Science and Technology Facilities Council

Conference Proceedings
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DAFNI Conference 2023: Building a Secure and Resilient World

Imperial College, London, UK
12th September 2023

L Harding, K Cartmell (editors)

December 2023

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DAFNI CONFERENCE 2023

BUILDING A SECURE AND RESILIENT WORLD

IMPERIAL COLLEGE, LONDON. 12 SEPTEMBER 2023

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CONFERENCE 2023

IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

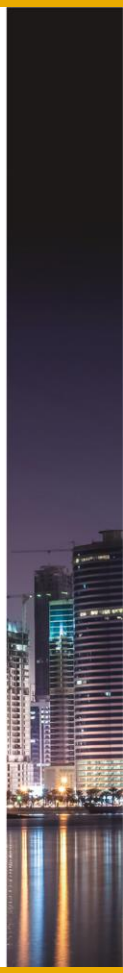
BUILDING A SECURE AND RESILIENT WORLD

Chair:

Dr Giuliano Punzo

Lecturer at the University of Sheffield

Director of the Sheffield Urban Flows Observatory



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UKRI Engineering and Physical Sciences Research Council

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DAFNI

Welcome to the DAFNI Conference 2023
Building a Secure and Resilient World

09:25 Welcome and Introduction

09:30 Keynote Presentation: DAFNI to improve capacity & resilience of infrastructure systems
Bridget Rosewell, Non-Executive Director at UK Infrastructure Bank (UKIB),
Formerly Commissioner of the National Infrastructure Commission (NIC)

10:10 DAFNI Exploring Resilience
Dr Brian Matthews, DAFNI Facility Lead, Scientific Computing, STFC

10:35 DAFNI Platform Presentation
Dr Bethan Perkins, DAFNI Team Lead

10:55 Break, Demos and Networking

11:25 The Challenges of Resilience
Dr Kristine Zaidi, Associate Director of Programmes, UKRI AHRC

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Welcome to the DAFNI Conference 2023
Building a Secure and Resilient World

11:45 Presentations from Centre of Excellence Talks

Resilience Scenarios for Integrated Water Systems - RIWS

Dr Ana Mijic

An agent-based model of flood infrastructure resilience – FIRM

Professor Richard Dawson

Uncertainty quantification and sensitivity analysis for resilient infrastructure systems – USARIS

Dr Francesca Pianosi

Building systemic resilience of interdependent infrastructure networks at the national scale – NIRD

Dr Raghav Pant

12:45 Networking lunch and demos

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BUILDING A SECURE AND RESILIENT WORLD

Keynote Speaker:

DAFNI to improve capacity & resilience of infrastructure systems

Bridget Rosewell

Non-Executive Director at UKIB,
Formerly Commissioner of the NIC

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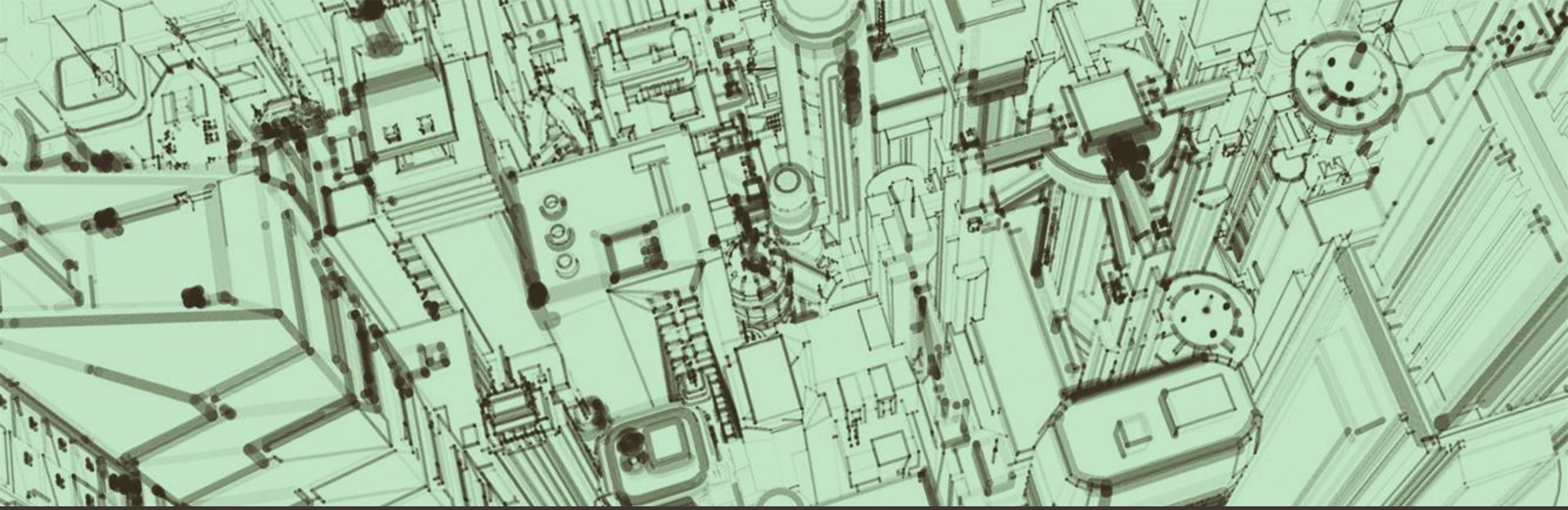

Data, resilience, infrastructure

Bridget Rosewell

How it used to be done?

- Over-engineering by eg Bazalgette
- Small continuous teams of men who knew their patch
- Tolerance of things going wrong
- Developing complacency?

Consequences

- Infrastructure thought of as having an infinite life
  - At current rates it will take several hundred years to replace all water pipes
- A loss of knowledge as data systems have changed
  - No way to incorporate soft information – brain dumps – as data became stored in machines
- Fragmented systems that couldn't or wouldn't talk to each other
  - Systems built around previous human based ways of managing information and jealous guarding of expertise, understandable but not helpful
- Late recognition of these disconnects
  - BIM systems only now implementable, recent recognition of the potential of 'digital twins'

Digital twins?

- Are only as good as the data that they incorporate
  - Compiling accurate data and maintaining is more difficult than people think
- Must identify the linkages and feedbacks between different data domains
  - Modelling can mislead as easily as it informs
- Risk being a new black box that no-one understands
  - And that is thought to fulfil purposes it cannot
- In the real world even identical twins have different life trajectories!
- DAFNI exists to help manage these challenges and identify tools that are fit for purpose

More and Less

- A small group can understand and learn its own part of the picture but won't see the rest of the elephant
- Large data sets are increasingly available but what do they tell us, for example about underground aging assets?
- Information needs to lead to insight, and be linked to creative decision making.
- In Northumbrian Water we are developing a 'tipping point' tool to help identify when intervention might be needed before failure. Risks going in too early as well as too late
- In Flood Re, looking at plans to reduce flood risk – how will nature based solutions fare when we haven't examples to look at?
- We need to leap from the 19th to the 21st century

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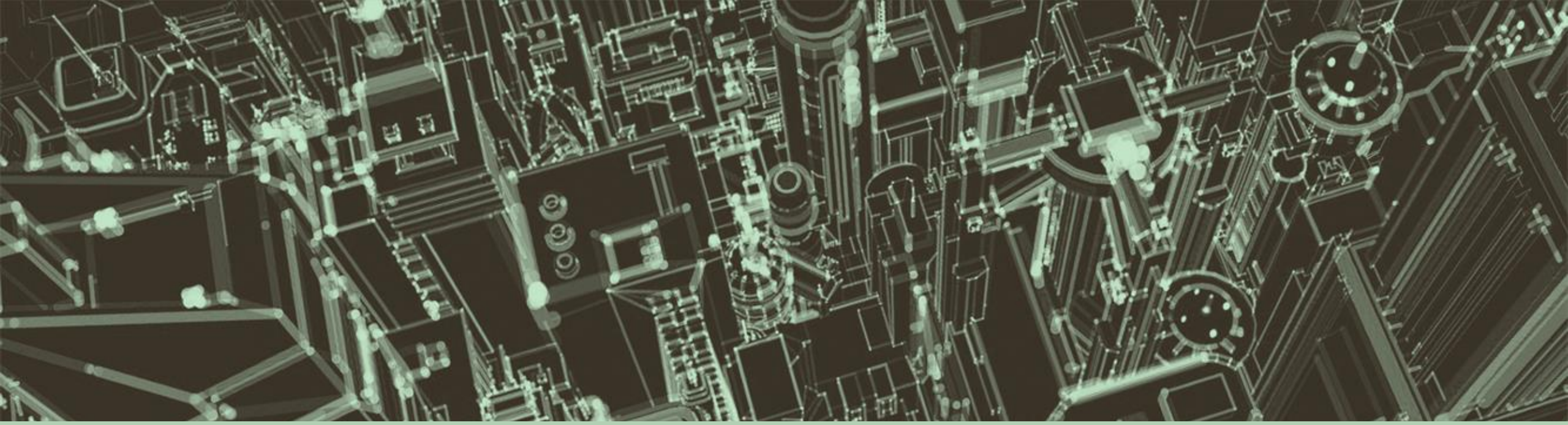
- Large scale capability
  - Manage large scale data
- Data combinations
  - Remember the shuttle disaster where measurement systems differed
- Software tools
  - Query and report
- Visualisation help
  - Does this make sense??
- Consideration of wider factors
  - Well being etc



Questions

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IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Speaker:

DAFNI: Exploring Resilience

Dr Brian Matthews

DAFNI Project Lead
Scientific Computing, Science and Technology Facilities

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Dr Brian Matthews
DAFNI Project Lead, Scientific Computing Department,
Science and Technology Facilities Council

DAFNI

4th July 2022

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BUILDING A SECURE AND RESILIENT WORLD

IMPERIAL COLLEGE, LONDON. 12 SEPTEMBER 2023

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Where has DAFNI come from?

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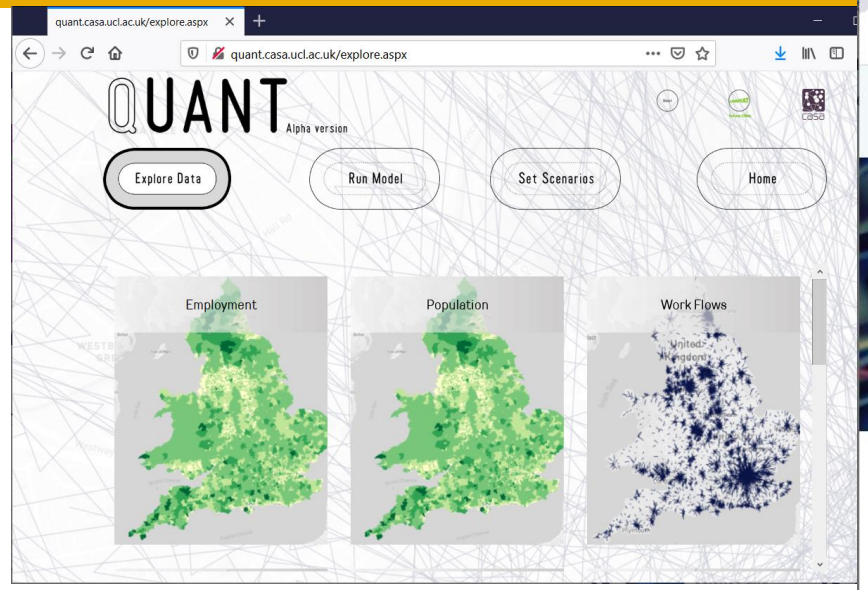
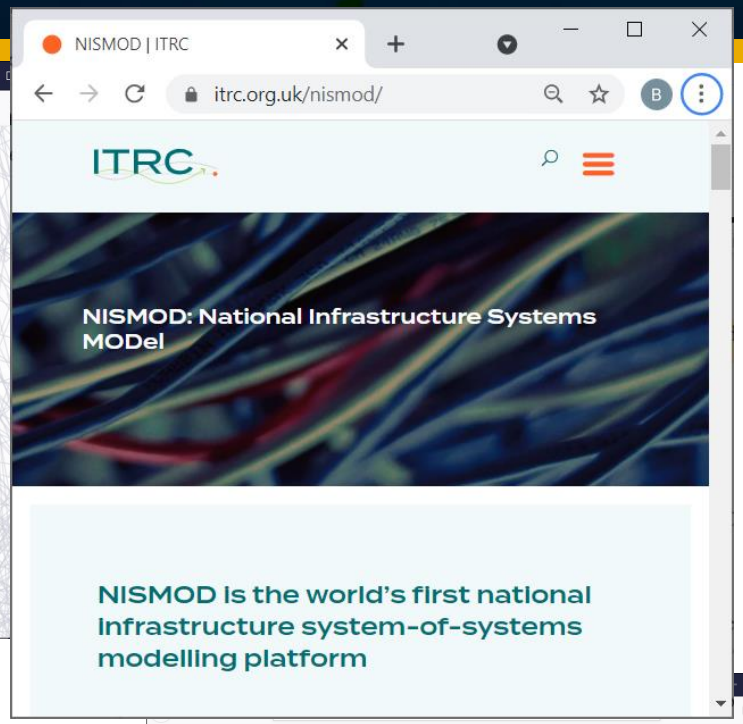
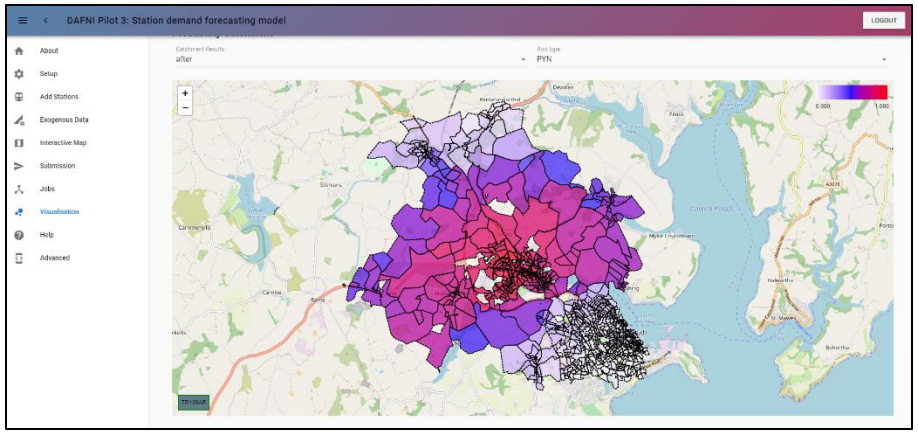
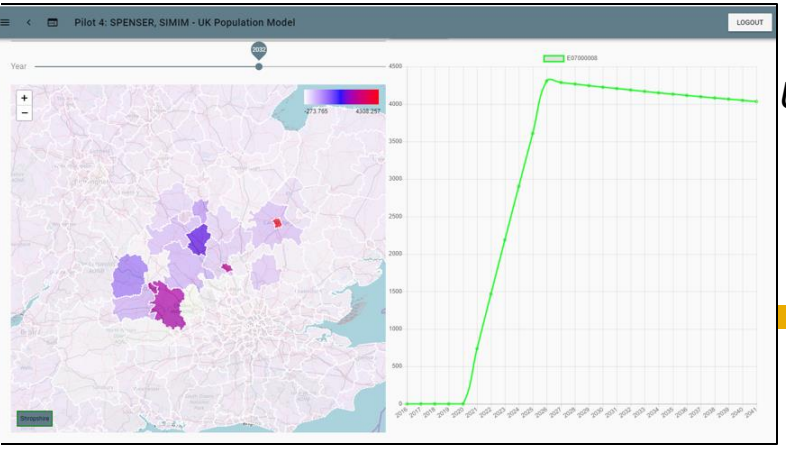
World-leading research



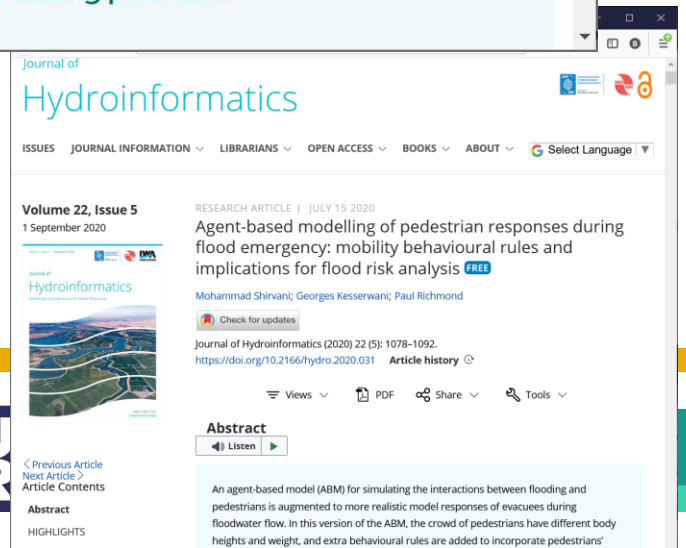


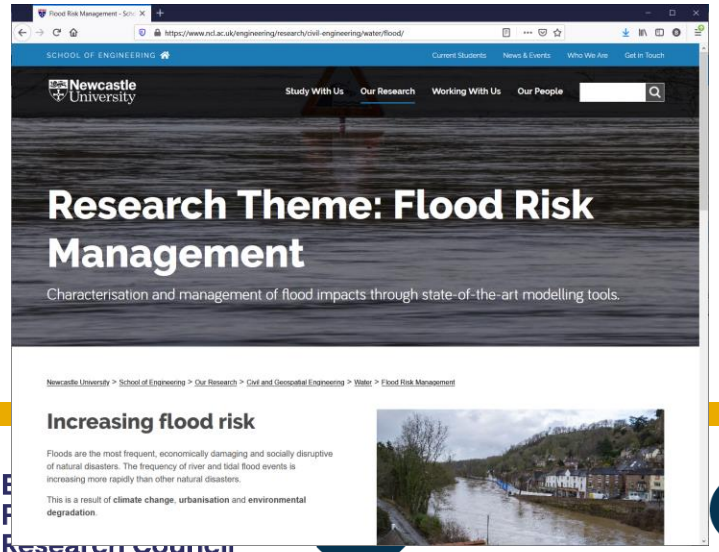
Station demand model, University of Southampton





SIMIM, University of Leeds





Phillip-James.jpg

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The DAFNI Partnership

Data and Analytics Facilities for National Infrastructure

Providing a computing platform for research into decision making for national infrastructure

£8M investment 2017-2021 under the UK Collaboratorium for Research on Infrastructure and Cities

Prof. Jim Hall
Uni. of Oxford

Prof. Stephen Hallett
Cranfield Uni.

Dr. Theo Tryfonas
Uni. of Bristol.

Dr Assad Faramarzi
Uni. of Birmingham

Dr. Aruna Sivakumar
Imperial College

Prof. Giuliano Punzo
Uni. of Sheffield

Dr Juan Bicarregui
STFC

Dr. Nik Lomax
Uni. of Leeds

Prof. Liz Varga
UCL

Prof. Julien Harou
Uni. of Manchester

Dr. Simon Blainey
Uni. of Southampton

Prof. Phil James
Uni. of Newcastle

Prof. Mike Batty
UCL

Dr. Ruchi Choudhary
Uni. of Cambridge

A Partnership of 12 universities and + STFC as development and hosting partner

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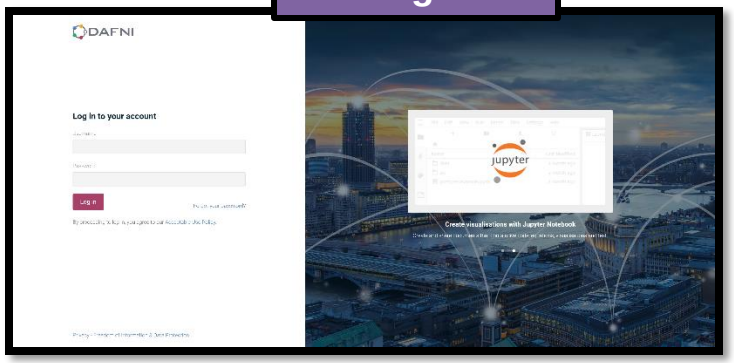
A Collaborative Platform

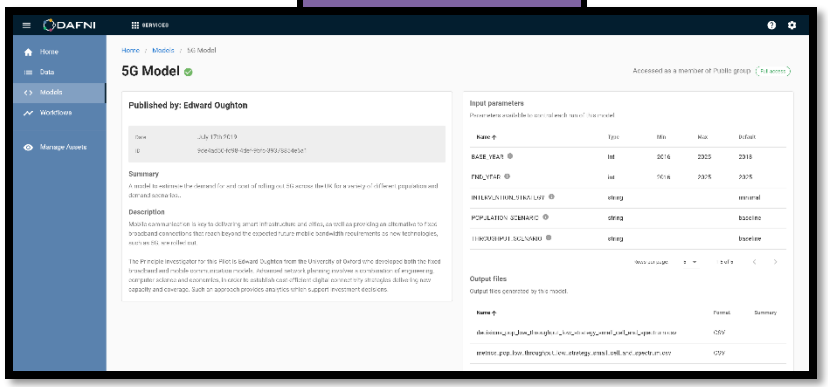
- To support scientific modellers in their technical collaborations
- To foster new connections and collaborations in research
- To spearhead new levels of transparency and reproducibility in model-based research
- To facilitate communication of scientific results to non-technical decision makers

DAFNI Functionality

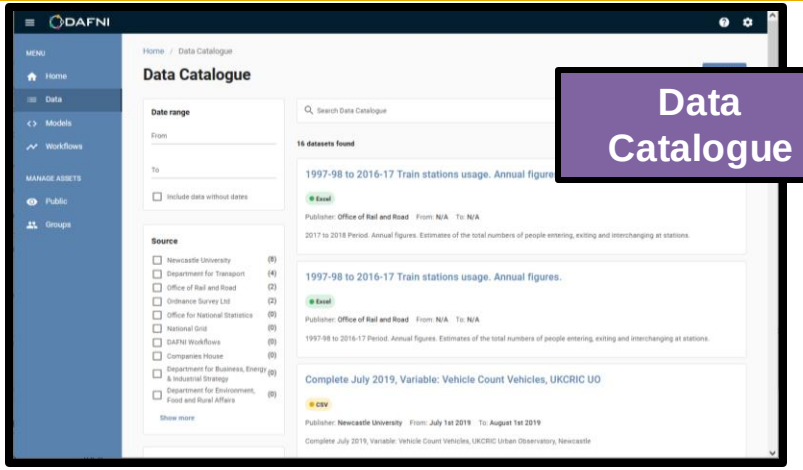
Login



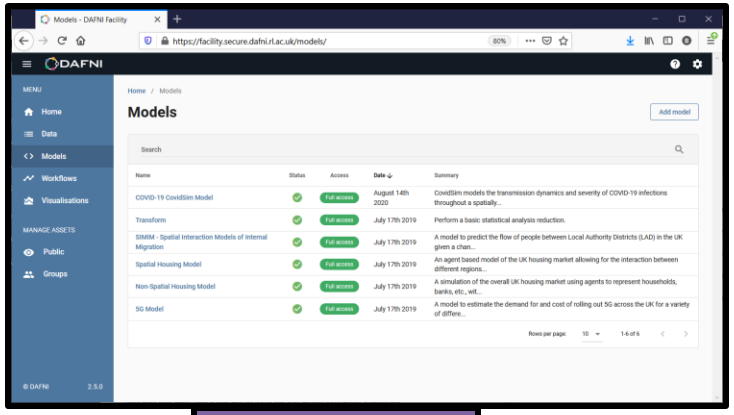
Data



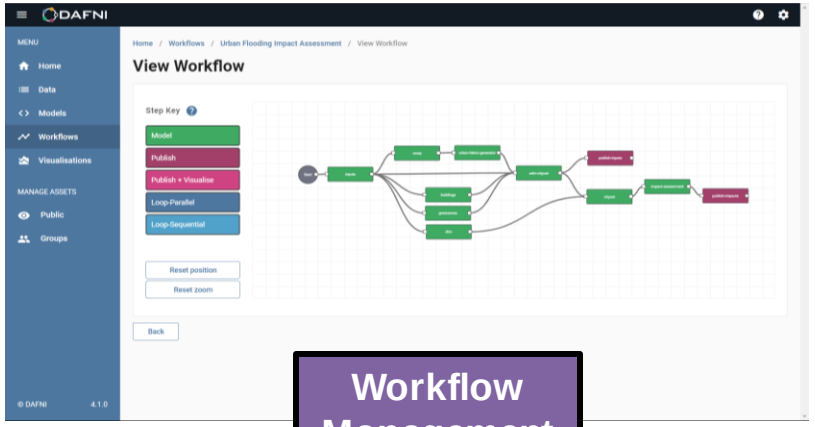
Data Catalogue



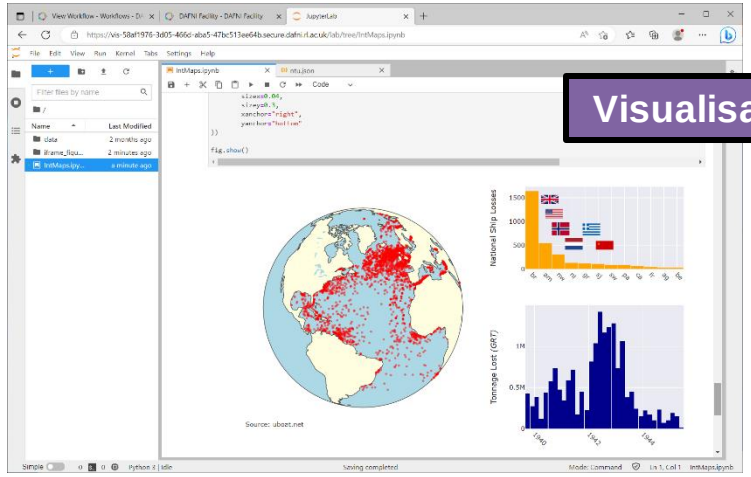
Model Catalogue



Workflow Management



Visualisation



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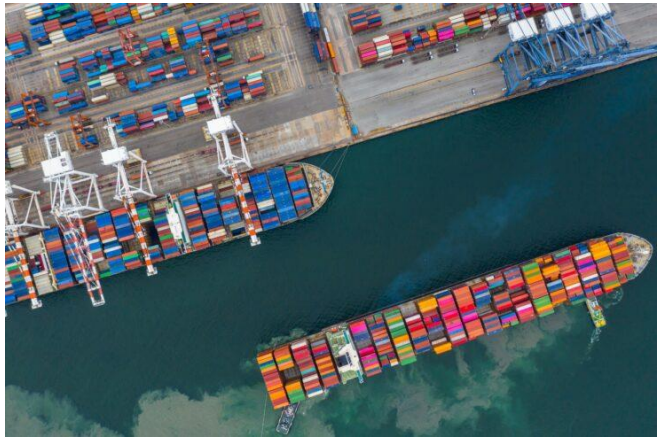
University College, London: A Shipping Model



Global shipping is currently responsible for 2-3 % of CO2 emissions, and with a business as usual scenario extrapolated into the future we could expect emissions from shipping to increase anywhere from 50-250 % in the next three decades.

Liz Varga,
Evangelia Manola

Cargo shipping has adopted a practice know in SFTW (steam fast, then wait) which has been encouraged by maritime law. Unfortunately this often results in shipping burning more fuel than is necessary to reach their destination in time.

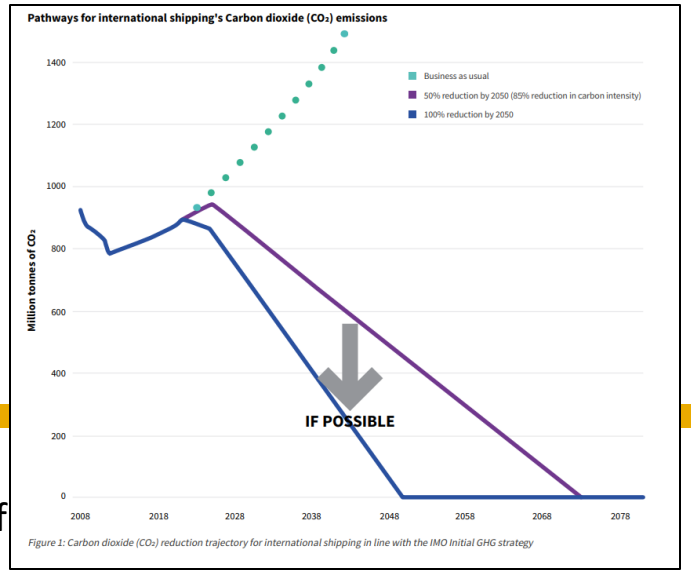


Figure 1: Carbon dioxide (CO_2) reduction trajectory for international shipping in line with the IMO Initial GHG strategy

The UCL pilot shipping project tracks the movements of selected ships and evaluates the potential fuel that can be saved (recorded as anywhere between 20-60 %). Information can then be relayed through the INMARSAT communications system to the ship.

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The DAFNI Centre of Excellence for Resilient Infrastructure Analysis

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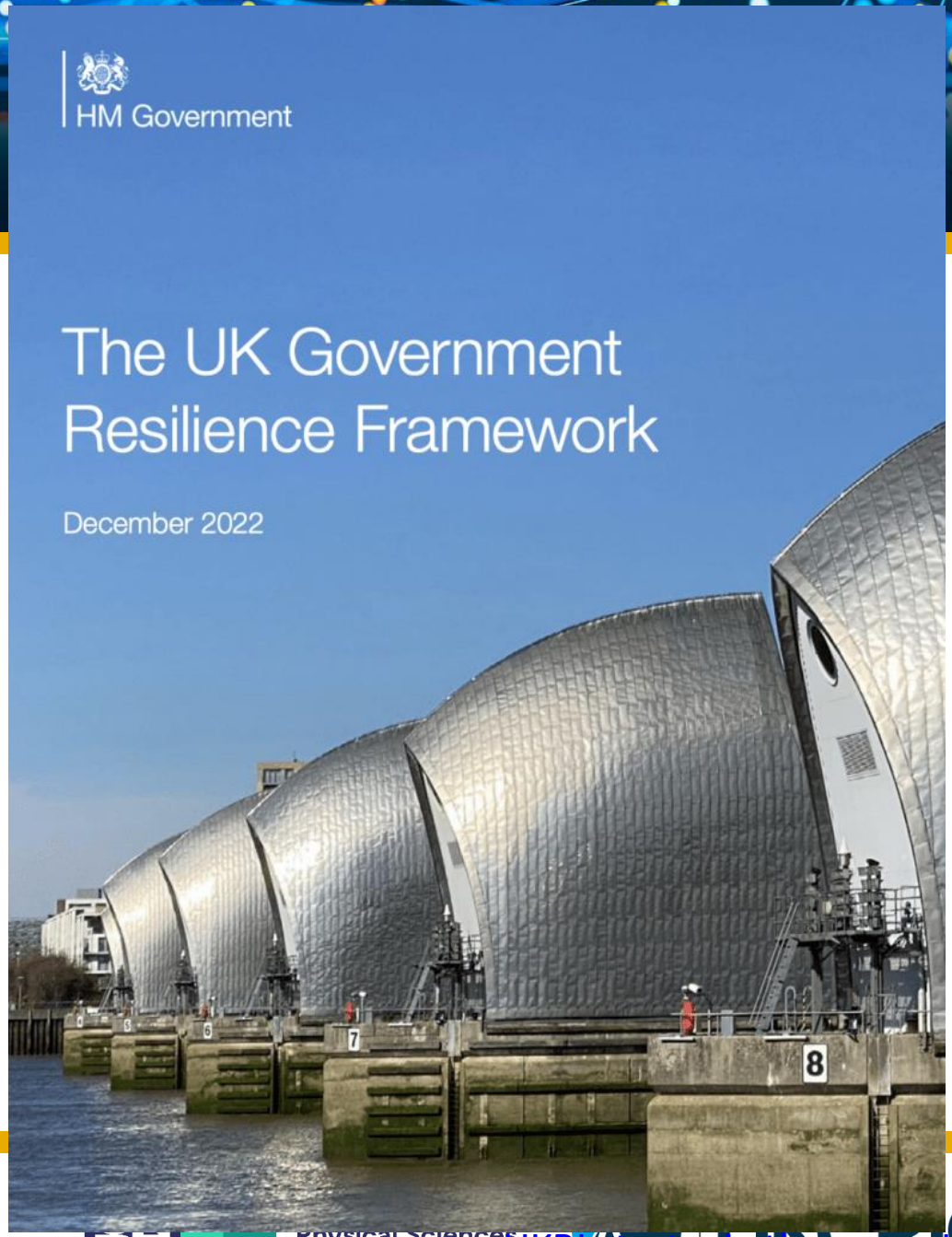
Building and Secure and Resilient world

UKRI Strategic Theme

This funding aims to strengthen social and economic resilience, and enhance national security across virtual and physical spaces, by improving awareness of risks and threats; preparedness, decision making and response; and allowing change to be understood as a force for good



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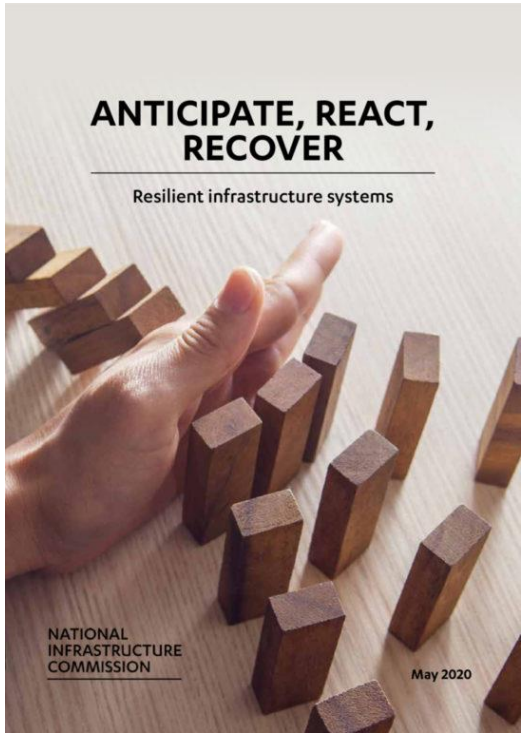
UKRI strategic themes – UKRI



https://nic.org.uk/studies-reports/resilience/

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A PROACTIVE APPROACH IS NEEDED TO MAKE THE UK'S INFRASTRUCTURE RESILIENT TO FUTURE CHALLENGES

The UK's water, energy, digital, road and rail infrastructure has, for the most part, proved resilient to shocks and stresses over recent years. But there may be different or harder challenges in the future.

RECENT EVENTS HAVE EXPOSED VULNERABILITIES

The 'Beast from the East' in 2018 left **200,000** people without water for 4 hours and **60,000** people without water for 12 hours across the UK

A power outage in August 2019 led to **1.1 million** customers being disconnected from the grid

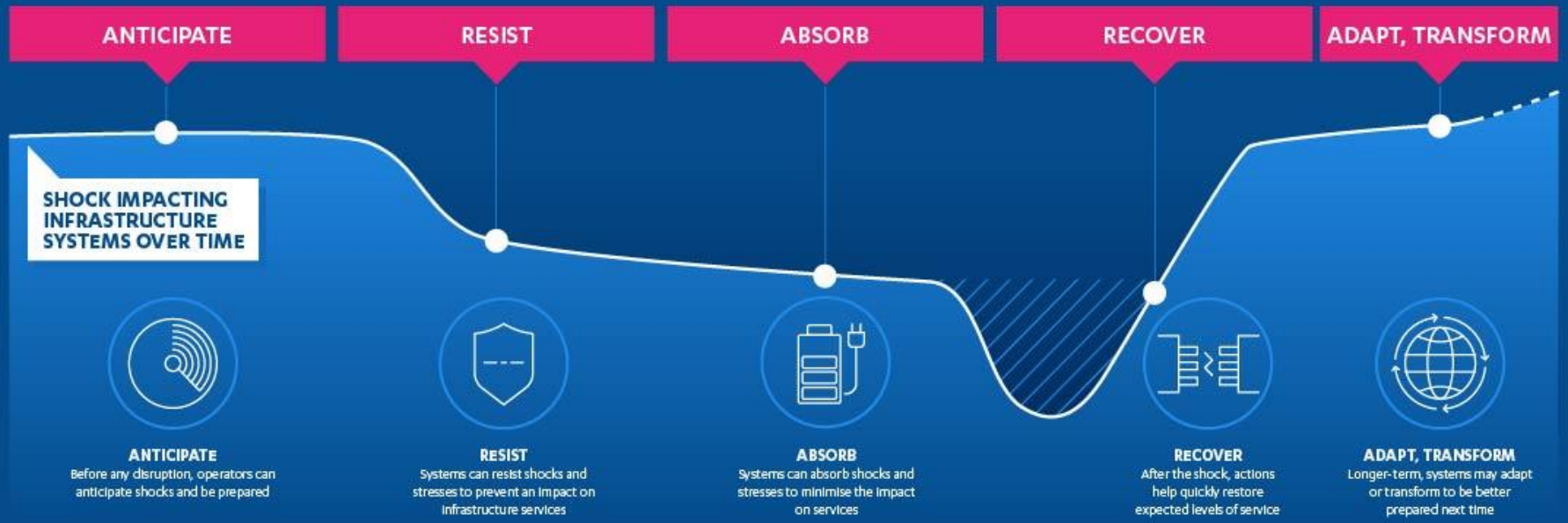
In December 2018, over **30 million** of O2's mobile network users were unable to get online for almost a whole day

In May 2018, rail timetabling changes disrupted Northern Rail and Govia Thameslink passengers' travel plans for **several weeks**

THE COMMISSION RECOMMENDS:

	ANTICIPATE	RESIST, ABSORB, RECOVER	ADAPT, TRANSFORM
The system architecture needs to...	Face uncomfortable truths	Test for and address vulnerabilities	Drive adaptation and value resilience properly
The Commission recommends that...	Government sets resilience standards	Regulators oversee regular stress testing Infrastructure operators address vulnerabilities	Infrastructure operators produce long term resilience strategies Regulators value resilience in decisions to support investment

THE COMMISSION HAS DEVELOPED A NEW FRAMEWORK FOR RESILIENCE



The DAFNI Centre of Excellence for Resilient Infrastructure Analysis:

Strengthening resilience in the natural and built environment in response to short-term and long-term threats via computational modelling

Short term shocks – e.g. flooding, heat events, emergency response

Long term shocks – e.g. effects and adaptations to climate change, demographic change

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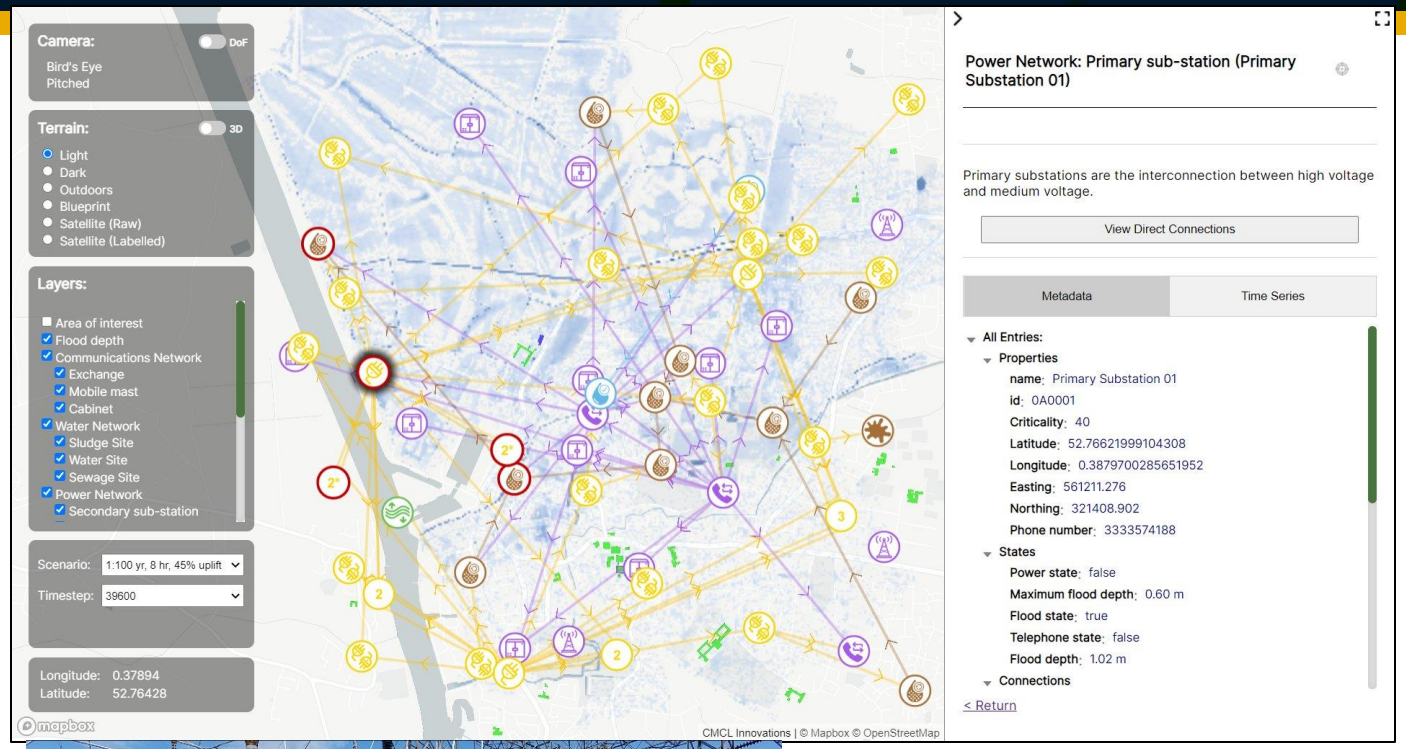
CReDo – Climate Resilience Demonstrator



The CReDo project aims to investigate the impact of climate change on infrastructrure networks, and how we can mitigate the potential economic and social damage caused.

CReDo is currently focussed on the impact of flooding on infrastructure networks, possibility of interrelated sites going down. Evidence based decision support for flood mitigation was also provided.

DAFNI also facilitates secure data holding for BT, Anglian Water, and UKPN.

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Why a Centre of Excellence in Computational Modelling?

- Resilience assessment and stress testing of infrastructure
  - Applying the best research in infrastructure modelling to analyse computationally the impact of shocks
  - Provide measures on the resilience
  - Assess impact of mitigations and adaptations to the model

- Look at the knock-on effects of co-dependency
  - Systems of systems modelling rather than each system in isolation
  - Data sharing and integration – data sharing agreements.

- Consider the impact of change in other domains to the resilience of the system
  - Changes in the built environment
  - Changes in demographics and economics
  - Changes in environmental conditions – especially climate change

- Make tools available for use and re-use in new scenarios

Objectives

Build on current DAFNI to form a Centre of Excellence in Modelling Resilience

- Provide a centre of expertise and capacity to support computational modelling of resilience challenges for the BSRW programme
- Provide a collection of compute and data resources to enable research in Resilience
- Provide demonstrators to explore resilience to shocks via computational modelling on the DAFNI platform
- To engage with the wider stakeholder community to exploit research into resilience

We need the engagement of the Research Community across all these objectives

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Research Programme

Three funding streams:

1. **Supporting Key Models**
   Providing key resources to explore resilience

2. **Developing a Resilience Framework**
   Providing tools to describe and measure resilience

3. **Exploring Resilience Scenarios**
   Providing research demonstrators of resilience in practise

A total fund of £1.4M is available overall for projects, for up to 18 months.

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A Programme of Research

Developing a Resilience Framework

- **USARIS: Uncertainty quantification and sensitivity analysis for resilient infrastructure systems**
  - Dr Francesca Pianosi, University of Bristol

Supporting Key Models

- **Pywr-WREW: A Water Resources model for England and Wales built in Python water resources simulation system**
  - **Dr Anna Murgatroyd, University of Oxford**
- **FIRM: An agent-based model of flood infrastructure resilience – FIRM**
  - Prof. Richard Dawson, University of Newcastle
- **SCQUAIR: Small Changes and Computer-Generated Spatial Interaction Modelling with QUANT**
  - **Dr Richard Milton, University College, London**

Exploring Resilience Scenarios

- **STORMS: Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks**
  - **Dr Xilian Xia, University of Birmingham**
- **RIWS: Resilience Scenarios for Integrated Water Systems**
  - Dr Ana Mijic, Imperial College London
- **SOFRAMODE: Sewer overflow flood risk analysis model DAFNI enabled**
  - **Dr Vassilis Glenis, University of Newcastle**
- **NIRD: systemic resilience of interdependent infrastructure networks at the national scale**
  - Dr Raghav Pant University of Oxford

Developing the CoE

- Projects will get underway from October onwards
  - DAFNI will be supporting them and helping them work together.
- Will also be working with other projects in the programme
  - Especially the Research and Coordination Hub
- Planning events
  - Including next year's DAFNI Conference!
- **Extending the coverage**
  - **Workshops and Sandpits**
  - **Transport, Energy, Telecommunications**
  - **Funding small exploratory studies**

Accessing DAFNI

Access to DAFNI is **FREE** to UK Researchers

Also as a facility in JeS

Trial accounts for others on application

Also inclusion on Research Grants

Talk to us

info@dafni.ac.uk

www.dafni.ac.uk

Sign up to the Newsletter

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Thank You
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IMPERIAL COLLEGE, LONDON. 12 SEPTEMBER 2023

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IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Invited Speaker:
DAFNI Platform Presentation

Dr Bethan Perkins

DAFNI Team Lead, STFC

Platform Development

Dr Bethan Perkins

Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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Technical Team

Bethan Perkins
Team Lead

Rose Dickinson
Tech Lead

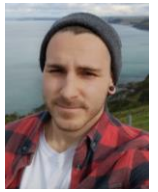
Jens Jensen
Security Architect

Archit Mantry
Scrum Master

Kyle Stevenson

Sarah Byrne

Caroline Haigh



Lewis Sampson

Esther Turner

Jack Haydock

Joel Davies

Platform Improvements 2022-2023

Workflows

- **Major UI overhaul:**
  - Drag and drop interface
  - Draw paths between steps
  - Deleting steps
  - Re-positioning and re-ordering steps
- Duplicate workflows
- Delete parameter sets
- Navigate to output Dataset/Visualisation from workflow
- Change version of model/data used in workflow
- **Workflow view mode**
- Faster Workflow viewing

Data

- Major backend overhaul of data management.
- Catalogue pagination improvements
- **Bulk file download**
- **Upload files greater than 5GB**
- Option to manually define spatial extent via Geojson

Visualisations

- Redesigned UI when creating visualisation

Groups

- Searching for group
- Searching for assets to add to group
- Change asset version before adding to group
- UI improvements

Other

- Option to automatically re-share asset when creating new version

Development Areas

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Current Development

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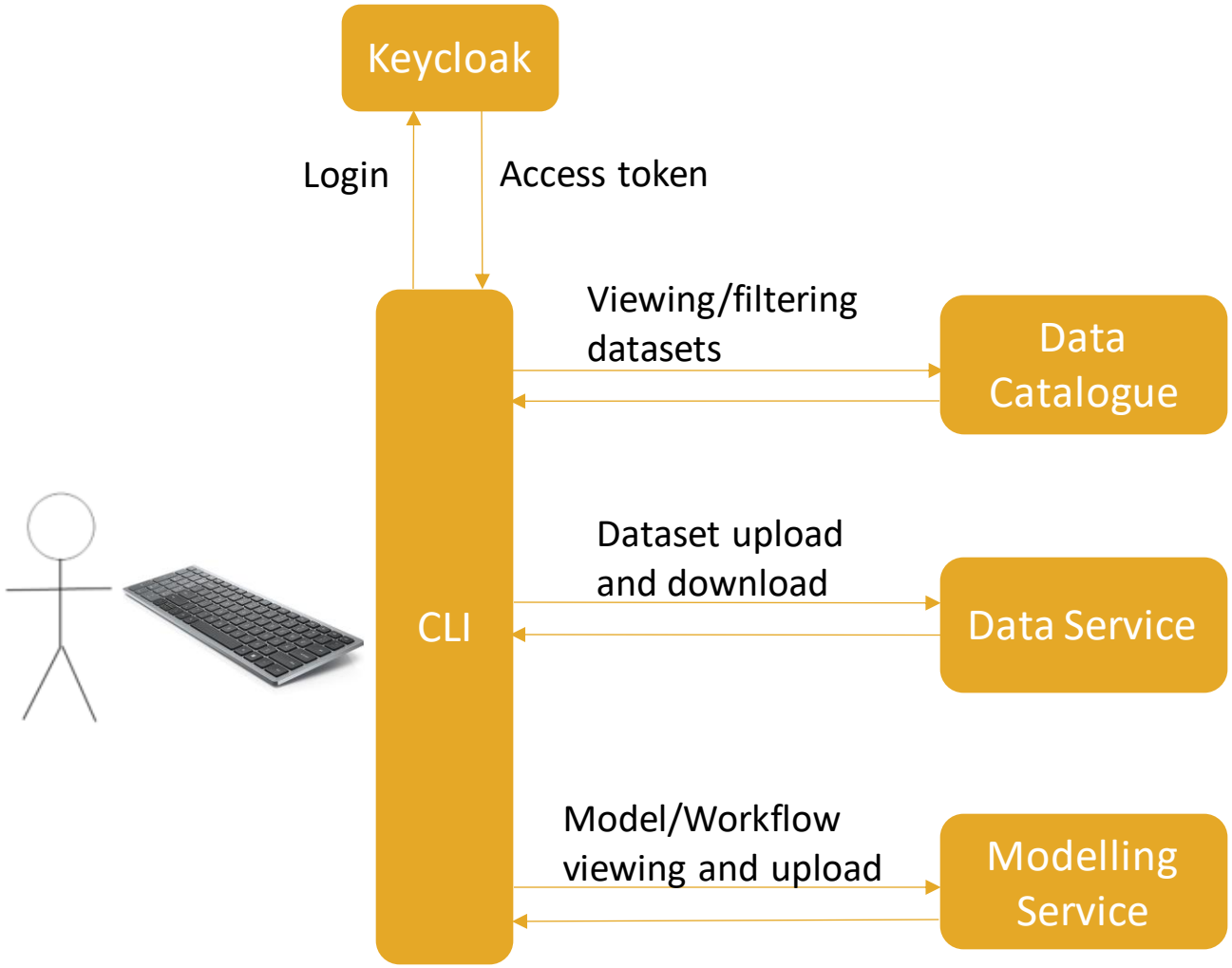
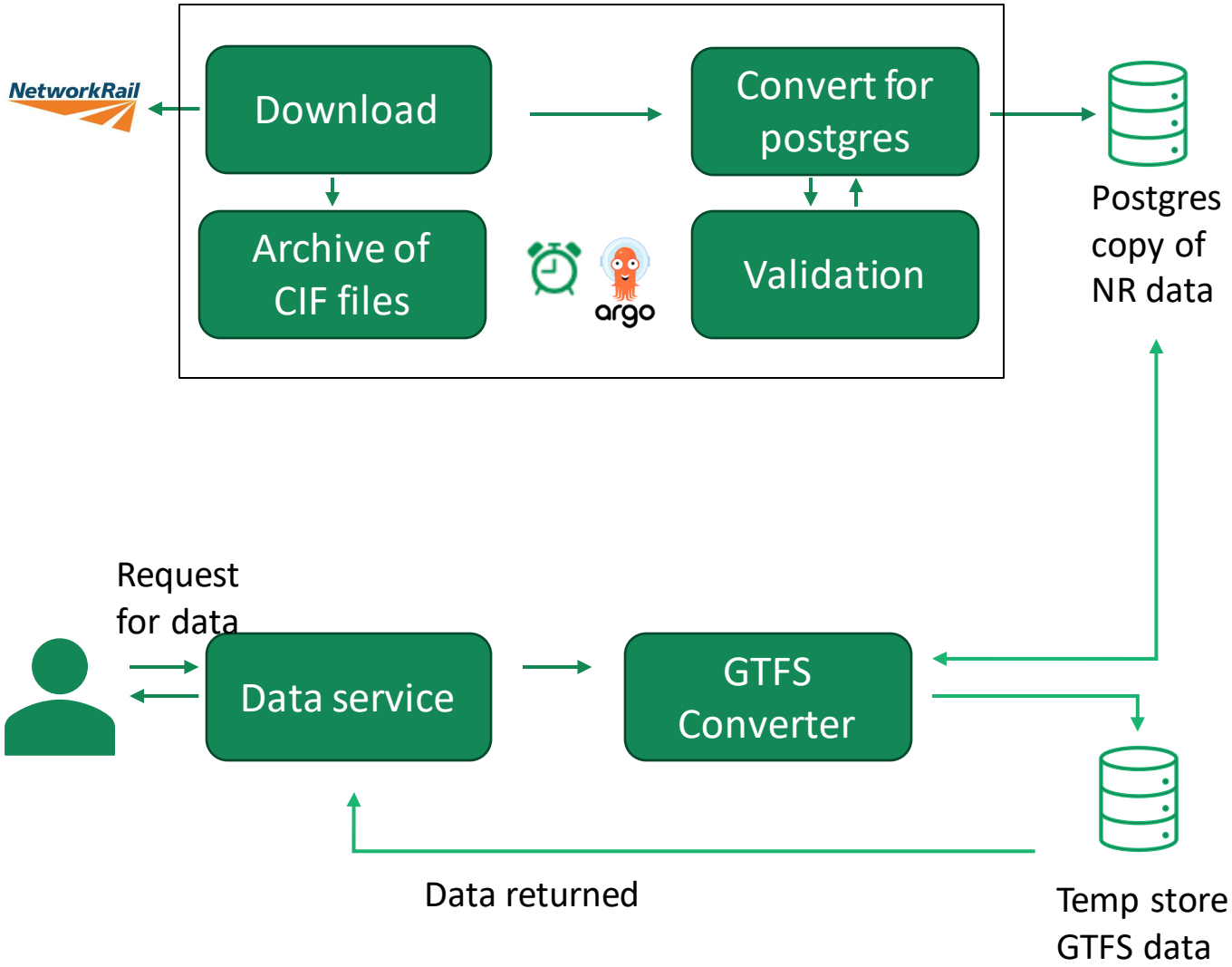
Command Line Interface



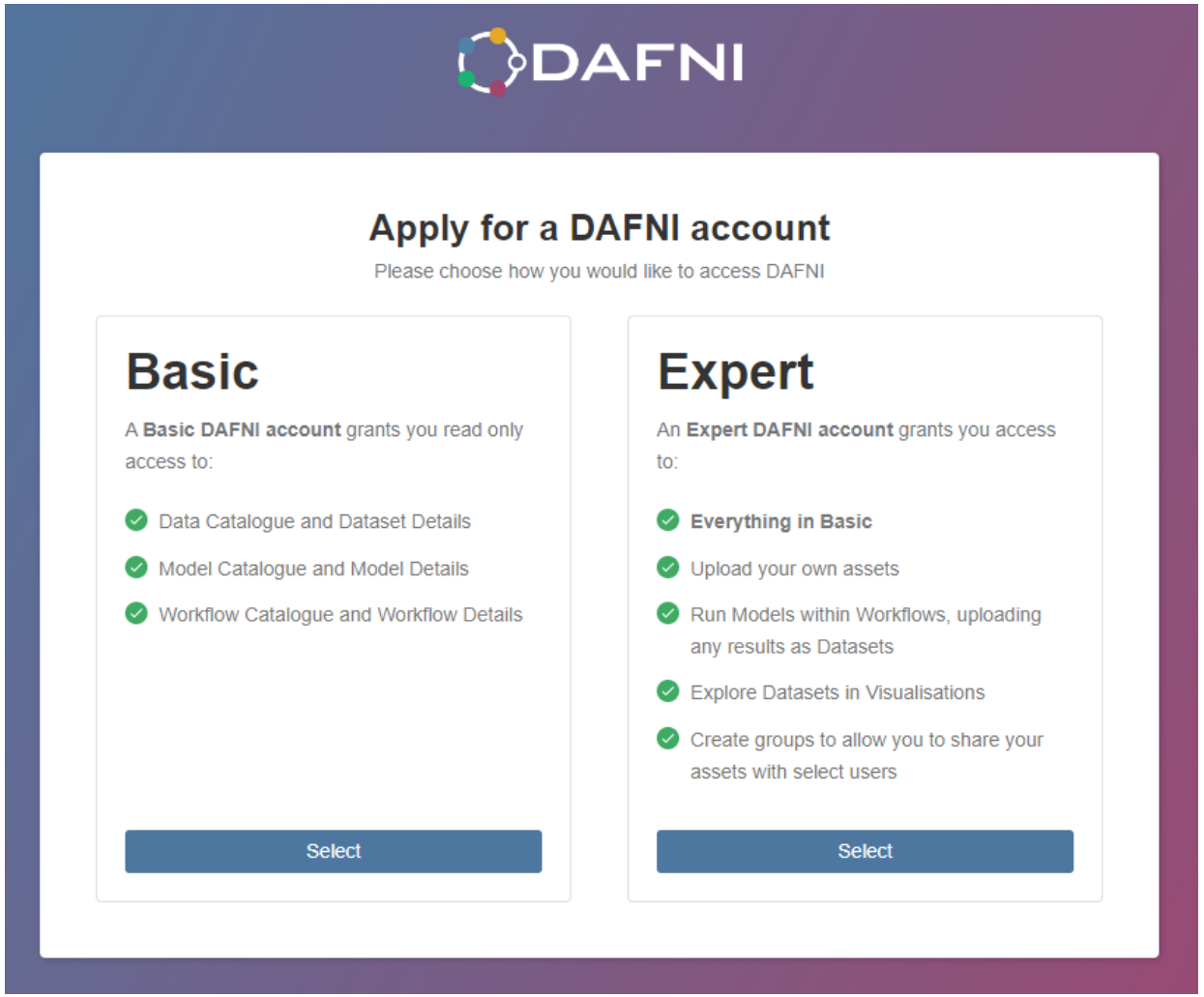
- Command line interface (CLI) can be used to view, upload, update and delete datasets, models and workflows.
- It will be available as a python pip package named **dafni-cli**. Due to release this week on Thursday 14th September.
- CLI source code is available from the DAFNI Github pages.

Sensor Data Pilot



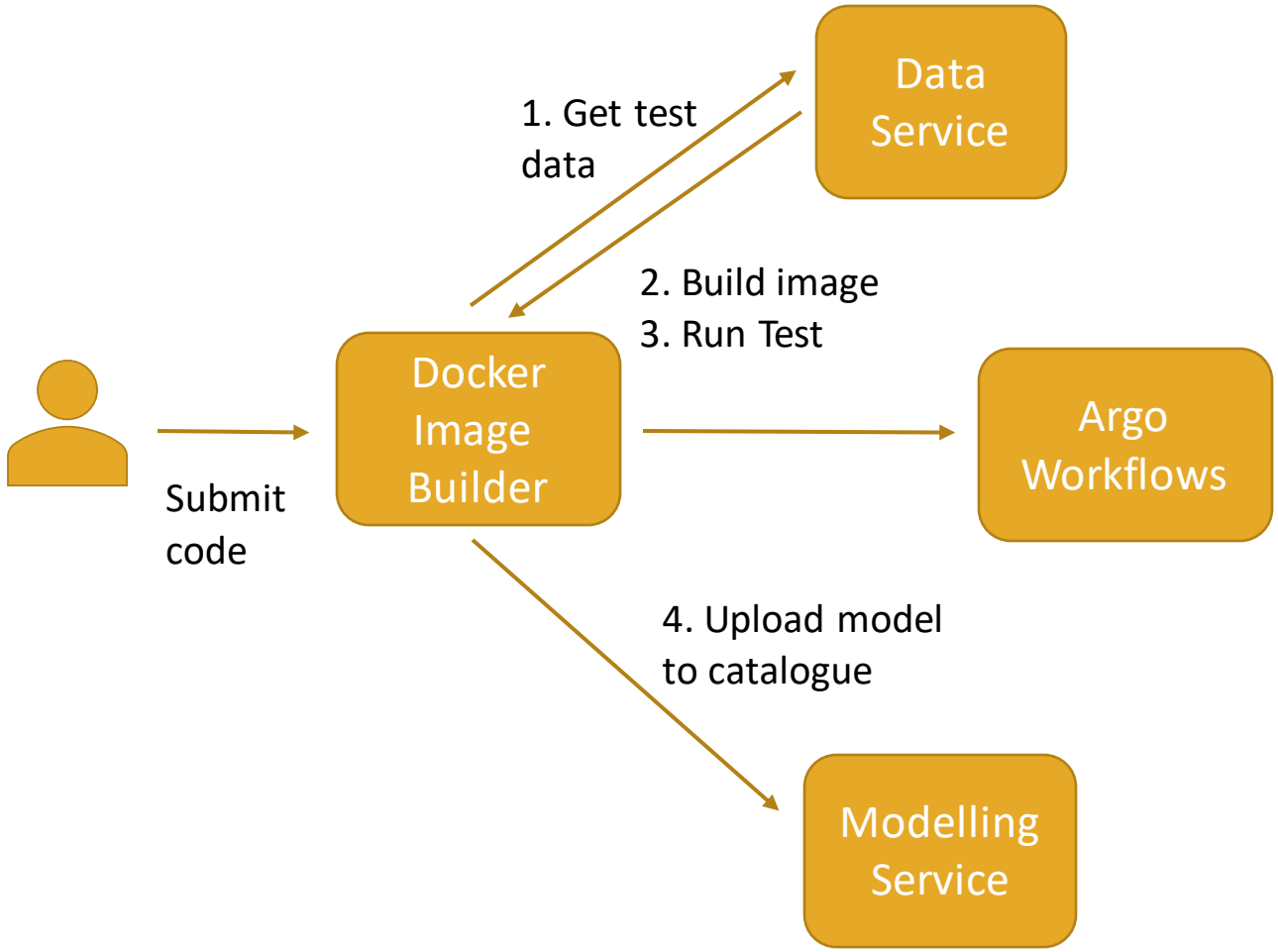
- Pilot project for bringing sensor data on to the DAFNI platform.
- Network rail data will be bought on to DAFNI and a historical record held on the platform in GTFS format.
- Part of a larger architecture to make external near real-time datasets available to workflows on DAFNI.

Basic User Accounts



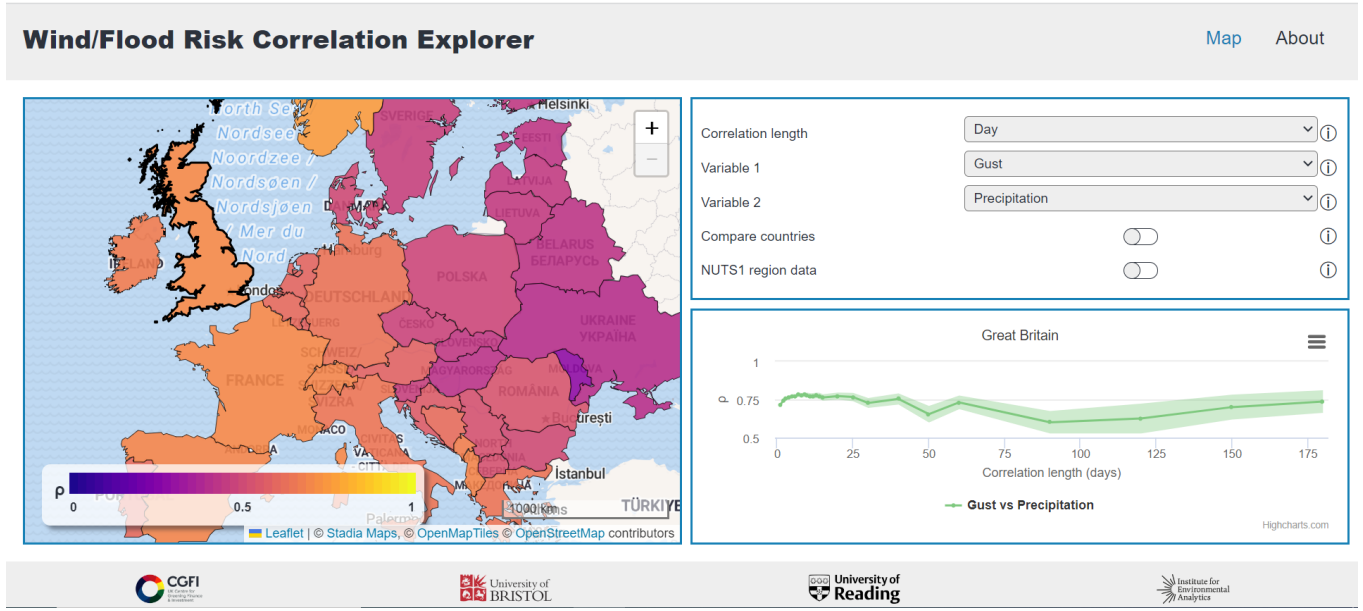
- Allow nonverified users view-only access of the platform.
- To share research results with stakeholders then publish results and send a link to your stakeholder to sign in with a simple account.
- Basic account holders will not be able to upload any assets to the DAFNI platform or see results which are not public.

DAFNI Model Builder ("Auto-Docker")



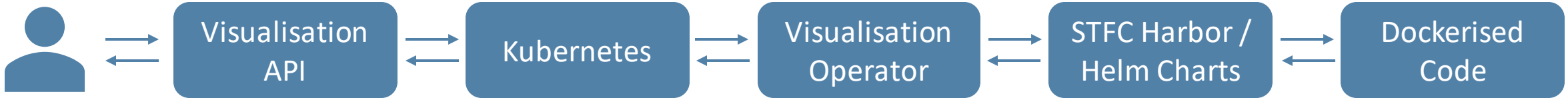
- Automatically create Docker Images for simpler models.
- Upload code or github repo URL.
- Language specific, will support a specific set of languages, including Python and probably CMake-based builds.
- Simple builds will be quick to run/debug. More complex builds will be scheduled as workflows
- Ability to quickly test a model by checking for expected outputs.

Visualisation Dashboards Pilots

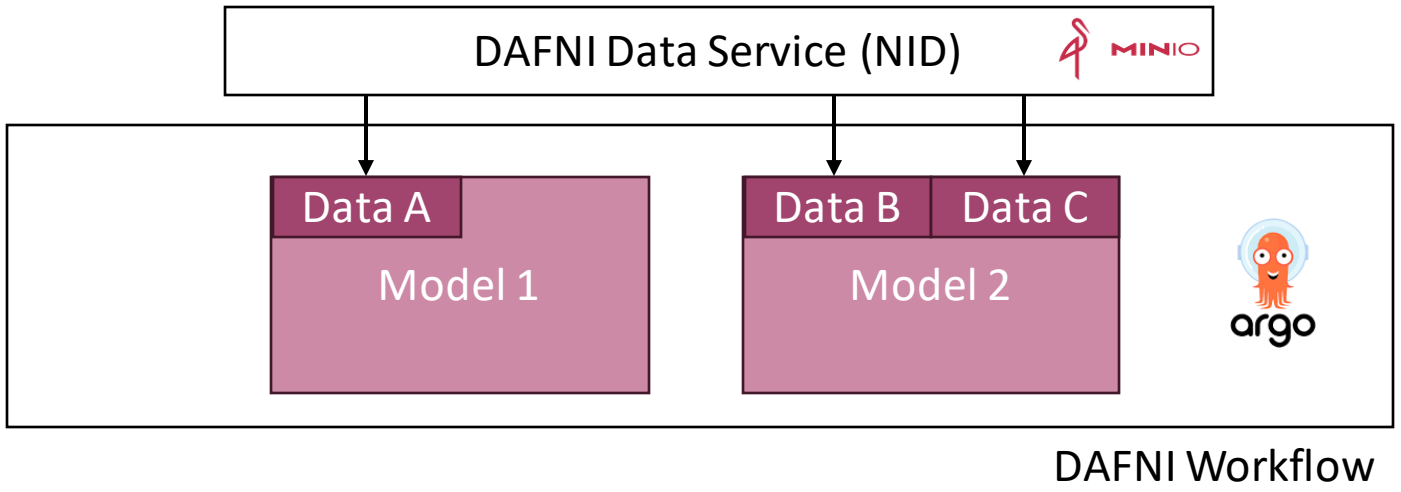


Interactive dashboard built by colleagues at the Institute for Environmental Analytics, showcasing the research of Bristol and Reading Universities.

- Allow users to bring dashboards to the DAFNI platform:
  - Interact with model outputs
  - Investigate and compare datasets
- Eventual service will be a model-style Docker Image upload service.
- This work is around a few bespoke dashboards to finalise architectural details and plan the final service.

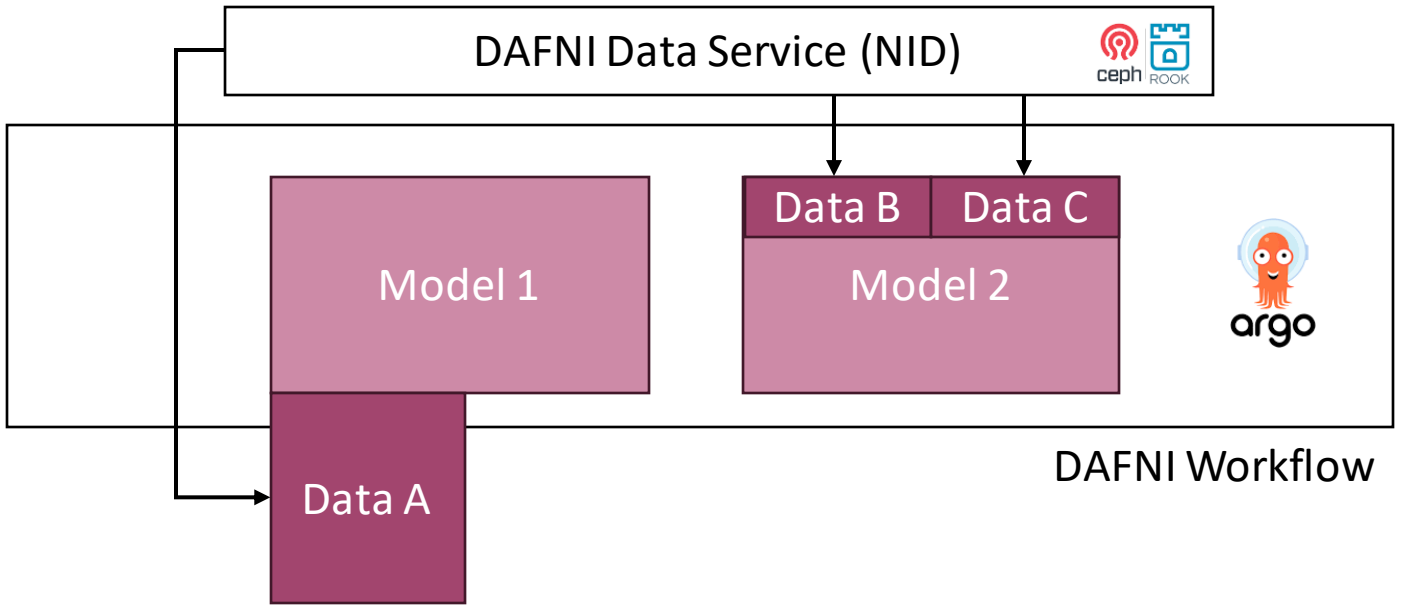


Read-only data for Workflows



- Allow users to access larger read-only datasets as part of a model run.
- Create update to workflows back-end, allowing data volumes to be mounted to the running container, rather than copying in.
- Will use Rook/Ceph on the new cluster.

Read-only data for Workflows



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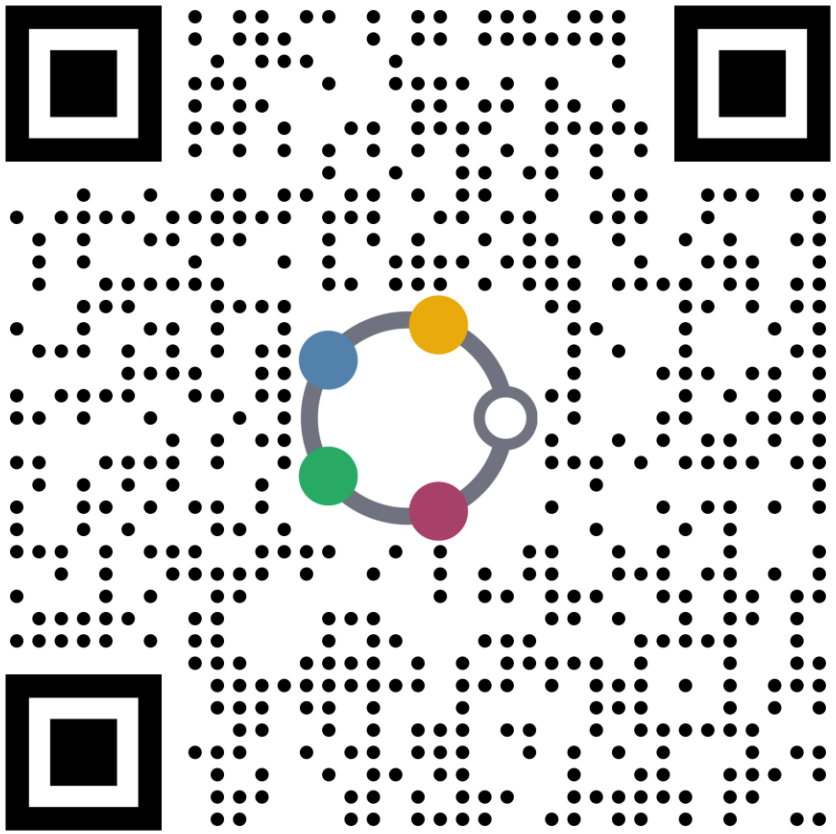
DAFNI

Community Feedback

UKRI Science and Technology Facilities Council
UKRI Engineering and Physical Sciences Research Council
UKCRIC

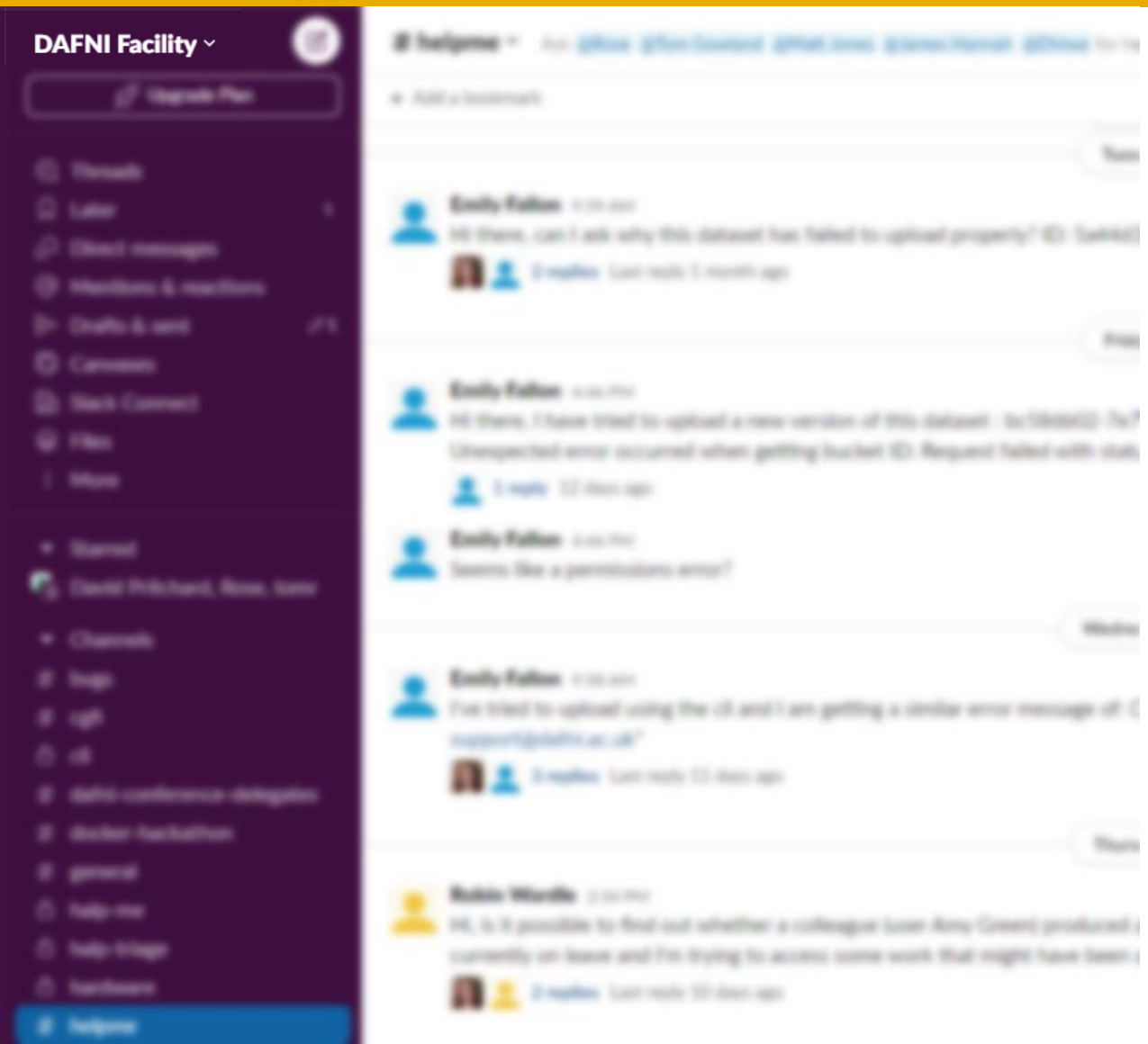
Technical User Group



Sign up here

- New group to meet regularly and hear technical updates from the DAFNI development team
- Opportunity to give feedback on UI choices and contribute to prioritisation discussions.
- No requirement to attend all meetings, agendas circulated beforehand.

Slack Notice



- We are retiring our DAFNI Facility Slack channels for everything but
  1. Log requests
  2. Networking
  3. Emergency support follow-ups
- To raise a ticket and talk to the dev team in future, please email support@dafni.ac.uk

DAFNI

Thank you

Technical User Group signup

Science and Technology Facilities Council
Engineering and Physical Sciences Research Council
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CONFERENCE 2023

IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

The DAFNI team will be in the foyer to provide demonstrations of the platform and answer any questions you may have.

Slido - #2299756

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Building a Secure and Resilient World

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CONFERENCE 2023

IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Invited Speaker:
The challenges of resilience

Dr Kristine Zaidi

Associate Director of Programmes, UKRI AHRC

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Science and Technology Facilities Council

Engineering and Physical Sciences Research Council

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UK Research and Innovation

UKRI Strategic Themes

Building a Secure and Resilient World

DAFNI Conference

12 September 2023

Dr Kristine Zaidi,

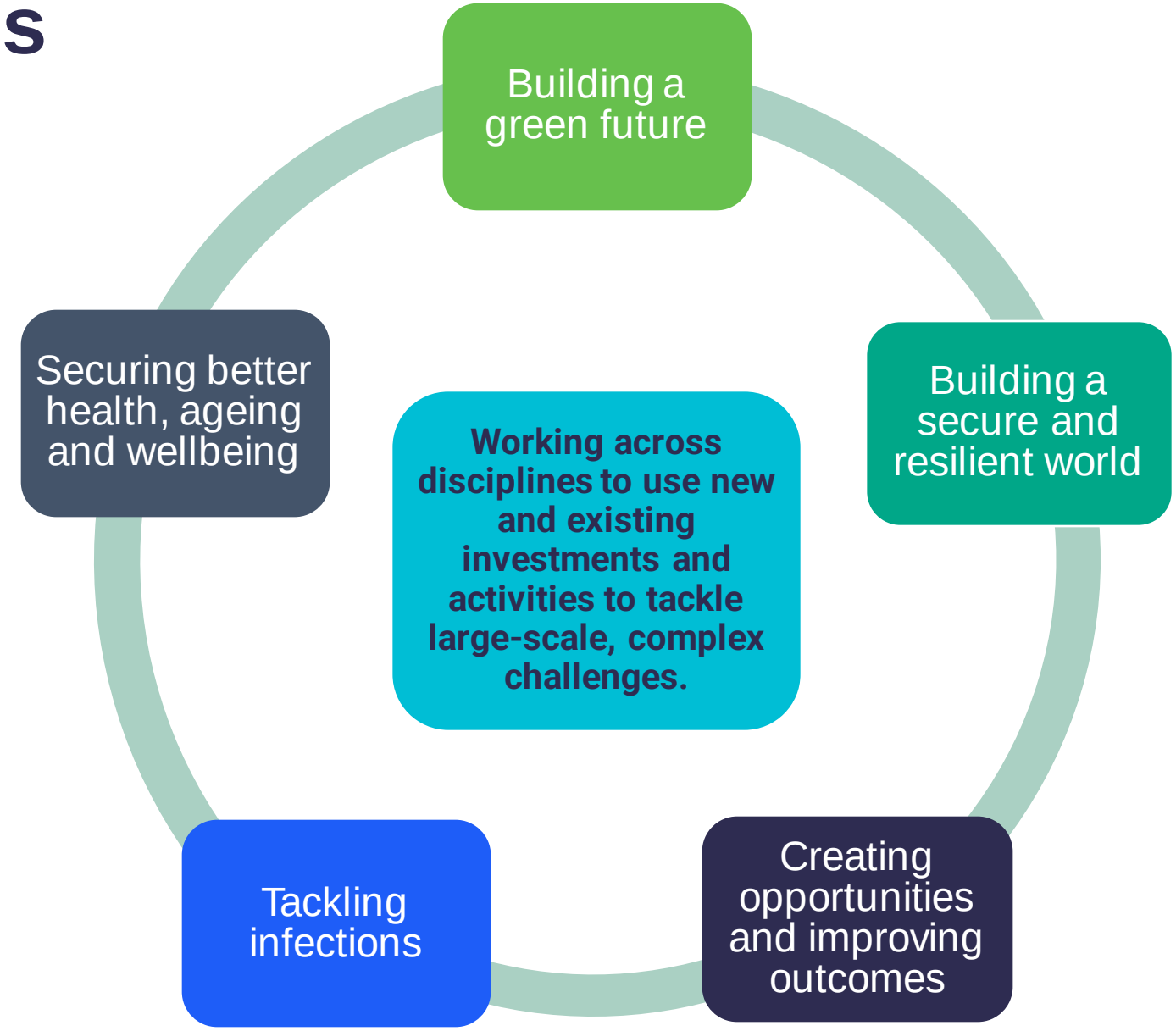
AHRC Associate Director of Programmes

Overview

- Born from UKRI's five year strategy Transforming Tomorrow Together
- Running from 2023 until 2029
- Speak directly to national and global priorities
- Five strategic themes each one encouraging working across disciplines to leverage new and existing investment and activity.
- Harnessing the full power of the UK's research and innovation system to tackle large-scale, complex challenges.

The strategic themes

- Each theme tackles a different large-scale, complex challenge
- Designed to be complementary to each other
- Distinct target areas but working together



UK Research and Innovation

Our approach

Each theme will address major national and global challenges by:

- Developing more coordinated and collaborative approaches across UKRI and with our many partners
- Using the breadth of our disciplinary and sector expertise to tackle major societal challenges
- Developing funding opportunities for multidisciplinary programmes aligned to our strategic themes
- Seeking opportunities to coordinate and leverage additional investment with other public, private, third sector and international funders
- Building strategic international partnerships
- Supporting UK leadership and participation in international research and innovation programmes to address challenges on a global scale

UK Research and Innovation

Building a Secure and Resilient World

The challenge: Building a secure and resilient world

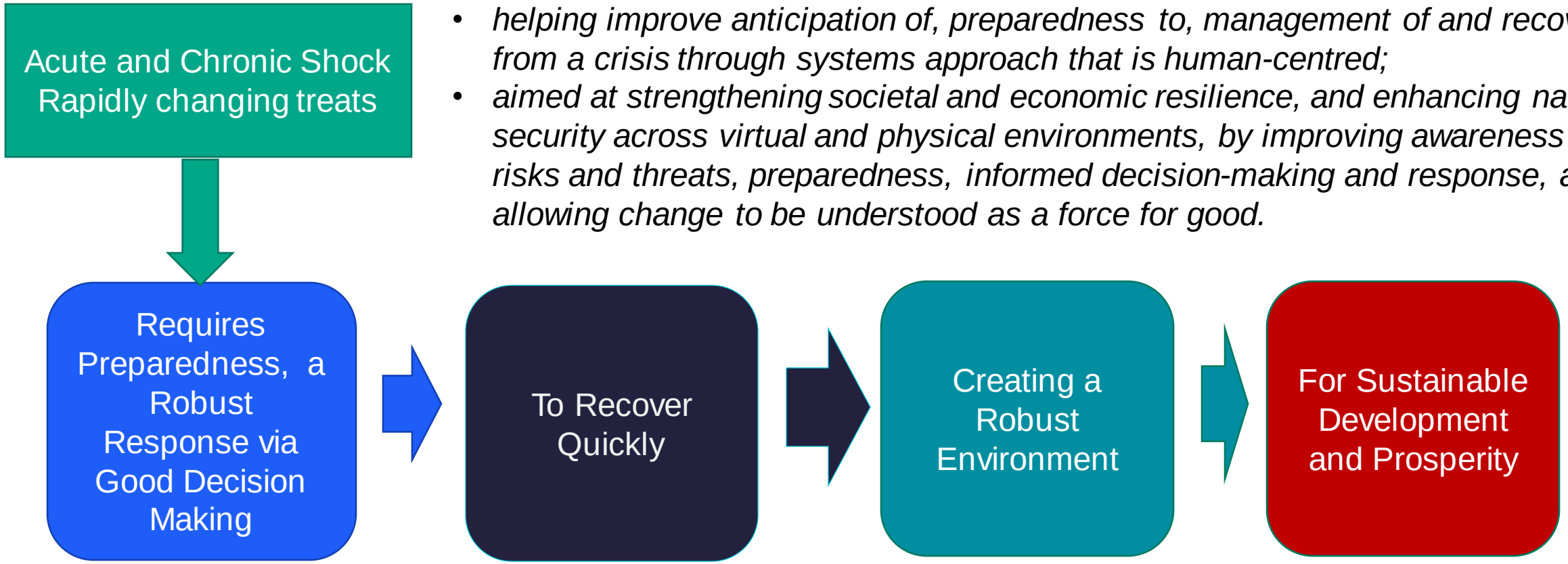
COVID-19, the war in Ukraine, global geopolitical shifts have all contributed to the UK experiencing issues across multiple areas that challenge our country's resilience and security.

From disruption to energy and food supply chains, to an increase in physical, environmental and virtual threats, these large and complex challenges cannot be solved individually.

UK Research and Innovation

Building A Secure and Resilient World: our vision

- *Research and Innovation positioned to address the impact of repeated systemic shocks from the financial crisis to pandemic to climate emergency to conventional armed conflicts;*
- *helping improve anticipation of, preparedness to, management of and recovery from a crisis through systems approach that is human-centred;*
- *aimed at strengthening societal and economic resilience, and enhancing national security across virtual and physical environments, by improving awareness of risks and threats, preparedness, informed decision-making and response, and allowing change to be understood as a force for good.*



Theme objectives: sub-themes

Each of five sub-themes views risks and vulnerabilities through a human-centred prism, from designing technologies and developing policies to preparing for and mitigating risks to making decisions in the aftermaths of a disaster.

Sub-Themes

Global order in a time of change
Help strengthen UK role in shaping an international order that is secure, resilient and just

Technologies for resilience security and defence
Advance the capacity of state defence and security, economy and society to reduce vulnerabilities, to respond to and recover from shocks through innovation and technological advancement

Resilient and Secure Supply Chains
Increase the resilience of supply chains (food, critical materials, manufacturing, complex systems) to a wide variety to potentially interacting shocks

Behavioural and Cultural Resilience
Reduce the impact of shocks on individuals and communities through adaptation and embracing change, deployment of resources for personal resilience that is fair and just

Strengthening Resilience in Natural and Built Environment
Mitigate impact of natural and anthropogenic hazards and risks on wider societal processes and operations being responsive to particular requirements of place

Subtheme	Investing into…			
Global order in a time of change	Polarities and Regions Network Plus			
Technologies for resilience, security and defence	Data and analytics facility for national infrastructure (DAFNI)	Quantum Technologies Position, navigating and timing (PNT)	Digital Twins	National centre for space situational awareness (NCSSA)
Resilient and secure supply chains	Strengthening resilience across UK food system	Supply chains as complex systems		
Behavioural and cultural resilience	Building behavioural science capability for defence and security research	Mobilising community assets to tackle health inequalities	Cultural Heritage and Climate Change	
Strengthening resilience in natural and built environments	Nature based solutions for equitable resilience	UK Climate Resilience	De-risking the risk of solid earth hazards (in partnership with India)	
Crosscutting	A research and coordination hub	BSRW Flexible Fund		

Ambition: building a secure and resilient world

By the end of the programme we aim to have improved communities abilities to prevent and respond to threats in the real world and online by:

- bringing people together from different communities and research areas to solve complex real world challenges
- recognising that different communities have different requirements and needs when responding to the same threat
- encouraging the translation and growth of knowledge from local to national and international communities
- discovering new solutions to existing problems and challenging assumptions about what will work for a community
- using our knowledge to help create a safer, more resilient world

UK Research and Innovation

UK Research and Innovation

Thank you!

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BUILDING A SECURE AND RESILIENT WORLD

Centre of Excellence Talks

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IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Centre of Excellence Speaker:

RIWS - Resilience Scenarios for Integrated Water Systems

Dr Ana Mijic

www.dafni.ac.uk

UKRI Science and Technology Facilities Council

UKRI Engineering and Physical Sciences Research Council

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Imperial College London

Resilience scenarios for integrated water systems (RIWS)

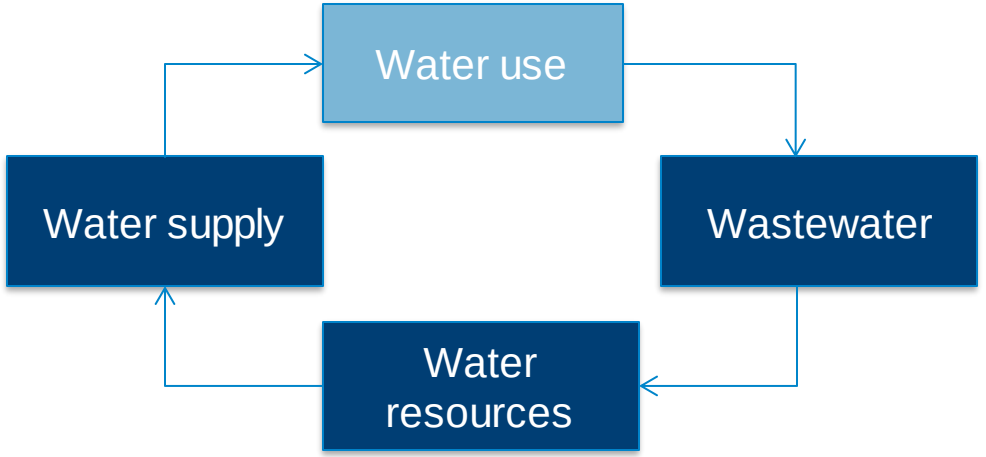
Ana Mijic, Leyang Liu, Jeni Giambona and Barnaby Dobson

DAFNI CONFERENCE 2023 – Building a secure and resilient world

Centre for Systems Engineering and Innovation

Imperial College London

Challenges of integrated water systems



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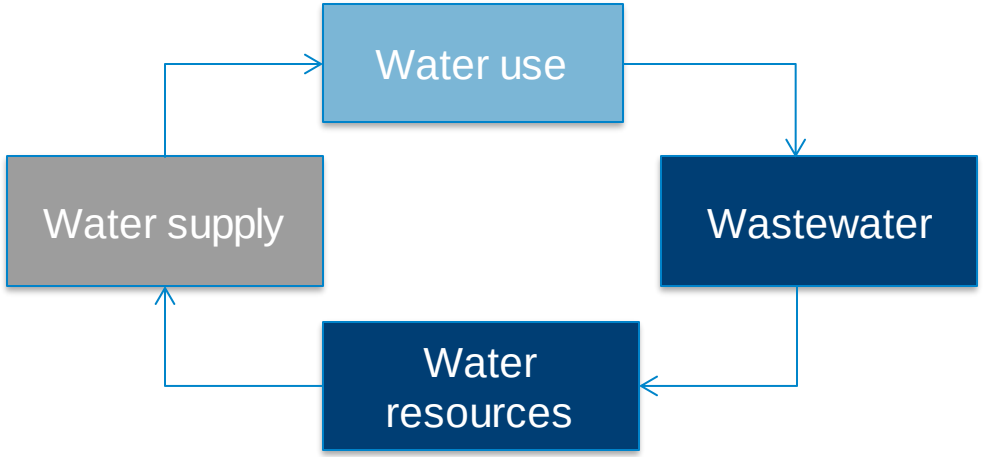
Challenges of integrated water systems

With high temperatures above 40°C in summer 2022 and critically low rainfall, decreased river flows triggered a hosepipe ban, impacting millions of people's water supply



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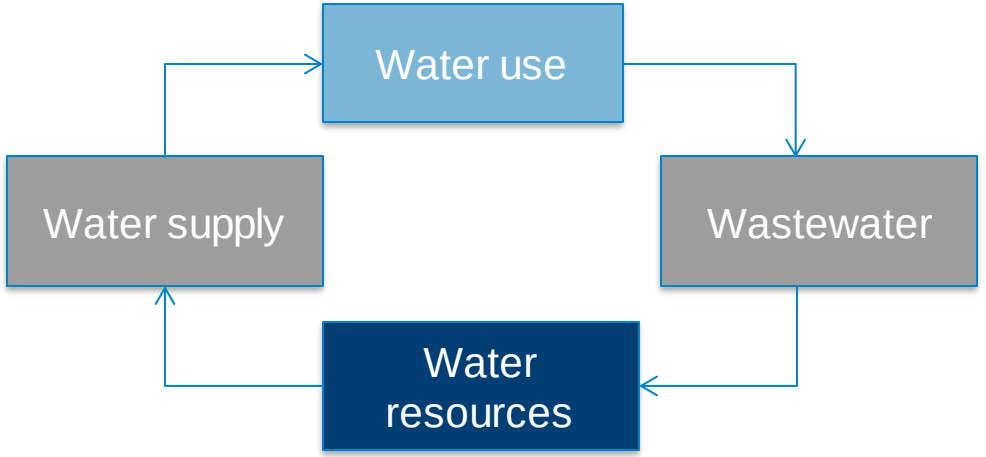
Challenges of integrated water systems



Water companies had to issue a public apology for uncontrolled sewage spills and promise £10bn investment in upgrading their wastewater systems

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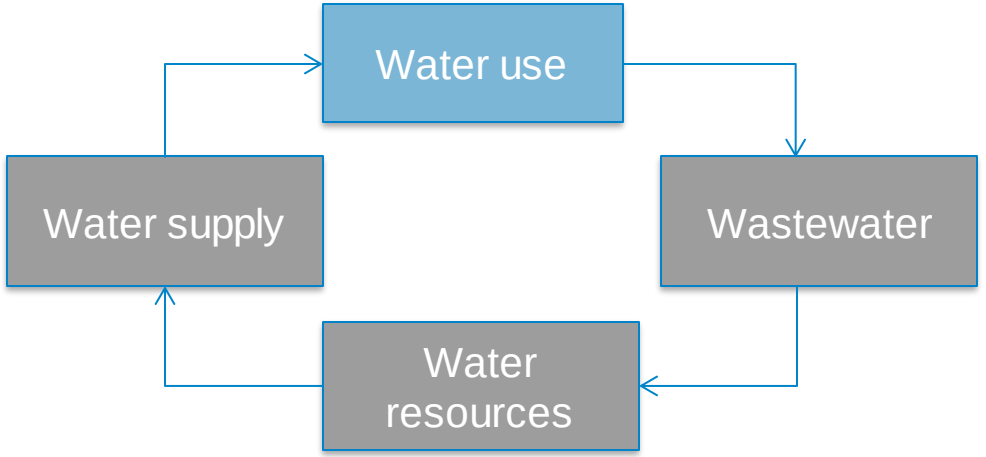
Challenges of integrated water systems



The Government's 2022 report on the river water quality revealed that 'only 14% of English rivers met good ecological status and no river met good chemical status'

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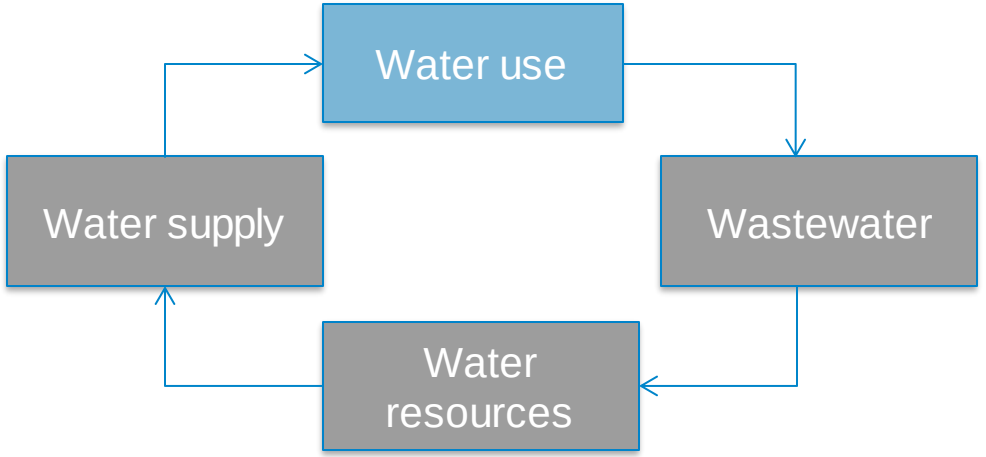
Challenges of integrated water systems



There is a need to develop resilience assessments to address interlinked challenges of water systems and the environment.

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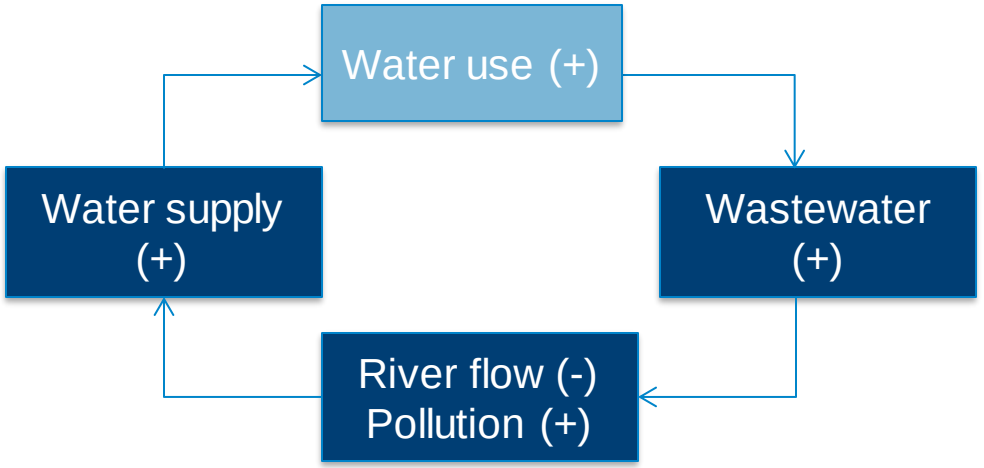
Resilience assessment challenges



[1] Water system interdependences

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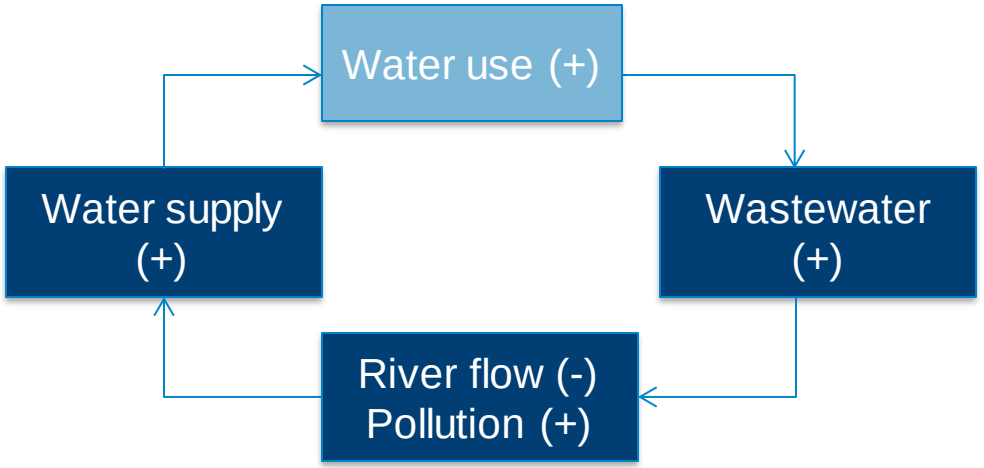
Resilience assessment challenges



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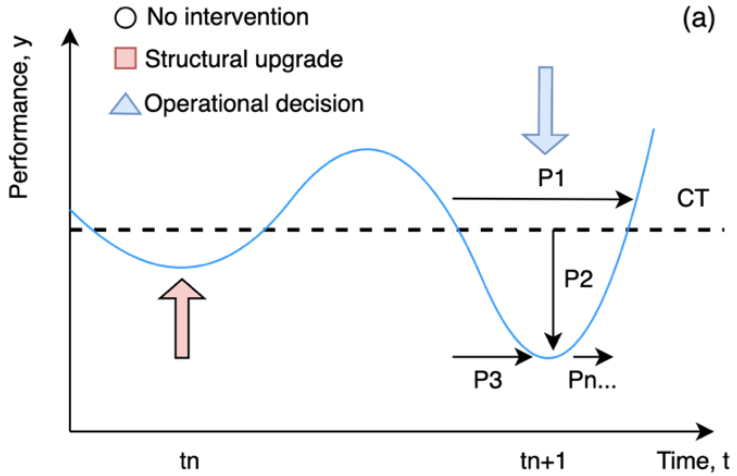

[2] Resilience metrics implementation

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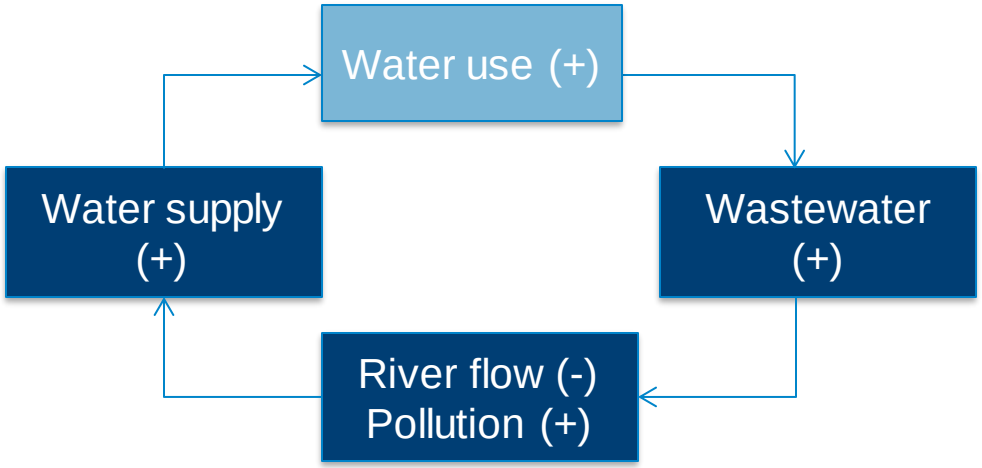
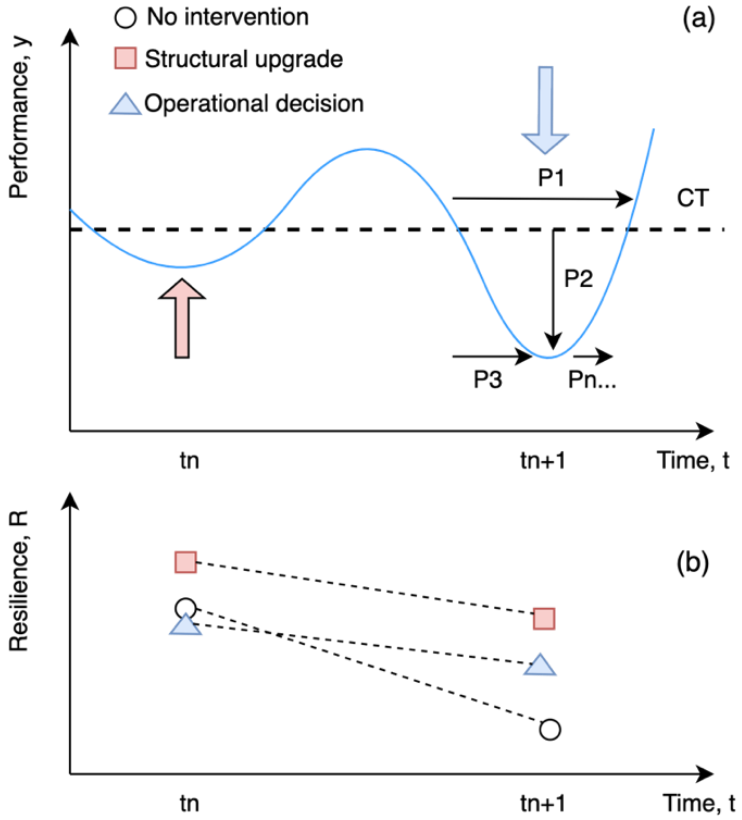
Resilience assessment challenges



[1] Water system interdependences



[2] Resilience metrics implementation

[3] Resilience for adaptive planning

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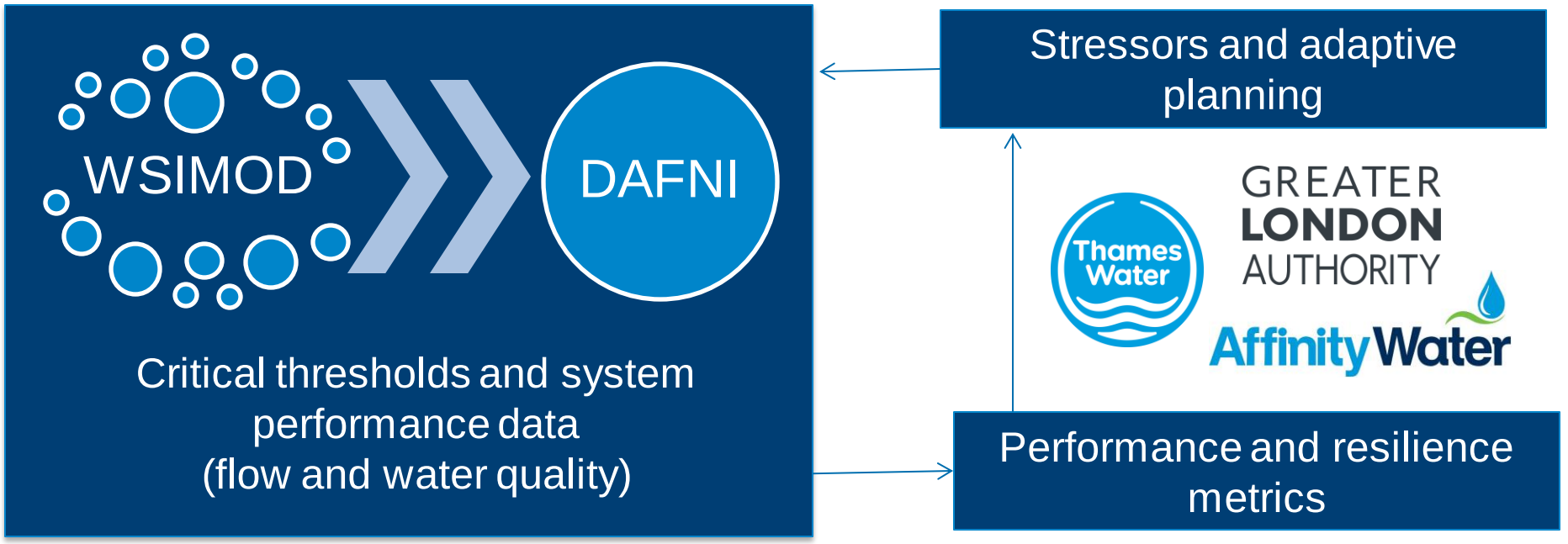
Resilience for integrated water systems project



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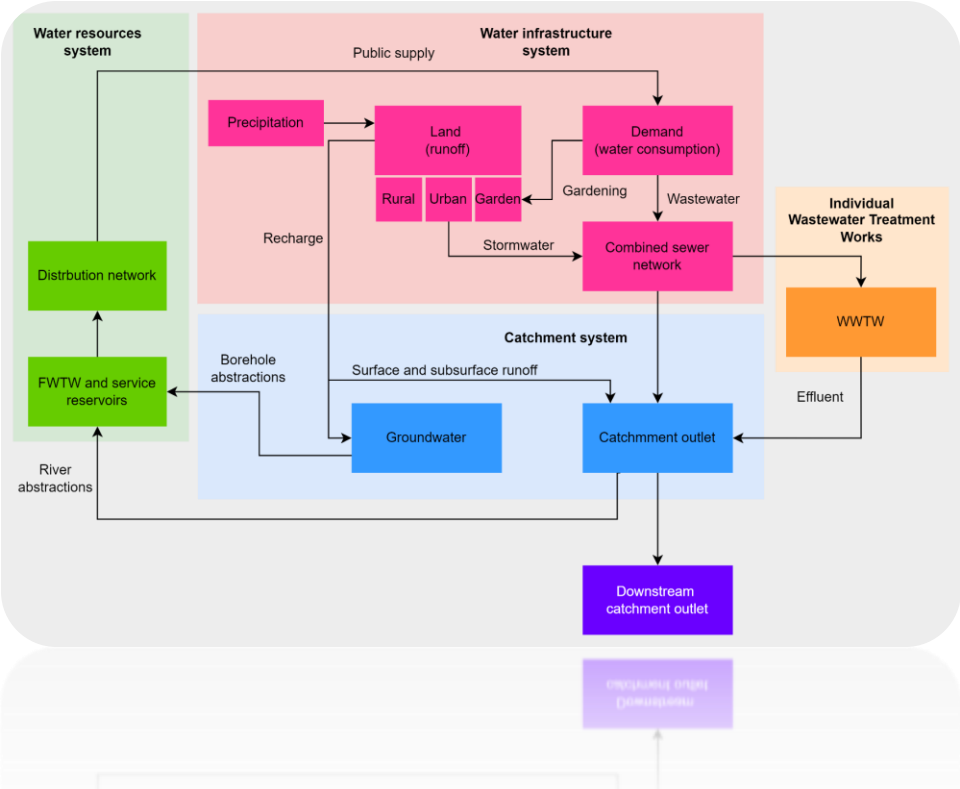
WSIMOD: Model for simulating human impacted water quality and quantity

WSIMOD generic configuration



Highly flexible whole-water system modelling Python package using well-documented, open-source software

Enables analysis of water management and long-term planning from a physically based, systems-level perspective

A range of urban and catchment scale applications described in 9 peer reviewed articles*

Used in 5 projects for regional water strategies in England with planning authorities and environmental regulators

WSIMOD

Imperial College London

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*list of references is included at the end of the presentation

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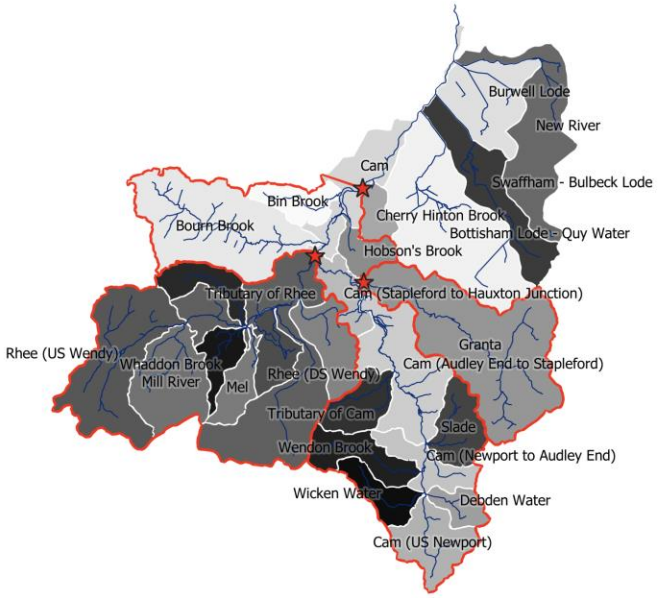
Integrated water planning

- **Purpose**: to coordinate water management options (WMO) implementations within a specified region, defined through multiple water plans
- **Evaluation**: to use in-river flow and water quality indicators and derived metric to evaluate impacts under future scenarios and effectiveness of WMO



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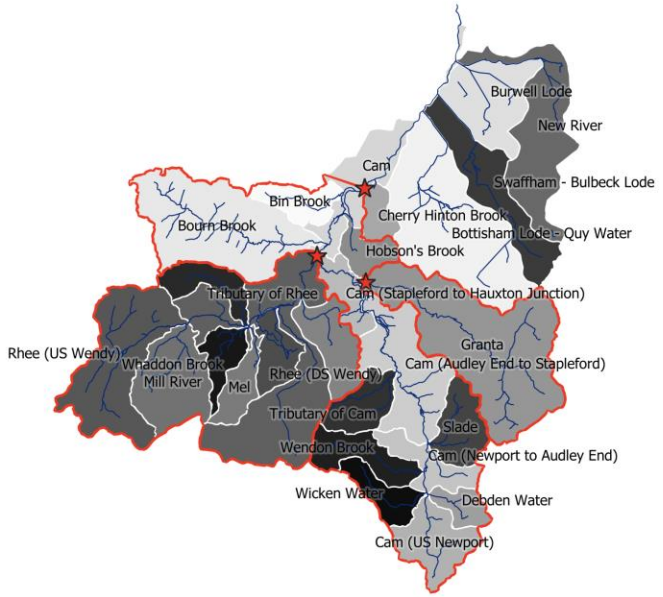

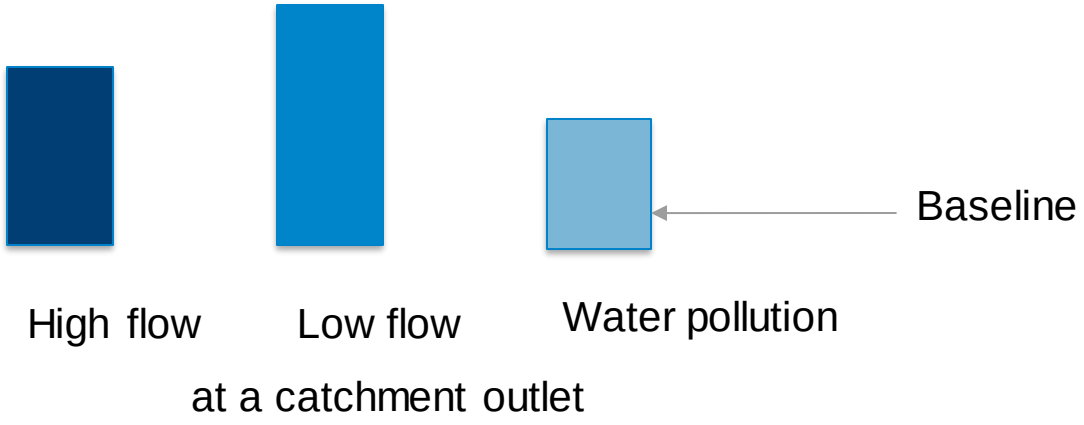

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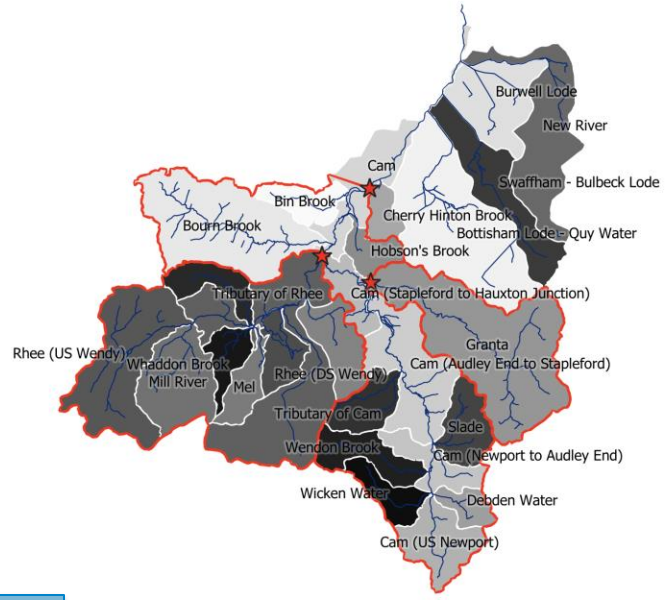

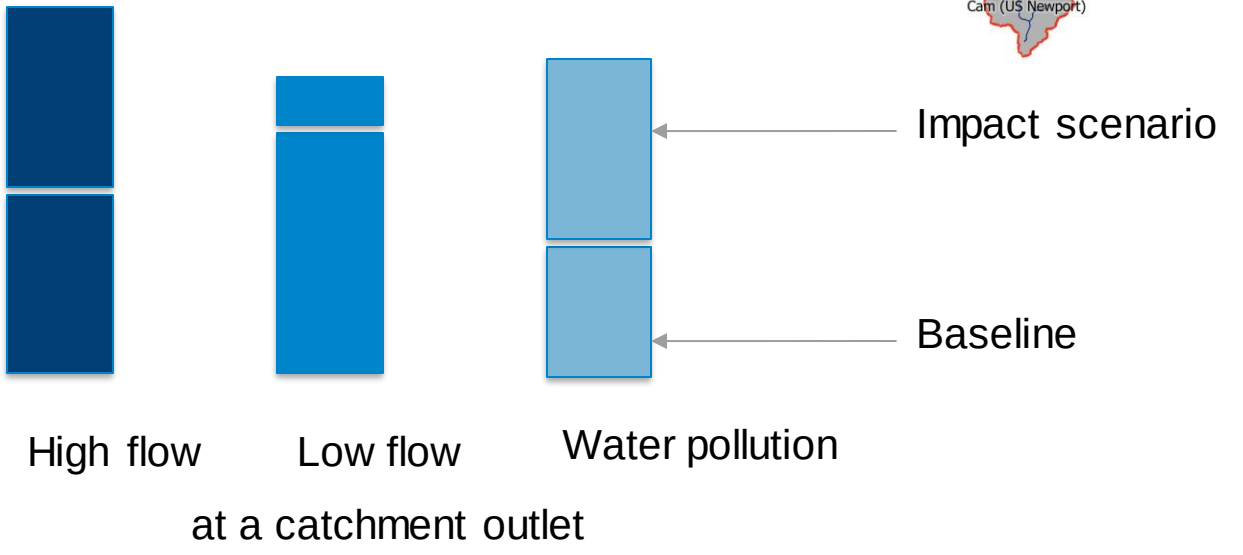

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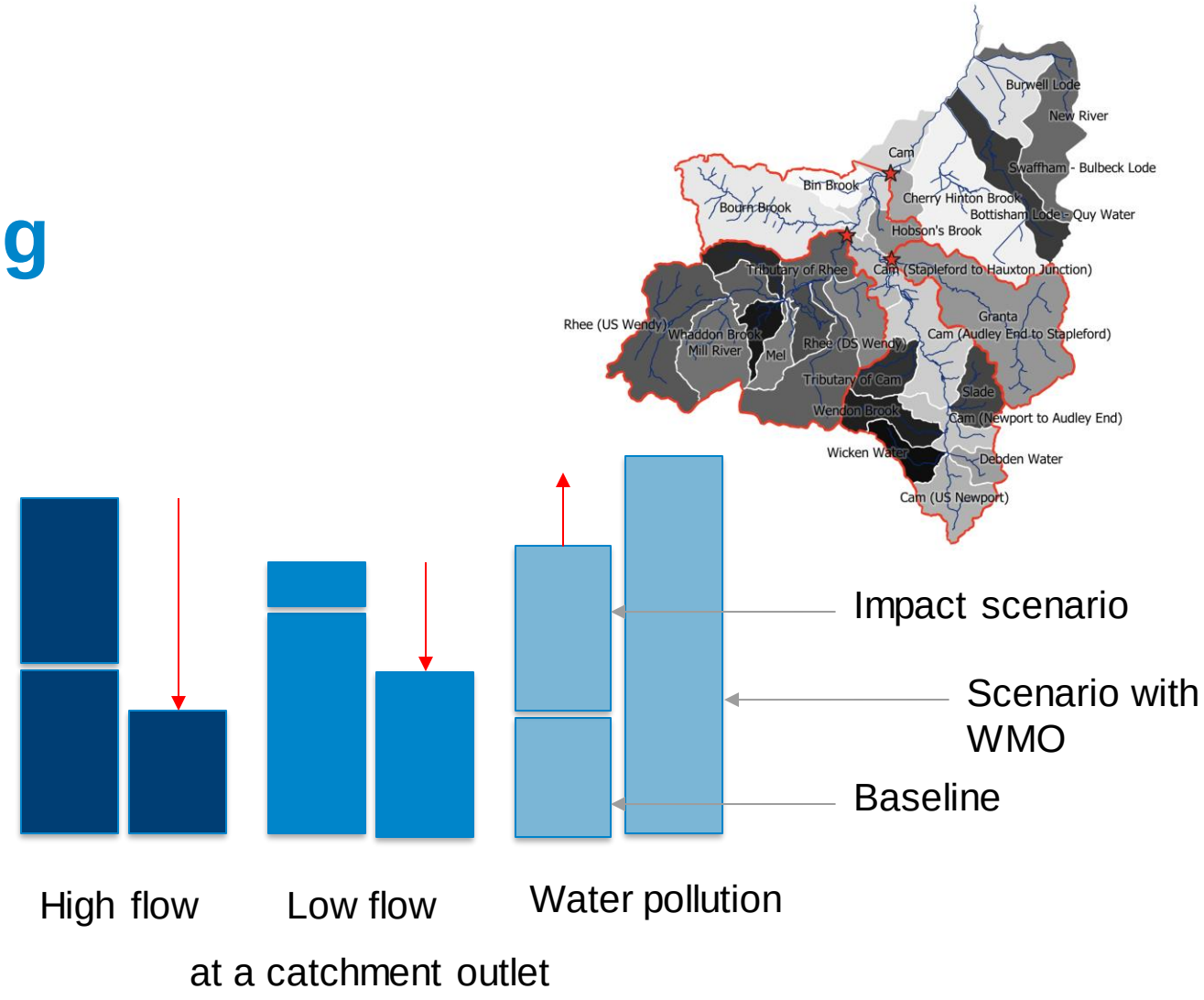

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Environment Agency

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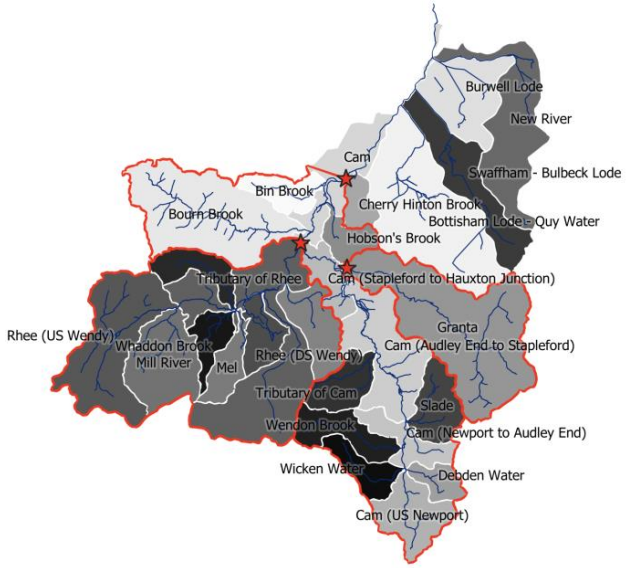
WSIMOD for future planning

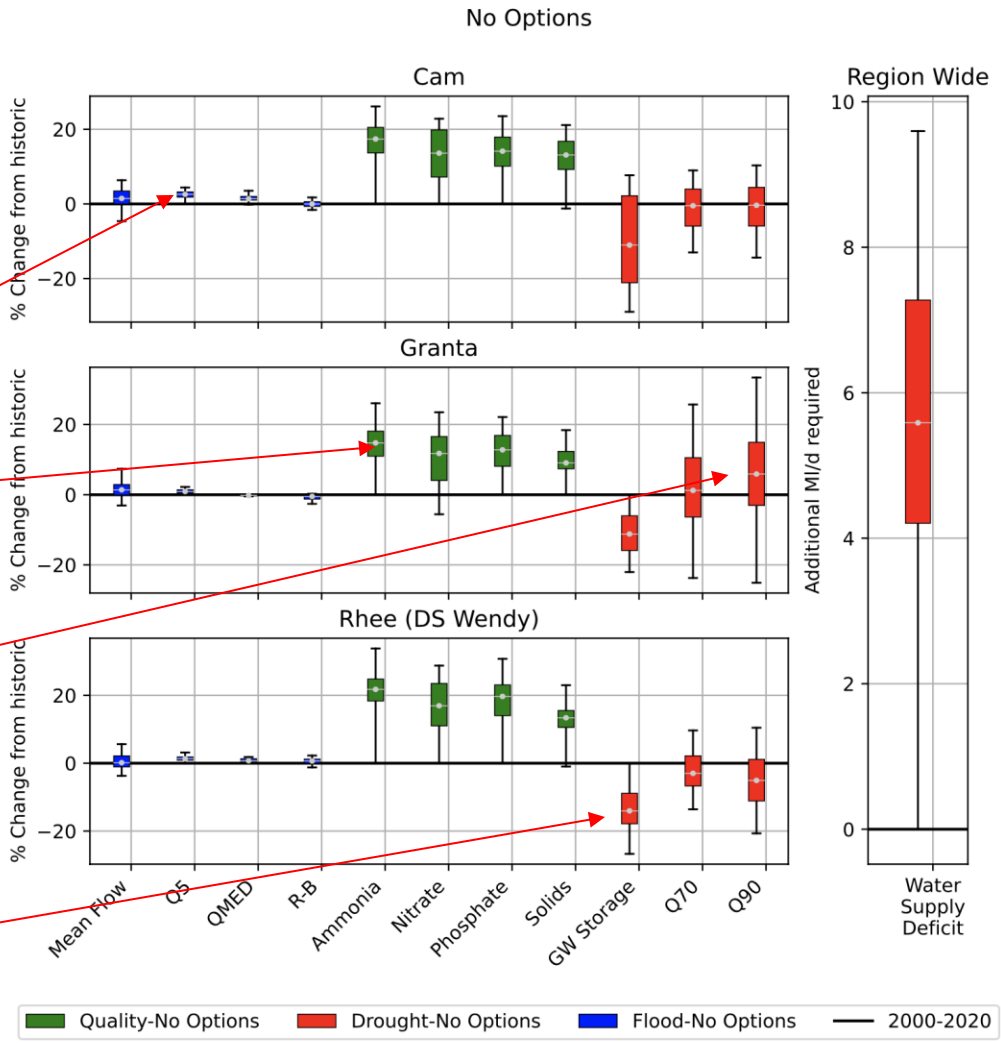


Minor impacts on flood risk

Significant worsening in river water quality

Increase in flow (Q70, Q90) in dry periods due to additional WWTP discharge

General trend of decrease in water availability



Oxford-Cambridge regional planning:

- 5 development and 2 climate scenarios
- 12 indicators

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Environment Agency

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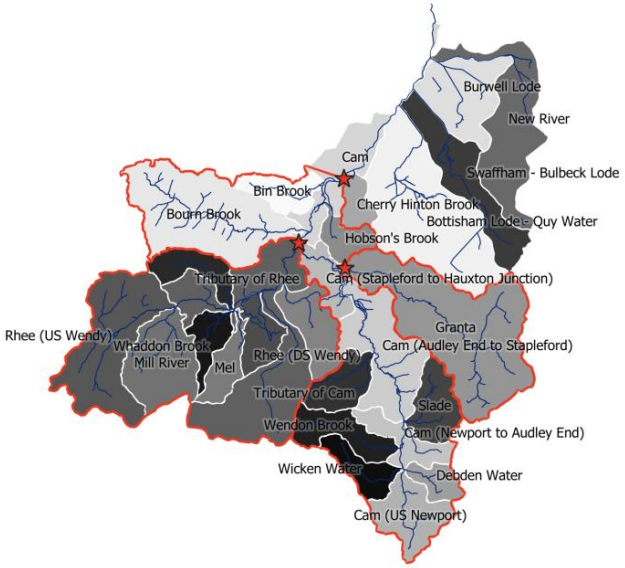
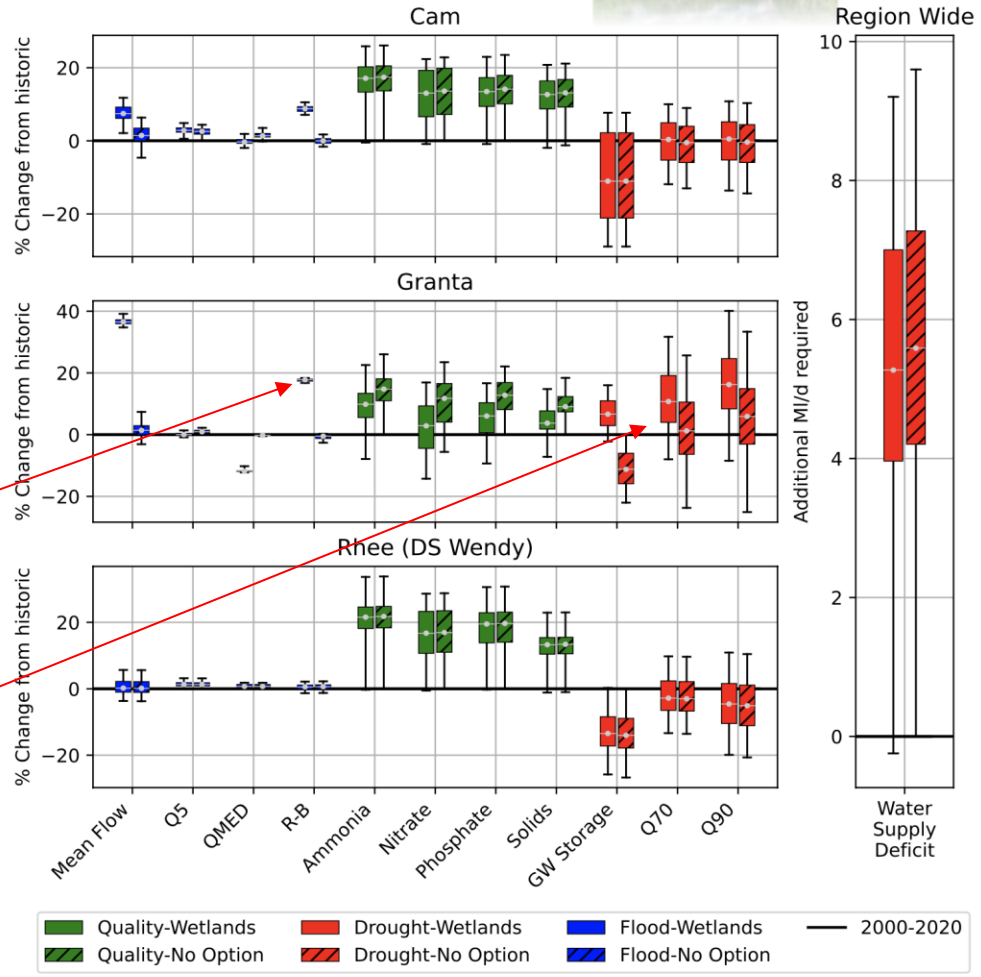
WSIMOD for future planning



Reduction of flooding and pollution

Increase in GW storage and baseflow

Wetlands



WSIMOD can assess effectiveness of planning options across a range of scenarios evaluated through flood, drought and water quality indicators

Dashed – no options
Solid – with wetlands

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Resilience scenarios for integrated water systems (RIWS)

Ana Mijic, Leyang Liu, Jeni Giambona and Barnaby Dobson

WSIMOD

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DAFNI CONFERENCE 2023 – Building a secure and resilient world

Centre for Systems Engineering and Innovation

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List of references

[1] Dobson, B., & Mijic, A. (2020). Protecting rivers by integrating supply-wastewater infrastructure planning and coordinating operational decisions. *Environmental Research Letters*, *15*(11), 114025.

[2] Dobson, B., Jovanovic, T., Chen, Y., Paschalis, A., Butler, A., & Mijic, A. (2021). Integrated modelling to support analysis of COVID-19 impacts on London's water system and in-river water quality. *Frontiers in Water*, *3*, 641462.

[3] Puchol-Salort, P., Boskovic, S., Dobson, B., van Reeuwijk, M., & Mijic, A. (2022). Water neutrality framework for systemic design of new urban developments. *Water Research*, *219*, 118583.

[4] Muhandes, S., Dobson, B., & Mijic, A. (2022). The value of aggregated city scale models to rapidly assess SuDS in combined sewer systems. *Frontiers in Water*, *3*, 206.

[5] Dobson, B., Watson-Hill, H., Muhandes, S., Borup, M., & Mijic, A. (2022). A reduced complexity model with graph partitioning for rapid hydraulic assessment of sewer networks. *Water Resources Research*, *58*(1), e2021WR030778.

[6] Liu, L., Dobson, B., & Mijic, A. (2022). Hierarchical systems integration for coordinated urban-rural water quality management at a catchment scale. *Science of The Total Environment*, *806*, 150642.

[7] Liu, L., Dobson, B., & Mijic, A. (2023). Optimisation of urban-rural nature-based solutions for integrated catchment water management. *Journal of Environmental Management*, *329*, 117045.

[8] Dobson, B., Liu, L., & Mijic, A. (2023). Water Systems Integrated Modelling framework, WSIMOD: A Python package for integrated modelling of water quality and quantity across the water cycle. *Journal of Open Source Software*, *8*(83), 4996.

[9] Liu, L., Dobson, B., & Mijic, A. (2023). Water quality management at a critical checkpoint by coordinated multi-catchment urban-rural load allocation. *Journal of Environmental Management*, *340*, 117979.

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IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Centre of Excellence Speaker:

FIRM - An agent-based Model of Flood Infrastructure Resilience

Professor Richard Dawson

www.dafni.ac.uk

UKRI Science and Technology Facilities Council

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DAFNI
Data & Analytics Facility for National Infrastructure

Newcastle University
UK | Malaysia | Singapore

An Agent-Based Model of Flood Infrastructure Resilience




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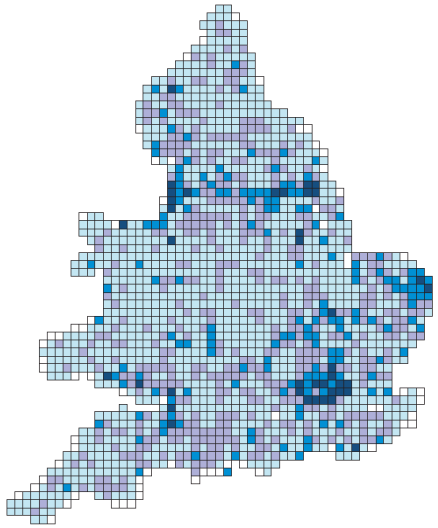
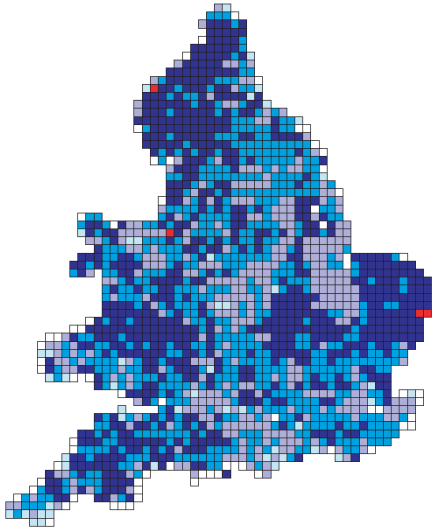
richard-dawson-newcastle

Typical assessment of flood risk

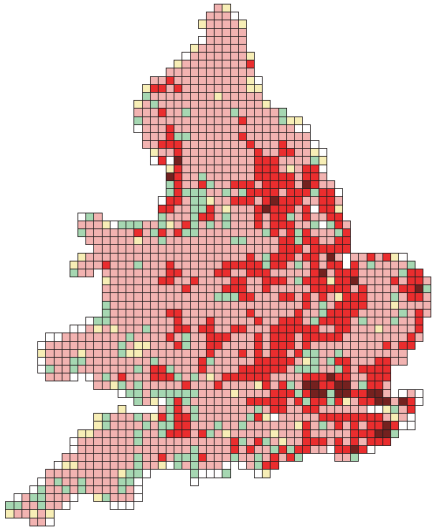
Property location



Probability of flooding



Flood Risk
(Expected Annual Damages)



Flood resilience

- Why do some floods generate higher damages or lead to greater loss of life – even in the same location?
- Why are some communities 'back on their feet' much more quickly?
- Role of individuals, communities, organisations in mediating short term risks and preparing for long term risks are crucial
- Resilience to a flood event does not just come from big flood defences but timely warnings, temporary barriers, evacuation
- Resilience is also enabled and enhanced by land use planning, design and operation of infrastructure networks etc.

ABM to capture flood incident responses

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Spatial data:
- Flood defences
- Ground elevation
- Transport network
- Property type and location

etc.

Behaviour rules:
- Normal interaction
- Response to warning
- Response to floodwater

etc.

Resilience actions:
- Evacuation strategy
- Flood warning *etc.*

Event conditions:
- Storm surge
- Failed defence
- Time of day *etc.*

ABM Platform

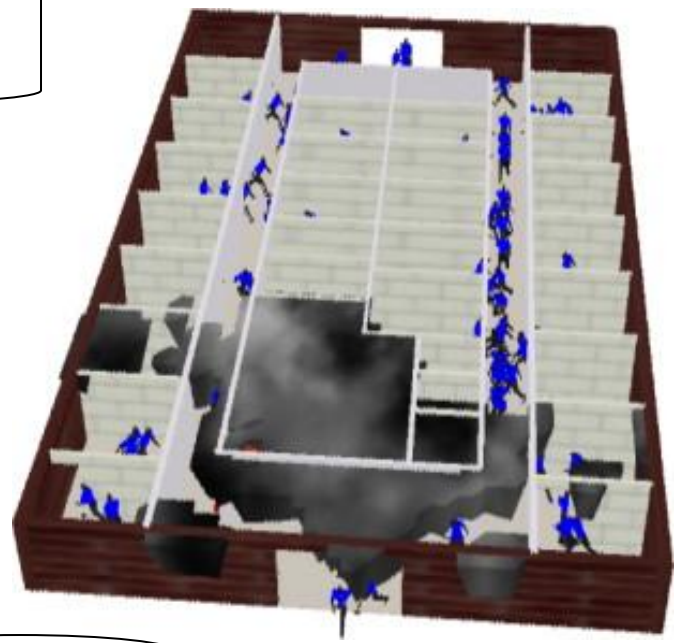
Hydrodynamic simulation

Agent simulation

Risk analysis

Vulnerability information:
- Economic
- Drowning

etc.



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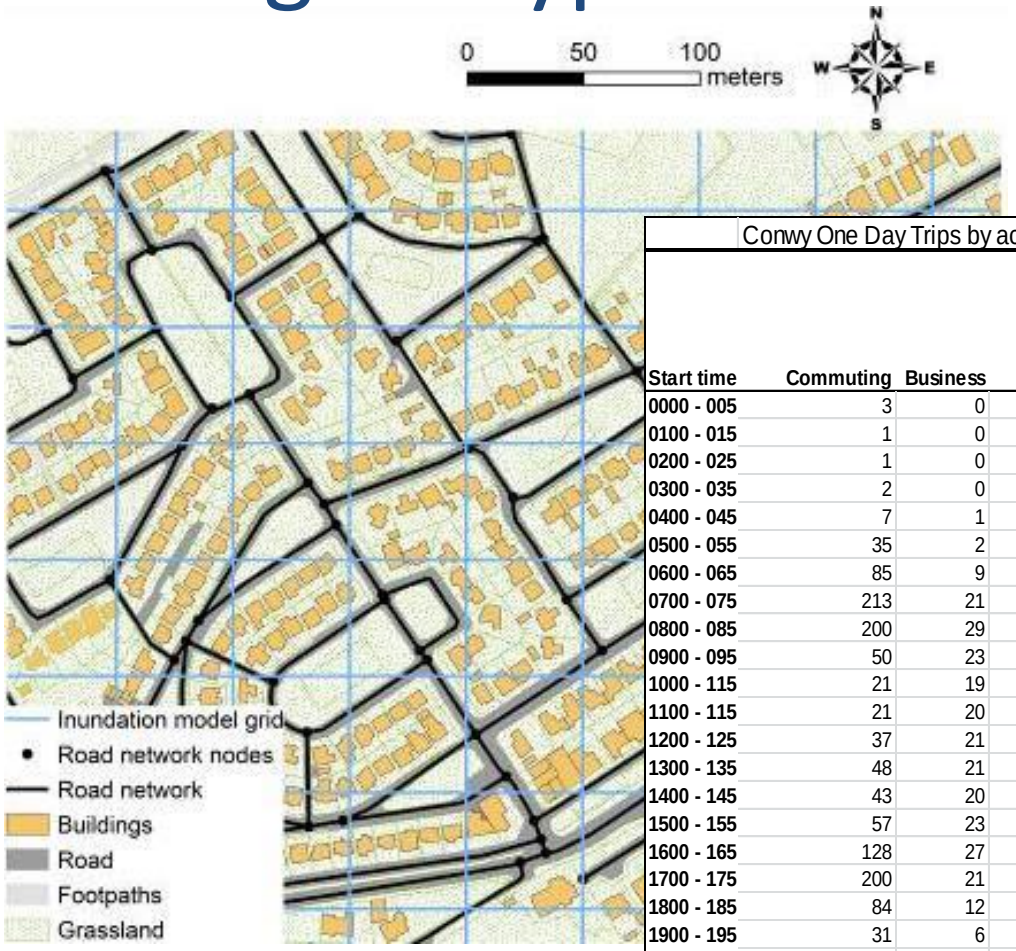
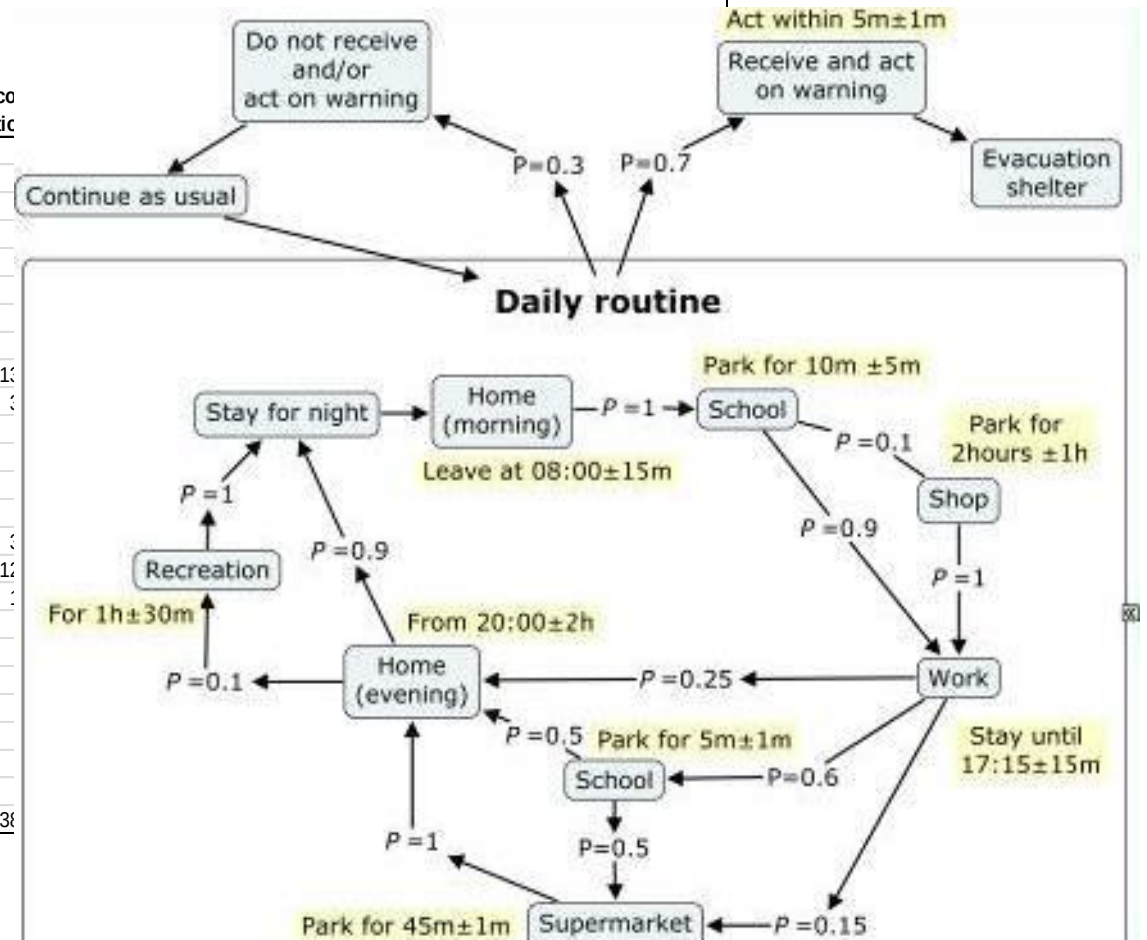
http://www.youtube.com/watch?v=o0EOlc5n9O8

Behaviour model for different demographic and agent types

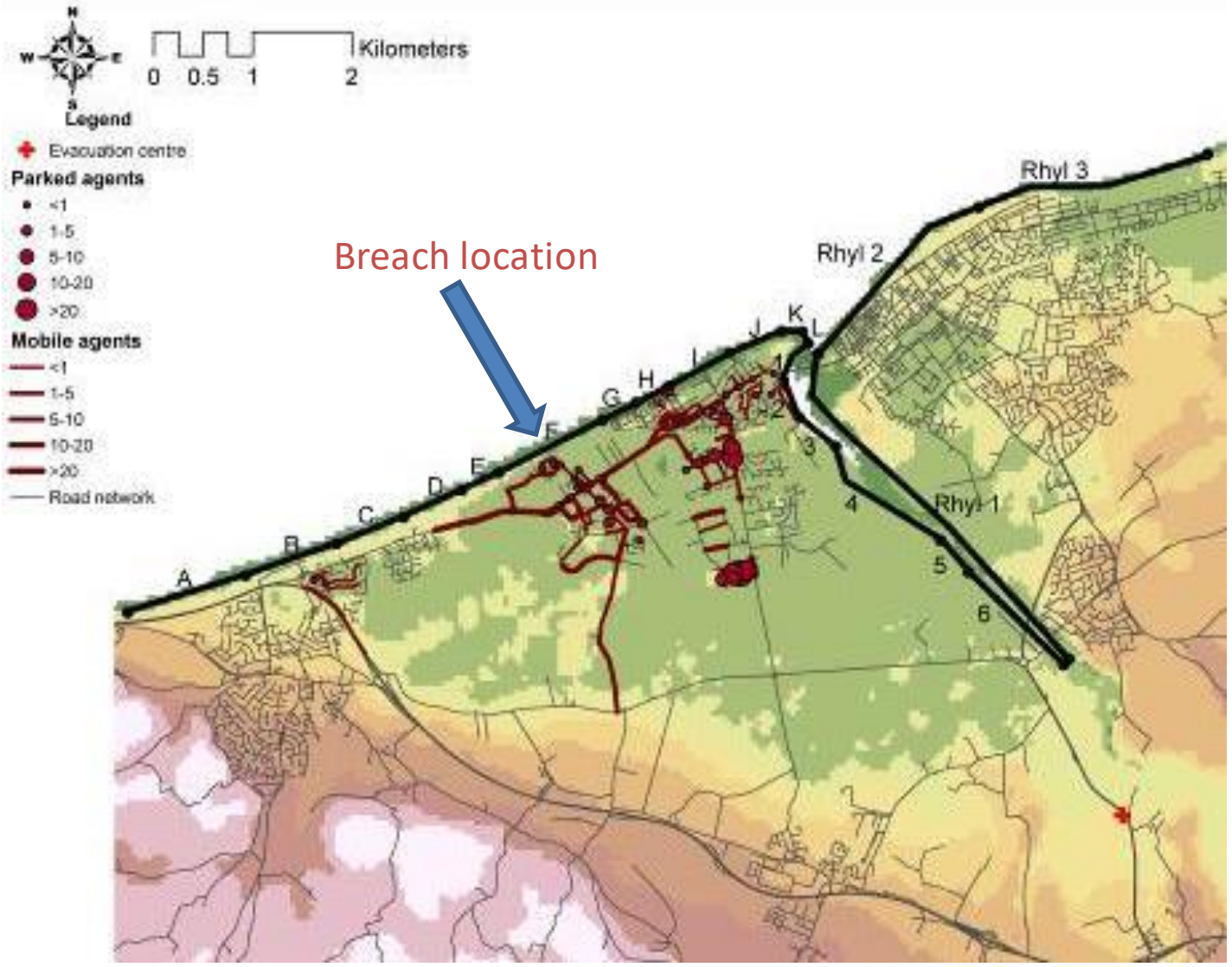


Conwy One Day Trips by activity types

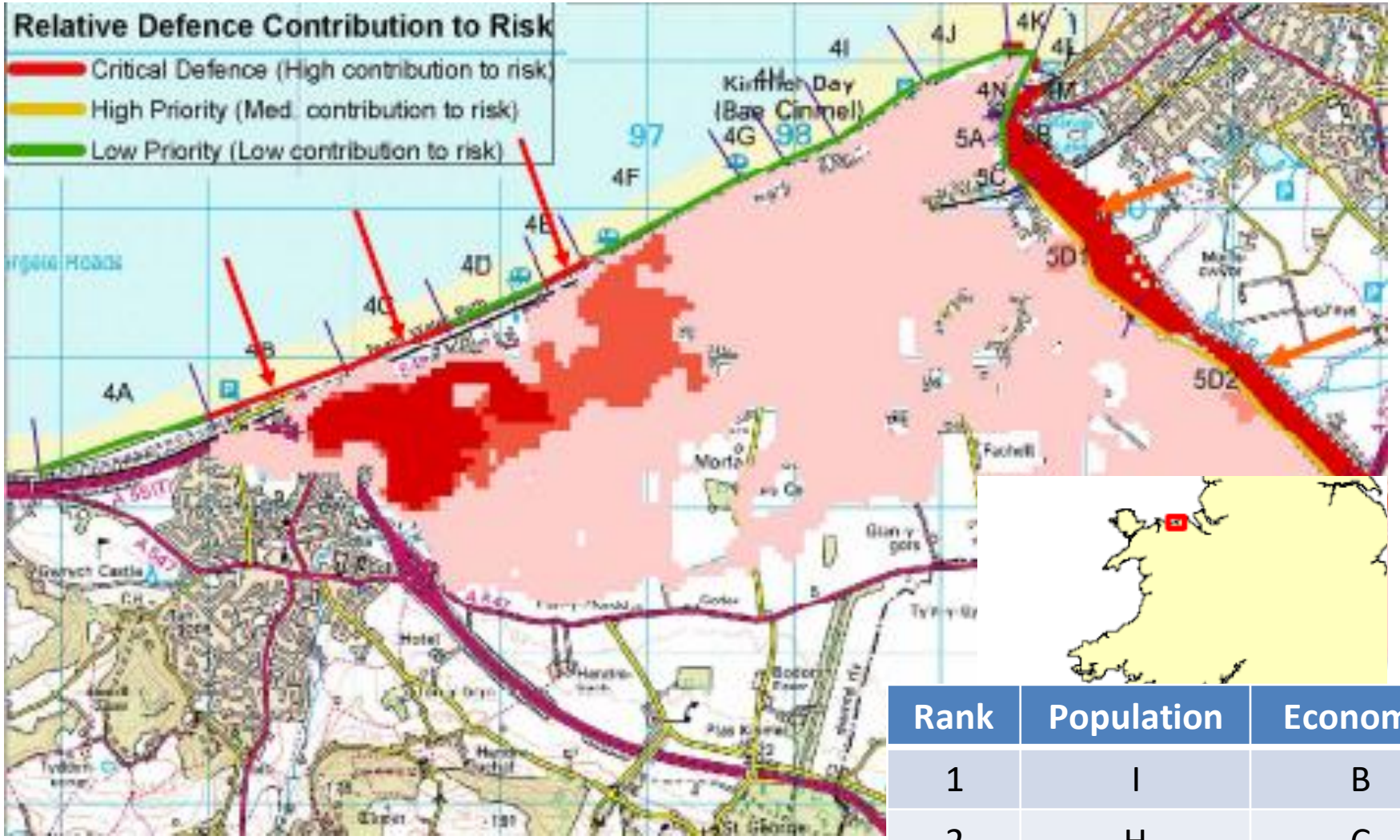
Start time	Commuting	Business	Education	Esco educatic
0000 - 005	3	0	0	
0100 - 015	1	0	0	
0200 - 025	1	0	0	
0300 - 035	2	0	0	
0400 - 045	7	1	0	
0500 - 055	35	2	0	
0600 - 065	85	9	1	
0700 - 075	213	21	38	
0800 - 085	200	29	232	1
0900 - 095	50	23	13	
1000 - 115	21	19	7	
1100 - 115	21	20	8	
1200 - 125	37	21	12	
1300 - 135	48	21	11	
1400 - 145	43	20	15	
1500 - 155	57	23	181	1
1600 - 165	128	27	30	
1700 - 175	200	21	13	
1800 - 185	84	12	4	
1900 - 195	31	6	2	
2000 - 205	22	4	1	
2100 - 215	18	3	1	
2200 - 225	16	2	0	
2300 - 235	9	1	0	
All day	1331	285	570	3



Spatial impacts: Single defence breach

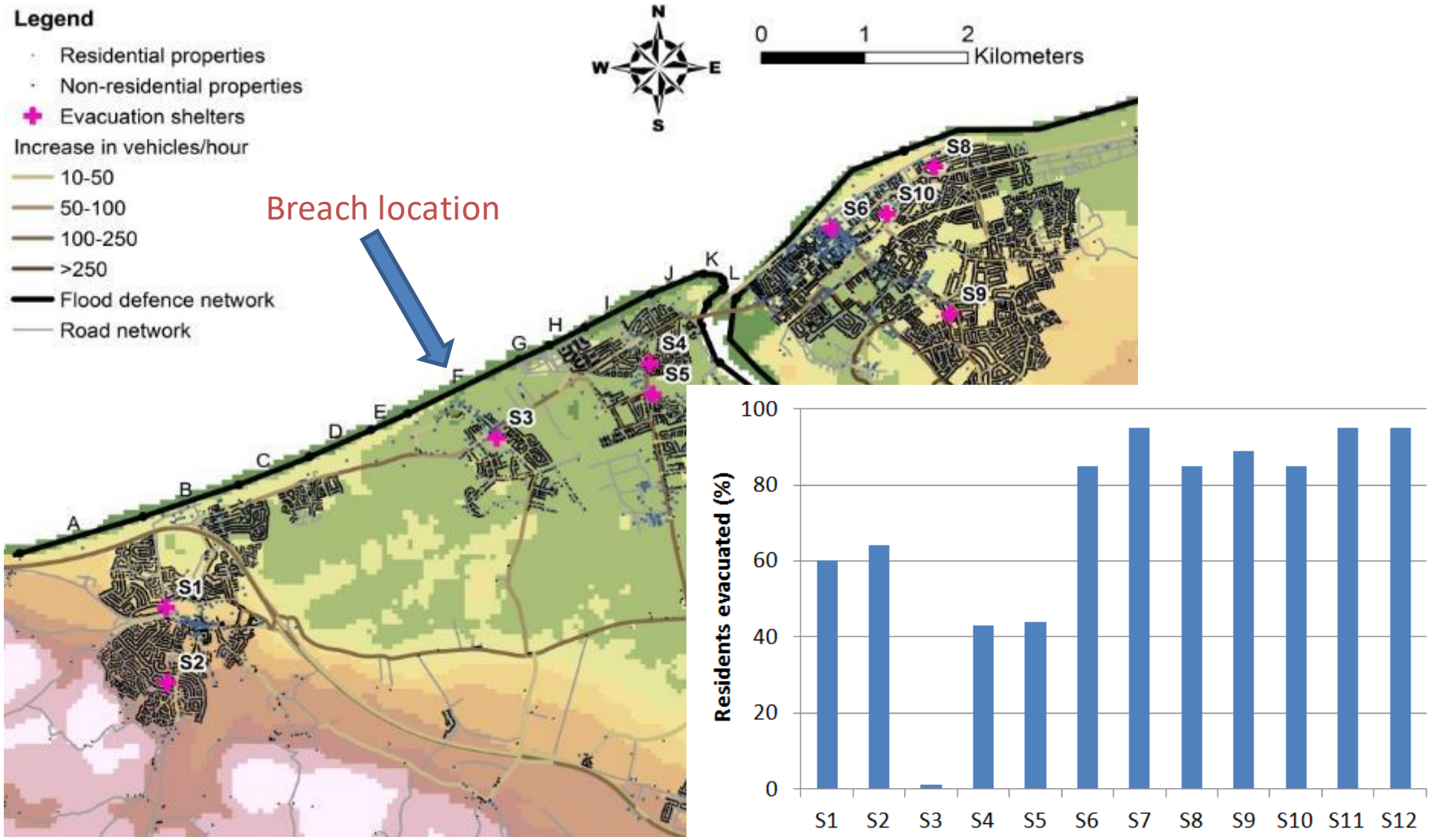


Risk to people vs. property

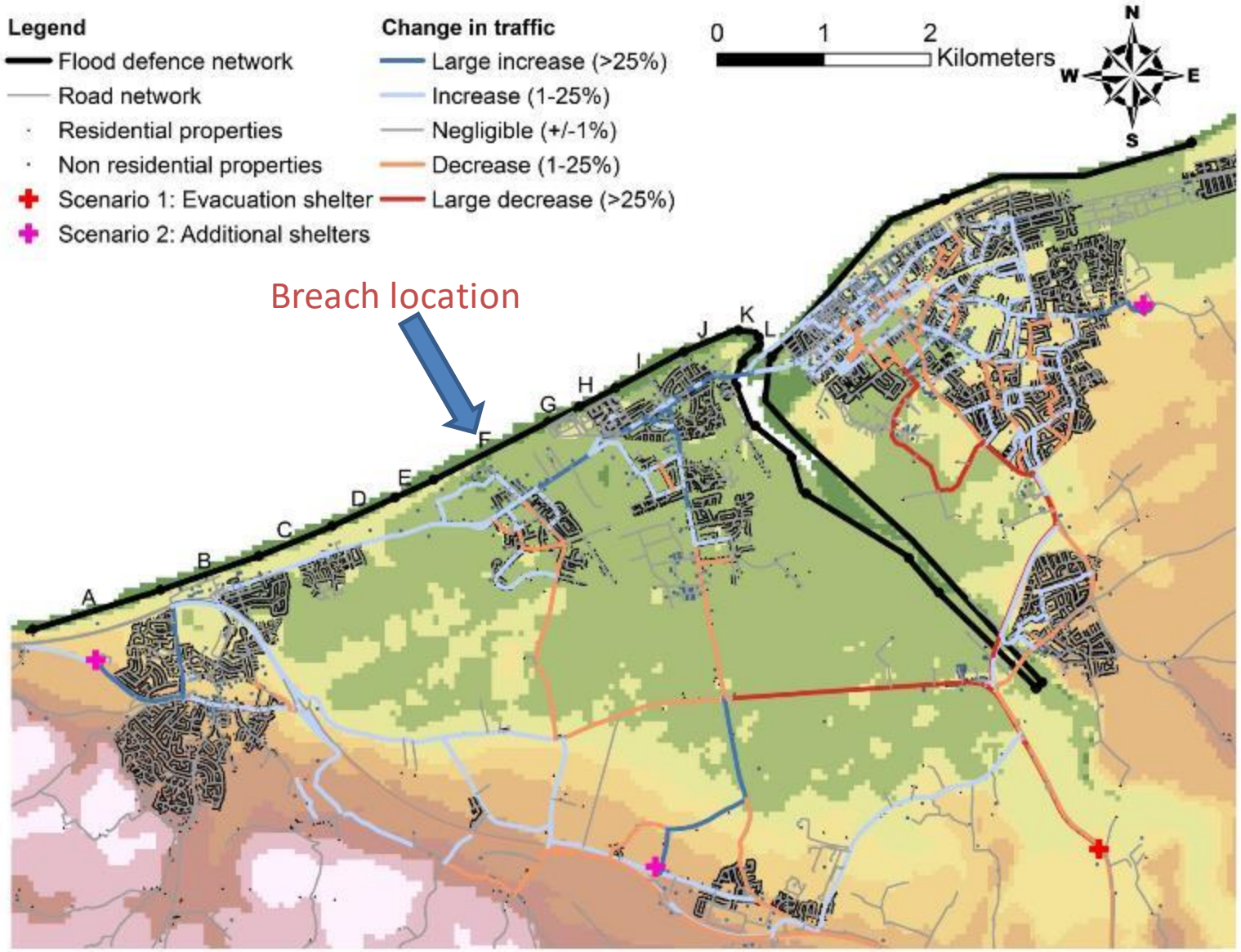


Rank	Population	Economic
1	I	B
2	H	C
3	J	E

Evacuation location



Congestion


Legend
Flood defence network
Road network
Residential properties
Non residential properties
Scenario 1: Evacuation shelter
Scenario 2: Additional shelters
Change in traffic
Large increase (>25%)
Increase (1-25%)
Negligible (+/-1%)
Decrease (1-25%)
Large decrease (>25%)
0 1 2 Kilometers
N
W
E
S
Breach location
A
B
C
D
E
F
G
H
I
J
K
L


Coventry, 2008


Houston, 2005

Centre of Excellence project

- Recode in Python and put on DAFNI (PyFIRM v1)
- Data pre-processing toolkit and workflow
- Upgrade model (PyFIRM v2)
  - Improve visualisation
  - Use DAFNI's workflow capabilities to enable third party flood model coupling (e.g. CityCAT)
  - Extend resilience options

Robin Wardle

Jannetta Steyn

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An Agent-Based Model of Flood Infrastructure Resilience




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Centre of Excellence Speaker:

USARIS - Uncertainty quantification and sensitivity analysis for resilient infrastructure systems

Dr Francesca Pianosi

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Uncertainty Quantification and Sensitivity Analysis for Resilient Infrastructure Systems (USARIS)

Hannah Bloomfield, Gemma Coxon, **Francesca Pianosi**, Saskia Salwey

University of BRISTOL

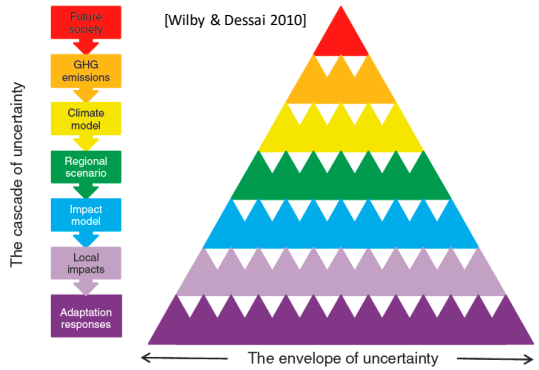
Newcastle University

DAFNI Annual Conference - 12th September 2023 – mail to: francesca.pianosi@bristol.ac.uk

Computational models have become an essential source of information to support infrastructure decisions, but…

Model outputs are conditional on many **uncertain assumptions**

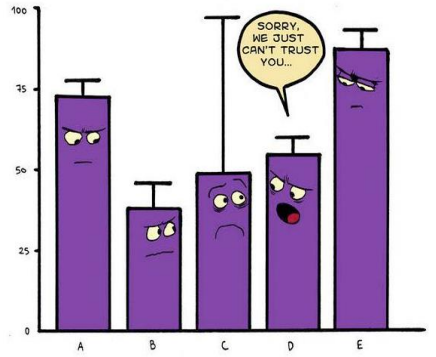
-- about the system's properties and drivers
-- how drivers will evolve in the **future**



[Wilby & Dessai 2010]

For models to be **trustworthy** and **effective** for infrastructure resilience we must:

-- avoid **spurious precision**
-- identify **key sources of uncertainty**
when does the model stops being valid?
where to start to improve the model?
-- identify **robust designs**
which designs perform "well enough" across a range of futures?



[Reading Local Group of the Royal Statistical Society]

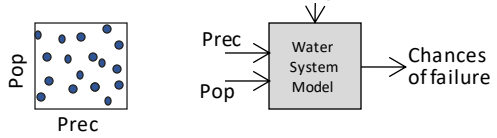
Uncertainty quantification (UQ) and sensitivity analysis (SA) provide a generic methodology to address these challenges

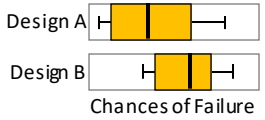
Step 1 **propagate** input uncertainties

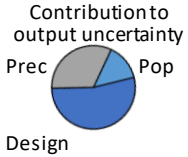
Step 2 **analyse** the input-output dataset

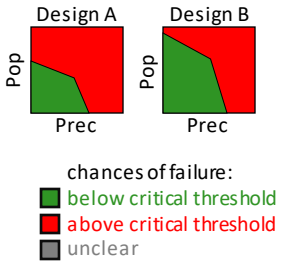
Monte Carlo simulations	quantifying uncertainty	quantifying sensitivity	stress-testing	
	How uncertain are model output(s) given uncertainty in inputs?	*Which inputs mostly contribute to the output uncertainty?*	*What designs perform **well enough** across a large range of inputs?*	*What are **threshold** values in the inputs that lead to "good enough" outputs?*

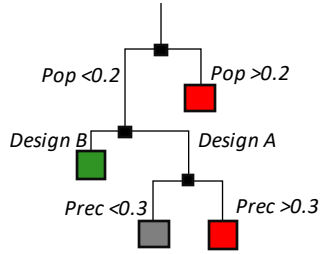
*What is the **precision** and **scope of validity** of the model?*











USARIS will set the foundations to include UQ&SA into DAFNI and demonstrate their value to the DAFNI users' community

DAFNI already enables Monte Carlo simulations so we will focus on step 2 (quantifying and attributing output uncertainty)

-- We will rely on existing UQ&SA packages (e.g. https://safetoolbox.github.io/)

-- The integration into DAFNI will be conducted by developing **two pilot applications** (**DAFNI workflows**) in **water** and **energy**

-- The workflows will be used for **training and dissemination** during the project (e.g. online trainings for EPSRC-CDT early-career researchers, 2024 annual workshop of the "*Next Generation Challenges in Energy and Climate Modelling Group*") and beyond

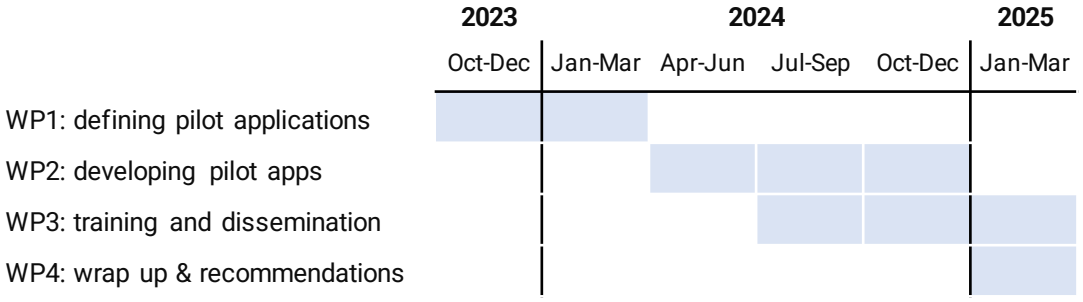
-- We will investigate scalability and provide **recommendations** for future developments of DAFNI

Pianosi
UQ&SA
water systems

Salwey
UQ&SA
water systems

Bloomfield
energy systems

Coxon
water systems



Long-term vision and community engagement

Ultimately USARIS will contribute to enable and promote best practices for responsible modelling in the DAFNI users community

Get in touch if you want to:

- learn more about UQ&SA
- brainstorm ideas on how UQ&SA can help in your sector
- discuss training opportunities
- provide pilot applications

francesca.pianosi@bristol.ac.uk

nature

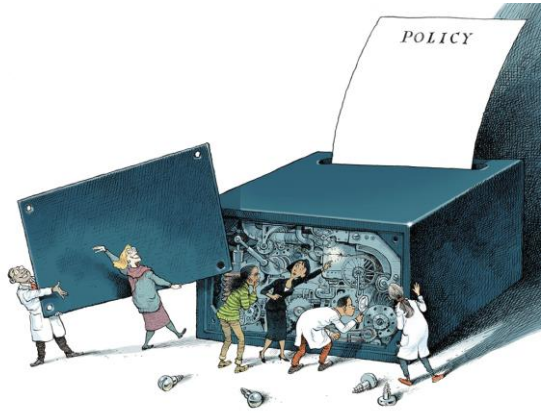
nature > comment > article

COMMENT | 24 June 2020

Five ways to ensure that models serve society: a manifesto

Pandemic politics highlight how predictions need to be transparent and humble to invite insight, not blame.

Andrea Saltelli, Gabriele Bammer, Isabelle Bruno, Erica Charters, Monica Di Fiore, Emmanuel Didier, Wendy Nelson Espeland, John Kay, Samuele Lo Piano, Deborah Mayo, Roger Pielke Jr, Tommaso Portaluri, Theodore M. Porter, Arnald Puy, Ismael Rafols, Jerome R. Ravetz, Erik Reinert, Daniel Sarewitz, Philip B. Stark, Andrew Stirling, Jeroen van der Sluijs & Paolo Vineis



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Centre of Excellence Speaker:

NIRD - Building systemic resilience of interdependent infrastructure networks at the national scale

Dr Raghav Pant

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OPSIS Oxford Programme for Sustainable Infrastructure Systems

eci

UNIVERSITY OF OXFORD

NIRD

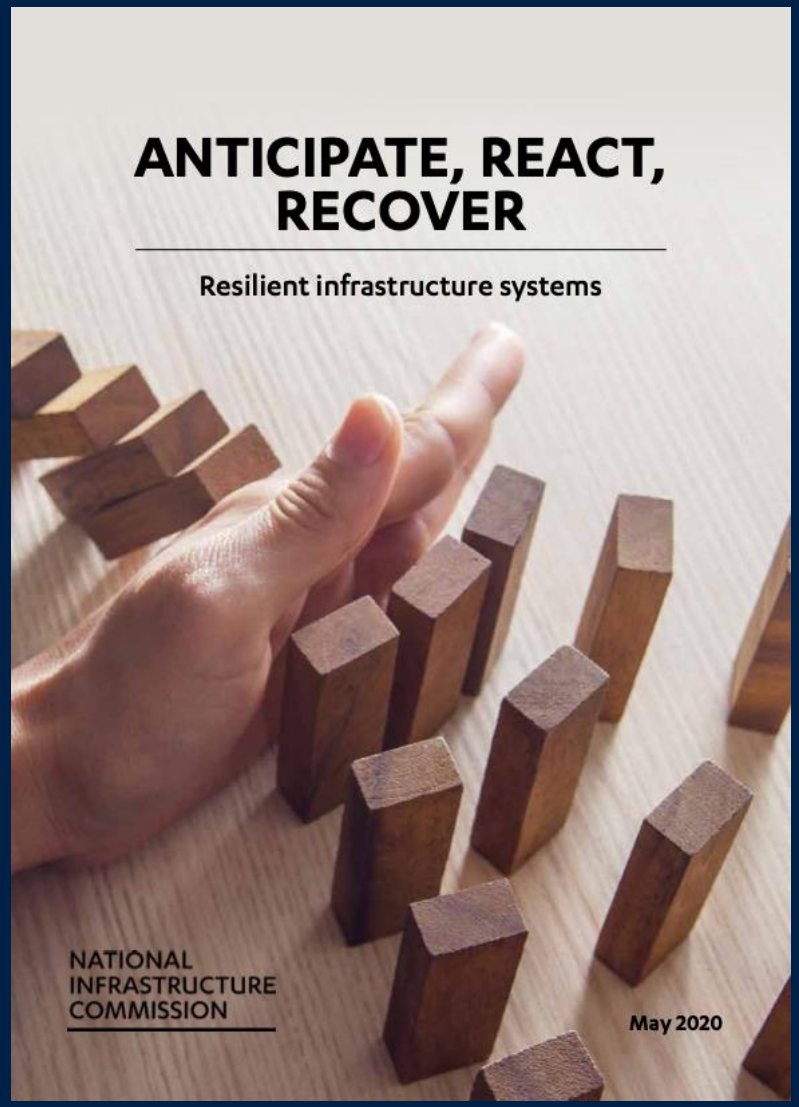
National Infrastructure Resilience Demonstrator

DAFNI Conference

Imperial College, London

12 September 2023

Gaps in resilient systems analysis



Recommendation

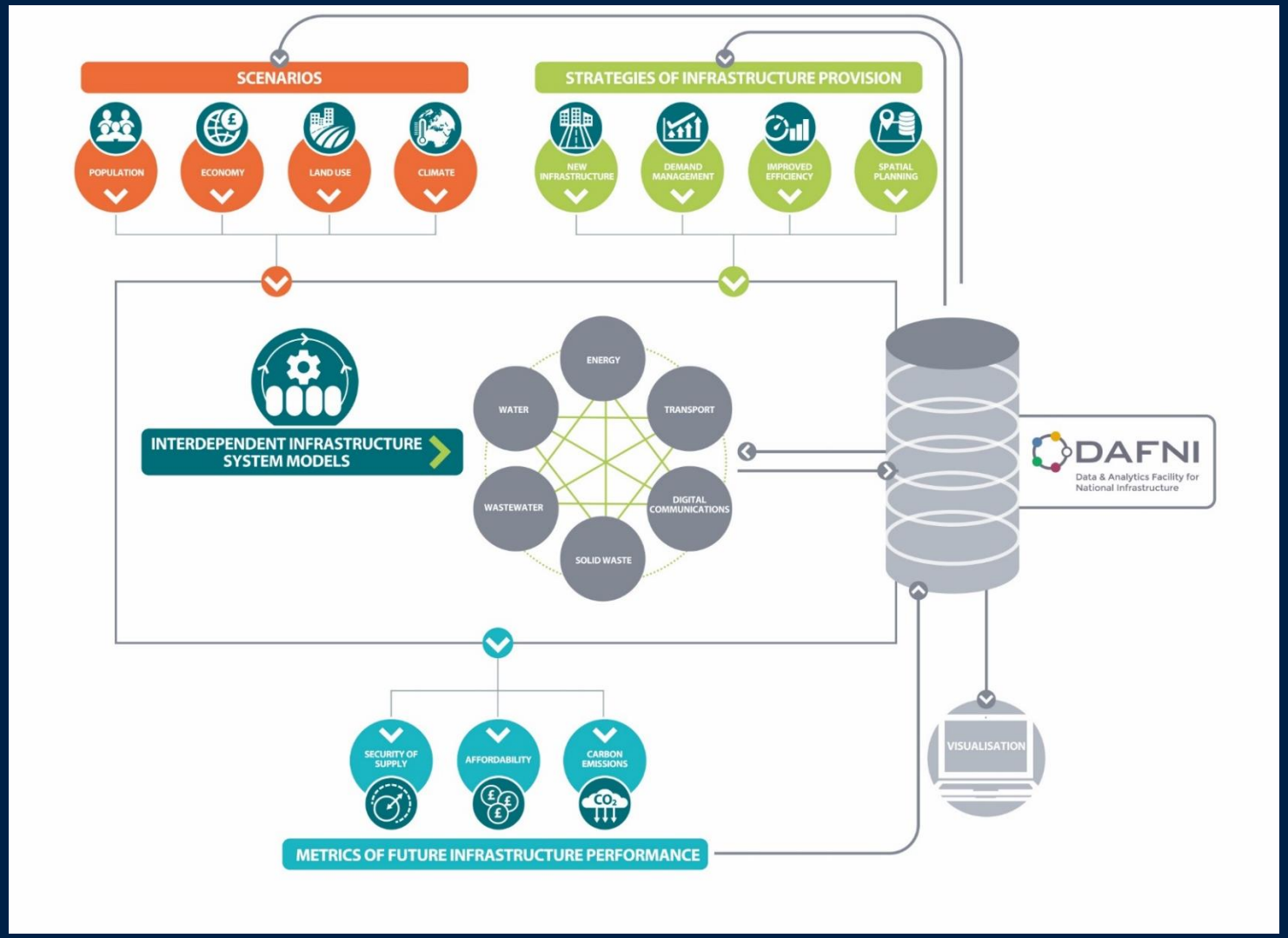
- Regulators should require a **system of regular stress testing by 2024 for energy, water, digital, road and rail infrastructure** operators, to ensure resilience standards for infrastructure services

Gaps

- **Lack of understanding of infrastructure interdependence** remains a major challenge for operators in estimating and tackling climate risks

- **Lack of coherent data for modelling infrastructure interactions** and **inconsistent risk measures** that makes it difficult to compare resilience outcomes across different sectors

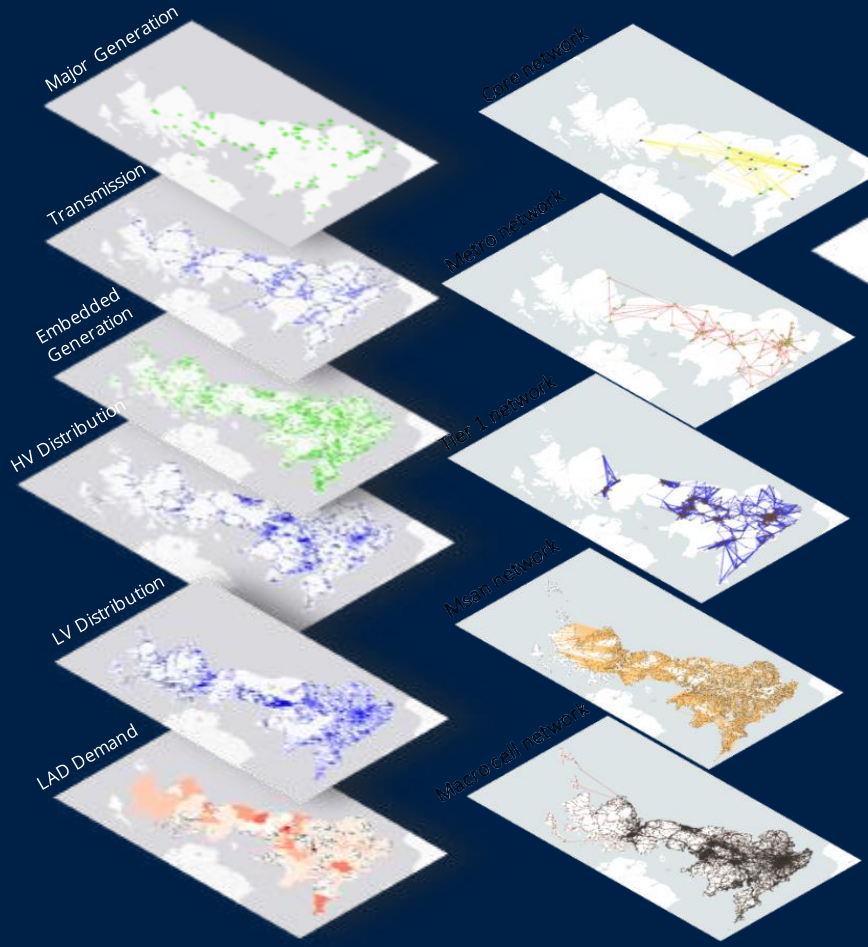
ITRC-Mistral NISMOD



£10 million EPSRC funded programme of research to build **national-scale systems modelling capability [2010 – 2020]**

National Infrastructure spatial network database

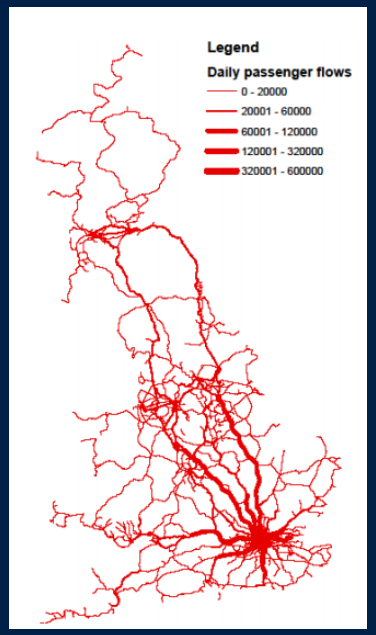
Electricity



Telecoms

Water supply

Railways



Roads (major)

- ~78,000 nodes
- ~140,000 edges
- 5 networks
- customer/user demands mapped on each network

Informing NIC resilience analytics

NATIONAL INFRASTRUCTURE COMMISSION

ITRC
Environmental Change Institute
eci
UNIVERSITY OF OXFORD

Resilience study research for NIC

Systems analysis of interdependent network vulnerabilities

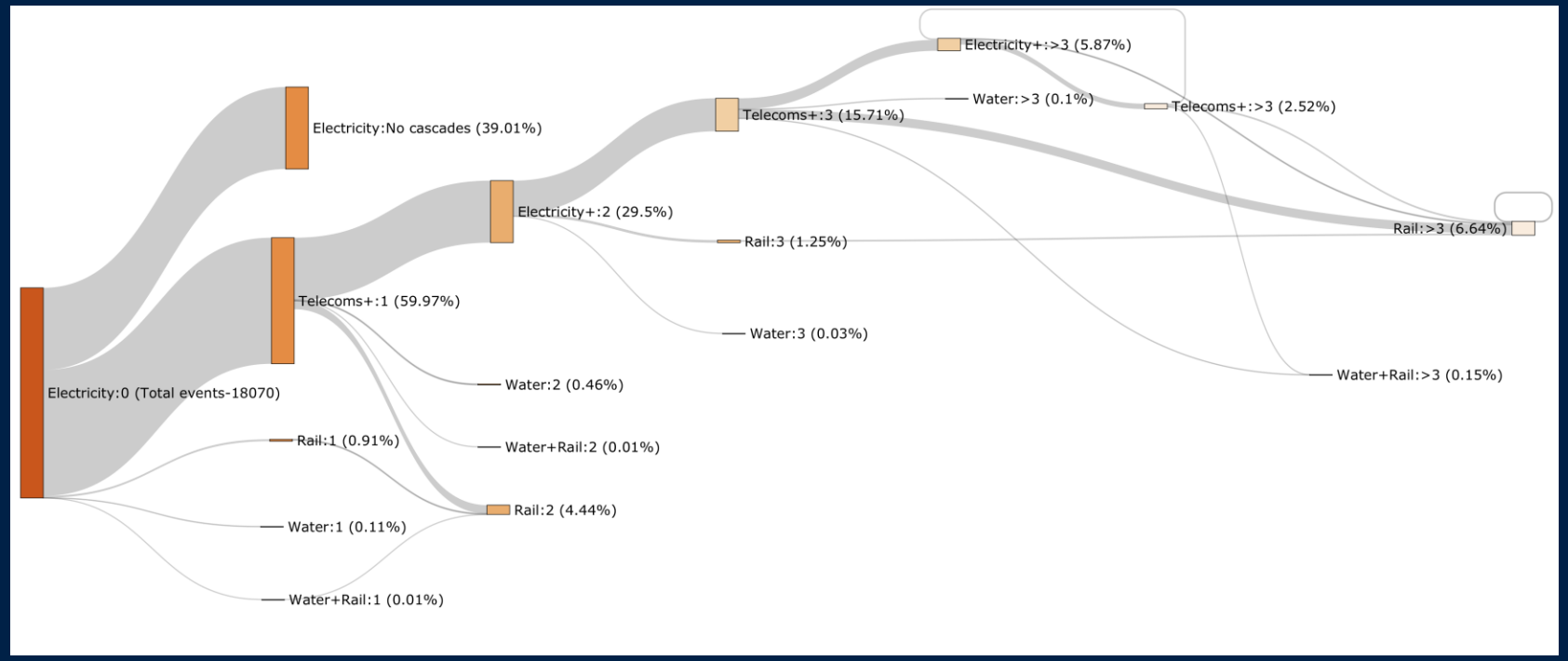
Final Report
April 2020

Dr. Raghav Pant
Mr. Tom Russell
Dr. Conrad Zorn
Dr. Edward Oughton
Prof. Jim W. Hall

Environmental Change Institute
University of Oxford
South Parks Road
Oxford, OX1 3QY

https://www.nic.org.uk/wp-content/uploads/Infrastructure-network-analysis.pdf

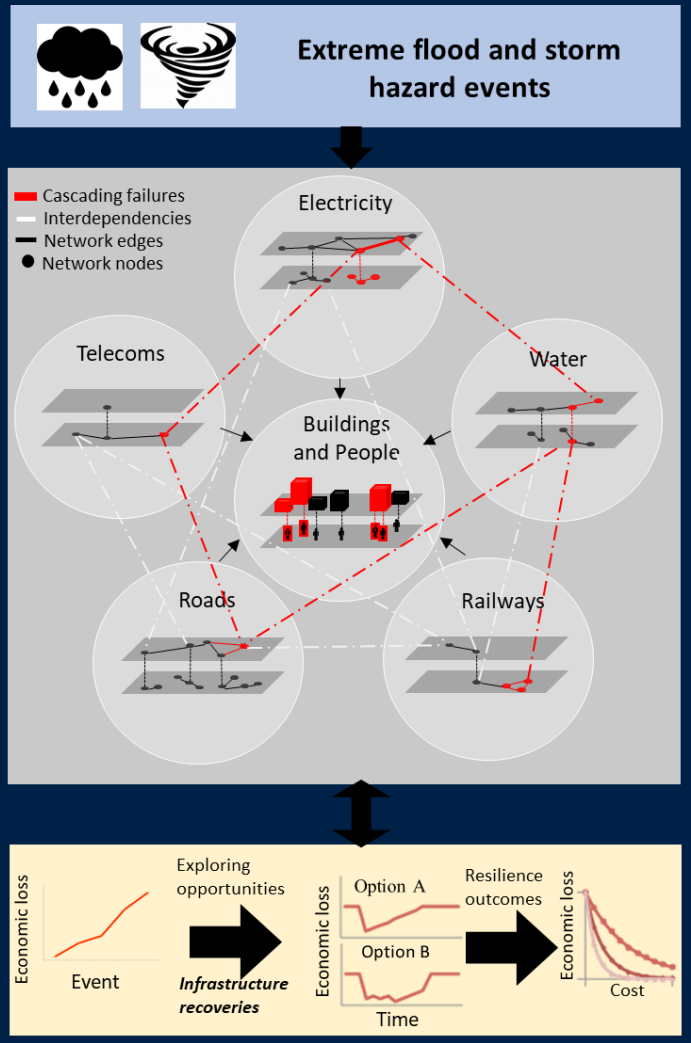
Single asset failures initiated in electricity networks



Resilience strategy experiment:
By connecting each electricity dependent asset to one more point on the electricity network only **5.6% of failure events** cascaded further

NIRD

National Infrastructure Resilience Demonstrator



Objectives

(1) Stress-test networks with **extreme flood and storm** events
(2) Model **interdependent network failure cascades** to quantify losses to people and economic activities
(3) Explore **resilience options** in reducing network failure losses

Project outcome

Deliver accessible **national-scale modelling capability and software tools** for quantifying UK infrastructure risk and resilience to extreme flood and storm events, supported by a unique spatial database of interdependent networks, population and economic activities

Vision for implementation on DAFNI platform

2-3 flood and storm event examples from JBA and Copernicus datasets

Database of **infrastructure networks** from ITRC-MISTRAL

Population and buildings datasets from Census and footprint datasets

Codebase

1. Hazard-network intersections and **asset failure sampling**
2. Network **flow disruption** analysis
3. Population and economic activity **loss estimation**
4. Risk and vulnerability **metrics**
5. Resilience **options** testing

python™

Usability and Reproducibility

1. User-manual with input-**data specification**
2. Jupyter notebooks with **example demonstrations**
3. Sample output **visualisations**

GitHub

Timeline

WP	Activity	2023			2024												2025		
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
0	DAFNI integration		D1				D2						D3				D4		D5,D6
0	Data and code creation and documentation																		
0	Stakeholder engagement			S1									S2						S3
1	Hazard event assembly																		
2	Infrastructure network data assembly																		
3	Socio-economic data assembly																		
4	Network service assignment																		
5	Infrastructure direct damages																		
6	Infrastructure service disruptions																		
7	Resilience options analysis																		

D1 - Scoping report of DAFNI integration process
D2 - Uploading of input datasets on DAFNI
D3 - Damage loss assessment results on DAFNI
D4 - Resilience options results on DAFNI
D5 - Final user guide, codes and presentations
D6 - Journal academic paper
S1 - Project awareness workshop
S2 - DAFNI conference to present risk results
S3 - Final project dissemination event

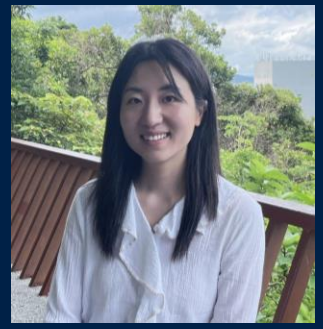
NIRD team members

Principle Investigator
Raghav Pant
Senior Research Associate, ECI

Co-Investigator
Jim W. Hall
Professor, ECI

Lead Software Expert
Tom Russell
Senior Research Software Engineer, ECI

Research Software Expert
Fred Thomas
Senior Research Software Engineer, ECI



Lead Model Developer
Yue Li
Post-Doctoral Research Associate, ECI

Project Manager
Tim Fowler
Programme Manager, ECI

Contact: **raghav.pant@ouce.ox.ac.uk**

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The DAFNI team will be in the foyer to provide demonstrations of the platform and answer any questions you may have.

Slido - #2299756

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IMPERIAL COLLEGE, LONDON. 12 SEPTEMBER 2023

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BUILDING A SECURE AND RESILIENT WORLD

Chair:

Dr Giuliano Punzo

Lecturer at the University of Sheffield

Director of the Sheffield Urban Flows Observatory

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Welcome Back

13:45 Welcome back and introduction to the afternoon session

13:50 Keynote Presentation: Spatial Planning Reimagined

Dr Wei Yang, Co-Founder & CEO, Digital Task Force for Planning; Chairman, Wei Yang & Partners

14:30 Standards in Practice - embedding Resilience in Infrastructure

Russell Price, International Standards Organization

14:50 Break, Demos and Networking

15:20 Presentations from Centre of Excellence Talks

Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks - STORMS

Dr Xilian Xia

A Water Resources model for England and Wales built in Python water resources simulation system – Pywr-WREW

Dr Anna Murgatroyd

Slido.com - #2299756

DAFNI

Welcome Back

Presentations from Centre of Excellence Talks - Continued

SOFRAMODE

Dr Vassilis Glenis

Small Changes and Computer-Generated Spatial Interaction Modelling with QUANT – SCQUAIR

Dr Richard Milton

16:20 Panel

Dr Giuliano Punzo

Dr Wei Yang

Dr Brian Matthews

Russell Price

16:50 Conference Closing Remarks

Dr Brian Matthews, DAFNI Facility Lead, Scientific Computing, STFC

17:00 Close of Conference

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Keynote Speaker:

Spatial Planning Reimagined

Dr Wei Yang

Co-Founder & CEO,
Digital Task Force for Planning

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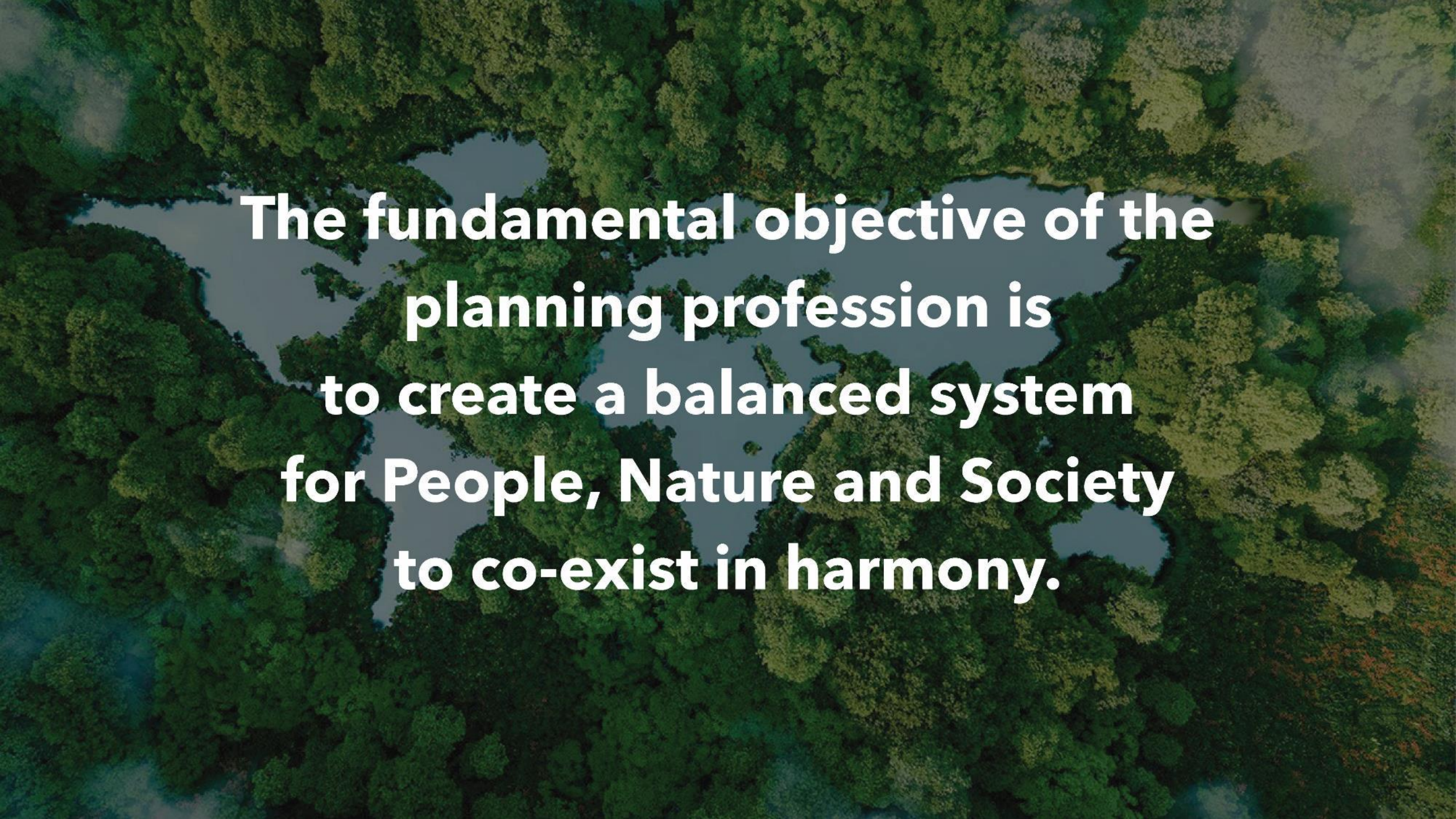
Spatial Planning Reimagined: Building a Secure and Resilient World

Dr Wei Yang
Co-Founder & CEO, Digital Task Force for Planning
Chairman, Wei Yang & Partners

DAFNI Conference 2023
12 Sep 2023


The fundamental objective of the
planning profession is
to create a balanced system
for People, Nature and Society
to co-exist in harmony.

Our Survival – the Interaction between People and Nature

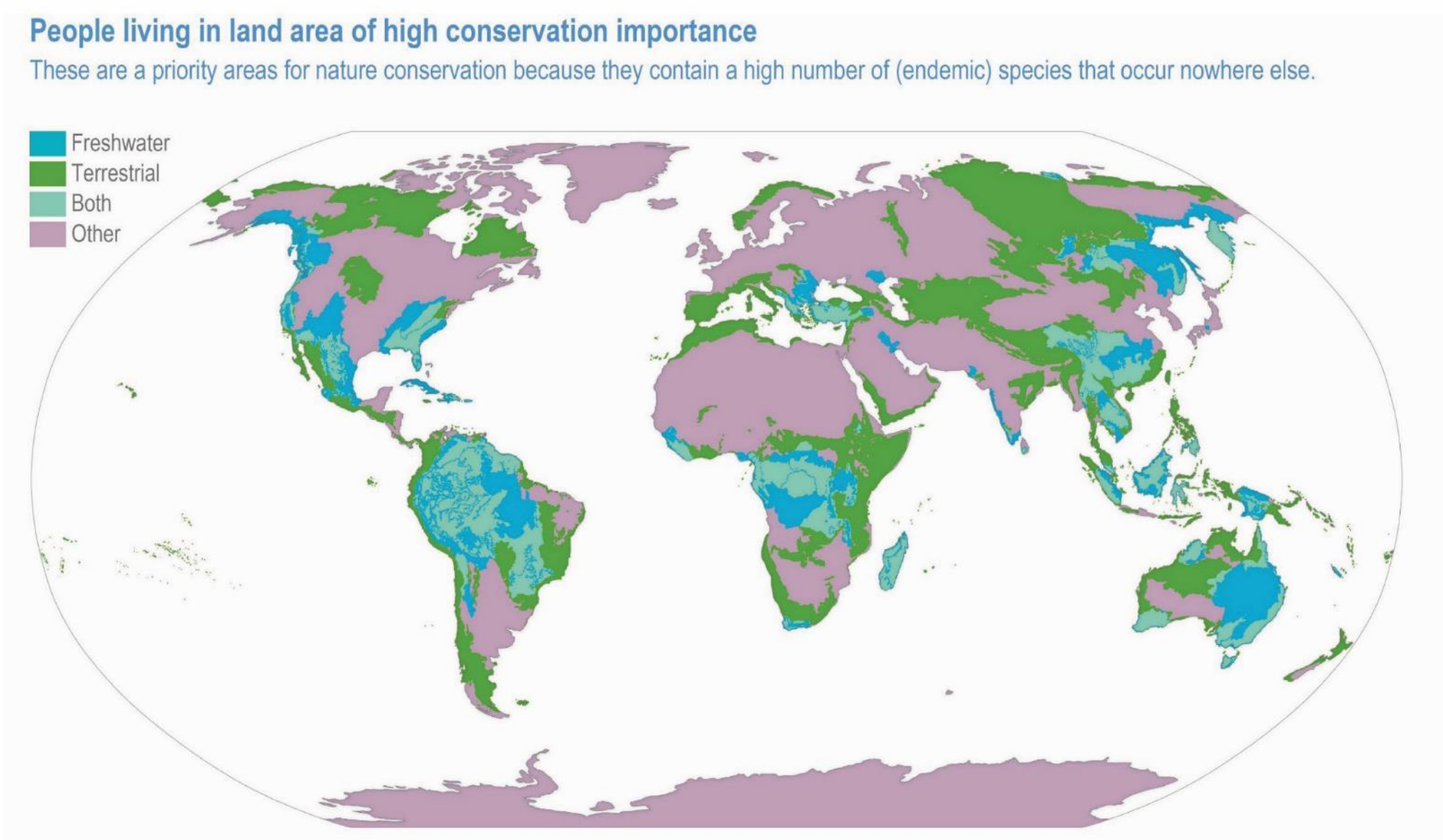
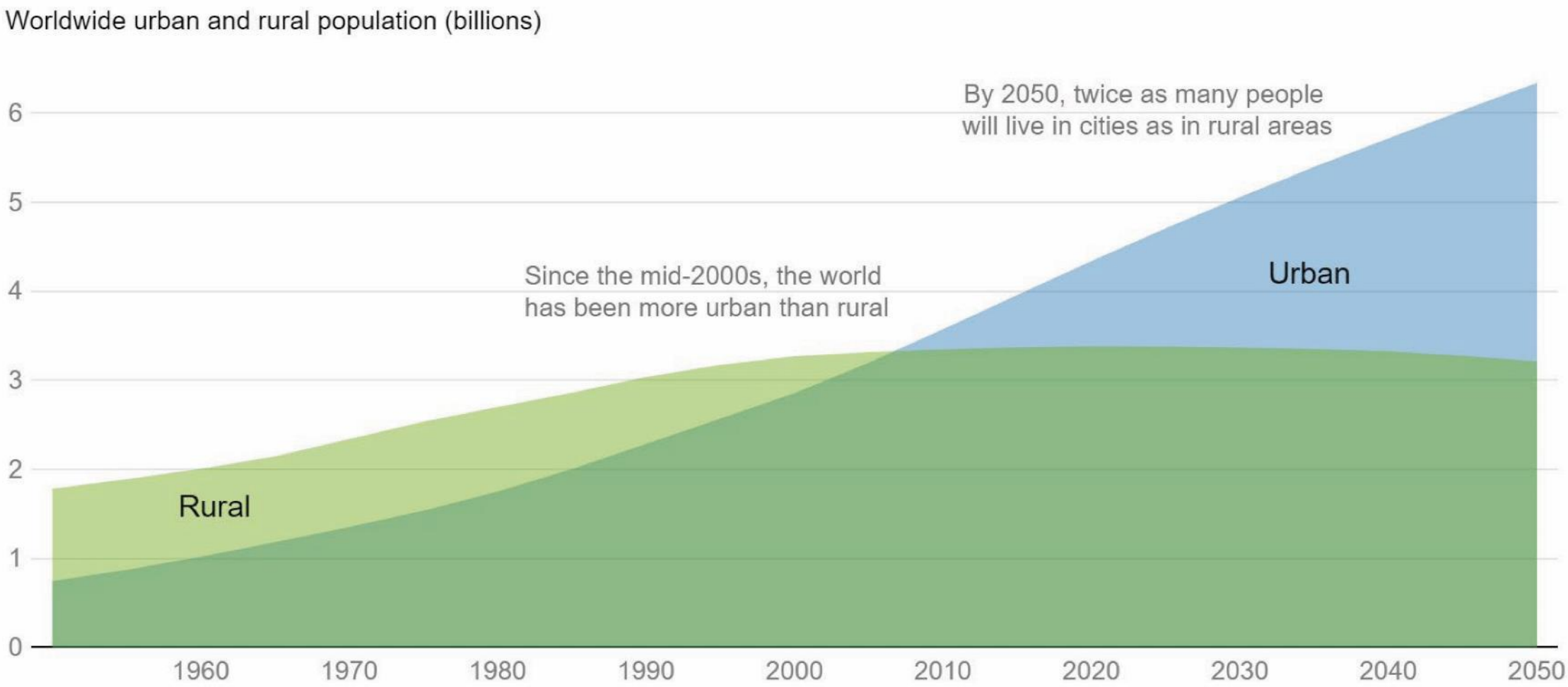


Image Source: IPCC, *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. (H.-O. Pörtner, *et al*.)

The Unprecedented Speed of Population Growth & Global Urbanisation



Source: UN World Urbanization Prospects

Image source: www.worldbank.org

A Rapidly Closing Window of Opportunity to Secure a Liveable & Sustainable Future for All

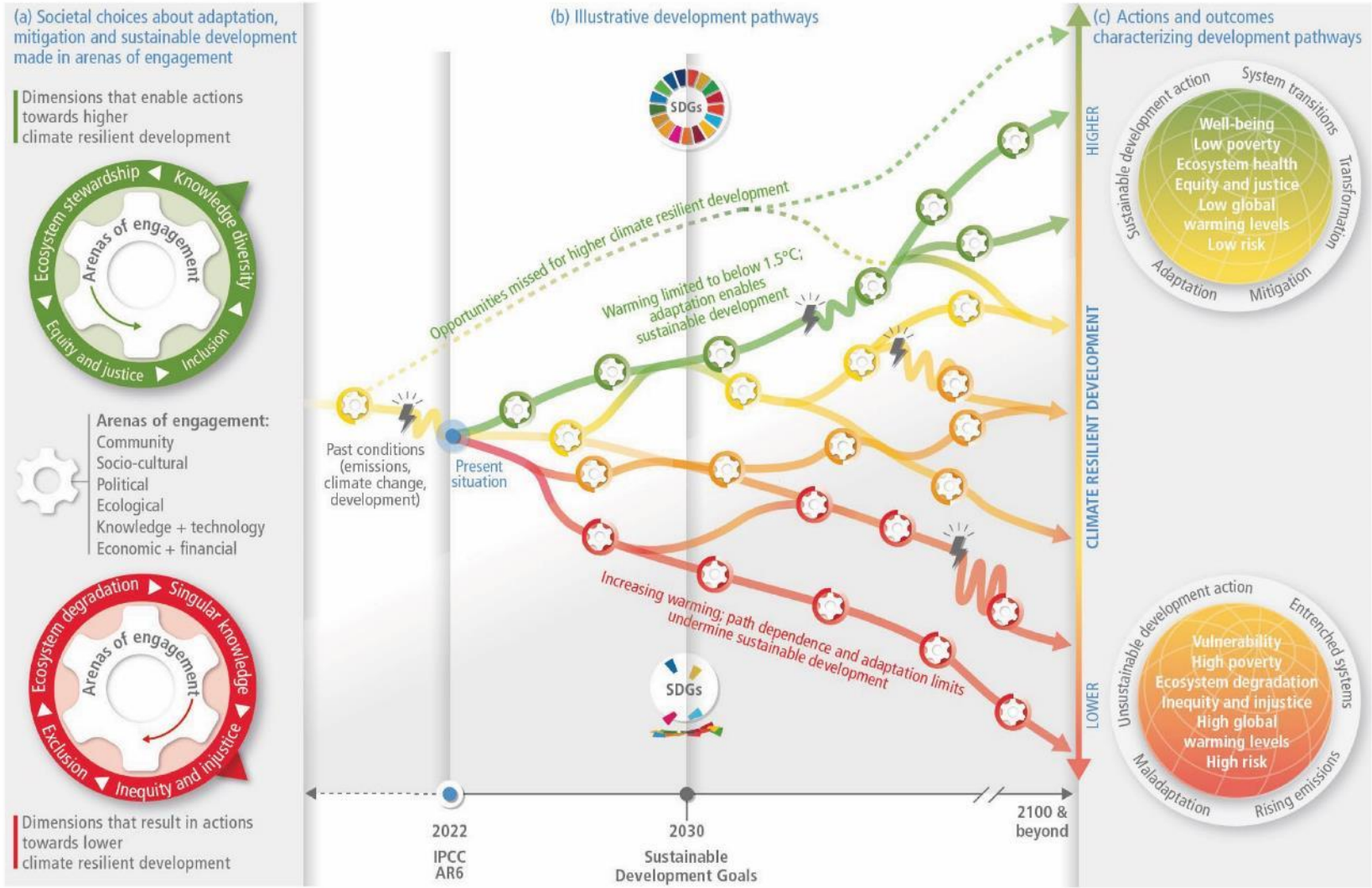
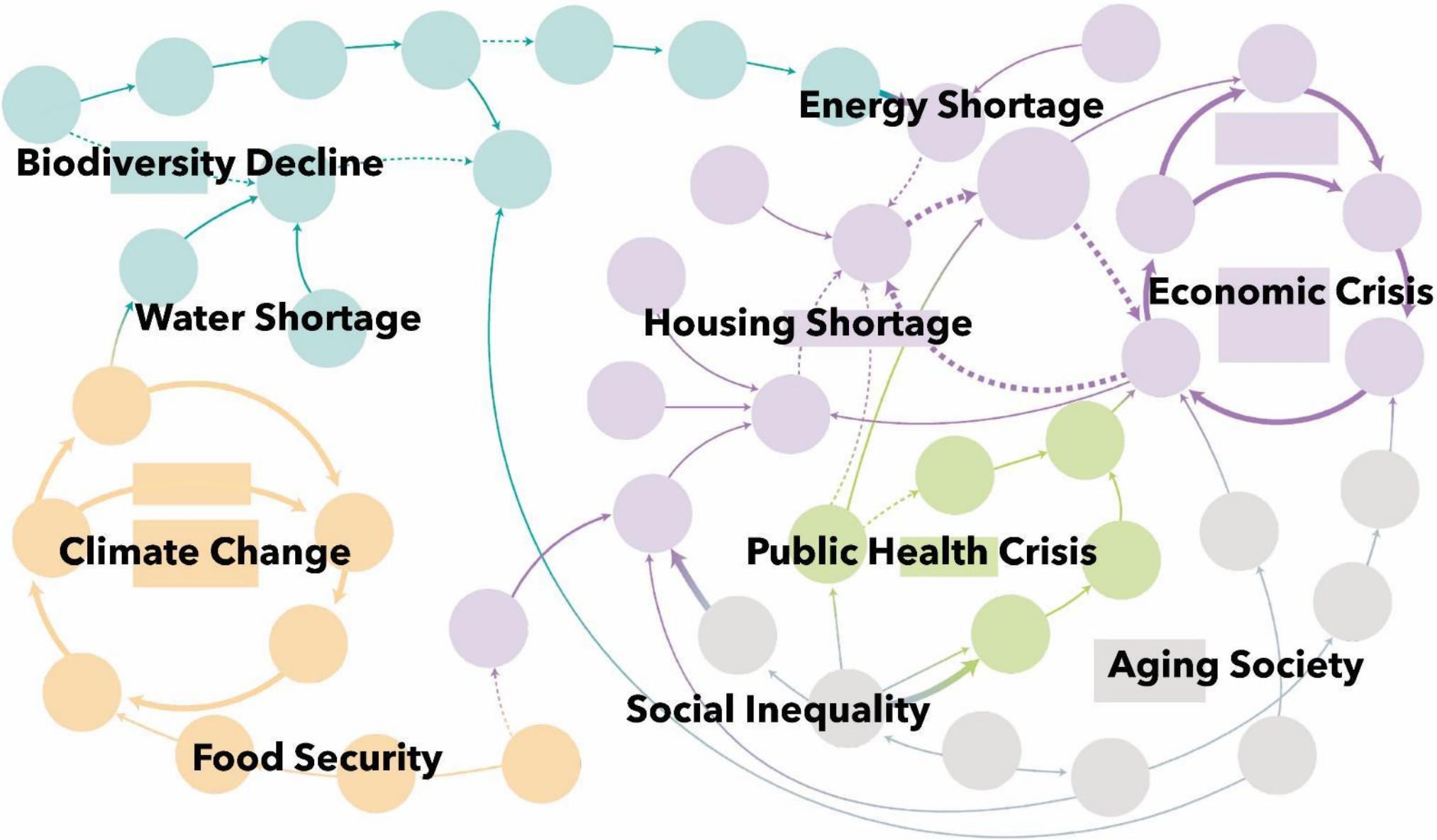


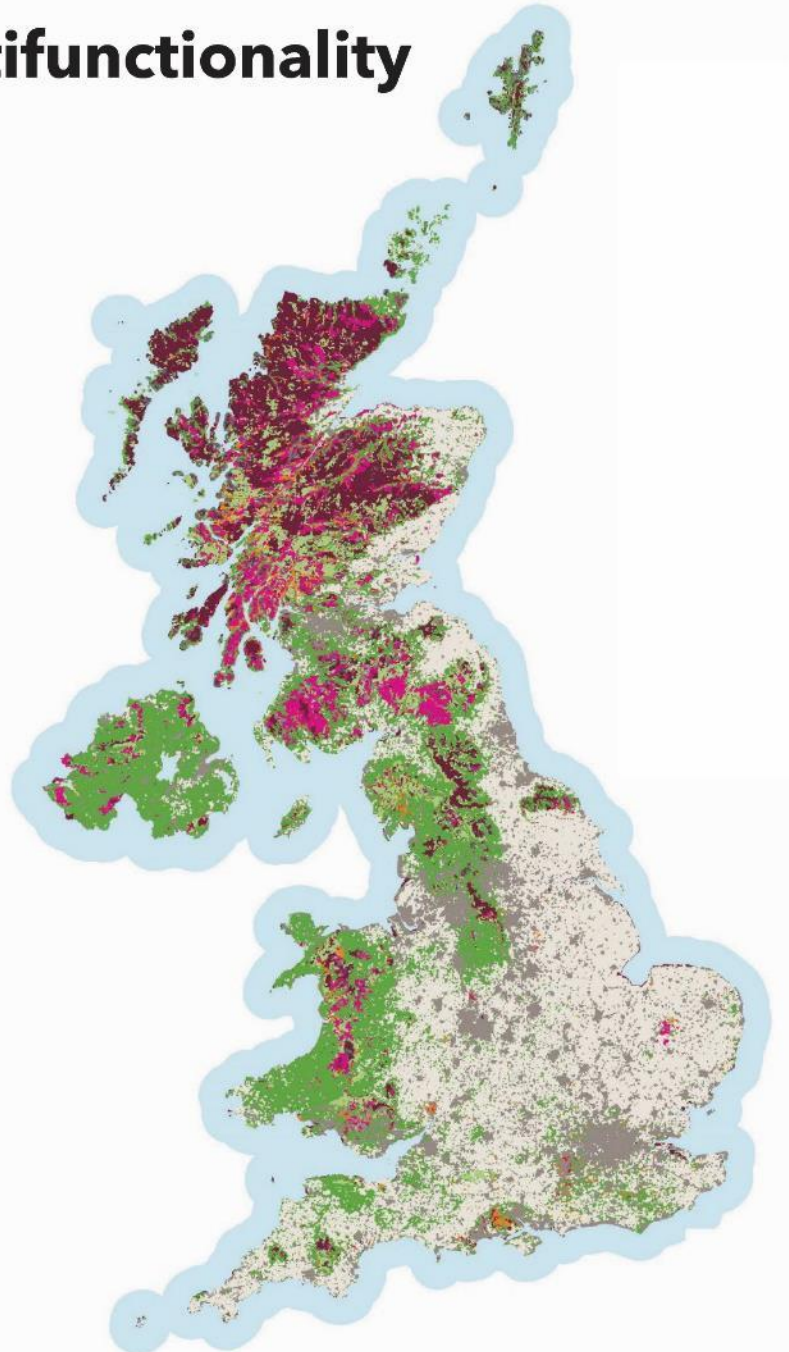
Image Source: IPCC, *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. (H.-O. Pörtner, *et al.*)

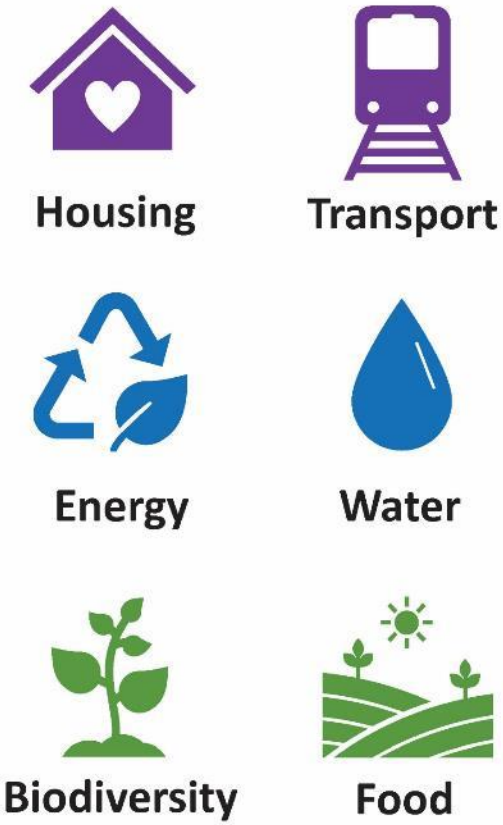
Current Problems: Silos + Lack of Joined-up Actions



Land Use: Spatial Planning & Multifunctionality

Urban fabric	4.7%
Sport and leisure facilities	1%
Mining, industry or commercial units	1.1%
Transport	0.2%
Green urban areas	0.2%
Arable land	36.9%
Pastures	27%
Broad-leaved forest	1.9%
Mixed forest	1.1%
Coniferous forest	4.2%
Transitional woodland	1.3%
Natural grassland	5%
Peat bogs	7.8%
Moors and heathland	6.4%
Sparsely vegetated areas	0.9%
Salt marshes	0.2%
Inland marshes	0.1%





Total Land Area of the UK: 24.25 million hectares

Map of U K Land Cover, Royal Society (2023), Multifunctional Landscapes (adapted from U K CORINE Land Cover 2021. U K Centre for Ecology and Hydrology).

Process: Planning, Development and Monitoring

Case Study: Nutrient Neutrality

- **In July 2020**, Natural England issued advice to the Council to avoid potential for further deterioration in water quality pending further investigations. Advice updated in November.
- **For example: Ashford Borough Council: Essentially, planning permissions are put on hold -** 10,000 dwellings affected (up to 2030), including 90% of Local Plan allocated sites.
- **In August 2023**, The nutrient neutrality rules were scrapped by the Department for Levelling Up, Housing and Communities (DLUHC) and the Department for Environment, Food and Rural Affairs (Defra).

Information and Image Source: Ashford Borough Council


We could miss the opportunity
to save ourselves
because we lose the ability
to plan for the FUTURE
collaboratively.

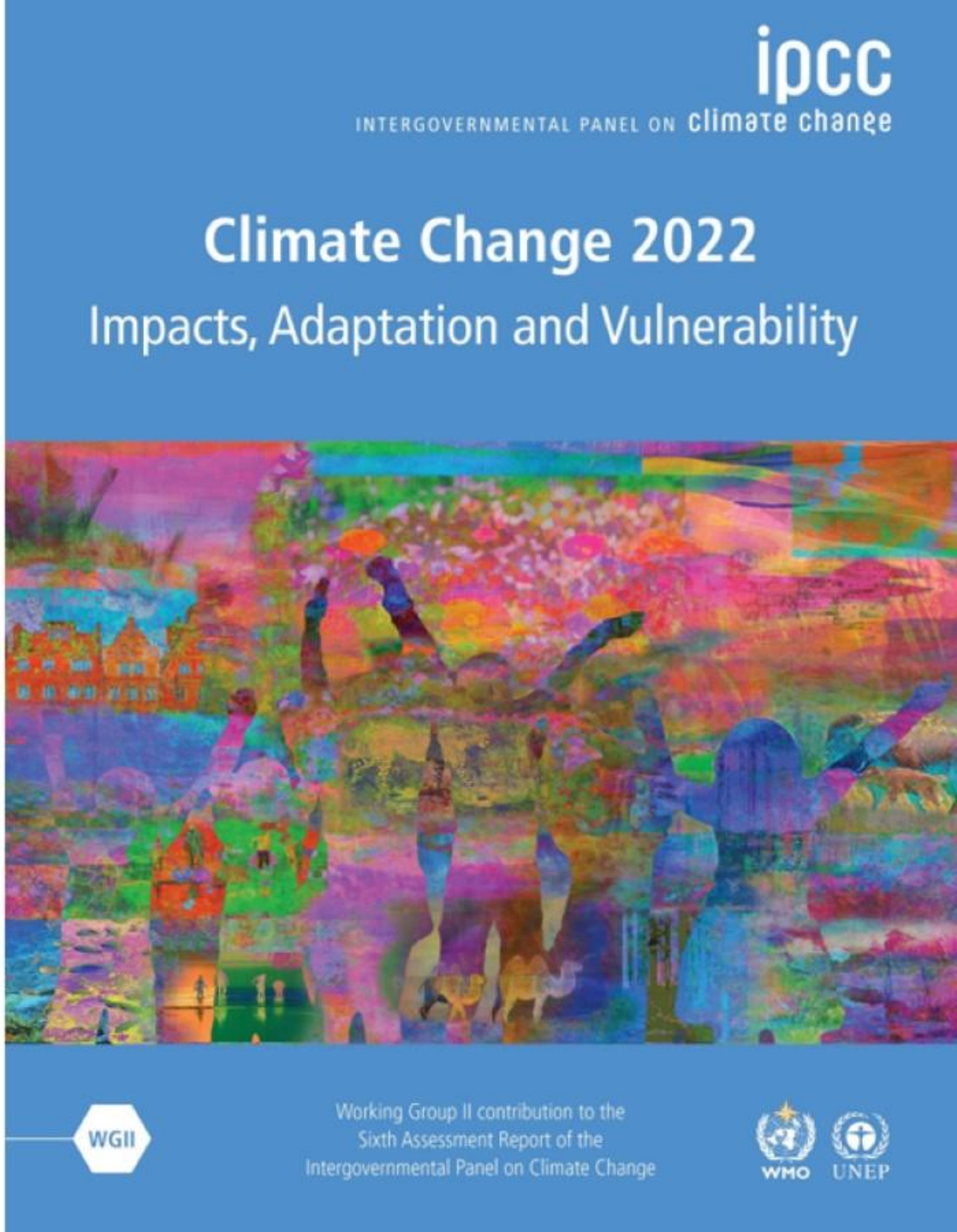
Call for Actions

"Spatial Planning needs the largest systemic changes as a key climate change adaptation option."

– **IPCC**

Climate Change 2022:
Impacts, Adaptation and Vulnerability

Data & Image source: *Climate Change 2022: Impacts, Adaptation and Vulnerability* (IPCC, 2022)



Call for Actions

"Humans have influenced and changed many ecosystems around the world…

One way in which we can manage this influence and activity, including for conservation and restoration, is through careful land-use and marine spatial planning to balance economic, social and environmental trade-offs."

- ***The Economics of Biodiversity: The Dasgupta Review*, 2021**

Data & Image source: *The Economics of Biodiversity: The Dasgupta Review* (2021)

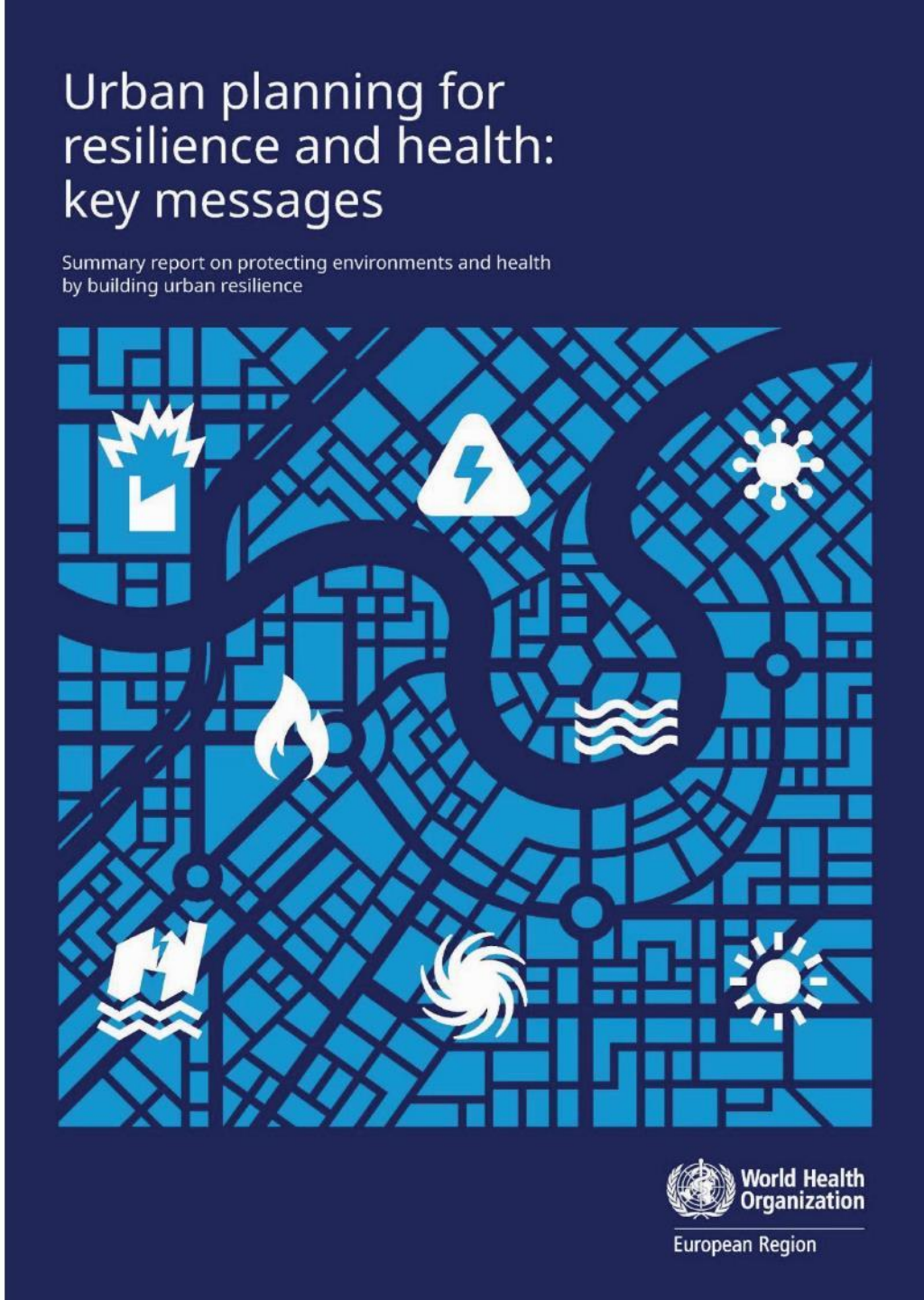
Call for Actions

"Urban planning and design can play a key role *in making cities more prepared for future emergencies, thereby protecting the health of their communities.*

Urban conditions and design features may have a direct impact in all four phases of emergency and risk management – Response, Recovery, Mitigation, Preparedness."

\- **WHO (World Health Organisation)**
Urban planning for resilience and health, 2022

Data & Image source: *Urban planning for resilience and health* (WHO, 2022)



Home, Health, Demographic Change & Social Equality

10 million people are living in non-decent homes across England

Care&Repair England

CENTRE FOR AGEING BETTER

4.3 million homes

in England are classed as non-decent – a shocking 19% of all homes.

10 million people

are living in conditions that may create or worsen health conditions and reduce their quality of life.

2 million

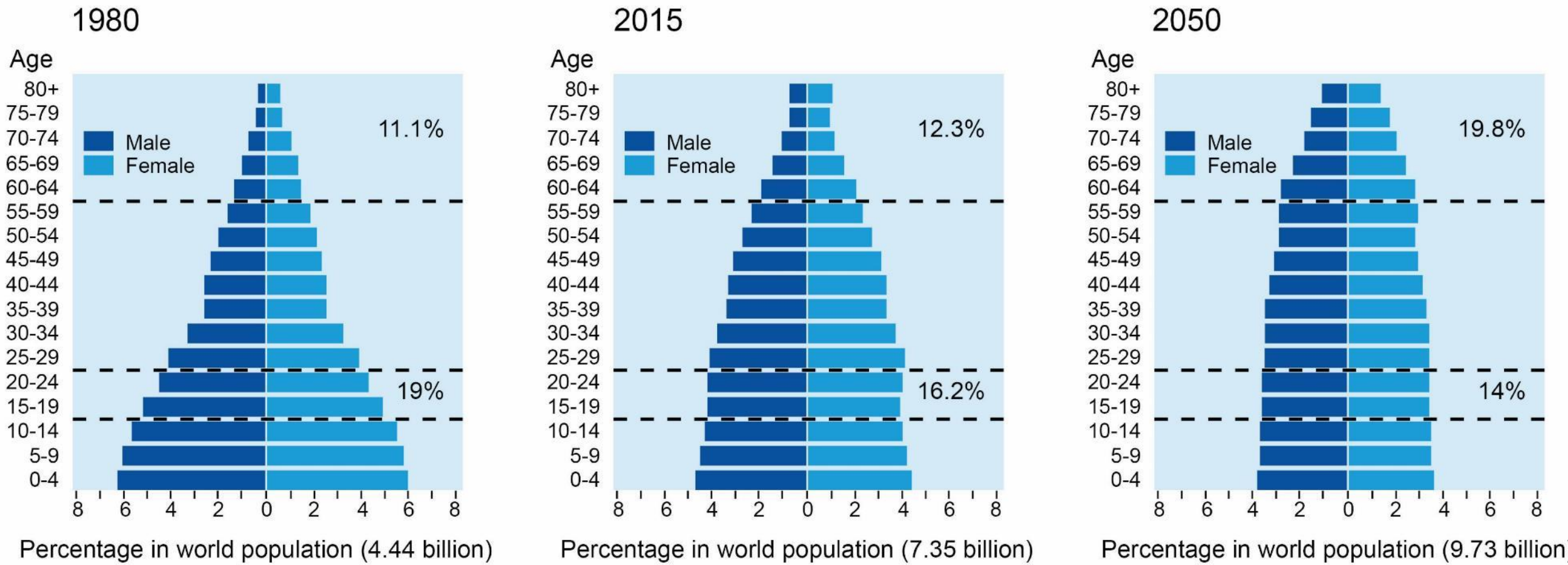
of these non-decent homes are lived in by someone over 55.

Nearly 1 in 5

18% of households where someone has a long-term illness or disability live in a non-decent home, and 15% of all wheelchair users live in a non-decent home.

Image Source: *Non Decent Homes Factsheet Report* (2020)

Purpose: For Whom Do We Plan?



Data Source: United Nations, Department of Economic & Social Affairs, Population Division (2014)
Image adapted from: Harvard University, David E. Bloom (2016)

A Systemic Transformation

Solutions: Re-building the Three Pillars of Spatial Planning

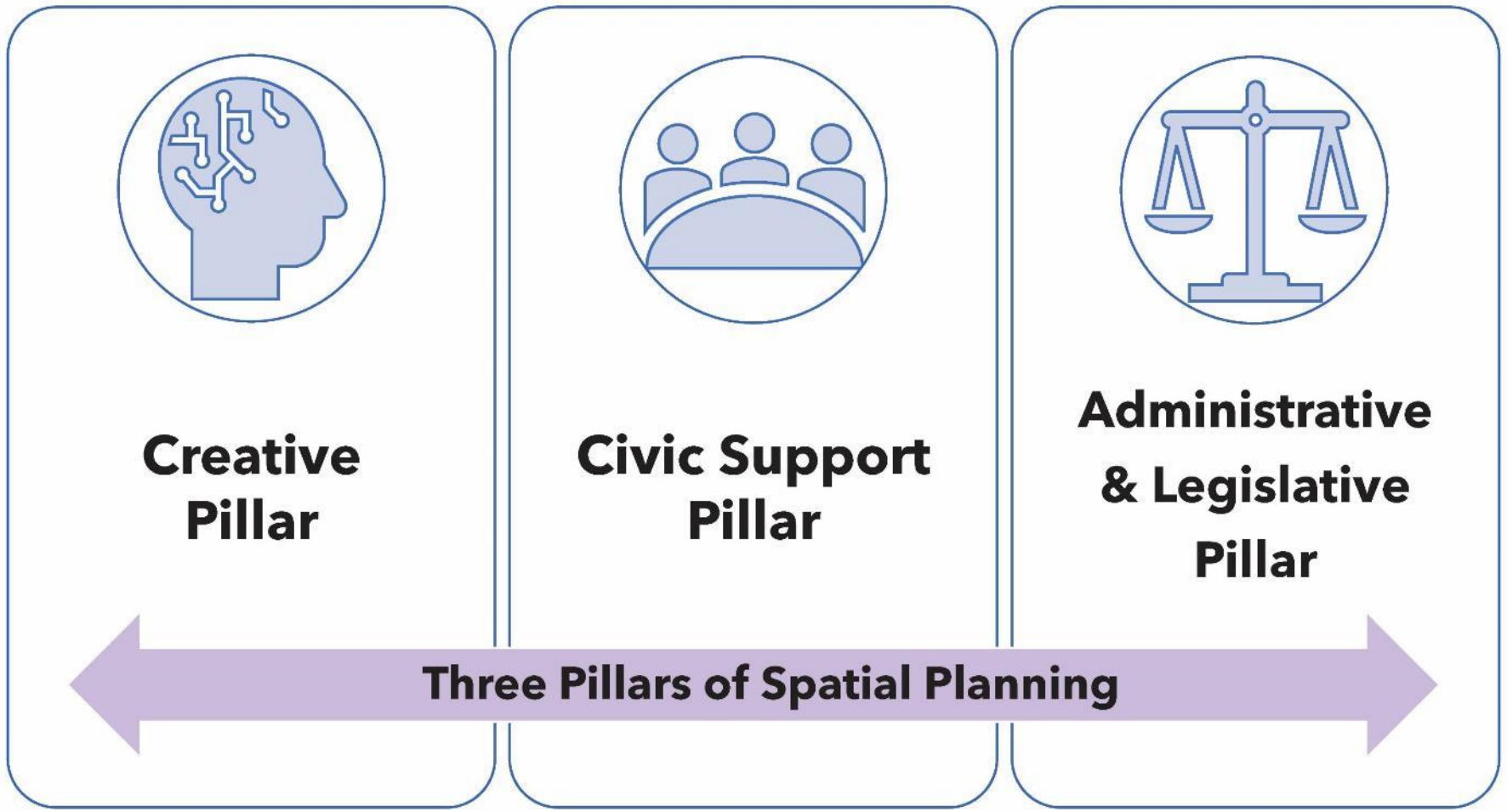


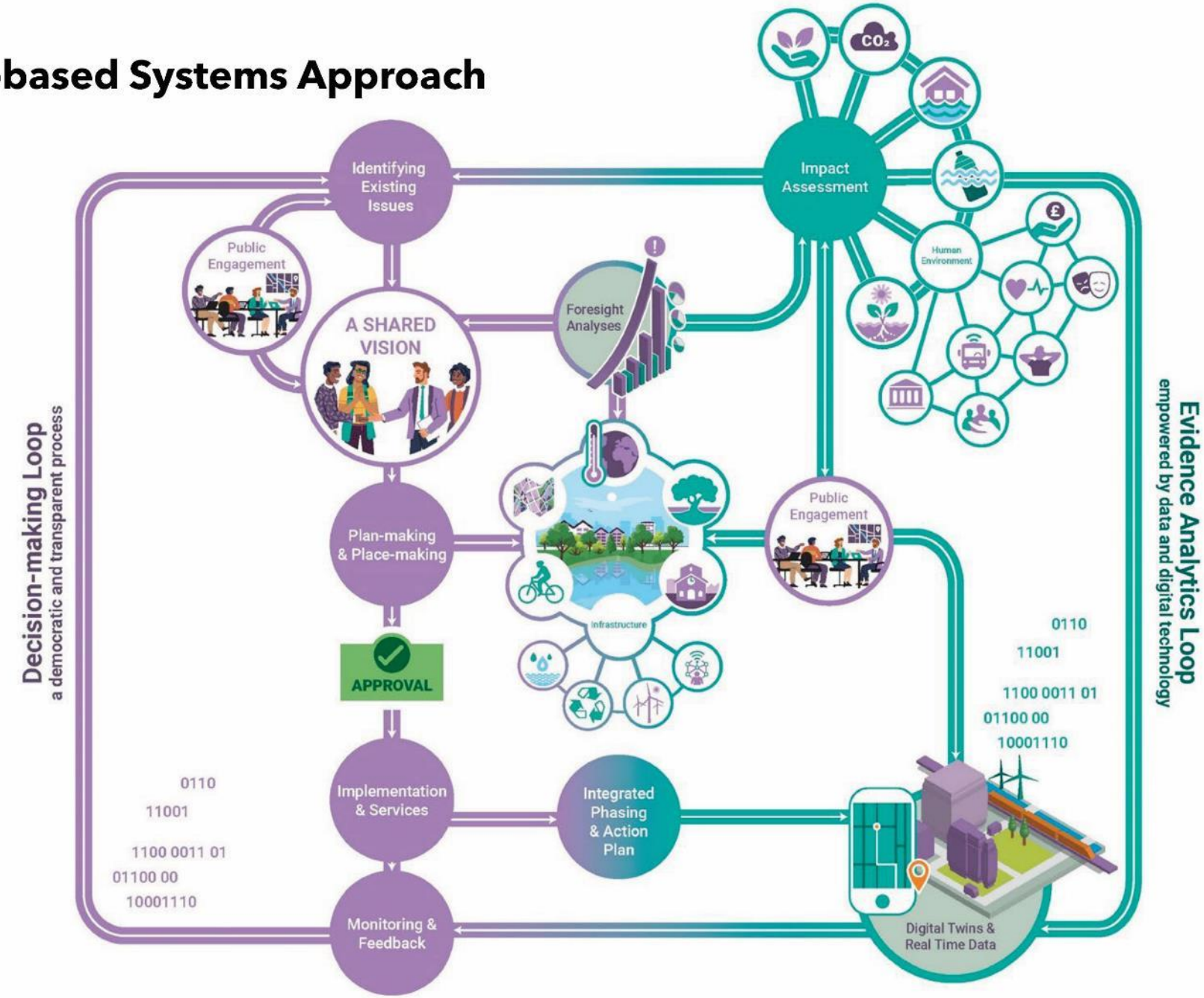
Image source: *Spatial Planning Reimagined* (Wei Yang, 2023)

A methodological change in Spatial Planning empowered by digital technologies and big data

- to establish a digitally enabled place-based systems approach to tackle the grand challenges and create sustainable communities.

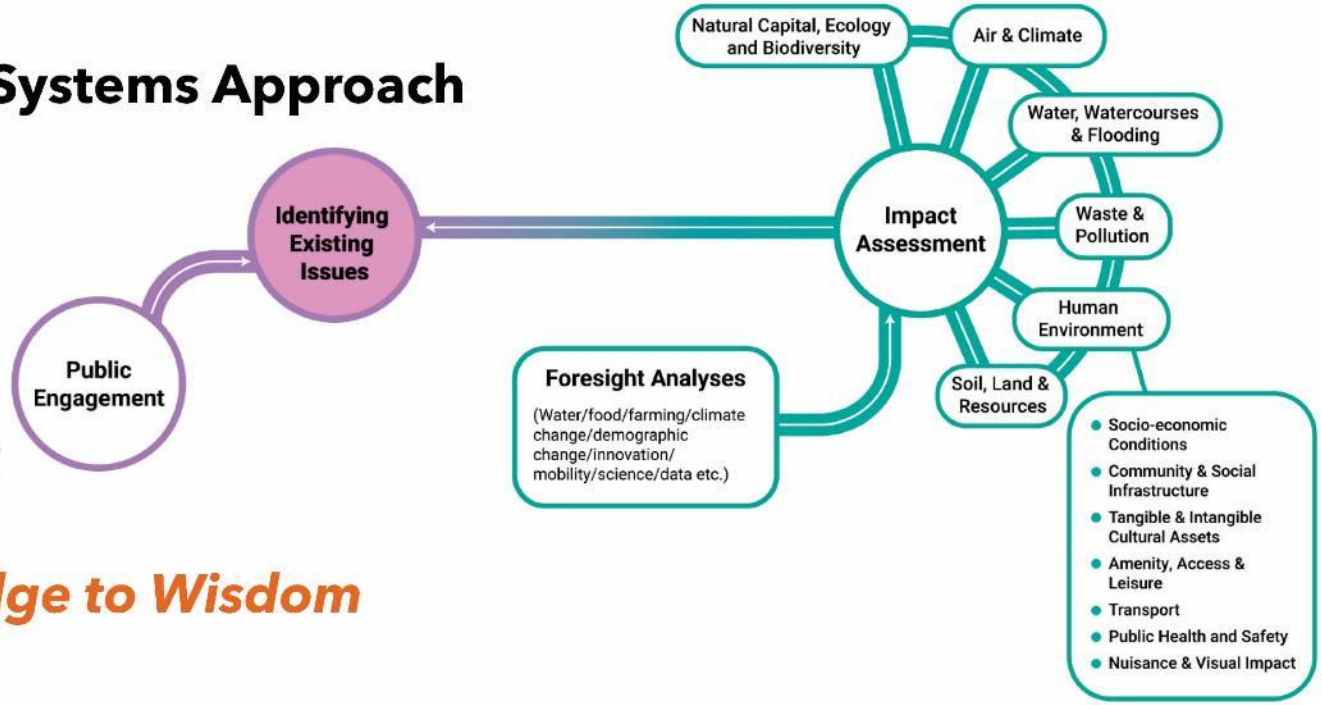
A New Methodology

– A Digitally Enabled Place-based Systems Approach



A New Methodology
– A Digitally Enabled Place-based Systems Approach

Stage 1: "Framing the right questions" – Community Needs, Existing Conditions, and Foresight



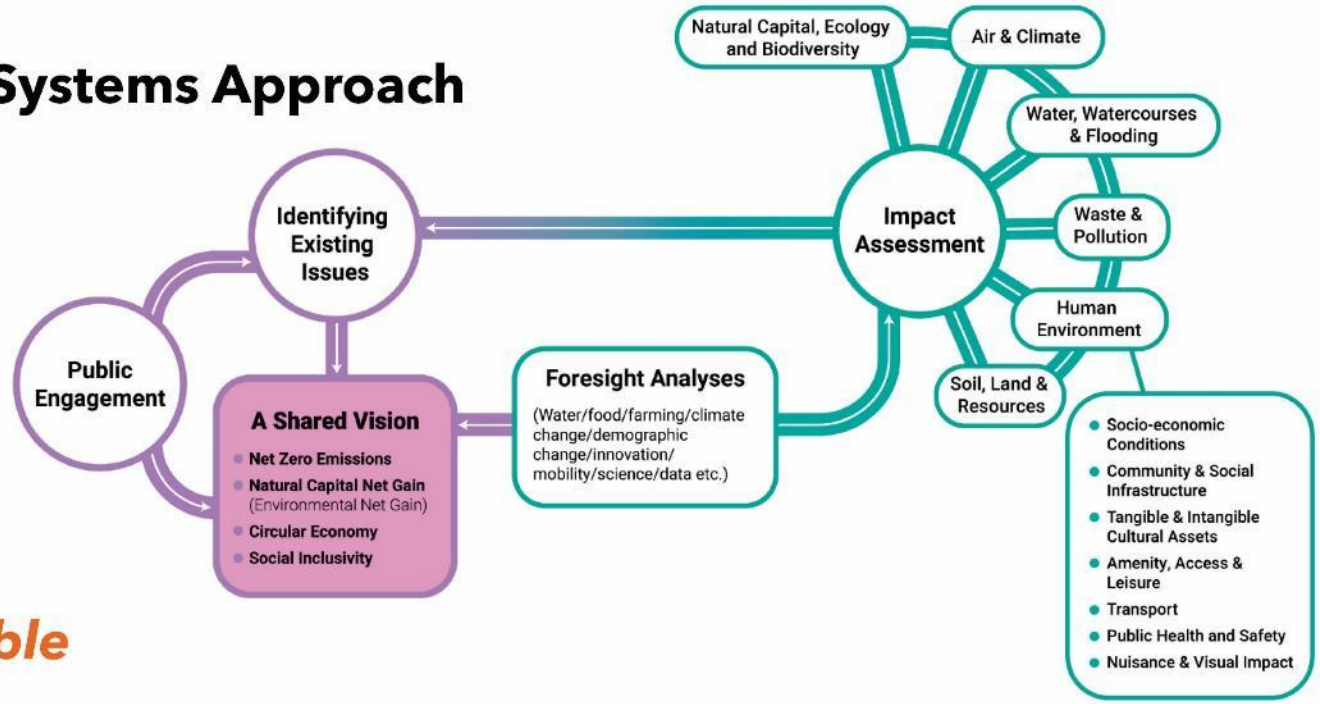
From Data – Information – Knowledge to Wisdom

What questions to ask?

- A common spatial data environment – global and national level
- Regional & local data input
- Utilising space satellite technology
- Participatory GIS – realtime data
- Underground resource & assets – geothermal
- Climate change impact simulation
- Artificial Intelligence & various analytic tools
- Etc.

A New Methodology
– A Digitally Enabled Place-based Systems Approach

Stage 2: Creating a Shared Vision

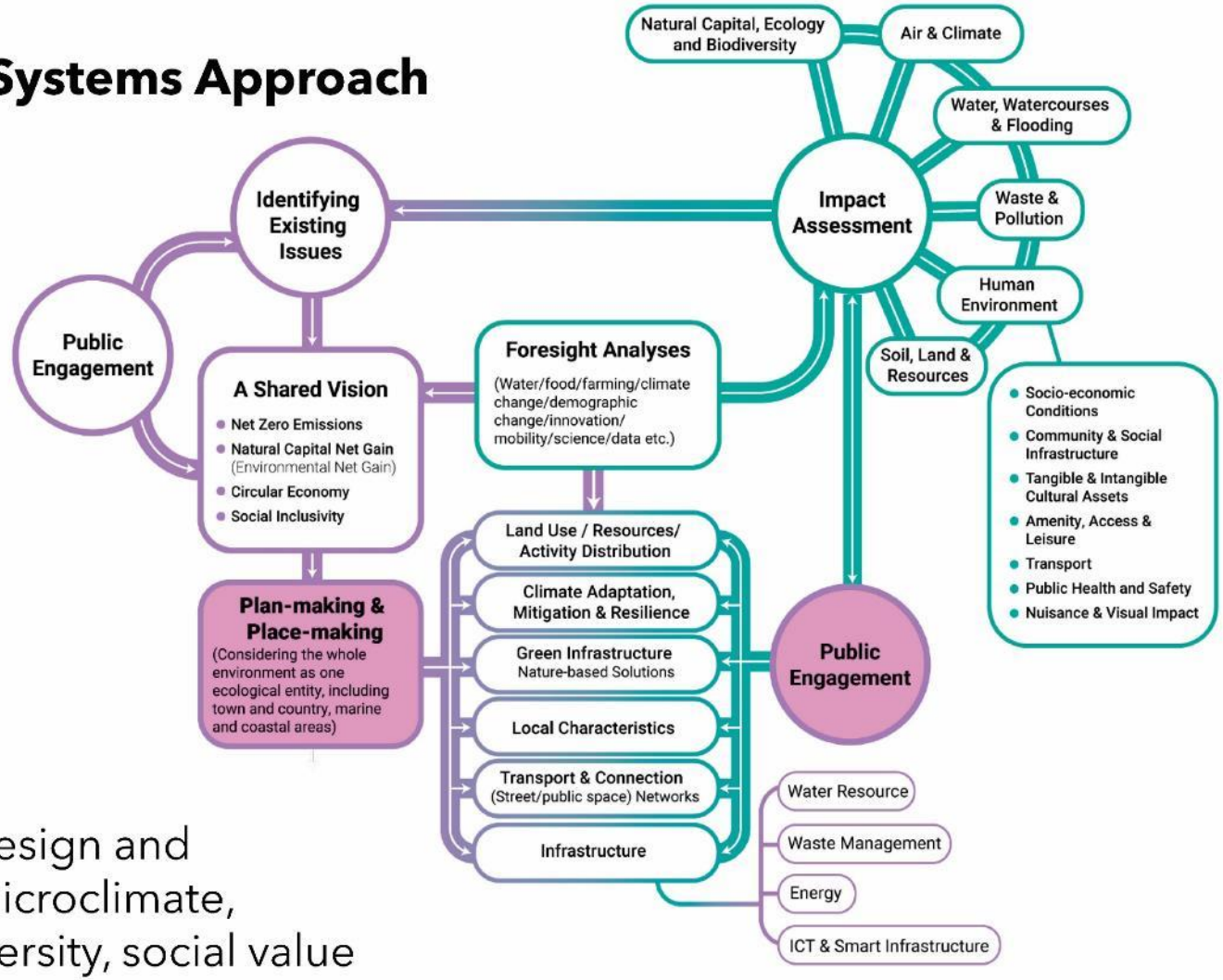


Interesting, Transparent, & Accessible

- Utilising GeoDesign approach
- Public participatory & engagement tools
- Visualisation, VR and AR
- Etc.

A New Methodology
– A Digitally Enabled Place-based Systems Approach

Stage 3: Plan-Making & Place-Making

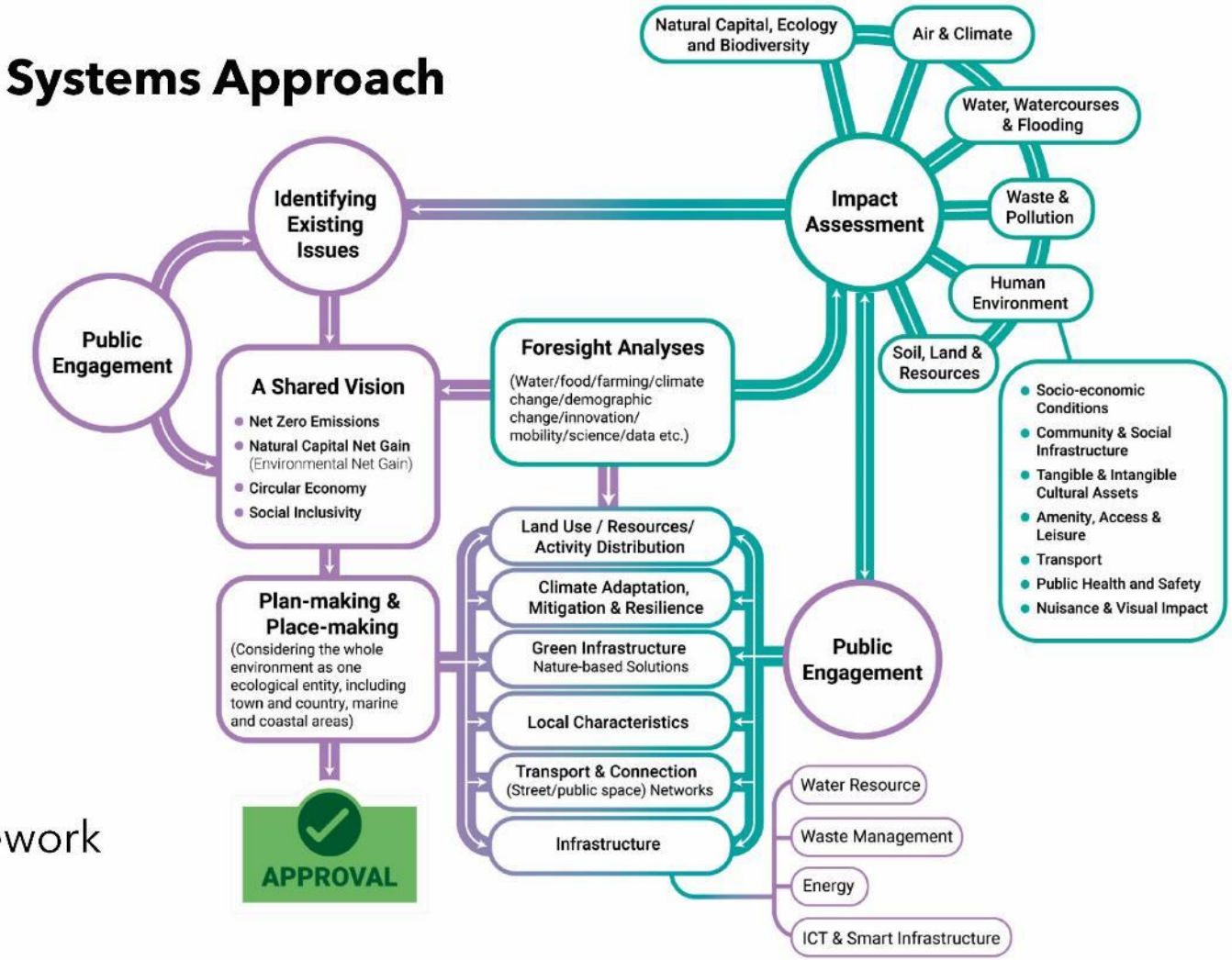


Co-Plan & Co-Design

- Participation and engagement tools
- Visualisation, CAD, VR and AR
- Analytic tools and models: scenario design and optimisation – walkability, transport, microclimate, renewable energy, retrofitting, biodiversity, social value and infrastructure, etc.
- BIM & digital twins
- Etc.

A New Methodology
– A Digitally Enabled Place-based Systems Approach

Stage 4: Approval



Evidence-based Decision Making

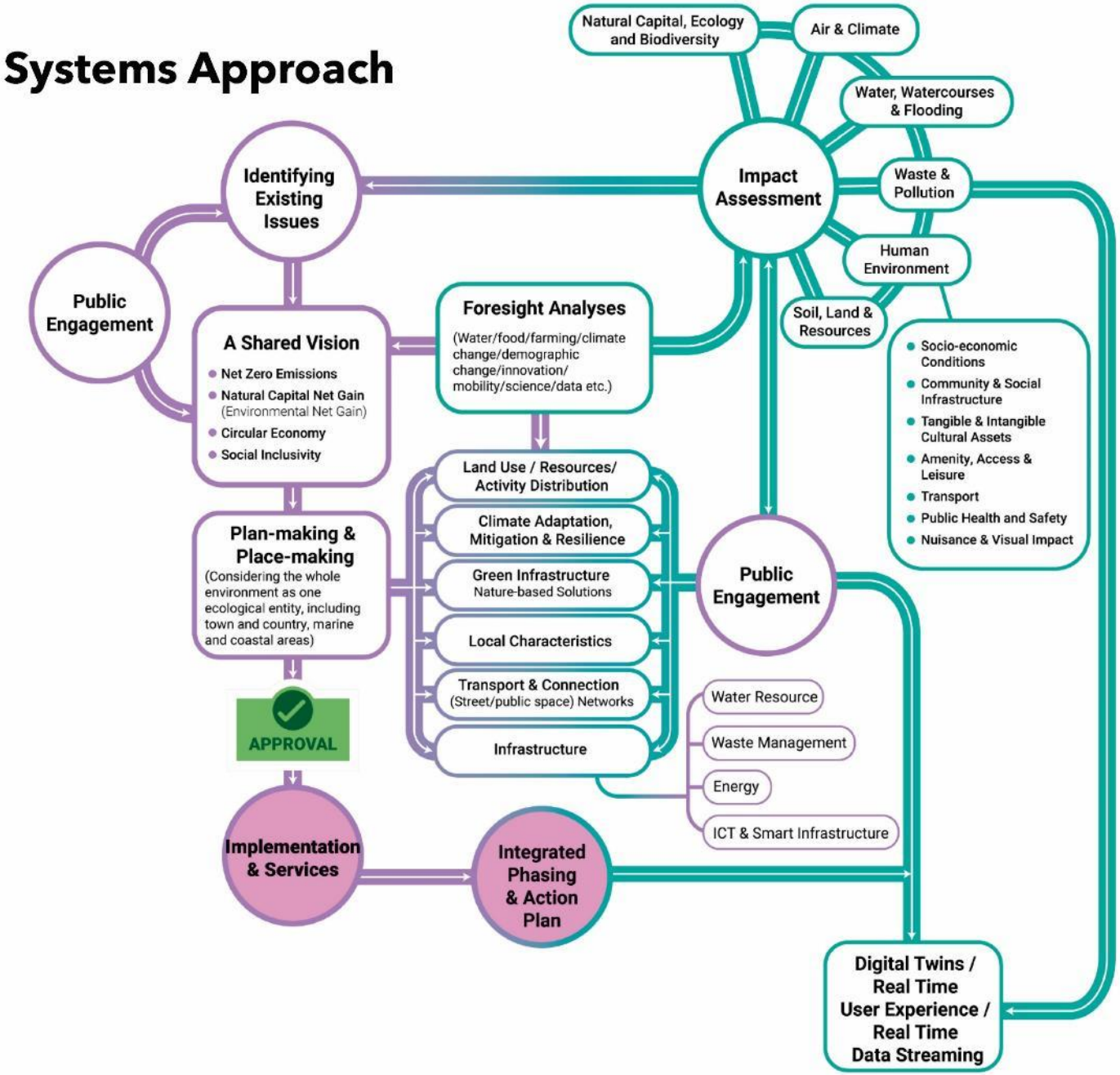
- Planning applications management
- Participation and engagement tools
- Integrated planning open data framework
- Etc.

A New Methodology
– A Digitally Enabled Place-based Systems Approach

Stage 5: Implementation & Services

An Integrated Systems Approach

- Database & information systems
- BIM & digital twins
- Real-time data streaming
- Etc.

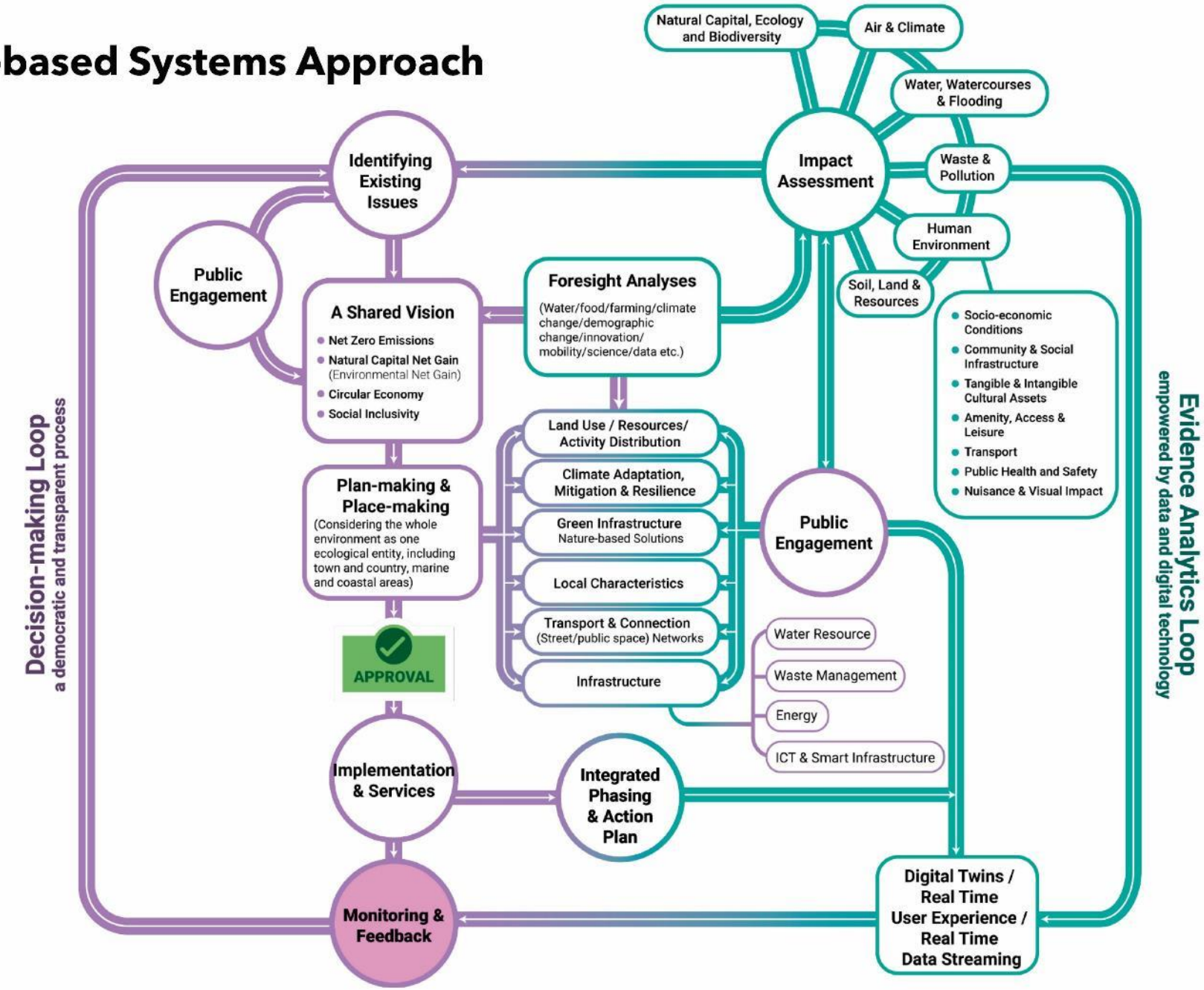


A New Methodology
– A Digitally Enabled Place-based Systems Approach

Stage 6: Monitoring & Feedback

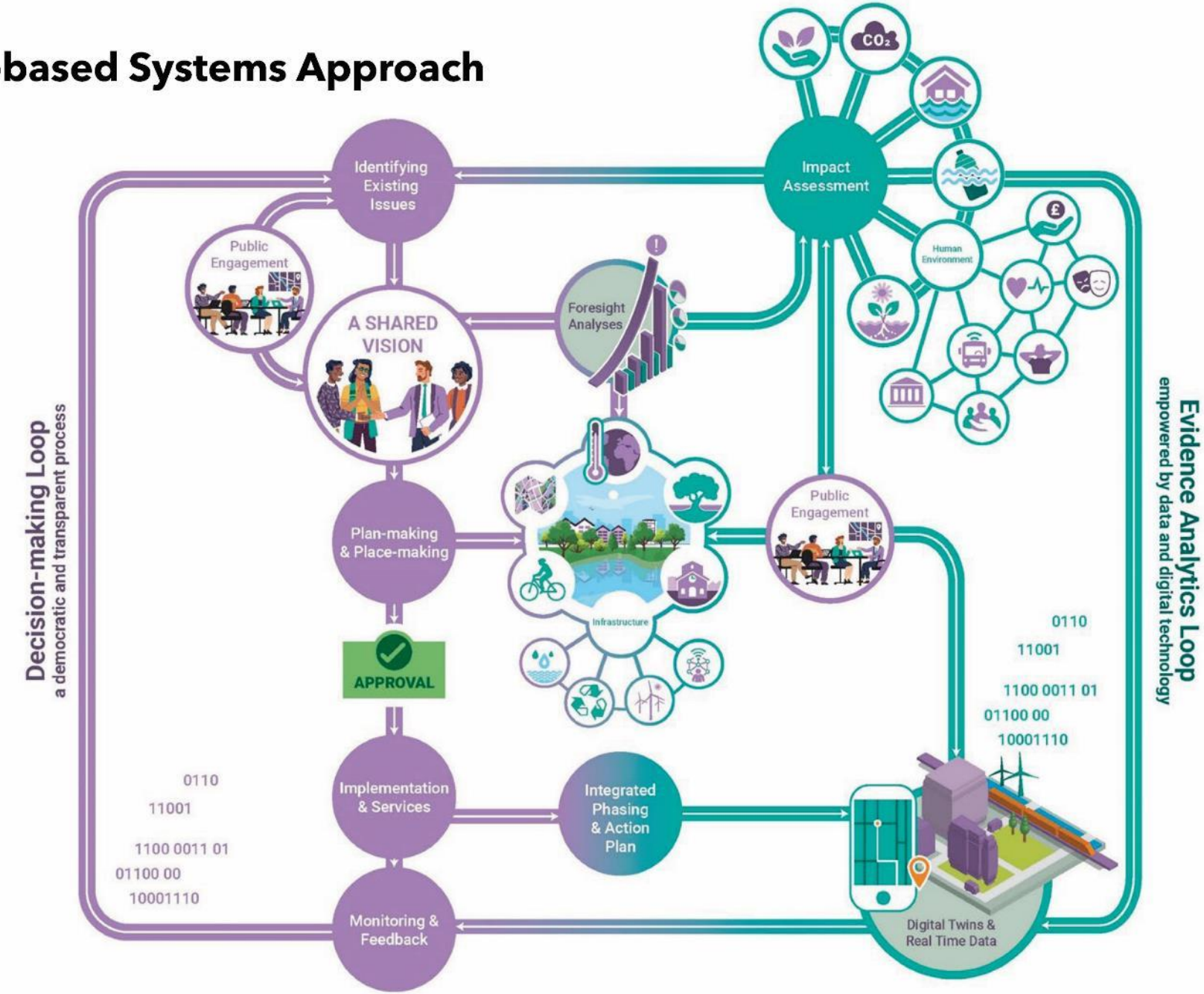
Interconnected Loops

- Database & information systems
- BIM & digital twins
- Participatory GIS
- Public engagement
- AI, user experience & performance real-time data streaming
- Etc.



A New Methodology
– A Digitally Enabled Place-based Systems Approach

A people focused, scientifically based, and digitally enabled decision-making process



Digital Task Force for Planning

Digital Task Force for Planning

The Task Force's First Stage work as an Independent Expert Panel (2021-2022)

The big question asked: ***"What should be done now to make our world a better place for our future generations through achieving a universal common good?"***

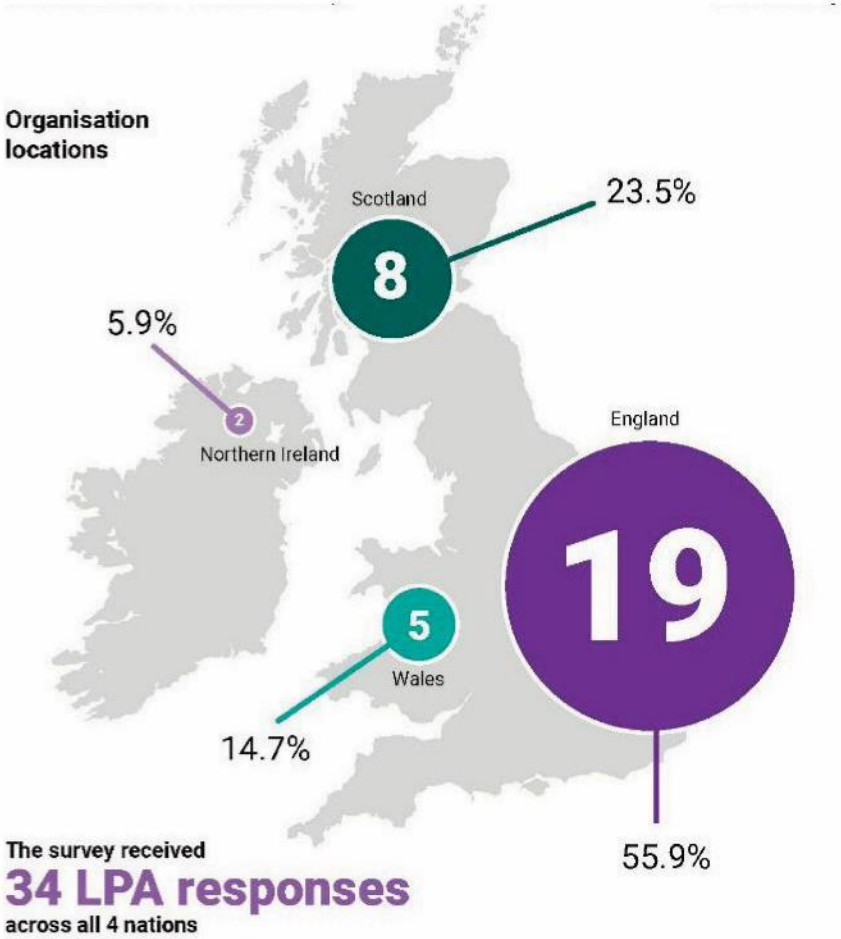
During 2021, the Task Force carried out a comprehensive cross-sector consultation programme, involving local and national government departments, agencies dealing with the natural and built environment, digital technology, public health, and higher education.

A Digital Future for Planning – Spatial Planning Reimagined (Batty & Yang, 2022)

https://digital4planning.com/

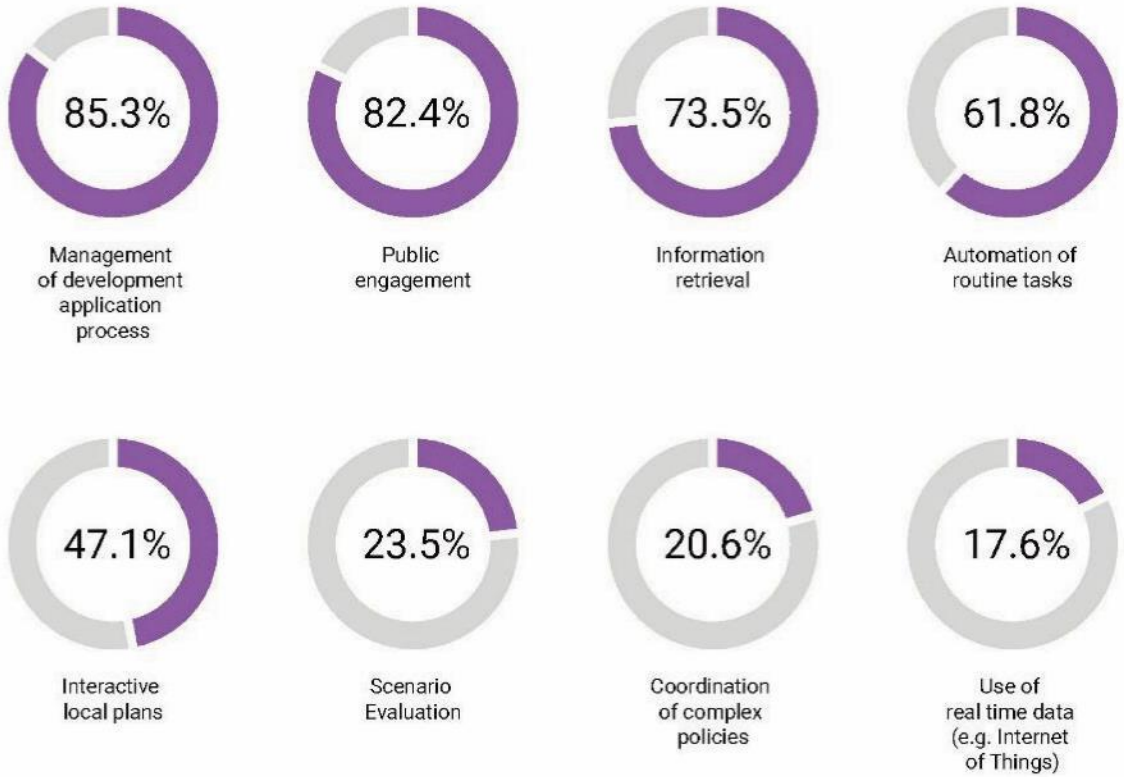
The Status of Digital Integration in Local Planning Authorities

Digital Task Force for Planning



The survey received
34 LPA responses
across all 4 nations

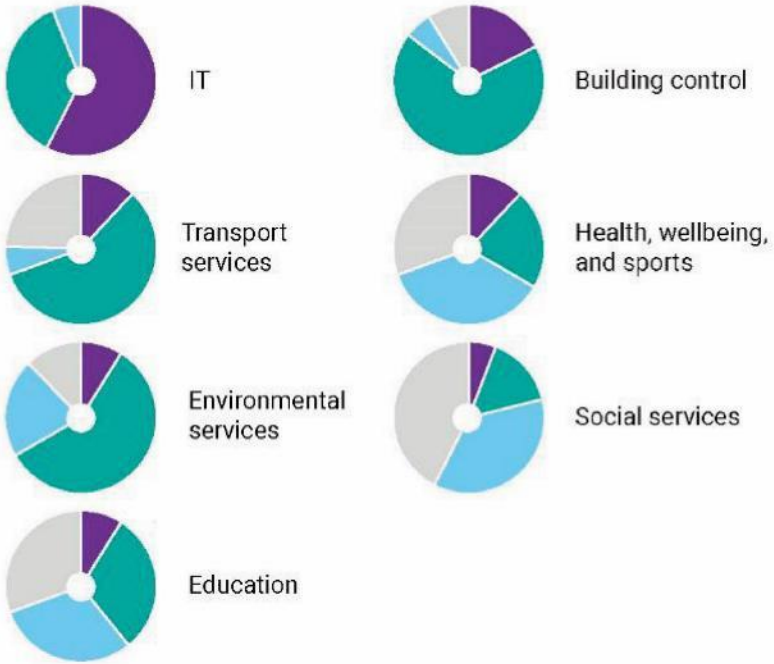
How are digital planning tools used within your organisation?



The Status of Digital Integration in Local Planning Authorities

Digital Task Force for Planning

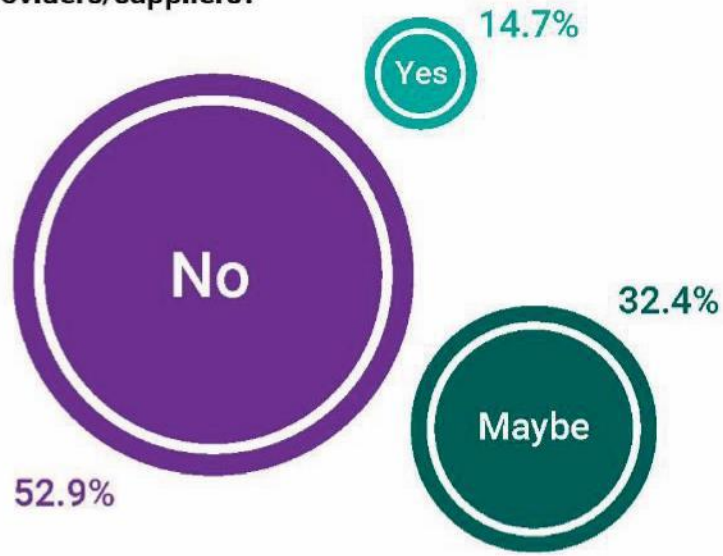
To what extent do you interact with other divisions of the local authority specifically on digital issues or shared data?



What challenges do you face when acquiring data?

>50% of the councils responded that they **do not** link planning application data with Local Development Plan preparation

Do you feel your organisation has sufficient staffing resource/capacity within the planning department to process current levels of applications and engage with existing service providers/suppliers?



Our Recommendations

1 Recognising the Vital Role of Spatial Planning as an Important Applied Science Discipline where Its Digital Transformation has the Potential to Tackle the Grand Challenges

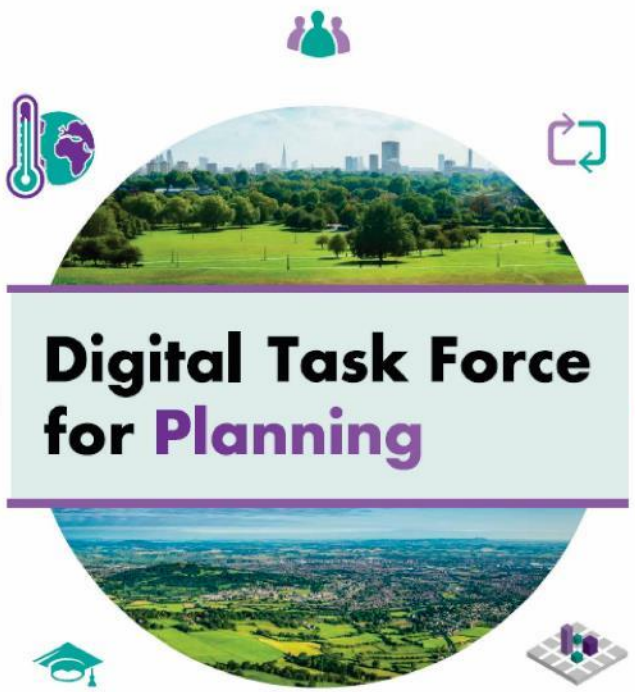
To maximise the potentials of digital transformation by establishing the key links between the grand challenges, the planning profession as an applied science discipline, and the continued development of new technologies and data.

2 Establishing a Chief Spatial Planning Officer Role in the Cabinet Office

To recognise the national significance of spatial planning for joined-up governance and to reinforce leadership in addressing the challenge of moving towards a more sustainable world.

3 Implementing an Integrated Digitally Enabled Spatial Planning Methodology

To create a digitally enabled cyclic system in planning through connecting the decision-making loop and the evidence analytics loop.



4 Establishing a Central Resource and Delivery Body to Empower Cross-Sector Innovation, and to Develop and Implement Digital Planning

To form a central resource and delivery body to lead the implementation of digital planning methodology as part of the levelling up agenda. The organisation will be responsible for coordinating the development of core digital capacities by setting up a national network of 'regional data observatories', promoting digital tools and technologies being mobilised in planning.

5 Creating a Comprehensive Mapping System, a Common Spatial Data Environment, and a Basic Set of Analytic Functions Tailored to Plan-Making

To establish an open data platform which integrates national data sources, development data, comprehensive mapping and associated analytic tools: focused on 1) Identifying Baseline Data; 2) Defining Consistent Spatial Data Standards; 3) Data Licensing, Security, and Confidentiality; 4) Establishing Common Datasets and Improved Monitoring; and 5) Developing Analytics for Better Local and Strategic Planning.

6 Establishing a Chief Spatial Planning Officer Role in Every Local Authority

To build and restore stronger leadership in spatial planning at the local level and to develop integration between local authority services using a whole systems approach.

7 Investing in Digital Planning and Forging an Ecosystem between Planning Research, Practice, Education, and Lifelong Learning

To integrate and invest in new forms of digital training and education in spatial planning through research, professional education, practice and lifelong learning, engendering a culture change in planning profession.

8 Developing a National Cross-Departmental Strategy for Digital Planning

To develop a national strategy to implement the digital transformation in planning enabled by a cross-departmental culture change. This should involve training in digital skills to support processes of levelling up and joining up across different planning agencies.

Digital Task Force for Planning

The Core Digital Capacities Required:

Data, Platforms, Tools, and Techniques

Digital Task Force for Planning

- **A Common Spatial Data Environment – National Mapping and Datasets**
- **A National Network of 'Regional Data Observatories' – Regional Data Input**
- **An Integrated Planning Open Data Framework – Input Data for Planning**
- **Planning Metadata and Information Management Standards**
- **Digital Tools and Techniques**
  - Data Bases, Information Systems and GIS Technologies
  - Analytic Tools and Models: Evaluation, Scenario Design, and Optimisation
  - Participation and Engagement
  - Visualisation, CAD, VR and AR
  - Planning Applications Management

Impact of the Digital Task Force for Planning

Digital Task Force for Planning

Over

14,000

website page views

From

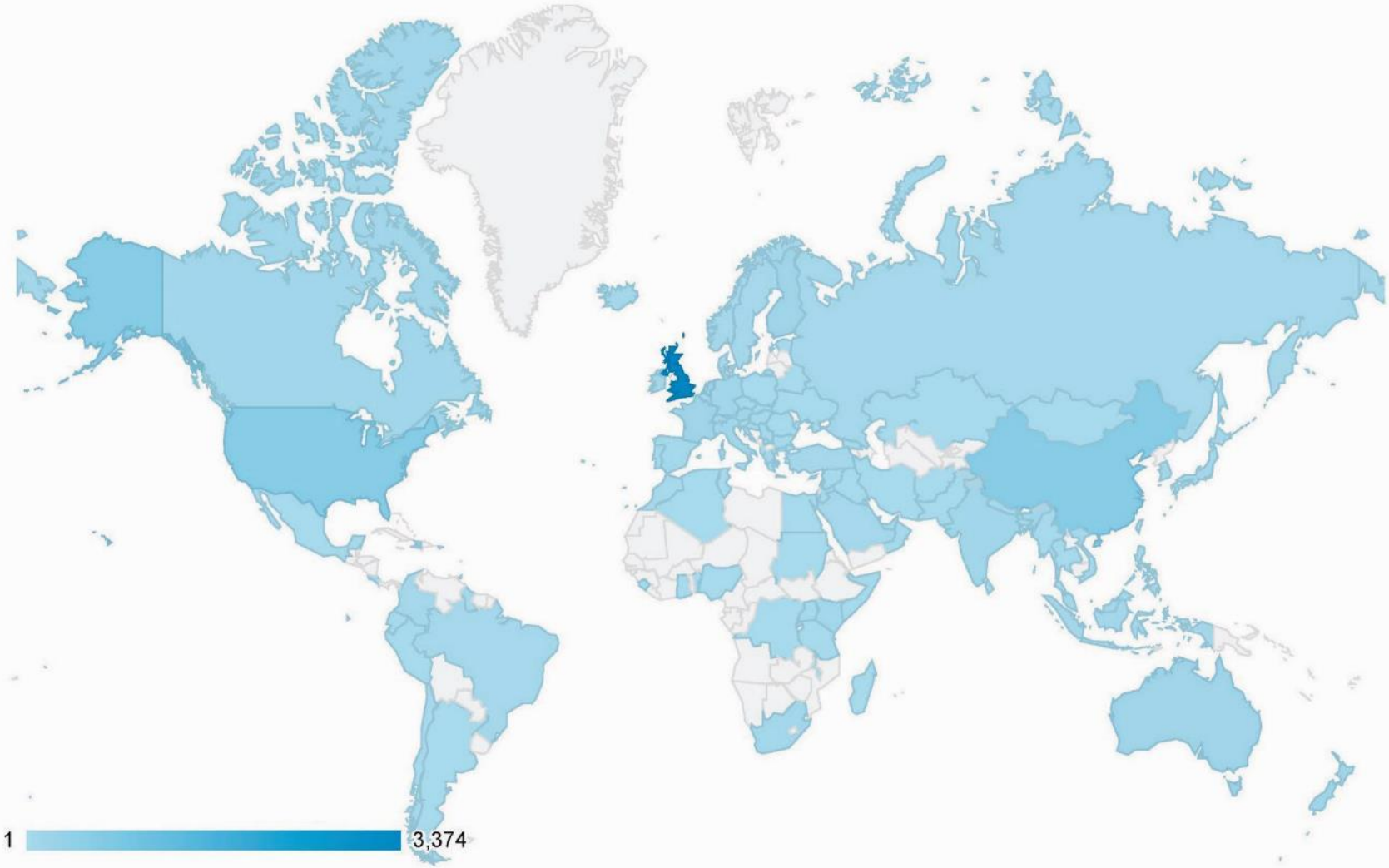
109

countries

Over

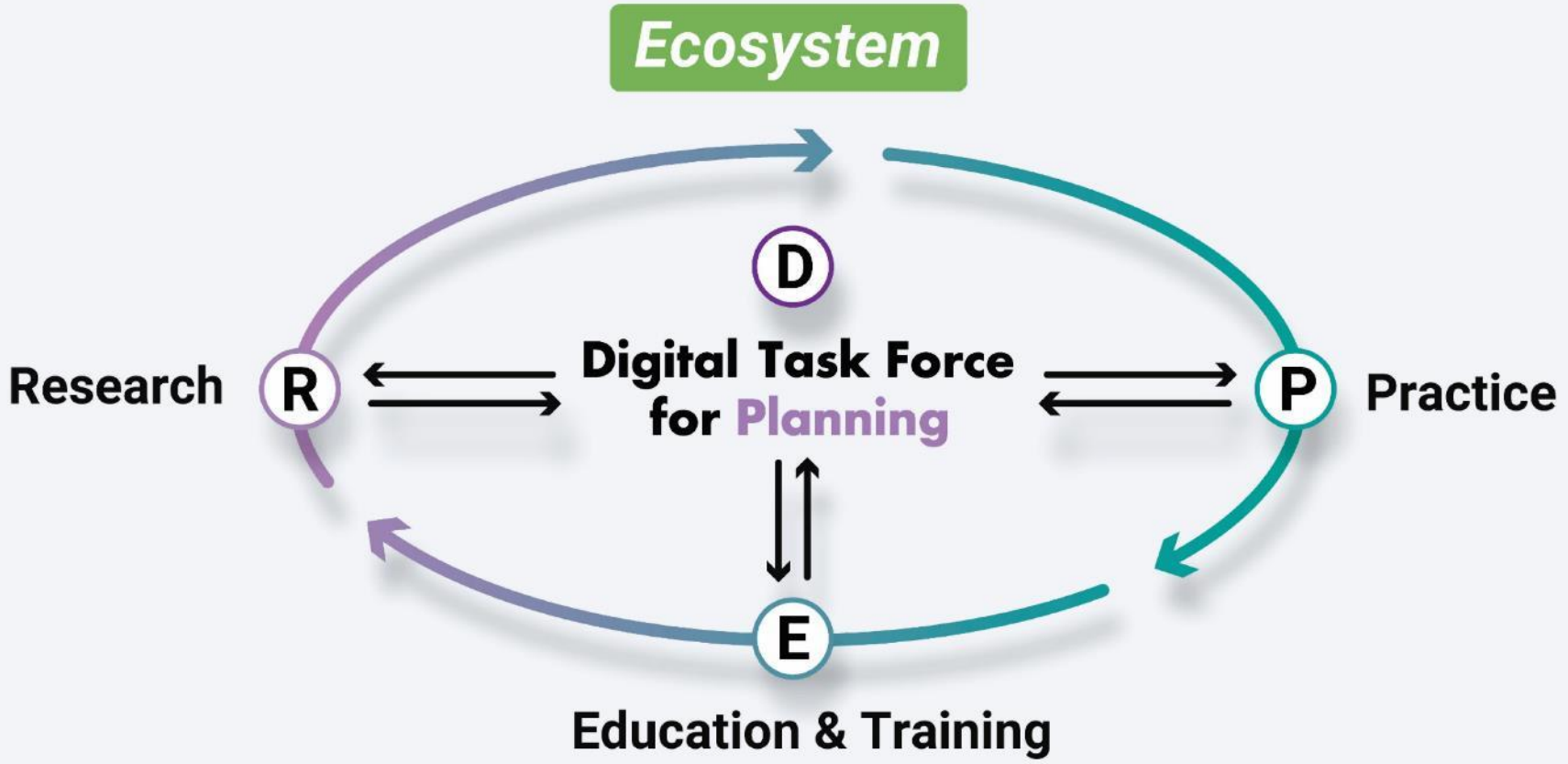
42,000

views of the Report



A New Venture of the Task Force - an Innovation-Led Social Enterprise

The Task Force focuses on the **Development part of R&D** - as a convenor, facilitator and enabler of digitalisation in mainstream planning practice & education to support the establishment of an integrated ecosystem for spatial planning innovation.



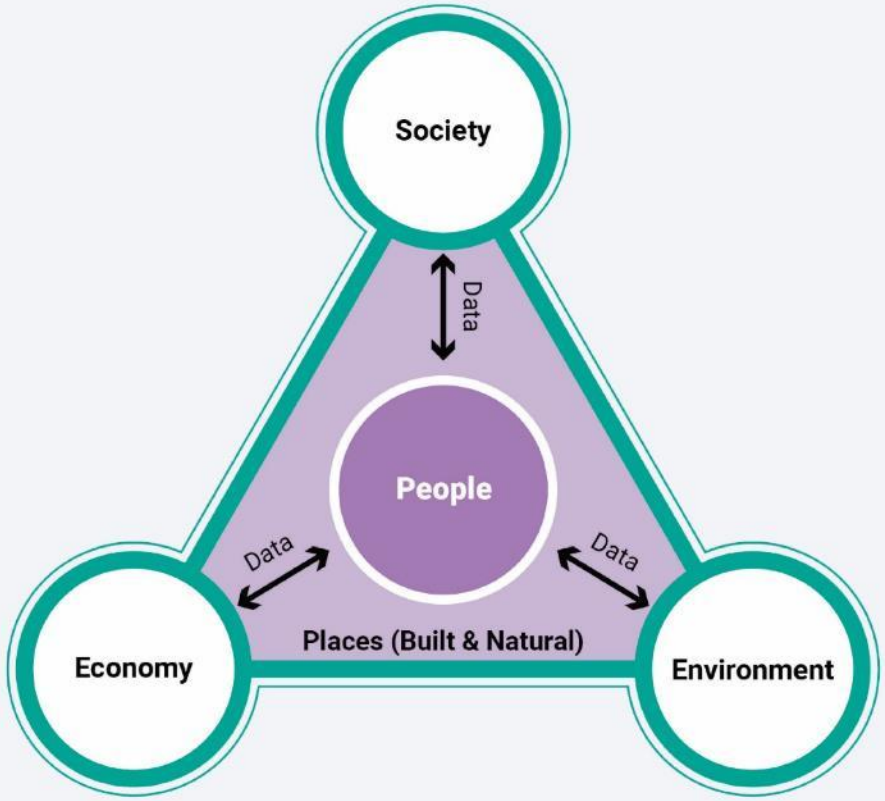
Key Offer as a Social Enterprise – a Digital 'National Trust'

Digital Task Force for Planning

The first of its kind in the world

Research outcomes will be made open source

- **Consolidating** existing digital planning research and tools, **identifying** research gaps, and **developing** practical solutions to systematically transform spatial planning practice to tackle the grand challenges in the 21st Century
- Digital Planning **Training**
- **Capacity building** promoting best practice through **publication, seminars, training, conferences, and awards**
- **Incubator** of digital planning innovation



An Integrated Digitally Enabled Approach to Spatial Planning

Recognition and Partnerships

UKCRIC™

UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES

GEOVATION from Ordnance Survey

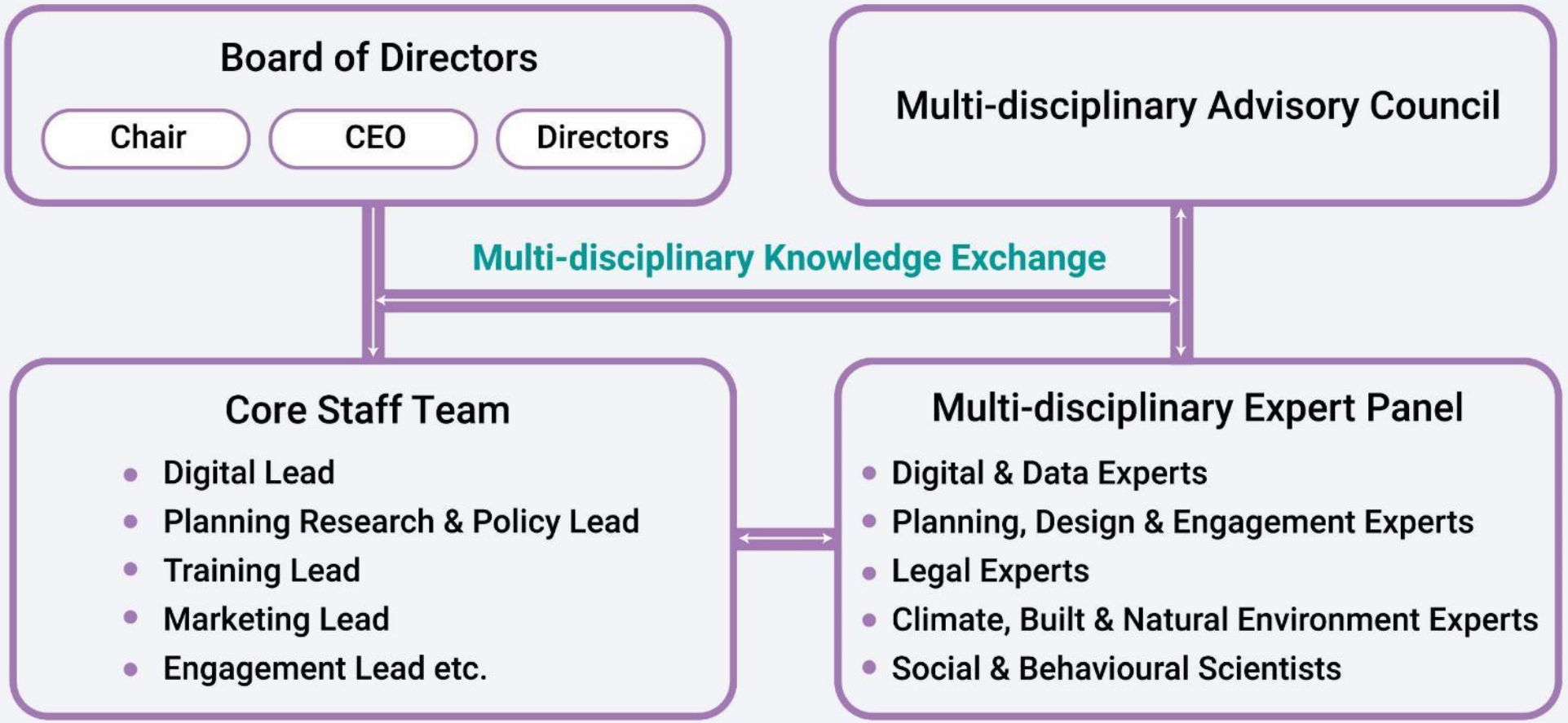
HM Land Registry

SPRING 2023

GEOVATION ACCELERATOR PROGRAMME MEMBER: PROPTECH

- Supported by the Geovation Accelerator Programme (by Ordnance Survey and LM Land Registry)
- UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC) – MOU Signed
- Centre for Postdoctoral Development in Infrastructure, Cities and Energy (C-DICE) – MOU signed

Organisational Structure to be Developed



OUR VISION

Seize the rapidly closing window of opportunity to steer the world back onto the correct trajectory.


If not us, WHO?
If not now, WHEN?

We invite you to be a part of our journey as we pioneer a way forward

Please get in touch:

Dr Wei Yang

Email: wyang@digital4planning.com

DAFNI

CONFERENCE 2023

IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Invited Speaker:

Standards in Practice - Embedding Resilience in Infrastructure

Russell Price

International Standards Organization:
Chair of ISO Technical Committee TC262

www.dafni.ac.uk

UKRI Science and Technology Facilities Council

UKRI Engineering and Physical Sciences Research Council

UKCRIC

Standards in Practice

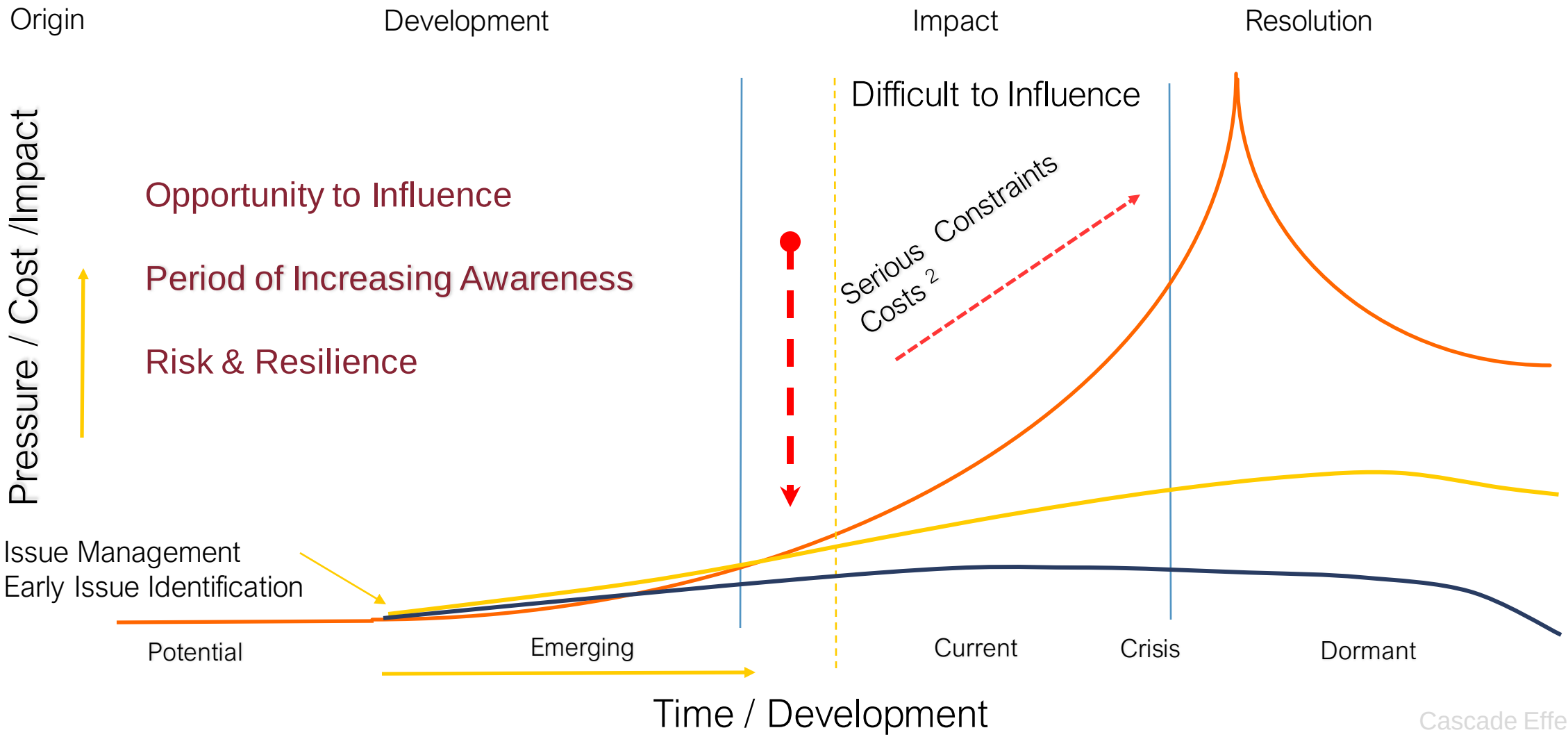
Embedding Resilience in Infrastructure

Russell Price
ISO Risk Management
Technical Committee Chair

Who are ISO?

- Founded in 1948, ISO is the worlds largest publisher of international standards covering 170 countries. It is an NGO and is based in Geneva.
- ISO provides a bridge between public & private sectors. Many of its members are part of government.
- ISO builds a consensus that aim to meet the needs of business and broader society.
- A critical component to World Trade Organization rules & national standards, regulation and legislation

Risk & Resilience Life Cycle



Landscape and Context

Development of standards

Business Continuity

Crisis Management

Information Technology & Security

Physical Security

Governance

Risk Management

Organizational Resilience

Disaster Recovery

Compliance & Regulation

Emergency Management

Bigger picture

Resilience: a quality of an organisation to 'keep going'

CAPABILITIES, e.g:

- Anticipation
- Response
- Adaptation
- Recovery
- Learn and Improve

ACTIVITIES, e.g:

- Risk management
- BCM
- Contingency planning
- Supply chain mgmt

ATTRIBUTES, e.g:

- Organisational culture
- Strategic insight
- Informed decision-making
- Adaptability
- Strong leadership

PRINCIPLES, including:

- Clarity and focus on why the organisation exists, its core values & value generating activities
- Commitment to resilience as a core value across the organisation
- Normalise risk and resilience thinking and planning at the team level
- Leadership and managerial commitment – engagement, teamwork and collaboration

Bigger picture

Protecting the future

How standards are changing and evolving

- Business Continuity
  - ✓ ISO 22301:2018
  - ✓ ISO 22313:2018
- Organizational Resilience
  - ✓ ISO 22316:2017
  - ✓ BS 65000:2022 Building on good practice
- Risk Management
  - ✓ ISO 31000:2018
  - ✓ IEC 31010:2019
  - ✓ ISO Guide 73:2009 & ISO 31073
  - ✓ ISO 31022 Legal Risk Management

Building insight and information to create and preserve value in society

Probability

We need an ISO on Resilient Infrastructure

Better information and improved national planning for critical infrastructure

- There currently are no ISO standards on resilient infrastructure
- Creates common understanding and consensus on “resilient infrastructure”
- Infrastructure investment and planning do not take into account the systems approach or complex nature of risks
- Infrastructure systems and the services they provide are increasingly being affected by natural and man-made hazards

ISO 22372 Resilient Infrastructure —Guidelines

Probability

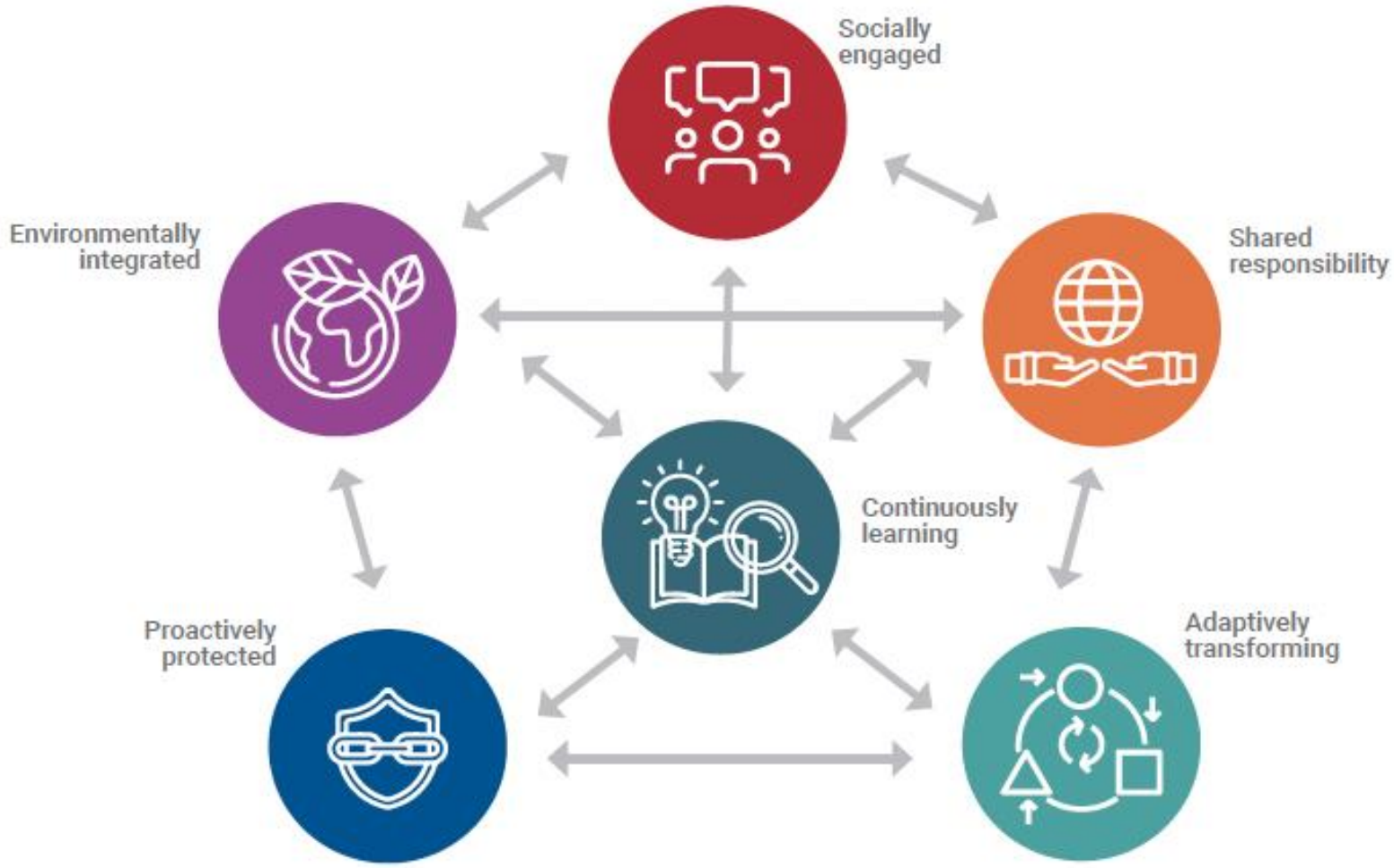
Foundations for success

Handbook for Implementing the Principles for Resilient Infrastructure

UNDRR UN Office for Disaster Risk Reduction

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

SUSTAINABLE DEVELOPMENT GOALS



Summary & Questions

Contact | russell.price@continuityforum.org Phone | +44 (0) 7770 666004

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CONFERENCE 2023

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BUILDING A SECURE AND RESILIENT WORLD

The DAFNI team will be in the foyer to provide demonstrations of the platform and answer any questions you may have.

Slido - #2299756

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Centre of Excellence Speaker:

STORMS - Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks

Dr Xilin Xia

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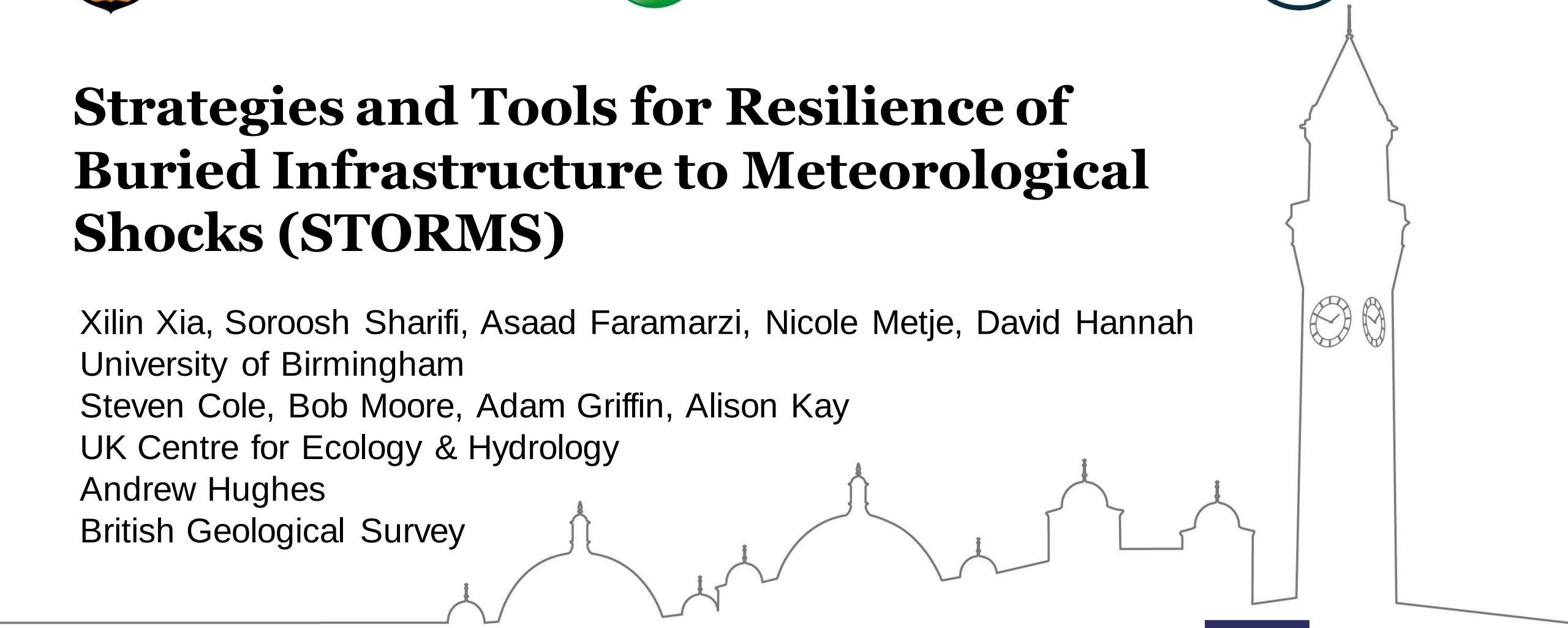
Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks (STORMS)

Xilin Xia, Soroosh Sharifi, Asaad Faramarzi, Nicole Metje, David Hannah
University of Birmingham
Steven Cole, Bob Moore, Adam Griffin, Alison Kay
UK Centre for Ecology & Hydrology
Andrew Hughes
British Geological Survey



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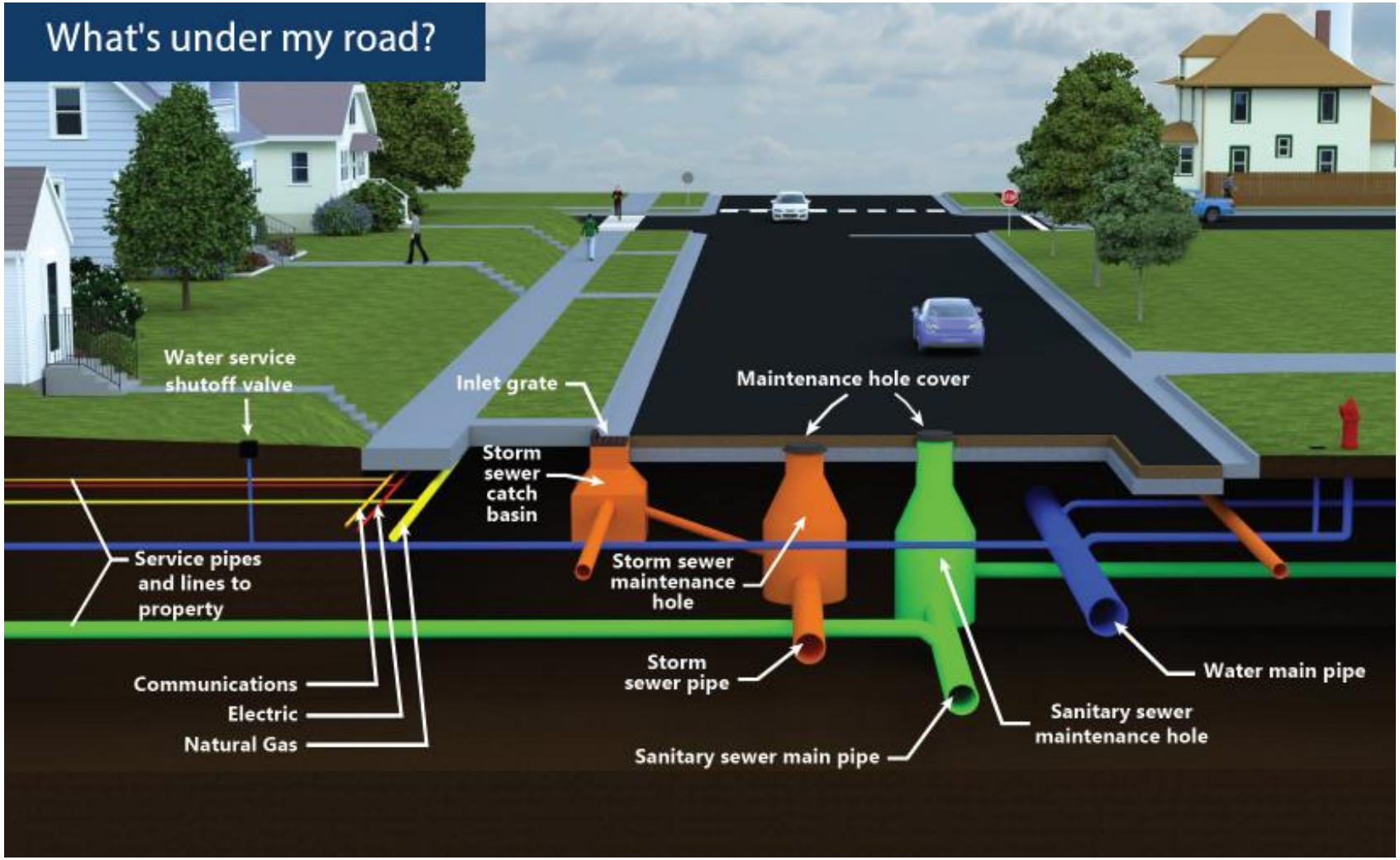
Imperial College London

Buried Infrastructure



Buried infrastructure provides essential services: Water, Energy and Communication

Impacts from extreme weather events

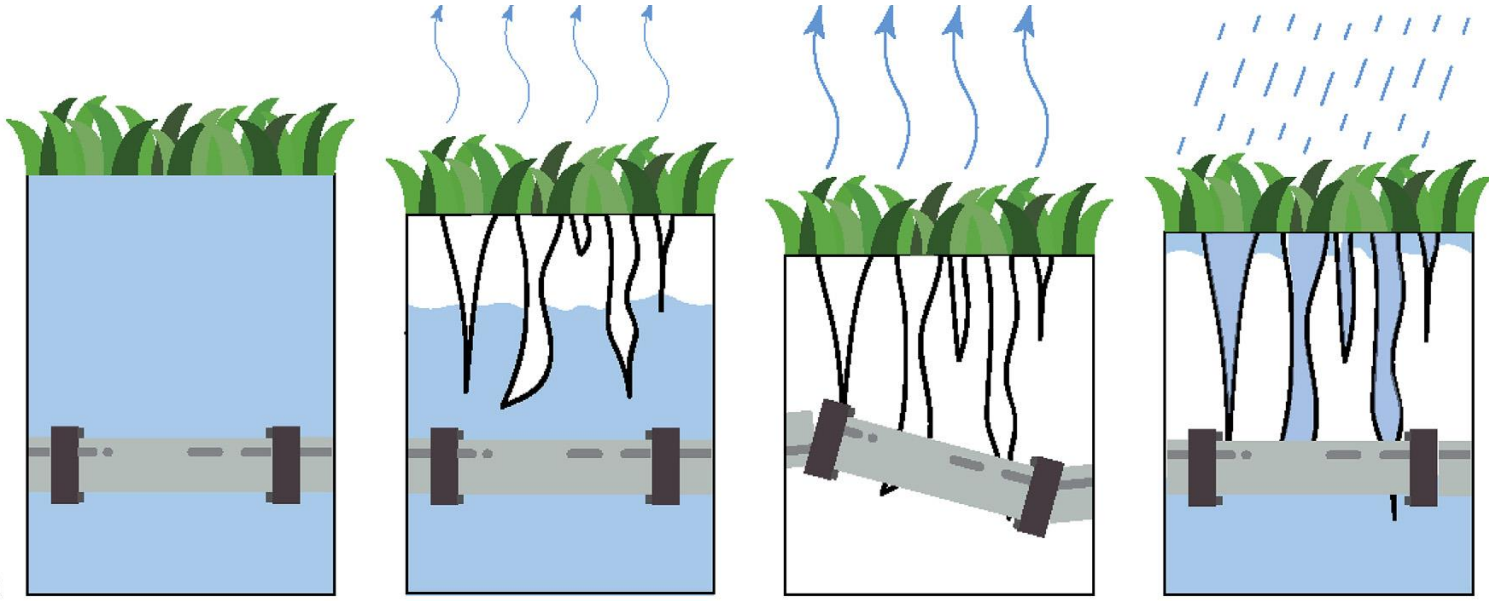
- Buried infrastructure is vulnerable to extreme weather events.
- The 2015/16 UK winter floods caused over **£100 million** in direct damages to utilities.
- The storm surge of Hurricane Sandy in 2012 caused more than **$10 billion** in damage to the underground infrastructure of New York.
- Damages to buried infrastructure is costly – over **£2.4 billion** per year.

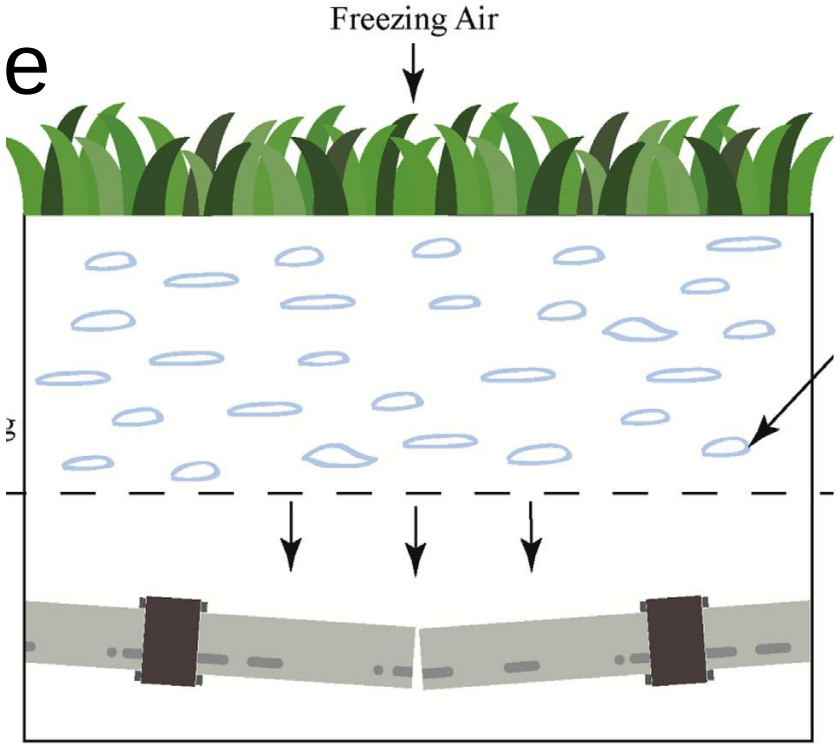
Impacts from extreme weather events

- Extreme floods
  - Wash-off
  - Sinkhole
  - Uproot of trees
  - Loss of bearing

Impacts from extreme weather events

- Wet-Dry Cycle and Freeze-Thaw Cycle
  - Differential soil movement (Swelling and Shrinkage)
  - Breakage of rigid pipes





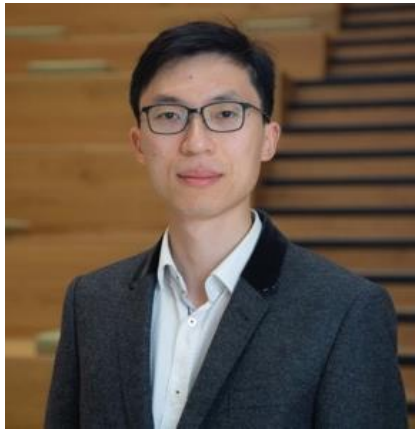
Barton at al. (2019)

Aim of STORMS project

- How a significant weather event, or 'shock', impacts the UK's buried infrastructure remains unclear
  - Likely and relevant weather/climate scenarios
  - Spatial and temporal distributions of impacts
- There is no established broad-scale risk assessment tool for buried infrastructure involving
- Our aim is to develop a **comprehensive weather-related risk assessment framework** to understand the potential impacts of scenarios under both current and future climate.
- Co-develop **adaptation measures** with stakeholders to increase resilience to extreme weather events and Climate Change.

STORMS team

University of Birmingham



Dr Xilin Xia

Dr Soroosh Sharifi

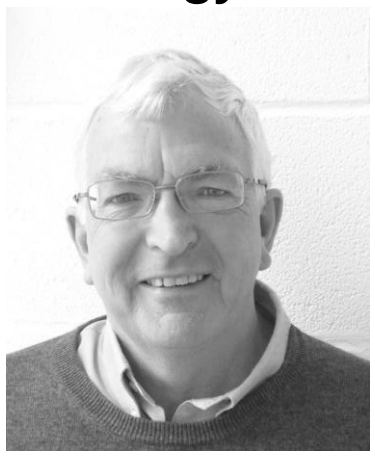
Dr Asaad Faramarzi

Prof Nicole Metje

Prof David Hannah

UK Centre for Ecology & Hydrology

Dr Steven Cole



Mr Bob Moore

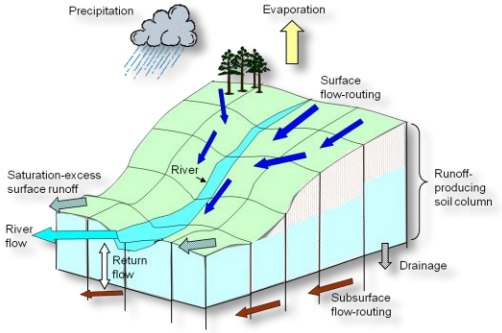
Dr Adam Griffin

Dr Alison Kay

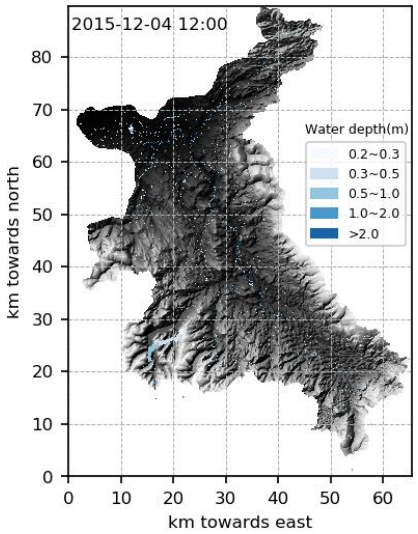
British Geological Survey

Dr Andrew Hughes

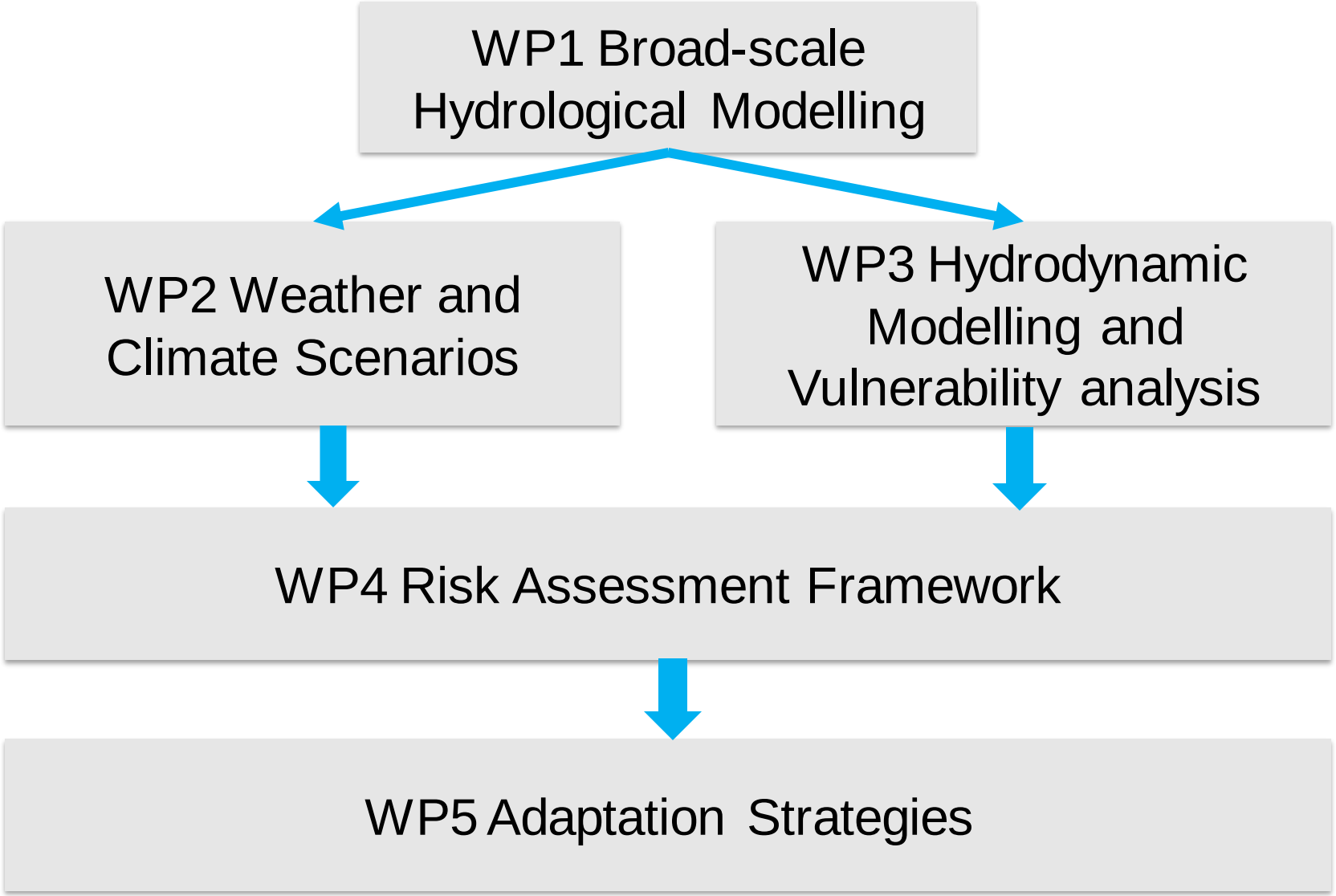
Models and Data



- UKCEH's Hydrological Model G2G – operational model for national flood forecasting across Great Britain
- Open-Source Hydrodynamic Model HiPIMS – a key flood model on DAFNI
- National Hydrological and Geological Datasets from UKCEH and BGS
- Experimental Datasets and Digital Twin from National Buried Infrastructure Facility– a £30M investment
- Asset datasets from industry partners: LSBUD, Northumbria Water, Thames Water



Work Packages



Key Deliverables and Impacts

- Risk assessment workflow on DAFNI for Buried Infrastructure
  - Extreme weather and hydrological scenarios and workflow for generating them
  - Multi-hazard hydrodynamic model (flood/landslide/entrainment)
  - Fragility curves for buried infrastructure assets
- Report for co-designed resilience and adaptation strategies
- Anticipated impacts
  - Enhanced decision-making
  - Guidance for climate adaptation
- Infrastructure on the ground can be benefited too

Stakeholder engagement

- We will engage widely: *Academia, Industry, Government Agencies, General public, International partners, other DAFNI-supported projects*
- A range of activities are planned:
  - Adaptation workshops
  - DAFNI training workshops
  - Outreach Activities
  - …

UK Research and Innovation

Thank you!

Email: x.xia.1@bham.ac.uk

UNIVERSITY OF BIRMINGHAM

UK Centre for Ecology & Hydrology

BGS British Geological Survey

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Centre of Excellence Speaker:

Pywr-Wrew - A Water Resources model for England and Wales built in Python water resources simulation system

Dr Anna Murgatroyd

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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

OPSIS Oxford Programme for Sustainable Infrastructure Systems

DAFNI Data & Analytics Facility for National Infrastructure

Environment Agency

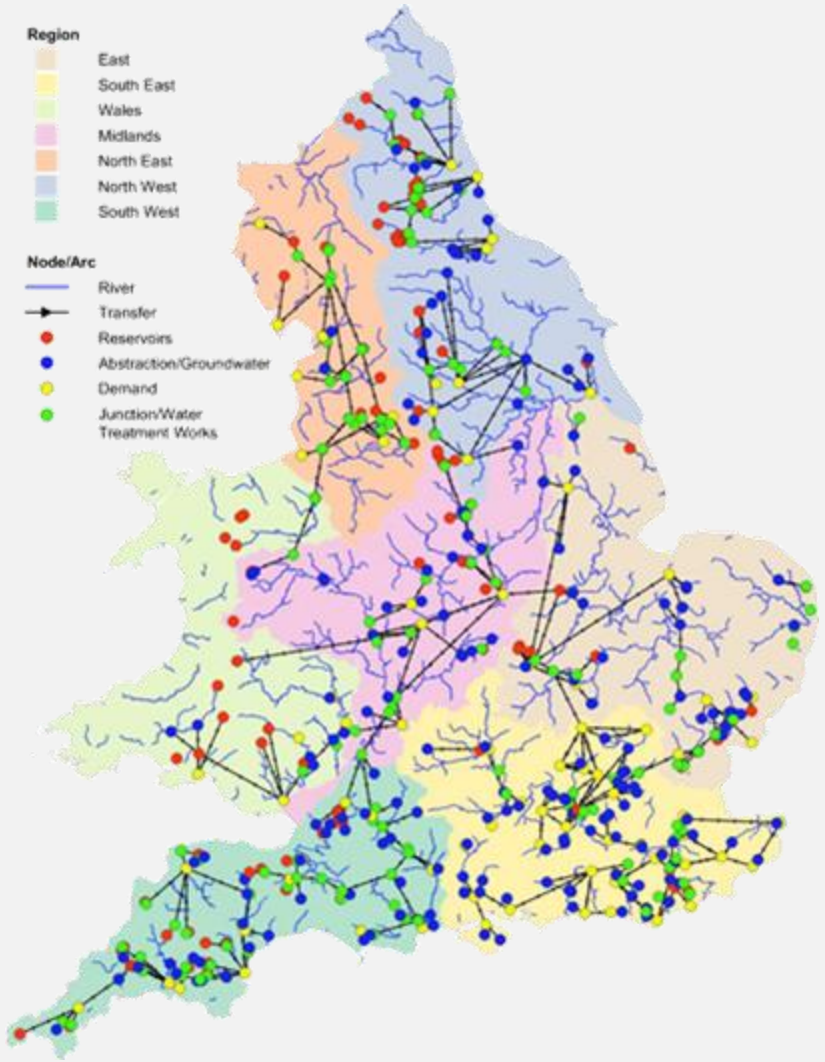
eci

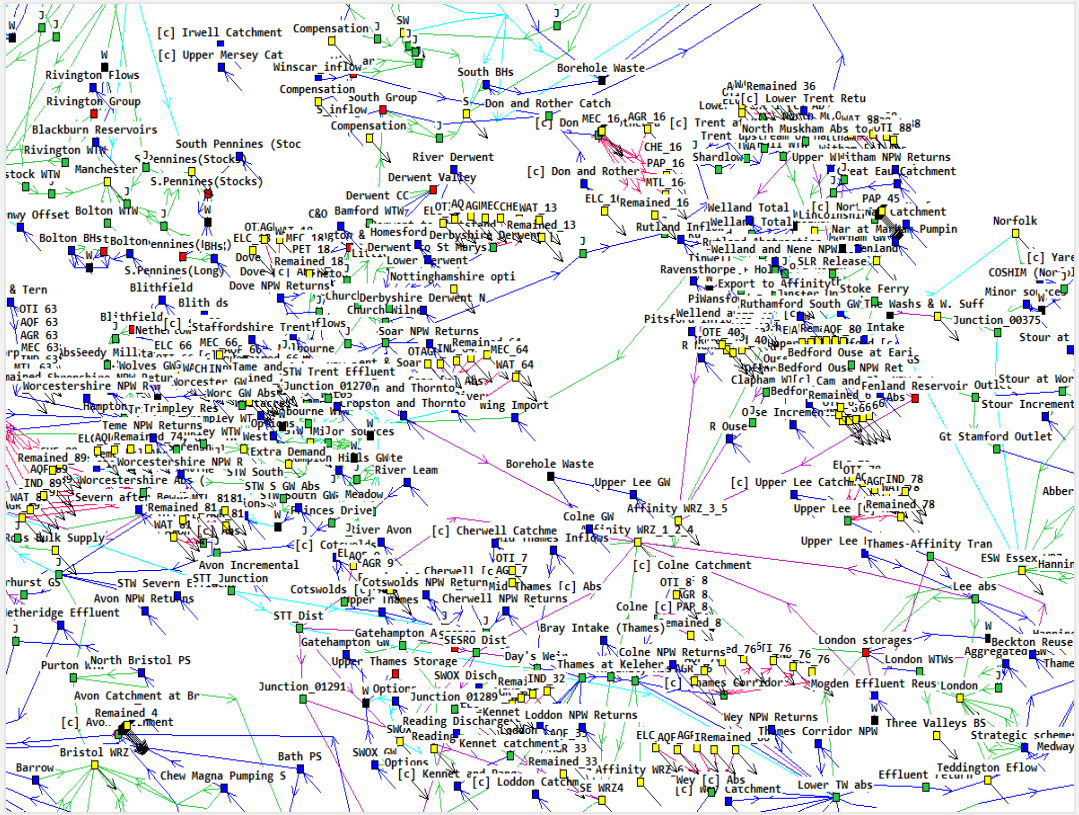
UNIVERSITY OF OXFORD

From WREW to Pywr-WREW

- What we've done
  - Developed and used WREW in the proprietary Wathnet framework (Kuczera 1992).
  - Assessed future drought risk and evaluated possible strategic infrastructure options, with England's Environment Agency, OFWAT and water utilities.
- What's needed
  - Continual improvements in communication and understanding of the national model in comparison with regional water company models, by regulators and companies.
- What's next
  - Rebuild the WREW model formulation on the open-source Python framework, Pywr (Tomlinson, Arnott and Harou 2020).

Water Resources model for England and Wales

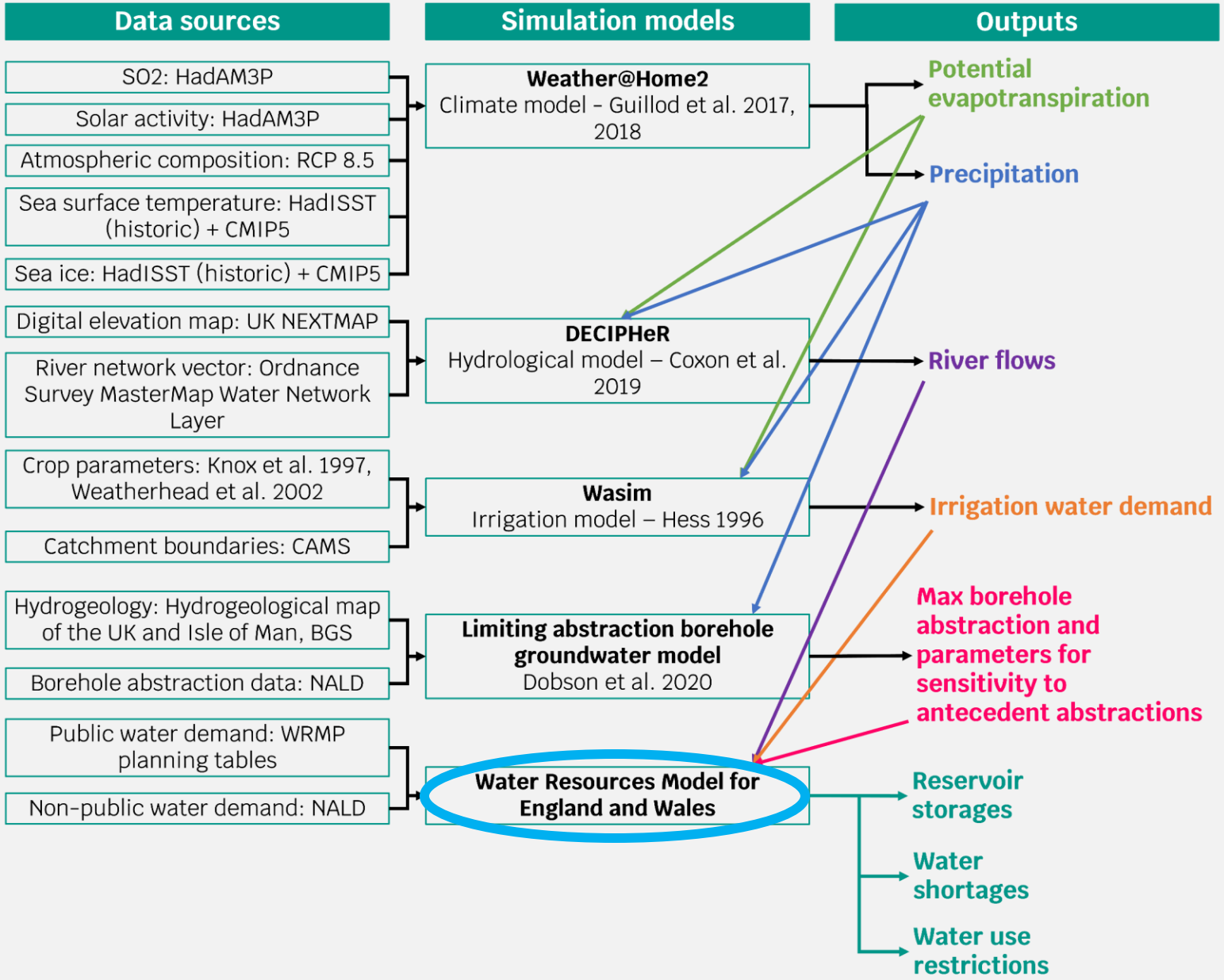




Model represents:

- 90% of England and Wales's population and public water use:
- 80 catchments; 70 WRZs; 16 water utility companies;
- All resources > 2Ml/day, and key transfers and assets;
- Some smaller sources & demand zones amalgamated or removed

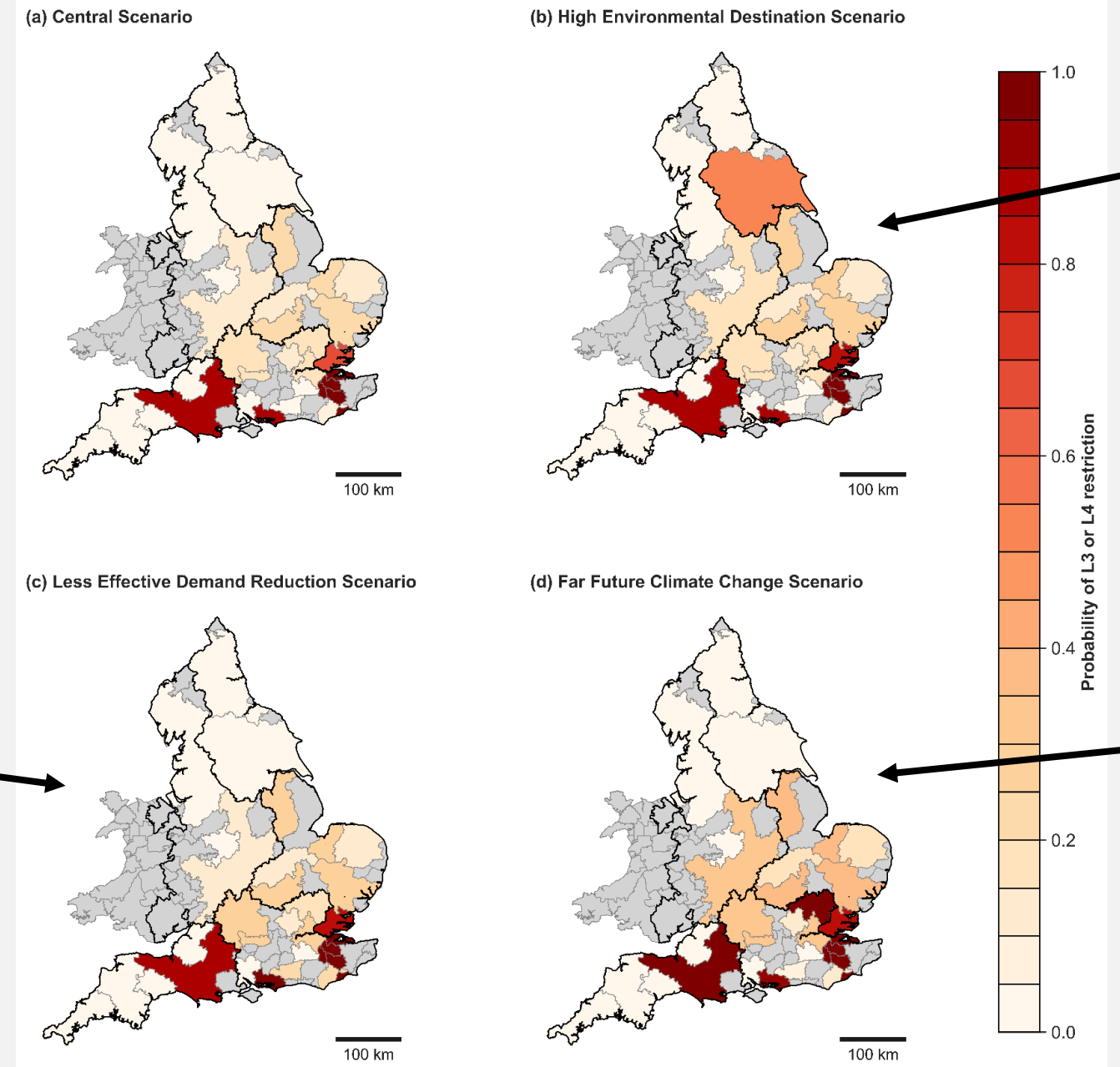
Fig. Overview of workflow, showing the main data sources, models and outputs.



Coupled modelling system developed to analyse strategic water resources in the context of large scale drivers of change, including:

- Climate
- Abstraction reform
- Changing demand

Fig. Probability of severe restrictions on water use for four different climate and demand scenarios.



More water retained for the environment (lower withdrawals from river)

Water companies fail to meet Per Capita Consumption targets (less effective demand and leakage management)

Climate ensemble for 2070-2099 used in simulations

Fig. Strategic Resource Options (SROs) modelled in WREW and key water company locations.

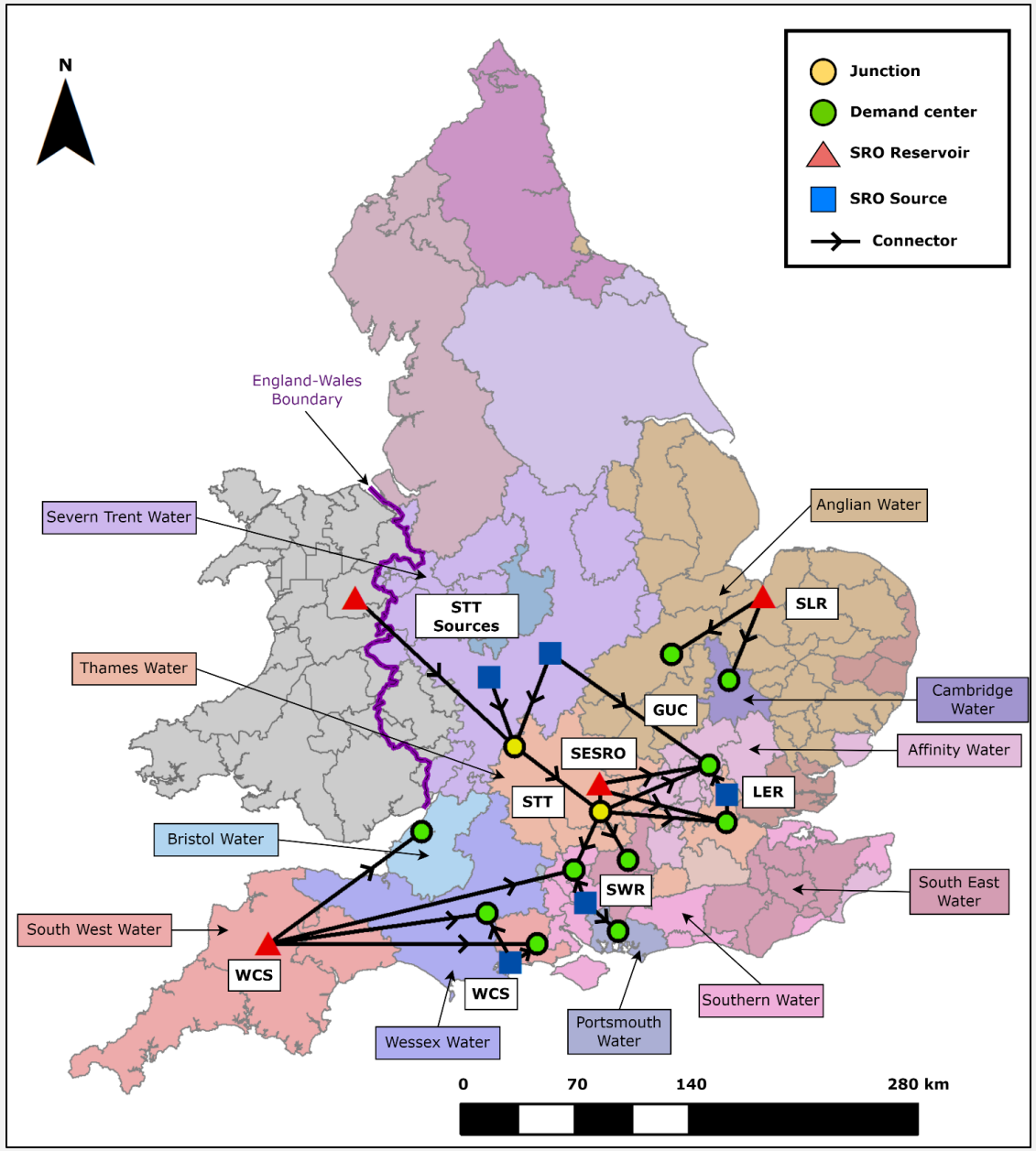
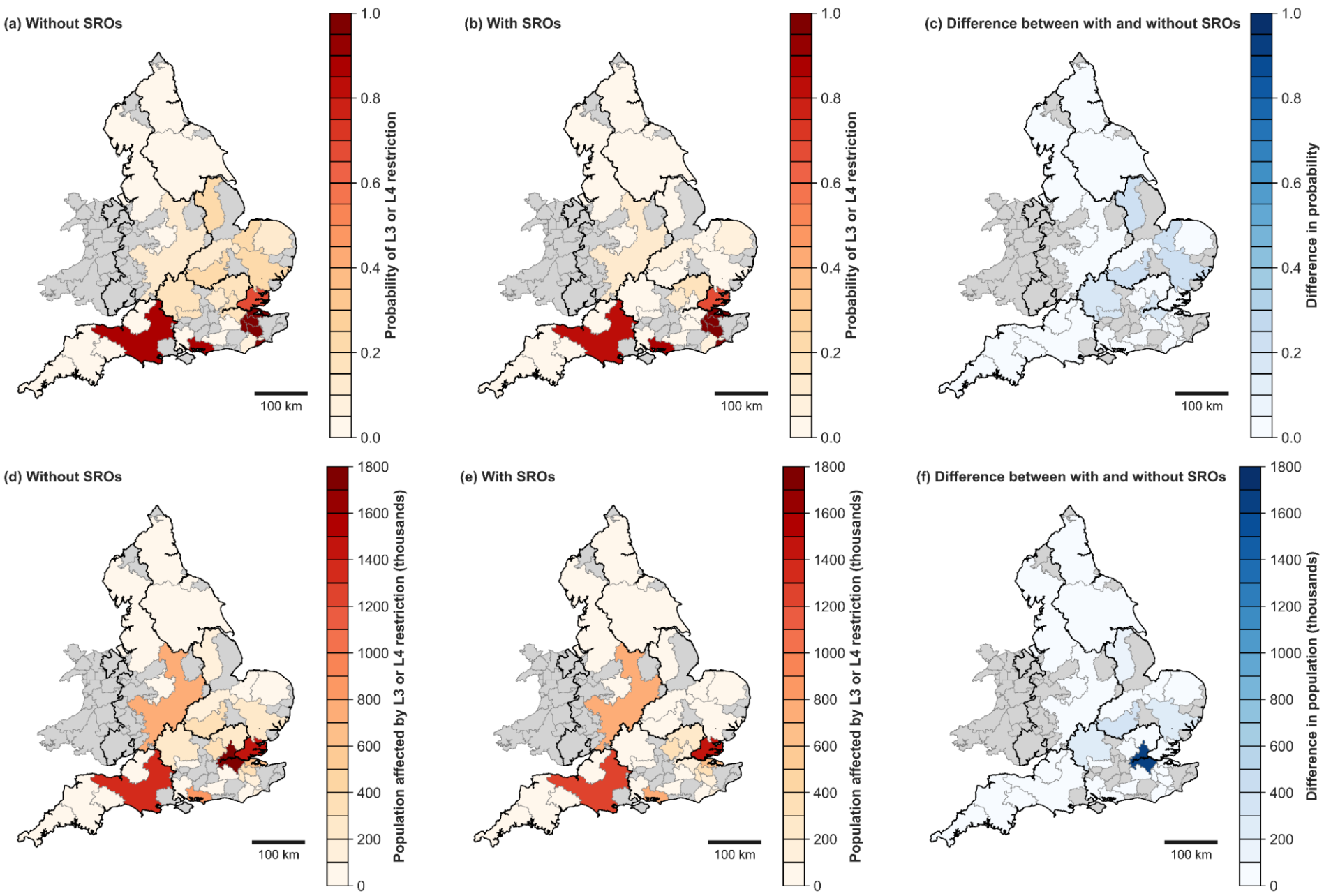


Fig.
Probability of severe restrictions on water use.

Expected population affected by severe water restrictions.

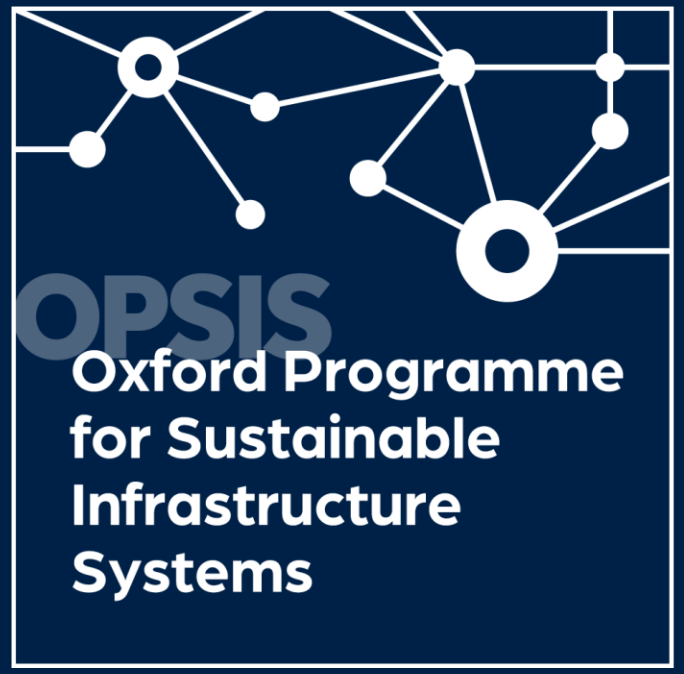


Pywr-WREW

- Re-build the national Water Resources model for England and Wales using the open-source generic dynamic python library for network-based resource allocation models, Pywr.
- Advantages of Pywr:
  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.

Our vision

- Create an open-source version of WREW, hosted by DAFNI.
- Pywr-WREW will offer a more transparent tool than the Wathnet-based WREW, making stakeholder engagement, model evaluations and result disseminations easier for all.
- Pywr-WREW will be ‘outcome-based’, helping decision makers better manage future climate risks to the national water supply network.
- The flexible nature of the Pywr platform will allow other important variables, such as cost and water quality, to be included in WREW in the future.
- A multi-objective national water resources model such as Pywr-WREW will play a critical role in identifying optimum and robust solutions, and will aid joint agreement and decision making across regulators.



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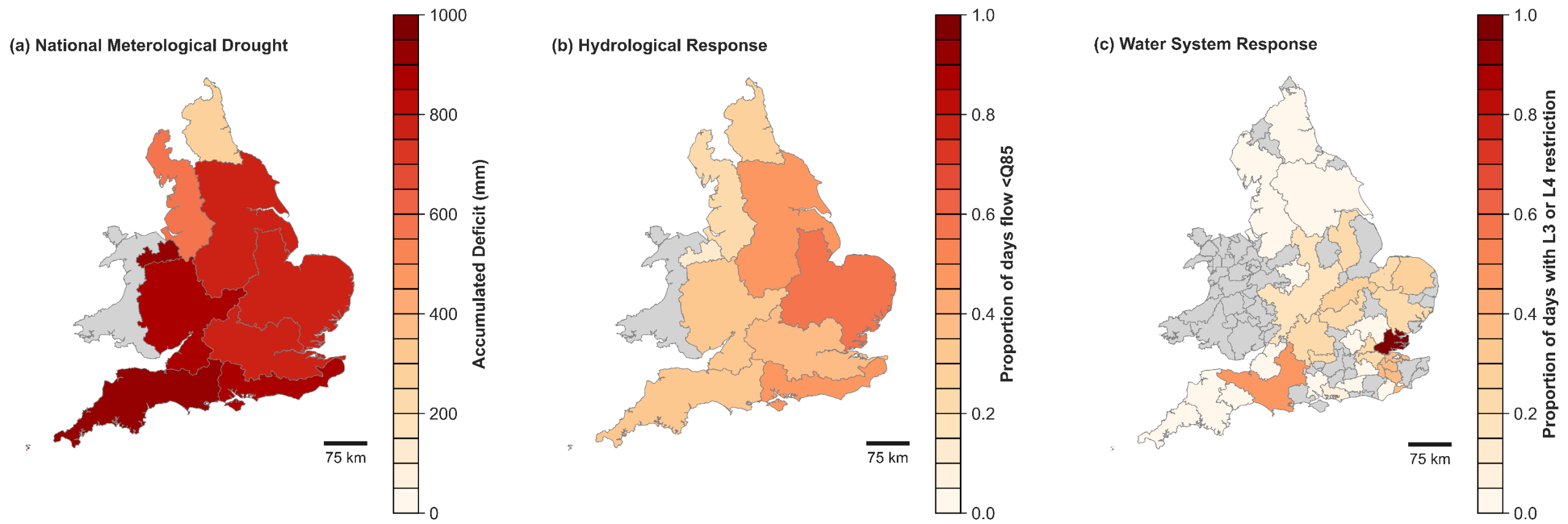
Extra slides

Fig. 24-month national meteorological drought and associated hydrological and water system response.

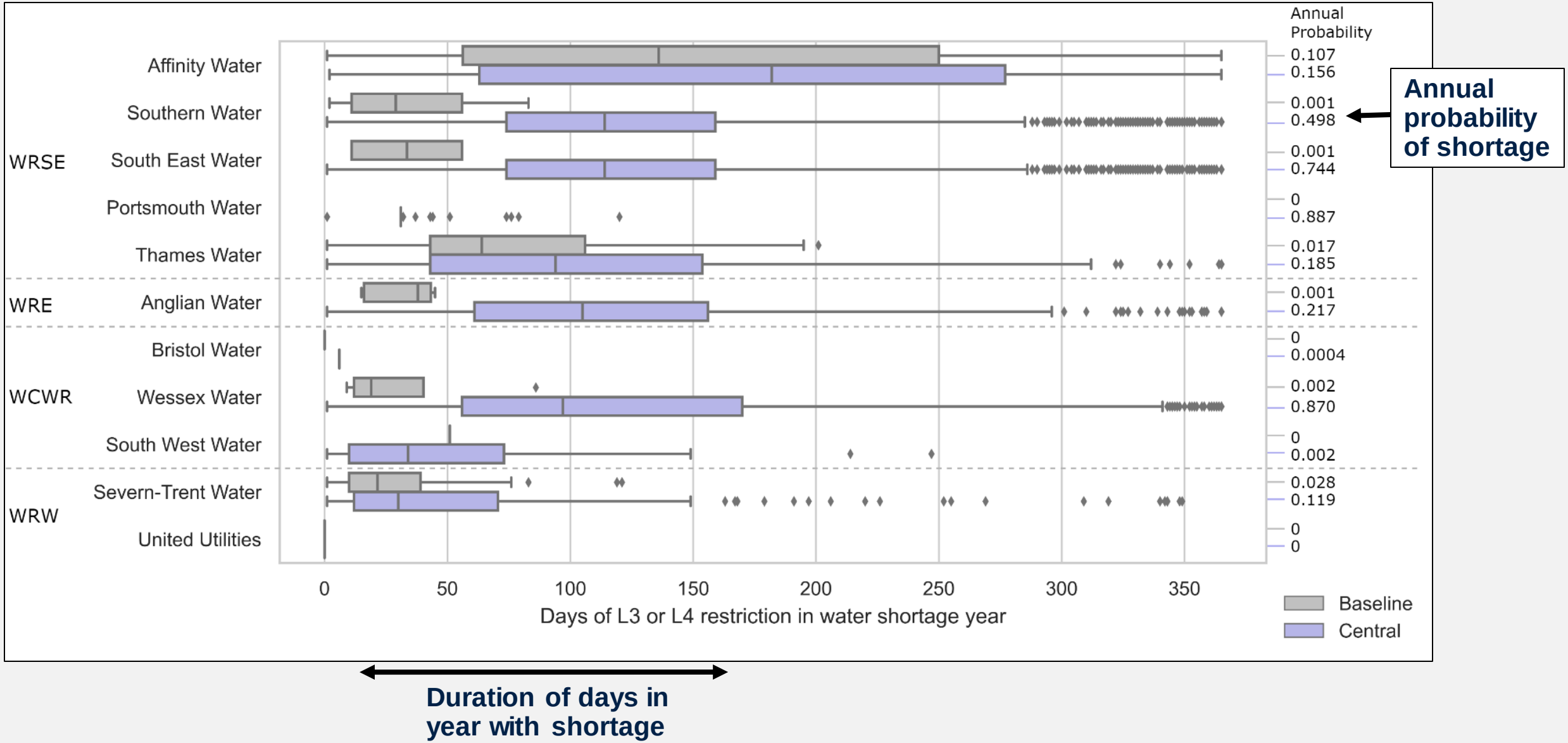


Accumulated deficit of drought events below Q50 threshold for effective precipitation

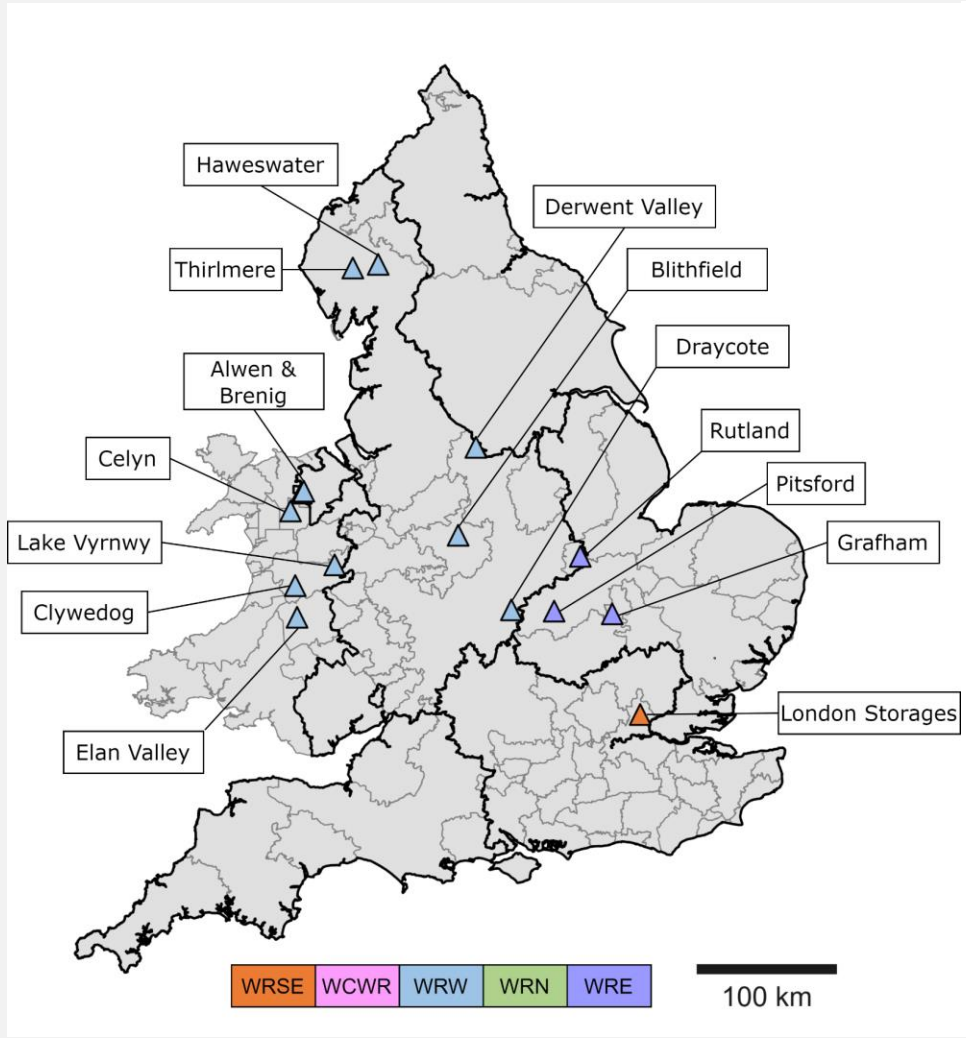
Proportion of days below Q85 threshold in key rivers (per basin)

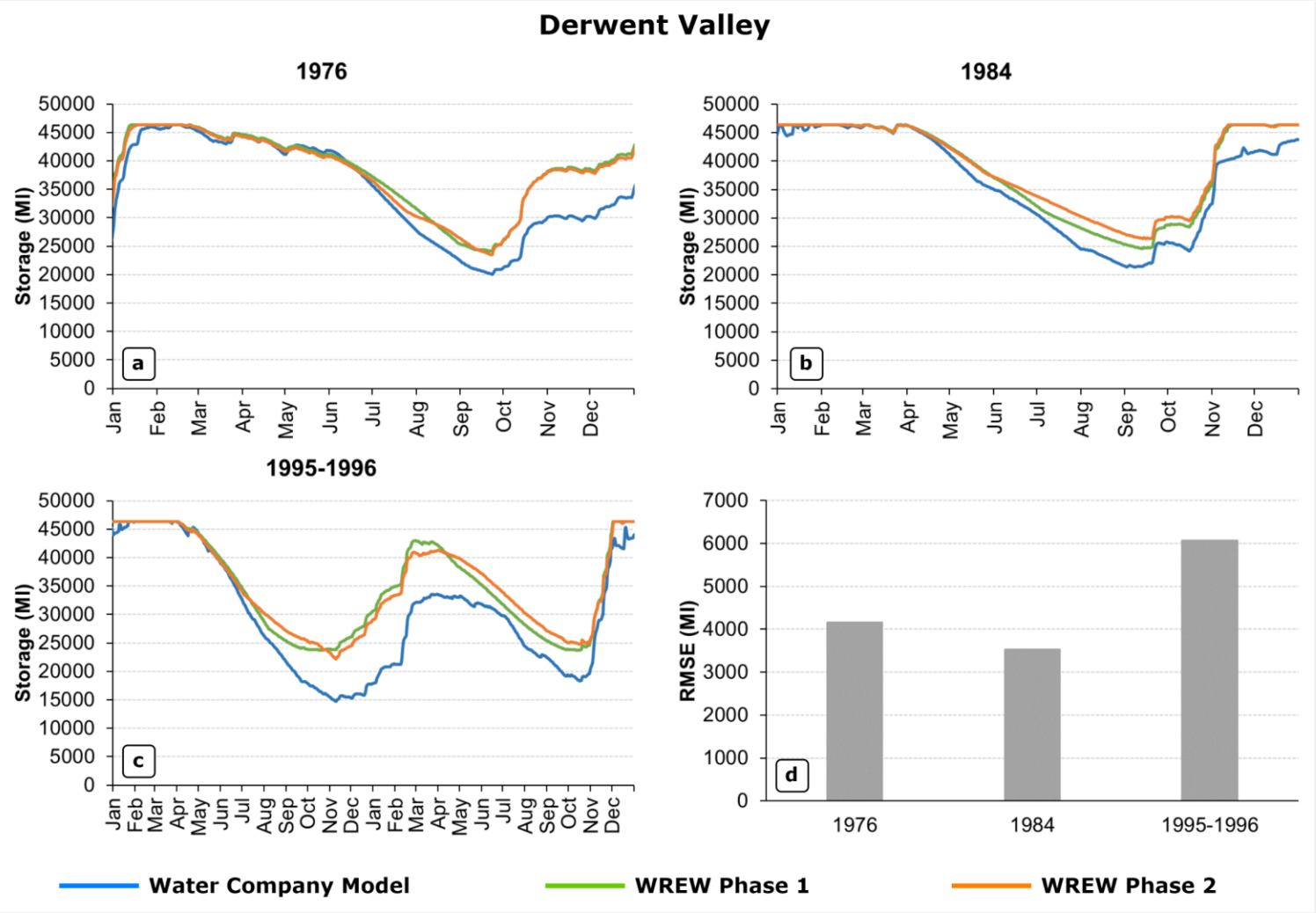
Proportion of days with severe water use restriction

Fig. Water shortage event probabilities and durations for different demand scenarios.

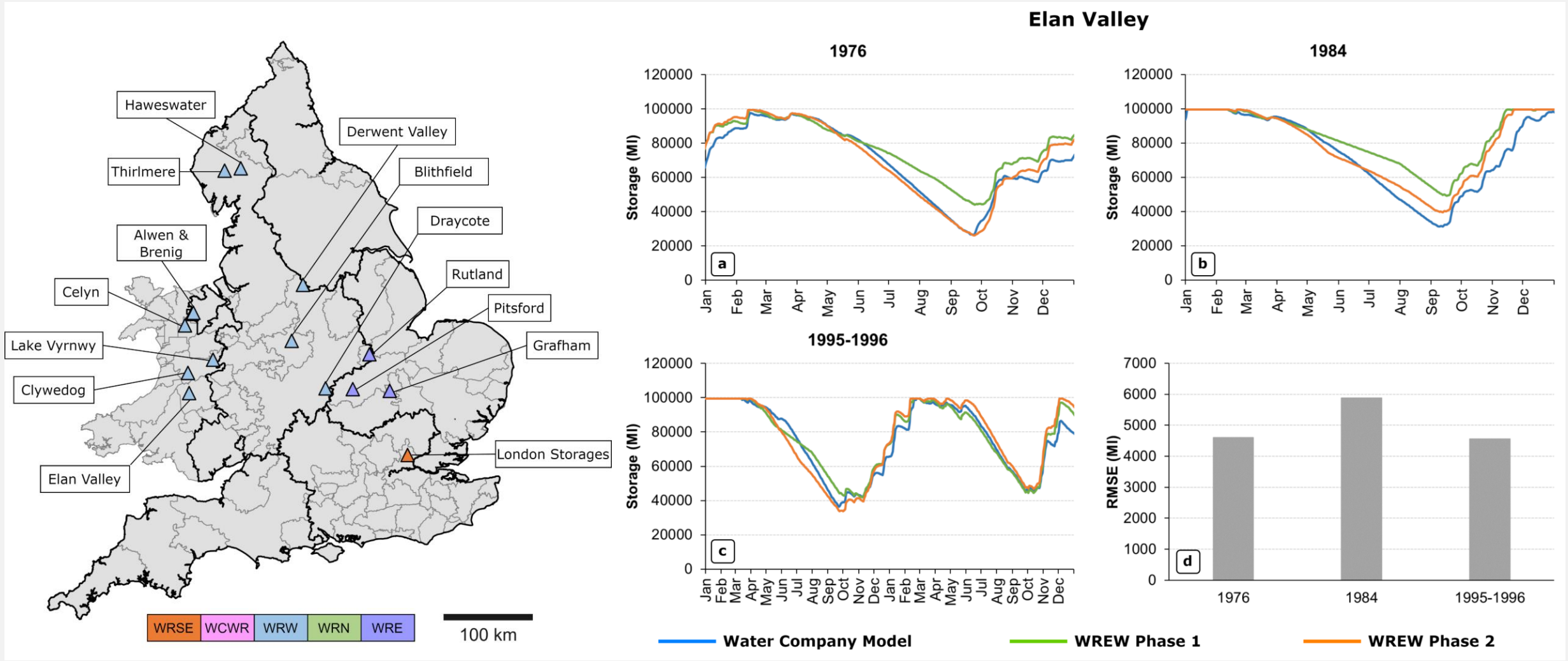


Reservoir validation





Reservoir validation



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Centre of Excellence Speaker:

SOFRAMODE - Sewer Overflow Flood Risk Analysis Model DAFNI Enabled

Dr Vassilis Glenis

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Sewer Overflow Flood Risk Analysis MOdel Dafni Enabled

Vassilis Glenis, Claire Walsh, Chris Kilsby, Stephen Birkinshaw

Newcastle University

City Catchment Analysis Tool - CityCat

CityCAT is a software tool for modelling, analysis and visualisation of surface water flooding.

It enables assessment of combined pluvial and fluvial flood risk and effects of different flood alleviation measures.

What's new?

- Easy to use
- Uses readily available data (OS Mastermap or OpenStreetMap and LiDAR)
- Includes buildings and green space and other urban features
- Coupled sewer drainage network and surface flow

City Catchment Analysis Tool

CityCat components:

- Mastermap parser (outlines of buildings, roads, infrastructure, etc.)
- Numerical grid generator
- Flow model: shallow water equations and numerical solutions
- Infiltration model: Green-Ampt method and Richards' equation for variably saturated flow in one-dimension.
- Roof storage: blue roofs and green roofs
- Sewer network: equations for mixed flow in pipes and integration with the overland flow model

City Catchment Analysis Tool

MasterMap data are used to delineate the urban features such as: buildings, roads and permeable surfaces

The computational grid is generated automatically using the DTM.

MasterMap data are used to exclude the buildings' footprint from the grid.

This improves the ability of the model to capture realistically the flow paths in urban areas and reduces the simulation time due to the reduction in the number of computational cells. The removed cells form the "buildings" layer are used in the roof drainage algorithms.

Free surface flow equations

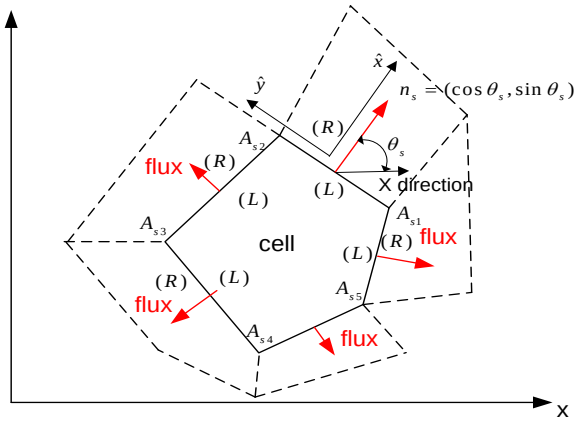
Shallow Water Equations

$$\partial_t \mathbf{Q} + \partial_x \mathbf{F}(\mathbf{Q}) + \partial_y \mathbf{G}(\mathbf{Q}) = \mathbf{S}(\mathbf{Q})$$

The vectors are given as follows:

$$\mathbf{Q} \equiv [q_1, q_2, q_3]^T = \left[h, hv_x, hv_y\right]^T; \mathbf{F}(\mathbf{Q}) \equiv [f_1, f_2, f_3]^T = \left[hv_x, hv_x^2 + gh^2/2, hv_x v_y\right]^T$$

$$\mathbf{G}(\mathbf{Q}) \equiv [g_1, g_2, g_3]^T = \left[hv_y, hv_x v_y, hv_y^2 + gh^2/2\right]^T; \mathbf{S}(\mathbf{Q}) = \boldsymbol{S_o} - \boldsymbol{S_f}$$



Where v_x and v_y represent the depth-averaged velocity components in the x and y directions respectively; h is the water depth; g is the gravity acceleration;

$\boldsymbol{S_o} = \left[0, gh\partial_x z_b, gh\partial_y z_b\right]^T$ is the bed slope source term and z_b denotes the bed elevation; $\boldsymbol{S_f} = \left[0, ghSf_x, ghSf_y\right]^T$ is the friction term

Infiltration model

Green-Ampt method

The Green-Ampt method is used to estimate infiltration in pervious areas as a function of the soil hydraulic conductivity, the porosity and the suction head

The time dependent solution is obtained using an iterative method.

Richards' equation

the Richards' equation for variably saturated flow in 1D can also be used to estimate infiltration:

$$\partial_t \theta = \partial_z [K \, \partial_z h] + \partial_z K$$

where h is the pressure head, $\theta(h)$ is the volumetric moisture content, t is time, z is the spatial coordinate, $K(h)$ is unsaturated hydraulic conductivity

Blue-green features

Roof storage model

Two types of roof storage are applied to the buildings layer of the grid. These are:

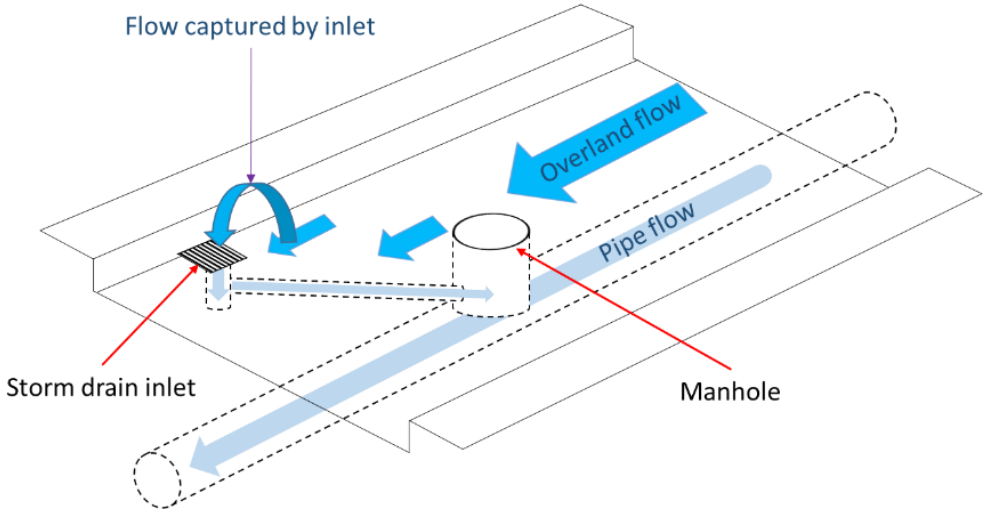
- “blue roof” which is based on the available volume of storage
- “green roof” which uses the Green-Ampt algorithm or the Richards’ equation.

CityCat – Drainage network

subsurface drainage network model

Subsurface drainage model can handle realistic conditions, i.e. both free-surface and pressurised flows as well as two-way flows (in and out of sub-surface).

Model realistic scenarios such as pluvial flooding due to blocked sewers and flooding from sewers due to insufficient capacity.



Bertsch (2019)

Drainage network models

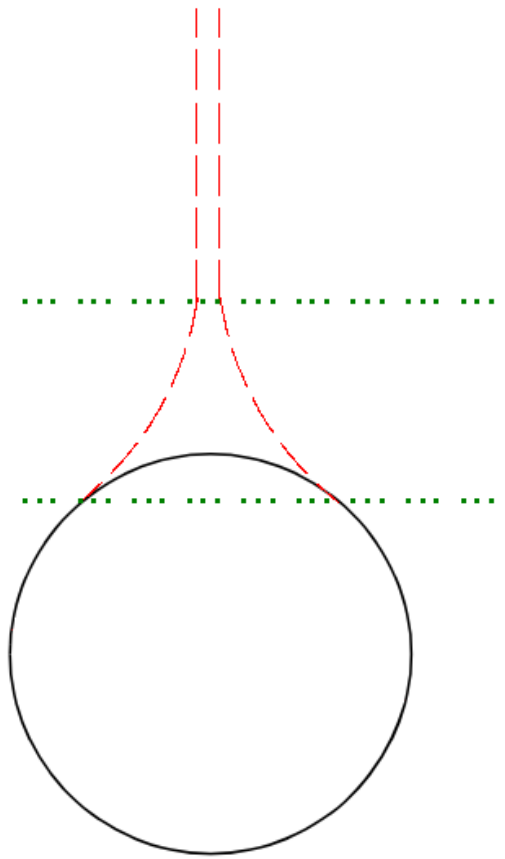
Subsurface drainage network models

There are a few models currently available for drainage networks.

All are based on the St. Venant equations which describe free surface flow.

The Preissmann slot is used to model pressurised flow. The method was introduced in 1964 by Cunge and Wegner.

The equations are solved using finite differences and the primitive variables are used (water depth and discharge)



Drainage network models

Subsurface drainage network models

Advantages:

- Very easy to implement. One set of equations is used for both free surface and pressurised flows
- Very fast. The numerical solution is very simple.

Disadvantages:

- The wave celerity which is the velocity with which a variation in the flow travels along the pipe can be very wrong.
- Problems with conservation of mass.

Drainage network models

CityCat subsurface drainage model:

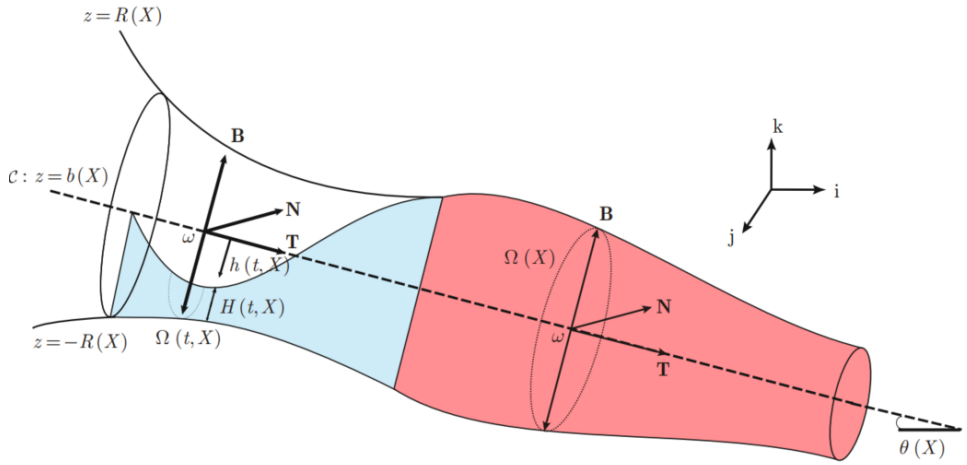
The model is based on the St Venant equations and a conservative form of the Allievi equations based on the compressible Euler equations

Advantages:

- Free surface, pressurised and mixed flows can be modelled accurately
- There is no restriction in pressurised wave speed
- Realistic situations can be modelled such as flooding from sewers due to insufficient capacity.
- Can be used for pumping stations

Disadvantages:

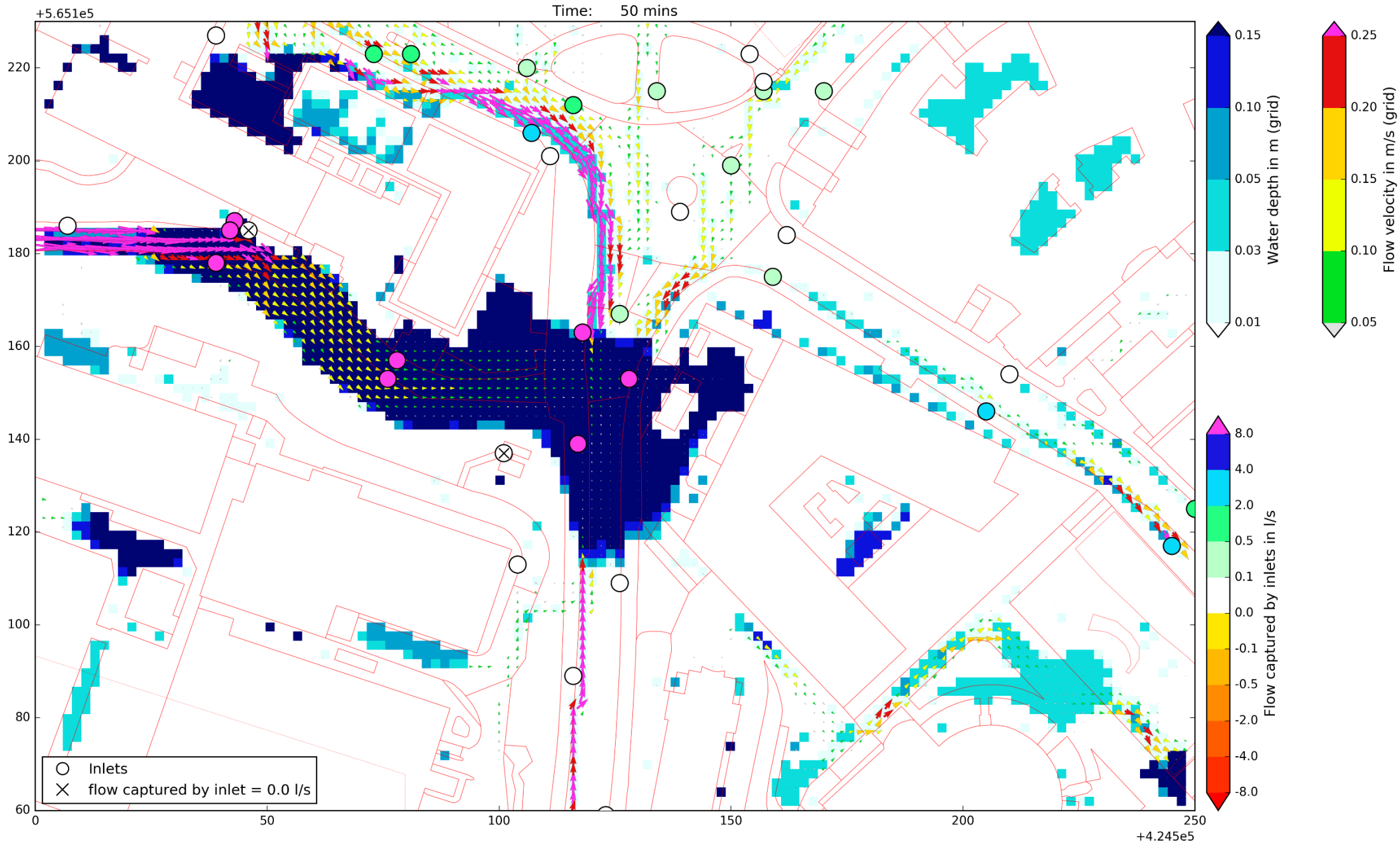
- Complex and difficult to implement
- Robust solvers required for the non-linear systems of equations.
- Slow compared to the Preissmann slot method.



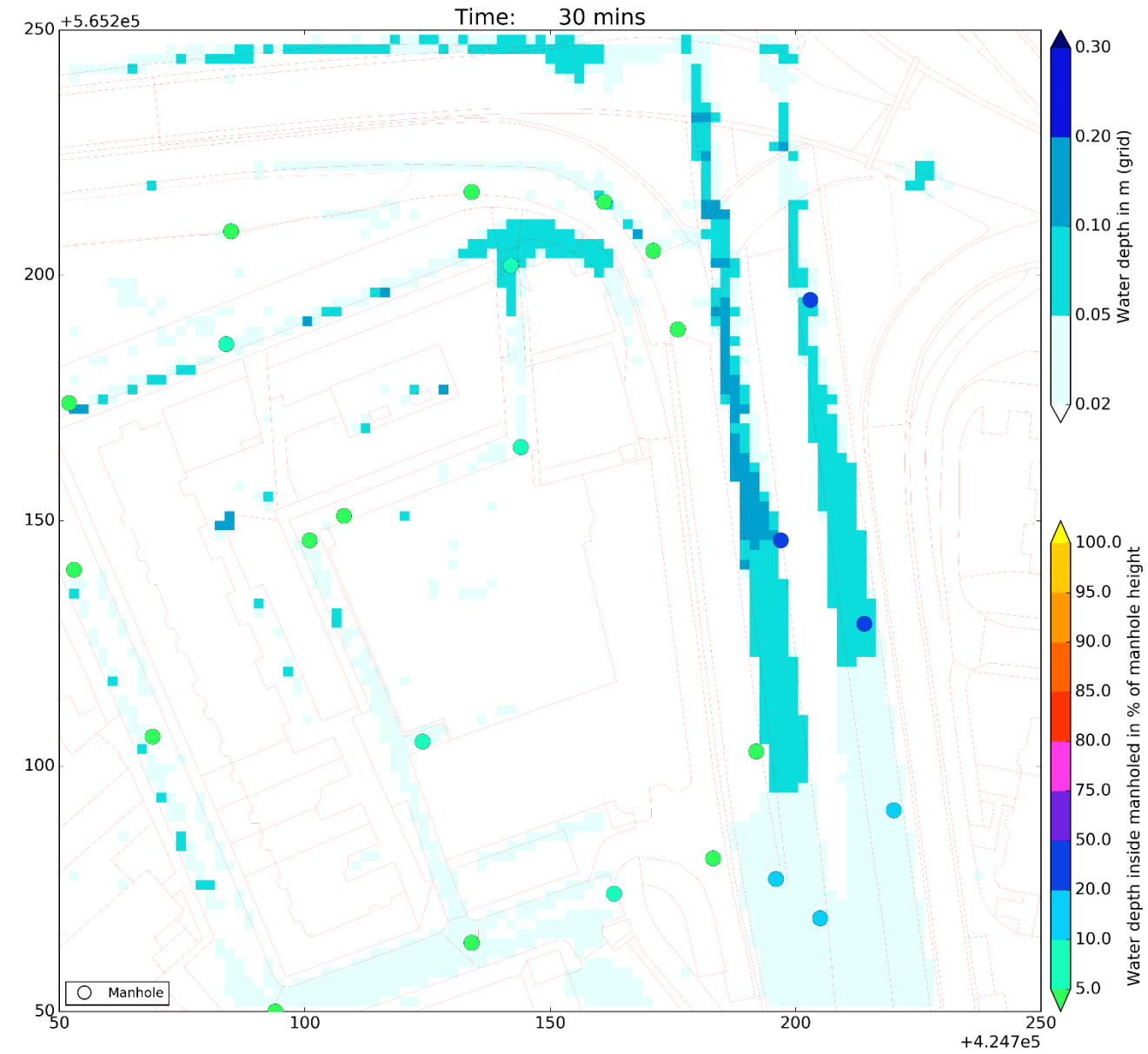
Bourdarias, et al. (2012)

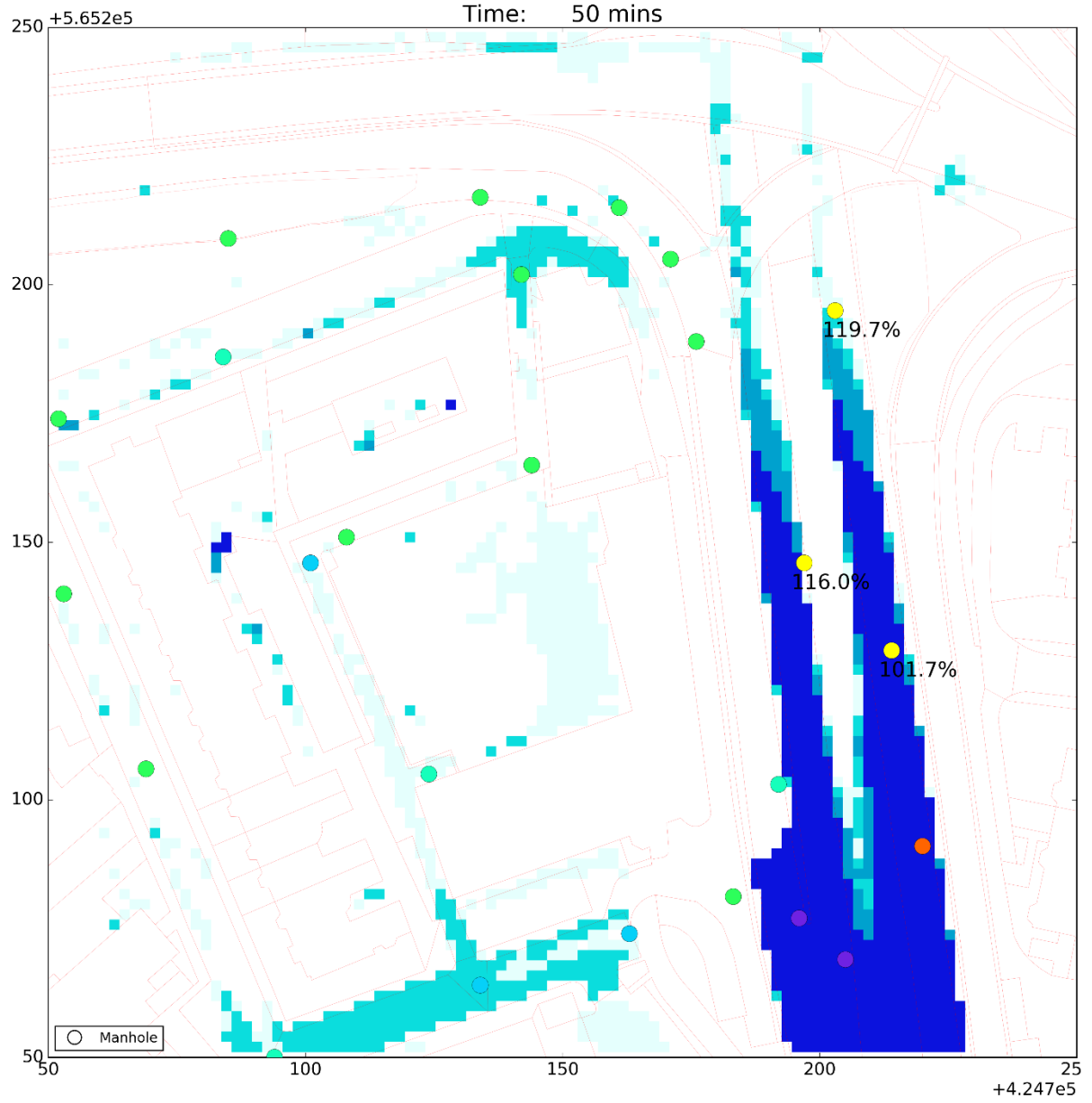
CityCat - Applications

Storm drain inlets



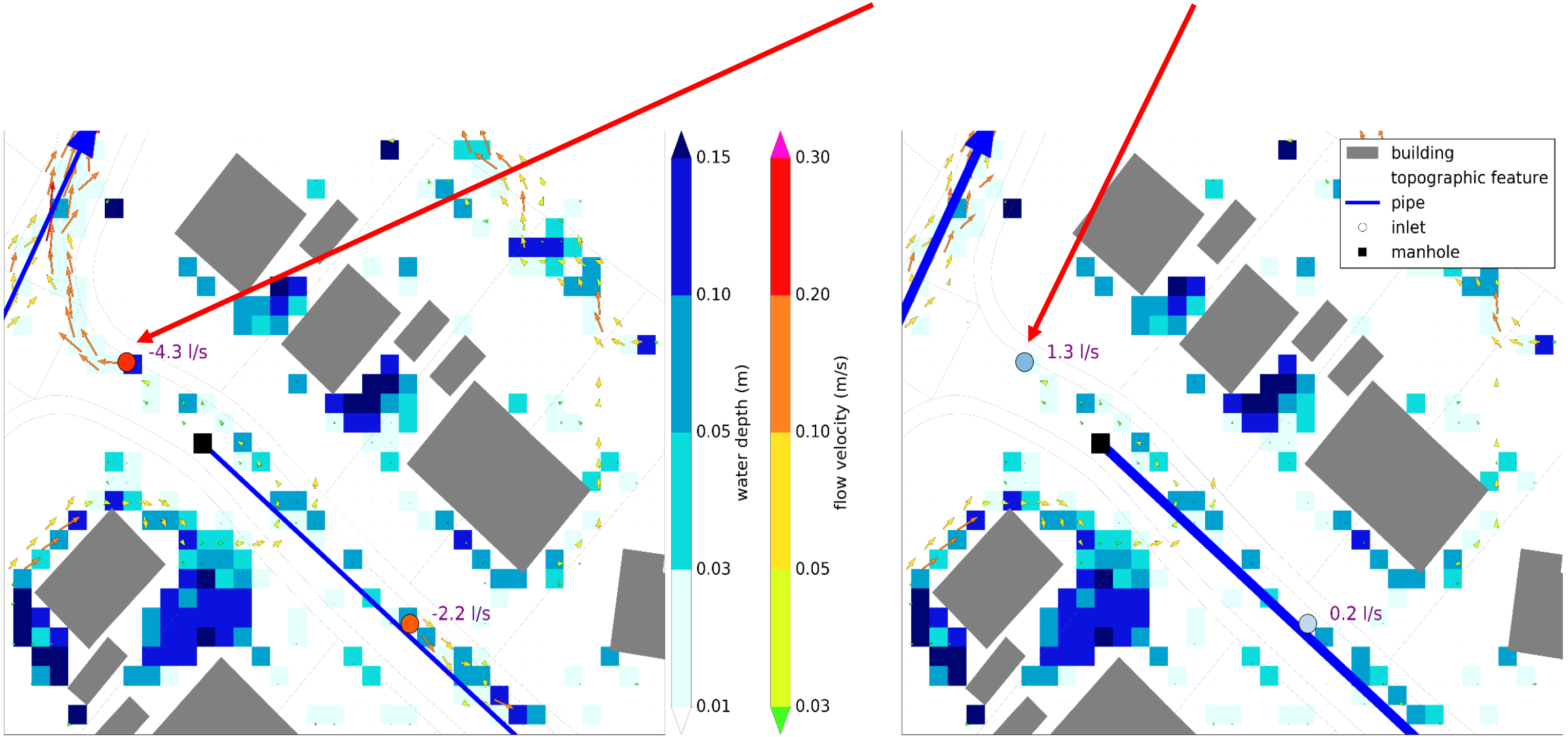
Manholes – pressurised (right)



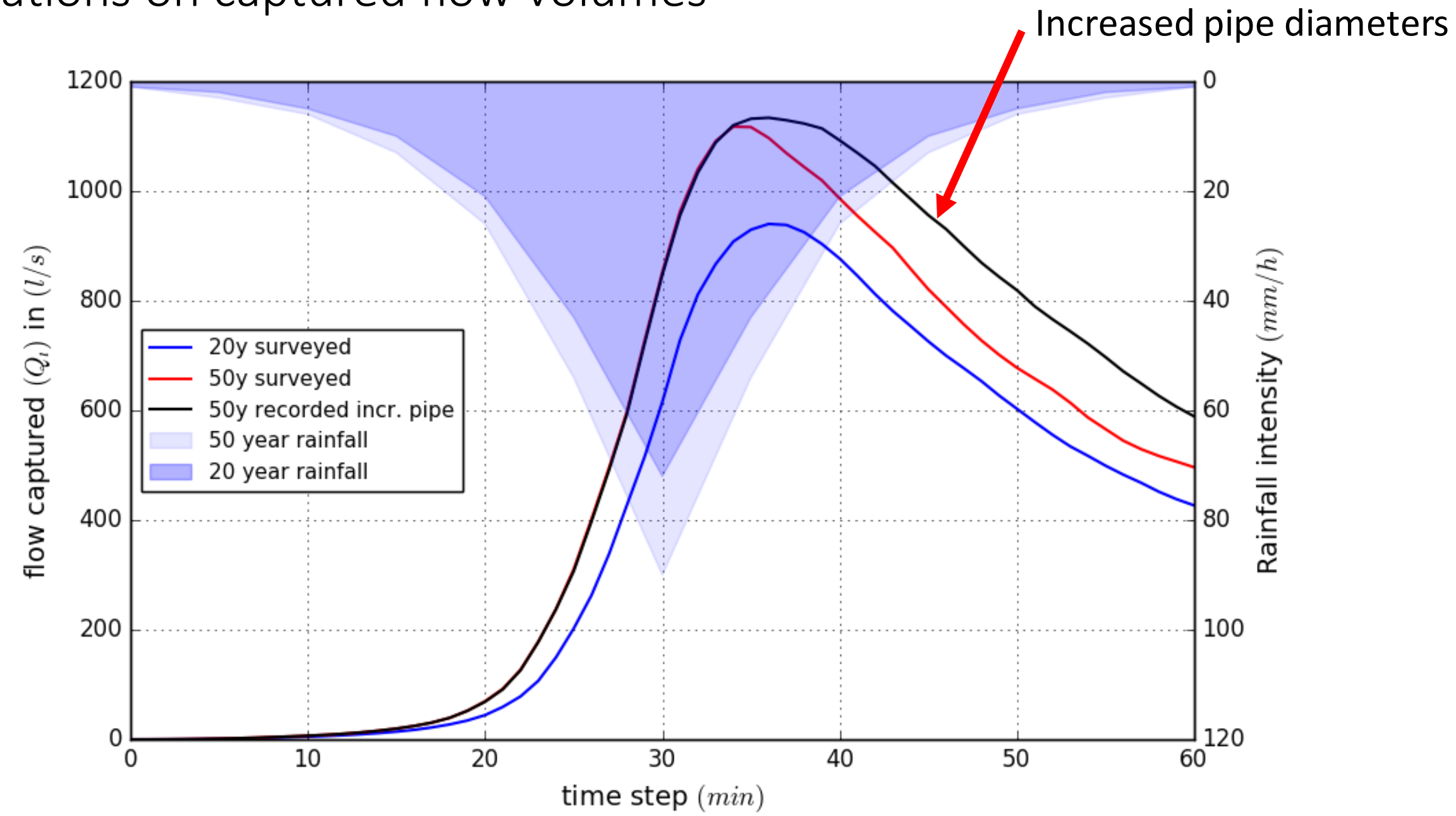


Scenarios – Pipe sizes

Implications on inlet condition: surcharging vs draining



Implications on captured flow volumes



Modelling Blue-Green Infrastructure

Permeable Surfaces

buildings | current green areas | additional green areas | model domain | topographic feature

Intervention

Impact

Permeable Surfaces & Water Butts

buildings | current green areas | additional green areas | building with 1000 litre water butt | model domain | topographic feature

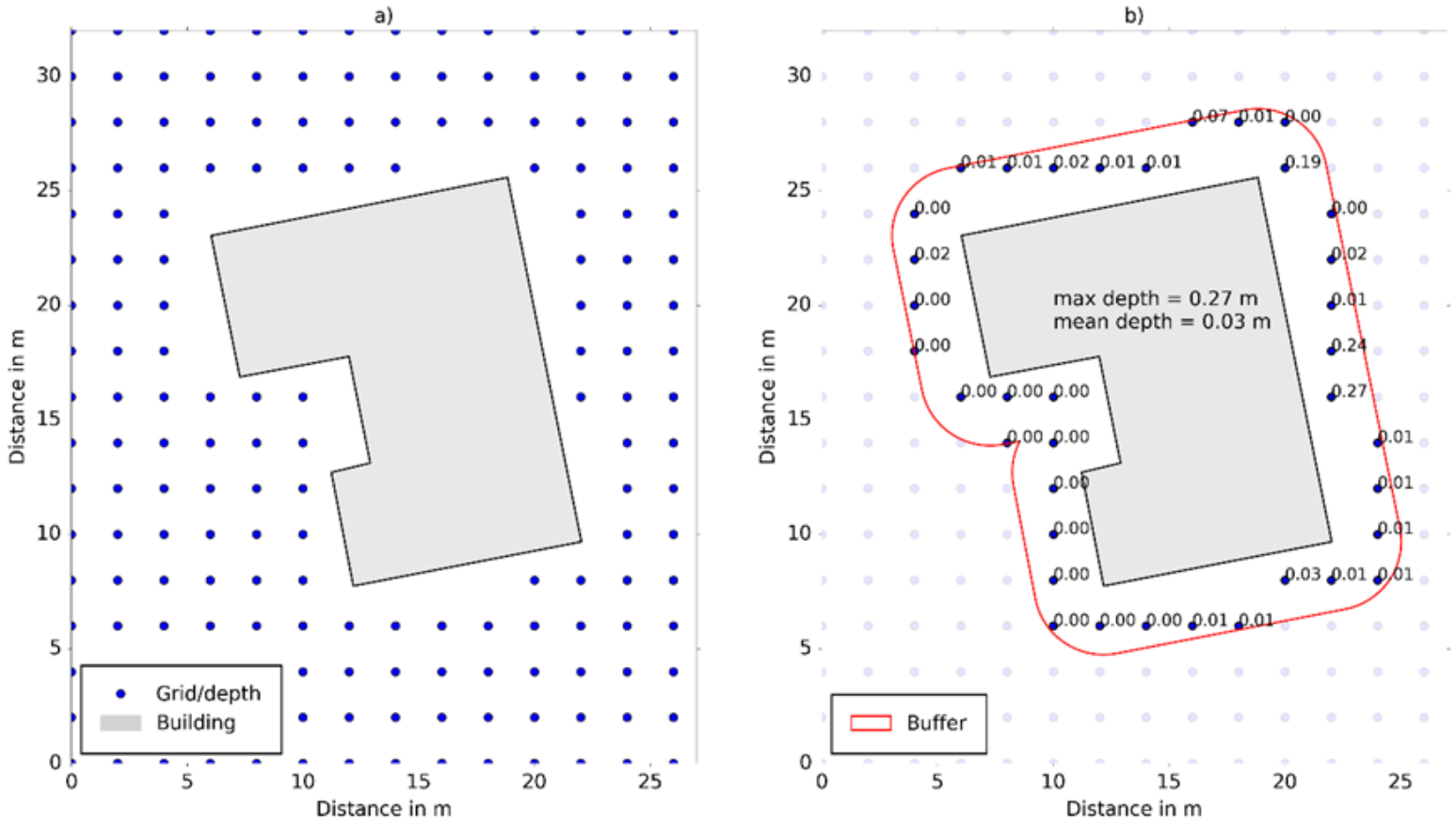
Intervention

Impact

Exposure Analysis

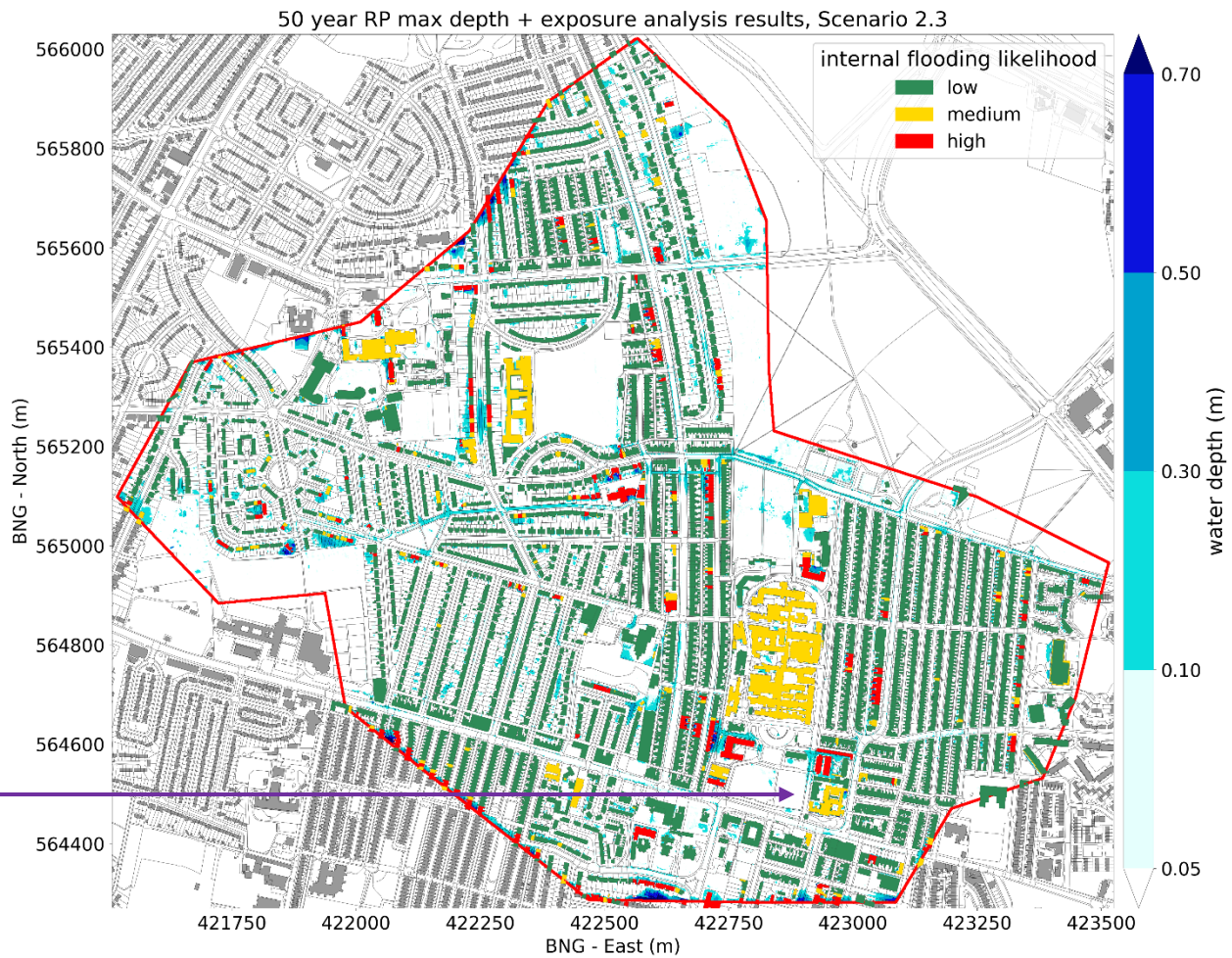
- High resolution hydrodynamic modelling results
- Exact building geometries
- Buffer analysis
- Classification scheme

class	*mean (m)*	*max (m)*	*internally flooded*
low	0.0 - 0.09	< 0.3	no
medium	0.0 - 0.09	> 0.3	no
	0.1 - 0.29	< 0.3	
high	>= 0.1	>= 0.3	yes

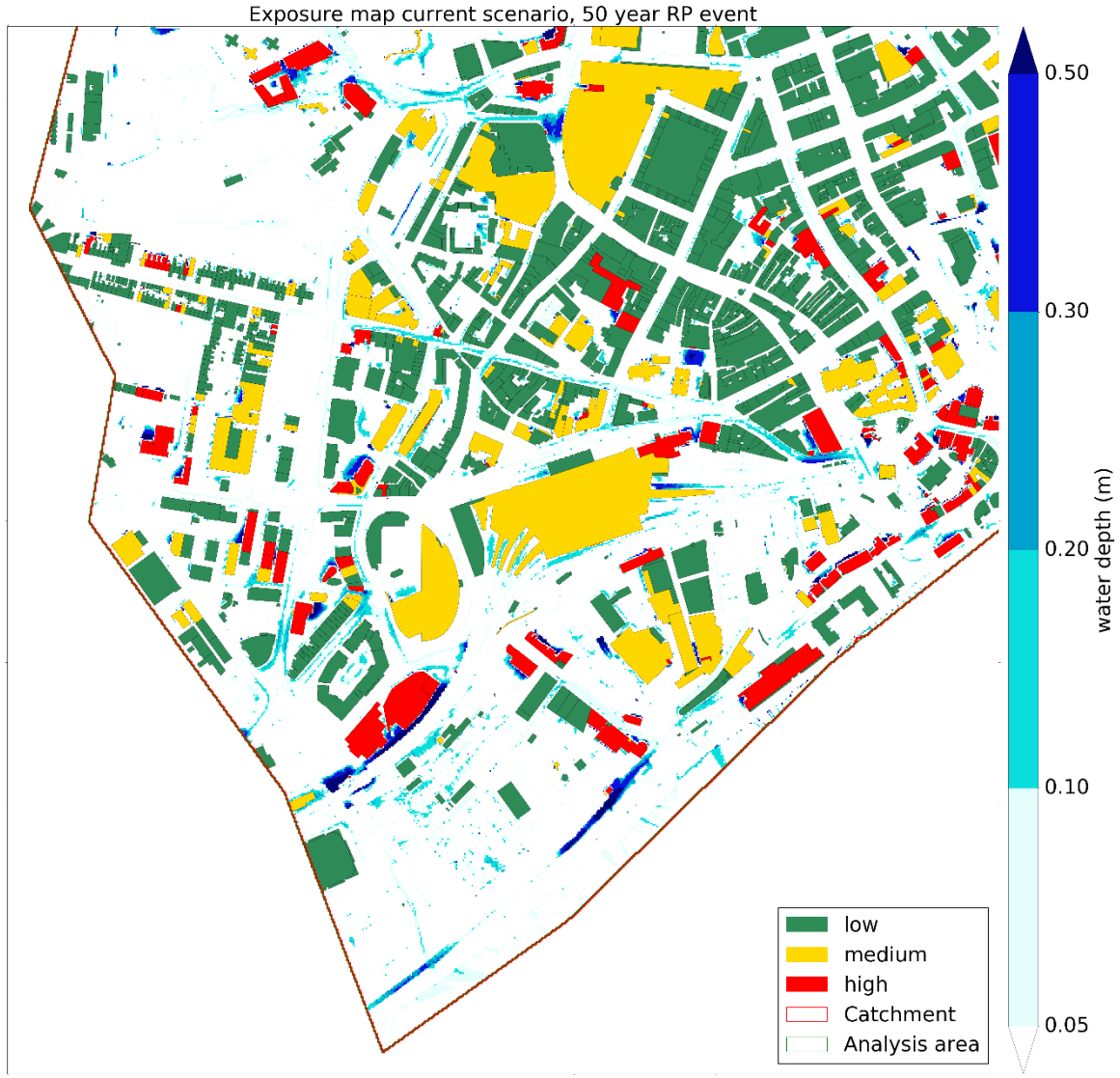


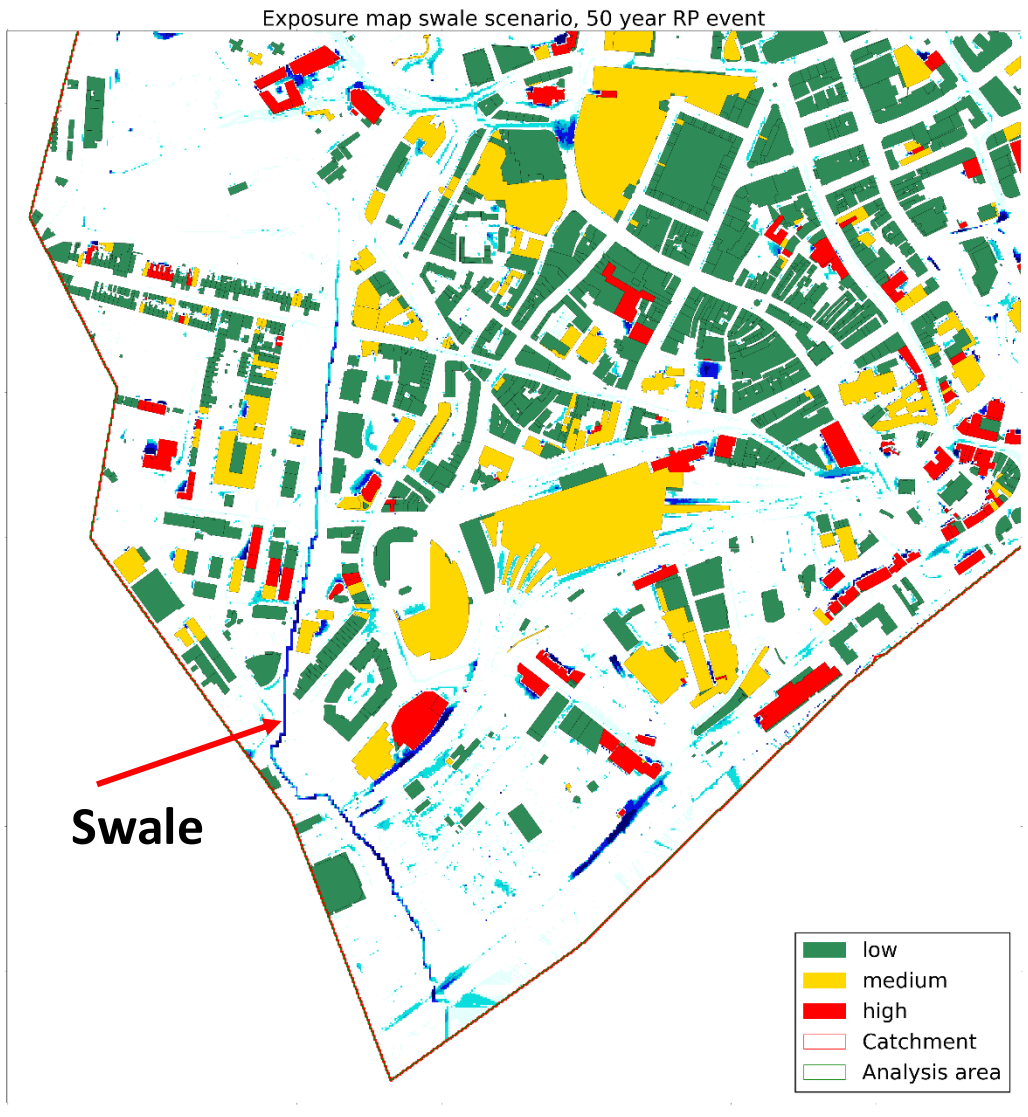
Current situation

Permeable Surfaces & Water Butts



Swale


Exposure map current scenario, 50 year RP event
0.50
0.30
0.20
0.10
0.05
water depth (m)
low
medium
high
Catchment
Analysis area


Exposure map swale scenario, 50 year RP event
Swale
low
medium
high
Catchment
Analysis area

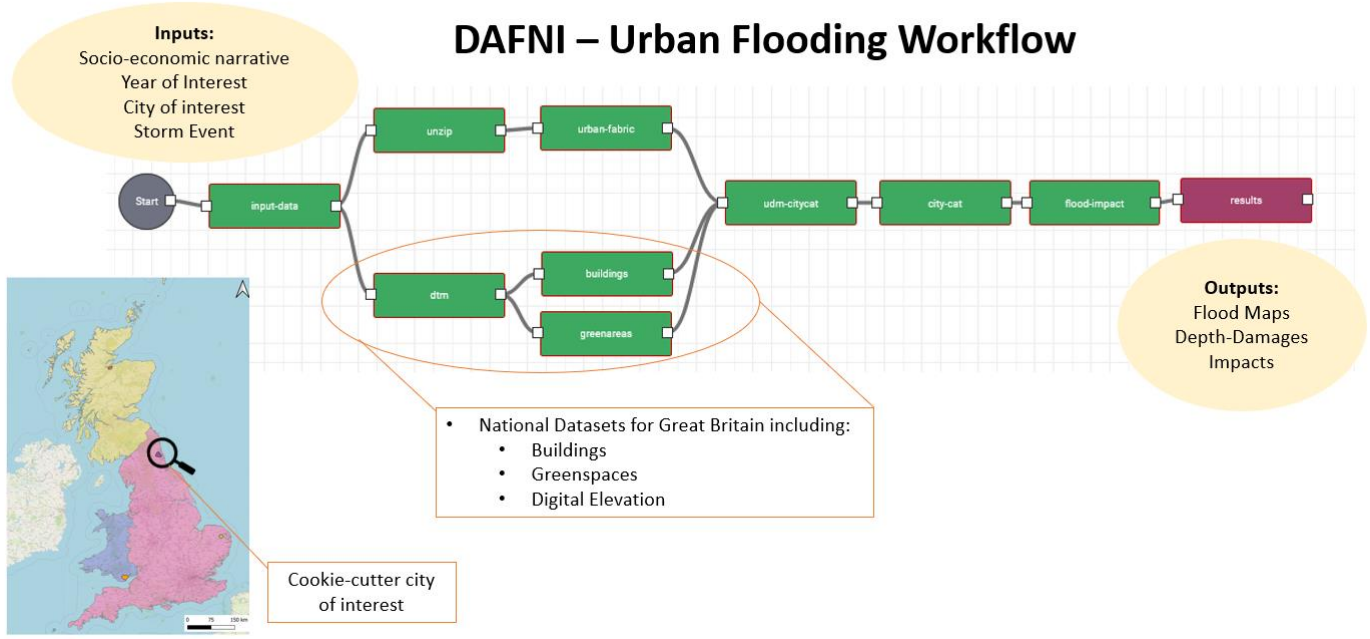
CityCat on DAFNI

CityCat on DAFNI

CityCat was containerised and deployed on DAFNI (OpenCLIM project)

The existing “Urban flooding workflow” allows users to run models to assess flood risk

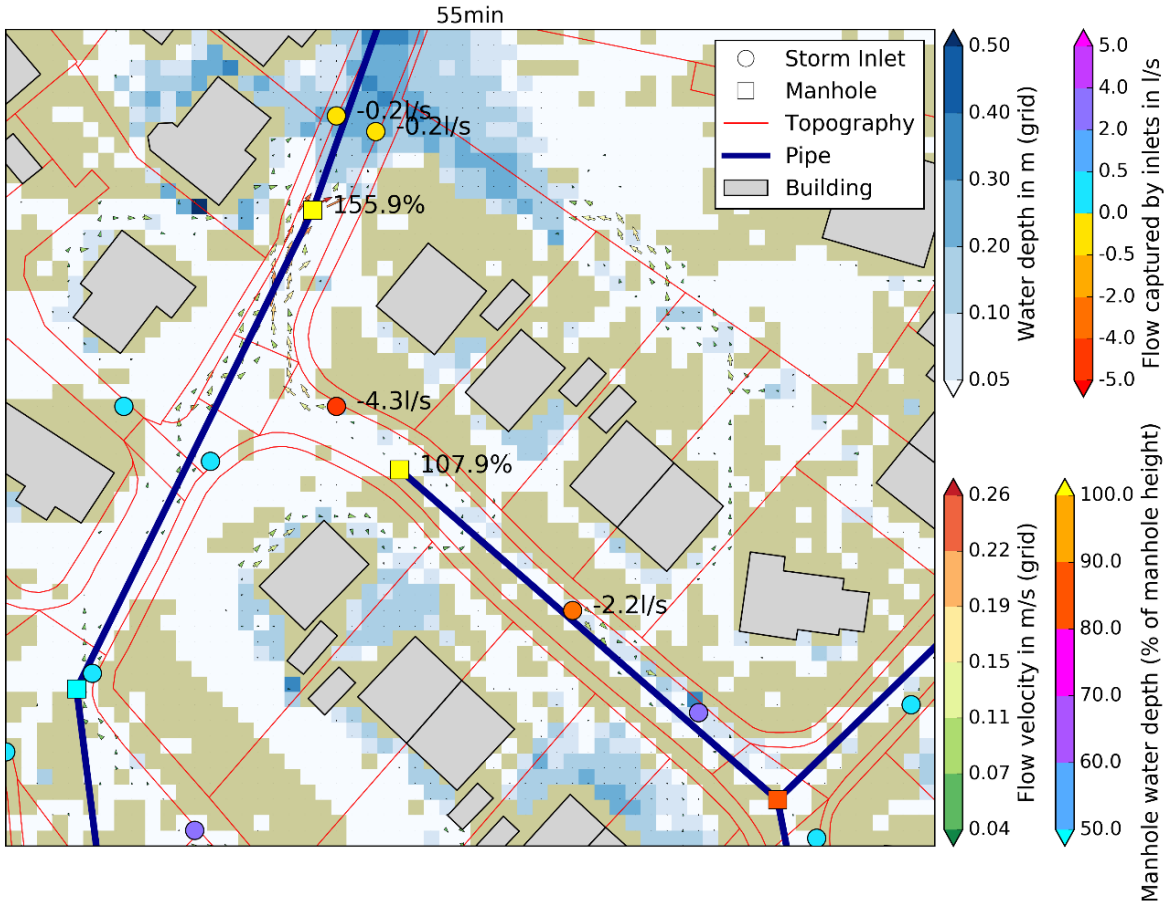
Models can be setup for any city in the UK for a range of storm events, climate uplifts and socio-economic narratives (UK-SSPs)



Aim of the project

Develop and demonstrate a platform on DAFNI for understanding and simulating urban drainage for any UK city.

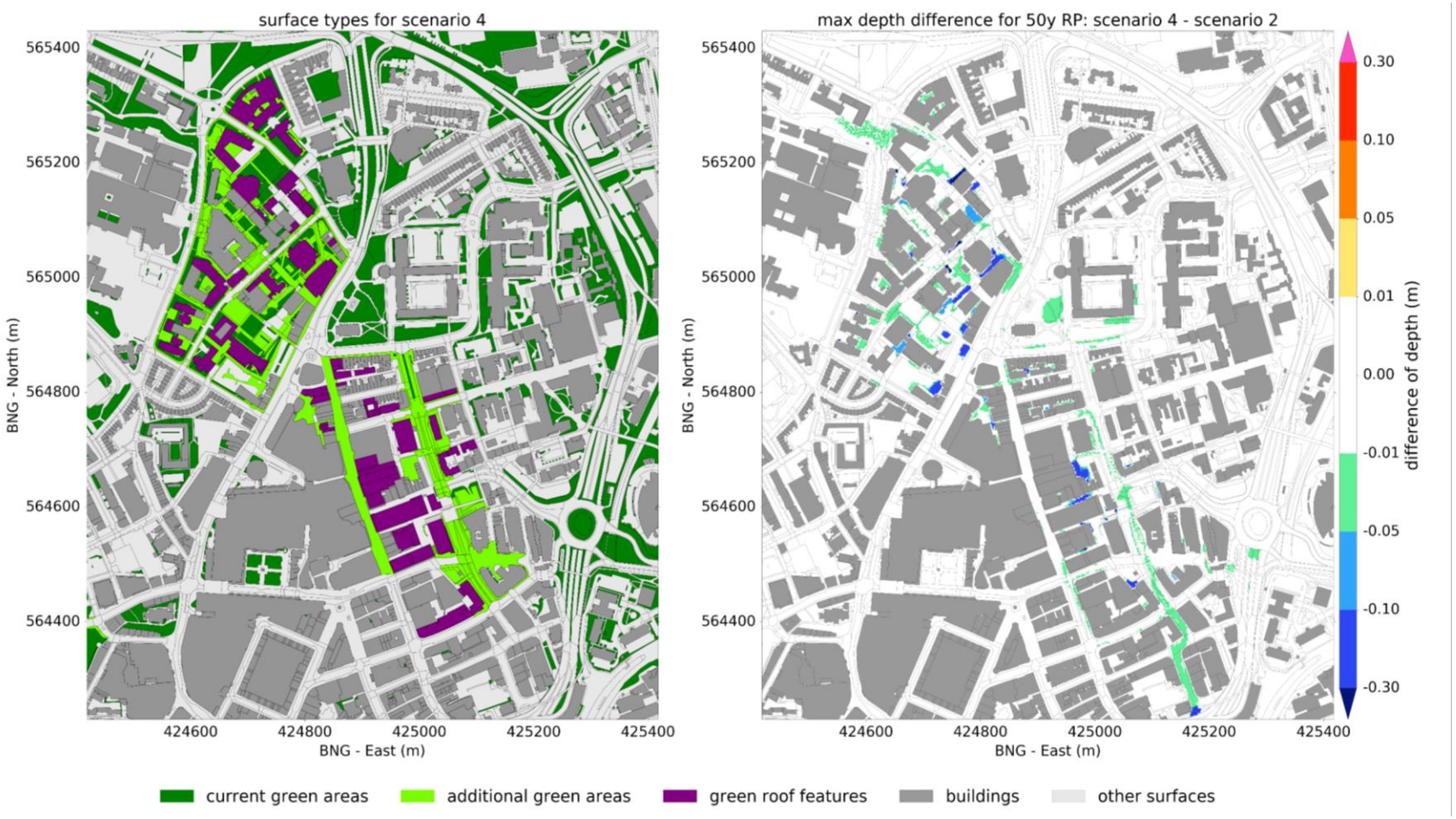
Functionality to design and test a range of strategies to mitigate Storm Overflows spills (or combined sewer overflows)



CityCat on DAFNI

How?

- Extend functionality to allow users to assess the effectiveness of blue-green mitigation features



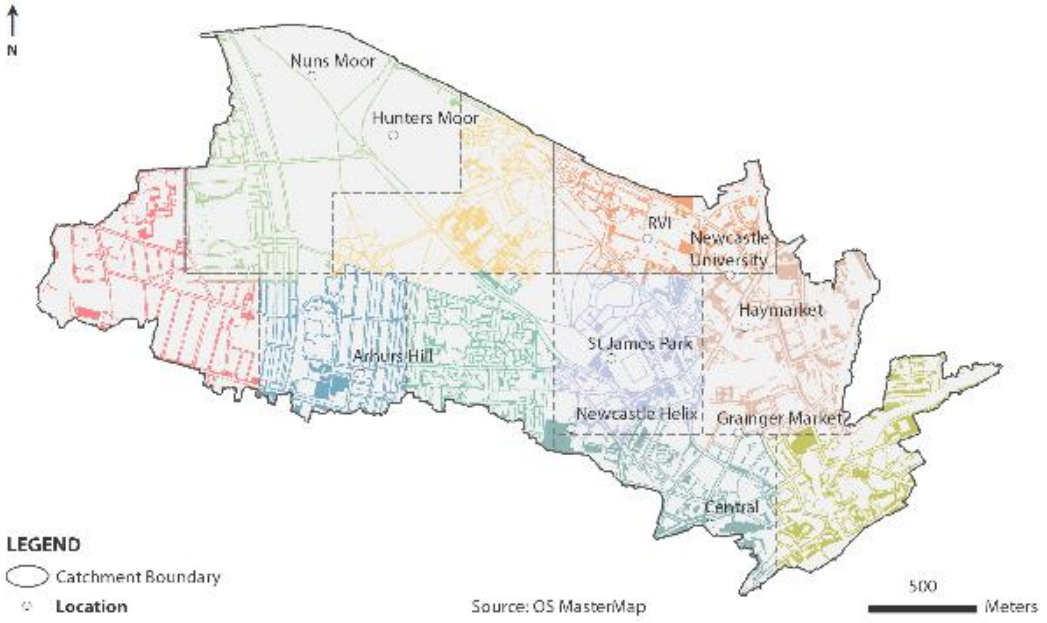
Intervention

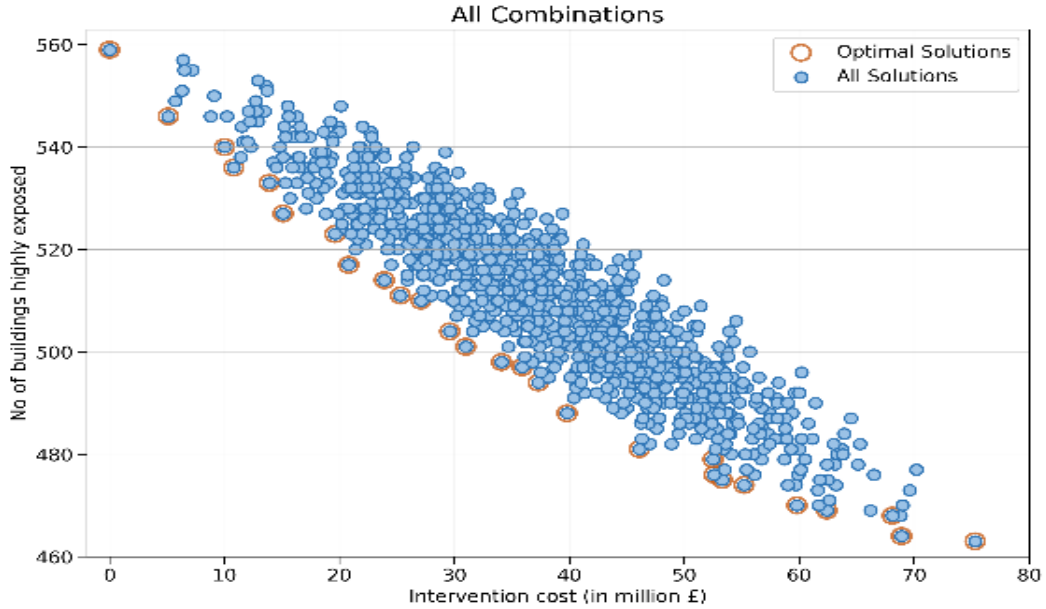
Impact

CityCat on DAFNI

How?

- Optimise BGI design using a Genetic Algorithm tool to optimise the location of BGI to allow users to assess flood and storm overflow risk





Aim of the project

How?

- Develop a tool to better visualise and use the (surface and pipe) drainage network for model set up and analysis of results

- develop a methodology to flexibly explore a wide range of rainfall events and design constraints.

Sewer Overflow Flood Risk Analysis MOdel Dafni Enabled

vassilis.glenis@newcastle.ac.uk

DAFNI

CONFERENCE 2023

IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Centre of Excellence Talks

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BUILDING A SECURE AND RESILIENT WORLD

Centre of Excellence Speaker:

SCQUAIR - Small Changes and Computer-Generated Spatial Interaction Modelling with QUANT

Dr Richard Milton

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QUANT

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Simulating the Resilience of Transport Infrastructures using QUANT (SCQUAIR)

Dr. Richard Milton

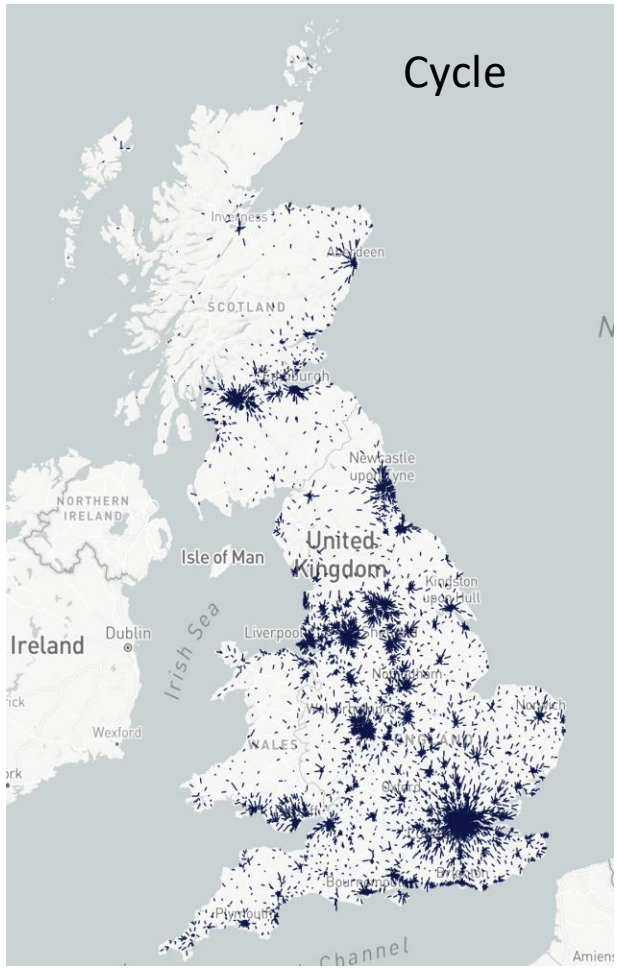
Prof. Michael Batty

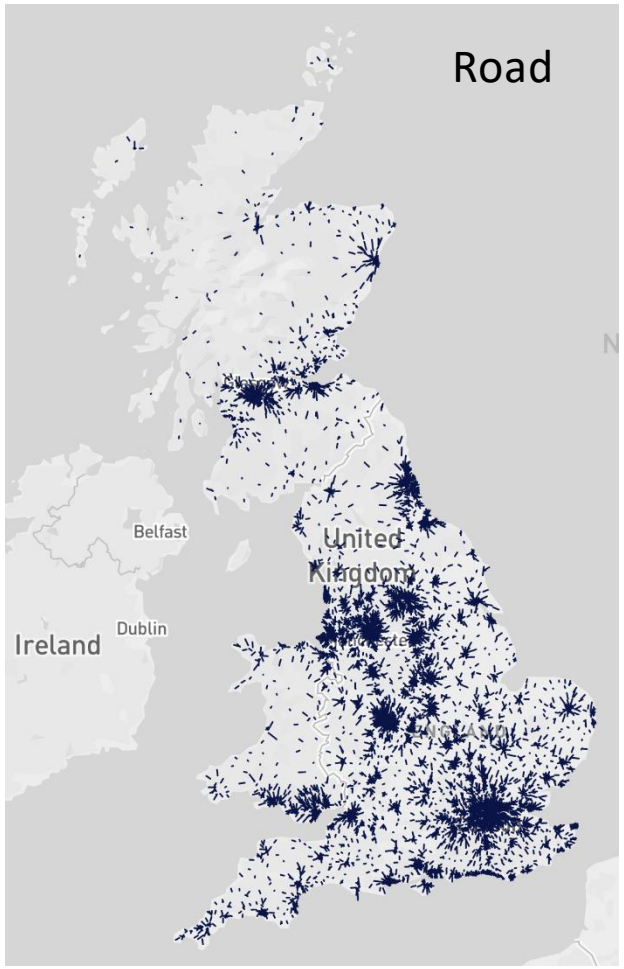
Bartlett Centre for Advanced Spatial Analysis, UCL

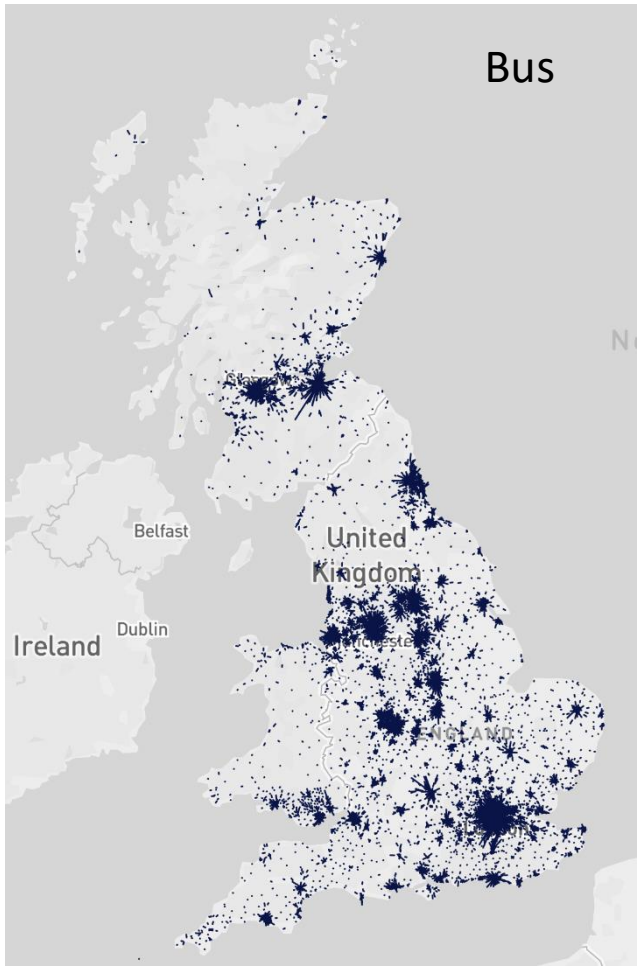
12 September 2023

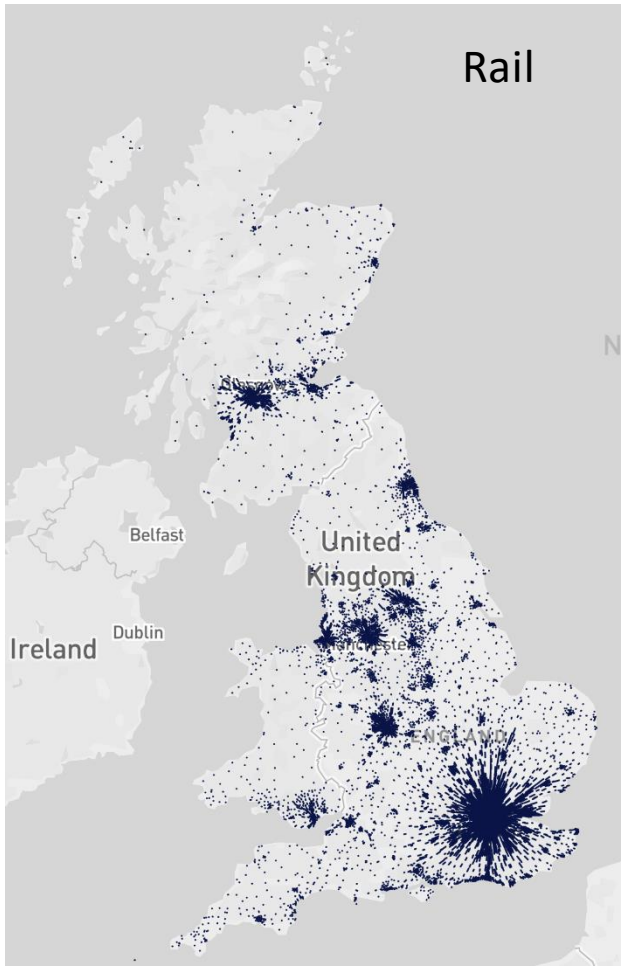
Travel to Work: Cycle, Road, Bus, Rail

Flow lines show mean magnitude and direction of people commuting



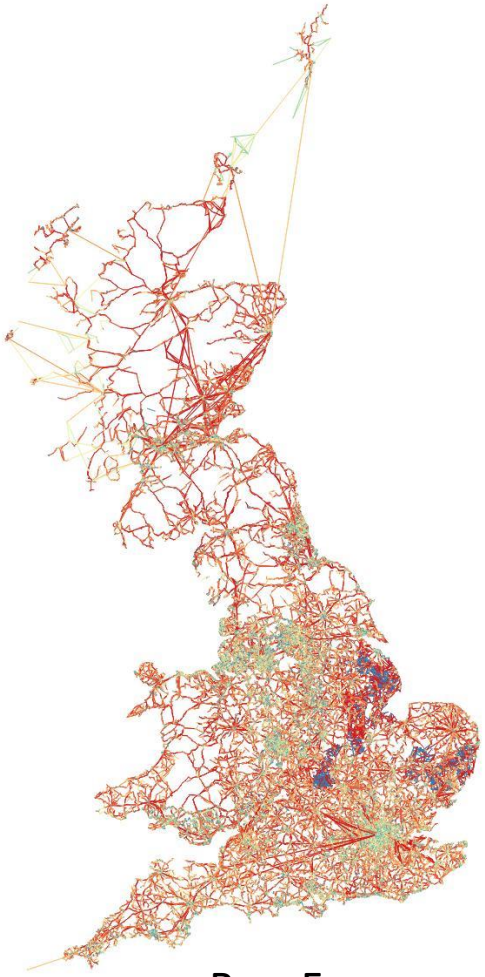




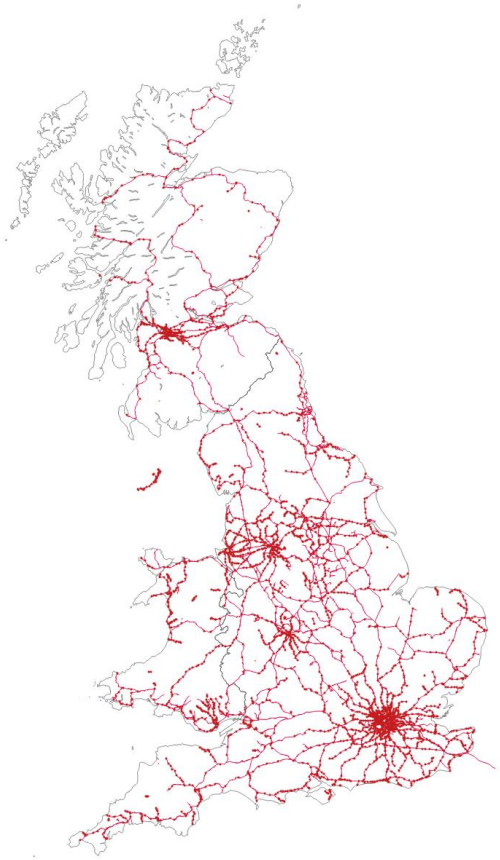


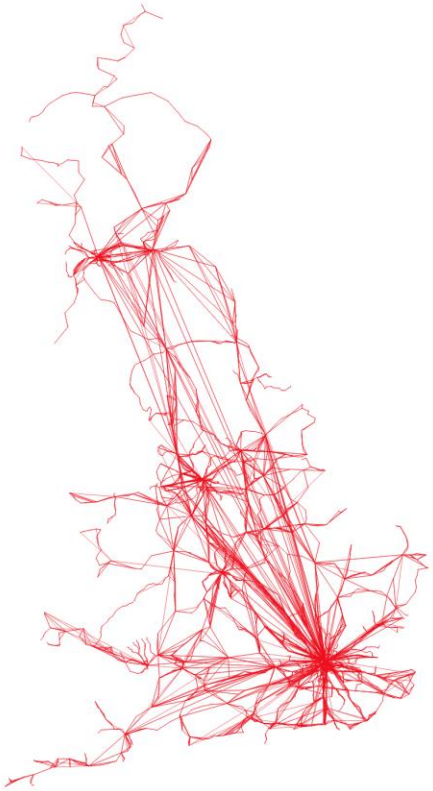
Transport Networks

Road,
v=3.5M, e=8.4M



Bus, Ferry,
v=0.29M,
e=0.42M





Rail, v=3165, e=10,269

SCQUAIR: Small Changes, QUant and AI Resilience - The Plan

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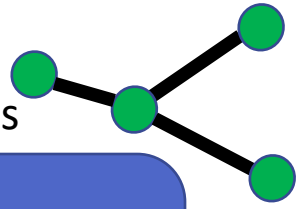
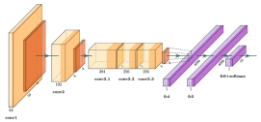
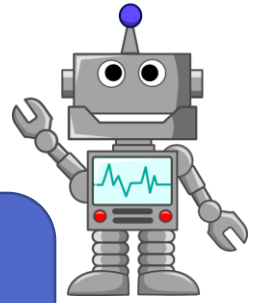
Data & Analytics Facility for National Infrastructure

docker

12,000 scenarios







WP1: QUANT running on DAFNI (2m)

WP2: Run Batches of Scenarios (4m)

WP3: Teach ANN to Run Scenarios (6m)

WP4: Visualise, Analyse, Write Papers (2m)

OUTPUTS:

- QUANT on DAFNI… linking models
- Research on making scenarios
- Portfolio of Plans
- Workshops
- Papers

HEATHROW 3rd RUNWAY

UCL

QUANT Alpha version

The Alan Turing Institute

casa

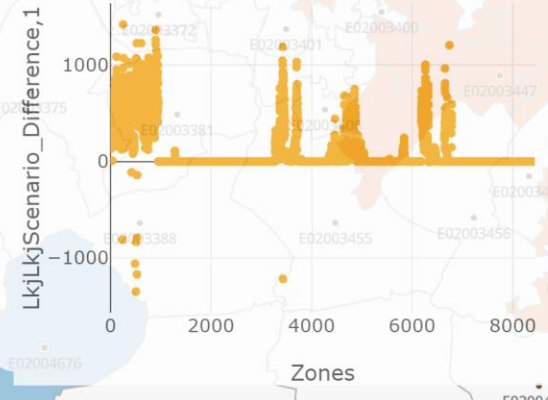
Lj Scenario Absolute Difference KM Travelled

663.57 to 1419.47
384.02 to 663.57
128.39 to 384.02
-789.84 to 128.39
-1346.73 to -789.84

This is the absolute difference in KM travelled after the scenario has been run. Change

Colours | Ranked | Mode: road

Map Opacity



Road: 727,071KM

Rail: 824,555KM

HEATHROW 3rd RUNWAY

UCL

QUANT Alpha version

The Alan Turing Institute

casa

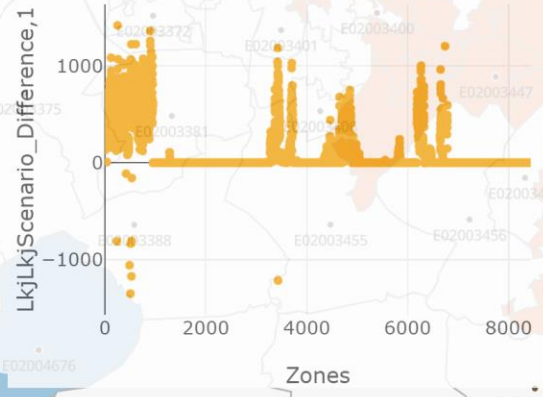
Lj Scenario Absolute Difference KM Travelled

662.54 to 1417.07
383.42 to 662.54
128.08 to 383.42
-807.21 to 128.08
-1350.45 to -807.21

This is the absolute difference in KM travelled after the scenario has been run. Change

Colours | Ranked | Mode: road

Map Opacity



926 secs

Road: 725,936KM

Rail: 826,317KM (35KM)

HEATHROW 3rd RUNWAY

UCL

QUANT Alpha version

The Alan Turing Institute

casa

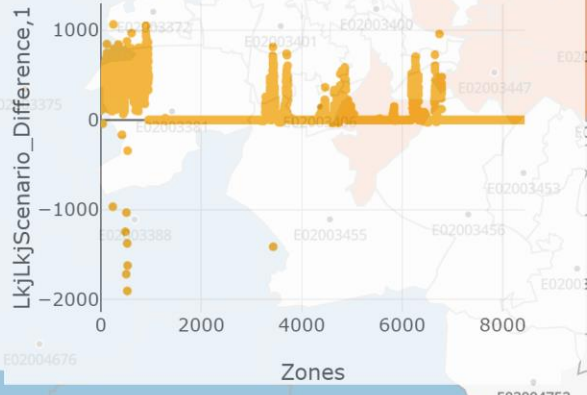
Lj Scenario Absolute Difference KM Travelled

512.01 to 1064.27
298.36 to 512.01
99.65 to 298.36
-967.96 to 99.65
-1905.62 to -967.96

This is the absolute difference in KM travelled after the scenario has been run. Change

Colours | Ranked | Mode: road

Map Opacity



367 secs
926 secs
537 secs
583 secs
516 secs
537 secs
598 secs
315 secs
301 secs

Road: 529,797KM

Rail: 1,296,217KM

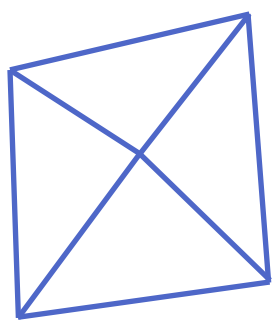
(193KM)

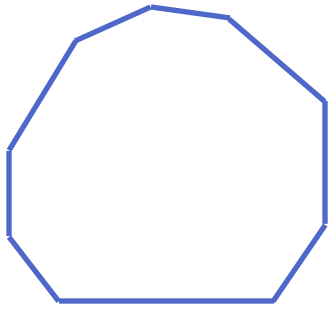
mapbox

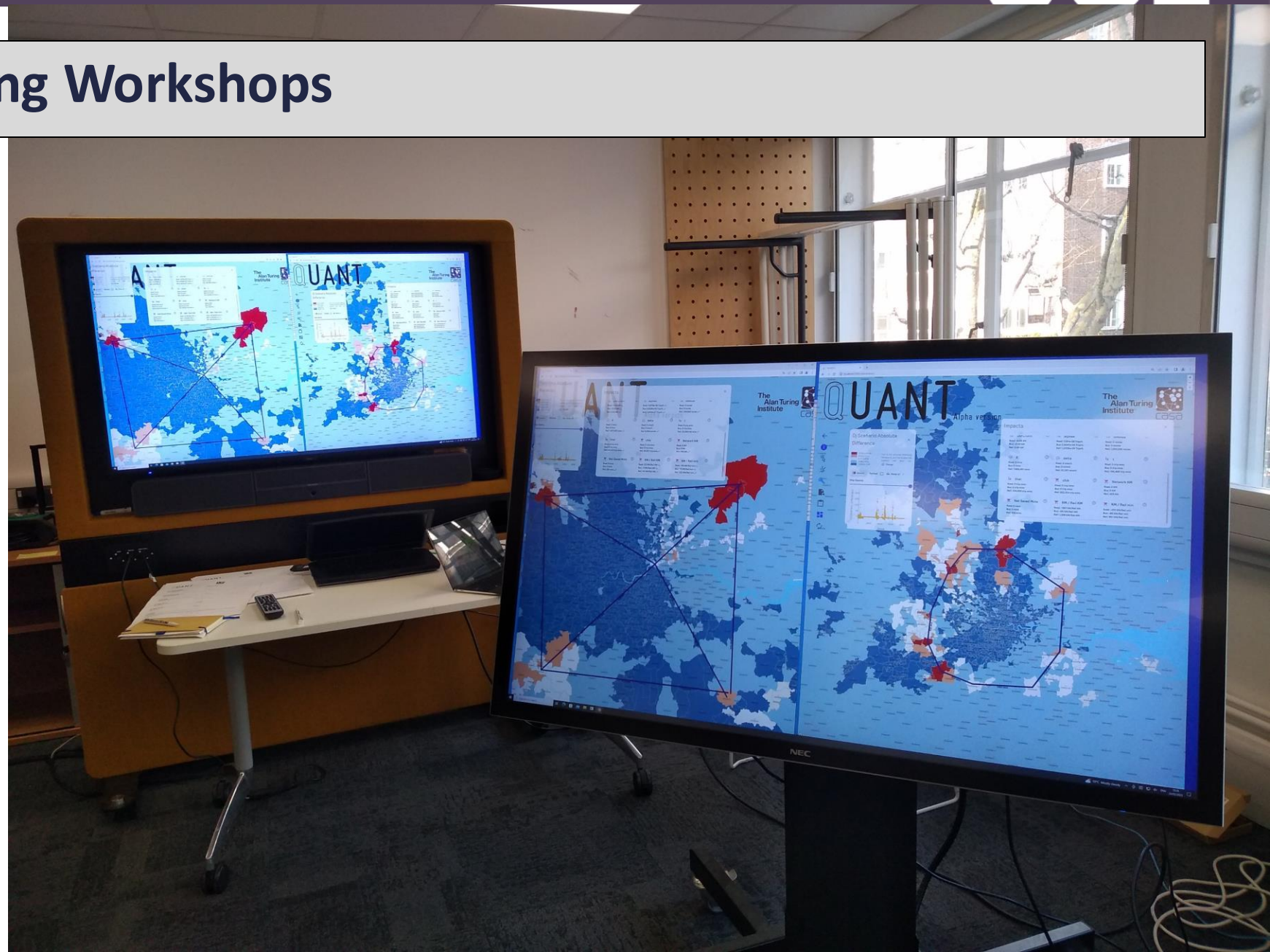
© Mapbox © OpenStreetMap Improve this map

QUANT Urban Planning Workshops

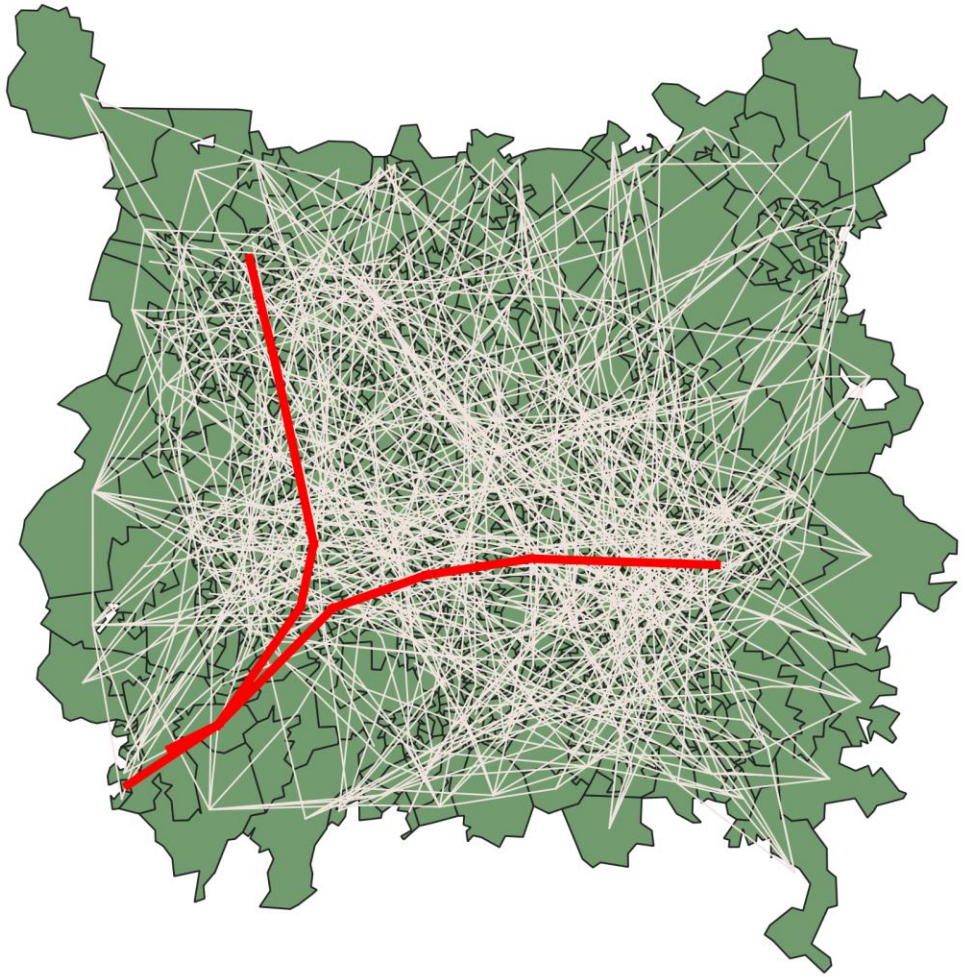
SQUARE and round plans to develop the green belt. The Circular ring around London had the better cost/benefit.



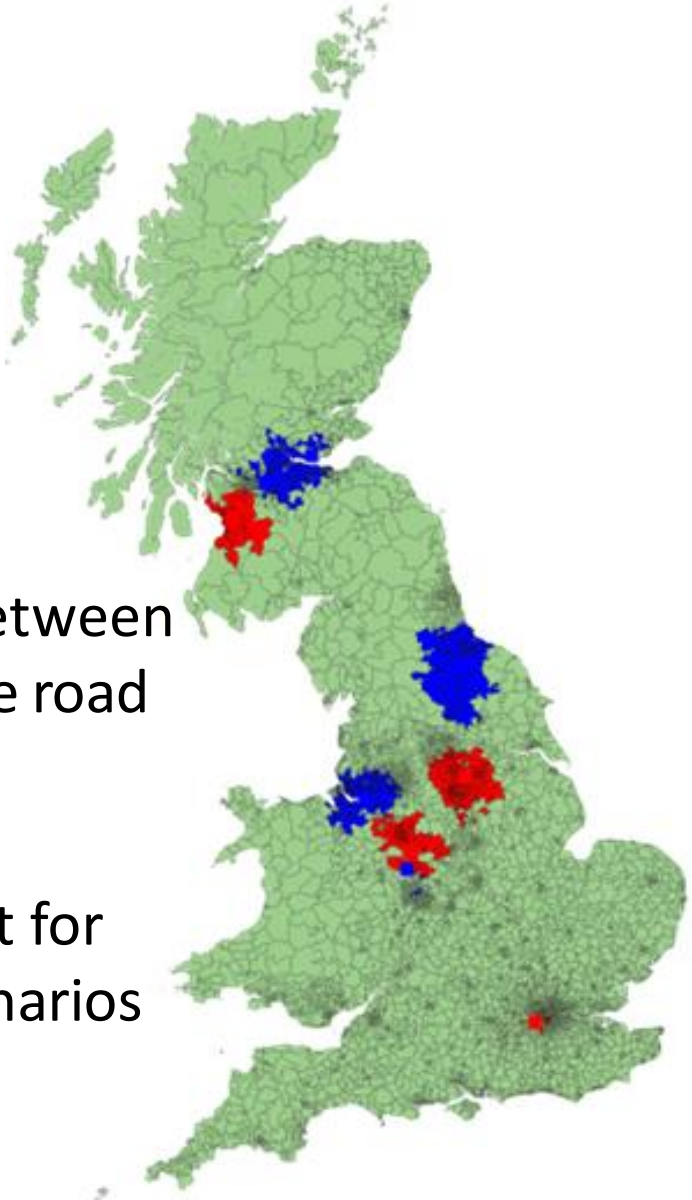




QUANT Gravity Model: Network and Job Changes

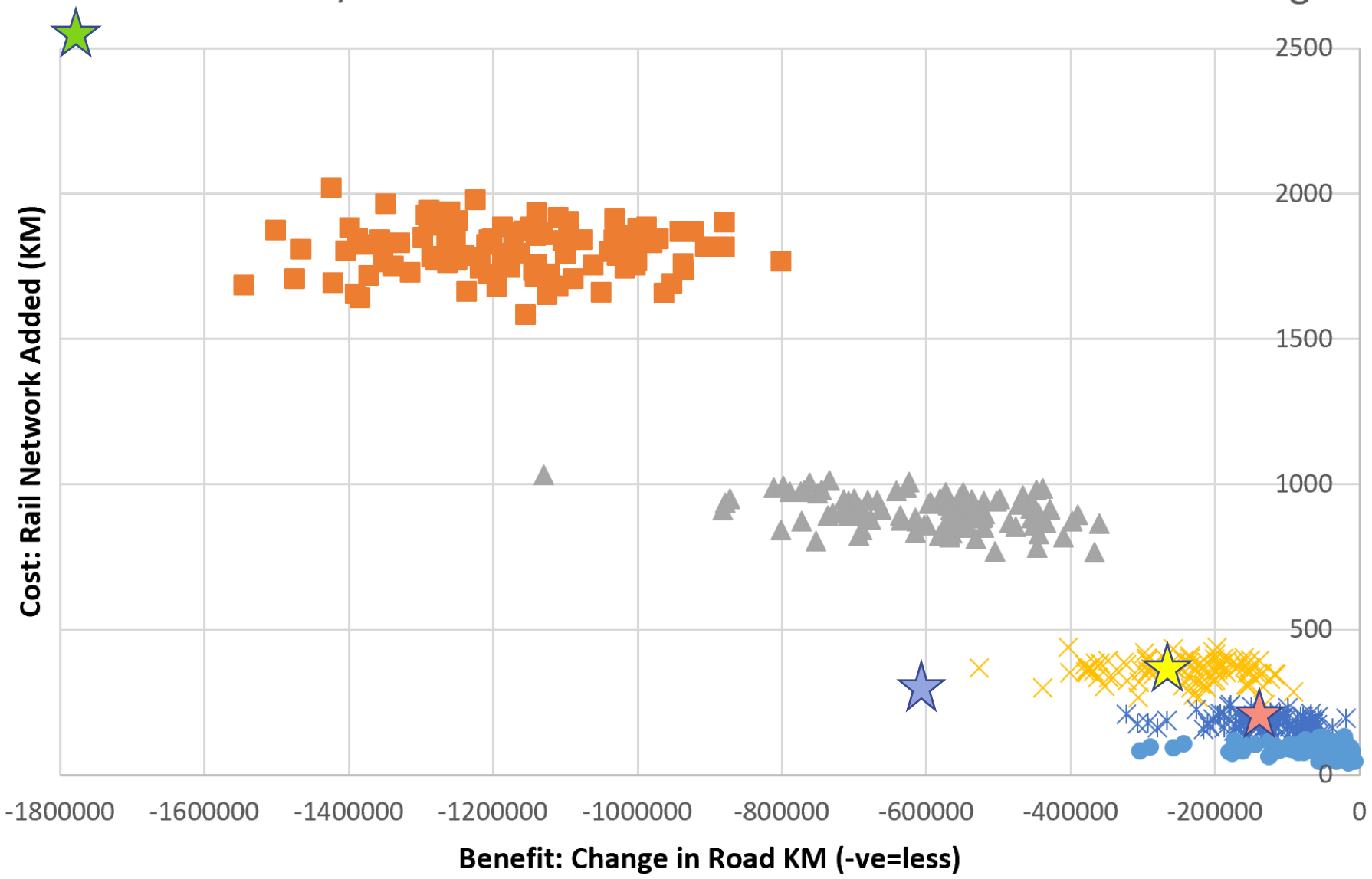


Birmingham: 300 random bus routes



UK: Job swaps between regions to reduce road KM driven.
Also, change the North/South split for Levelling Up Scenarios

Cost/Benefit: Rail Scenario Size and Road Commute Changes



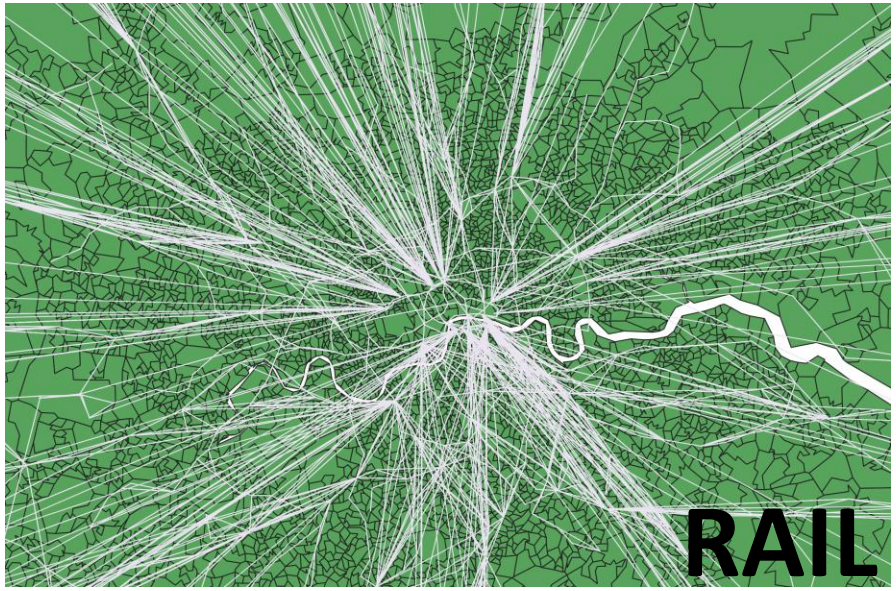
Scenario	Road KM	Rail KM
HS2 IRP	-1.8M	3,000
CAMKOX	-610,188	284
HS2 Phase 1	-248,026	329
Crossrail	-179,924	229

- Random 200
- Random 100
- Random 40
- Random 20
- Random 10

LIMIT TO 30 KM RADIUS LINKS

Network Resilience: Reachable Locations and Recovery Time?

Network measures of resilience and recovery? Community, centrality, hierarchy and accessibility



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QUANT

Alpha version

Simulating the Impacts of Large Scale Change in UK

Dr. Richard Milton
richard.milton@ucl.ac.uk

Professor Michael Batty
m.batty@ucl.ac.uk

DAFNI

Panel
Questions: Slido
#2299756

Dr Giuliano Punzo
Dr Wei Yang
Dr Brian Matthews
Russell Price

UKRI Science and Technology Facilities Council
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CONFERENCE 2023

IMPERIAL COLLEGE LONDON : 12 SEPTEMBER

BUILDING A SECURE AND RESILIENT WORLD

Speaker:
Closing Remarks

Dr Brian Matthews

DAFNI Project Lead
Scientific Computing, Science and Technology Facilities

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Thank you all for taking part

For Partnership opportunities email:

katie.cartmell@stfc.ac.uk

To request access to the DAFNI Facility: https://dafni.ac.uk/dafnilogin/

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CONFERENCE 2023

BUILDING A SECURE AND RESILIENT WORLD

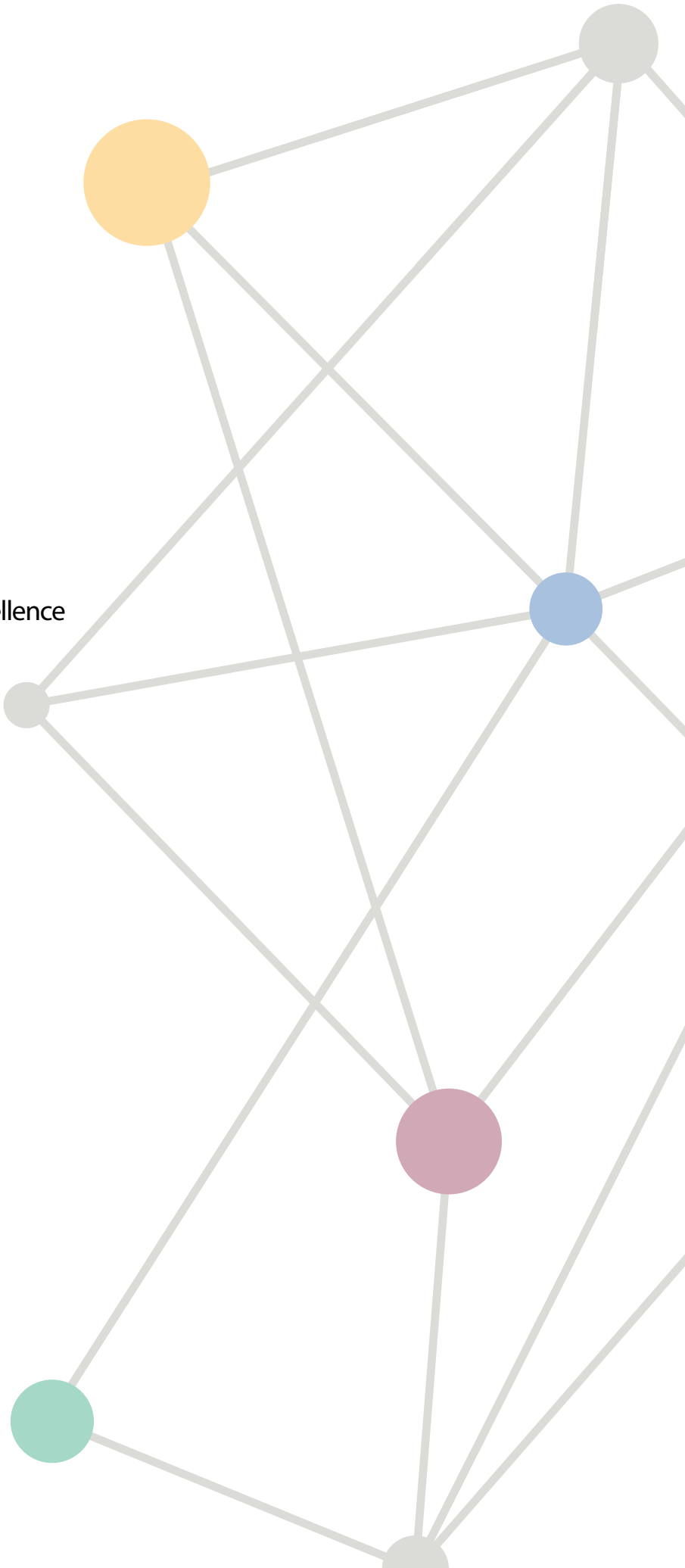
IMPERIAL COLLEGE, LONDON. 12 SEPTEMBER 2023

Data & Analytics Facility for National Infrastructure

CONTENTS

Audience participation is welcomed throughout various points in the programme.

To pose your questions and get involved, please download the Slido App from your app store or access Slido at the following address **sli.do** and enter event ID **#2299756.**



WELCOME

Welcome to the DAFNI Conference, 2023. This year we are back with an in-person event in London. I look forward to catching up with the DAFNI community and building new networks!

At last year's conference, our theme was Environmental Impacts and we saw how users are now using the platform. The platform has changed since last year and today you will be able to hear from the DAFNI technical team on DAFNI's new features and see the platform live in demonstrations during the breaks.

This year's conference is focused on 'Building a Secure and Resilient World', a new research theme within UKRI that DAFNI is a part of. We have an exciting programme today, with keynote and invited speakers, DAFNI demonstrations, and the launch of our Centre of Excellence for Resilient Infrastructure Analysis.

Today we will learn more about the grant holders' projects that form an essential part of the Centre and look forward to its further activities. The outputs from this community can provide policymakers, private companies with the analysis and scenario-planning vital to ensure the UK is resilient against potential future risks.

I very much look forward to working with these exciting projects over the next 2 years.

I am delighted to welcome our two keynote speakers, who will help paint the picture for 'Building a Secure and Resilient World'. Bridget Rosewell, a Non-Executive Director at UK Infrastructure Bank (UKIB), will tell us how DAFNI helps to improve capacity and resilience of infrastructure. Wei Yang, a Co-Founder of the Digital Task Force for Planning, will then discuss her work on Spatial Planning Reimagined. We also have invited speakers, Kristine Zaidi and Russell Price. Kristine is a programme lead on the UKRI BSRW programme and will give a talk on the challenges of resilience for research. Russell is the Chair of ISO Technical Committee TC262 and will discuss using standards in practice, embedding resilience in infrastructure.

I look forward to meeting you and hope that you enjoy the day.

Dr Brian Matthews leads the DAFNI programme at Rutherford Appleton Laboratory (RAL).

He 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. He 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 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.

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Professor Liz Varga
University College London

Programme

PROGRAMME

Chair: **Dr Giuliano Punzo, Lecturer, University of Sheffield; Director of the Sheffield Urban Flows Observatory**

09:00 **Arrival and Breakfast Networking**

09:25 **Welcome and Introduction**

09:30 **Keynote Presentation: DAFNI to Improve Capacity & Resilience of Infrastructure Systems**
Bridget Rosewell, Non-Executive Director at UK Infrastructure Bank (UKIB), Formerly Commissioner of the National Infrastructure Commission (NIC)

10:10 **DAFNI – Exploring Resilience**
Dr Brian Matthews, DAFNI Facility Lead, Scientific Computing, STFC

10:35 **Presentation - DAFNI Technical Team**
Dr Bethan Perkins, DAFNI Team Leader

10:55 **Break, Demos, Networking**
Building a Secure and Resilient World

11:25 **The Challenges of Resilience**
Dr Kristine Zaidi, Associate Director of Programmes, UKRI AHRC

11:45 **Presentations from Centre of Excellence**

Resilience Scenarios for Integrated Water Systems - RIWS
Dr Ana Mijic, Imperial College London

An Agent-Based Model of Flood Infrastructure Resilience – FIRM
Professor Richard Dawson, Newcastle University

Uncertainty Quantification and Sensitivity Analysis for Resilient Infrastructure Systems – USARIS
Dr Francesca Pianosi, University of Bristol

Building Systemic Resilience of Interdependent Infrastructure Networks at the National Scale – NIRD
Dr Raghav Pant, University of Oxford

12:45 **Networking Lunch and Demos**

13:45 **Welcome Back and Introduction to the Afternoon Session**

13:50 **Keynote Presentation: Spatial Planning Reimagined**
Dr Wei Yang, Co-Founder & CEO, Digital Task Force for Planning; Chairman, Wei Yang & Partners

14.30 **Standards in Practice - Embedding Resilience in Infrastructure**
Russell Price, International Standards Organization

14:50 **Break, Demos, Networking**

15:20 **Presentations from Centre of Excellence**

Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks – STORMS
Dr Xilin Xia, University of Birmingham

Pywr-WREW, a Water Resources model for England and Wales Built in Python Water ResourcesSimulation System
Dr Anna Murgatroyd, University of Oxford

Sewer Overflow Flood Risk Analysis Model DAFNI Enabled - SOFRAMODE
Dr Vassilis Glenis, Newcastle University

Small Changes and Computer-Generated Spatial Interaction Modelling with QUANT – SCQUAIR
Dr Richard Milton, UCL

16:20 **Panel**
Dr Giuliano Punzo
Dr Wei Yang
Russell Price
Dr Brian Matthews

16:50 **Conference Closing Remarks**
Dr Brian Matthews, DAFNI Facility Lead, Scientific Computing, STFC

17:00 **Close of Conference**

Keynote Speakers

Bridget Rosewell

CBE, MA, MPhil, FICE, FACSS, FSPE

Non-Executive Director, UK Infrastructure Bank (UKIB)

Bridget Rosewell is an experienced director, policy maker and economist, with a track record in advising public and private sector clients on key strategic issues. She chairs Atom Bank and the M6 Toll Company and is a non-executive for the UK Infrastructure Bank and Northumbrian Water Group. Among other roles, she has been a Commissioner for the National Infrastructure Commission, chaired DVSA, been Senior Independent Director for Network Rail and Chief Economic Adviser to the Greater London Authority.

She was appointed CBE in December 2018 and is also a Fellow of the Institution of Civil Engineers, the Academy of Social Science and the Society of Professional Economists. She writes on finance, risk and uncertainty as well as infrastructure and modelling validation.

She has worked extensively on cities, infrastructure and finance, advising on projects in road and rail and on major property developments and regeneration. She has advised on changes to planning regulation and TfL's finances and has appeared at planning Inquiries.

Dr Wei Yang

Co-Founder & CEO, **Digital Task Force for Planning**;
Chairman, **Wei Yang & Partners**

Dr Wei Yang is an internationally renowned town planner and urban designer who champions a place-based, whole-systems approach to tackle the grand challenges of our times. She is an influential thought leader and a powerful advocate for climate action, nature-based solutions, health and well-being, and social equality. She was named a Net Zero Hero by Digital Leaders in 2022.

Wei is the Chairman of Wei Yang & Partners, an award-winning master planning firm in London. She possesses extensive experience in managing multi-disciplinary teams. Her professional strengths lie in combining innovative planning inspirations with feasible implementation solutions.

Wei is a leading figure in researching, promoting, and implementing 21st-century garden city and green and low-carbon development approaches worldwide.

Wei is a Fellow of the Academy of Social Sciences, a Fellow of the Royal Town Planning Institute (RTPI) where she served as President in 2021, and an Honorary Professor at the Bartlett Centre for Advanced Spatial Analysis, University College London.

She will serve as the first female Chair of the Construction Industry Council (CIC) from June 2023.

Invited Speakers

CHAIR

Dr Giuliano Punzo

Lecturer, University of Sheffield;
Director of the Sheffield Urban Flows Observatory

Giuliano Punzo obtained an MEng in Aerospace Engineering at the University of Naples (Italy) 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 Governance Board.

INVITED SPEAKER

Dr Kristine Zaidi

Associate Director of Programmes, UKRI AHRC

Kristine Zaidi joined the Arts and Humanities Research Council (AHRC) in September 2017 as Strategic Lead for Literature, Languages and Area Studies. Her current portfolio includes Public Policy, Public and Engagement and International. She is a programme lead for the UKRI strategic theme on Building a Secure and Resilient World.

Prior to AHRC, she held various positions in the Economic and Social Research Council (ESRC). Her work included data policy, research infrastructure, security and urban studies. Kristine started her professional life as a civil servant in the government of the Republic of Latvia, working in international relations at the Ministry of Defence, and strategic planning in the State Chancellery.

INVITED SPEAKER

Russell Price

Chair of Risk Management Committee,
International Standards Organization

Russell brings a unique perspective to Risk, Continuity and Resilience Management based on a breadth and depth of experience across multiple sectors in organisations. He has been at the forefront of development across Risk and Resilience fields for over 20 years and continues to lead industry thinking and professional practice. Russell is an adviser to governments, regulators, and businesses on the management of risk around the world.

He is currently Chair of the Risk Management Committee (TC262) for the International Standards Organization (ISO) responsible for ISO 31000 - the global risk management standard. He also serves on other International Standards Organisations' Technical Committees covering Climate Change (4Cs), ESG Coordination, Governance (TC309) and Security and Resilience (TC292), as well as Information Security (ISO/IEC JTC 1/SC 27).

Centre of Excellence Grant Holders

Dr Ana Mijic

Reader in Water Systems Integration; Director of the Centre for Systems Engineering and Innovation, Imperial College London

Project Acronym: RIWS

Dr Ana Mijic is a Reader in Water Systems Integration and Director of the Centre for Systems Engineering and Innovation at Imperial College London. Her research focuses on advanced systems modelling and water systems analysis. She is leading the development of novel simulation tools focused on quantifying interactions between the water cycle and sustainable development. The work has aimed to inform policy, regulatory bodies, and the water industry around if and how we can support economic growth whilst ensuring sustainable water use and flood and water quality management under future uncertainties. Prominent areas of research include developing frameworks for a systems approach to catchment and urban water management, including applications to irrigation water use in India, Blue-Green infrastructure and water infrastructure planning under deep uncertainty and urban water-energy nexus. To support systems-level water management analysis, her team has developed the Water Systems Integration Modelling (WSIMOD) framework. The WSIMOD includes urban and rural water system models at a catchment scale and simulates flow and water quality. The model can flexibly integrate elements of the whole water cycle, including land management, water and wastewater infrastructure, operational rules, demand behaviour and river water quality, supporting integrated and collaborative decisions for long-term planning of water and land systems. Ana is passionate about pushing the boundaries of scientific evidence for policy and water management plans development and implementation. She worked on multiple knowledge transfer projects and supported steering committees and policy forums. Through her innovation placement with the Environment Agency, she has developed a systems approach to water management in the context of the UK's 25-Year Environment Plan. Her work was featured in media such as Guardian, Evening Standard, ITV, and Sky News.

Abstract:

The resilience of water systems in the context of climate change, weather extremes, planning and operational decisions is crucial to water infrastructure service delivery and environmental management. In the UK, water systems are under extreme pressure from exceptional droughts like in the Summer of 2022, or challenges to manage sewage spills. At the same time, the latest report on river water quality shows that only 14% of rivers in England meet good ecological status.

Therefore, there is a need to develop resilience assessment to address the challenges of water systems and the environment. This project (RIWS) led by Ana Mijic, Imperial College London, addresses a critical knowledge gap in resilience scenarios for integrated water systems for various stressors.

It also aims to develop scenarios that can provide evidence for water companies, planning authorities and environmental regulators on the feasibility of water systems adaptive planning when assessed by resilience metrics.

Professor Richard Dawson

Professor of Earth System Engineering
and Director of Research in the School of Engineering,
Newcastle University

Project Acronym: FIRM

Richard is Professor of Earth Systems Engineering and Director of Research in the School of Engineering at Newcastle University. Richard's research has focused on infrastructure resilience to extreme weather and climate change. He is a member of the UK's Committee on Climate Change and Lead Author of the Cities, Settlements and Infrastructure Chapter of the Intergovernmental Panel on Climate Change 6th Assessment Report.

Flood resilience simulation on DAFNI:

Actions taken before, during and after the shock of flood infrastructure can threaten lives and damage infrastructure through slow evacuation, or failure to erect temporary flood defence infrastructure.

Principal Investigator from Newcastle University is heading a project called the Flood Infrastructure Resilience Model (FIRM), a computational model that is used to explore the impact of flood infrastructure failure on flood resilience, and to test strategies to mitigate the impact of these shocks.

Through the funding awarded, the project aims to re-code FIRM into Python for great inter-operability and integrate FIRM onto DAFNI to make it more accessible to the community, and to provide virtual and in-person training to support the wider uptake of the model and DAFNI.

Dr Francesca Pianosi

Senior Lecturer in Water and Environmental Engineering, University of Bristol

Project Acronym: USARIS

Francesca is Senior Lecturer in Water and Environmental Engineering based in the School of Civil, Aerospace and Design Engineering at the University of Bristol. Her research focuses on advancing the way mathematical modelling is used to inform decision-making under uncertainty, particularly for water resource and natural risk management. She is an international expert on uncertainty quantification and sensitivity analysis and the lead author of the open-source SAFE toolbox, which is used by thousands of scientists and practitioners worldwide to analyse the propagation of uncertainty in mathematical models.

Uncertainty quantification and sensitivity analysis for resilient infrastructure systems:

Principal Investigator, Francesca Pianosi from the University of Bristol, is delivering a computational model allowing the evaluation of risks and benefits of different infrastructure options on a virtual system. The model will allow a design to be tested through various constraints before committing to a particular design, and combat overconfidence in model results and insufficient consideration of the breadth of possible futures.

For example, when planning water infrastructure for drought resilience, we need to make a set of uncertain assumptions about the way that future climate will affect water sources and how changes in the economy, society and lifestyle will affect future water demand.

Dr Raghav Pant

Senior Research Associate at the Environmental Change Institute, University of Oxford

Project Acronym: NIRD

Dr. Raghav Pant is a Senior Research Associate at the Environmental Change Institute, University of Oxford. He holds a Bachelors in Technology in Civil Engineering for Indian Institute of Technology in Kanpur, a MSc in Civil and Environment Engineering from Princeton University, and a PhD in Industrial Engineering for University of Oklahoma. Raghav is associated with the Oxford Programme for Sustainable Infrastructure Systems (OPSIS), and has led risk and resilience analysis research teams as part of the EPSRC funded Infrastructure Transitions Research Consortium. His analysis of failure criticality of Great Britain's national infrastructure networks, undertaken in collaboration with Infrastructure UK in HM Treasury was the first piece of evidence instrumental in moving the policy thinking from silo-sectored to a multi-sector and cross-sector one. He led the first evidence-based systems analysis of interdependent network vulnerabilities of UK's interconnected networks to support the National Infrastructure Commission's recommendations of a new resilience framework in UK. Raghav has worked with a range of organisations within UK and globally such as World Bank, Global Centre for Adaptation, Department for Transport, National Grid, Network Rail, JBA Group, ARUP, Scottish Water, HR Wallingford, CH2M. He held and holds PI and Co-I roles in UKRI funded project to plan for resilience of interdependent infrastructure networks exposed to multi-hazard impacts and EU H2020 funded project Multi-hazard Infrastructure Risk Assessment for Climate Adaptation. His research paper on vulnerability assessment of Great Britain's railway infrastructure was awarded the 2016 Lloyds Science of Risk Prize in Systems Modelling, while another paper in co-authorship was runner-up at the 2021 Lloyds Science of Risk Prize in the cyber category.

Building systemic resilience of interdependent infrastructure networks at the national scale

In recent years, extreme flood and storm events across the UK have affected large numbers of infrastructure networks and their customers, resulting in economic damages and losses of the order of tens of millions of pounds.

Government agencies and infrastructure operators have noted the lack of coherent datasets of interconnected networks and cross-sectoral resilience metrics which makes it challenging to plan for and respond to extreme large-scale weather events. This project led by Raghav Pant, Principal Investigator from the University of Oxford, aims to address the above challenges by delivering an open-source modelling framework on the DAFNI platform for stress-testing interdependent network resilience against flood and storm events.

Dr Xilin Xia

Assistant Professor in Resilience Engineering within the School of Engineering at the University of Birmingham

Project Acronym: STORMS
Project partners: UK Centre for Ecology & Hydrology (UKCEH), British Geological Survey

Xilin is an Assistant Professor in Resilience Engineering within the School of Engineering at the University of Birmingham. He is mainly working on computational modelling of natural hazards and their impacts. His research interests cover computational hydraulics, high-performance computing, machine learning and their applications in modelling and understanding physical processes involved in natural hazards such as flooding and landslides. His research was funded by UKRI, the UK Met Office and The Royal Society. He has published over 30 peer-reviewed journal papers. Xilin's papers have been highlighted as 'featured article' and 'top cited paper' by prestigious journals such as Water Resources Research and Advances in Water Resources. By developing new algorithms and models, his work has been critical for new applications such as large-scale impact-based flood forecasting and digital twin for climate resilience.

STORMS: Strategies and Tools for Resilience of Buried Infrastructure to Meteorological Shocks

Buried infrastructure, which include cables and pipes vital to city and urban lives, are vulnerable to meteorological shocks or extreme weather events, such as floods and droughts. Such events can lead to soil movement, thermal contraction and expansion, sinkholes, and various other problems.

Despite the urgency to be prepared for these impacts, our understanding of what the UK's buried infrastructure can cope with remains poor, because existing risk assessment tools do not comprehensively consider impacts from these extreme weather events.

The framework will be applied to understand the potential impacts of extreme weather events, or 'shocks', and climate change on these infrastructures. This will lead to fewer service disruptions, potential cost savings, and increased resilience of infrastructure systems in the face of meteorological shocks and climate change.

Dr Anna Murgatroyd

Postdoctoral Researcher at the Environmental Change Institute (ECI), University of Oxford

Project Acronym: Pywr-WREW

Dr Anna Murgatroyd is a Postdoctoral Researcher at the Environmental Change Institute (ECI), University of Oxford. Anna is currently a member of the Environment Agency (EA)/Ofwat National System Simulation Modelling (NSSM) project, the GCRF Water Security and Sustainable Development Hub, and the Food and Climate systems Transformations Alliance. Anna has pioneered risk-based approaches to defining and managing water security in the UK, exploring key trade-offs between competing goals of water resource systems such as ecosystem resilience and the reliability of public water supply. Anna led the technical development of new climate simulations and the Water Resources model for England and Wales (WREW) for the NSSM project, and is working with the EA to undertake joint resilience assessments exploring the impact of climate change on regional and national water resources.

Pywr-WREW, a Water Resources model for England and Wales built in Python water resources simulation system

With growing concerns to England's water supplies due to population growth, climate change, and ecological needs, traditional water resource management, focused on individual companies, is no longer sufficient to address the complex issues posed by these factors.

Anna Murgatroyd, Principal Investigator from the University of Oxford, in collaboration with the Environment Agency and Ofwat, initiated the National System Simulate Modelling (NSSM) project. As part of this, they developed a comprehensive Water Resource model for England and Wales (WREW) that integrates various water usage sectors and future scenarios to assess potential water shortages and solutions.

However, they are limited by the model's reliance on commercial software, and the Centre of Excellence for Resilient Infrastructure Analysis provides a way to address this limitation and aims to enhance the model's accessibility and usability for researchers and practitioners.

Dr Vassilis Glenis

Senior Lecturer in Hydroinformatics,
School of Engineering, Newcastle University

Project Acronym: SOFRAMODE

Vassilis Glenis is Senior Lecturer in Hydroinformatics in the School of Engineering at Newcastle University. His research background is in hydrodynamic modelling, where he has developed advanced shock-capturing finite volume methods and applied them using cloud computing. As the originator and main developer of the CityCAT hydrodynamic simulation software, his work has focussed on flood modelling in urban environments, coupling the surface and pipe networks and incorporating blue-green interventions. He has also developed and applied stochastic weather generators for climate change impact assessments, notably for the UKCP09 national climate projections.

Sewer Overflow Flood Risk Analysis Model DAFNI Enabled (SOFRAMODE)

Using DAFNI, Vassilis Glenis from Newcastle University, aims to develop and demonstrate a state-of-the-art platform for understanding and simulating urban drainage related to surface water flooding and high-profile storm overflow events, for any UK town or city.

The scenarios will encompass a wide range of current and future rainfall event magnitudes, and provide functionality for industry and researchers, to design and test strategies to mitigate surface water flooding. This platform will be underpinned by CityCat model.

Dr Richard Milton

Senior Researcher, Centre for Advanced Spatial Analysis, UCL

Project Acronym: SCQUAIR

Richard Milton is a senior researcher at UCL's Centre for Advanced Spatial Analysis where he has worked since 2005. Most recently he has been on secondment to the Alan Turing Institute for AI and Data Science, where he has been developing the current evolution of the "QUANT" spatial interaction model with an emphasis on AI for building new transport infrastructure scenarios for carbon net zero. He has been working on different versions of the QUANT spatial interaction model since the initial development, which was funded by the Future Cities Catapult in 2014. This includes using his QUANT expertise to build a model for the Royal Society's pandemic response project (RAMP), leading to a RAMP Early Career Investigator Award (RECIA) in 2021.

Simulating the Resilience of Transport Infrastructures using QUANT

Principal Investigator, Richard Milton from the University College London has developed a model, called QUANT, which simulates the pattern of land use and transportation for Great Britain.

The model will act to look at "what-if" scenarios so that users can run thousands of scenarios of the use of land and transport to predict impacts that enable stakeholders to test various plans. It will also demonstrate how AI can be used to inform the generation of many scenarios, including the impact of shocks to the land by new infrastructures such as High Speed TWO in Birmingham.

To develop the model, Great Britain was configured into thousands of small zones and identifies three modes of transport, which bind together employment at place of work and population at place of residence.

The inclusion of identifying three modes of transport networks across GB enables to trace the repercussions of land use and transport change across networks which is key to assessing the repercussions of major changes on the UK's urban system.

Meet the DAFNI Team

DAFNI TEAM

Dr Brian Matthews
DAFNI Programme Lead

Sarah Byrne
Software Engineer

Katie Cartmell
DAFNI Partnership Manager

Joel Davies
Scientific Computing Graduate

Catherie Dhanjal
Media Manager

Rose Dickinson
Senior Software Engineer / Technical Lead

Caroline Haigh
Research Software Engineer

Lyndsey Harding
Administrator

Jack Haydock
Software Developer

Dr Jens Jensen
Data Scientist

Archit Mantry
Project Co-Ordinator

Dr Bethan Perkins
DAFNI Team Leader

Marion Samler
Business Development Manager

Lewis Sampson
Research Software Engineer

Kyle Stevenson
User Liaison

Esther Turner
Senior Research Software Engineer

About DAFNI

About the Data & Analytics Facility for National Infrastructure (DAFNI) and the Centre of Excellence for Resilient Infrastructure Analysis

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.

The **Centre of Excellence for Resilient Infrastructure Analysis** fosters research in the area of resilience in the natural and built environment as part of the overarching UKRI programme 'Building a Secure and Resilient World' (BSRW), a 5-year programme which seeks to tap the UK's research and innovation system to tackle large-scale, complex challenges for the UK.

In March 2023, UKRI awarded a £4m grant to the Scientific Computing Department, part of the Science and Technology Facilities Council (STFC), to establish a national Centre of Excellence for Resilient Infrastructure Analysis, and moves DAFNI into its new phase.

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.

The DAFNI platform offers:

- A hybrid high-performance computing platform
- A secure repository for heterogeneous national infrastructure data and models.
- A place for sharing and combining data and models

Including a hybrid high-performance computing platform and a secure repository for national infrastructure data and models

- A place to support collaborations and deploy applications through a collaborative platform to research multi-system models of infrastructure
- A place as a legacy where researchers can make data and models available for the long-term

Apply for your DAFNI account

UK Academic Organisations and other bodies where there is a clear link to research may register their interest at: https://www.dafni.ac.uk/accessing-dafni/

Access DAFNI training

If you're an existing DAFNI user, access our support team through the Slack channels.

If you're interested in becoming a DAFNI user, consider joining one of our technical training sessions, run regularly online. Find out more at: https://www.eventbrite.co.uk/o/dafni-31793198351

DAFNI Use Cases

DAFNI Use Cases

Dr Patrick Tully

Project manager for UKCRIC activities at the University of Bristol

> The unique value of the DAFNI platform lies in the ability that it gives researchers to combine existing datasets regarding infrastructure — and there's a lot of interest in that across the UK and further afield.
>
> We will also be able to analyse and visualise data on DAFNI to use with the immersive space.

Professor Stephen Hallett

Chair in Applied Environmental Informatics in the Centre for Environmental and Agricultural Informatics at University of Cranfield

> DAFNI is an integral part of Digital Twin and environmental projects running at Cranfield and further afield.
>
> The DAFNI platform offers a powerful and unique facility offering enormous HPC powers coupled with an advanced workflow user interface, plus access to absolutely enormous stores of data which can come from external sources as well as other people's model runs.

Dr Ben Waterson

Associate Professor in Transportation at the University of Southampton's Transportation Research Group

> I've been a data scientist and analyst for many years but it's become harder and harder to understand what is going on with data… We can analyse it but need to be able to see the data, what it means, what the consequences are in reality, and to be able to interact with it.
>
> For us the DAFNI hardware fund represented a fantastic opportunity to develop the 'human in the loop' part of visualisation; to go beyond tables and graphs and to enable people to interact with it – with simulated real-life situations and models.

DAFNI Use Cases

Professor Daniel Coca

Formerly, Honorary Professor of Nonlinear and Complex Systems, University of Sheffield. (Professor Coca is now Head of School of Engineering and Professor of Nonlinear and Complex Systems at Newcastle University.)

"The DAFNI hardware is being used to develop a Sheffield Traffic Digital Twin. The Digital Twin uses historic and real-time traffic data from more than 640 sensors in the Sheffield area to predict the evolution of the traffic and where congestion might occur.

The DAFNI hardware is being used to carry out computationally expensive simulations as well as to train very large machine learning models that continuously learn from incoming data the traffic patterns to produce more precise traffic forecasts."

Dr Liz Varga

Professor of Complex Systems at the Infrastructure Systems Institute in the Department of Civil, Environmental & Geomatic Engineering, UCL

"Using the DAFNI platform will increase the visibility of researchers' models to the wider research community and it also acts as a repository so that other researchers can build on previous work.

The DAFNI platform, analytics and visualisation tools is an opportunity to highlight insights into infrastructure challenges and opportunities for industry and government."

DAFNI
CONFERENCE 2023

If you would like to get involved in DAFNI, please contact
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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

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