, both within and external to STFC, using her software engineering and information management expertise to deliver effective services to user communities. Her work interests are the digital curation of software & data, demonstrating FAIR-ness of research data and linking research outputs (data, publications and software).

Elizabeth Newbold

Elizabeth Newbold is the Open Science Theme Lead at the Science and Technology Facilities Council (UKRI-STFC). The Open Science Theme includes activities related to data stewardship, open repositories and library services supporting open sciences practices and research at STFC. She has a background in scientific information with a focus on open access, FAIR and open data. Elizabeth is currently a member of the pan-UKRI research data policy working group that is developing a new research data policy for sharing and managing research data arising from UKRI-funded research. She has contributed to European Union funded projects in the areas of FAIR data, is a contributor to the Physical Sciences Data Infrastructure and was a member of the project team that delivered the research data cloud pilot project "Digital Infrastructure for National Infrastructure Exploring Challenges and Opportunities in Data Sharing".

Holger Kessler,

Senior Stakeholder Manager, Utility Solutions - Infrastructure UK & Ireland at AtkinsRéalis

From hackathon to legislation - the journey of NUAR

Lessons learnt from the past 6 years in government, academia and industry

Holger is an experienced professional with over 25 years of working in geoscience, environment and infrastructure. He has a strong background in research and government programs, emphasising collaboration, digital transformation and data sharing. Notably, he contributed to the National Underground Asset Register at the Geospatial Commission. His expertise spans project management, team leadership, policy development and strategic stakeholder engagement, both in the UK and internationally.

Holger Kessler

As a trained geographer, soil scientist, and chartered geologist, Holger is known for his dynamic approach to forming inclusive teams and communities focused on innovation and change. He advocates for the use of geospatial data and digital transformation to address societal issues and the effects of climate change. Holger's career includes significant time at the British Geological Survey and a leadership role in The Future of the Subsurface Foresight Project at the Government Office for Science before moving to AtkinsRealis in 2024.

Jonny Wilson,

National Water Resources Modelling Lead,
Environment Agency

National Water Quality Modelling
From research to delivery

As with many parts of the world, the cumulative impacts of climate change, economic growth and the needs of our environment are challenging England's future water availability. The Environment Agency has evaluated our nation's need in the recent "National Framework for Water Resources (v2) – 17th June 2025. Unchecked this concludes there will be a deficit of around 5,000 million litres per day by 2050 (over 1/3 of current daily public water supplies). The report also sets out our intent to meet this need whilst also protecting and improving the environment. This entails ambition both on demand, driving down leaks from our water distribution networks and encouraging water efficiency in homes and businesses, but also increasing sources of supply. Action on the supply side includes a ~£50 billion programme of 28 major new infrastructure schemes including 10 reservoirs, 9 long distance transfers 8 water recycling schemes and 2 desalination plants.

The Environment Agency, Ofwat and Drinking Water Inspectorate have worked with academia to develop national modelling tools. These tools have help build the evidence base of future water need as well as optimise the investment plans to meet this challenge. This talk will explore this collaboration and how research as help shape policy and operational decision-making.

Jonny Wilson

Jonny is the National Water Resources Modelling Lead at the Environment Agency, where he oversees a technical team responsible for establishing in-house modelling capabilities to support regulatory decision making. He is passionate about the use of data and novel modelling tools to understand strategic water needs for England and identify solutions that balance competing goals, such as minimising cost, increasing supply system resilience and protecting the environment. Jonny joined the Environment Agency in 2018, after building a decade of experience creating and applying models for subsurface decision-making as a product owner in a leading hydrocarbon consultancy firm, as well as developing inverse prediction models during his research degree in geophysics at the University of Cambridge.

DAFNI
Team Speakers

Sarah Byrne,

Senior Software Engineer

Sarah Byrne is a Senior Software Engineer and the technical Product Owner of the DAFNI platform. She leads the technical team on product direction, guiding the development of the platform's capabilities to continue to meet the needs of the community. Sarah also provides some technical leadership, having recently led a security review and update of the platform's backend services, as well as previously overseeing the transition of the platform onto an updated hardware cluster. She has been a member of the DAFNI team for over 3 years, having joined as a Graduate in 2022.

Mini case studies of DAFNI projects

Higher quality research predictions. **USARIS (Uncertainty quantification and Sensitivity Analysis for Resilient Infrastructure Systems)**. The USARIS project has developed a toolkit to allow researchers and analysts to improve understanding of uncertainty in infrastructure models. Government and industry in the infrastructure sector can use this toolkit to put model results into context and to use model predictions in a more appropriate and responsible way.

The UK's airports are underprepared for the mass diversion protocols required during complete airport closure. The **MARS (Flight Diversion Modelling for the UK Aviation System)** project models 35 biggest airports in the UK, plus an algorithm to simulate diversion options, with a view to helping the aviation network to move to minimise the (currently severe) ripple effects of a major airport closure due to catastrophic IT failure, drone activity, fires and other unexpected reasons for closure. It is acting as a central and innovative tool around which industry can have a targeted discussion about mitigation strategies; it supports and simulates airline and airport contingency plans.

There are millions of kilometres of buried infrastructure in the UK, including water and gas pipelines, electricity and telecoms cables, and sewer structures. **STORMS (Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks)** is researching adaptation models for safe underground structures and presents graded risks for failure of pipes in soil at risk from increasing weather extremes caused by climate change. The project's innovative modelling approaches shows significant potential for influencing national policy, such as the Climate Change Risk Assessment (CCRA4).

New weather extremes and energy demand. **BRINES (Building Risk-Informed redundancy for Net-zero Energy Systems)**, seeks to answer the challenging question of whether our present and future energy systems are prepared for more extreme weather driven by climate change, coupled with changing electricity generation methods. It models how to ensure resilience in the energy system during these weather-driven periods of stress on the networks now, as we head towards Net Zero in 2030, and as far ahead as 2080.

Planning for water shortages. The **Pywr-WREW (Water Resource Model for England and Wales)**, focusing on the impacts of drought on water supplies in a national water supply model and helping decision makers better manage future climate risks to the national water supply network. The new Pywr-WREW model will offer a more transparent, open source tool than the commercially-licensed WREW, making stakeholder engagement, model evaluations and result disseminations easier for all.

Introduction to DAFNI

DAFNI is a computing platform which aims to support advanced research into national infrastructure, including transport, water, and energy and city scale modelling. The DAFNI platform supports research that aims to provide the UK with a world-leading infrastructure system that is more integrated, efficient, powerful, reliable, resilient and affordable. It is enabling the community to conduct research that is able to generate new insights at a higher level of detail and accuracy than ever before.

DAFNI was originally funded by an £8 million EPSRC investment in the UK Collaboratorium for Research in Infrastructure and Cities (UKCRIC) and a £1.2m grant under EPSRC's Resource Only Strategic Equipment. Its aim has been to become the national platform to satisfy the computational needs in support of data analysis, infrastructure modelling and visualisation, and encourage whole-system thinking for the UK's infrastructure research needs.

In March 2023 UKRI awarded £4m to STFC Scientific Computing to establish a national Centre of Excellence for Resilient Infrastructure Analysis, and move the Data & Analytics Facility for National Infrastructure (DAFNI) into its new phase.

If you would like to get involved in DAFNI, please contact Katie Cartmell, Delivery Manager: katie.cartmell@stfc.ac.uk

Contact us on: info@dafni.ac.uk

Keep up to date with latest news and sign up for our DAFNI Mailing list at:

www.dafni.ac.uk

UKRI Science and Technology Facilities Council

UKRI Engineering and Physical Sciences Research Council

UKCRIC

DAFNI

DAFNI CONFERENCE 2025

BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

Welcome and introduction

Tom Kirkham

DAFNI Science Lead,
Scientific Computing STFC

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

UKCRIC™
UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES

Housekeeping

Fire alarm test is today

The fire alarm will sound for a few seconds at around 10am

Should there be a real alarm, the alarm will sound continuously, and the venue staff will enter the room to evacuate.

The meeting point is at the front of the building and there are 5 exit points within this room.

DAFNI

DAFNI CONFERENCE 2025

BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

Chair:

Giuliano Punzo

Director of Sheffield Urban Flows Observatory

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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DAFNI

DAFNI CONFERENCE 2025

BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

Keynote speaker:
Making Good Choices

Dr Juliet Mian

Director of Arup's Climate Services and Sustainability

UKRI Science and Technology Facilities Council

UKRI Engineering and Physical Sciences Research Council

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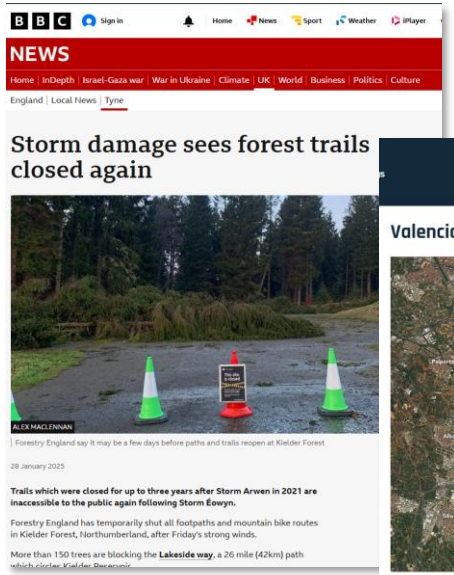
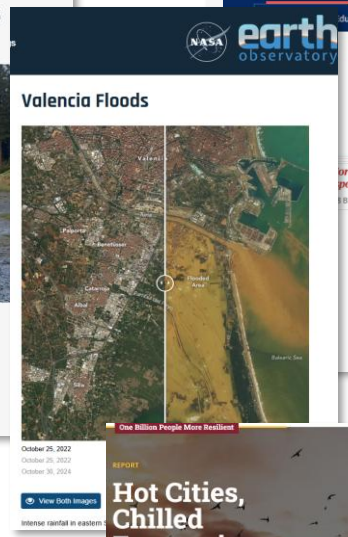
Making good choices

DAFNI conference – bridging the gap between academia and industry

Dr Juliet Mian, Director and Arup Fellow

September 2025





ARUP

We help our clients to integrate climate risks into climate informed decisions that help to **build resilience** and create value from their investments.

This contributes to **safe**, **resilient** and **regenerative** places, where communities will **thrive**.

ARUP

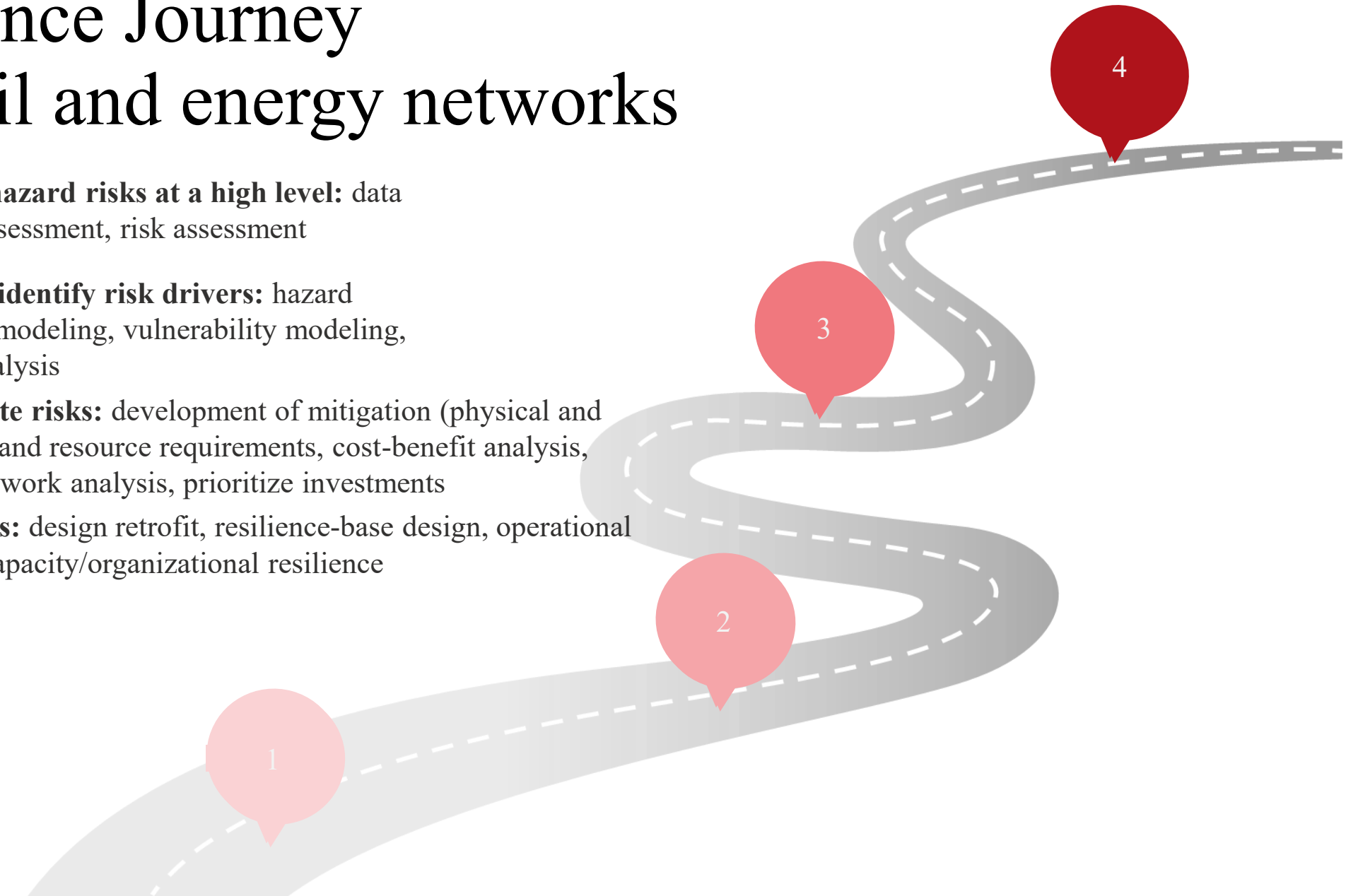
The Resilience Journey for road, rail and energy networks

01 **Understand multi-hazard risks at a high level:** data collection, hazard assessment, risk assessment

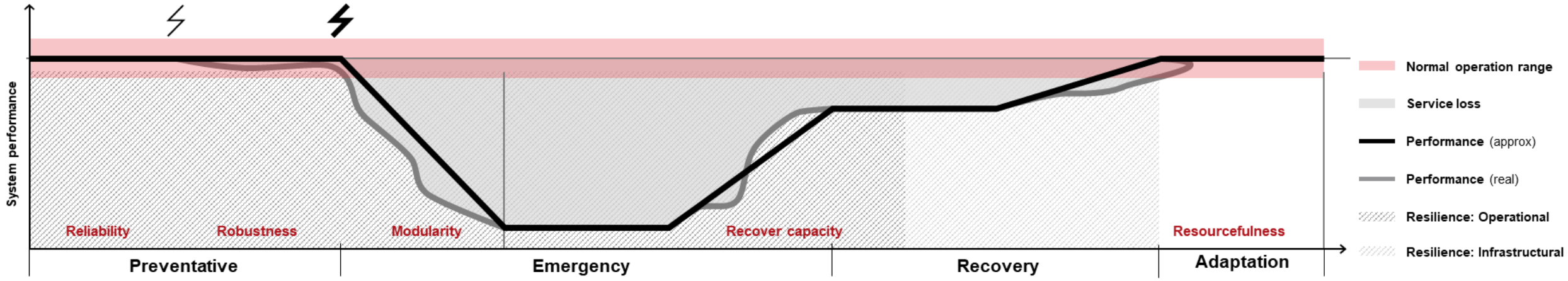
02 **Quantify risks and identify risk drivers:** hazard modeling, exposure modeling, vulnerability modeling, quantitative risks analysis

03 **Strategize to mitigate risks:** development of mitigation (physical and operational) options and resource requirements, cost-benefit analysis, multi-decision framework analysis, prioritize investments

04 **Implement solutions:** design retrofit, resilience-base design, operational planning, adaptive capacity/organizational resilience



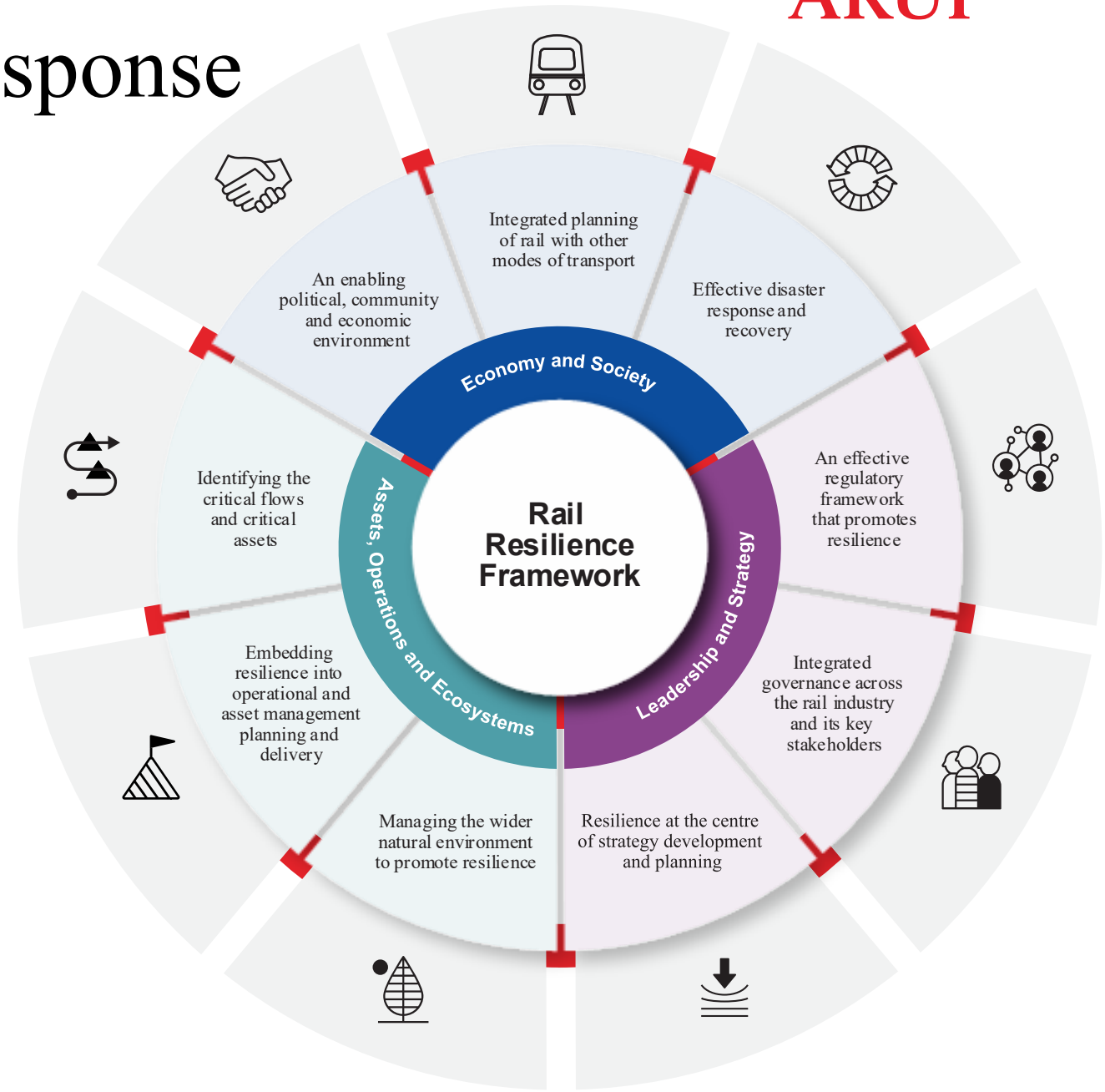
ARUP



Resilience Curve, Jasiunas et al (2021), "Energy Systems Resilience- A review"

Taking a whole-system response

- Work across multiple dimensions to achieve resilience
- Identify which goals need attention and by who
- Make tangible and systemic progress towards resilience



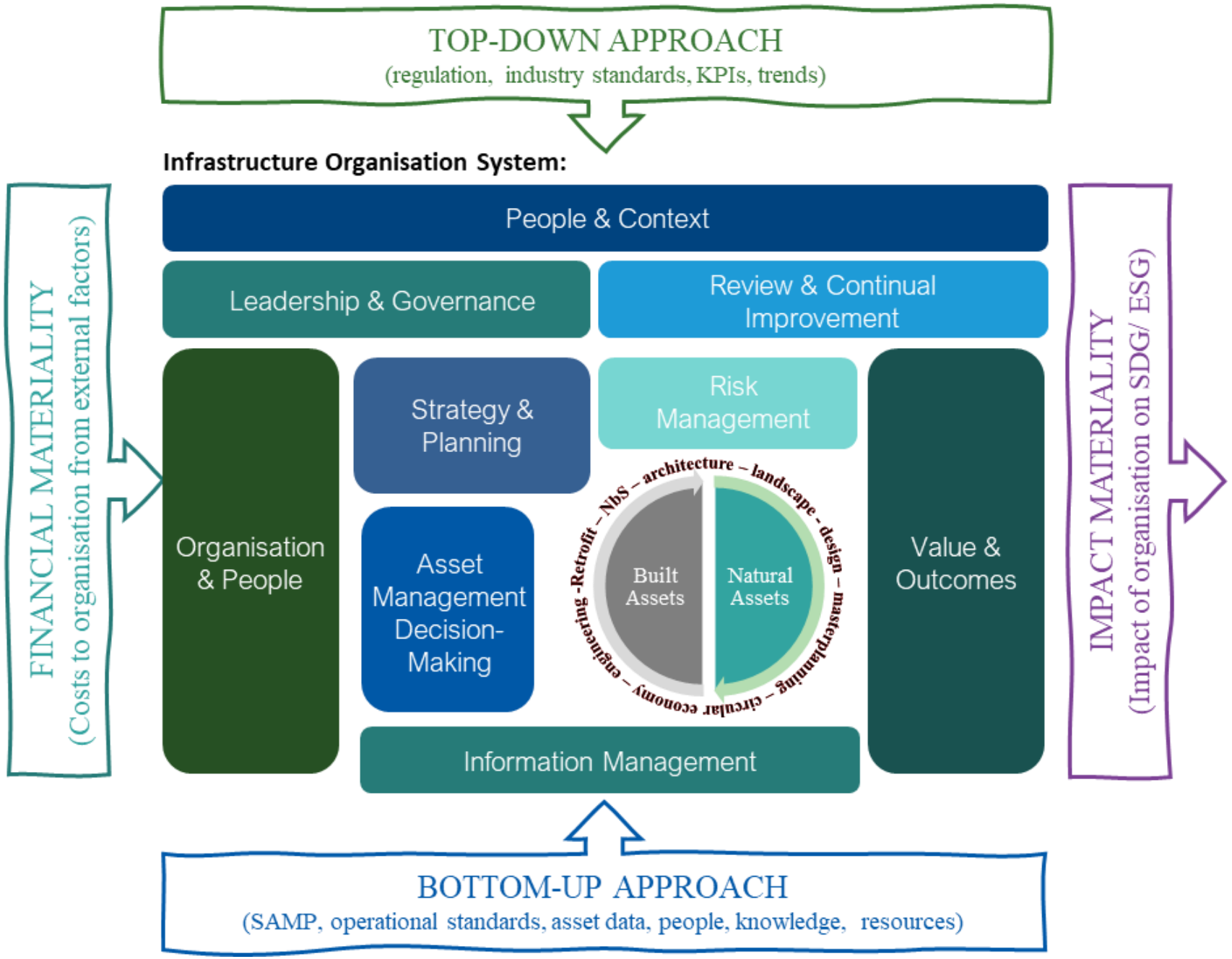
ARUP

1. The big picture – what choices are we making, and why?

Theory of change

Root causes → Problem → Resources (inputs) → Activities → Outputs → Outcomes → Impacts

ARUP


TOP-DOWN APPROACH
(regulation, industry standards, KPIs, trends)
Infrastructure Organisation System:
FINANCIAL MATERIALITY
(Costs to organisation from external factors)
People & Context
Leadership & Governance
Review & Continual Improvement
Organisation & People
Strategy & Planning
Risk Management
Asset Management Decision-Making
Built Assets
Natural Assets
architecture – landscape - design – masterplanning – circular economy – engineering -Retrofit – NbS –
Value & Outcomes
Information Management
IMPACT MATERIALITY
(Impact of organisation on SDG/ ESG)
BOTTOM-UP APPROACH
(SAMP, operational standards, asset data, people, knowledge, resources)

ARUP

An organisation's resilience journey

Asset portfolios

Site Development

Decision to proceed

Decision to take recommendations

Final design

High Level risk assessment

Deeper dives

Quantitative or resilience-based design

Site selection → **Due diligence** → **New construction**

Portfolio Management

Prioritization

Internal validation with sites

Site resilience solutions action

High Level risk assessment (all hazards)

Quantitative (deeper dives for higher risks only

Develop site-specific measures

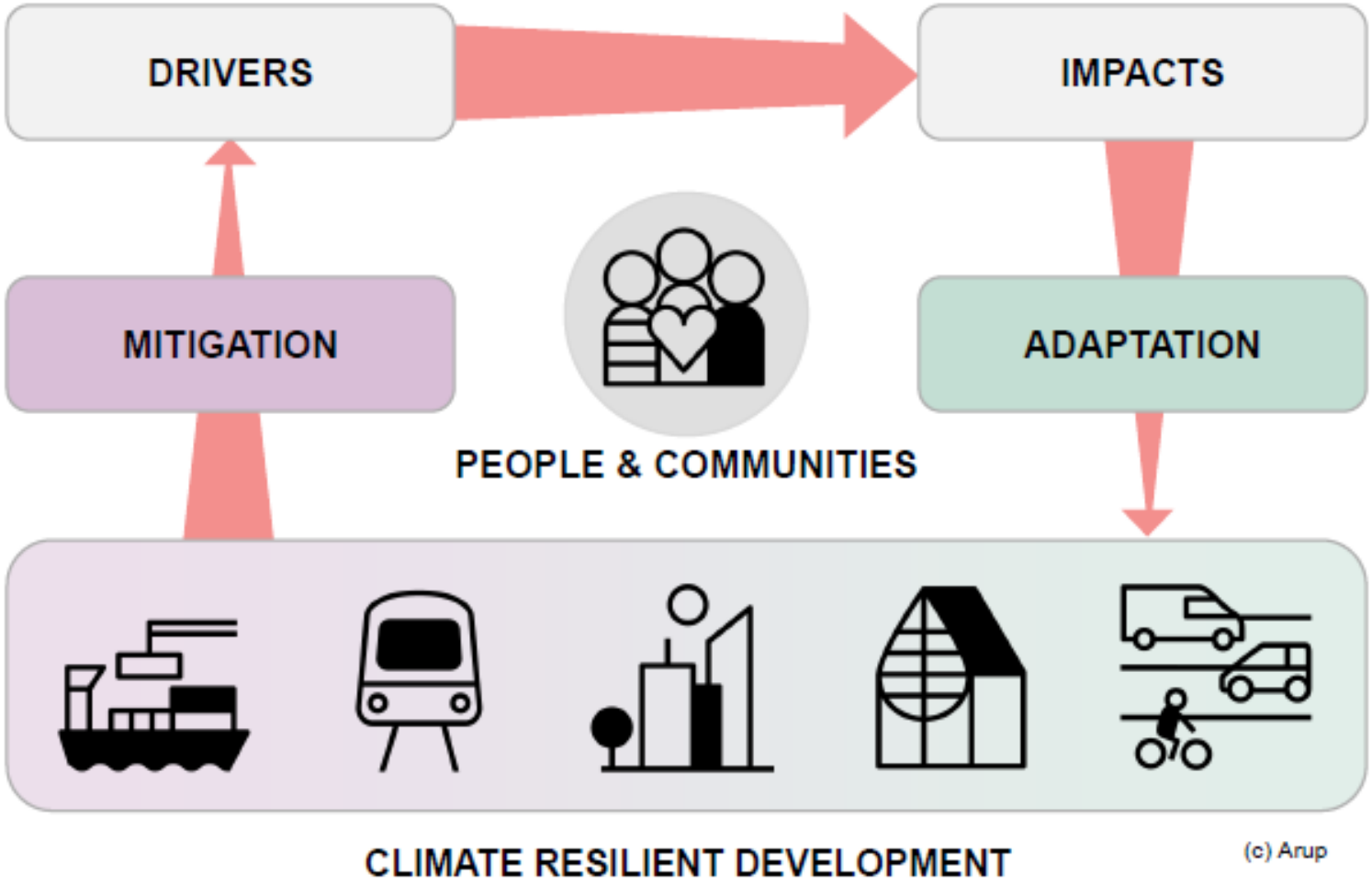
Portfolio assessment → **Cluster assessments** → **Corrective measures**

ARUP

2. The long and lasting impact of infrastructure choices

Safe, resilient and sustainable

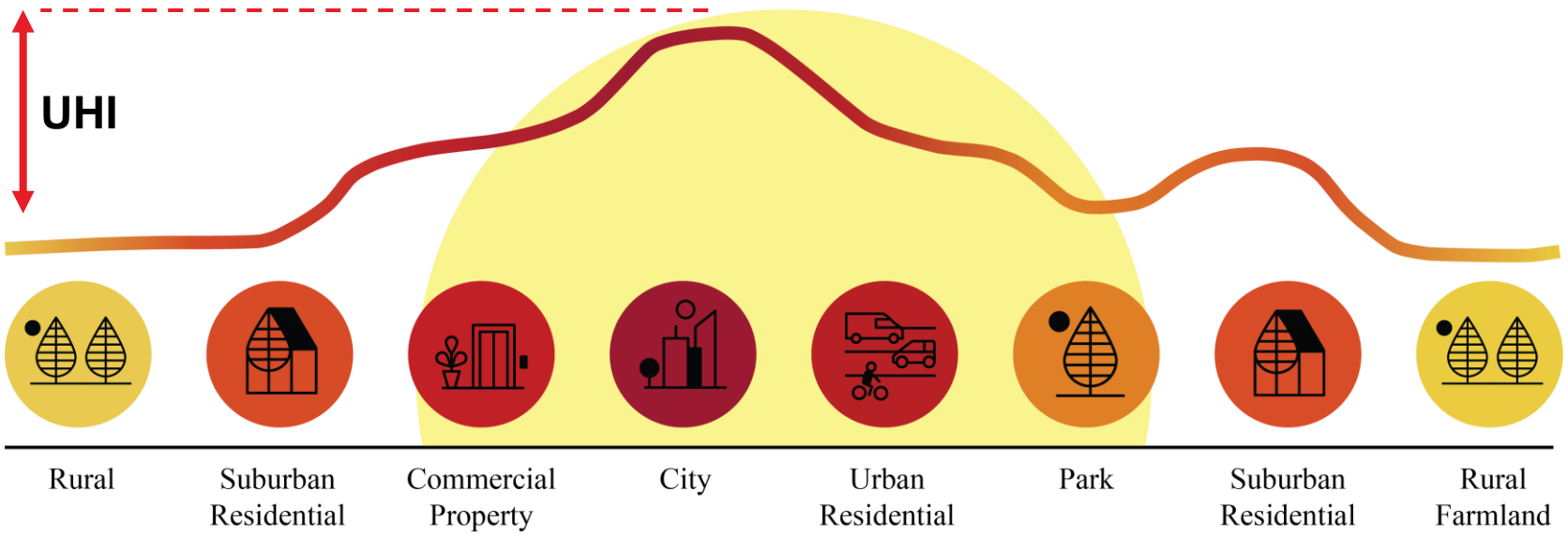
ARUP



ARUP

Urban Heat Island (UHI) effect

Warmer temperatures urban areas experience compared to rural surroundings



x3

expected increase in number of cities exposed to heat above 35°C by 2050

ARUP

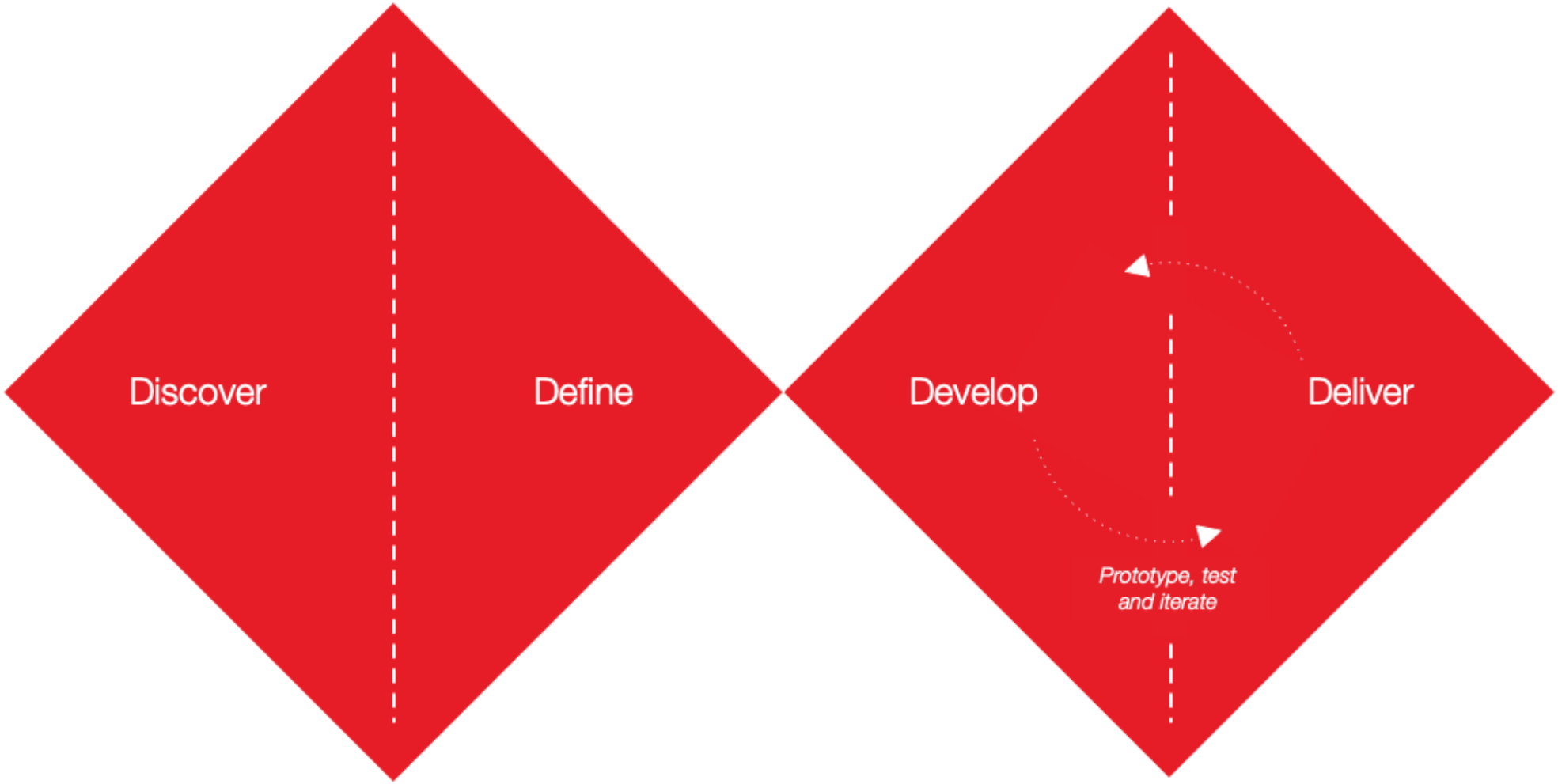
In 2022, global food prices reached an all-time high, driven in part by disruptions in transport networks caused by extreme weather events. Delays in supply chain systems led to shortages, driving up food prices and impacting economies worldwide.

ARUP

3. Framing the choices that we make

ARUP

Zoom out before zooming in



Adapted from UK Design Council Double Diamond

The need for resilience

Energy system example - disrupting factors

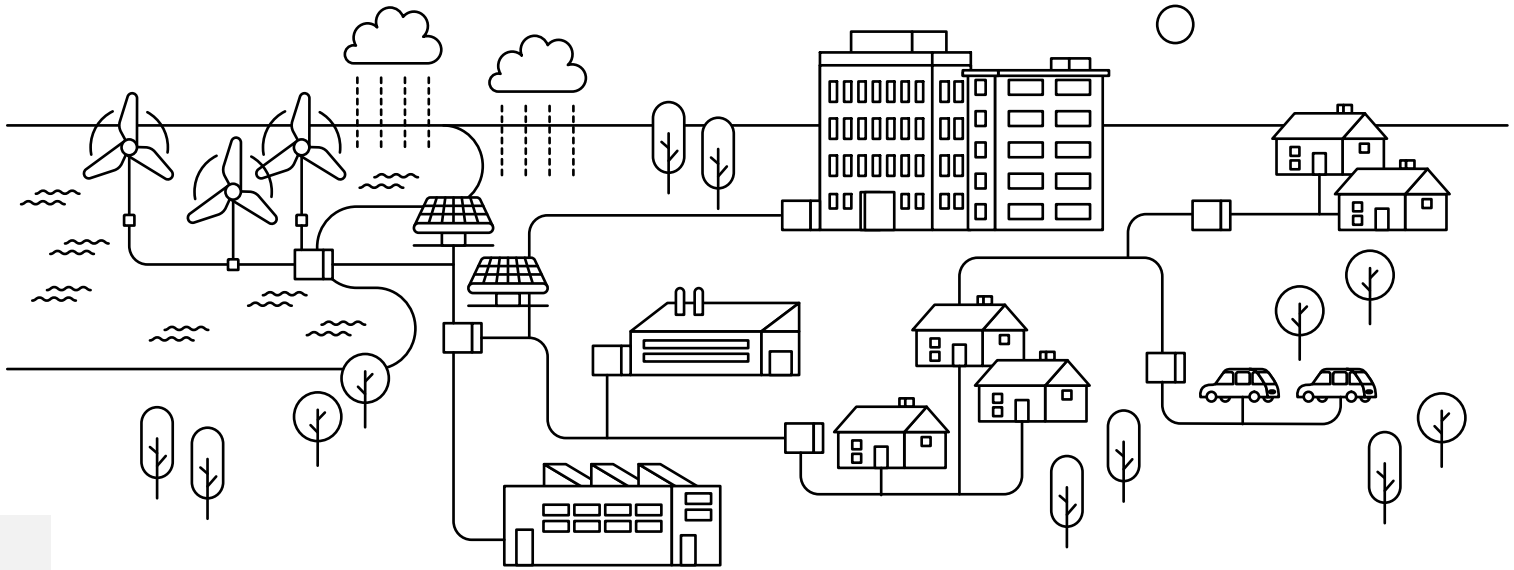
Climate change & Extreme events

Climate change

Extreme weather events

Natural hazards

Geopolitical uncertainty



Technological

Electrical grid outage

Intermittency of renewables

Digitalization

New, disruptive technologies

Increasing interconnectedness of systems

Transformation

Energy market transformation

Regulatory Compliance

Decarbonization & Net Zero strategies

Electrification

Human factors

Growing population

Changing demand & consumer behaviors

Human error

Adversarial

War

Cyber-attacks

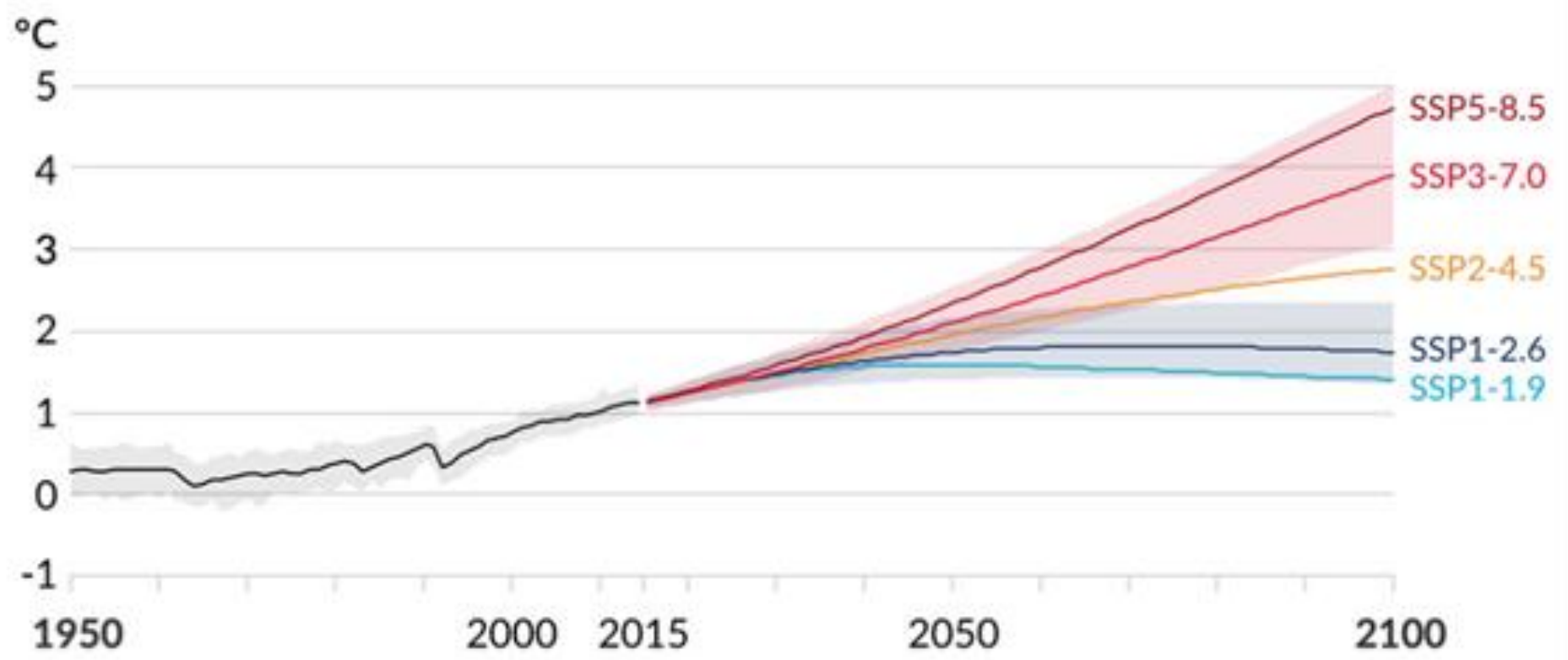
Acts of terror

Energy price instability

ARUP

Climate Change Analysis

Climate Change Models

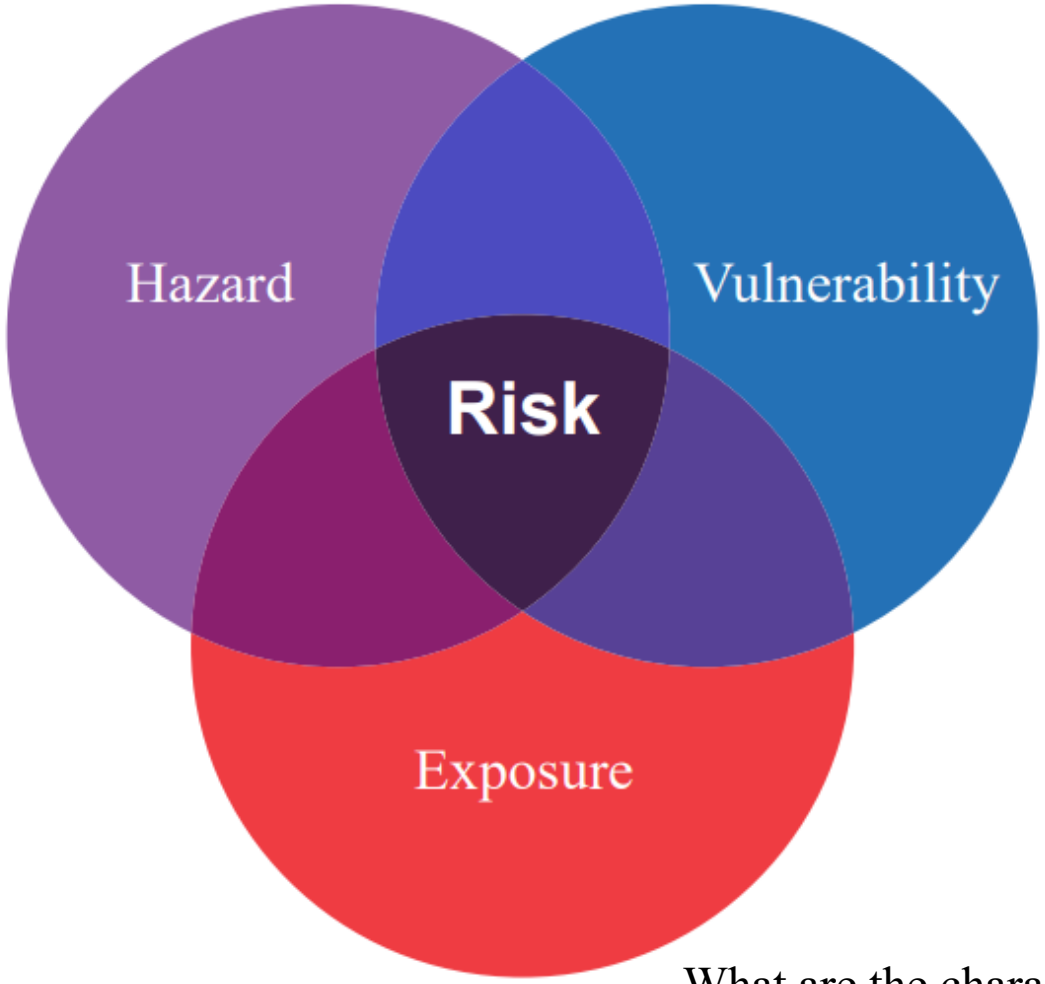


Projected global average surface temperature change in each of the five SSP scenarios.

ARUP

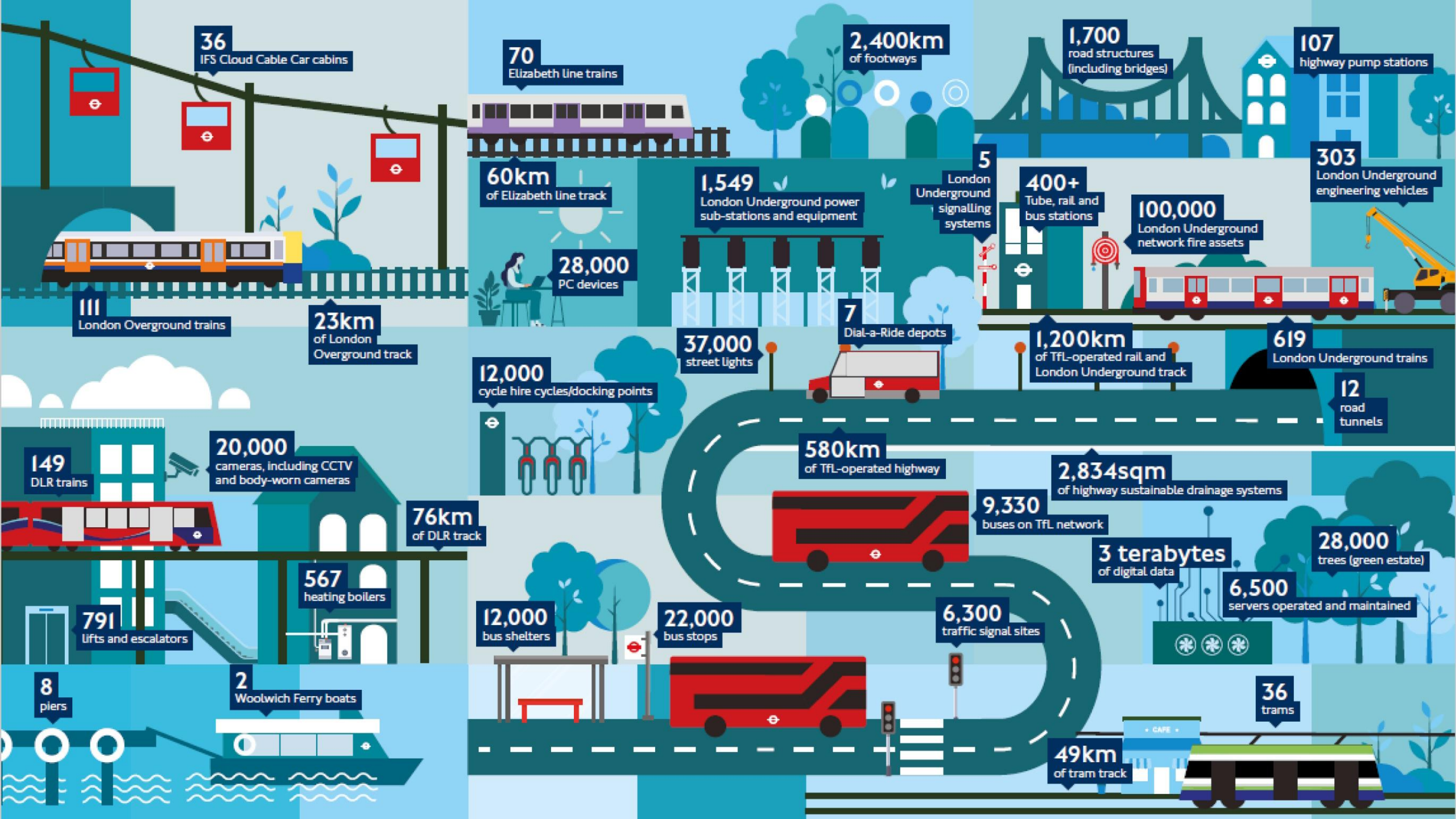
Climate risk analysis

How likely is a hazard event to occur, and what is the intensity?



How damageable are the exposed assets and how susceptible are building occupants?

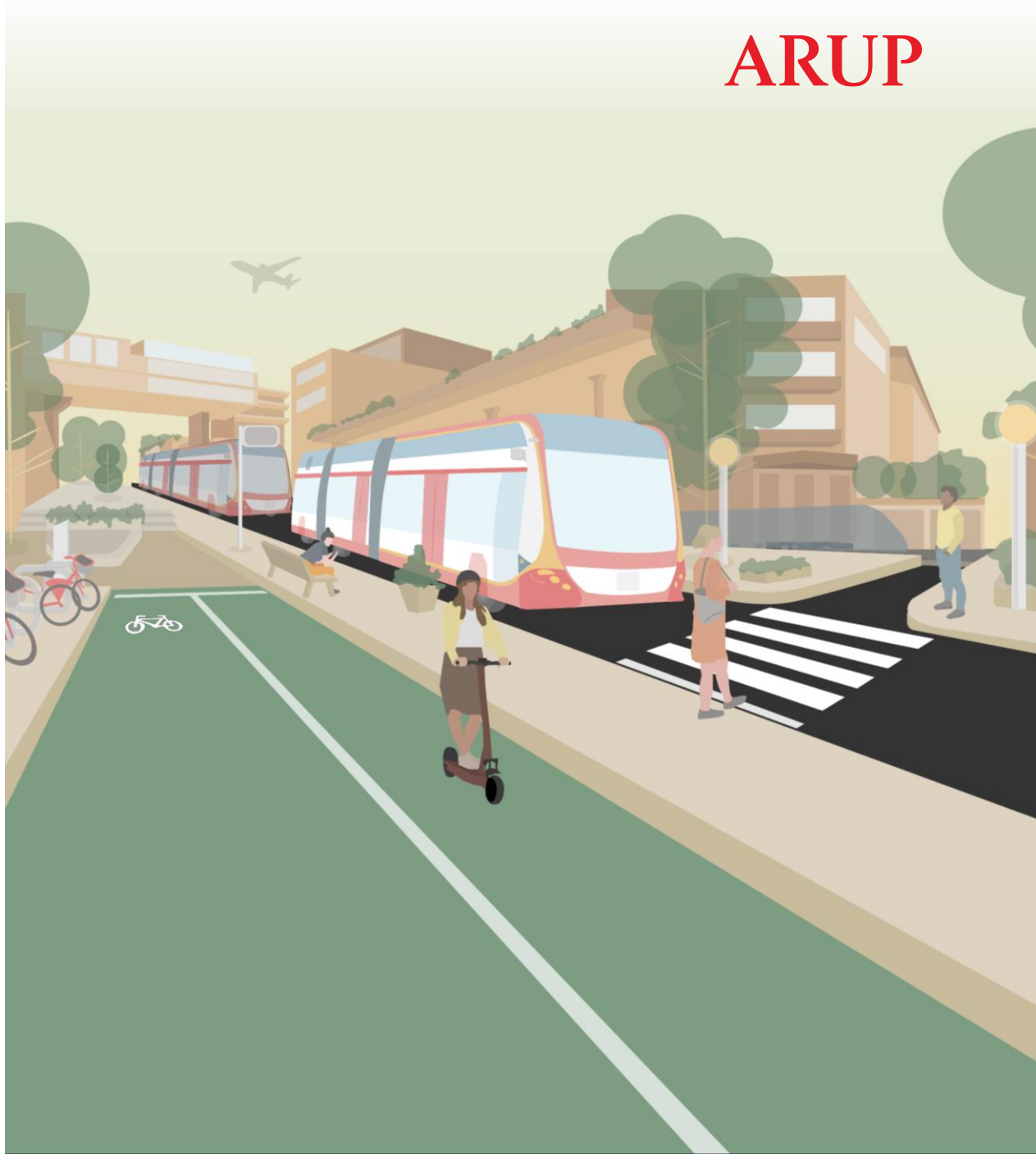
What are the characteristics, functions, and replacement values of exposed assets or the number of building occupants?


36
IFS Cloud Cable Car cabins
111
London Overground trains
23km
of London Overground track
70
Elizabeth line trains
60km
of Elizabeth line track
28,000
PC devices
2,400km
of footways
1,549
London Underground power sub-stations and equipment
5
London Underground signalling systems
1,700
road structures (including bridges)
107
highway pump stations
303
London Underground engineering vehicles
400+
Tube, rail and bus stations
100,000
London Underground network fire assets
619
London Underground trains
1,200km
of TfL-operated rail and London Underground track
12
road tunnels
7
Dial-a-Ride depots
37,000
street lights
12,000
cycle hire cycles/docking points
580km
of TfL-operated highway
2,834sqm
of highway sustainable drainage systems
9,330
buses on TfL network
3 terabytes
of digital data
28,000
trees (green estate)
6,500
servers operated and maintained
6,300
traffic signal sites
12,000
bus shelters
22,000
bus stops
36
trams
49km
of tram track
149
DLR trains
20,000
cameras, including CCTV and body-worn cameras
76km
of DLR track
567
heating boilers
791
lifts and escalators
8
piers
2
Woolwich Ferry boats

Investing in resilience is no longer optional, it’s essential

Achieving resilience begins with understanding that every place has its own story, shaped by geography, culture, and unique set of challenges. Making infrastructure networks more resilient requires tailored solutions that address these local contexts, while ensuring long-term functionality.

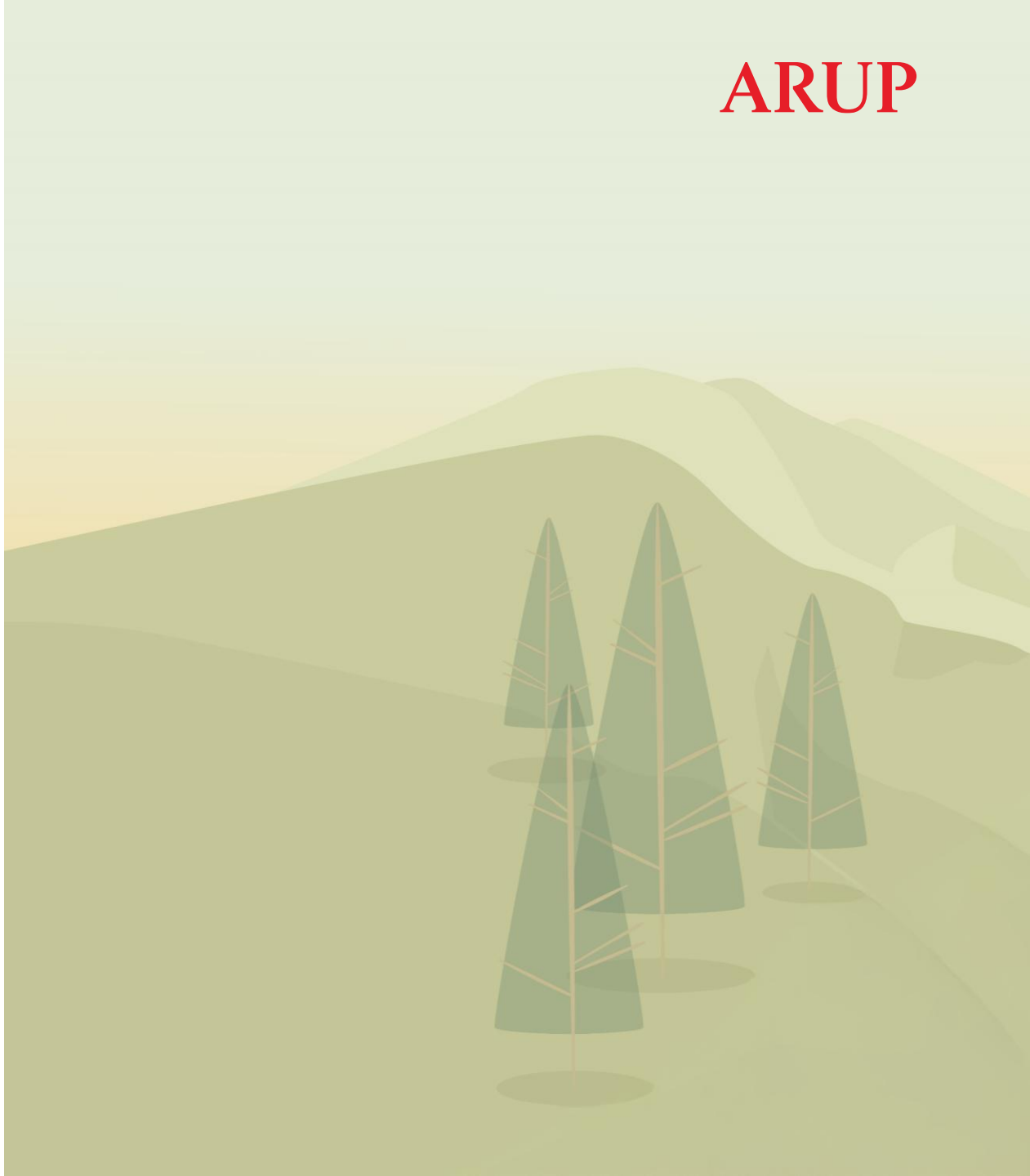
Resilient road networks reduce the risk of disruption, protect and connect communities, and help secure sustainable economic growth. Acting now saves money in the long term and helps enable adaptable, future ready infrastructure.



4. What's stopping us?

We are navigating an environment of extreme uncertainty. Despite this, certain realities are clear: assets, operations, and people will inevitably be affected by climate change. Organisations must make strategic decisions on allocating limited resources, addressing immediate shocks, and preparing for long-term stresses and disruptions.

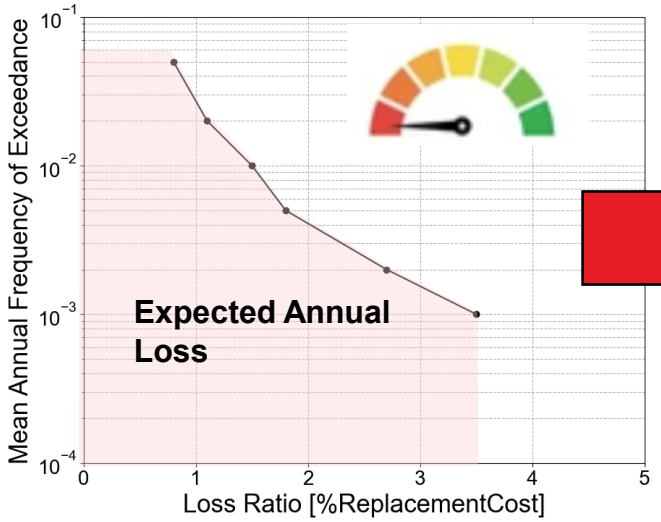
Every $1 spent on preventive road maintenance saves $6 to $10 in future repair costs [American Association of State Highway and Transportation Officials (AASHTO)]



ARUP

Selection of adaptation measures using CBA

Calculate **risk** considering the as-built assumption



List possible **adaptation** measures

Reassess the risk considering the implementation of the adaptation measure to understand **the risk reduction** associated to each adaptation measure

Adaptation measure #1

Adaptation measure #2

Adaptation measure #3

Perform a **cost-benefit analysis** to understand the **most effective** solution

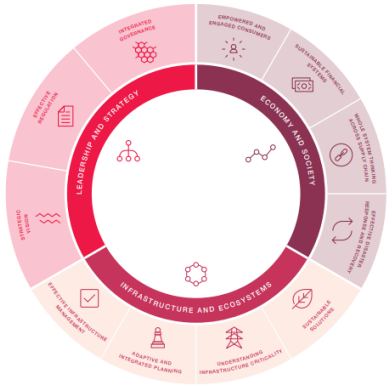
A tiered approach to assessment

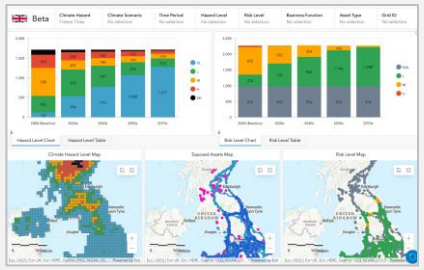
Energy systems need several levels of detail for resilience planning and implementation

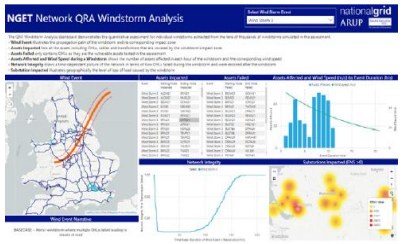
Tier 1
Screening models or indices. Widest engagement, holistic view for opportunities and roadmap.

Tier 2
Semi-quantitative risk assessment. Decision support and investment prioritisation.

Tier 3
Quantitative system modelling. Actionable insights for specific shocks/stresses.







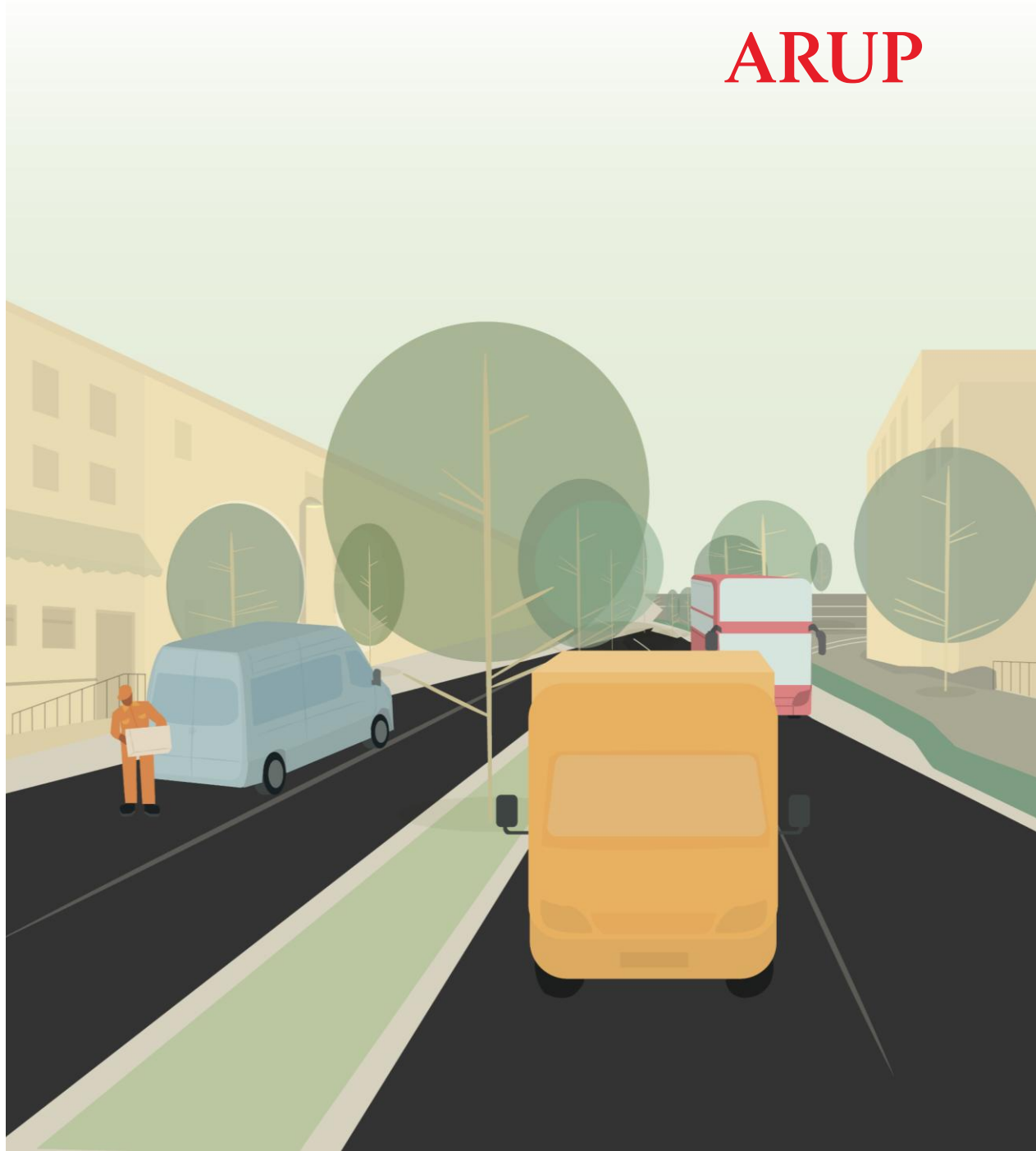
- Holistic understanding
- Creating the right tools for the job
- Prioritisation and proportionality of investment
- These are all prior to adaptation

5. The outcomes we want to see

Safe and connected communities

Imagine infrastructure networks that keep communities safe and connected, even as demand increases, infrastructure ages, storms become more extreme and temperatures rise. This is what resilience looks like when we adapt together.

Our infrastructure systems are the backbone of our communities, local businesses, and essential services.



ARUP

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Speaker:

DAFNI Update

Sarah Byrne

Senior Software Engineer / Product Owner

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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DAFNI

DAFNI Platform Update

Sarah Byrne
Product Owner / Senior Software Engineer

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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Who are we?

Technical Team

Sarah Byrne

Senior Software Engineer / Product Owner

Rose Dickinson

Senior Software Engineer/ Technical Lead

Aaron Larkins

Software Engineer

Jack Haydock

Software Developer

Elizabeth Mamtsits

Research Software Engineer & Liaison

Dr. Server Kasap

DevOps Engineer

Dr. Lewis Sampson

Research Software Engineer

Akhil Dubakunta

Software Engineer

Who are we?

Technical Team

Dr. Jens Jensen

Data Scientist

Dr. Kyle Stevenson

User Liaison

Dr. Saiful Khan

Senior Data Scientist

Teagan Zoldoske

Data Curator

Karen VanHaltren

Data Curator

Earl Talavera

Scientific Computing Graduate

Lizzie Salmon

Scientific Computing Graduate

Overview

Focus Areas

- Improved infrastructure
- Broadening access to data on DAFNI
- Platform security
- Supporting projects through feature development

Infrastructure

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Engineering and Physical Sciences Research Council

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DAFNI
Data & Analytics Facility for National Infrastructure

Improved Infrastructure

- New Kubernetes cluster latest version
- Switched to using flux/helm to deploy apps and services
- Access to more 3rd party packages for expanded functionality
- Switched to hosted databases and S3 storage (within STFC)
- Hardware updates (future)

DAFNI / STFC Cloud Hybrid

- Started investigating blending own resources with cloud resources
  - Provisioned node from STFC cloud for DAFNI
  - Working through hurdles blocking integration
  - Look into automated provisioning (future)
- Goal to establish what is possible for hybrid solution, for example
  - Running workflows with access to larger compute
  - Accessing more GPUs on request

Connecting to JASMIN

- Started project to investigate possibility of pulling JASMIN data into DAFNI
- Initial phase of identifying use cases and understanding architectures
- If you use DAFNI and have a use case for connecting to JASMIN please come and speak to us

Broadening access to DAFNI

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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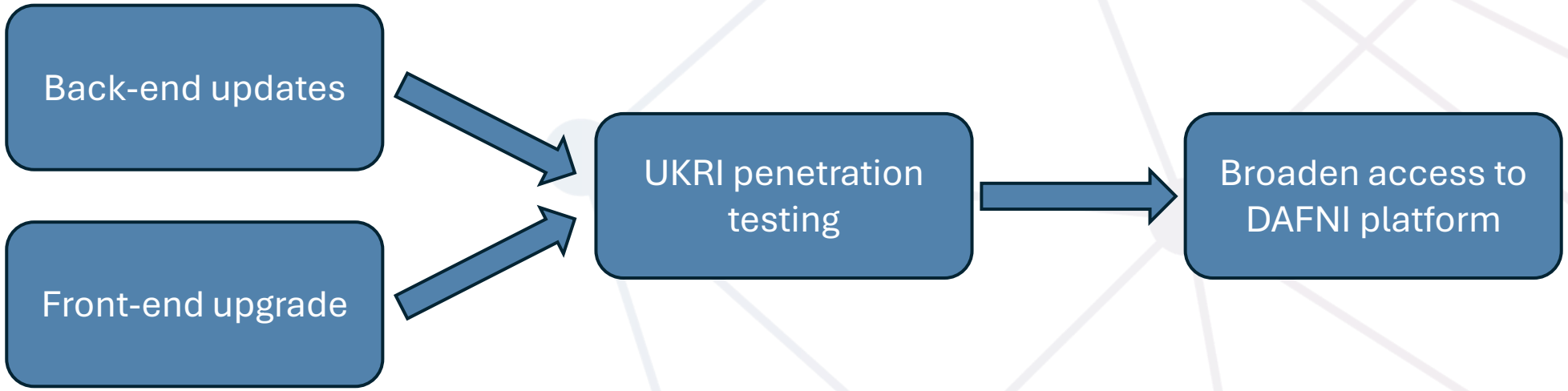
DAFNI
Data & Analytics Facility for National Infrastructure

Broadening Access



- Back-end focused on dependency updates for security patching
- Front-end work is a full upgrade to newer framework + accessibility and usability review

‘Basic User’ Accounts

- Currently on platform all users have same access level
  - Access to all resources for uploading and running models + visualising results
  - All trusted users -> know who they are and what they’re doing
- Introducing account types that come with access levels
  - ‘**Expert User**’ accounts -> current access level
  - New ‘**Basic User**’ accounts -> read-only instant access upon registration

DAFNI

Log in to your account

Username or email

Password

Log In

Remember me

Forgot Password?

Apply for an account

Terms of use

Platform Features

Parameter Sweep Steps

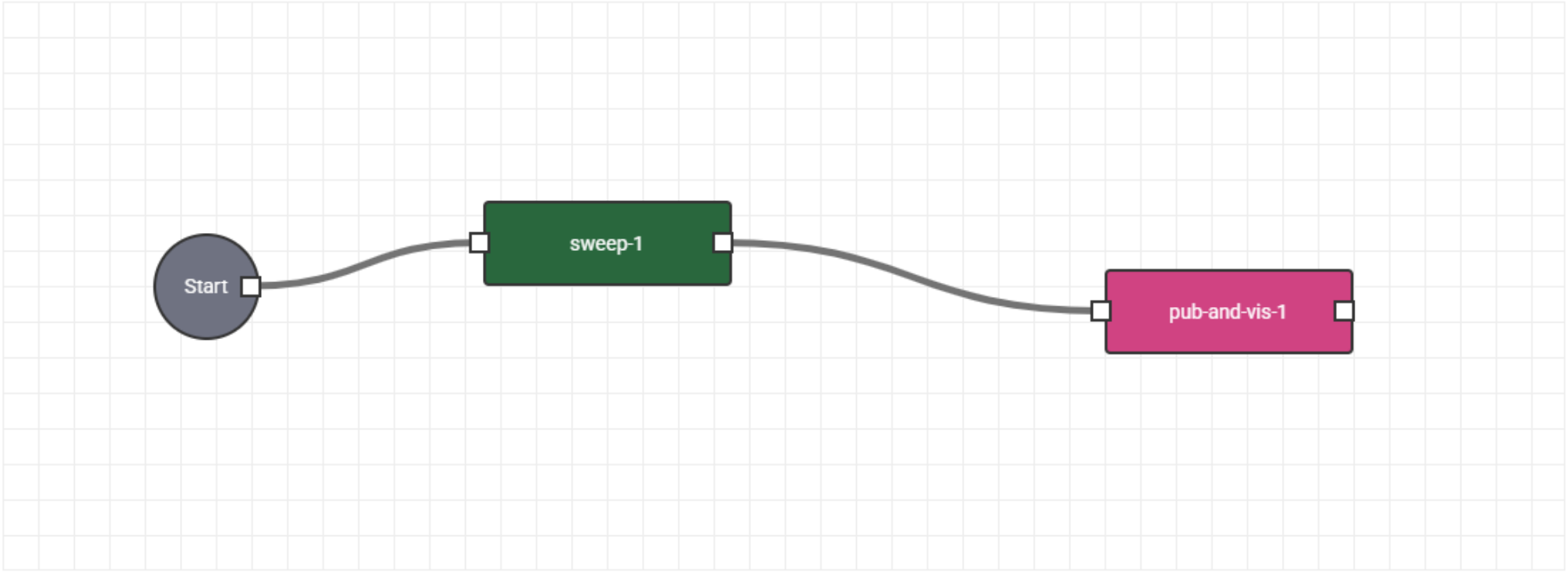
- Developed in collaboration with USARIS project (BSRW)
    - Uncertainty quantification and sensitivity analysis for resilient infrastructure systems
- Allows many more iterations over a model within a workflow
    - From 50 to 4000

Parameter Sweep Steps

1 Workflow steps — 2 Workflow metadata — 3 Parameter set values — 4 Parameter set metadata

Add Workflow Steps

- Model
- Parameter Sweep
- Publish
- Publish + Visualise
- Loop-Parallel
- Loop-Sequential
- Reset position
- Reset zoom



Parameter Sweep Steps

DAFNI

Array Azimuth (90 is facing E, 180 S etc.)

☑ Iterate Values

☐ Generate Values

90 105 120 135 150 165 180

Default: 180, Min: - , Max: -

Start Time *

☐ Iterate Values

2023-06-06 02:00

Default: 2023-06-06 02:00

Number of days in calc.

☑ Iterate Values

☑ Generate Values

Count *: 50

Distribution *: Normal

Standard Deviation: 2

Mean: 14

Default: 14, Min: - , Max: -

Rows per page: 10 1-9 of 9

Parametric Combination Mode

This controls how we calculate the combinations of parameter values that are being swept. If 'All' is selected we will calculate all possible combinations of the parameter values. If 'Specified' is selected we will use the combinations as you have specified them i.e. if you have 2 parameters A and B and provide 1,2,3 as values to A and 4,5,6 to B then we will produce three combinations - 1,4 | 2,5 | 3,6.

Parametric combination mode *: All combinations

Metadata Improvements

- Added new metadata fields across assets
  - Subject for models and workflows
  - Project name and url, funding details, embargo end date for all assets
  - Source field for datasets
- New process for making data public on platform
  - Ensuring metadata for all publicly shared assets is filled in correctly

What comes next?

Public Collections

- New way to display/archive project outputs all in one place
- Public version of groups with extra fields
    - Publications, multiple contact points, acknowledgements
- Public to all DAFNI users

Public Collections

DAFNI

DAFNI

MENU

- Home
- Data
- Models
- Workflows
- Visualisations

MANAGE ASSETS

- Public
- Groups
- Collections

Home / Collections

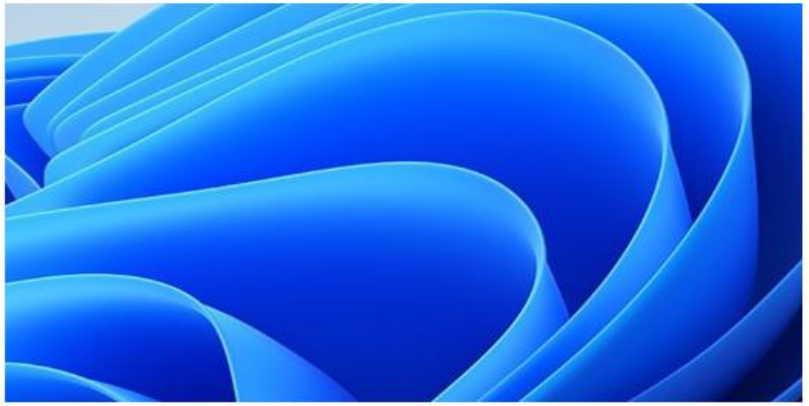
Collections

Create collection

Search by title or subject or keyword

test collection

test collection 20/11



Technical User Group

- DAFNI needs you!
- We want our development to continue to meet your needs
- Come and share your ideas with us


Any questions?

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Networking break

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Hope you enjoyed your break
Please return to your seats for the next set of speakers

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Speaker:
SALIENT

Dr Richard Kirkham

Principal Investigator on Building a Secure And Resilient World, University of Manchester

UKRI Science and Technology Facilities Council

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Speakers:
Assessing the resilience of infrastructure in the UK

Rachael Steller
Climate Change Committee

Karina Rodriguez Villafuerte
Climate Change Committee

UKRI Science and Technology Facilities Council

UKRI Engineering and Physical Sciences Research Council

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11 September 2025

Assessing the resilience of infrastructure in the UK: the 2025 Adaptation Progress Report

Rachael Steller and Karina Rodriguez Villafuerte, Climate Change Committee

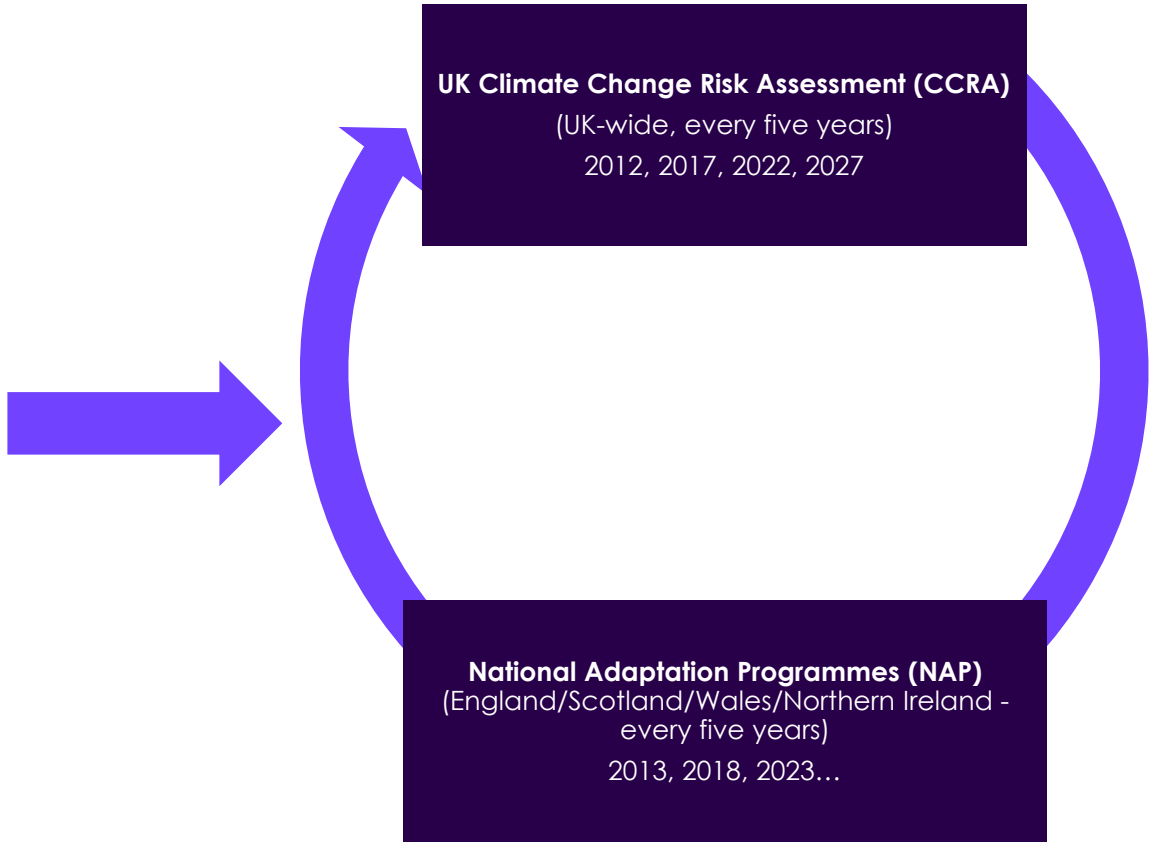
Contents

Advising and assessing climate risk

Evidence cycle for informing adaptation in the UK

Climate Change Committee advice on CCRA **(CCRA4 Evidence Report due in May 2026)**

Climate Change Committee progress reports **(Next Scotland Progress Report Q3 2026)**



UK climate projections (Met Office)

Climate impacts and adaptation research

Adaptation Reporting Power (ARP)

Regional and sectoral adaptation plans

Government policies

Adaptation progress report 2025: cross economy assessment

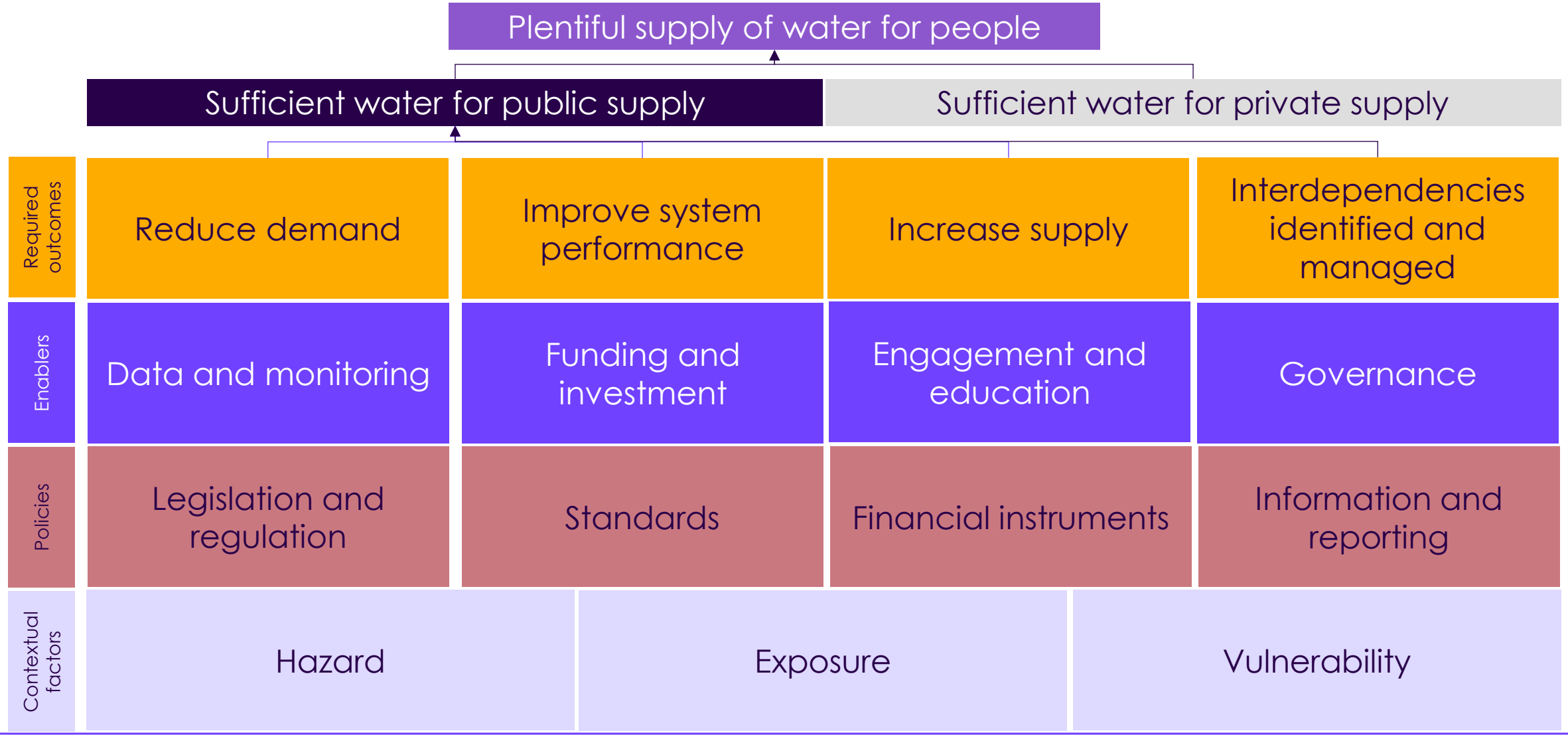
Measuring progress on adaptation

Key areas of adaptation for a well-adapted UK

Land, nature, and food	Infrastructure	Built environment and communities	Health and wellbeing	Economy
Nature	Water supply	Towns and cities	Health	Business
Working land and seas	Energy	Buildings		Finance
Food security	Telecoms and ICT	Community preparedness and response		
	Transport			

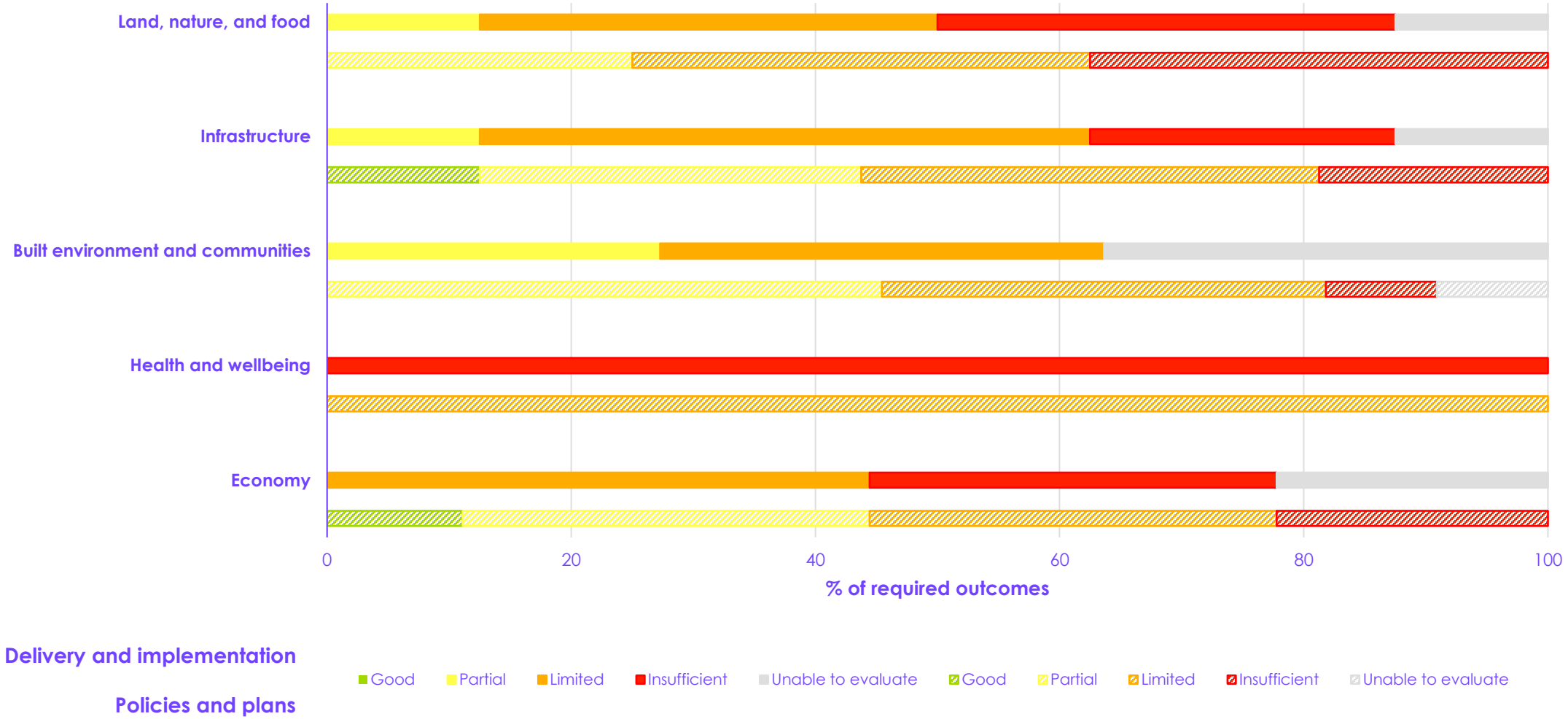
Measuring progress on adaptation

How we monitor preparedness for climate change



Summary of progress on adapting to climate change

The UK's preparations for climate change remain inadequate



Source: CCC analysis

Assessment of adaptation progress for infrastructure

Infrastructure adaptation planning is still failing to lead to demonstrable delivery of adaptation

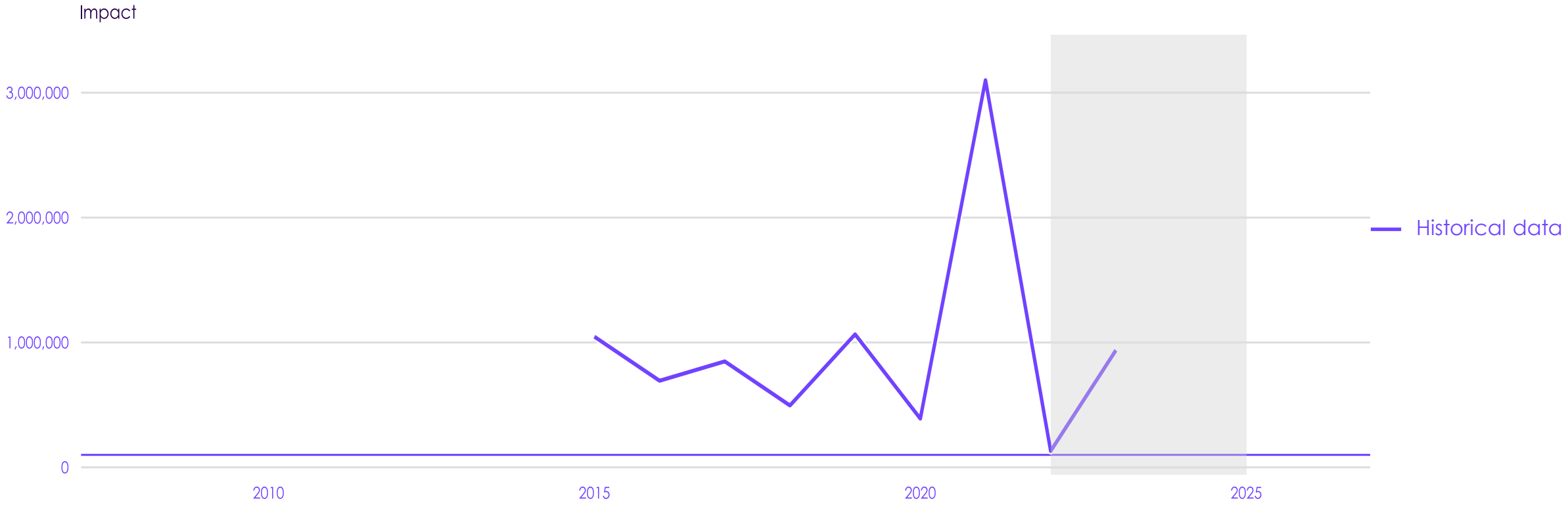
Infrastructure outcome scores			
Thematic area	**Outcome**	**Delivery and implementation score**	**Policies and plans score**
Water supply	Reduce demand	Insufficient	Partial
	Improve system performance	Insufficient	Partial
	Increase supply	Partial	Partial
	Interdependencies identified and managed	Limited	Limited
Energy	Reduced vulnerability of energy assets to extreme weather	Limited	Partial
	Climate-resilient supply	Limited	Limited
	Interdependencies identified and managed	Partial	Insufficient
Telecommunications and ICT	Vulnerability of assets reduced	Unable to evaluate	Limited
	System level resilience	Unable to evaluate	Limited
	Interdependencies identified and managed	Insufficient	Insufficient
Transport	Asset and system level reliability of rail network	Limited	Good
	Asset and system level reliability of strategic road network	Limited	Good
	Asset and system level reliability of local roads	Limited	Insufficient
	Asset and system level reliability of airport operations	Limited	Partial
	Asset and system level reliability of port operations	Insufficient	Limited
	Interdependencies identified and managed	Limited	Limited

Adaptation progress report 2025: examples of data underpinning energy findings

Key indicators for energy

Customer interruptions due to severe weather vary year-on-year based on weather events

c) Number of severe weather customer interruptions to energy supply in Great Britain



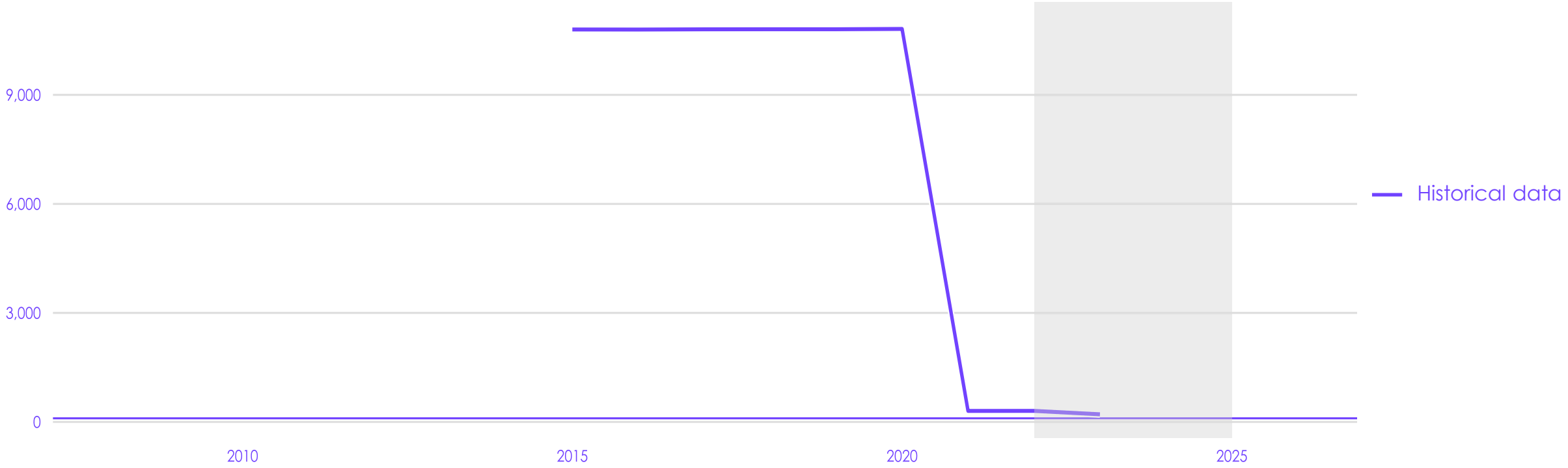
Source: Ofgem

Key indicators for energy

Less critical customers supplied by substations at risk of flooding addresses interdependency risks

a) Number of critical customers supplied by substations at risk of flooding in Great Britain

Implementation



Source: Ofgem
Notes: Critical customers are: "connected customers that provide a vital service to the community, where the loss of supply to these sites is likely to lead to mass evacuation".

Fourth Climate Change Risk Assessment (CCRA4)

CCC outputs for CCRA4

Independent Assessment and statutory advice

Technical Report

Review the published evidence to:

- Identify climate risks and opportunities to the UK
- Assess the urgency of taking additional action to manage each risk

Well-Adapted UK report

Synthesise published evidence and conduct innovative research to:

- Discuss target levels of climate resilience
- Set out what actions are needed to build climate resilience

Statutory Advice Report

Provide independent advice to:

- Recommend policy actions needed in the next set of national adaptation plans

What are the risks that need to be managed?

What actions are needed to manage these risks?

What should governments do to ensure these actions are delivered?

CCC's Independent Assessment to Government
CCRA4 - IA

CCC's statutory advice to Government

Next steps
Further opportunities to engage on CCRA4-IA

- Technical Report:
  - The Met Office-led consortium are progressing with analysis and drafting.
  - An interim version of the Technical Report will be published for Community Review in November 2025.

- Well-Adapted UK report:
  - We are looking for potential indicators to track adaptation progress.
  - Please share your ideas via this Mentimeter survey: menti.com, code: 8330 6697
  - Reach out to rachael.steller@theccc.org.uk and karina.rodriguezvillafuerte@theccc.org.uk

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DAFNI

DAFNI CONFERENCE 2025

BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

Speaker:
CROSSEU

Professor Nicholas Vasilakos

University of East Anglia

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

UKCRIC™
UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES

CrossEU

Climate Shocks and Income Inequality: Some first results

Nicholas Vasilakos
University of East Anglia

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

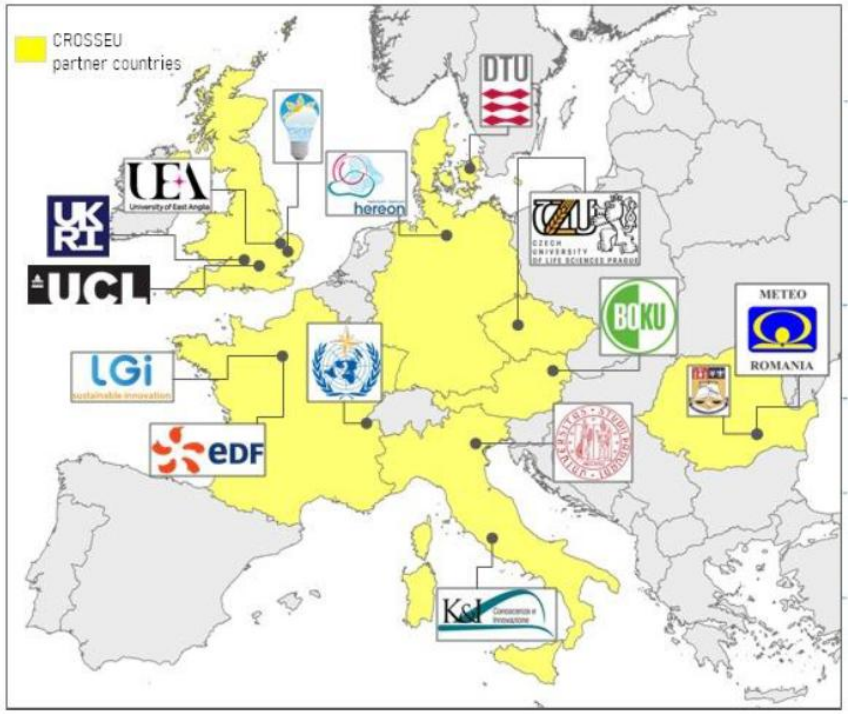
UK participants in this project are co-funded by UK Research and Innovation (UKRI).

Co-funded by the European Union

UK Research and Innovation

What we do

Cross-sectoral Framework for Socio-Economic Resilience to Climate Change and Extreme Events in Europe (CROSSEU)



What we do

Cross-sectoral Framework for Socio-Economic Resilience to Climate Change and Extreme Events in Europe (CROSSEU)

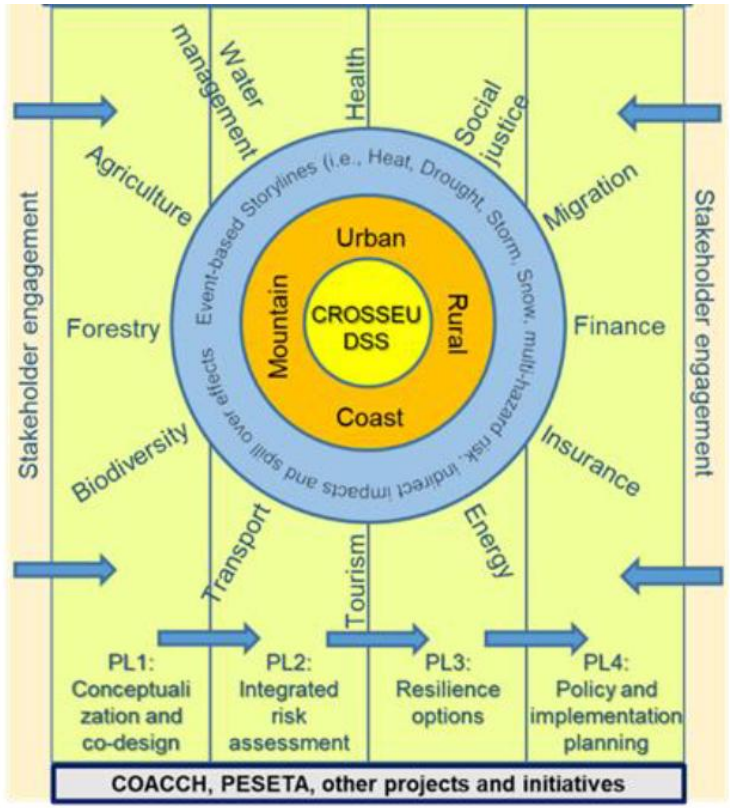


Figure 1. CROSSEU concept

🌎 What does CROSSEU do?

Quantifies economic losses and distributional impacts (income inequality) from past and future extreme weather events.

Integrates climate science, economics, and social policy.

Provides tools for better risk mitigation and adaptation planning at EU and national levels.

🔬 Scientific Packages (WPs):

WP1: Macroeconomic modelling (Econometrics/CGE, Global)

WP2: Sectoral and regional analysis (Case studies)

WP4: Governance analysis and policy recommendations

Our case studies

Case Study 1: The impact of the unprecedentedly hot decade (2010–2019) on the health sectors in the United Kingdom and Czech Republic.

Case Study 2: The impact of the 2018-2022 multi-year drought on agriculture and food security in Central and South-Eastern Europe (SEE).

Case study 3: Storm damages in South Western Denmark and Northern Germany.

Case study 4: Valuation of social benefits of floods and flash floods adaptation and mitigation in Northeastern Italy.

Case study 5: Snow-related hazard risks in the European Alps and Carpathians under different climate sce-narios and impacts on the tourism sector and mountain communities.

Case-study 6: Shifting climate seasonality and water availability: risks for socio-ecological systems in the Lower Danube (LD).

Case-study 7: Impacts on energy demand and energy security in systems with high shares of renewable energy from heatwaves, drought and storms concurrent climate hazards on energy systems in Europe.

Case-study 8: Transboundary effects on agriculture and labour productivity due to climate impacts in the rest of the world.

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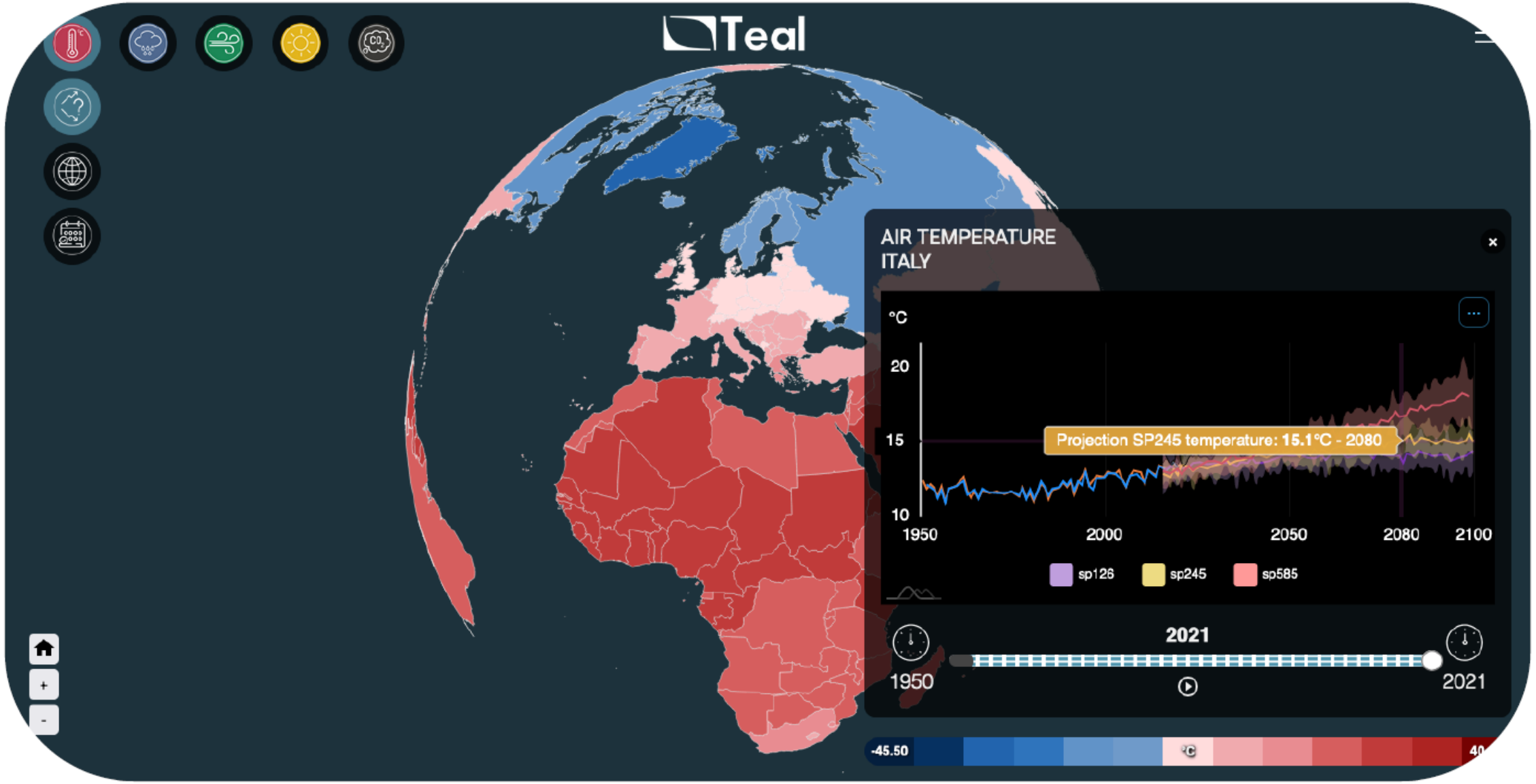

Teal
AIR TEMPERATURE
ITALY
°C
20
15
10
1950
2000
2050
2080
2100
Projection SP245 temperature: 15.1°C - 2080
sp126
sp245
sp585
2021
1950
2021
-45.50
°C
40

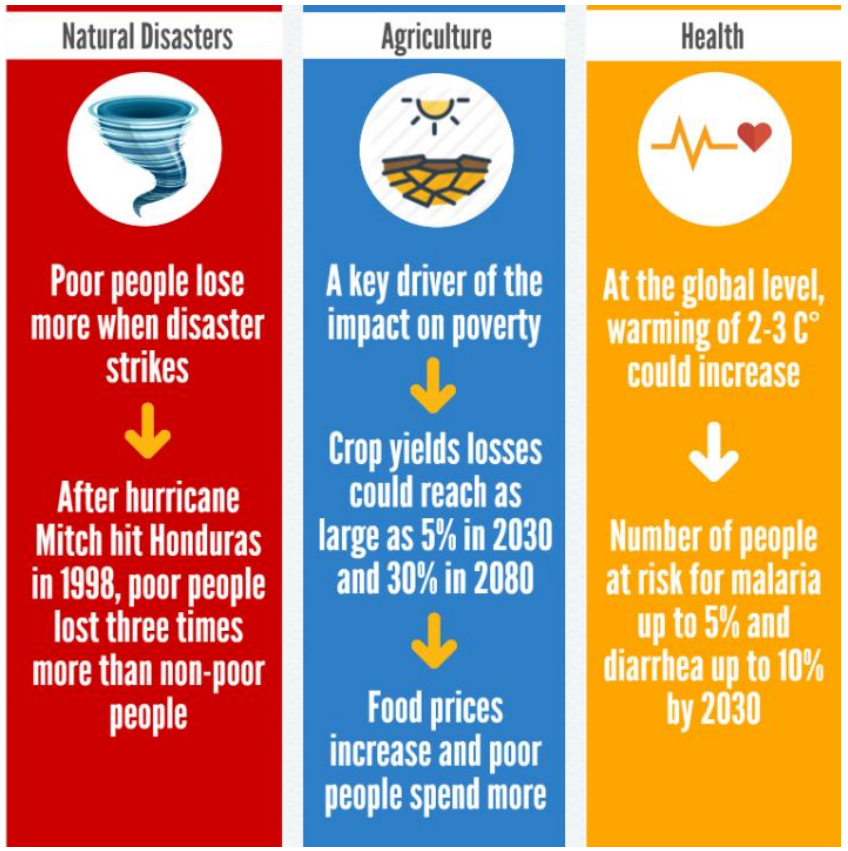
CrossEU

Climate Change & Society: Focus on Income Inequality (preliminary findings)

Drawing on findings from Vasilakos, Zhang, Jenkins, Forstenaeusler (2025)

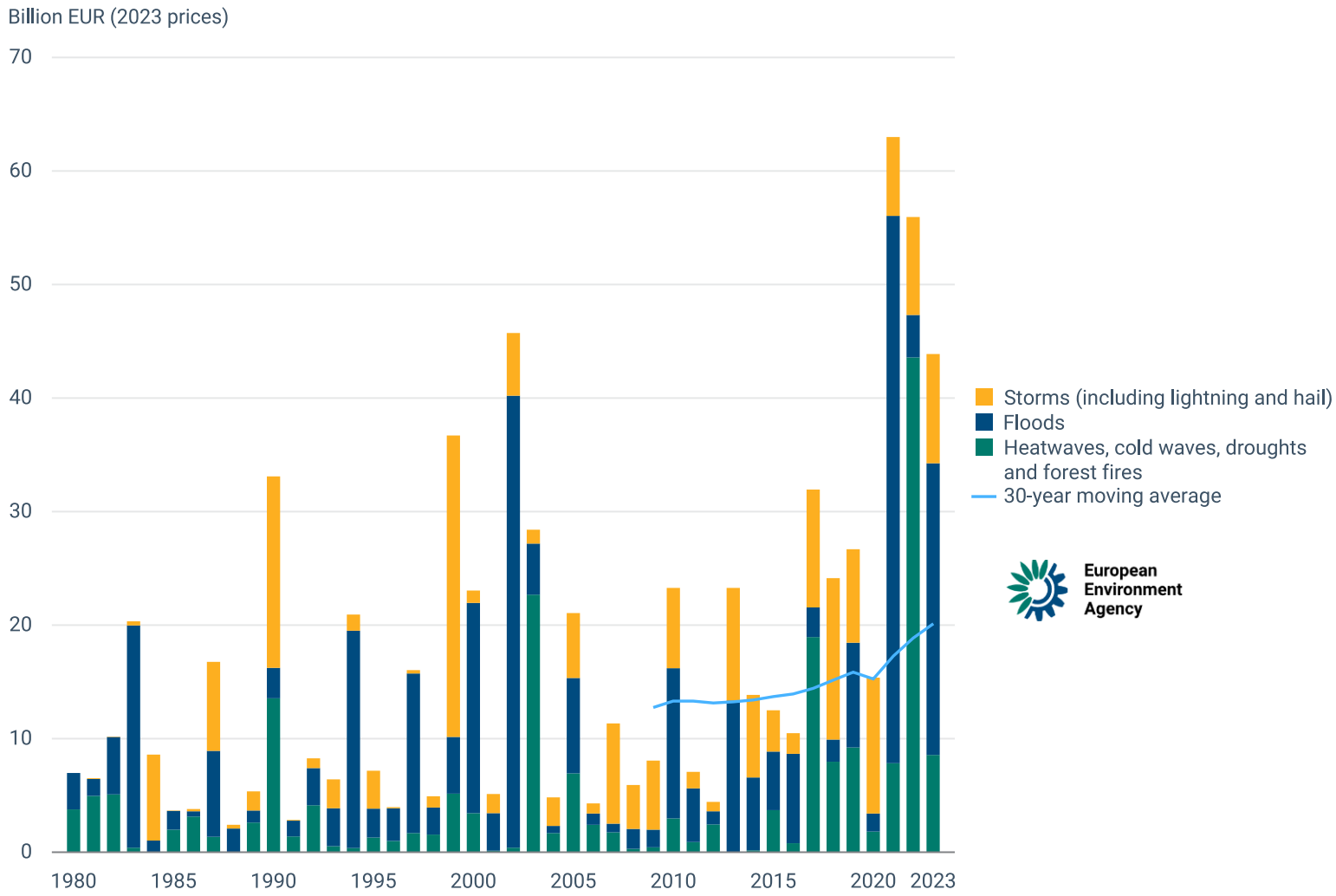
Motivation

- This research links extreme weather to worsening income inequality
  - Findings from Vasilakos et al. *(2025)* use data from 145 countries and show that lower-income populations are consistently hit harder by extreme events.
- When disasters strike, informal workers, low-wage earners, and those in rural or precarious housing suffer the most, amplifying pre-existing inequalities.
- Our results show that a 1 standard deviation increase in the frequency × intensity of extreme weather is associated with a disproportionately negative impact on the bottom 30% of the income distribution.
  - Lower-income groups often work in climate-sensitive sectors (e.g. agriculture, construction), lack insurance or savings, and live in areas more exposed to physical risk.
  - A feedback loop: As inequality rises, adaptive capacity falls, further entrenching vulnerability. This dynamic fuels social unrest, migration pressures, and long-run productivity losses.



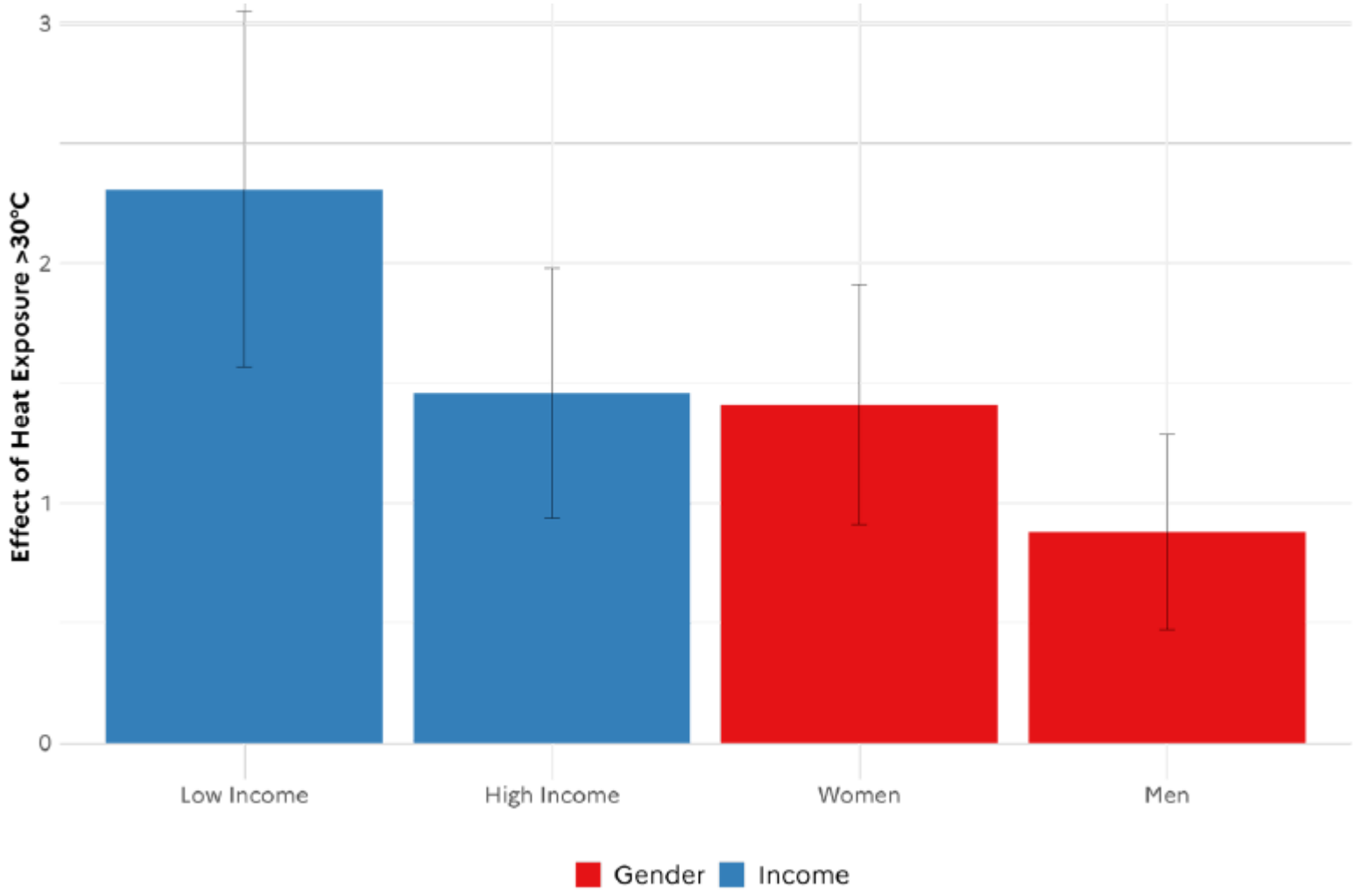
How does climate change make people poorer? | World Economic Forum

Annual economic losses caused by weather-and climate-related extreme events (all EU)



CrossEU

The climate-income-gender inequality nexus: unequal effects of heat exposure on mental health in the US



WORLD INEQUALITY LAB

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Methodology

- Our paper investigates how different types of extreme weather events affect income inequality across the entire income distribution, using panel data globally.

- By combining reanalysis climate data (ERA5), harmonised inequality metrics (PIP), and economic performance indicators, we estimate the extent to which climate risks drive regressivity in income outcomes, and how this varies by sector, region, and policy environment.
  - Climate variables included (so far): heatwaves, cold waves, icing days, hot days, and heavy precipitation
  - Poverty and Inequality Platform (PIP), World Bank:
    - Comprehensive global poverty and inequality data.
    - Covers ~2,400 surveys across 160+ countries up to 2024.
  - Standardised World Income Inequality Database (SWIID):
    - Extensive cross-country and longitudinal coverage.
    - Harmonised Income Study (LIS), ensuring high reliability.

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Methodology – Climate variables

Measurement Approach & Definitions:

- Extreme events - we follow the IPCC definition: “an extreme weather event is an event that is rare at a particular place and time of year’, and an extreme climate event as ‘a pattern of extreme weather that persists for some time, such as a season’” (Seneviratne et al., 2021, p. 1522).
    - Categorised into ‘Hot and Cold’ or ‘Wet and Dry’ events (Ranasinghe et al., 2021).
- For each climate event, we calculate both intensity and frequency and normalise the variables to account for differences in their measurement scales.
- We apply principal component analysis to combine intensity and frequency into a single representative variable for each climate event, denotes as HW_IF, CW_IF, $Icing\_IF$, Hot_IF, and $Rain10mm\_IF$.

Index	Condition
Hot-days	Daily maximum temperature > 35°C
Heatwave	Excess Heat Factor is positive
Coldwave	Excess Cold Factor is negative
Icing days	Daily maximum temperature < 0°C
Rain 10mm	10mm rainfall over agricultural land

Methodology – Economic variables

Measurement Approach & Definitions:

- Economic performance indicators :
  - Sectoral value-added (GDP): real GDP constant in 2017 (in logs) denoted as ln_real_Agri_GDP, ln_real_Ind_GDP, ln_real_Serv_GDP.
  - Household consumption expenditure: calculated as log of (Final Consumption Expenditure – Government Consumption) per capita, constant in 2017, denotes as $ln\_real\_per\_HFCE$.
  - Principal Component of Sectoral GDP: log of sectoral GDP (Agriculture, Manufacturing, Services) combined using Principal Component Analysis (PCA), denoted as PC_ln_GDP.
- Unemployment Rate
- Domestic Credit to Private Sector (as % of GDP) - captures financial development
- Working-Age Population (15–64 years)
- Female Labour Force Participation Rate (15+ years)
- Polarisation index (as in Esteban and Ray, 1994) – captures “group separation”
- Trade Openness, as net exports of goods and services (% of GDP).
- Governance Indicators
  - Six dimensions: Control of corruption, government effectiveness, political stability, rule of law, regulatory quality, voice and accountability. Dimensionality reduced using Principal Component Analysis (PCA). First principal component (explains 87.42% variance), denoted as: IQ_PC.

Methodology – Economic variables

- Specification 1 – Baseline model

$$\ln\_ave\_inc^{q}_{i,t} = \alpha + \boldsymbol{\beta_1 CR_{i,t}} + \beta_2 \ln\_real\_sectorGDP^{s}_{i,t} + \boldsymbol{\beta_3 X_{i,t}} + \gamma_i + \theta_t + \epsilon_{it}$$

where

- $ln\_ave\_inc^{q}_{i,t}$ denotes our measure of income inequality in country i and year t, represented as the logarithm of the average income of decile q.
- $\boldsymbol{CR_{i,t}}$ is a vector of extreme climate events, including HW_IF, CW_IF, $Icing\_IF$, and Hot_IF.
- $ln\_real\_sectorGDP^{s}_{i,t}$ captures either three sector-specific specifications of real GDP, where s refers to $\ln\_real\_Agri\_GDP_{i,t}$, $\ln\_real\_Ind\_GDP_{i,t}$, or $\ln\_real\_Serv\_GDP_{i,t}$.
- The vector $\boldsymbol{X_{i,t}}$ refers to the control variables.
- γ_i and θ_t represent country and time fixed effects, respectively; ϵ_{it} is the error term; and α is the intercept.

Methodology – Economic variables

- Specification 2

$$\ln\_ave\_inc^{q}_{i,t} = \alpha + \boldsymbol{\beta_1 CR_{i,t}} + \beta_2 ln\_real\_per\_HFCE_{i,t} + \boldsymbol{\beta_3 X_{i,t}} + \gamma_i + \theta_t + \epsilon_{it}$$

Similar as in Specification 1, except for household final consumption expenditure per capita.

- Specification 3

$$\ln\_ave\_inc^{q}_{i,t} = \alpha + \boldsymbol{\beta_1 CR_{i,t}} + \beta_2 PC\_ln\_GDP + \boldsymbol{\beta_3 X_{i,t}} + \gamma_i + \theta_t + \epsilon_{it}$$

uses principal component of log of sectoral GDPs as economic performance indicator.

Results -- Full distribution (Agricultural sector)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Agri	Agri	Agri	Agri	Agri	Agri	Agri	Agri	Agri	Agri
VARIABLES	ln_ave_inc1	ln_ave_inc2	ln_ave_inc3	ln_ave_inc4	ln_ave_inc5	ln_ave_inc6	ln_ave_inc7	ln_ave_inc8	ln_ave_inc9	ln_ave_inc10
HW_IF	-0.016***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.011***
	(0.005)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
CW_IF	-0.012**	-0.010**	-0.009**	-0.008**	-0.009**	-0.009**	-0.009**	-0.009**	-0.009**	-0.009**
	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Icing_IF	-0.022**	-0.016**	-0.011	-0.006	-0.005	-0.006	-0.006	-0.007	-0.007	-0.010
	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Hotdays_IF	-0.022***	-0.015***	-0.012**	-0.011**	-0.011**	-0.011**	-0.012**	-0.010*	-0.011**	-0.011*
	(0.008)	(0.006)		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
ln_real_Agri_GDP	0.027***	0.024***	0.021***	0.019***	0.018***	0.019***	0.019***	0.019***	0.019***	0.009
	(0.009)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
ln_Pop_1564	-0.489***	-0.644***	-0.681***	-0.690***	-0.680***	-0.677***	-0.666***	-0.662***	-0.662***	-0.716***
	(0.068)	(0.049)	(0.047)	(0.046)	(0.047)	(0.047)	(0.047)	(0.047)	(0.046)	(0.050)
Unemp_rate	-1.840***	-1.408***	-1.325***	-1.267***	-1.269***	-1.297***	-1.301***	-1.282***	-1.249***	-1.394***
	(0.189)	(0.138)	(0.131)	(0.130)	(0.131)	(0.131)	(0.131)	(0.131)	(0.130)	(0.139)
Female_rate	-0.234	-0.189	-0.173	-0.180	-0.180	-0.154	-0.128	-0.124	-0.143	-0.247**
	(0.161)	(0.117)	(0.112)	(0.111)	(0.111)	(0.112)	(0.112)	(0.112)	(0.111)	(0.119)
Trade_Openess	0.197**	0.201***	0.194***	0.198***	0.210***	0.202***	0.204***	0.205***	0.208***	0.199***
	(0.089)	(0.065)	(0.062)	(0.061)	(0.061)	(0.062)	(0.062)	(0.062)	(0.061)	(0.066)
DCPS	0.057**	0.078***	0.082***	0.081***	0.079***	0.076***	0.078***	0.081***	0.085***	0.105***
	(0.026)	(0.019)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)
IQ_PC	0.077***	0.077***	0.085***	0.089***	0.091***	0.090***	0.090***	0.090***	0.089***	0.071***
	(0.013)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)
polarisation	-5.414***	-3.628***	-2.789***	-2.273***	-1.834***	-1.393***	-0.959***	-0.501***	0.040	1.353***
	(0.165)	(0.120)	(0.114)	(0.113)	(0.114)	(0.114)	(0.114)	(0.114)	(0.113)	(0.121)
Constant	13.908***	16.320***	16.909***	17.090***	16.966***	16.913***	16.744***	16.709***	16.803***	18.188***
	(1.089)	(0.790)	(0.753)	(0.749)	(0.750)	(0.754)	(0.754)	(0.753)	(0.749)	(0.801)
Observations	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
R-squared	0.682	0.721	0.698	0.672	0.646	0.621	0.596	0.570	0.543	0.498
Number of country_id	145	145	145	145	145	145	145	145	145	145
Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	ln_ave_inc1	ln_ave_inc2	ln_ave_inc3	ln_ave_inc4	ln_ave_inc5	ln_ave_inc6	ln_ave_inc7	ln_ave_inc8	ln_ave_inc9	ln_ave_inc10
Results respect to log of industrial GDP										
HW_IF	-0.017***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.014***	-0.013***	-0.013***	-0.011***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
CW_IF	-0.012**	-0.010**	-0.009**	-0.008**	-0.008**	-0.008**	-0.008**	-0.008**	-0.009**	-0.009**
	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Icing_IF	-0.021**	-0.015**	-0.010	-0.005	-0.004	-0.005	-0.005	-0.006	-0.006	-0.009
	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Hotdays_IF	-0.023***	-0.015***	-0.012**	-0.011**	-0.012**	-0.012**	-0.012**	-0.011**	-0.012**	-0.012**
	(0.008)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
ln_real_Ind_GDP	0.057***	0.053***	0.049***	0.047***	0.047***	0.047***	0.047***	0.047***	0.048***	0.039***
	(0.009)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Results respect to log of service GDP										
HW_IF	-0.016***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.010***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
CW_IF	-0.012**	-0.010**	-0.009**	-0.008**	-0.009**	-0.009**	-0.009**	-0.009**	-0.009**	-0.009**
	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Icing_IF	-0.021**	-0.015**	-0.010	-0.005	-0.004	-0.005	-0.005	-0.006	-0.006	-0.009
	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Hotdays_IF	-0.023***	-0.015***	-0.012**	-0.011**	-0.012**	-0.012**	-0.012**	-0.011**	-0.012**	-0.012**
	(0.008)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
ln_real_Serv_GDP	0.050***	0.049***	0.045***	0.043***	0.043***	0.043***	0.043***	0.043***	0.043***	0.035***
	(0.009)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	ln_ave_inc1	ln_ave_inc2	ln_ave_inc3	ln_ave_inc4	ln_ave_inc5	ln_ave_inc6	ln_ave_inc7	ln_ave_inc8	ln_ave_inc9	ln_ave_inc10
Results respect to log of real household final consumption expenditure per capita										
HW_IF	-0.016***	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***	-0.009***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
CW_IF	-0.015**	-0.012***	-0.011***	-0.010**	-0.010**	-0.011***	-0.010**	-0.011***	-0.011***	-0.011**
	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Icing_IF	-0.022**	-0.016**	-0.011	-0.006	-0.005	-0.006	-0.006	-0.007	-0.007	-0.010
	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Hotdays_IF	-0.025***	-0.017***	-0.015***	-0.014***	-0.015***	-0.014***	-0.015***	-0.013**	-0.015***	-0.016***
	(0.008)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
ln_real_per_HFCE	0.046***	0.043***	0.040***	0.038***	0.037***	0.038***	0.038***	0.038***	0.038***	0.028***
	(0.009)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Results respect to principal component of log of sectoral GDPs										
HW_IF	-0.016***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.010***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
CW_IF	-0.012**	-0.010**	-0.009**	-0.008**	-0.009**	-0.009**	-0.008**	-0.009**	-0.009**	-0.009**
	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Icing_IF	-0.021**	-0.016**	-0.010	-0.005	-0.004	-0.005	-0.006	-0.006	-0.007	-0.009
	(0.010)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Hotdays_IF	-0.023***	-0.015***	-0.012**	-0.011**	-0.012**	-0.011**	-0.012**	-0.011*	-0.012**	-0.012**
	(0.008)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
PC_ln_GDP	0.065***	0.061***	0.057***	0.054***	0.053***	0.053***	0.053***	0.054***	0.054***	0.040***
	(0.013)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)

Results - Full distribution (focus on heavy precipitation Rain 10mm)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	ln_ave_inc1	ln_ave_inc2	ln_ave_inc3	ln_ave_inc4	ln_ave_inc5	ln_ave_inc6	ln_ave_inc7	ln_ave_inc8	ln_ave_inc9	ln_ave_inc10
R10mm_IF	-0.001	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln_real_Agri_GDP	0.028***	0.025***	0.021***	0.019***	0.018***	0.019***	0.019***	0.020***	0.020***	0.009
	(0.009)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
R10mm_IF	-0.001	-0.001**	-0.001**	-0.001***	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln_real_Ind_GDP	0.057***	0.053***	0.050***	0.047***	0.047***	0.047***	0.047***	0.048***	0.048***	0.038***
	(0.009)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
R10mm_IF	-0.001	-0.001**	-0.001**	-0.001***	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**	-0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln_real_Serv_GDP	0.051***	0.049***	0.046***	0.044***	0.043***	0.043***	0.044***	0.044***	0.044***	0.035***
	(0.009)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)

Results – Arid, Tropical, Tropical/Temperate climate zone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	ln_ave_inc1	ln_ave_inc2	ln_ave_inc3	ln_ave_inc4	ln_ave_inc5	ln_ave_inc6	ln_ave_inc7	ln_ave_inc8	ln_ave_inc9	ln_ave_inc10
Results respect to log of agricultural GDP										
HW_IF	-0.010	-0.009*	-0.009*	-0.010**	-0.010**	-0.010**	-0.011**	-0.011**	-0.010**	-0.002
	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Hotdays_IF	-0.017*	-0.013**	-0.011*	-0.010*	-0.011*	-0.011*	-0.011**	-0.010*	-0.011*	-0.009
	(0.010)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
ln_real_Agri_GDP	0.098***	0.059***	0.045***	0.040***	0.036**	0.034**	0.036**	0.037**	0.038***	0.036**
	(0.026)	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)
Results respect to log of industrial GDP										
HW_IF	-0.007	-0.007	-0.007	-0.008*	-0.008*	-0.008*	-0.009*	-0.008*	-0.008*	0.001
	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Hotdays_IF	-0.021**	-0.016***	-0.013**	-0.012**	-0.013**	-0.013**	-0.014**	-0.012**	-0.013**	-0.011*
	(0.009)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
ln_real_Ind_GDP	0.157***	0.119***	0.103***	0.096***	0.093***	0.092***	0.093***	0.095***	0.097***	0.089***
	(0.022)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
Results respect to log of service GDP										
HW_IF	-0.008	-0.007	-0.008	-0.008*	-0.008*	-0.009*	-0.009*	-0.009*	-0.008*	-0.000
	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Hotdays_IF	-0.019**	-0.015**	-0.012**	-0.011**	-0.012**	-0.012**	-0.013**	-0.011**	-0.012**	-0.010*
	(0.009)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
ln_real_Serv_GDP	0.142***	0.103***	0.086***	0.078***	0.074***	0.074***	0.076***	0.077***	0.079***	0.071***
	(0.024)	(0.016)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)

Results – Temperate and varied climate zone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	ln_ave_inc1	ln_ave_inc2	ln_ave_inc3	ln_ave_inc4	ln_ave_inc5	ln_ave_inc6	ln_ave_inc7	ln_ave_inc8	ln_ave_inc9	ln_ave_inc10
Results respect to log of agricultural GDP										
HW_IF	-0.028***	-0.023***	-0.020***	-0.020***	-0.019***	-0.020***	-0.019***	-0.020***	-0.021***	-0.021***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ln_real_Agri_GDP	0.006	0.001	0.000	0.000	-0.000	-0.000	-0.001	0.000	0.001	0.005
	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Results respect to log of industrial GDP										
HW_IF	-0.028***	-0.023***	-0.021***	-0.020***	-0.020***	-0.020***	-0.020***	-0.020***	-0.021***	-0.021***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ln_real_Ind_GDP	0.030**	0.028***	0.028***	0.029***	0.028***	0.028***	0.028***	0.028***	0.030***	0.033***
	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Results respect to log of service GDP										
HW_IF	-0.028***	-0.023***	-0.020***	-0.020***	-0.019***	-0.020***	-0.019***	-0.020***	-0.021***	-0.021***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ln_real_Serv_GDP	0.029**	0.028***	0.028***	0.029***	0.029***	0.029***	0.028***	0.029***	0.030***	0.034***
	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)

Conclusions

- All climate shocks exhibited regressive effects: lower-income groups suffer more
  - Heatwaves and Coldwaves are consistently associated with rising income inequality, disproportionately affecting lower deciles.
  - Icing days show stronger effects on the poorest deciles, likely through disruption of agriculture and mobility.
  - Heavy Rainfall (10 mm+) has weak to strong statistically significant negative effects on the income groups.
- Sectoral GDP matters: differences in impacts between sectors
- Interaction terms show that lower-income deciles experience amplified inequality effects from climate events.
- The magnitude of inequality effects varies across climate zones.
- These results highlight the complexity of climate impacts (and the importance of integrating climate justice into climate policy – at the European and global level).

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UK participants in this project are co-funded by UK Research and Innovation (UKRI).

UK Research and Innovation

DAFNI

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BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

Networking Lunch

- Exhibition and poster session
- The DAFNI team will be available for questions and demonstrations

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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Hope you enjoyed your break
Please return to your seats for the next set of speakers

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Chair:

Tom Kirkham

DAFNI Science Lead,
Scientific Computing STFC

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Keynote speaker:
Do it once and share it many times

Dr Sarah Hayes

Chair Data Sharing Working Group, Independent Consultant

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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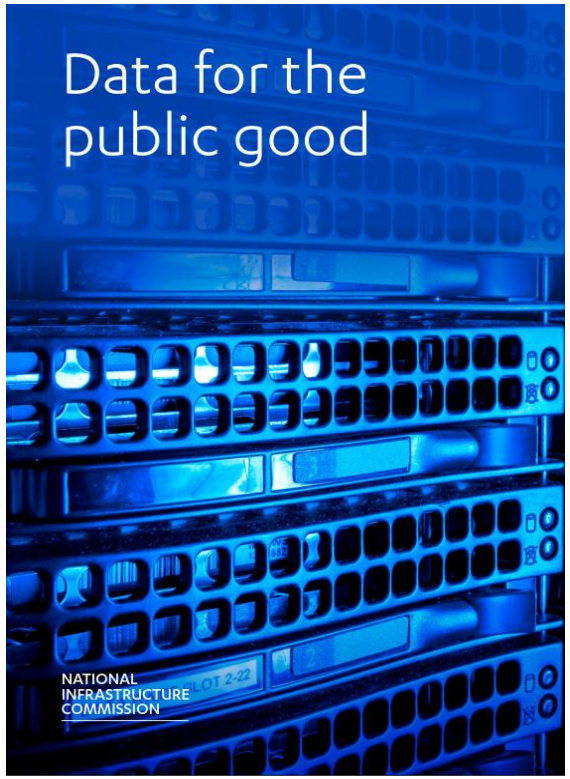
"DO IT ONCE AND SHARE IT MANY TIMES"
DATA SHARING WORKING GROUP, DAFNI CONFERENCE, 11 SEP 2025

SARAH HAYES, CHAIR DATA SHARING WORKING GROUP, INDEPENDENT CONSULTANT

SARAH@DIGITALTWINNERCOUK.ONMICROSOFT.COM

MY JOURNEY 2017-2022

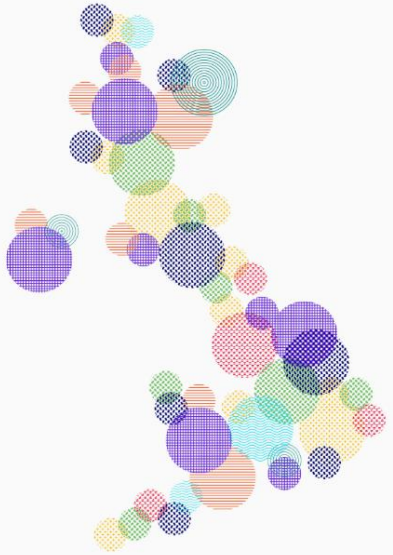


DAFNI
Data & Analytics Facility for National Infrastructure

CReDo

National Digital Twin Programme

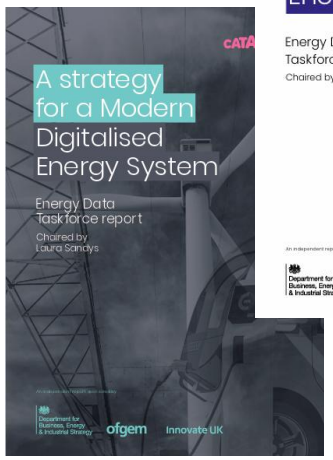
NATIONAL DIGITAL TWIN PROGRAMME



cdbb
Centre for Digital Built Britain

CLIMATE RESILIENCE DEMONSTRATOR 2021-23

MULTIPLE DATA SHARING INITIATIVES IN 2023



GROWING COORDINATION PROBLEM

Disconnected data sharing initiatives

Connected use cases

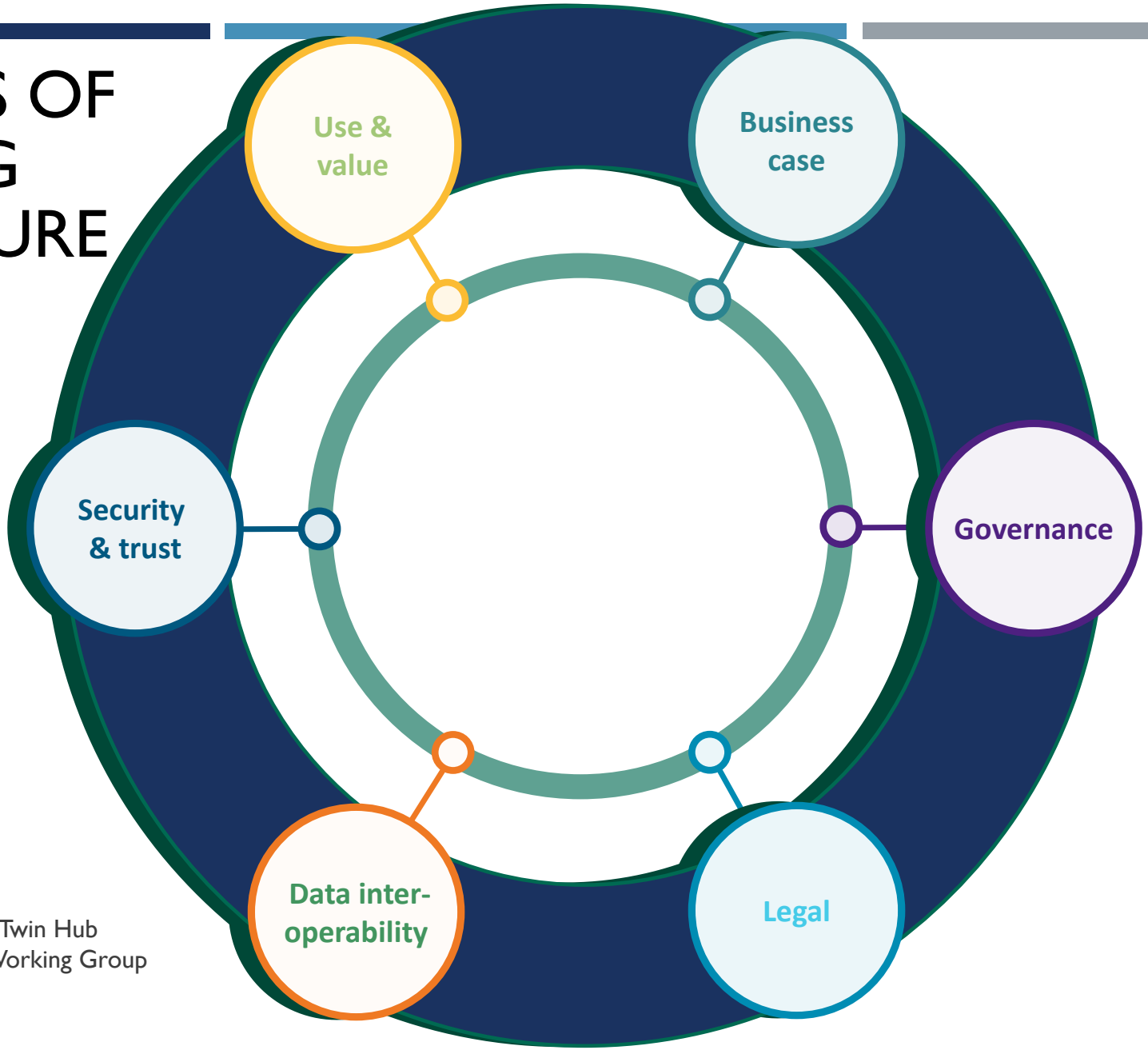
Interoperability is harder to achieve

DATA SHARING WORKING GROUP

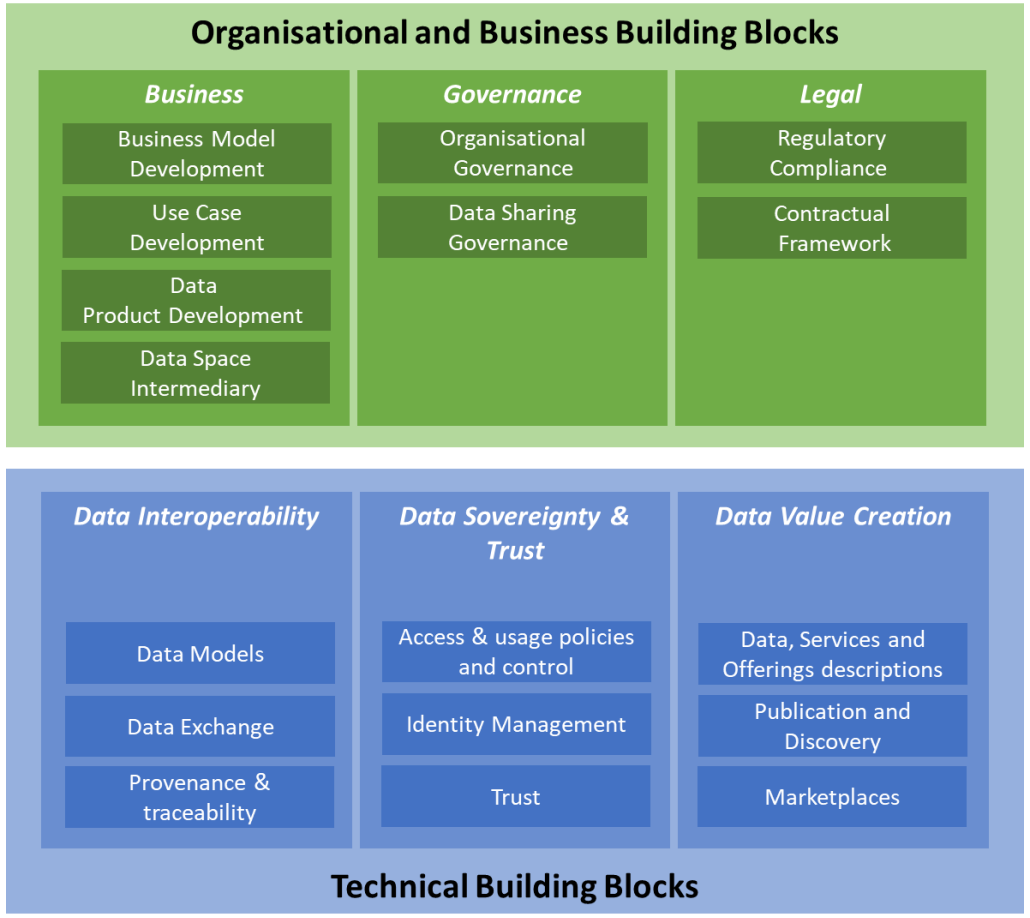
- Set up in 2022 as a voluntary group
- The purpose of DSWG is to bring people together to discuss and develop data sharing best practice in a collaborative way that builds upon existing work and avoids duplication
- Recognise challenges to sharing data
- Our motto is "Do it once and share it many times"
- Cross sector: across government, industry and academia
- Open and collaborative with other groups eg Digital Twin Hub Working Groups
- Sharing best practice and how to describe things

WHAT IS DATA SHARING INFRASTRUCTURE?

COMPONENTS OF DATA SHARING INFRASTRUCTURE



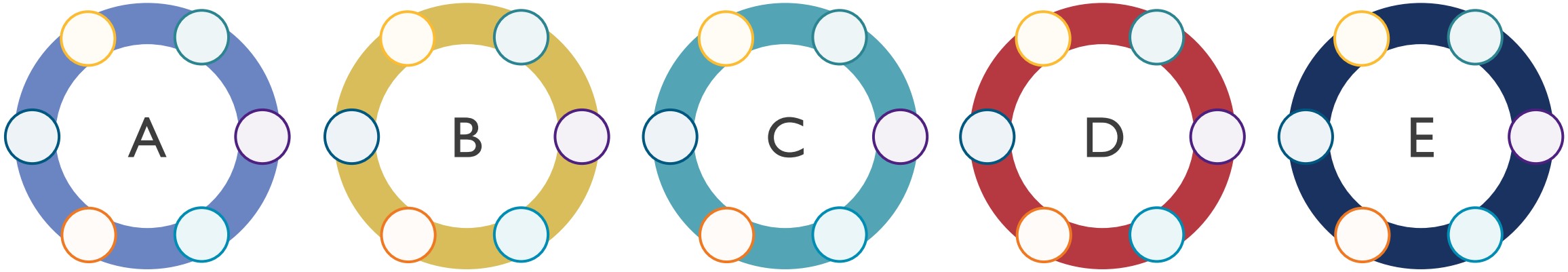
EU DATA SPACES PROGRAMME



- Dutch report: "Sustainable Revenue Models for Data Sharing Initiatives" April 2025, JADS and Tilberg University

MANY DIFFERENT DATA SHARING INITIATIVES

"This suggests other countries have more data space activity than they realize. The challenge isn't starting from zero. It's identifying and connecting existing efforts." IDSA



Source: Digital Twin Hub
Data Sharing Working Group

MULTIPLE DATA SHARING INITIATIVES

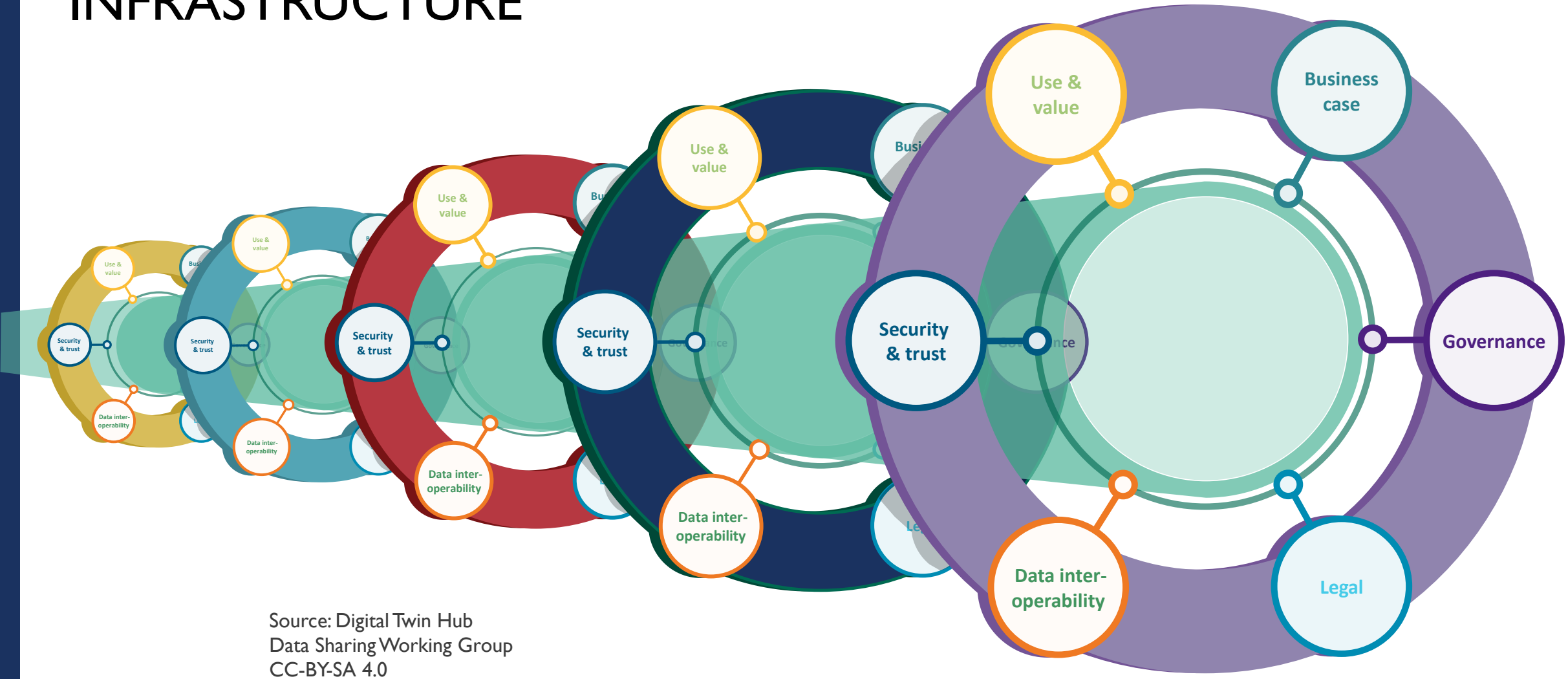
- Understand differences and similarities
- Build on existing work
- Key is to understand which part of DSI you are building and communicate that well
- Dutch lessons learnt

GEMINI

The table below sets out a snapshot of data sharing initiatives using this framework, showing that by using the categories it is possible to describe different data sharing initiatives alongside each other in summarised form

Initiative	Business case	Governance	Legal
Apollo Protocol	An initiative to unlock the benefits of connected digital twins delivering a mechanism for formalising communication between sectors	Executive Board and Advisory Board supporting Apollo Forums	Open initiative curre The Alan Turing Inst Manufacturing Rese
CReDo	Climate change adaptation digital twin platform to improve system-wide resilience across infrastructure networks. Current use cases include strategic resilience planning use case. Business case to reduce cost of disruptions, regulatory use case	Led by Connected Places Catapult, alongside partners Anglian Water, BT Group and UK Power Networks, funded by Innovate UK, Ofgem SIF, Ofwat Breakthrough	Bespoke data licen exploration licence
Earth Observation (EO) Data Hub	Increase use of EO Data to new markets and improve ease of access to all EO data sources. Minimise duplication and transfer of large datasets	EO Data Hub Board, EO Data Hub end user and stakeholder forum	Licensing: Open acc Individual data licer end user
Energy Data Sharing Infrastructure	Net zero and resilience, multiple use cases	Ofgem consulting on interim Data Sharing Infrastructure coordinator, Ofgem Data Best Practice. NESO pilot (requested by DESNZ) under Virtual Energy System programme governance	For pilot and minim leveraging existing obligation to share legal framework to

DATA SHARING INFRASTRUCTURE



Source: Digital Twin Hub
Data Sharing Working Group

WHAT ARE WE DOING IN DSWG?

Recent sessions:

- Energy data sharing infrastructure
- DAFNI DINI
- Stream
- NUAR

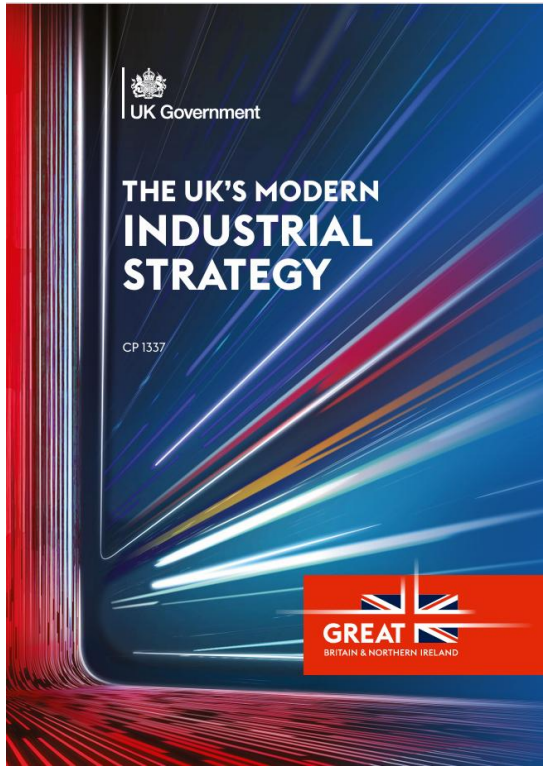
Planned sessions:

- Data valuation
- Industrial strategy
- Smart data
- Data marketplaces

INDUSTRIAL STRATEGY COMMITMENTS

- "By 2035, we aim to establish the UK as a global leader in data-driven innovation and content creation, with a **robust, secure, and interoperable data-sharing infrastructure** that supports sustainable economic growth"
- "Invest in UK Data Sharing Infrastructure Initiatives from April 2026. Learning from international practices, including the Common European Data Spaces**, these will promote effective and more coordinated approaches to governance, legal considerations, regulations, data interoperability, security, and trust."**

Need for governance and a British culture of collaboration



ACTIONS

- Join the DSWG
- Share what you do in a reusable way!
- Do it once and share it many times

DO IT ONCE AND SHARE IT MANY TIMES

Data Sharing Working Group

DAFNI

DAFNI CONFERENCE 2025

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Speaker:
DSIT

Oliver Tones

Head of Data Sharing and Technology, Department for Science, Innovation and Technology

UKRI Science and Technology Facilities Council

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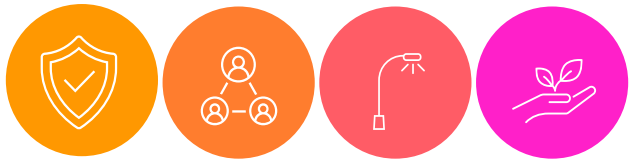
Department for Science, Innovation & Technology

Researcher Data Access Pilot Programme

September 2025



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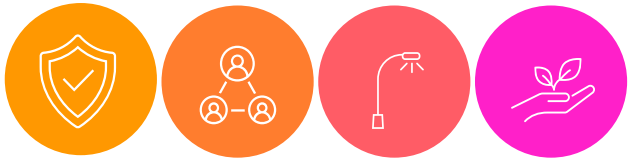
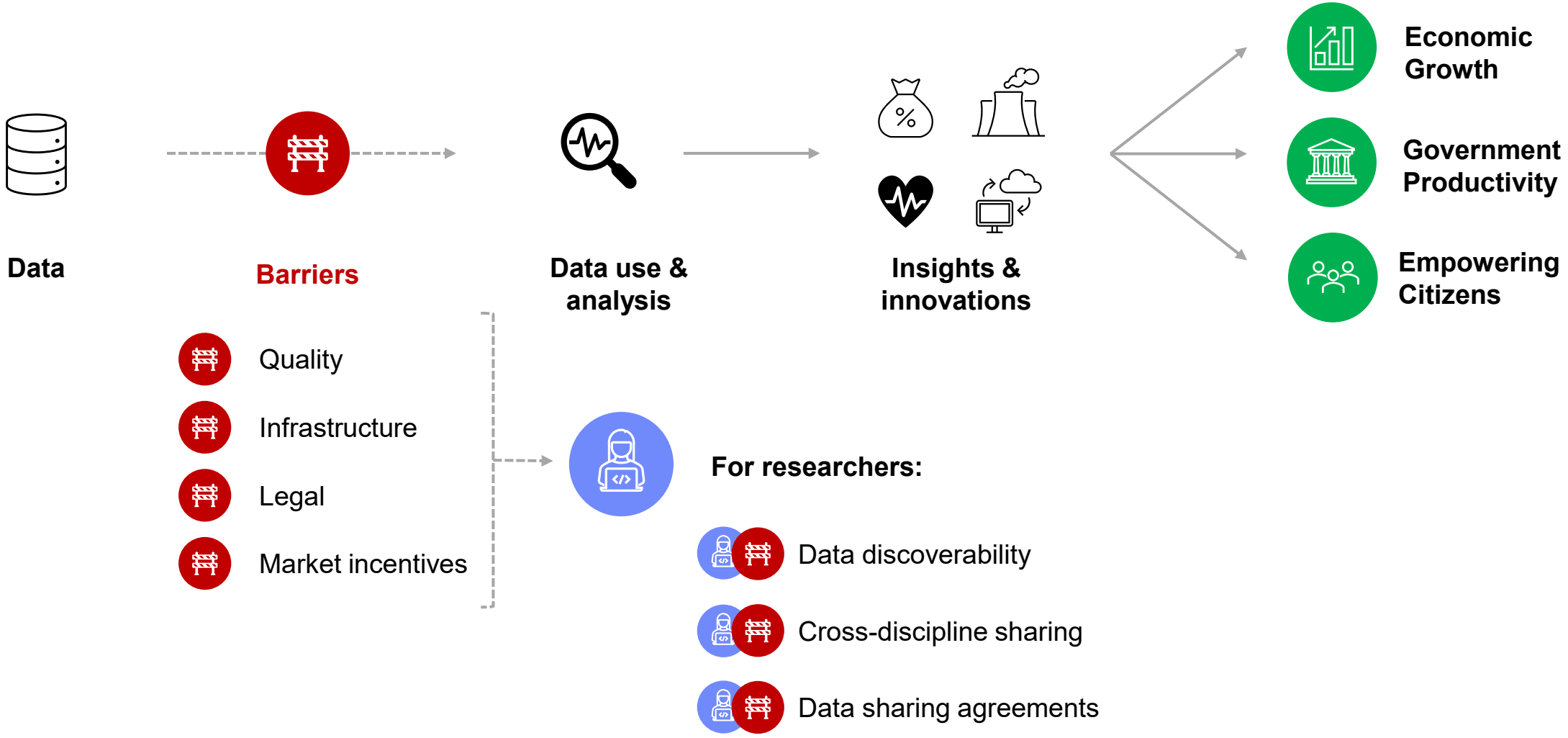
1. Overview



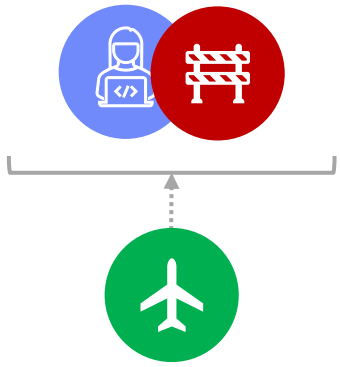
Data access is not optimal in the UK



We piloted ways to improve data access for researchers

Objective

To pilot ways of addressing data sharing barriers in the research ecosystem



£5m from UKRI's Digital Research Infrastructure Programme

Pilots

Safe People Registry
(HDR UK)

FAIR Data Accelerator
(UK SKA Regional Centre & UCL)

DINI
(DAFNI)

BOOST-EDS
(NERC)

Outputs

Better use now

Lessons for the future

DSIT coordinated activity to support pilot delivery

Cross-programme coordination → **Outputs**

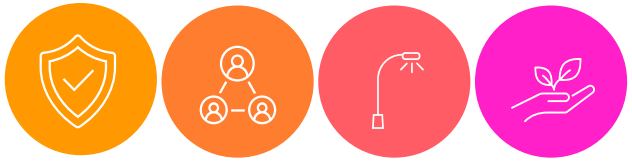
	Activity	Approach
1	**Progress tracking**	Bi-monthly governance boards
2	**Monitoring & evaluation**	Custom evaluation plans
3	**Pilot join-up**	Deep dive workshops
4	**Communications**	Webinars, newsletters

Better use now:
successful pilot delivery

Lessons for the future:
gathering information on 'what works well'

Department for Science, Innovation & Technology

2. Pilots

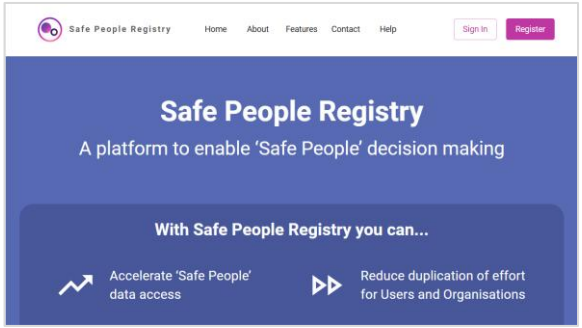


Safe People Registry

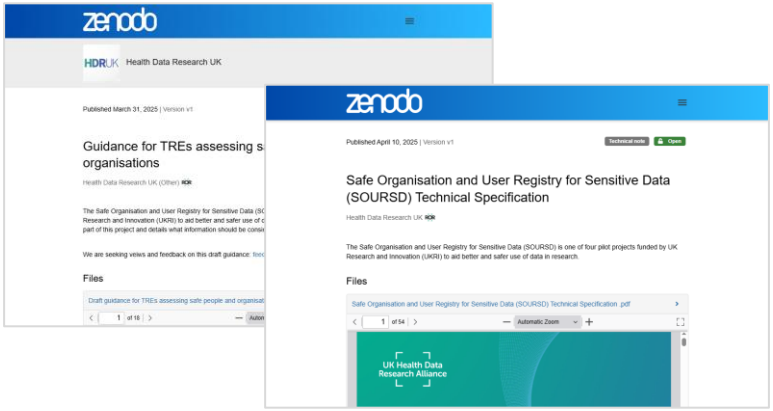
Safe People Registry

(Health Data Research UK)

Objective: streamlining how researchers access sensitive data in secure environments



Prototype of a 'researcher registry'



Guidance on what a 'safe' researcher looks like

Safe People Registry: Headlines

1

Tools reduce risk…

Data custodians and users have specific roles in the data sharing process – tools and systems can help them **execute duties responsibly** (and contribute to **de-risking** the process)

2

… but legal complexities can make them less comprehensive

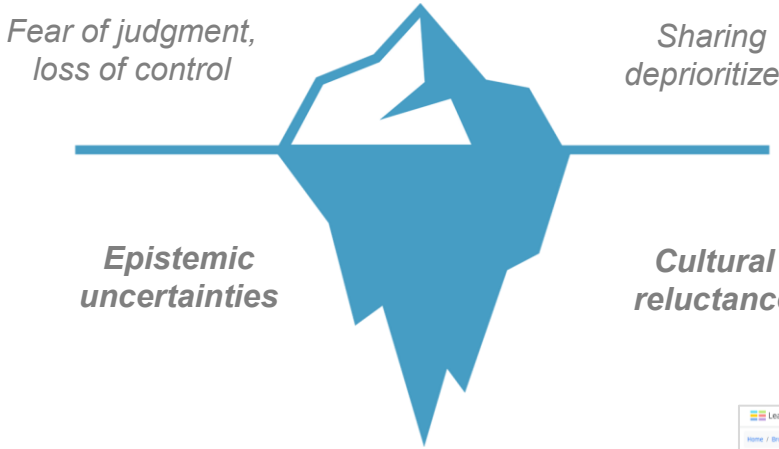
The original aim (a nationally standard way to approve access) was descoped, as each individual TRE has **unique legal issues** to navigate. **Concerns about liability** also slowed development of a way to record infringements.

3

The public have a stake

It's the general public's data that's in TREs. Information about this project & product was therefore made accessible to the general reader (use of plain English; + demonstrators & explainer videos).

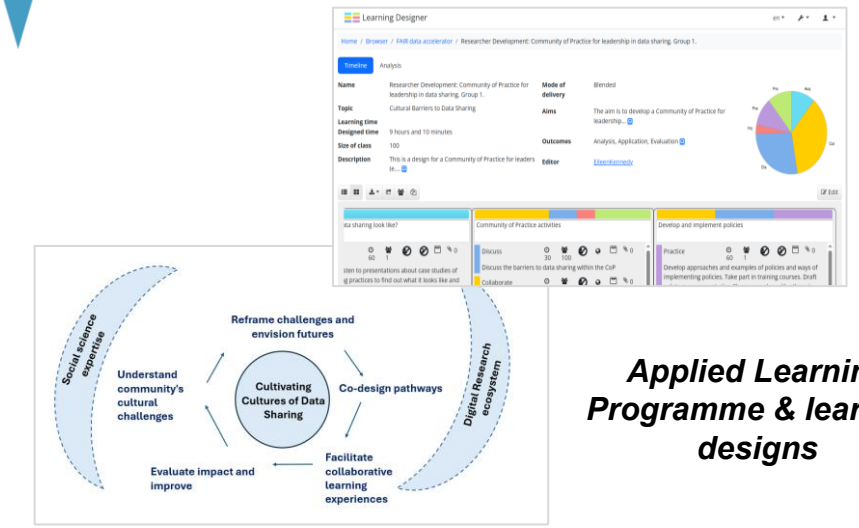
FAIR Data Accelerator



Social science concepts applied to cultural & social data access barriers

FAIR Data Accelerator

(UCL & SKA Regional Centre)



Applied Learning Programme & learning designs

Objective: tackling social and cultural barriers to data sharing & access

FAIR Data Accelerator: Headlines

1

Data access won't improve without social change

Cultural norms (enforced by disengaged leadership, lack of incentive) and **fears** (of judgement for data quality or losing control of 'my' asset) must both be tackled to enable optimal data access

2

There is no leader grasping this agenda (but lots could be done)

A central actor could fix this through (i) **quick wins** (guidance, repositories, tagging methods) & (ii) **substantial actions** (forums; funding of communities, training, challenges, frameworks) – **unclear who**

3

The problem will evolve (so sustained support is vital)

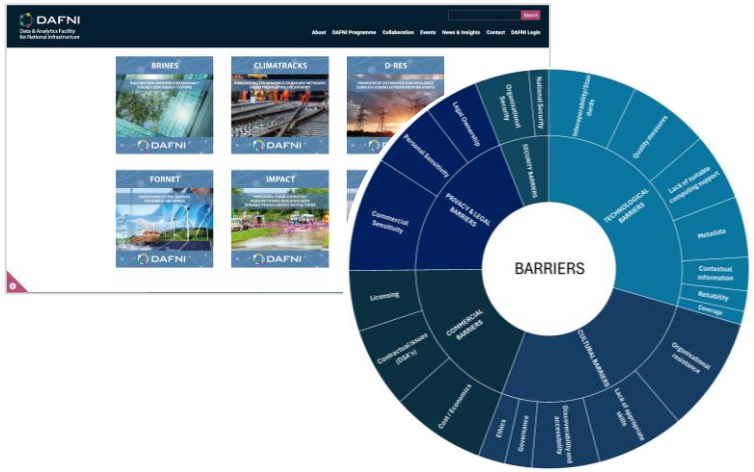
Possibilities for data will keep evolving – creating cultures has to be resourced so it can be done on an **ongoing basis** to respond to that (*and* help **new communities** start in the 'right way')

DINI

Data Infrastructure for National Infrastructure

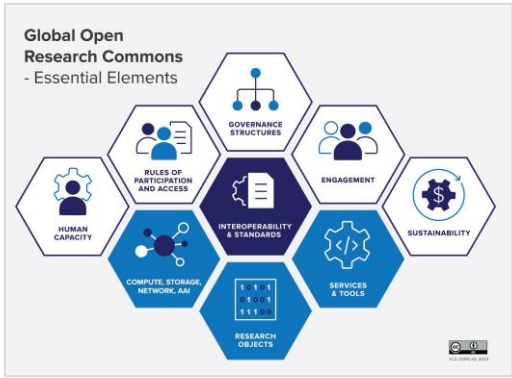
(DAFNI)

Study on the barriers to sharing national infrastructure data



Technical specs to improve DAFNI's links to JASMIN & external datasets

Energy sector ontology review



Vision for a future Data Infrastructure for National Infrastructure

Objective: providing insights & better capabilities to improve national infrastructure data analysis

DINI: Headlines

1

Working w. data holders can mitigate the sharing incentive problem

Supplying data is costly & complex for data holders. **Secondments** into their organisations; a third party **broker;** or investing in one-off **'reference datasets**' w. standard access conditions can all speed up access.

2

Professional support needs to be prioritised

Managing data (properly) is resource intensive. Investment in a specific '**data stewardship**' profession, or new **communities of practice** in management, sharing & publication, can help maintain assets.

3

Complexity hinders collaboration

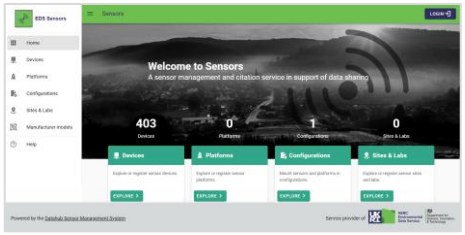
An **interoperability framework** could map different sector standards to a common framing, enabling (i) reuse of data by, & (ii) collaborations between, other sectors & industries who are not specialists in the original field.

BOOST-EDS

BOOST Environmental Data Service

(Natural Environment Research Council)

'Persistent Identifier' service to label digital objects



Exploring piloting geospatial software in TREs

Modular genomics workflow framework

Toolkit supporting co-creation of user-focused data services

Objective: improving how data is used across the EDS: the UK's largest collection of environmental science data

Review to improve interoperation between platforms

BOOST-EDS: Headlines

1

Technology can solve the sharing incentive problem

Digital citations (including authorship) can be attached to data. They can be **tracked,** so whenever data is reused (i) **authors get credit**, and (ii) funders can **measure data's use, impact & derived value in the long-term**.

2

Infrastructure is about people

Good data infrastructure enables access. But it doesn't operate properly without **knowledge sharing**, including (i) **networks of specialists** (e.g.: TRE experts) and (ii) **training to help users** use the technology.

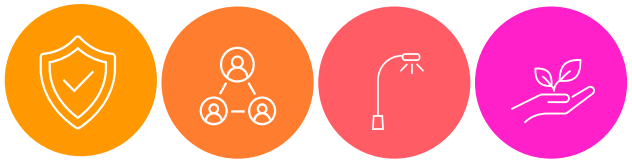
3

Multidisciplinary research is in demand, but difficult to deliver

Research disciplines are increasingly specialised, including their data use. **Shared vocabularies** to bridge gaps need to be in place, to tackle x-cutting issues (e.g.: climate change) that draw on multiple disciplines' data.

Department for Science, Innovation & Technology

3. Conclusions



Data access & sharing can be broken down to 3 themes

Culture & co-ordination

Systematic practices and perceptions that underpin data coordination practices

for example:

- *Organisational guidelines*
- *Incentives*
- *Trust (public, stakeholder)*

Data characteristics

Structural characteristics of the data being accessed and shared

for example:

- *Sensitivity*
- *Quality (**F**indability, **A**ccessibility, **I**nteroperability, **R**eusability)*

Frameworks & resources

Legal, financial, infrastructure & skill factors underpinning data coordination

for example:

- *Legal regulations*
- *Technical infrastructure & investment*
- *Data-related skills & knowledge*

DSIT & the pilots discussed the programme format

A relatively **small amount of funding can build momentum for broader change**, by creating tangible examples of 'what works' (*but **challenges persist in turning pilots into operational services***)

Strengths

- **Improvements now:** programme saw the beginnings of FAIR data sharing, and delivery of real tangible outputs
- **Convening:** range of projects offered the opportunity to identify common challenges & issues; and created the foundations of a community with shared interests
- **Foundation for future work:** data quality and interoperability issues persist, but these pilots are creating the technical and community infrastructure to tackle them

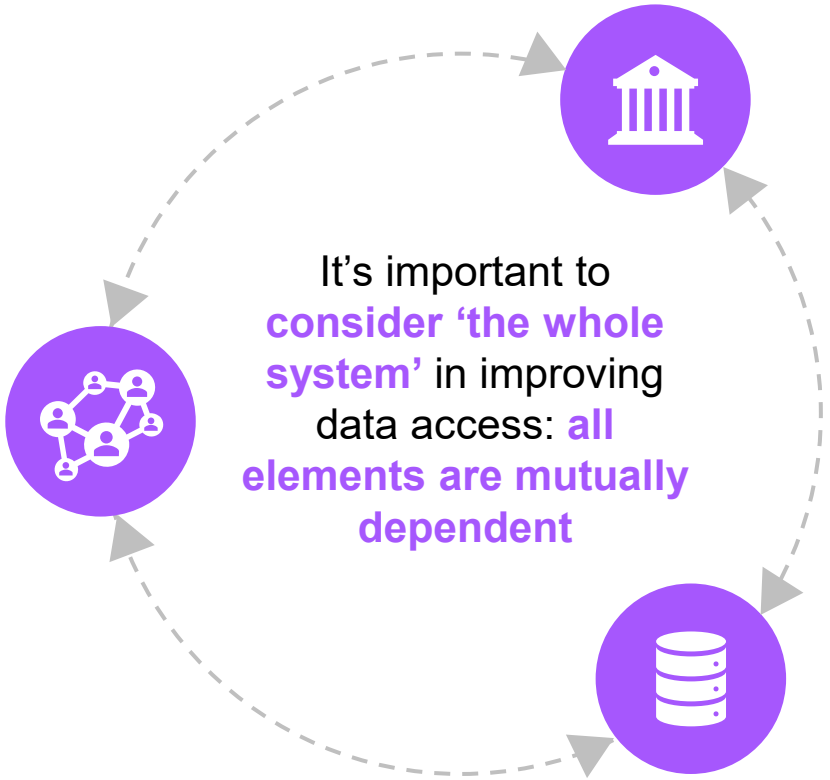
Challenges

- **Data access barriers:** legal complications and a lack of shared data standards made delivering the pilots difficult at times
- **Financial:** the pilots had a relatively small budget that needed to be spent quickly, which could be challenging to manage
  - *(but became a good stress of what was possible)*
- **Next steps:** considering how to use these short-term projects to make longer-term, or permanent, progress / changes

DSIT reflected on the programme's findings as a whole

Culture & co-ordination

Good data access & use depends on **connecting people**, often **across diverse areas & different skillsets** (*e.g.: public / private sectors, different research disciplines, experts / non-experts*)



Frameworks & resources

Open governance mechanisms can have both a **social impact** (building trust, buy-in to the importance of FAIR data practices) & **technical impact** (more efficient access processes)

Data characteristics

Clear communications, aided by development of **common vocabularies** (**technical & non-technical**) to describe data and its application can enable better **research outputs**, better sharing **cultures**, and better **investment decisions**

DAFNI

DAFNI CONFERENCE 2025

BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

THE EDGE . SHEFFIELD . 11 SEPTEMBER 2025

Speakers:
DINI

Elizabeth Newbold
Open Science Theme Lead, STFC

Catherine Jones
Energy Data Centre Lead, STFC

UKRI Science and Technology Facilities Council

UKRI Engineering and Physical Sciences Research Council

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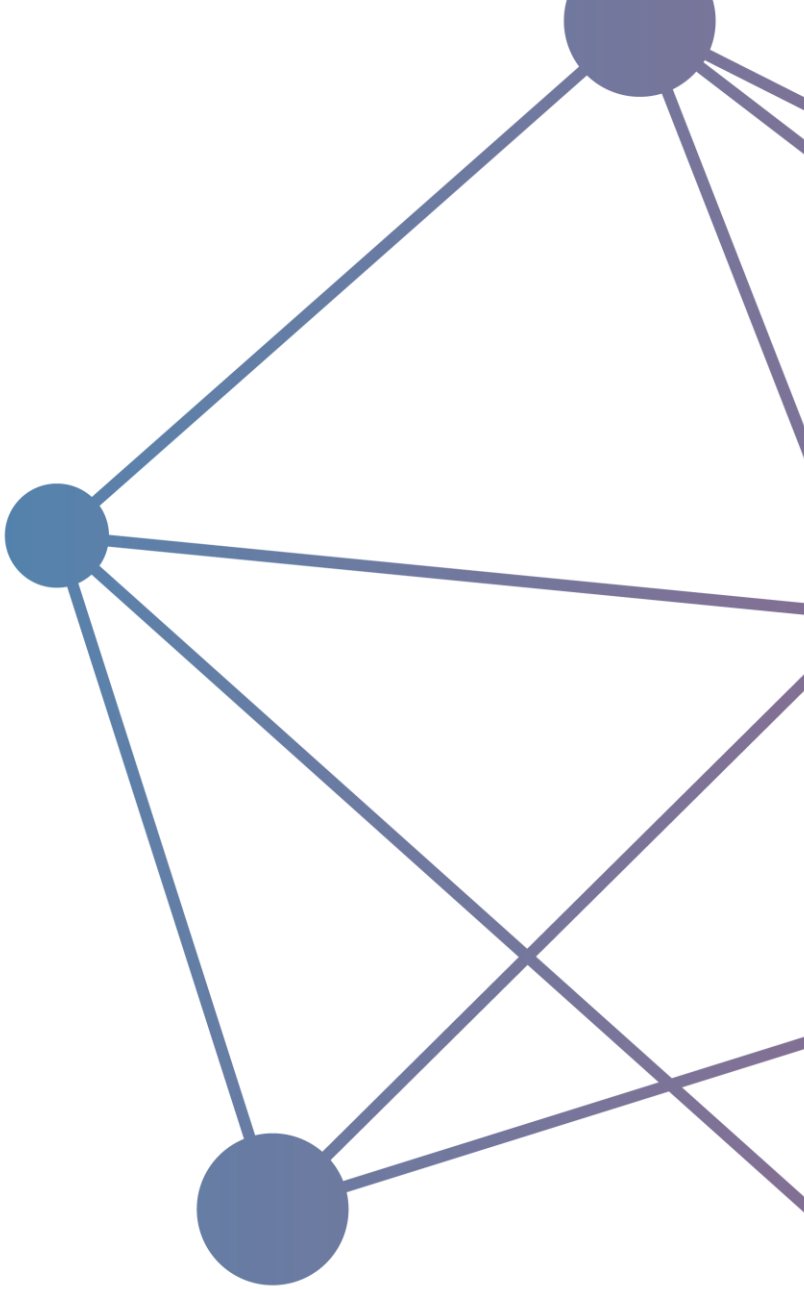
DAFNI

DINI: Digital Infrastructure for National Infrastructure

September 11, 2025

Catherine Jones and Elizabeth Newbold
Science and Technology Facilities Council



Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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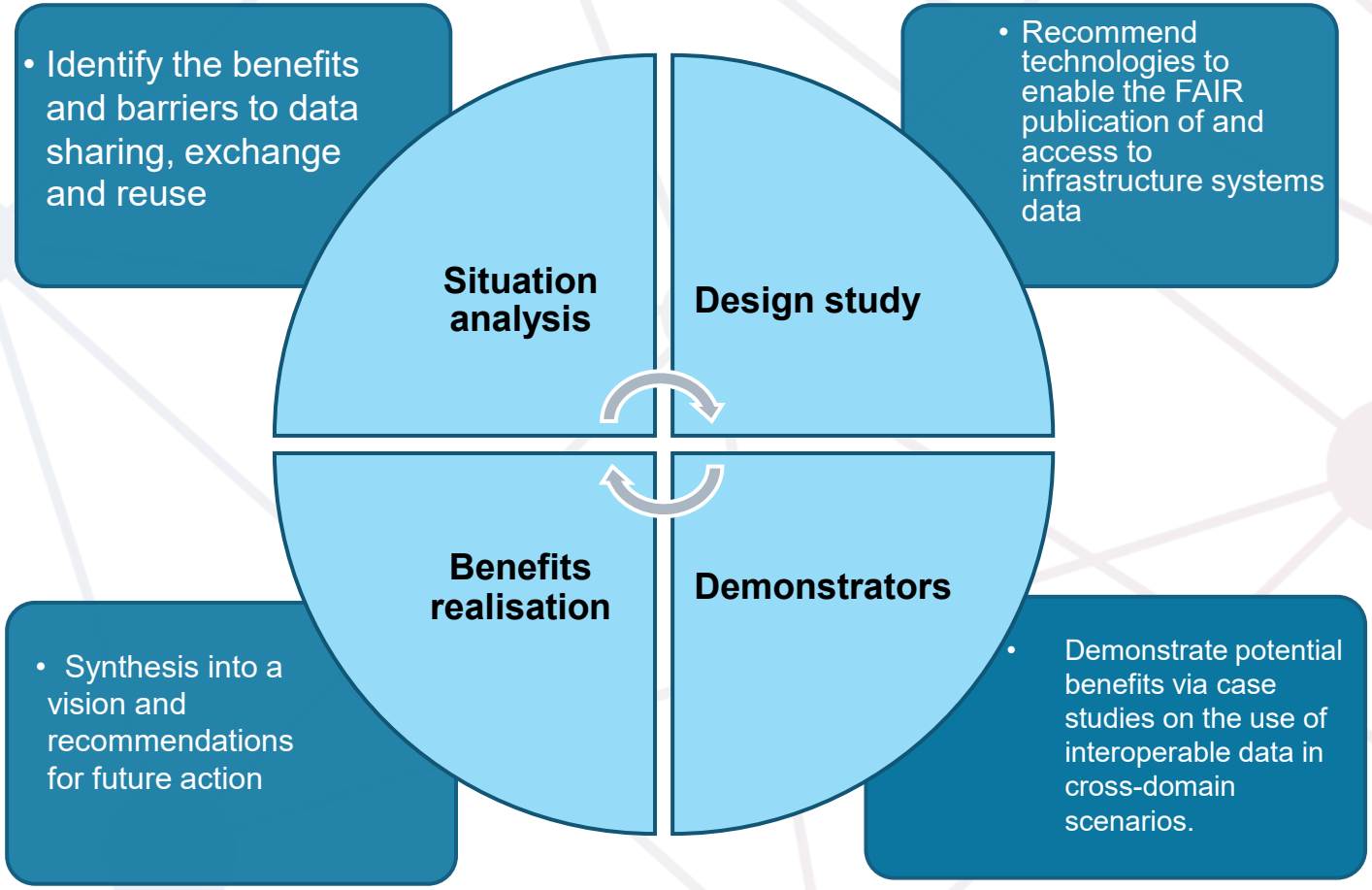
DINI: Research Data Cloud Pilot

A pilot study on the requirements and impact of supporting sharing and analysis of **data** across **National Infrastructure systems,** with a focus on **energy, water** and **transport,** and the related natural, built and social and economic environment



Partners:

- DAFNI
- Energy Data Centre
- Centre for Environmental Data Analysis
- Digital Curation Centre
- UKCRIC
- IceBreakerOne

+ Partners in 11 research studies

Collecting the Evidence

Community Consultation

- 4 Workshops with the Digital Curation Centre (including Northern Ireland, Scotland, Wales)
- IceBreakerOne
  - Literature Review
  - Surveys, interviews and 2 workshops
- UKCRIC – 2 workshops with research leaders and with urban observatories
- Energy Data Centre workshop on sharing Energy Data Models

Use cases

3 Champions studies

- Liz Varga - Water Systems Leakage data,
- Giuliano Punzo, Daniel Coca - near-real time transport data
- Sam Gunner, Theo Tryfonas - urban mobility data

8 research demonstrator use cases – water, energy, transport
(Soframode, STORMS, ClimaTracks, IMPACT, MARS, D-RES, ForNET, BRINES)

Technical studies

- APIs for Energy Data
- Ontologies for Energy
- Indexing Services
- Federating Research Platforms

Benefits of Data Sharing

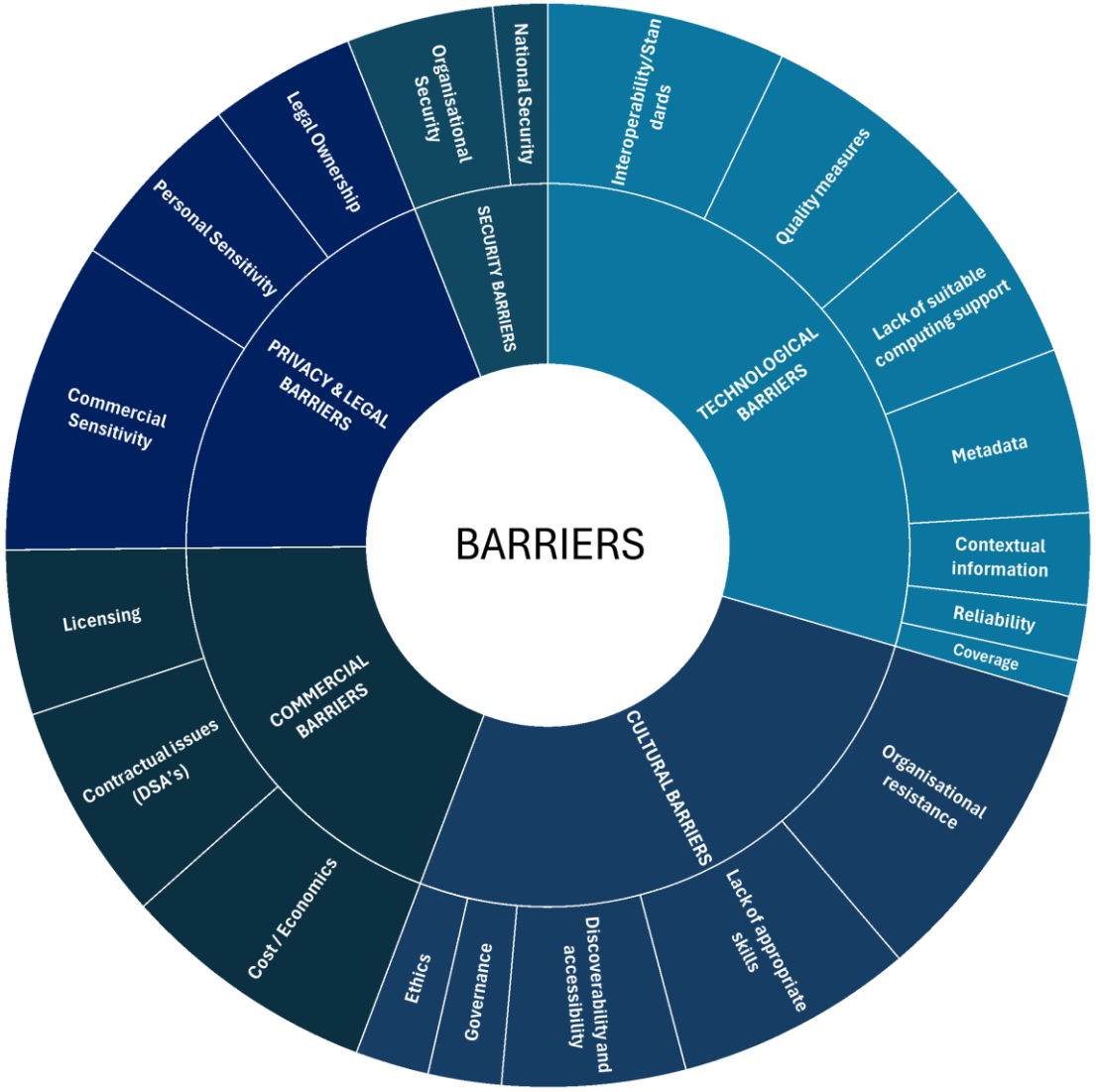
DAFNI

Benefit	**Enable research and innovation**	**Enhance Collaboration and interoperability**	**Foster Transparency and trust**
Effect	**Support policy development and evidence-based planning decisions**	**Improve accuracy and validation**	**Improve operational efficiency and monitoring**
Impact	**Society** *engagement, emergencies*	**Economy** *effectiveness, innovation*	**Environment** *carbon reduction, water quality*

Barriers to Data Sharing

1. **Privacy and legal barriers**: around the sharing and use of restricted data.
2. **Security barriers**: sharing data may lead to security breaches
3. **Commercial barriers**: the costs of sharing are perceived to be greater than the expected So, sharing data may lose competitive advantage.
4. **Cultural barriers**: habits, policies and attitudes within organisations that oppose data sharing.
5. **Technical barriers**: challenges in sharing the data from a technical perspective, such as the data not being in the right format

"the nature of the barriers identified through this analysis have changed little from the earliest reports reviewed (2017) to the most recent (2024), indicating that there is still much work to be done to address these challenges."
IceBreakerOne, Literature review



Barriers to Data Sharing

Legal

- Legal and contractual concerns have a significant impact on data sharing and have been widely raised from across the DINI activities.
  - the legislative and regulatory framework, especially in the more regulated sectors,
  - the overheads and complexities of negotiating Data Sharing Agreements, and the
  - requirement to respect privacy of individuals when handling personally sensitive data
- Worries about this can stall progress
- And we see this in practise in projects

Security

- Underlying recognition that the is a need for safe and secure handling of data
  - respecting the sensitivity needs of the data suppliers
- This barrier can be seen as the complement to the legal barriers above.
- Tension between benefits of open data sharing and need to respect restrictions
  - *“as open as possible, as closed as necessary*

Barriers to Data Sharing

Commercial

- Sharing data always has a cost to the supplier organisation, particularly the labour costs involved.
- Interacting with researchers can be burdensome
- Shortage of skilled staff in data supplier organisations

Cultural

- Lots of champions in data suppliers - but also not always seeing that the benefits outweigh the costs
- Concerns on data quality
- Lack of clarity on responsibility for releasing data
- Depends on who you know

Barriers to Data Sharing

Technical:

- Non-technical barriers often more prominent, but still a major impediment to practical data use
  - Approximately 1/3 of the total issues raised
- Data Discoverability and good metadata
  - Knowing what's available and what it means
- Lack of standardisation
  - Common data standards
- Quality indications on data

"Reproducing a model is not only laborious; it is unlikely to yield fully comparable results when carried out by two different parties, with the most probable cause due to differing data sources/versions. This creates a potential for lack of trust, which may be inferred as reliability issues. In general, many energy systems models, which result in rich and diverse forms of output to support widespread research innovation, lack standardisation leading to interoperability issues. These barriers affect Researchers, Data Users, Data Aggregators, Innovation / Research Agencies." D-RES

Recommendations from the project

16 Recommendations – 11 specifically outlining what a DINI should do and 5 more general recommendations.

- **Data providers** and **policy makers** must invest in co-designing appropriate and open governance for data sharing within and across sectors.
- **Research funders** should advocate for the practical and strategic benefits of sharing national infrastructure data with researcher.
- **Funders of research** and other **data sharing programmes** should invest in best-practice case studies with commercial organisations to demonstrate the tangible benefits of academic re-use of data.
- **Data suppliers** and **users** should work to establish and apply, domain expectations and standards on data quality.
- **Researchers** should be encouraged to manage and describe their research outputs, such as data, models, research software and protocols, to ensure application of FAIR principles and to support interoperability, transparency and reproducibility.

Recommendations – A “DINI” Should:

Work with partners and the wider community to

- **manage trusted access** and broker data sharing agreements between data suppliers and researchers.
- **broker access** to industry and government data for use within research.
- **support** the identification and creation of **reference data** with clear access conditions and agreed data sharing arrangements.
- **provide guidance** for data suppliers and researchers on best data publication practices.
- **build** a **network of communities of practice** through guidance, training and setting standards.

Recommendations – A “DINI” Should:

Technically provide/support

- have a **long-term plan** and **sustained investment** on its maintenance.
- **provide access** to data from a **federated infrastructure** of trusted **repositories.**
- **provide access** to **federated trusted computing resources** to perform analysis.
- **support** a common **data interoperability framework** in conjunction with wider community efforts to set data sharing standards.
- **provide services** to **discover** and access research data, and other associated research outputs.
- **provide data stewardship expertise** to work with researchers and other data suppliers to support long-lived research products.

A Vision for a Data Infrastructure for National Infrastructure

DINI should coordinate research infrastructure and expertise to:

- broker access to data from industry and government for use by research and impact partners;
- provide access to data via a federated infrastructure of trusted repositories;
- support a common data interoperability framework;
- provide access to trusted computing resources to perform analysis;
- build a network of communities of practice through guidance, training and setting standards;
- and collaborate with cross-sector initiatives to build consensus.

Further Information

- BM Matthews et al. Data Infrastructure for National Infrastructure. A UK Research Data Cloud Pilot: Final Report. STFC Technical Reports STFC-TR-2025-004. UK Research and Innovation, Science and Technology Facilities Council, 2025. https://doi.org/10.5286/stfctr.2025004

- L Sampson and B Matthews. Data Infrastructure for National Infrastructure: Data indexing service review. STFC Technical Reports STFC-TR-2025-005. STFC, 2025. https://doi.org/10.5286/stfctr.2025005

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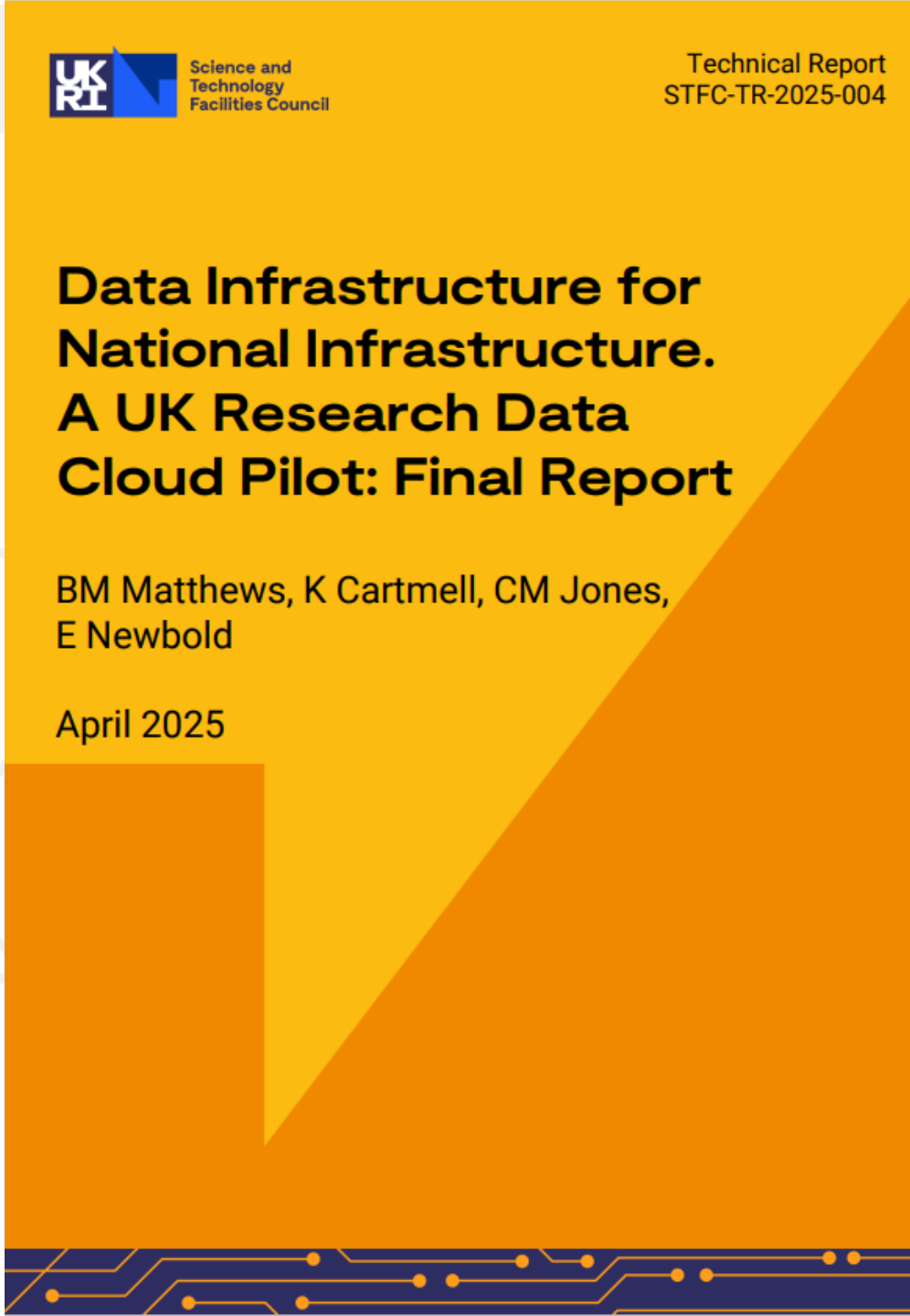
- Jones, C., VanHaltren, K. and Zoldoske, T., Reviewing the Energy Semantic Artefacts Landscape, 2025. https://doi.org/10.5286/UKERC.EDC.000987

- Jones, C., Newbold, E., Yates, K., Zoldoske, T., Boston, A., Colechin, M., Colechin, K., Davidson, J., Lines, C. and Jasinska, A. UKERC DINI Energy Modelling Workshop Report. 2025 https://doi.org/10.5286/UKERC.EDC.000985

- Stanaway, C et al, National Infrastructure Data Literature Review, 2024. IB1-DAFNI-DINI-2024-LITREVIEW

- Stanway, C et al, National Infrastructure Data. A landscape analysis on data sharing with researchers. 2024. IB1-DAFNI-DINI-2024-REPORT



DINI Team

The Data and Analytics Facility for National Infrastructure (DAFNI) (https://www.dafni.ac.uk) is a computing platform hosted by STFC which supports collaborative research into national infrastructure, including transport, water, and energy.

The **Energy Data Centre** (www.ukerc.rl.ac.uk) is a capability of **UK Energy Research Centre**

JASMIN (https://jasmin.ac.uk/) is a data analysis facility providing storage and compute facilities to enable data-intensive environmental science.

The Digital Curation Centre (DCC) (https://www.dcc.ac.uk/)

IceBreaker One (https://ib1.org/) is a neutral non-profit that works on data sharing and sustainability.

The UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC) (https://www.ukcric.com/)


Any questions?

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Networking break

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Hope you enjoyed your break
Please return to your seats for the next set of speakers

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Trusted research panel: Discussion

David Batho
Director of Security
Jisc

Tash Buckley
Lecturer
Cranfield University

Kathryn Dally
Director of Programmes
UK Research Integrity Office (UKRIO)

Jason Feehily
Head of Trusted Research Team
University of Nottingham

Emily Jefferson
Chief Technology Officer
Health Data Research UK

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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Speaker:

From hackathon to legislation - the journey of NUAR

Holger Kessler

Senior Stakeholder Manager, Utility Solutions - Infrastructure UK & Ireland at AtkinsRéalis

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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Speakers:
National Water Quality Modelling

Jonny Wilson

National Water Resources Modelling Lead, Environment Agency

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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National Water Resources Modelling: From research to delivery

Jonny Wilson

RAPID

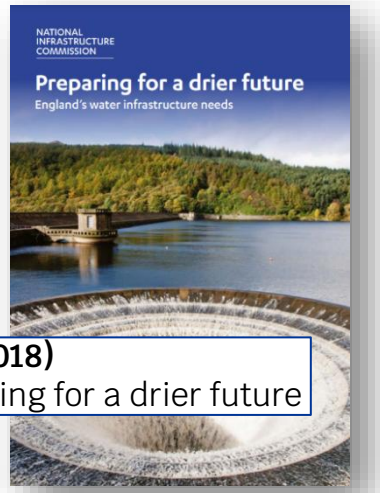
Environment Agency

Content

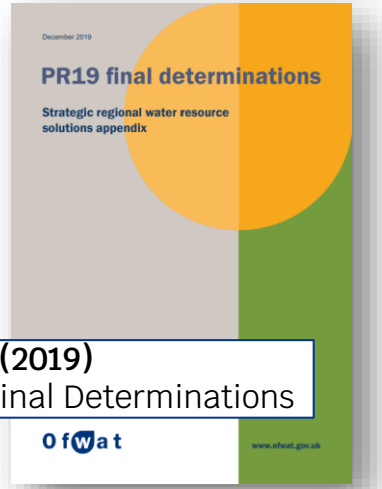
1. Background
2. National System Simulation Modelling Project
3. National Water Resources Modelling tools and their uses
4. Future plans – WR modelling & DAFNI

Background – water needs and strategic approach

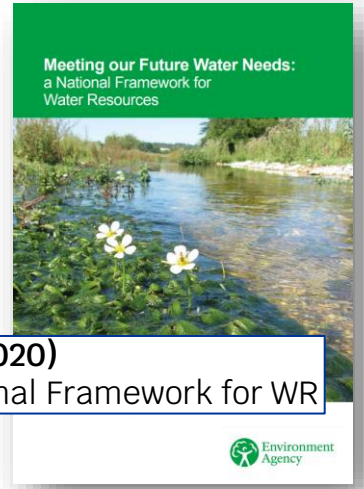
Policy reacts to an evolving water resource challenge



NIC (2018)
Preparing for a drier future



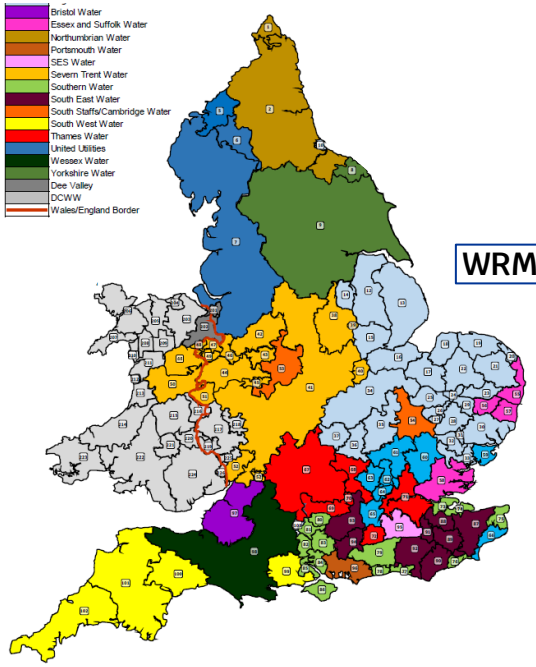
Ofwat (2019)
PR19 Final Determinations



EA (2020)
National Framework for WR

HMT (2020)
National Infrastructure Strategy

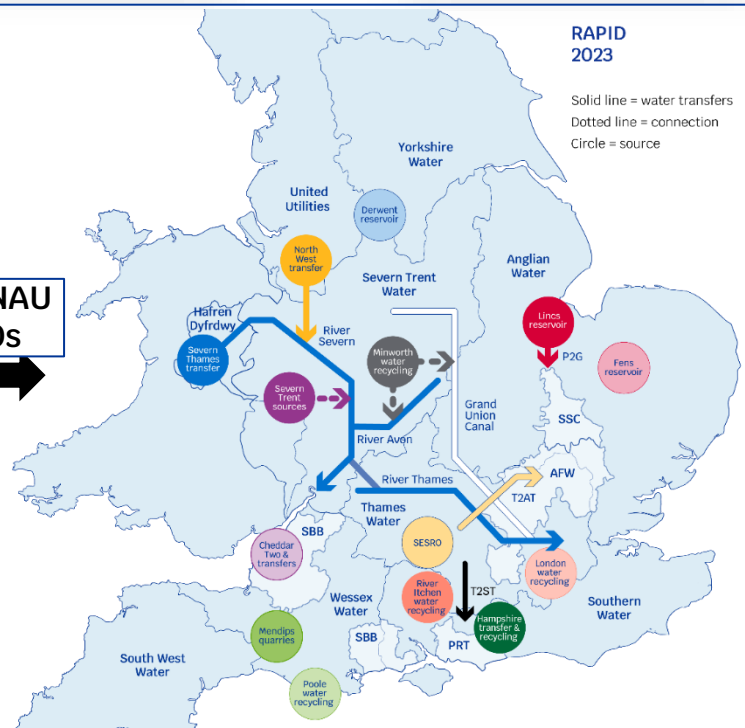
WR planning and industry reacts to challenge



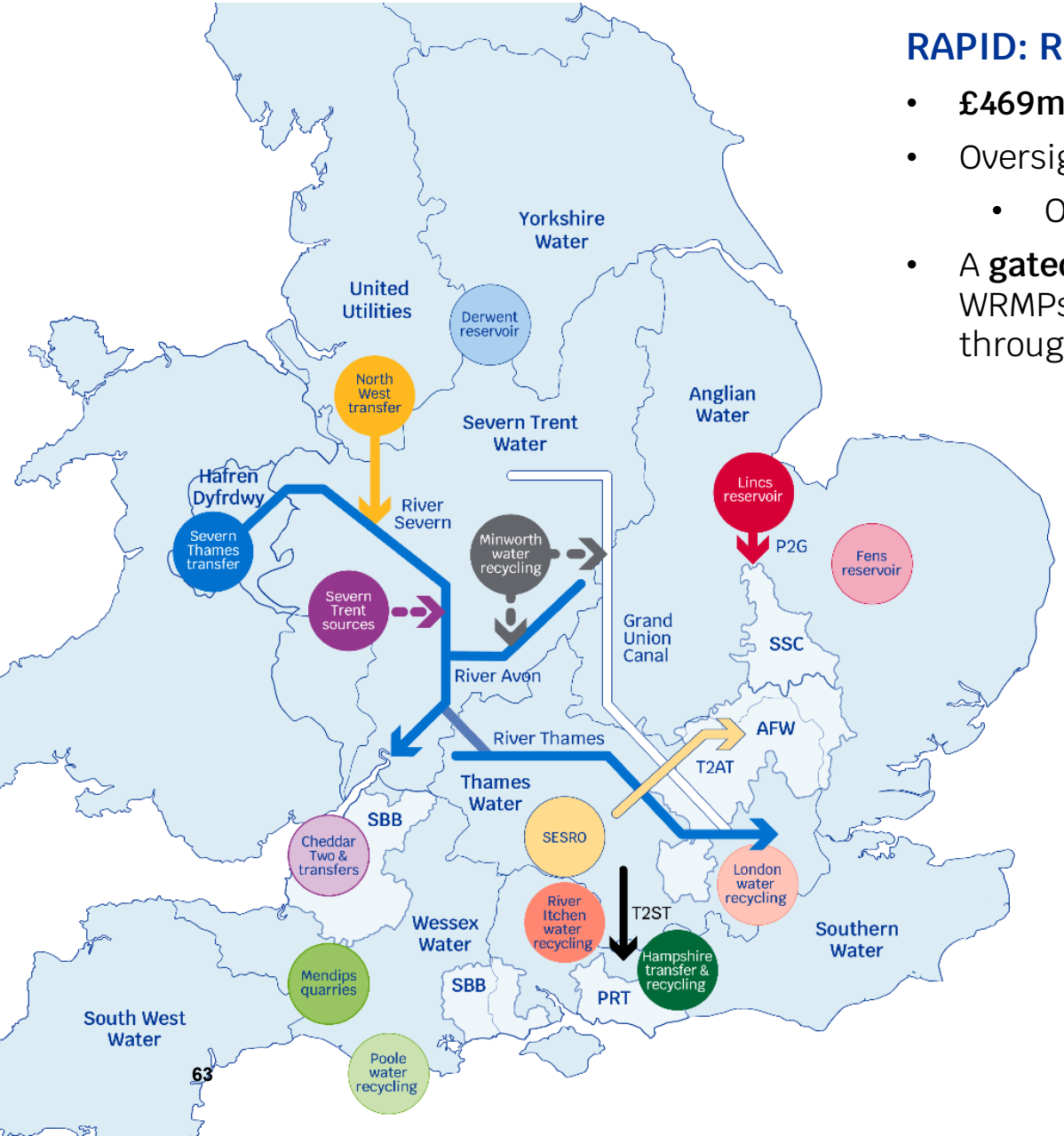
WRMP19

WRMP24

RAPID/NAU & SROs

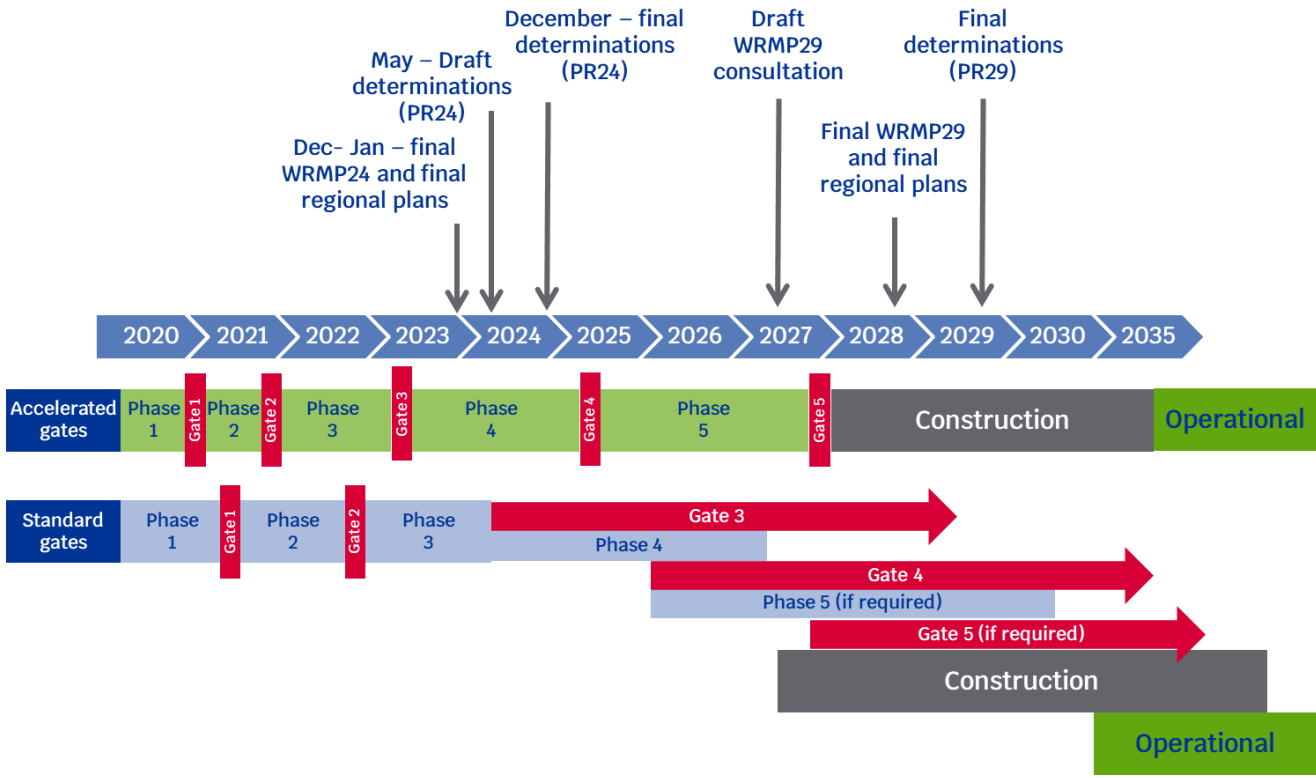


RAPID, NAU & the Strategic Resource Options



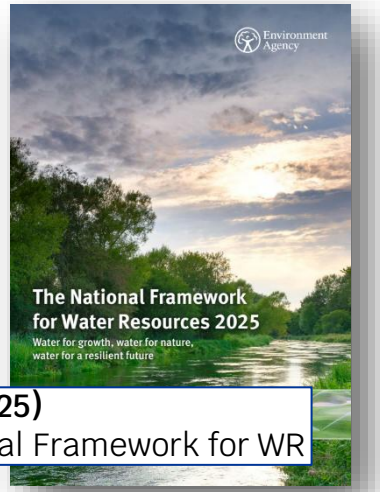
RAPID: Regulators Alliance for Progressing Infrastructure Development

- **£469m fund** for the continued development of strategic resource options (SROs);
- Oversight from regulators to overcome policy and planning risks and barriers
  - Ofwat, Environment Agency & Natural England, Drinking Water Inspectorate;
- A **gated process** to allocate funding across **18 options**, with SRO submissions and WRMPs needing to demonstrate SRO is feasible and best value to progress through each gate.



Evolving picture of water needs and solutions

Policy and planning react to an evolving water resource challenge



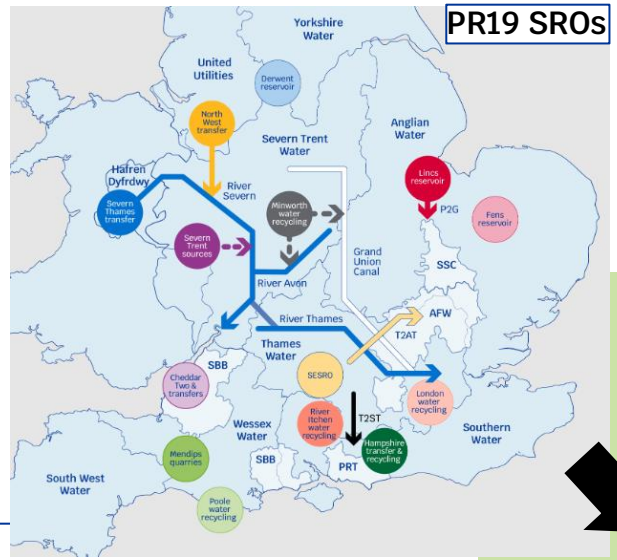
EA (2025)
National Framework for WR

Ofwat (2025)
PR24 Final Determinations

- Refresh of the National Framework in June 2025 shows that an additional **4,940 Ml/d** of water is needed to address future pressures on public water supply by 2050
- Increase of **~1,500 Ml/d** since first NF published in 2020

- PR24 includes **17** New significant infrastructure projects
- **11** of the options are **new SROs** to be developed under the RAPID gated process.
- **£2.4billion** of funding allowed at **PR24** for developing SROs

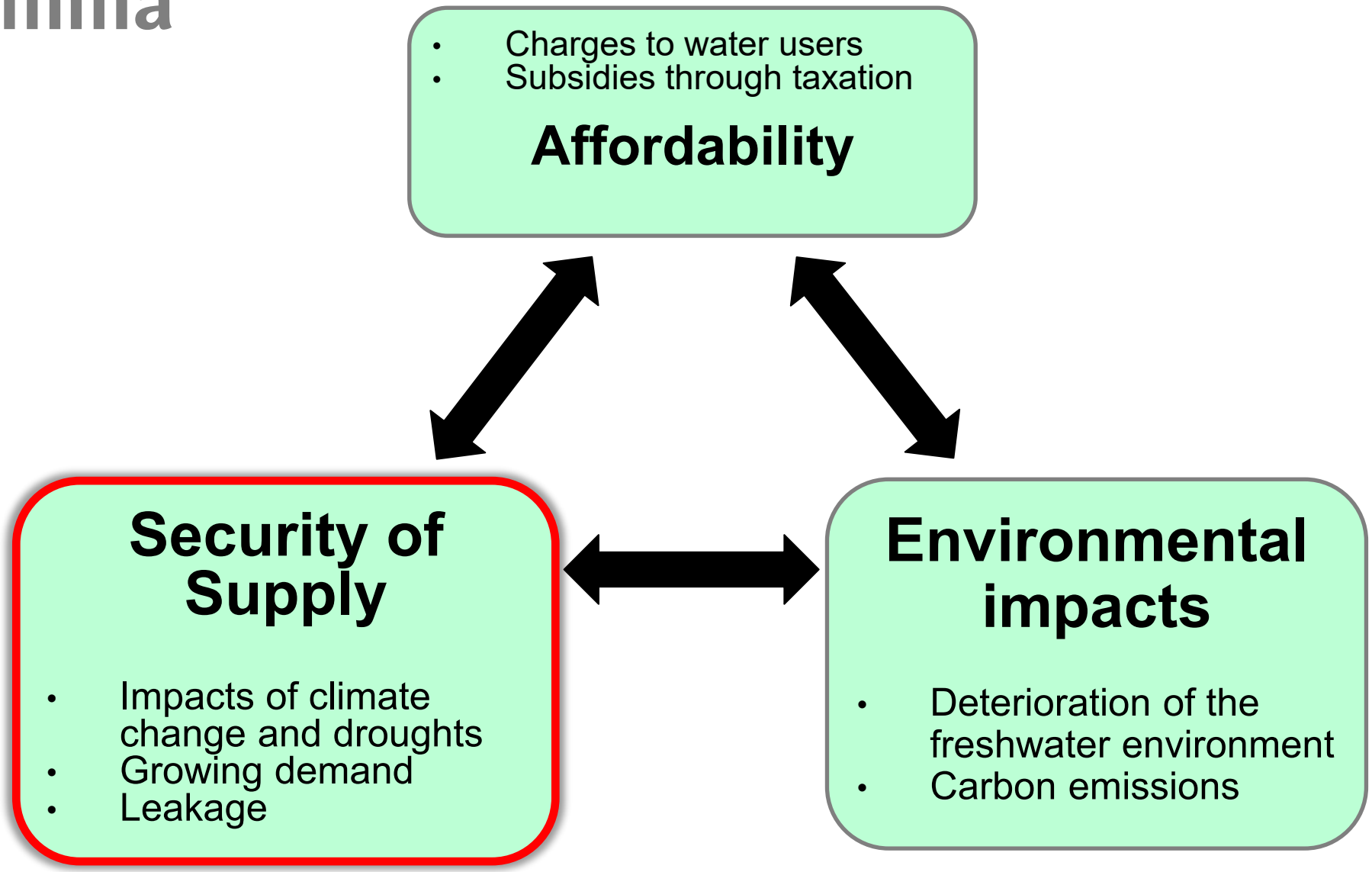
PR19 SROs



PR24 SROs

- RAPID now oversees a **~£50billion** programme of **28** major new infrastructure schemes.

Trilemma



RAPID

Environment Agency

The National System Simulation Modelling (NSSM) project

Team

Regulators

- Paul Hickey
- Elliot Tinton
- Haydn Johnson
- Fiona Lobley
- Jonathan Dennis

Academia

- Jim Hall
- Anna Murgatroyd
- Rachel Pugh
- Alison Peard
- Tom Russell
- Gemma Coxon
- Yanchen Zheng
- Doug Hunt

Technical

- Jonathan Wilson
- David Pritchard
- Richard Rowan-Robinson
- Saman Hashemi

☺ **With governance and technical support from the regional groups and water companies, SRO teams and industry experts** ☺

Aims

1. Technical: **Independently assess Strategic Resource Options and WRMP options**

Test the resilience of SROs against nationally-coherent droughts and climate change impacts to provide a regulator check on the most resilient set of SROs

Sense check emerging regional plans through national system stress-testing of WRMP scenarios.

Use outputs to support decision making around the selection of supply options

2. Long Term: **Develop cross-regulatory integrated modelling approach**

Quantitative evidence to support joined-up regulatory decisions and advice.

Approach

- Different way of looking at the problem: top-down vs bottom-up approach to modelling
- National modelling **does not replace** the detailed company, solution and regional models. It is a tool to look more holistically at the resilience and planning problem;
- Working **collaboratively and transparently** with water companies and solution teams to achieve appropriate system and solution representation, and to influence new ideas and solutions.

The National System Simulation Modelling (NSSM) project – Phases

Phase 1

Proof of concept, working with solution teams and WCs to represent SROs and independently test the resilience of individual solutions

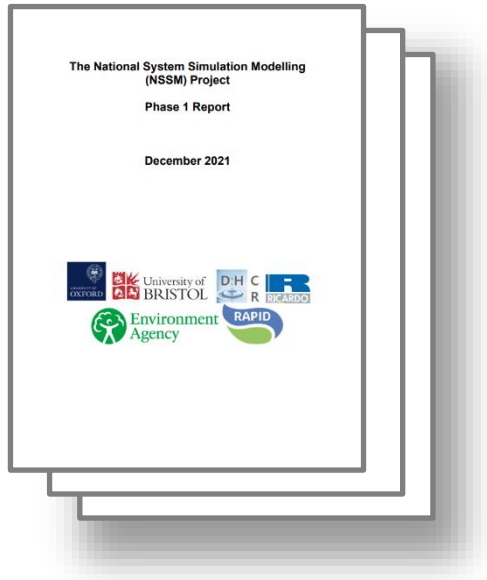
Phase 2

Testing the drought resilience of SROs in combination and exploring possible scenarios of demand, climate change and environmental destination

Phase 3 (current)

Independently test the full range of WRMP24 scenarios to explore the range of uncertainty and assess if there are any sensitivities associated with large scale, severe, long duration droughts.

- Help inform thinking around low/no regrets SROs
- Timing and configuration of solutions later in the planning horizon where uncertainty is greater



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EA/RAPID national WR modelling tools

1 ‘Aggregate’ modelling

1a National WR Supply-Demand model

- Low-resolution (WRZ scale, yearly timestep) ‘model’ built on data from WRMP19 tables
- Provides high-level quantitative evidence on future water needs under different scenarios of water availability, policy and demand

1b National WR Supply-Demand model for options comparison

- Allows for rapid identification of the most cost-efficient set of options for meeting water demand under different scenarios
- Used to test benefit of improving connectivity via new transfers

2 System Simulation modelling

National System Simulation Model (NSSM) –

- Most similar to water company modelling but at the national scale
- The model is way of stress testing the system and a risk analysis tool for reliably exploring uncertainty

What do National WR Models tell us?

Aggregate WR modelling

- **Define the planning problem/challenge** by quantifying how much water is needed nationally under a range of plausible future scenarios of water needs and pressures.

- **Identifying new options for meeting water needs** – are there new large/national scale options that could help meet water needs more efficiently than options currently considered in WRMPs?

National System Simulation Modelling

- **Sense checking WRMPs** - Independent assurance on the options selected by Water Companies in their water resources management plans.
    - Do the SROs provide the benefits (drought resilience) presented in WRMPs?
    - Does the performance of SROs change when tested against national scale droughts, or other types of drought not sampled by water company methods?
    - Are the best combination of options are chosen in WRMPs?

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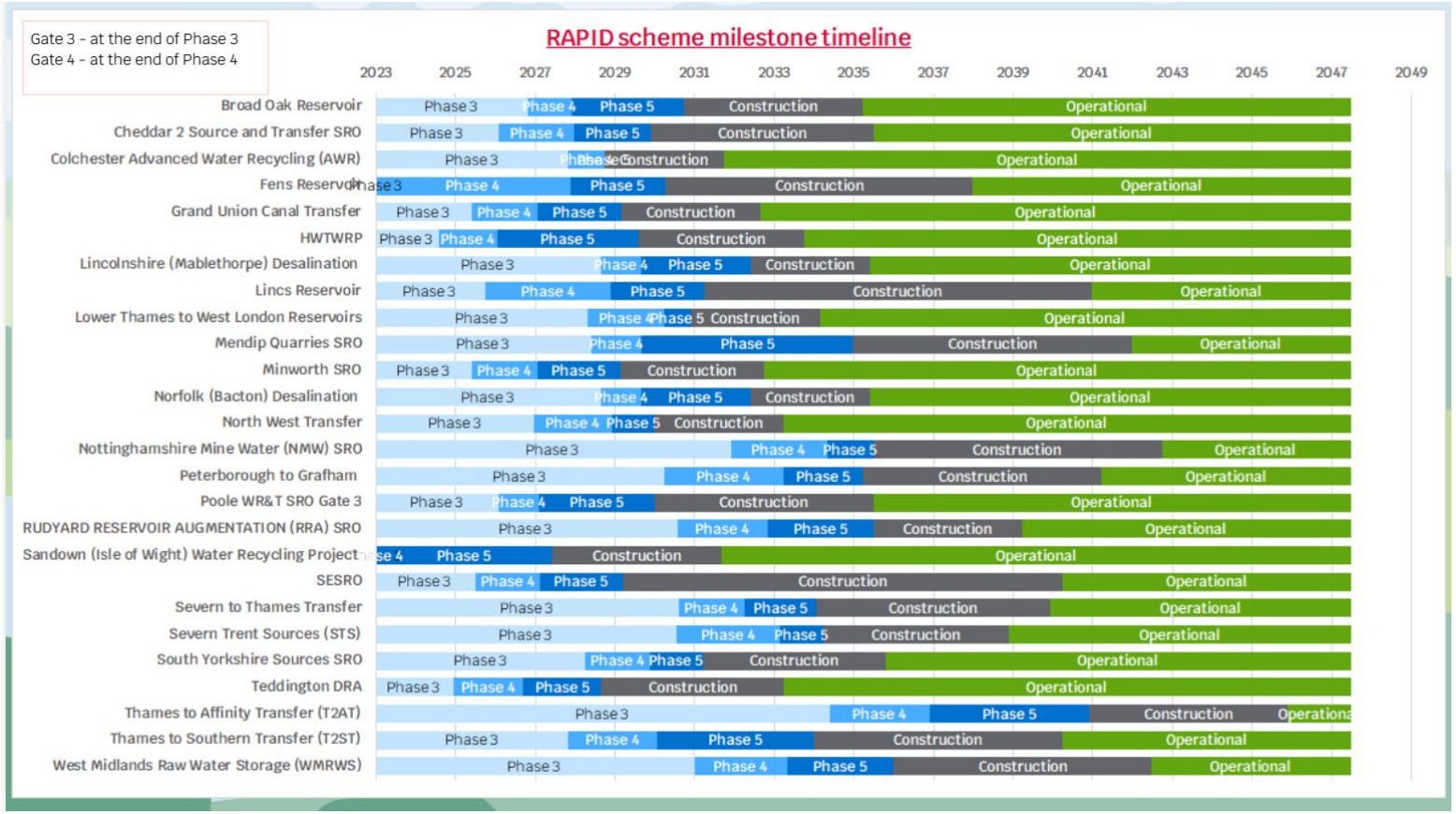
What do National WR Models tell us?

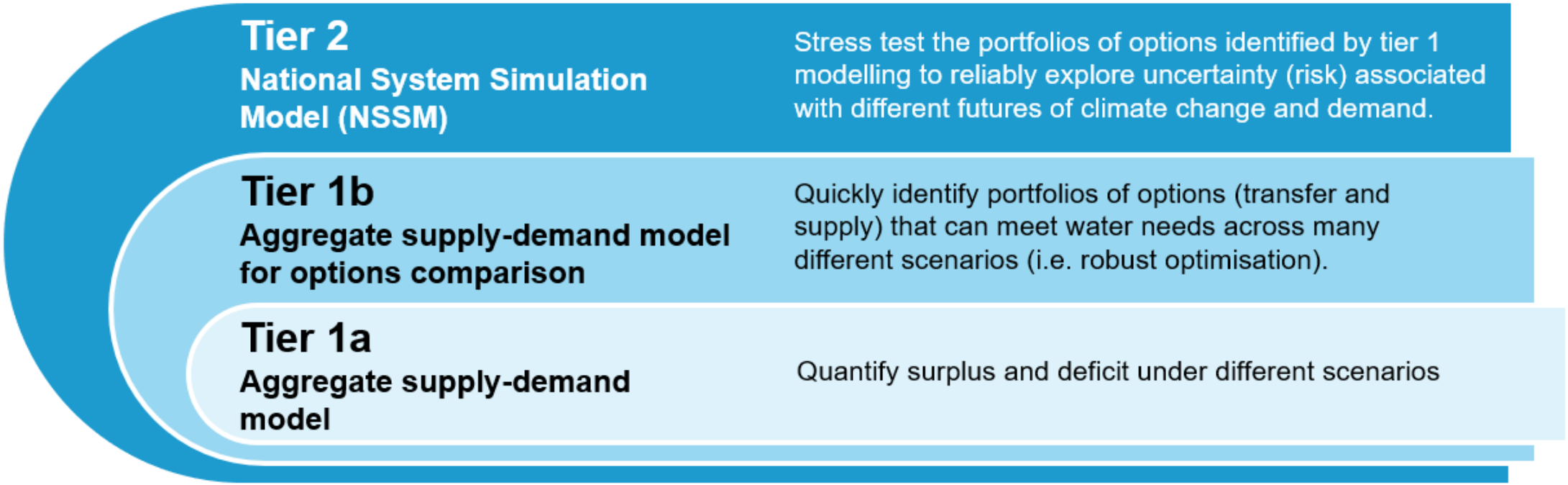
Aggregate WR modelling & National System Simulation Modelling

- **Explore the consequences of delays to delivery of SROs** the current SRO milestones and timeline is quite ambitious and regulators need to understand the implications of delays to schemes.
  - Which delays carry the greatest impact/risk?
  - Where are there insufficient options to mitigate delays and could new national options help?



Future Plans – WR modelling & DAFNI

Tiered modelling strategy to join up aggregate modelling & NSSM, and leverage the strengths of each approach.



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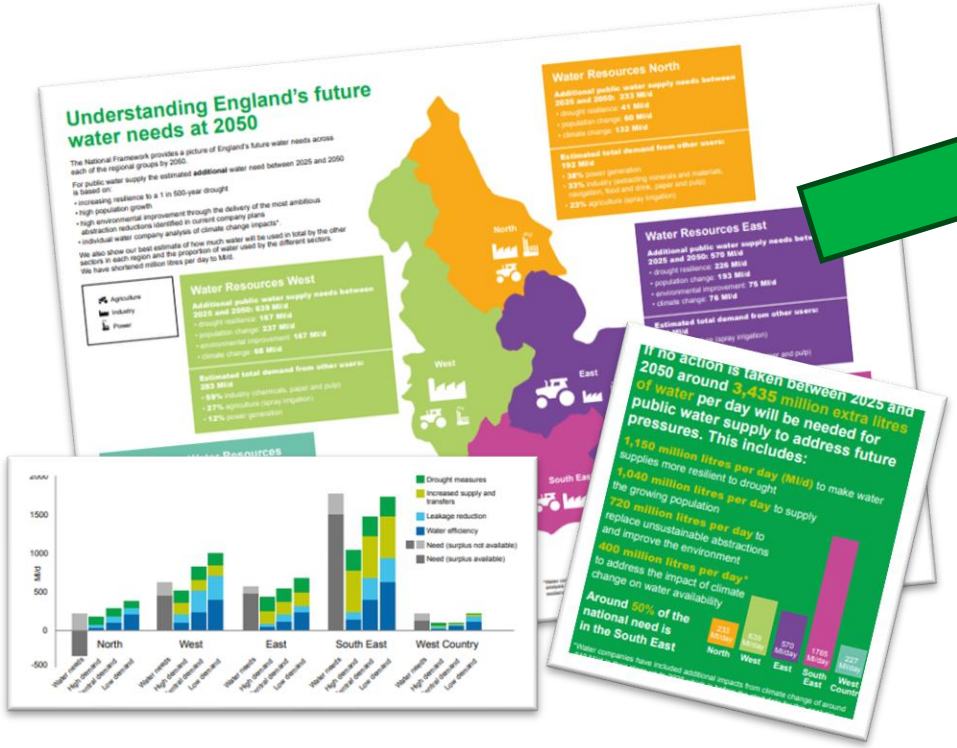
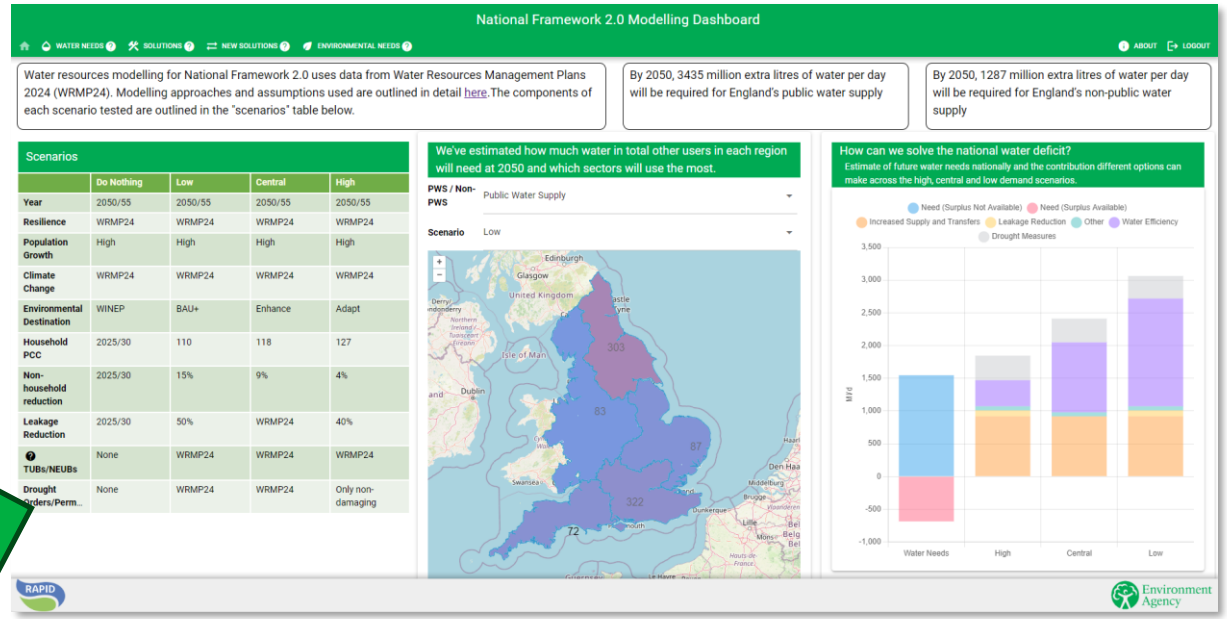
Future Plans – WR modelling & DAFNI

Stakeholder engagement through interactive visualisation

NF1.0

- Standalone figures and reports
- Lack of transparency uncertainty management
- Limited and inefficient data sharing and access
- Limited user experience/engagement with data





NF2.0

More complex problems & subsequent ambitious modelling requires a change in approach to engagement including improved transparency, accessibility & user experience

➢ Interactive visualisation dashboard!

- Ability to interact and visualise with data and scenarios
- Ability to download input and output data/figures/maps
- Ability to explore a range of scenarios

Future Plans – WR modelling & DAFNI

Stakeholder engagement through interactive visualisation

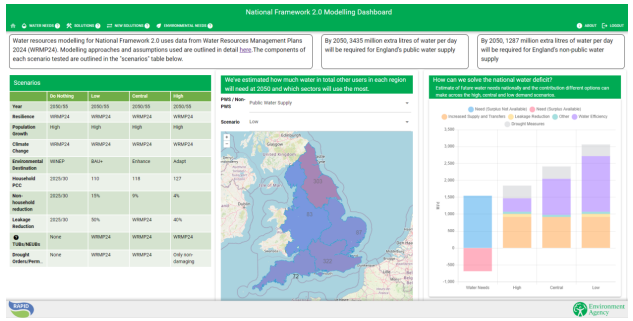
Summary landing & information page

- Summary of modelling outputs
- Models & assumptions

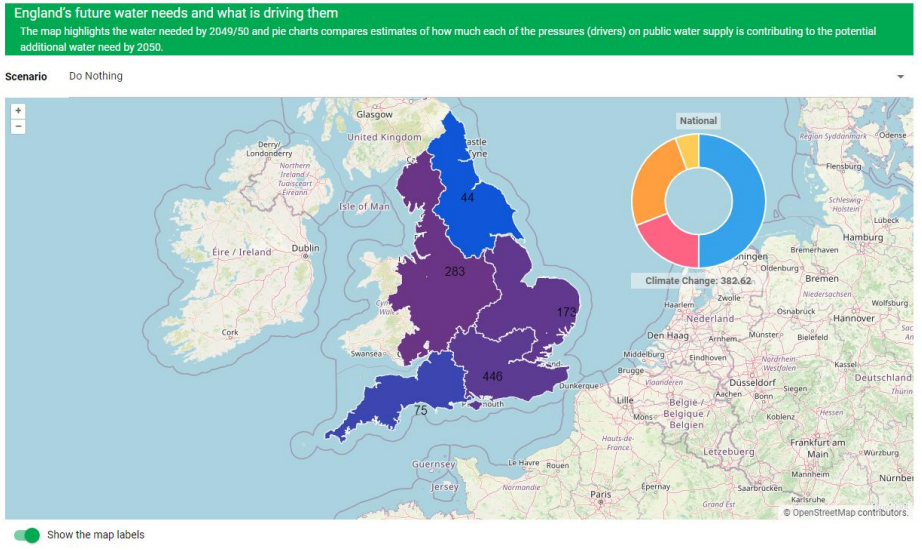
"Explorer pages" including:

- **Water needs explorer** – visualises and compares future water needs at different scales under different future scenarios
- **Solution explorer** – visualises how WRMP24 supply and demand options can meet the range of future water needs
- **New transfer explorer** – visualises potential new transfer options, assess trade-off between options(cost/yield) and comparison to WRMP24 portfolios
- **Environmental needs explorer** – visualises and compares future environmental needs

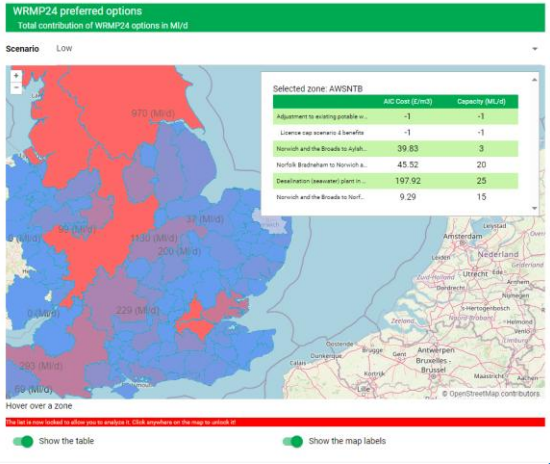
Summary landing page



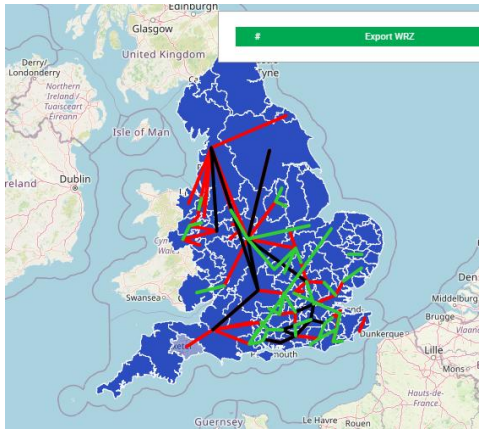
Water needs explorer



Solution explorer



New solution explorer



Future Plans – WR modelling & DAFNI

Pywr-WREW

1) **Open-source:** Pywr's source code is available on GitHub. Given that the framework is devised entirely in the widely-used Python programming language, users can easily detect and fix bugs, as well as implement new features.

2) **Free to use:** Pywr has been designed to be free end-to-end. This means that models can be formulated and solved using open-source optimisation solvers (e.g., GLPK), avoiding expensive license fees.

3) **Strong support base:** Pywr's userbase spans the globe, which provides a strong support base for users. Since Pywr is currently the only open-source water resources modelling framework, its documentation and features are continuously growing.

Wathnet5

pywr

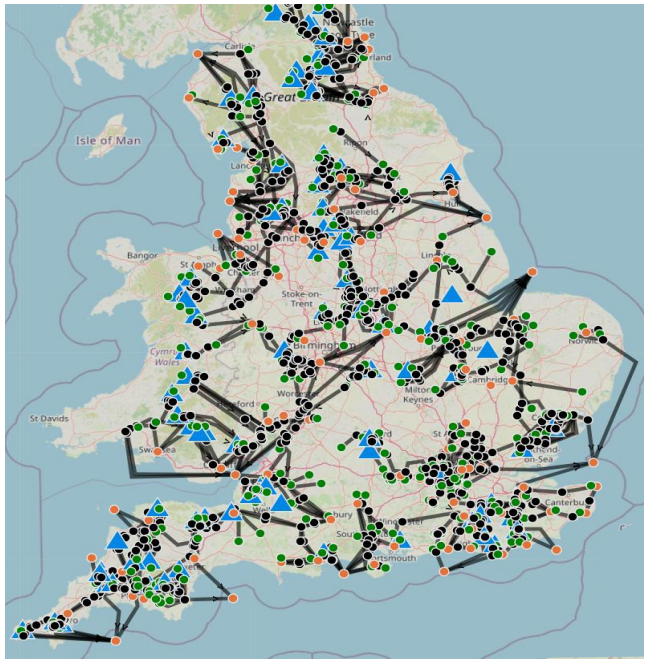
Newcastle University

Pywr-WREW

A Water Resources model for England and Wales to enable strategic analysis of the drought resilience of water supply infrastructure

Dr Anna Murgatroyd, Prof Jim Hall, Tom Russell

DAFNI Newcastle University Environment Agency eci University of Oxford



Future Plans – WR modelling & DAFNI

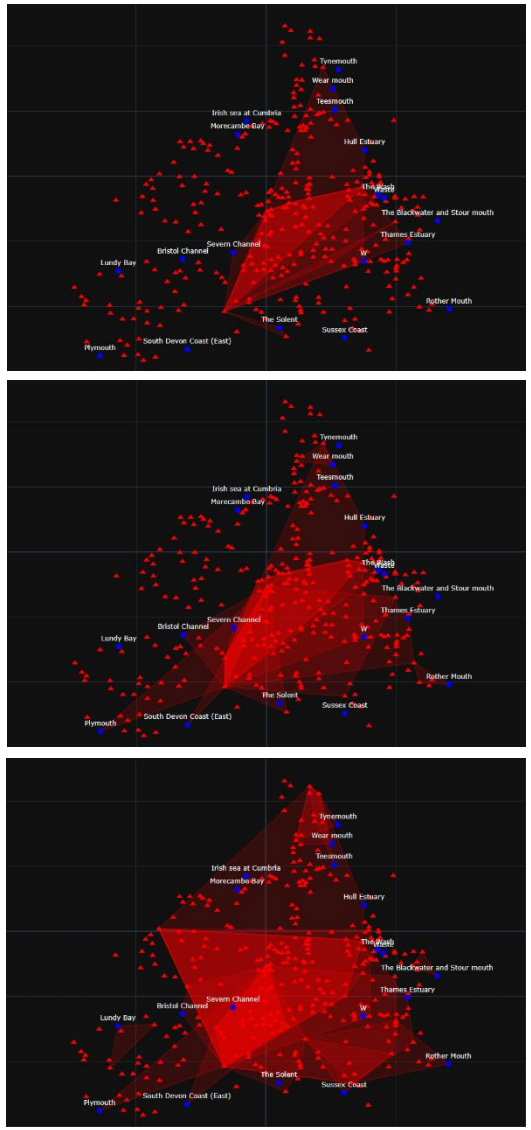
Collaboration with other DAFNI users/modellers

Dr. Michael Foster
Dr Neil Walkinshaw
Dr Farhad Allian
Prof. Robert Hierons
Richard Sommers

The University Of Sheffield.

CITCoM – **C**ausal **I**nference for **T**esting **Co**mputational **M**odels

- The NSSM is a complex computational model, and it is therefore difficult to assess whether output is to be expected – e.g. is non-convergence of optimisation significant/meaningful?
- Researchers at Uni Sheffield have developed a framework for testing computational models via the application of statistical analysis approaches know as causal inference
- Allow us to draw justifiable conclusions about model behaviour
- Possible to test "what if" questions about simulations that have not yet been executed.



Increasing confounding effect between model elements

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Future Plans – WR modelling & DAFNI

IWC report – key themes and recommendations relevant to National WR modelling include:

Expansion of the RAPID programme

"The **RAPID** framework to speed up delivery of major projects could be **expanded** to **increase coverage and effectiveness**."

"The scope of RAPID should be **expanded to include wastewater projects** and strategically important projects that do not **meet current size and complexity thresholds**"

Focus on long-term water needs

"**There is an urgent need to strengthen long-term strategic direction for water supply**…including consolidating the modelling and assumptions underpinning long-term and interim targets."

National consistency of methods

"The national coordinator should take on responsibility for ensuring the consistency in scenarios, assumptions, and metrics for water industry planning… introducing a **consistent standard method for forecasting various assumptions** including **population growth** and **climate change**."

Integrated regulation & Systems planning

"A new integrated body would better equip regulators to manage current **trade-offs** in the system. By **integrating economic functions with water environment and water industry regulation within a single body**… the regulator would be able to take a **holistic** view of the development of water company plans"

"The new regulator would bring together **Ofwat**, the **DWI** and the water regulatory functions from the **EA** and **NE**."

"Systems planners should ensure that water supply is sufficient to meet the **current** and **future needs** of the region and is robust to **future water system stress**"

"Systems planners would **review plans** and **select** the **preferred options** based on criteria set by the government. Systems planners would have 'constrained discretion' to make **trade-off decisions**"

"The systems planner would support all sectors in **developing feasible options**"

Thank You

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BRIDGING THE GAP BETWEEN ACADEMIA, GOVERNMENT AND INDUSTRY

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Closing remarks

Tom Kirkham reflects on the day. Close of conference.

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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Thank you for attending

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