CAMELLIA

Community Water Management for a Liveable London

CAMELLIA Impact Report May 2025

IMPERIAL

British Geological Survey

UNIVERSITY OF OXFORD

UCL

Natural Environment Research Council

Contents

Executive summary

The CAMELLIA project (Community Water Management for a Liveable London) is a multi-stakeholder initiative funded by the Natural Environment Research Council (NERC) under its Regional Impact from Science of the Environment (RISE) programme. Its primary aim was to address the pressing challenges of sustainable urban water management in London. By integrating advanced research, community engagement, and systems thinking, the project sought to deliver innovative solutions to enhance water resource management, improve environmental quality, and foster social resilience. This impact report highlights the key achievements and contributions of the CAMELLIA project, emphasising its transformative impact across multiple dimensions:

- Stakeholder Engagement: CAMELLIA has successfully fostered collaboration among local authorities, water companies, community groups, and researchers, ensuring co-developed solutions align with the needs and aspirations of all stakeholders.
- Innovative Tools and Models: The development and implementation of advanced modelling tools, such as causal loop diagrams (CLDs), have enabled stakeholders to better understand complex water systems and predict the outcomes of policy and infrastructure decisions.
- Community Empowerment: By engaging communities through participatory workshops and consultations, CAMELLIA has empowered residents to actively contribute to water management strategies, fostering a sense of ownership and stewardship.
- Sustainability Outcomes: The project has delivered measurable improvements in urban water management, including enhanced flood resilience, increased water recycling, and reduced environmental impact.
- Knowledge Dissemination: CAMELLIA's findings have been widely shared through academic publications, conferences, and workshops, contributing to the global dialogue on sustainable urban water management.

Looking ahead, CAMELLIA remains committed to scaling its impact by expanding its partnerships, refining its tools, and ensuring the continued integration of community-driven approaches. This report underscores the project's significant contributions to creating a more sustainable and liveable urban future for London. The results and outputs from CAMELLIA are freely available through its Water Info Hub (waterinfohub.org).

Introduction

CAMELLIA was a five-year programme, funded by the Natural Environment Research Council under its Regional Impact from Science of the Environment (RISE) programme. The aim of RISE was to bring research organisations together with businesses, policy bodies and other organisations to deliver high impact through focused research translation and innovation in environmental science. CAMELLIA is shorthand for *Community Water Management for a Liveable London*. Its regional (though not exclusive) focus was the greater London area, and its overarching aim was to develop solutions that will encourage growth through improved ways of managing water and the environment. It sought to achieve this by bringing together engineers, urban planners, and socio-economic experts along with regional and local government, industry, developers, citizens and local residents to work together to understand the communal perception of the water system, its challenges, and common goals.

Water challenges

Urban environments are under pressure from a wide range of challenges, which affect the quality of life for those live and work within them. London, like many urban areas, faces a variety of water-related challenges. Some of the key issues include:

Water Supply and Demand

- Population Growth: London's population continues to grow, putting increasing pressure on the water supply.
- Climate Change: Climate change is altering rainfall patterns, which can lead to periods of drought or excessive rainfall. This makes it harder to predict and manage water supply.

Water Quality and Wastewater Management

- Pollution: Urban runoff, industrial waste and untreated sewage can pollute rivers and water sources and affect the quality of water in reservoirs and rivers supplying drinking water.
- Combined Sewer Overflows (CSOs): London's sewer system can combine stormwater and wastewater. During heavy rainfall, this system can overflow, releasing untreated sewage into rivers or the Thames. This poses environmental and public health risks.

Flooding

- Increased Rainfall: Due to climate change, London is experiencing more intense rainfall events. This can overwhelm the city's drainage systems and lead to flash floods, particularly in low-lying areas.
- Urbanisation: The expansion of the city with more buildings and impermeable surfaces reduces the capacity of the land to absorb water, contributing to surface water flooding.

Use of space

- Water bodies are part of a wider group of natural spaces, and it is important to consider how these perform for people and from an environmental perspective.
- There is a need to understand the complex interactions what the performance of natural spaces and how it affects people's use of these spaces

CAMELLIA has sought to help its partners and stakeholders address these challenges.

Ambition

Vision & Strategy

CAMELLIA's vision was: "To enable water security for a liveable city by facilitating a real participatory process through a system approach based on environmental science".

Its strategic objectives for impact can be broken down into the broad areas of Policy & Governance, Community and Stakeholders Engagement, Environment & Water Cycle and Technology, as shown in Figure 1. The programme has generated additional matched and leveraged funding of nearly £2 million, and over £17 million of affiliated funding (Annex 5). It was co-designed with key water management, housing and engineering organisations in the region, including policymakers, regional government, the water industry, housing providers and developers, as well as SMEs and NGOs representing businesses, communities and citizens. CAMELLIA is led by Imperial College London (ICL), working in collaboration with researchers at University College London (UCL), The University of Oxford (UO), and the British Geological Survey (BGS).

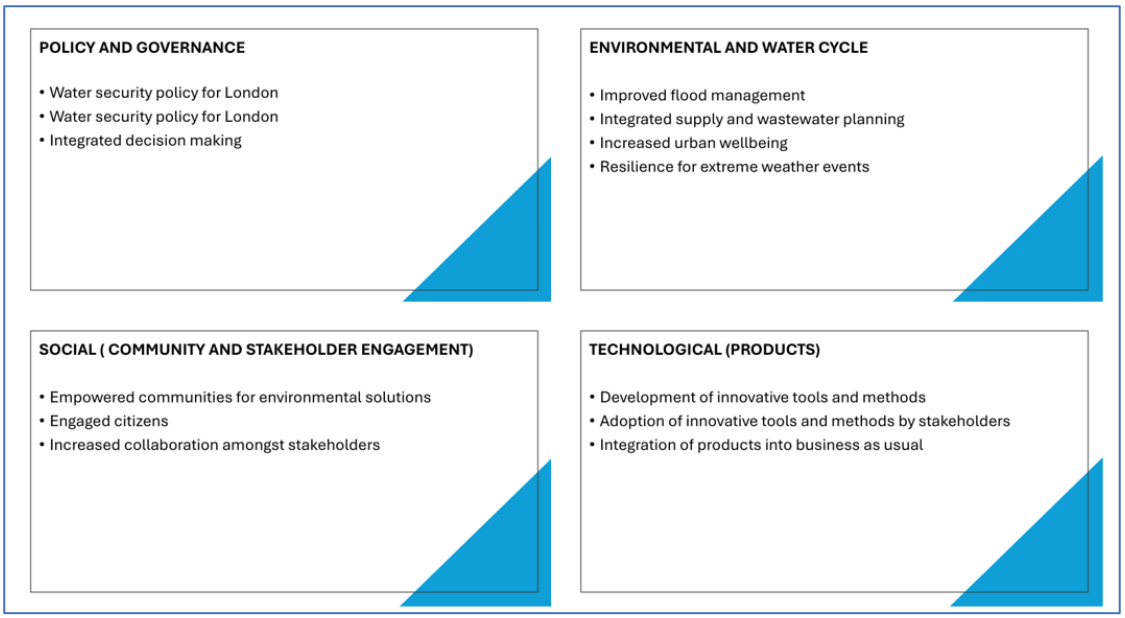

Figure 1. CAMELLIA's strategic objectives

Key approach: Integration

CAMELLIA developed a new approach to the management of London's water by facilitating integration across various communities and institutions through new methods of community engagement using co-design aided by participatory system dynamics (Figure 2). To support this work, we developed a range of tools and processes to provide guidance to local communities on water management, as well as developing integrated systems models of the water cycle. This allows decision-making across a range of scales from the local site (e.g. household water management) up to borough, city and catchment scales. Although the work was primarily focussed on greater London, the tools and methods are designed to be location independent and therefore applicable anywhere within in the UK and, in some cases, internationally.

A key element of CAMELLIA's integrated approach is the use of multiple sets of spatial environmental and water related data supported by visualisation tools. These allow user groups to interrogate data both visually and through model simulations to explore and investigate water management options. To achieve these objectives and realise our vision, we have also produced tools to support collaborative projects. These were either developed for or tested with our project partners. This has helped us to achieve tangible impacts for London and its citizens.

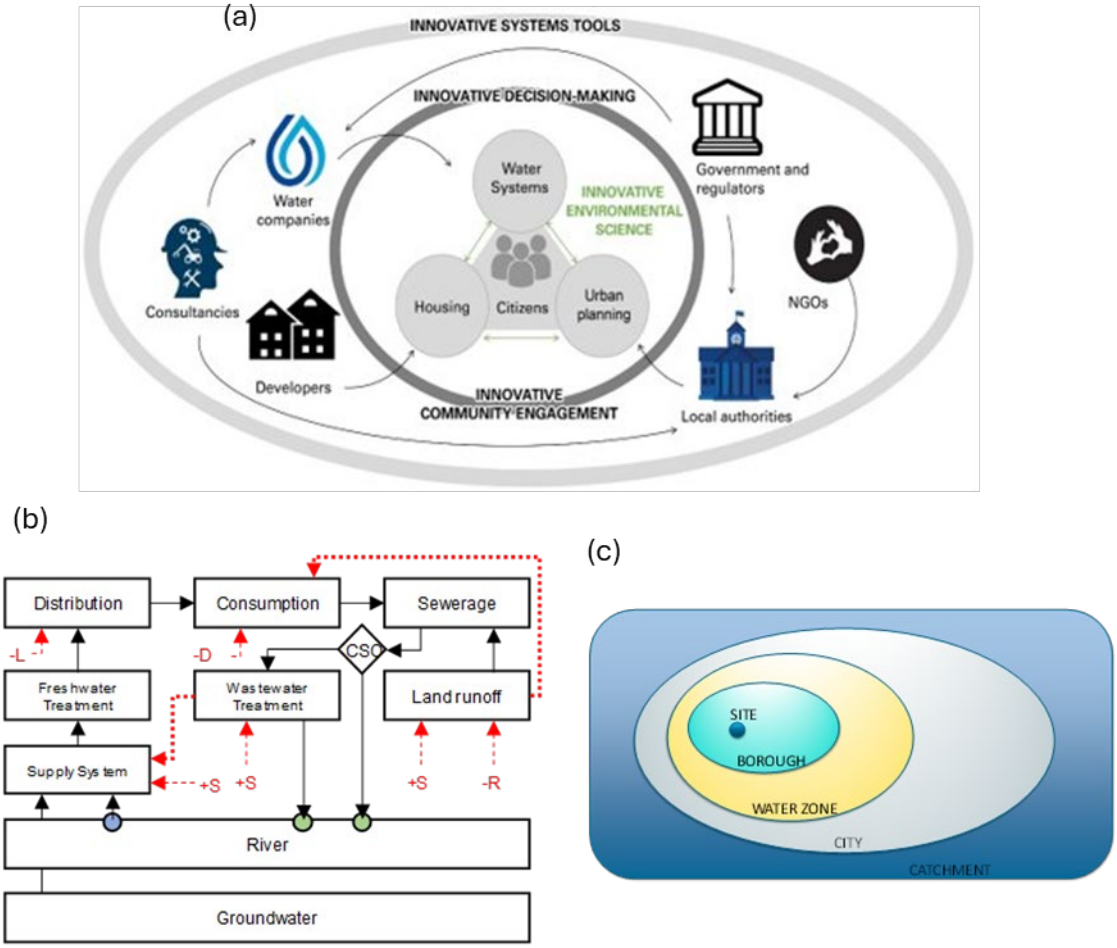

Figure 2. (a) CAMELLIA's stakeholders and environmental and social challenges, (b) Integrated water system, showing areas (in red) where communities can affect flow and water quality, (c) Range of scales that affect urban water management.

Project Overview

CAMELLIA work programme

The work programme was structured under four work packages, summarised as: COMMUNITY, TOOLS, SYSTEMS & DISSEMINATION (described in detail below). We sought to place citizens at the heart of the work as illustrated in Figure 3a. The COMMUNITY work stream covers community engagement, whereas SYSTEMS refers to our engagement at the institutional level. The TOOLS work stream provides tools that support both levels of engagement. Within each of these work streams are products being developed by CAMELLIA to support collaborative projects within partners. These projects are largely based in four areas of London as well as at the city scale (Figure 3b). The four areas represent key challenges that affect

London's water management and the lives of its citizens. In West London there are constraints to growth along with adverse impacts on the environment due to critical water infrastructure, i.e., Thames Water's Mogden wastewater treatment works. In Enfield there is the need for integrated planning to manage flooding and water quality as part of the Borough's planned development. In Thamesmead there is the challenge of achieving net zero water with new housing as well as utilising the role of urban natural capital in new development. Whereas in Southwark we are addressing the challenge of urban greening in the inner city. Finally, lessons learned from these case studies are then explored in term of policy and impact at the city scale.

(a) (b)

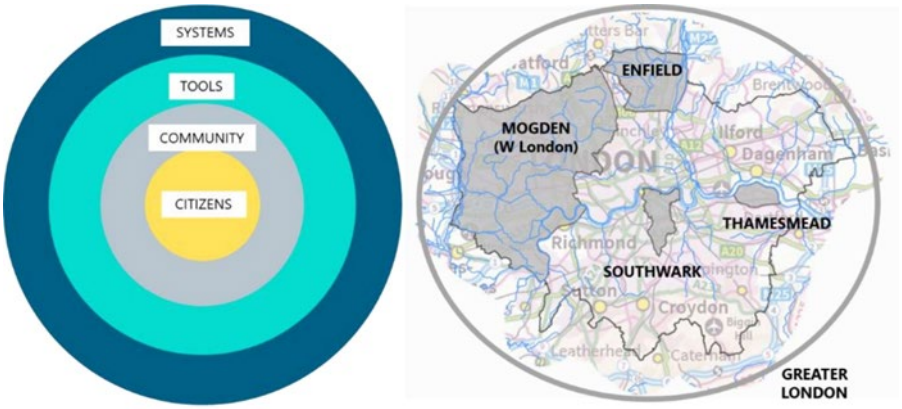

Figure 3. CAMELLIA's work streams (a) and case study areas (b).

Project Scope

System Dynamics (SD) is a powerful approach to stakeholder engagement. A key tool in SD modelling is the causal loop diagram (CLD). This enables individuals and groups to produce a visual representation of their understanding and inter-relationships of a complex system. Even more powerfully, it can be used by different groups to work together on a shared understanding of a system. As the urban water system is a particularly complex system and given it central role in the work of CAMELLIA, the team members (Investigators, impactors, PhD students) held a workshop during the early stages of the project (i.e. in 2019) where they developed a CLD on the urban water cycle (Figure 4).

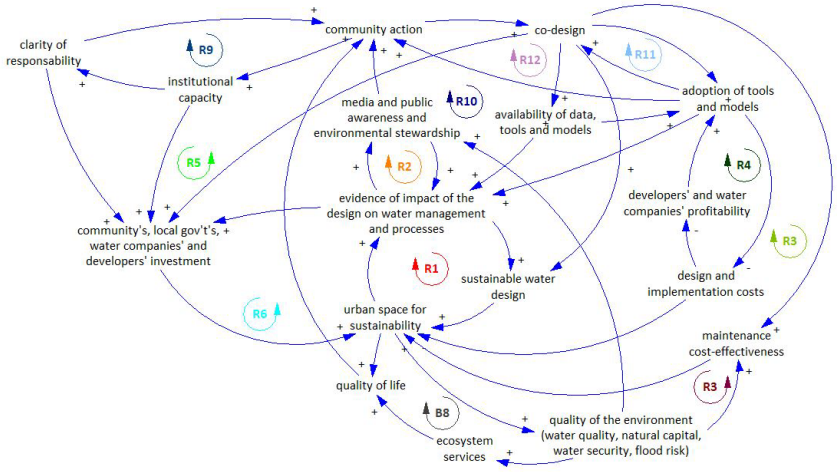

Figure 4. CLD developed during CAMELLIA workshop

The above diagram shows the extent and complexity of the problem. The team identified 12 loops with perceived positive and negative feedback cycles. The diagram informed the project's theory of change by allowing us to describe the context of our work in a highly visual manner. We also used it for our own project evaluation, where it re-confirmed the breadth of our work programme and helped us track how the project had created impact.

Work packages

As mentioned above, there were four main work packages. These are listed below, along with the lead and supporting organisations.

1) WP1: Environmental Science for System Modelling **TOOLS** (Lead: ICL supported by BGS)
    a. WP1.1: Small scale modelling (Butler – ICL)
    b. WP1.2: Large scale modelling (Jackson – BGS)
2) WP2: Community Engagement with Models, Infrastructure and Planning **COMMUNITY** (Lead: UCL supported by UO/ICL)
    a. WP2.1: Community modelling (Landström – UO)
    b. WP2.2: Co-designing community water infrastructure (Bell / Teh – UCL)
    c. WP2.3: Support for integrated planning and policy (Collins – ICL)
3) WP3: Systems Integration **SYSTEMS** (Lead: ICL supported by UCL)
    a. WP3.1: System perception (Zimmermann – UCL)
    b. WP3.2: System dynamics (Mijic – ICL)
    c. WP3.3: System level benefits (Collins – ICL)
4) WP4: Innovation for Impact **DISSEMINATION** (Lead: BGS supported by ICL)
    a. WP4.1 Requirements gathering and model collation (Watson – BGS)
    b. WP4.2 Community Water Management Portal (Hughes – BGS and Butler – ICL)
    c. WP4.3: Integrated systems analysis (ISA) (Hughes – BGS and Mijic – ICL)

WP1 covered the implementation of the environment science into the tools needed to underpin the applications and outcomes in connection with community engagement, WP2, and managing London's water as an integrated system, WP3. The final work package, WP4, brought together these outcomes, along with data collation, into a management portal, which eventually became the Water Info Hub.

Members of the CAMELLIA team mapped the various work packages onto the CLD in Figure 4. This shows the extent to which CAMELLIA members considered that their work would be covering the integrated urban water cycle and the contribution the different work packages would make (Figure 5). What is interesting is that the team at that time was not clear on how various costs associated with the water industry would be impacted by the project along with water-related policies and strategies. It was these gaps we aimed to fill with our project partners during the CAMELLIA work programme.

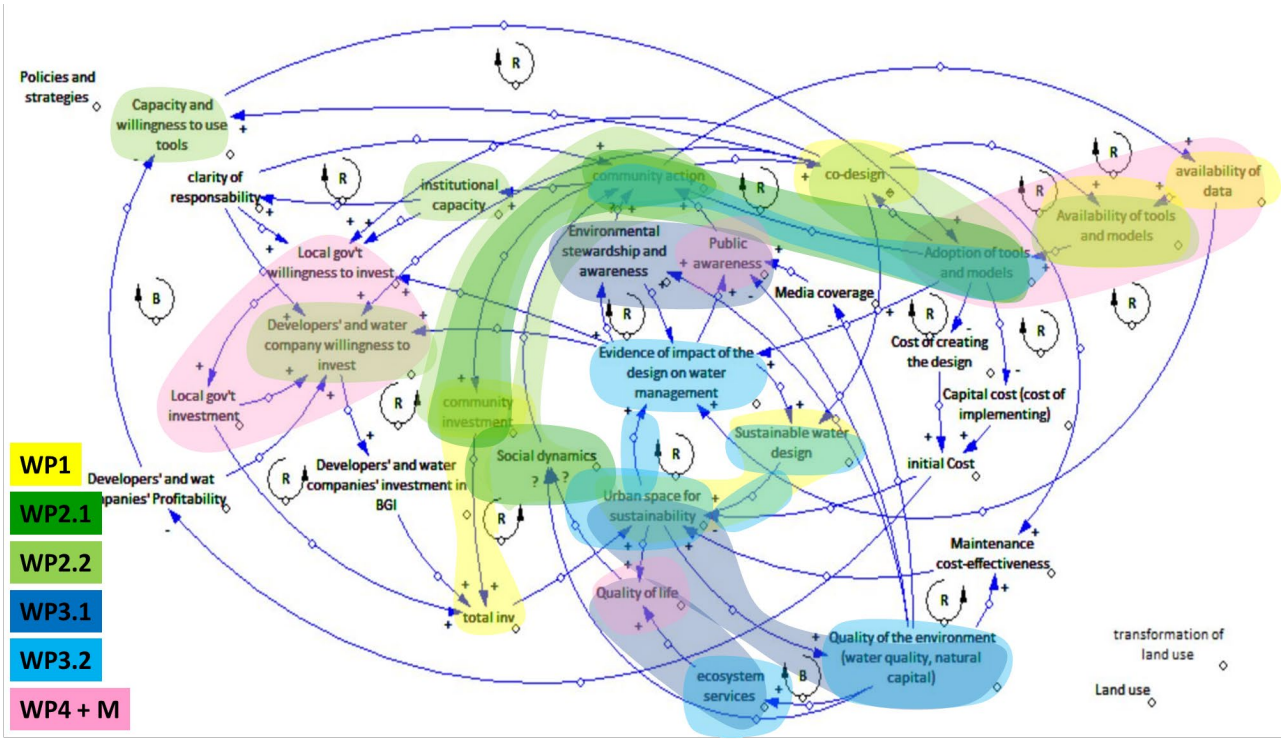

Figure 5. Mapping of the various work packages onto the project CLD.

Management

Day-to-day management of the project was undertaken by the Project Coordinator / Manager in collaboration with the PI. An Impact Manager was employed for part of the project period to assist with our impact coordination. We also had input from Dr Simon de Stercke, a NERC Coordination Fellow based at Imperial who coordinated outcomes and impact across the four RISE projects. Management on a weekly to monthly timescale was undertaken by the CAMELLIA Management Steering Group (MSG) meetings, via Microsoft's Teams coupled was occasional in-person meetings. The CAMELLIA Teams site was also used as a key resource for developing a storing documents, reports and other items of information. An Advisory Panel of international experts provided general oversight and advice on the project through annual hybrid meetings. In addition, Stakeholder Group meetings were held at strategic points during the overall programme to communicate outcomes and obtain feedback and suggestions.

Communication

CAMELLIA has a dedicated website describing the aims of the project, the team members, and projects, as well as storing newsletters, blogs, and contact information at www.camelliawater.org. CAMELLIA also has a Twitter/X account with the handle @CamelliaWater (although this is no longer operative). Information, tools, and project outcomes beyond the funded period of the project are provided by the Water Info Hub (www.waterinfohub.org), originally entitled the Community Water management Portal (WP4.2), which was developed and is being managed by BGS.

CAMELLIA Project design and delivery

The work programme was delivered through a set of projects and other supporting activities. Some of these projects (e.g. Kipling roof garden) were part of the original proposal, others arose from stakeholder-centred activities and product development (Figure 6, Table 1), where:

PROJECTS are work carried out in a geographical area (e.g., Southwark) with direct engagement/ collaboration from stakeholders (e.g., Kipling residents), with whom we worked on the project. Products were often generated as an output of the project (e.g., co-design methodology). Thus:

PRODUCTS are either a method or tool that was often created in conjunction with or in response to a stakeholder need, but which could be used up by different stakeholders in addition to those originally associated with its development.

CAMELLIA programme development, implementation and integration

Given the importance placed by NERC on the regional context for RISE projects, the work programme was based around various areas of greater London. Figure 6 shows most of the various CAMELLIA related activities, their geographical context and place within the overall work programme.

One important aspect of CAMELLIA was the "organic" way in which the overall programme developed. This is shown graphically in Figure 7. A key reason for this was its overall timescale of 5 years of funding, in practice over 6.5 years (the additional 18 months due to delays in staff appointments and impacts from Covid-19). Whilst the programme developed in response to community needs in a manner not fully envisaged during the writing of the original proposal, nevertheless, there was a coherence to the work programme which meant it was highly integrated, as shown by the causal loop diagram (Figure 5) and programme timeline (Figure 7).

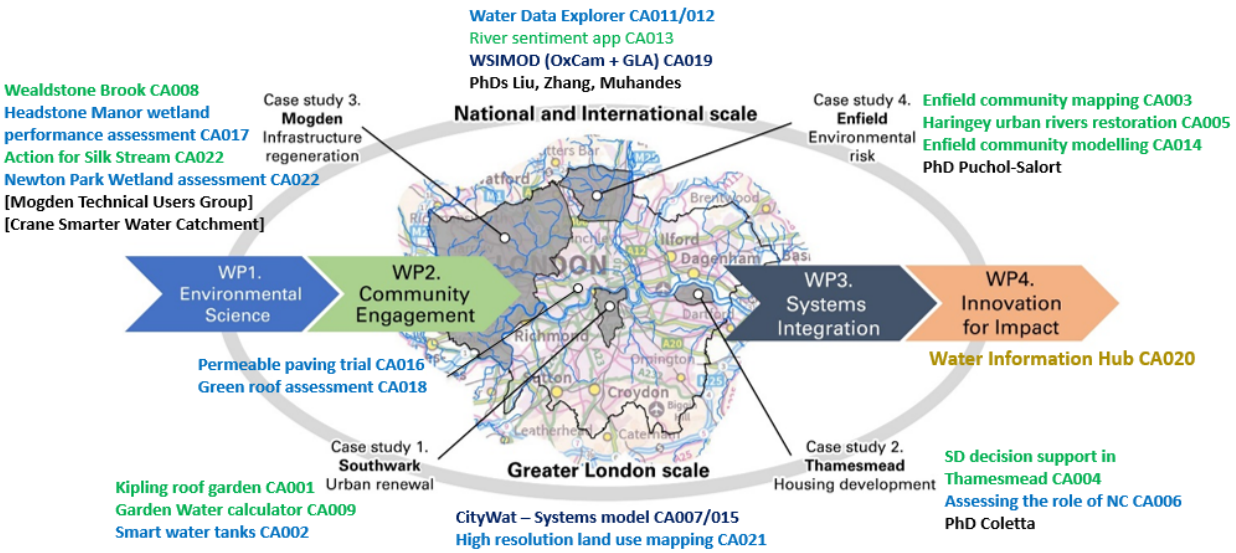

Figure 6. CAMELLIA projects showing their geographic location and work package.

Table 1: CAMELLIA projects and associated products

PROJECT			PRODUCT	
ID	**Name**	**WP**	**Tool**	**Process**
CA001	Kipling rooftop garden co-design	2.2	Kipling Calculator	Co-design
CA002	Smart water tanks for rain harvesting and flood alleviation	1.1	Smart water butt	Feasibility study
CA003	Enfield Community Mapping for Water Management	2.1		Snowball sampling
CA004	System Dynamics to capture perceptions and support decision making in Thamesmead	3.1	SD model for urban space	Participatory system mapping
CA005	Haringey urban rivers restoration	2.1		Engagement for river restoration
CA006	Assessing the role of natural capital in a sustainable urban environment	3.3	Urban Natural Capital Assessment Tool	
CA007	CityWat - Systems water management models for integrated water infrastructure planning and operation	3.2	CityWat & CityWatStorm modelling tools	
CA008	Wealdstone Brook water quality workshops (formerly Mogden Community Mapping for Water Infrastructure)	2.1		Wealdstone Brook workshops and CIRIA report explaining process on conducting participatory workshops
CA009	Garden Water Calculator (formerly Walworth Community Garden Network watering impact)	2.2	Water Neutral Garden Calculator	Watering assessment framework
CA010	Water Futures education programme	3.3		Water future learning tool
CA011	Water Data Explorer road runoff integration	1.2	Water Data Explorer Road Pollution Solutions Tool	
CA012	Water Data Explorer development for engagement and decision-making	1.2	GIS web site	
CA013	Twitter - Exploring Digital Water Publics	2.1	River sentiment app	
CA014	Enfield Community Modelling	2.1	Wetland Explorer	
CA015	CityWat SD	3.2	Integrated modelling software	
CA016	Permeable Pavement trial at White City	1.1	Field trial & dataset	
CA017	Headstone Manor flow meters (Crane SWC)	1.1	Portable 3D printed flow meter	
CA018	Roof Garden experiments at East side (Imperial College)	1.1	Field data	
CA019	WSIMOD	3.2	WSIMOD integrated modelling system (available via Github)	
CA020	Water Info Hub (WIH)	4.2	Web pages with links to data, tools and models developed during CAMELLIA	
CA021	High-resolution land use mapping	1.2	High resolution land use map of greater London	

CA022	Action for Silk Stream	2.2		Community engagement
CA023	Newton Park Wetland Assessment	1.1	Field data set	

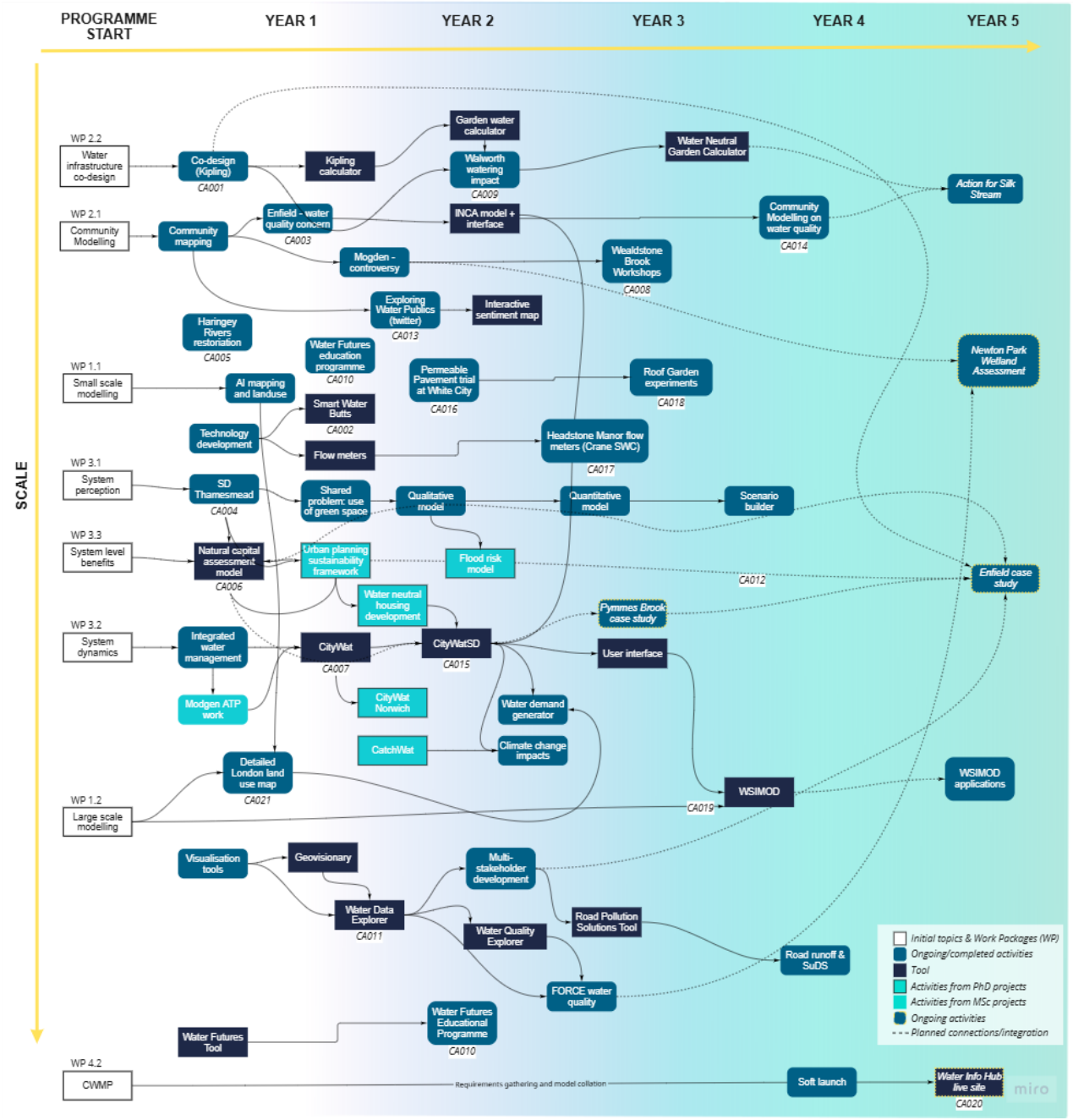

Figure 7. Diagram showing the organic nature and linkages of the CAMELLIA work programme

Description of CAMELLIA projects

In the following sections, the various projects are described. They are structured to provide a narrative on both how the overall work programme developed and its integrated structure.

Community Mapping (CA003)

One of the early projects in the Community Engagement Work Package (WP2) was a community mapping exercise (CA003), which was conducted amongst various community and institutional groups in the Enfield area. A key outcome from this was the insight that while cost-benefit analysis legitimised public expenditure on readily demonstrable economic benefits, such as flood risk mitigation, it could also lead to withholding funds from water quality improvement. This was a significant finding, as river water quality was highly valued by local citizens and community support groups, such as local river trusts. It was concluded that the current appraisal practice frustrates the delivery of blue and green infrastructure projects that would respond to local demand for improving rivers[1]. This outcome was a major impact for CAMELLIA. It led to a variety of changes in our work programme and placed a greater emphasis on water quality and on improved ways of delivering blue-green infrastructure. It was clear that improved ways of community engagement were needed to help resolve problems hindered by disjointed multi-institutional cooperation. A particularly poignant example of this is the Wealdstone Brook.

Wealdstone Brook Workshops (CA008)

This tributary of the river Brent in west London. The water quality of the Wealdstone Brook suffers from persistent pollution primarily caused by sewage entering the water course through interconnected stormwater and foul water drainage systems as well as private misconnections[2]. Through our partnership with Thames Water, CAMELLIA was invited to be part of the Wealdstone Brook Action Group. The quarterly meetings, funded and chaired by Thames Water, provided local residents and environmental groups an opportunity to raise matters of concern directly with the water company. From these meetings, it was obvious that a different method of working was needed to help progress matters. This led to the Wealdstone Brook Water Quality Workshops (CA008).

An initial survey of stakeholders found that weakly developed collaborative governance formed a barrier to implementing solutions for improving water quality, and that multiple stakeholders need to work together to raise funds and drive the execution of schemes. To address this, two workshops were held. The first workshop created a shared understanding among catchment stakeholders of the various issues affecting water quality and its governance across the topic areas of organisation, funding, stormwater and foul water systems interaction, private misconnections, riparian ownership, housing development, commercial waste, sewer abuse, and surface water runoff. The second workshop had participants design and evaluate solutions that address these issues. Five different solution ideas were developed ranging from hands-on interventions to deal with waste and vegetation management to a comprehensive scheme addressing a range of infrastructure and environment issues in the catchment. The solutions detailed the governance models required to deliver tangible progress on the ground, defined responsibilities for planning and delivery, and emphasised the critical role of company stakeholders for the success of any project while acknowledging that the local community remains the focus for delivery. The methodology and outcomes from these workshops are available as an open report, published by CIRIA (Construction Industry Research and Information Association) one of our original project partners[3].

[1] Peters, H, & Landström, C, 2021. The public and its assets: Performing appraisal and advocacy for blue and green infrastructure in London, England. Environment and Planning E: Nature and Space. https://doi.org/10.1177/25148486211049912

[2] https://www.bbc.co.uk/news/uk-england-london-61187853

[3] Peters, H, Teh, T-H, Collins, A, Landström, C, Butler, A (2024) Catalysing change in an urban river catchment: the case of the Wealdstone Brook, London, X537, CIRIA, London, UK (ISBN: 978-0-86017-958-0)

During the two workshops it became clear that one of the main barriers to the delivery of improvements in water and environmental management is the lack of engagement of local councillors, who ultimately have the power to implement decisions. To address this, all elected councillors in the London Boroughs of Harrow and Brent were invited to attend a webinar where we presented the results and outcomes of the study. This has helped push forward a major solution for addressing the Wealdstone Brook.

River Sentiment Dashboard (CA013)

The Covid-19 pandemic, and its resulting lockdown periods, had a major impact on CAMELLIA's community engagement work. One positive outcome, however, was a pilot project by UO and Thames21, another of CAMELLIA's project partners, to develop a River Sentiment Dashboard (CA013)[4]. Using publicly available Twitter data, the dashboard displays social media sentiment alongside data about the ecological status of more than 400 rivers in the Thames basin in England. An analysis of data over the period 2008 – 2022 showed a marked contrast in sentiment between citizens and NGOs and water companies and the regulator demonstrating at the basin scale similar results to those previously obtained at the local scale.

Constructed wetlands and community modelling (CA014)

One important "blue green" option for addressing water quality is the use of constructed wetlands. The implementation of such wetlands can present challenges to residents, councils and other stakeholders. To help address this, CAMELLIA commissioned a small modelling project with Prof Paul Whitehead (UO) and Dr Gianbattista Bussi (Water Resource Associates) to update a modelling study of water quality in two key rivers in the Enfield area – the Pymmes Brook and Salmons Brook[5]. These are heavily urbanised rivers, which flow into the River Lee, are impacted by misconnected sewers and urban runoff and have excess levels of nitrogen (both as nitrate and ammonium) and phosphorous. A few constructed wetlands had already been installed in the catchment and others were planned. To improve community engagement and to help facilitate a co-design process, a community modelling project was set up in Enfield (CA014). This was led by UO and project partner Thames21 as well as Enfield council. In addition, staff at BGS supported the work by developing the Wetland Explorer. This web-based tool allows users to visualise model outputs and explore the modelled space in an interactive manner. The graphical outputs facilitating discussion on the management and use of wetlands. Although the tool was developed for the Enfield area, it can be adapted to other water quality model outputs and other areas within the UK and beyond.

Smarter Water Catchments: Headstone Manor (CA017) and Newton Park (CA023) Water Quality Monitoring

Constructed wetlands typically have a dual role – to improve water quality and provide flood alleviation. Assessing both aspects is an important factor in determining their overall benefit. A small-scale project to help quantify this impact was undertaken by CAMELLIA at Headstone Manor. Headstone Manor is a medieval farmhouse that is now a museum and park run by Harrow Council. The manor house has an historic moat, which is connected to the Yeading Brook West, part of the upper reaches of the River Crane catchment. The River Crane is one of the rivers being trialled as part of Thames Water's Smarter Water Catchments (SWC) initiative[6]. The SWC is providing new partnerships to tackle key environmental pressures on rivers in London and the wider Thames area. CAMELLIA has played an important role

[4] River Sentiment Dashboard

[5] Bussi G, Whitehead P, Nelson R, Bryden J, Jackson C, Hughes A, Butler A, Landström C, Peters H, Dadson S, Russell I (2022). Green infrastructure and climate change impacts on the flows and water quality of urban catchments: Salmons Brook and Pymmes Brook in north-east London. Hydrology Research 1, 53 (4): 638–656 June 3, 2024.

[6] https://www.cranevalley.org.uk/smarter-water-catchments/

through its representation (by Prof Adrian Butler and Dr Catharina Landström) on the River Crane SWC Steering Group. As well as helping to guide the funding of (to date) £5M, CAMELLIA collaborated with the Zoological Society of London and Harrow Council on the use of ultrasonic sensors to measure changes in water levels and through these values measure flows within the constructed wetland (CA017)[7]. The work provides an important demonstration of these low-cost methods for flow measurement. The derived flows were combined with water quality measurements to access nutrient fluxes through the wetland. Alongside this work, one of CAMELLIA's impact researchers developed a low-cost portable 3D printable flow meter suitable for citizen scientists to make spot measurements of river flow[8]. The meters were tested at various sites including some tributaries of the River Eden in Cumbria on NERC funded PhD studentship.

Regular monitoring of surface water in the Crane catchment by the Crane Valley Partnership through the Smarter Water catchment programme has shown the ecosystem condition of the River Crane is 'poor' to 'bad' in the middle and upper catchment. Specifically, there have been concerns about contamination in the area of the Newton Park wetland. Collaborating with the Newton Farm Ecology Park, Friends of the River Crane Environment (FORCE), and the Environmenta Agency, BGS undertook sediment sampling and analysis to determine the occurrence of polyaromatic hydrocarbons (PAH) in flood soils and sediments. Total PAH concentrations were found to be slightly higher than that expected for typical London soils but far lower than those typically observed in contaminated industrial/brownfield soils. The results of the study are presented in a BGS report[9] (CA023).

Uban Rivers Restoration (CA005)

In many urban catchments monitoring flows is not possible as access to rivers is not possible due to them being cover or culverted. This can deprive residents of the benefits that access to open water. River restoration provides an opportunity to reverse this. During the early phase of its work programme, CAMELLIA was involved in engagement work in Haringey on the restoration of the lost river of the Moselle Brook and Stonebridge Brook (CA005). Working with Peabody, one of CAMELLIA's major project partners, along with Haringey River Forum and the LB Haringey, CAMELLIA developed tools to support early community engagement. A key outcome was the raising the capacity of local councillors and officers to delivery water and environmental management policies. This recognition for better engagement directly with elected local councillors, and not just officers, using improved communication tools and presentation methods was an important outcome from CAMELLIA's community engagement work.

Kipling rooftop garden co-design (CA001)

In addition to wetlands, blue green infrastructure plays a major role in urban water management. This has been an important part of CAMELLIA's work with London's communities and residents. Our work in this area commenced with a co-design project with the residents of the Kipling Estate in Southwark (CA001). Located close to the "Shard" London's tallest building next to London Bridge station, the Kipling Estate comprises to large tower blocks and other associated lower rise buildings. Existing links with the Residents' Association (JMB) through Prof Sarah Bell at UCL meant this project started almost immediately. Its aim was to help the residents develop an unused area of the roof for a car park sited between the two tower blocks. Three co-design workshops were led by CAMELLIA Co-Investigators from UCL and Imperial College London. The first workshop explained in a highly accessible way the types of

[7] https://www.cranevalley.org.uk/wp-content/uploads/2023/04/Evidencing-the-Impact-of-Constructed-Wetlands-Headstone-Manor-Park-March-2023.pdf

[8] https://www.sciencedirect.com/science/article/pii/S0955598623001656

[9] Vane, C, Moss-Hayes, V & Tye, A (2025). Occurrence of Polyaromatic Hydrocarbons (PAH) in flood soils and sediments, River Roxborough (Newton Park, Harrow), London, England. British Geological Survey Report.

planting and “green roofs” that were available. It also explained how these had the added benefit of reducing flow and hence impacts from flooding. In addition, we discussed the water requirements of different plant types and how these requirements could be met either from mains water or through rainwater collected from roof runoff and stored in a water butt or tank. This was an important consideration, where access to mains water often isn’t available in such developments and a failure to account for this can result in a major loss of planting during prolonged periods of hot and dry weather, which is both costly and distressing to those involved.

Along with the residents, participants from Thames Water, Southwark Council and the Environment Agency were also present to learn from the engagement process. Also present were data analysts from BGS. During a session in the second workshop where residents used paper cut outs to construct designs for the roof space. This exercise revealed the need for a calculator to help residents compare the different effects of their garden designs on water use and runoff. Members from BGS took this opportunity to develop a digital water calculator. This tool became known as the Kipling calculator and was trialled at the third workshop. The calculator displayed a gridded background of the roof area on to which users could place different types of planting or garden items (such as a shed, tables, seating). As they added the different plant types, an indicator showed a percentage runoff reduction along with a water demand for the plants during summer in litres per day. Water butts can also be added to meet this demand. The residents found this “gamified” experience both stimulating and informative. A further element of the Kipling tool was a pdf output that converted the final version of the roof design into a summary statement which could be use by the residents for funding applications. This proved highly successful with the residents using the tool to bid and obtaining funding for a garden from Southwark Council and the GLA. In the end, they were unable to develop the roof garden due to structural issues. Instead, the funds were used to develop a ground-based community garden, which is now being enjoyed by the residents on the Kipling estate.

Water Neutral Garden Calculator (CA009) & Silk Stream (CA0022)

In view of the successful use of the Kipling calculator to design a community garden, we sought to make this tool more widely available. To achieve this, we teamed up the Walworth Community Gardening Network (WCGN), a group of south London community gardeners based around the Elephant and Castle area. This work involved meeting with representatives from the Brandon Estate (a large housing estate in Walworth) and Berwick Court (a private housing estate near Borough). Through visits to the gardens and conversations with WCGN gardeners BGS working with CAMELLIA members at Imperial and UCL, was able to develop a garden water management tool, which became known as the Water Neutral Garden Calculator (WNGC) (see following section). This still retained the concept of a garden planting reducing runoff but also needing water and providing the user with a gamified experience. Towards the end of the project the members of the WNGC project team linked up with Sam Proctor who used the WNGC to assess water management associated with her winning garden at the RHS Chelsea Flower Show. In addition, CAMELLIA and Sam contributed to an article on the WNGC tool and garden water management in the June 2024 issue of the Garden Design Journal. We also teamed up with members of Harrow and Barnet councils to assess the potential use of the tool for encouraging runoff reduction to improve flood alleviation for residents living in the vicinity of the Silk Stream (CA022)[10] and with the RHS, who is promoting the tool on their garden water management website[11].

[10] https://www.ciwem.org/news/barnet-harrow-launch-silk-stream-flood-resilience-project
[11] https://www.rhs.org.uk/gardening-for-the-environment/water

Smart Water Tanks (CA002)

The importance of collecting rainwater for garden watering and reducing storm runoff was explored through smart water butts. The concept behind these is to use water butts (i.e. storage tanks which collect rainwater from roofed surfaces) in a dual-purpose role. If drained, they can intercept runoff and reduce storm runoff. If full, they provide water for plant watering thus saving on mains water. Unfortunately, these roles are in conflict. The "smart" function is to drain the tank in advance of rainfall. Whilst this appears a good solution our work showed that there were major cost-benefit challenges in making such a device function robustly and reliably at scale. Instead, the role or passive slow draining devices with a residual storage for garden watering looked to be a more appropriate solution, as being trialled by Severn Trent water.

Permeable Paving Trial (CA016) & Roof Garden Experiment (CA018)

More extreme temperatures due to climate change are a major challenge for large urban centres, such as London, where such events can exacerbate an existing urban heat island effect. As well as this, there is also the risk of enhanced pluvial flooding due to high intensity rainfall events. This is a concern to local and regional governments. CAMELLIA was approached by the GLA to investigate the potential of permeable block paving help address both effects. Working with the Interpave consortium, a trial was set up at Imperial's White City campus in west London (CA016). A four-month experimental trial was set up over the summer of 2021. considered the cooling potential from two 4m x 4m "pads". Using a portable thermal camera, along with a low-cost thermal imaging system to record time lapse images of surface temperature. The results showed that although there was a cooling of around 1°C this was largely within the body of the pavement and not at the surface. Such an amount appeared to be insufficient to have a major impact on the ambient environment. Following the completion of the field experiment, the weather station was redeployed on the roof top of the Eastside halls of residence at Imperial College London's South Kensington campus. Where it was used on 3m square soil pads associated with an old green roof experiment. The period of deployment coincided with an extreme heatwave on 17-18 July 2022 (Figure 8). The results demonstrated the problem of unwatered green roofs during such events, where the maximum internal temperature of the soil pad was over fifty degrees centigrade on consecutive days.

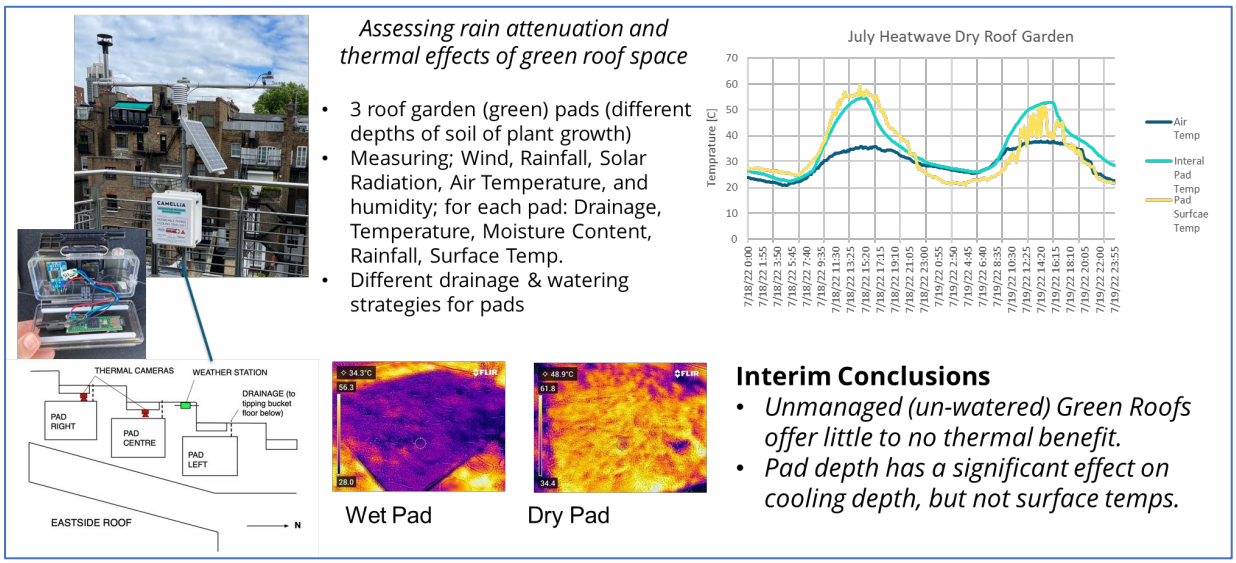

Figure 8. High roof temperatures on Imperial College London's student accommodation during July 2022 heatwave due to unwatered "green" roof.

Water Data Explorer (CA011), Road Runoff Integration (CA012), Hi-Resolution Land Use Map (CA021)

Through discussions with stakeholders, especially community groups such as the Friends of the River Crane Environment (FORCE), it became clear that data visualisation in space and time was an important requirement for facilitating greater awareness of water issues and communicating information. In response to this need, the geospatial mapping team at BGS developed the Water Data Explorer, which also incorporated the Water Quality Data Explorer (CA011). These were refined through a series of focus group meetings with different stakeholder groups. The work has been of great benefit to Thames Water where it had a major influence on the development of their DWMP (Drainage and Wastewater Management Plan) Practitioners GIS Portal[12]. One of the key outcomes from this work was a recognition of the impacts of road runoff pollution and the need to mitigate these impacts. This led to the development of the Road Pollution Solutions Tool in a project involving BGS, Thames21 and Middlesex University and the GLA (CA012). Further details on this tool are provided below. In addition to these activities, it was realised that dealing with data at a range of scales was crucial if interventions at the local scale (i.e. household, road, park, river reach) were to have an impact at the borough, city or even catchment scale. There was a need, therefore, to delineate land use at the small scale but over a large area. This led to the BGS high-resolution land use mapping project (CA021). Using a variety of data sources (such as the EA's lidar, the OS Master Map and detail aerial imaging, a land use map of the greater London area has been developed at a resolution of 2m. An example of this output is shown in Figure 9. Owing to ongoing licencing issues on the aerial photography (one of the underlying datasets) general release of this product has been delayed.

Urban Development: Natural Capital (CA006) and use of System Dynamics in Decision Making (CA004)

Population growth and demographic changes mean housing is a major challenge for the UK. This is particularly true in southeast England and the greater London area. Development in this part of the country also faces the added challenges of water scarcity and urban flooding – both due to get worse this century because of climate change. Blue-Green infrastructure can play an important role in flood alleviation as well as improving place making. Encouraging resident communities, as well as developers, planners and local councils, to adopt blue-green solutions is vital if the benefits these provide are to be realised. One area of London where there is a major development opportunity is Thamesmead. Built in the late 1960s and hailed as the town of tomorrow, it's now home to 47,000 people and a growing population. Peabody, one of the UK's oldest not-for-profit housing associations, and an original CAMELLIA project partner, is working together with local people and local partners to regenerate the area, so that by 2050 more than 100,000 people will living in Thamesmead. With existing lakes and canal waterways, Thamesmead is an ideal location to trial and develop the benefits of blue green space. CAMELLIA researchers at Imperial, working with Peabody, Thames 21, the Environment Agency, GLA, and Thames Water developed a tool to assess the role of blue green space in Thamesmead to help in providing a sustainable urban environment (CA004). This work has been developed through three interlinked projects. The work led by Imperial's Centre for Environmental Policy has developed an urban natural capital evaluation model. This systems dynamics tool allows users quantify the multiple benefits natural capital can provide and how changes in the built or natural environment can positively or negatively impact a community[13].

[12] Email from Graeme Kasselman, Wastewater System Planning Lead (London) Thames Water, to Adrian Butler & Chris Jackson, dated 14/11/2024.

[13] https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1002/pan3.10317

The Imperial's team at the Department of Civil and Environmental Engineering, through PhD work of Dr Pepe Puchol-Salort, developed the Urban Planning Sustainability Framework (UPSUF), a systems-based approach integrating urban design, stakeholder planning processes, and GIS-based evaluation to promote sustainable development through Blue-Green Infrastructure and enhanced Urban Ecosystem Services[14]. The framework was then used to develop a Water Neutrality framework with London as a case study. The CityPlan-Water framework - a systemic design approach for achieving urban water neutrality integrated spatial data, stakeholder-led planning, and the CityWat model to assess how design options like Blue-Green Infrastructure and efficient appliances can offset water demand, flood risk, and pollution impacts from new urban developments in London[15].

This led to UPSUF - an Urban Planning Sustainability Framework, where a common conceptual framework combines sustainability evaluation, design solutions and planning system process and operation. This enables improved sustainability design, assessment and decision-making for a multi-stakeholder urban development project. It was facilitated by CityNC – an urban natural capital evaluation model. A systems dynamics tool that allows users quantify the multiple benefits natural capital can provide and how changes in the built or natural environment can positively or negatively impact a community.

Finally, major CAMELLIA project in the Thamesmead area was led by UCL, in partnership with Marsh Dykes and Thamesmead catchment partnership, along with Thames 21, London Wild Trust, Environmental Agency, GLA, Peabody, Thames Water, The Young Foundation, and the Clever Cities project in the GLA, and the CUSSH project also at UCL[16]. This showed how participatory system dynamics could be used to identify and bring together stakeholders, to map their perception of the blue/green/built infrastructure, and to model and analyse systemic interventions which would address those problems leading to effective sustainable decisions (CA006). Details on the tools developed by these projects are given in the following section.

Integrated System Modelling for urban water management: CityWat (CA007), CityWatSD (CA015), WSIMOD (CA019)

The urban water cycle is extremely complex. This is particularly true for London. Consequently, it needs to be understood as an integrated system. In addition, such an understanding of the system needs to consider both water quantity and quality, as both are of direct concern and interest to water managers and local residents. A key CAMELLIA output, therefore, was the Water System Integrated Modelling framework (WSIMOD).

WSIMOD originated from a series of development projects which commenced at the city scale with the lumped modelling tool, CityWat (CA007). CityWat provided a theoretical demonstration of how integrating water supply with wastewater infrastructure and downstream river water quality could provide new insights into the management of London's water[17]. The open-source, stylised systems model gave it great flexibility as well as accessibility, a feature which has been retained throughout its subsequent development.

The next key development was a semi-distributed version (CityWat-SD). This was developed during the global pandemic and was used to undertake analysis of COVID-19 impacts on London's water system

[14] Puchol-Salort et al., Sustainable Cities and Society, 2021
[15] Puchol-Salort et al., Water Research, 2022
[16] https://www.ucl.ac.uk/complex-urban-systems/
[17] Protecting rivers by integrating supply-wastewater infrastructure planning and coordinating operational decisions

and river water quality[18]. A key development in the model was the introduction of different wastewater zones, which enabled the impacts from different treatment works and their collection areas to be included and explored (Figure 9)

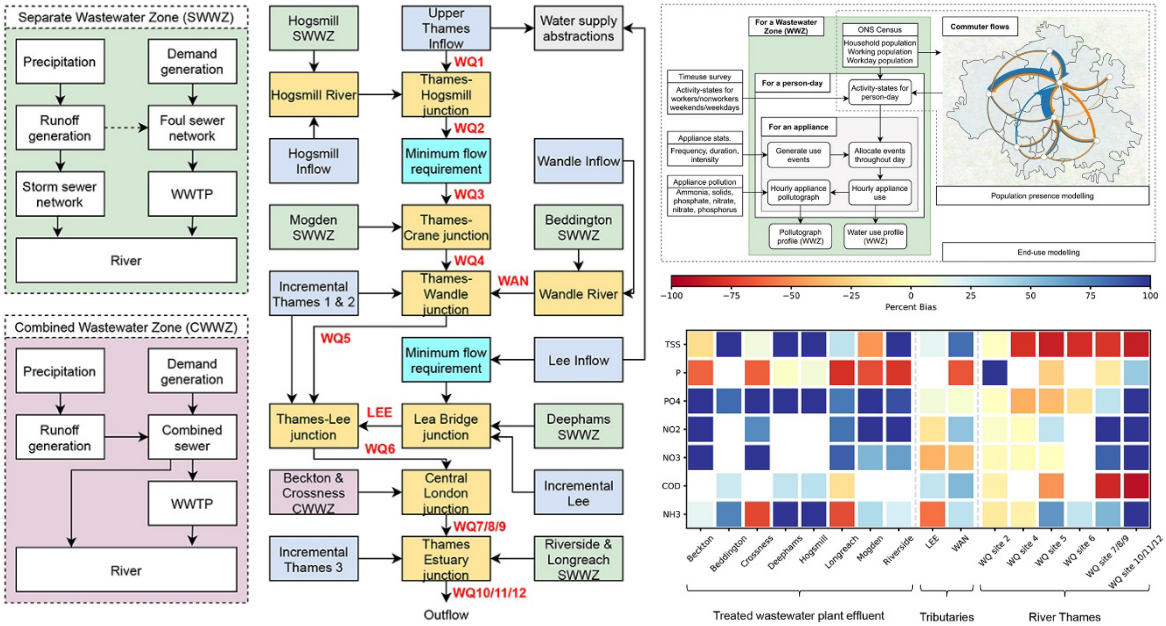

Figure 9. A flow chart demonstrating the key stages in the end-use modelling (a), Schematic depicting nodes of the London model (b), Percentage bias metric between simulated and sampled water quality values for treated effluent arcs (left side), in-river arcs for tributaries to the River Thames (central) and in-river arcs for the River Thames (right side) (c) (Dobson et al., 2021).

These previous integrated modelling exercises resulted in the Water Systems Integrated Modelling (WSIDMOD) Framework, which is described in detail below. Critical review of the work has been received through peer viewed publications. Some of the development and testing has been achieved through PhD projects at Imperial College London (see Table 2).

Table 2. Imperial PhD students and projects associated with WSIMOD

Name	Thesis / Project title	Status
Leyang Liu	Whole-water systems modelling for sustainable catchment management	Awarded 2023
Samer Muhandes	Modelling and evaluation approach for Sustainable Drainage Systems long-term planning at a catchment scale	Submitted: minor corrections
Fangjun Peng	Impacts of constructed wetlands on river flow using WSIMOD	Ongoing
Wangdong Zong	Groundwater abstraction licenses as an intervention for integrated water management	Ongoing

Education (CA010) and dissemination and the Water Info Hub (CA020)

Water Futures Teaching Resource

To help inform the next generation of citizens scientists, engineers and managers about the importance of water management, CAMELLIA members from University of Oxford and BGS in

[18] https://www.frontiersin.org/articles/10.3389/frwa.2021.641462/full

collaboration with our partner Thames21 and with additional funding obtained from the Royal Bank of Canada's "Tech for nature" initiative, CAMELLIA contributed to incorporating water resources management into mainstream education (CA010). We created a new educational resource which provides secondary school teachers with new ways to teach how London's water supply works and about future water resource challenges. Lessons plans and a role playing activity built on previous work by the University of Oxford and Thames21, which created Water Futures – an interactive visualisation of water supply scenarios and modelled outcomes for the River Thames catchment (Figure 10).

The teaching tool[19], aimed at GCSE students, comprises three lesson which explain direct and indirect water use, defines a 'water footprint', and outlines how water is moving through the city, from lakes to tap and back again to rivers to illustrate the effect of population increase and climate change on water resources. The students analyse outputs from a real water resource management model and interpret these results to support decisions about water saving solution which they use to present their recommendations and support their stance using model outputs.

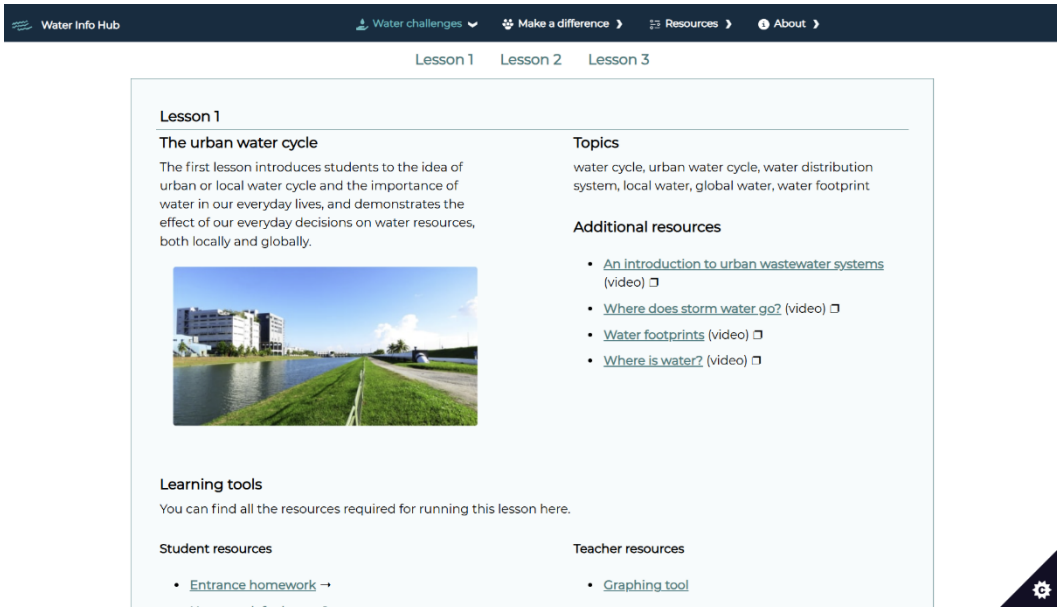

Figure 10. Online lesson plans available through waterinfohub.org

Philip Dunne, Environment Act 2021

Back in March 2020 an opportunity, arose via Prof Sarah Bell, for members of CAMELLIA to assist Rt Hon Philip Dunne MP. Philip Dunne was Chair of the Environmental Audit Committee. Philip Dunne had the opportunity to introduce a private members bill on Sewage (Inland Waters), which would place a duty on water companies to ensure that untreated sewage is not discharged into rivers and other inland waters. It also proposed measures to upgrade urban drainage infrastructure to separate household sewage from surface water drainage, helping reduce the risk of overspills. It also included measures to expand the number of inland bathing waters and set legally binding targets to increase the number of bathing waters classified as "good" or "excellent". In connection with this Prof Adrian Butler (CAMELLIA PI) and Prof David Balmforth (chair of CAMELLIA's Advisory Panel) joined a working group setup by Philip Dunne and one of our PhD students, Ariel Sheppard, was seconded to his office to assist him with this

[19] Water Futures a teaching case study

work. By early 2021, the impacts of the Covid-19 pandemic meant that the bill couldn't progress. Instead, the working group assisted Philip wit two key amendments which included a requirement for water companies to progressively reduce the impact of discharges from storm overflows, along with obligations for the government to publish a storm overflow discharge reduction plan.

FloodEx

FloodEx is now an annual exhibition of new developments in flood management held at the Excel centre in East London, each November. During the 2022 event, CAMELLIA had a stand to display and promote our activities and products and Prof Butler has provided a talk on the work of CAMELLIA at each of the last three events.

Conferences, showcase event and Webinars

On 24 November 2021 CAMELLIA hosted an on-line conference addressing the question "Do we have an urban water quality crisis (and what can we do to solve it)?". Keynote speakers were David Johnson (*Rivers Trust*), Helena Soteriou (*Thames Water*), Philip Dunne (*MP*) and David Balmforth. These were followed by a panel discussion chaired by Jacob Tompkins (*The Water Retail Company*) and an interactive showcase of various CAMELLIA tools under development, which provided helpful feedback to the team members. CAMELLIA also held a workshop with the Singapore Public Utilities Board (PUB) on the use of digital tools for community engagement on 8th March 2022 and then presented our work at the Singapore International Water Week in May 2024. A final meeting to showcase our work and tools took place at the WWT London Wetland Centre in Barnes on 7th May 2024 (Figure 11).

Figure 11: CAMELLIA Showcase Event on 7th May 2024

In addition, during autumn 2024 CAMELLIA ran a series of webinars hosted by the British Geological Survey (BGS) demonstrating our various digital tools (see following section) and the Water Info Hub (see below).

Water Info Hub

Evidence-based decision-making is a key requirement for water management decisions. The Water Info Hub[20] (CA020) envisions a future where access to information about the water environment is universal and equitable. CAMELLIA has sought to achieve this by providing access to data, tools and methods that evolves over time, ensuring that both decision-makers and citizens have access to the knowledge necessary for informed choices about water management. This is an important outcome as current access to relevant and timely data on water resources is often uneven, with decision-makers having advanced tools and information whilst citizens can lack these, leading them to feel disconnected from

[20] https://waterinfohub.org/home.html

decision-making processes that affect their local communities. Such a disparity can lead to decisions that do not reflect the needs and values of local populations, ultimately hindering effective water management and environmental sustainability.

The Water Info Hub seeks to bridge this gap by developing a platform that democratizes access to data, tools and methods related to the water environment. Our approach involves curating comprehensive datasets, user-friendly tools alongside best practice for engaging with communities that are designed to grow and adapt over time. By fostering collaboration among researchers, policymakers, and local communities, we aim to create a dynamic environment that benefits all stakeholders.

Originally referred to in our proposal as the Community Water Management Portal, the Water Info Hub seeks to bridge this gap by developing a platform that democratizes access to data, tools and methods related to the water environment. Our approach involves curating comprehensive datasets, user-friendly tools alongside best practice for engaging with communities that are designed to grow and adapt over time. By fostering collaboration among researchers, policymakers, and local communities, we aim to create a vibrant knowledge-based environment that benefits all stakeholders.

The site has four main components:

- **Water Challenges:**
  This allows users to explore various topics of concern, such as: Water quality, Flooding, Urban Drainage, Drought etc.
- **Make a Difference:**
  Where communities can utilise outputs from CAMELLIA in order to help solve complex issues using integrated modelling approaches.
- **Resources:**
  This is where users can explore and visualise data relevant to water management, learn about community engagement methods developed within CAMELLIA and access various tools and resources (described in more detail in the following section).
- **About:**
  This final section provides the user with information on CAMELLIA's vision along with background information on the project.

Originally developed by BGS, funding has been secured for BGS to maintain the Water Info Hub for a further 5 years beyond the project's end date of 31/03/2025. As the Water Info Hub continues to develop, we will continue to prioritize community engagement to ensure that the platform meets the diverse needs of its users. We will also explore new partnerships with academic institutions and organizations to expand our datasets and enhance our analytical capabilities, to increase the resources available to both decision-makers and citizens.

CAMELLIA Tools

Overview

CAMELLIA has developed a suite of innovative tools that have significantly contributed to the project's goals and broader societal and environmental impacts. These tools are designed to support sustainable water management in urban environments and have demonstrated their utility across several key dimensions.

They have been instrumental in influencing business cases and driving strategic investments in sustainable urban water management. For instance, the integration of these tools into planning frameworks has provided stakeholders, such as local governments, water utilities, and private investors, with robust evidence-based insights. This has enabled them to:

- Optimise resource allocation, particularly for green and blue infrastructure projects.
- Enhance resilience planning against climate-related risks.
- Align investments with long-term environmental sustainability goals.

The tools have been leveraged across multiple work packages and case studies, ensuring a cohesive approach to addressing water management challenges. By integrating data from diverse sources, including hydrological models, social surveys, and economic assessments, the tools have facilitated:

- Holistic decision-making that incorporates technical, social, and economic dimensions.
- Collaboration across various disciplines and stakeholder groups, ensuring well-rounded solutions.
- Consistent project-wide methodologies that streamline analyses and reporting.

The CAMELLIA tools have also created significant opportunities for skills development and capacity building. Training programs and workshops have been organized to equip stakeholders, including project partners and external users, with the skills to use these tools effectively. Key outcomes include:

- Upskilling of technical staff in using advanced modelling and decision-support tools.
- Enhanced stakeholder understanding of integrated water management concepts.
- Creation of educational resources that can be utilized beyond the project's lifecycle.

Their deployment and application have strengthened partnerships among academic institutions, government agencies, industry stakeholders, and community groups. These partnerships have been fortified through:

- Joint development and testing of tools, ensuring relevance and usability.
- Shared learning experiences that build trust and foster long-term collaboration.
- Collective ownership of project outcomes, leading to commitments for continued engagement and tool application beyond the project’s duration.

The tools are not just technical assets but also enablers of systemic change. They exemplify how innovative solutions can influence strategic decisions, empower stakeholders, and strengthen partnerships to address complex challenges in urban water management sustainably. Further details about the CAMELLIA tools are outlined in the following sub-sections.

Road Pollution Solutions Tool

The Road Pollution Solutions Tool (RPST) helps to identify sections of roads that are likely to contribute most pollution to rivers and to explore where sustainable drainage schemes could be placed to reduce this. The methodology underpinning the tool was developed by Middlesex University in partnership with Thames21 and the South East Rivers Trust. It quantifies the mass of selected pollutants deposited on road surfaces that can potentially enter rivers through road stormwater runoff; not accounting for the size of the entry waterway or any dilution that might occur. The methodology was applied the whole of outer Greater London and provides a static map showing rates of pollution across the city's roads.

The CAMELLIA team, working in partnership with Thames21 who leveraged additional funding from a range of organisations, used this as a starting point to develop the interactive RPST web application. The resulting tool provides a suite of dynamic functions that allow users to explore localities in detail and the suite of potential pollutants. In addition, the team implemented methods to map the suitability of different interventions, providing green infrastructure planners with valuable information to support decisions. Key water quality improvement interventions that have been incorporated into this tool include Sustainable Drainage Schemes (SuDS) and constructed wetlands. Information on existing SuDS, e.g. constructed wetlands built over the last decade by the London Borough of Enfield, was also included, providing a valuable repository of knowledge (Figure 12).

To our knowledge, this is the first attempt at this scale to identify which roads and drainage networks are polluting our rivers and to then develop evidence-based resolution strategies including nature-based solutions.

There is considerable opportunity to expand and refine this work. First, we expect it to be rolled out to other areas across the UK. For example, and a consortium of three water companies, Surrey County Council and the Environment Agency has already funded its extension to the area covered by the River Thames catchment between Maidenhead and Teddington and the county of Surrey. Furthermore, in May 2024, BGS, Imperial College London and Thames21 won funding (£242k) from the Government Office of Technology Transfer to incorporate pollution from agriculture into the tool.

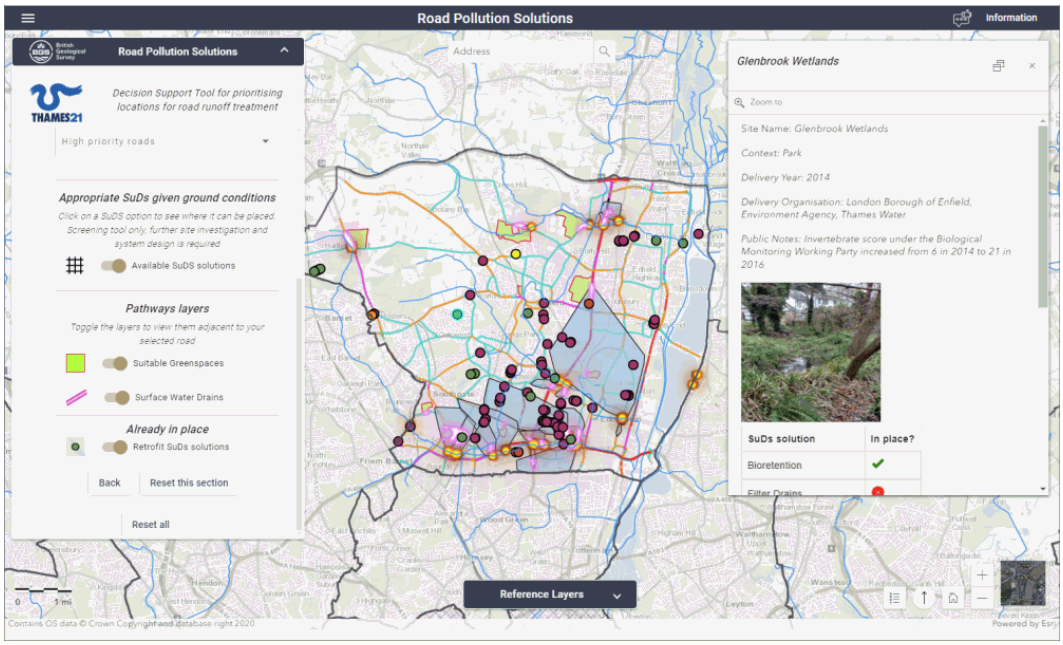

Figure 12. Road Pollution Solutions Tool

John Bryden, Head of Improving Rivers at Thames21, said: “We have been delighted to see the development of the Road Pollution Solutions Tool and the impact it has had since it went live. Our collaboration with the CAMELLIA team and the range of partners across London and the Thames has generated a first-of-its-kind tool, which will underpin the development of green infrastructure to tackle pollutants from road runoff that are having a devastating impact on our aquatic wildlife”.

Wetland Explorer (WE)

The Wetland Explorer is used to explore how wetlands can improve the health of a river. This interactive web application allows the user to investigate how the creation of new wetlands within a catchment could reduce the levels of pollution in its rivers.

Some wetlands that have been lost or degraded, can be restored. Restoration aims to return a site to a natural or near-natural condition. It is also possible, where conditions are suitable, to create new wetlands. At its simplest, wetlands can be created by placing an appropriately designed obstruction across a stream, such as a small dam made of logs or earth, so that water ponds behind it. However, much more complex wetlands can be built, for example, to treat sewage, stormwater runoff or industrial wastewater. The term ‘constructed wetland' is often used to describe these. The interactive web tool is demonstrated using two catchments in north London; the Pymme's Brook and Salmon's Brook, both of which flow into the River Lea. Adding different constructed wetlands into these catchments allows the user to explore a range of computer model scenarios which simulate the resulting change in river water quality. Changes in rainfall due to climate change are also included, as these can affect river flow and therefore river water quality. The tool has been used to support community groups in the Enfield area to consider where the creation of new wetlands should be prioritised. See Figure 13.

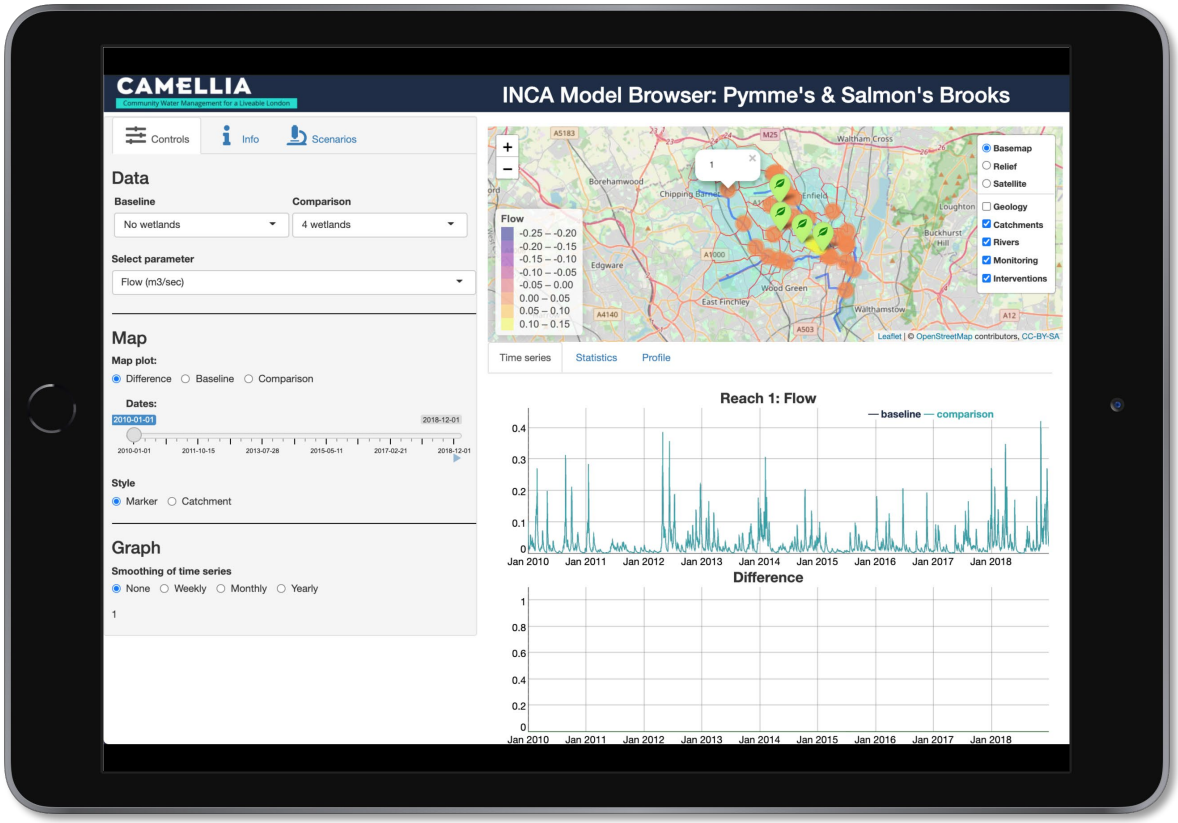

Figure 13. CAMELLIA Wetland Explorer being demonstrated on a tablet screen.

Use of Urban Natural Space (system dynamics model)

Thamesmead is a neighbourhood in South-East London currently undergoing an important urban regeneration. It is characterised by an extended network of urban natural spaces (both, blue and green) with several sites of nature conservation interest. However, our case study stakeholders underlined how these natural areas are underused.

Through a participatory SD modelling process (Figure 14), we created a System Dynamics (SD) model aimed at collectively designing strategies for improving people's Use of Urban Natural Space (UoS) in Thamesmead. The simulation model was used as a mechanism to build learning and co-produced knowledge on people's use of natural space, whilst taking a holistic approach to investigating the factors that influencing this. The model captures these factors and their interdependencies: for instance, usability and accessibility, maintenance and space condition, residents' perceived safety and awareness of the spaces, community participation, biodiversity, time constraints and structural poverty. The model was used to in a co-design pilot on 'Pathways to the Thames' managed by the Peabody housing trust. Through an online accessible interface, the model allowed the stakeholders to jointly test different scenarios, exploring the impact on people's use of space by capturing the dynamics between the influencing system elements. It was an example of true co-production of knowledge. The model has more than 130 variables and its structure and parameters are based on information elicited from workshops and interviews with relevant stakeholders and from the scientific literature. The model is calibrated on an adjusted dataset from the MENE survey (Natural England). The model has two different versions. The initial version focuses on the use of natural space and the factors influencing it (v1); while the second extended version adds two health sub-models (v2). Overall, the model uses three different indicators:

1) Use of Natural Space Indicator (measured by the average number of weekly visits per person in the area under consideration; v1 and v2).
2) Physical Health Indicator (measured by the relative risk of mortality; v2).
3) Mental Wellbeing Indicator (measured by the relative perceived risk of stress; v2).

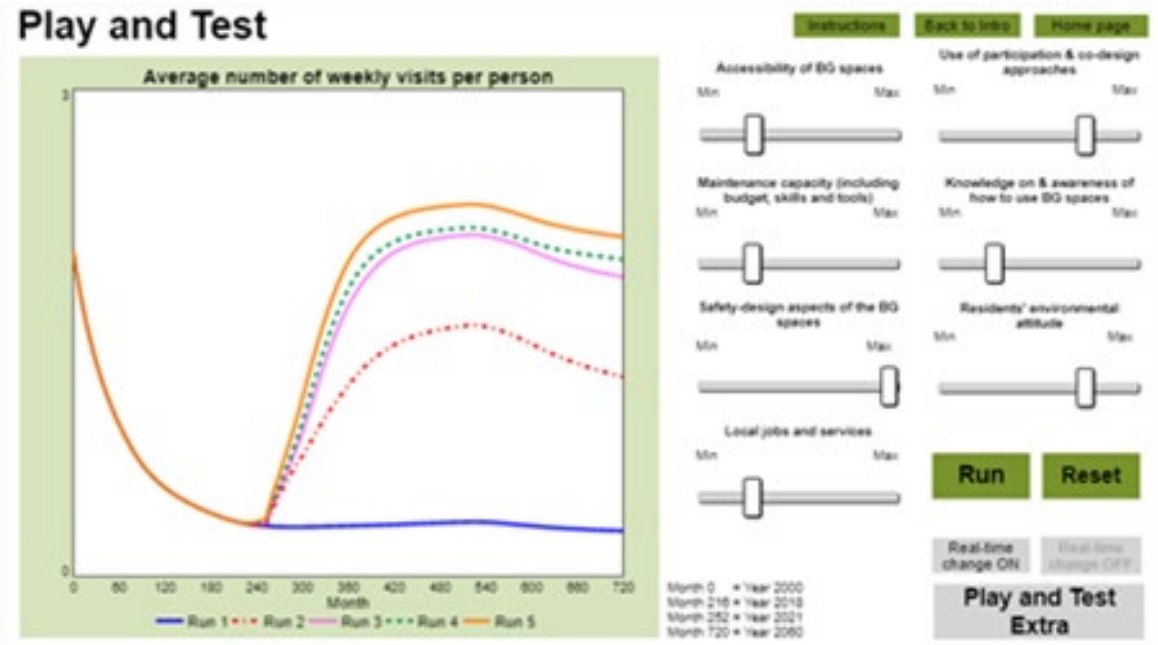

Figure 14. system dynamics model- Use of Urban Natural Space

In its final version, the model allowed the following actions to be assessed: a) to support knowledge co-production within Peabody and knowledge-sharing between Peabody members and residents; b) to enable a conversation on levers; c) to structure, manage and unpack complexity around the topic of the use of natural space; d) to agree on priorities and ideas to bring to the co-design pilot.

Four key insights can be derived from the case study application:

1) Stakeholders quickly realise that maximising the built environment components (e.g., accessibility and safety design aspects) alone does not have a major impact on improving the use of space, while strategies focusing on community interventions have larger influence.
2) Scenarios focusing on the maintenance capacity show a slow increase of the use of space; although this intervention depends on a substantial increase of the maintenance budget, which stakeholders report to be difficult to achieve in practice.
3) The effects can be improved when attention is paid to the local community demands (through better – fit for purpose – co-design of space) or social cohesion building and community engagement activities, showing the need for combined strategies when planning interventions.
4) The model enabled stakeholders to better understand also the social-economic aspects of the use of space and discuss interventions that, for instance, would improve residents' leisure time.

This work was co-funded by the CUSSH (Complex Urban Systems for Sustainability and Health).

Natural Space Performance (system dynamics model)

This was also focussed on the Thamesmead area, in particular the Thamesmead Waterfront Development Plan, an urban development site that does not have any population yet but with plans to build more than 11,500 new homes during the next 20–30 years.

The SD model quantifies and assesses the impact of different urban development scenarios on natural capital and informs design evaluation. It uses a novel indicator, the Natural Space Performance (NSP), to evaluate the capacity of natural space to provide ecosystem services in combination with urban infrastructure. The NSP indicator provides a semi-quantitative measure of system-wide impacts of change within a combined natural, built, and social systems. The model consists of several sectors including the built and the natural areas, but also biodiversity and hydrological performance and infrastructural access standards (see Figure 15).

The NSP model enables interested parties to test different environmental scenarios and design configurations, identifying pathways which address concerns while satisfying housing needs and helping make ecosystem services knowledge actionable. For instance, it compares very different urban design scenarios from high-density building to low-density building design, and it allows to integrate different nature-based solutions such as green roofs. In summary, the NSP model is a tool to directly include and operationalise stakeholders' priorities around NSP, addressing a gap in practice and research by temporally integrating the social, built, and natural systems where key links and feedback are considered.
This work was also co-funded by the CUSSH (Complex Urban Systems for Sustainability and Health).

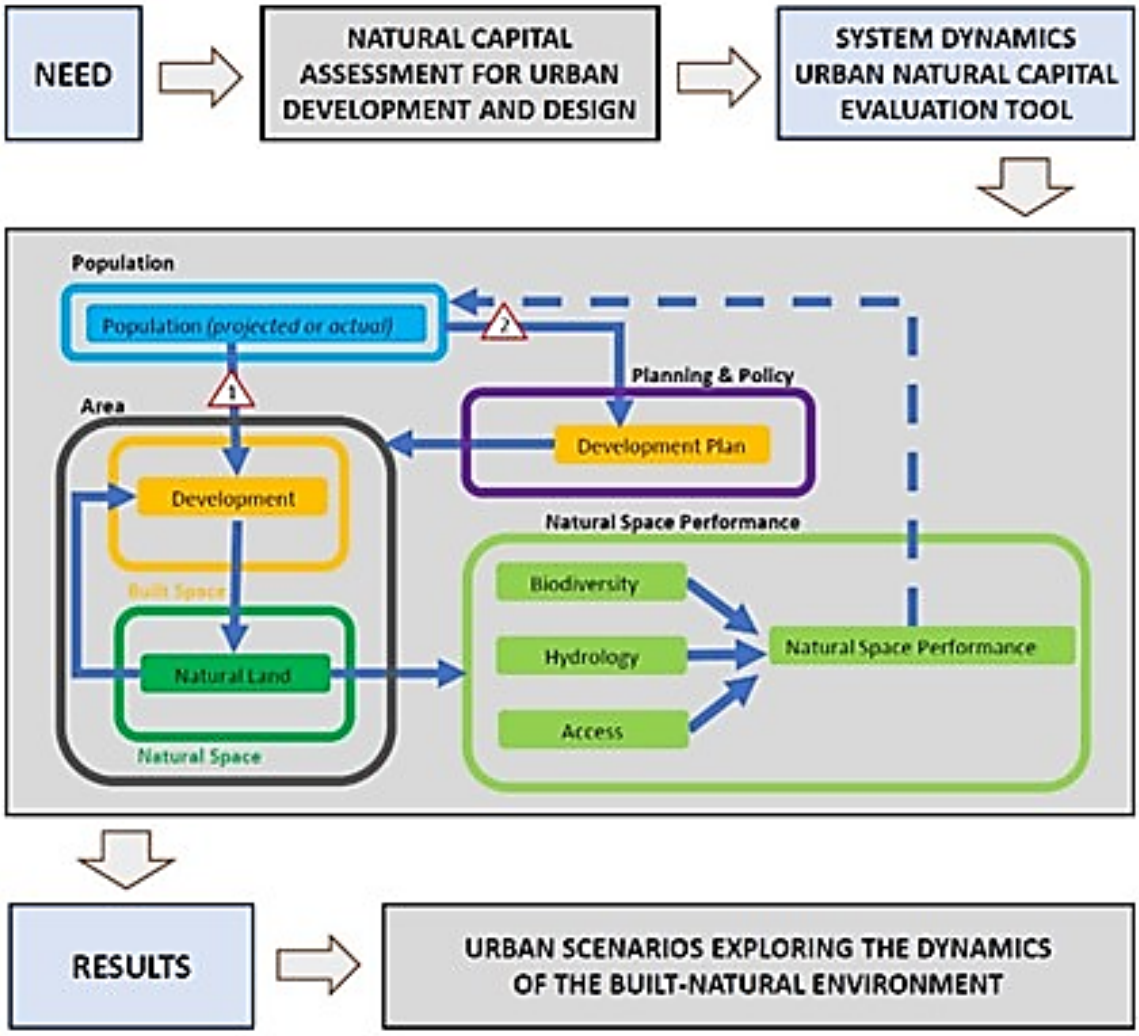

Figure 15. system dynamics model- Natural Space Performance

Urban Flood Resilience (system dynamics model)

Another tool that was developed in conjunction with work jointly undertaken by CAMELLIA and CUSSH at Thamesmead was on urban flood resilience. Thamesmead was formerly an inhospitable marshland, which was drained in the 1960s when the Greater London Council decided to transform the reclaimed land into a residential area. It's low lying, however, means that the area is vulnerable to four types of flooding mechanisms: tidal, fluvial, pluvial, as well as groundwater flooding. The main objective of the simulation model is to provide useful information for decision-makers at a strategic level to increase the level of flood resilience in Thamesmead. This model combines a simplified flood estimation model with other sectoral models (such as the effects of climate change and population growth) to explore alternative urban pathways. It enables a) understanding on how qualitative and quantitative aspects interact and influence the urban system; b) systematic exploration of a very large number of possible future scenarios; c) provision of useful information at a planning or strategic level.

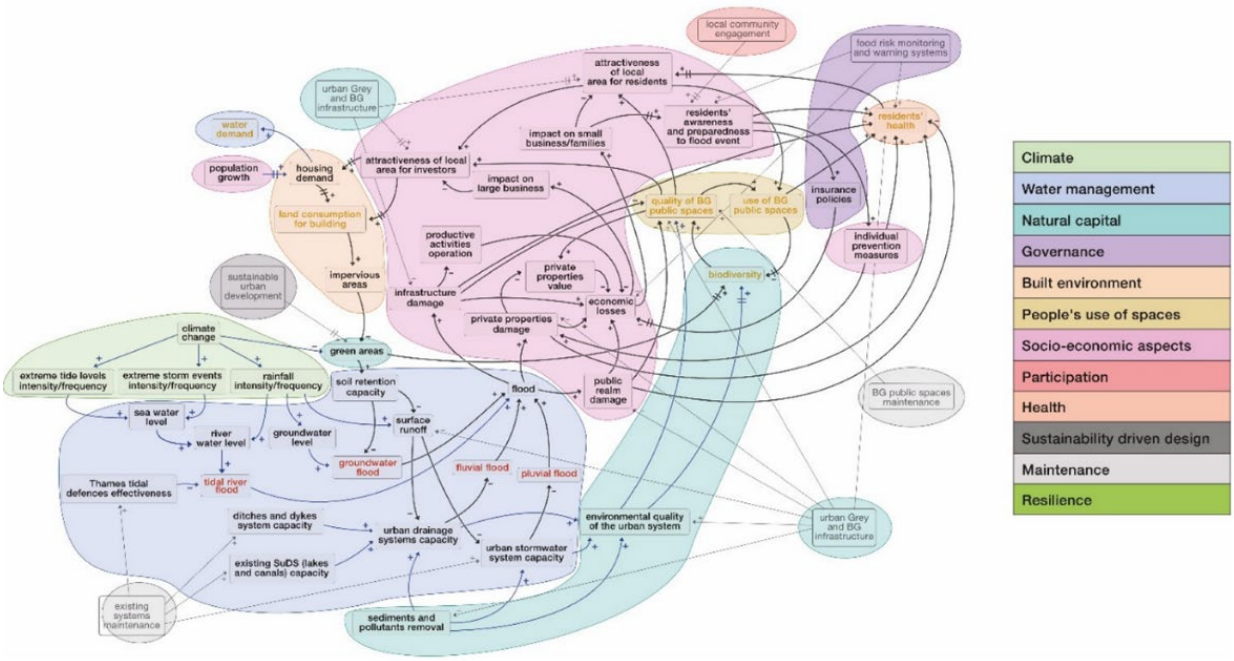

Figure 16. system dynamics model- Natural Space Performance- Urban Flood Resilience

A system dynamics (SD) approach was adopted due to its capacity for building a holistic understanding, while allowing an evaluation of different management solutions and identification of suitable strategies for both flood risk reduction and urban resilience increase (Figure 16). It provides a broader view of the urban system and allowed comparisons of different solutions and strategies. An iterative integration of different knowledge allows peculiarities of the case study to be accounted for. blue-green (BG) infrastructure can provide multiple benefits, namely hydrological performance, and social/environmental co-benefits. The socio/environmental co-benefits cannot be achieved by grey infrastructure alone. The resilience-enhancing ability of hybrid infrastructure (blue-green infrastructure + existing grey infrastructure) should be exploited. Indeed, the blue-green infrastructure implementation would not be sufficient on its own to fully reduce flood risk and enhance urban flood resilience. The implementation of BG infrastructure along with the regular maintenance of existing grey infrastructure might be the most suitable strategy. Social and environmental aspects are calculated in a semi-quantitative manner and therefore need to be explored further. The model was developed by Dr Virginia Rosa Coletta as part of her PhD thesis. Virginia works at the Polytechnic University of Bari (Italy), and this model was built in collaboration with the UCL team and co-funded by the CUSSH (Complex Urban Systems for Sustainability and Health).

Water Neutral Garden Calculator

The Water Neutral Garden Calculator (WNGC) is an educational design tool aimed at gardeners and community groups. It seeks to disseminate knowledge about how improved water management and better garden design can benefit the broader urban water network. The tool was initially inspired by a vision to create sustainable and ecologically beneficial green spaces for residents of a housing estate in South London. The first version of the tool (Figure 17) was developed for a single-site use case, specifically tailored to the Kipling Community Garden Project.

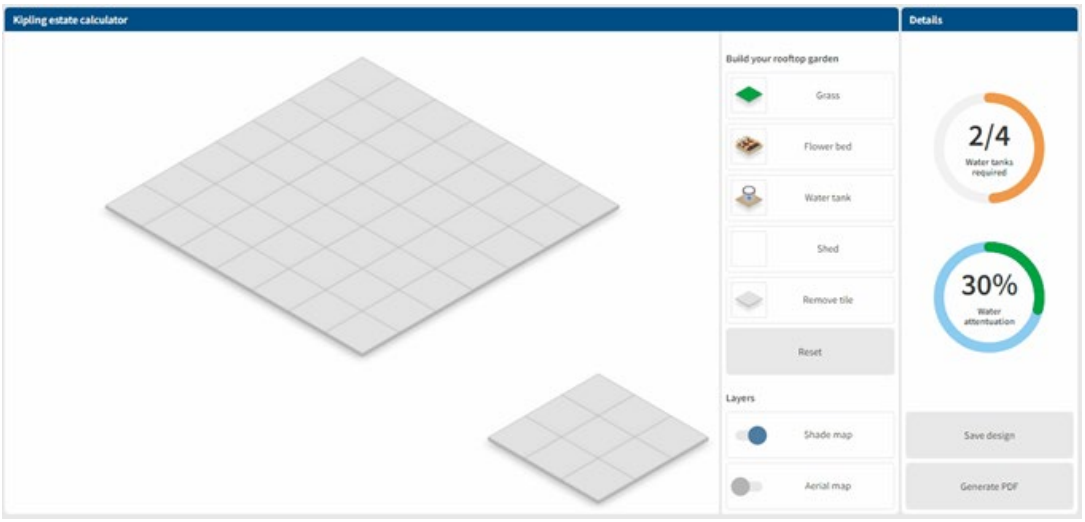

Figure 17. WNGC- Community-driven sustainability

The estate's community group expressed interest in optimizing the use of their roof space, with a key objective being the reduction of water consumption. Understanding approximate watering needs and required storage volumes enabled them to plan their time commitments more effectively.

Over time, the tool evolved into a versatile application adaptable to diverse urban environments. It now helps users create water-neutral green spaces regardless of their location. This benefits communities by providing accessible urban green areas for residents to enjoy, while also supporting water companies and local authorities by reducing surface runoff. This, in turn, alleviates pressure on urban sewer and water management systems—pressures increasingly intensified by climate change and the rise in extreme weather events.

By promoting innovative garden and greenspace designs, the WNGC fosters collaboration across previously disconnected communities. It supports gardeners, schools, industries, local governments, and urban planners by encouraging water conservation and embedding sustainable practices into public spaces.

In addition to its engagement with local community groups, the project brought together academics and researchers from various disciplines: hydrology (Imperial College London), urban planning (UCL), landscape architecture, and environmental and geospatial sciences (British Geological Survey). The emphasis on co-design with stakeholders and end-user communities ensured a tool that is both scientifically robust and grounded in real-world needs.

The WNGC highlights the importance of water conservation and limiting surface water runoff in an era of increasing water management challenges. Built using the ArcGIS Maps Software Development Kit (SDK) for JavaScript, the tool leverages 3D visualization capabilities to provide users with an immersive and gamified experience. This allows them to design their gardens with a realistic representation of their environment while learning about water management based on current scientific research.

Users can draw different surface types on the map using the API's web tools. These surfaces represent areas with varying water demands—such as low, medium, and high watering needs—as well as impermeable surfaces. The area of each surface type is calculated and visualized through an interactive dashboard (see Figure 18).

Figure 18. WNGC - Gamified user experience

The ArcGIS Maps SDK for JavaScript also enables the capture of garden designs and assets, storing them locally in the user's browser. Among the tool's standout features is the Daylight Widget, which provides accurate sunlight and shadow projections for any time and day throughout the year. This helps users make informed decisions based on shade and light exposure. For example, by adjusting the height of buildings, accessories, or large plants, users can tailor garden designs to suit planting types appropriate for shaded or sunlit environments.

Developed as a modern, responsive web application optimized for desktop use, the WNGC focuses on the Greater London area. It utilizes the Ordnance Survey (OS) MasterMap™ vector basemap to display detailed building footprints, aiding users in pinpointing specific houses or buildings as a starting point for their garden designs. While initially focused on Greater London, the application can be used globally, as there are no location-based restrictions. However, the OS MasterMap™ layer is limited to UK use.

The out-of-the-box features provided by the ArcGIS Maps SDK for JavaScript significantly streamlined the development process, enabling rapid deployment and enhanced functionality (see Figure 18).

We envision this tool being used by individual gardeners aiming to reduce the ecological footprint of their gardens, by community groups looking to re-green urban areas, and as an educational resource in schools to teach children about water conservation. Urban planning authorities could also use the tool to inform the design of new residential developments, with the aim of improving local water management and reducing runoff into sewer systems.

Following discussions with the Silk Stream project group, the WNGC has been further developed to include additional elements, such as roof infrastructure, in its rainwater runoff calculations. The integration of different roof types—including green roofs and roofs disconnected from the main surface water drainage systems—enables users to assess not only the impact of their garden designs but also the potential benefits of broader property-level infrastructure changes.

Water Systems Integrated Modelling (WSIMOD)

The water cycle is highly interconnected (Figure 19). Water fluxes in one part depend on physical and human processes in all other parts. For example, rivers are simultaneously:

- A water supply
- A receiver of wastewater
- An aggregate of many hydrological, biological and chemical processes

Because of this, simulations of the water cycle that have highly constrained boundaries may exclude key interactions that could create unanticipated effects or unexpected opportunities. Integrated environmental models aim to resolve this, but they do have some important limitations; in particular, there is a significant need for a parsimonious, self-contained suite that is both accessible and easy to set up. Traditional approaches to water system modelling broadly fall into two categories:

- highly numerical models that excel in representing individual subsystems
- systems dynamics models that create broad representations but lack a physical basis

Early attempts at a physical representation of the water cycle combined existing numerical models through an integration framework. While successful, this approach has an incredibly high user burden, because each subsystem model is so detailed and consequently difficult to customise.

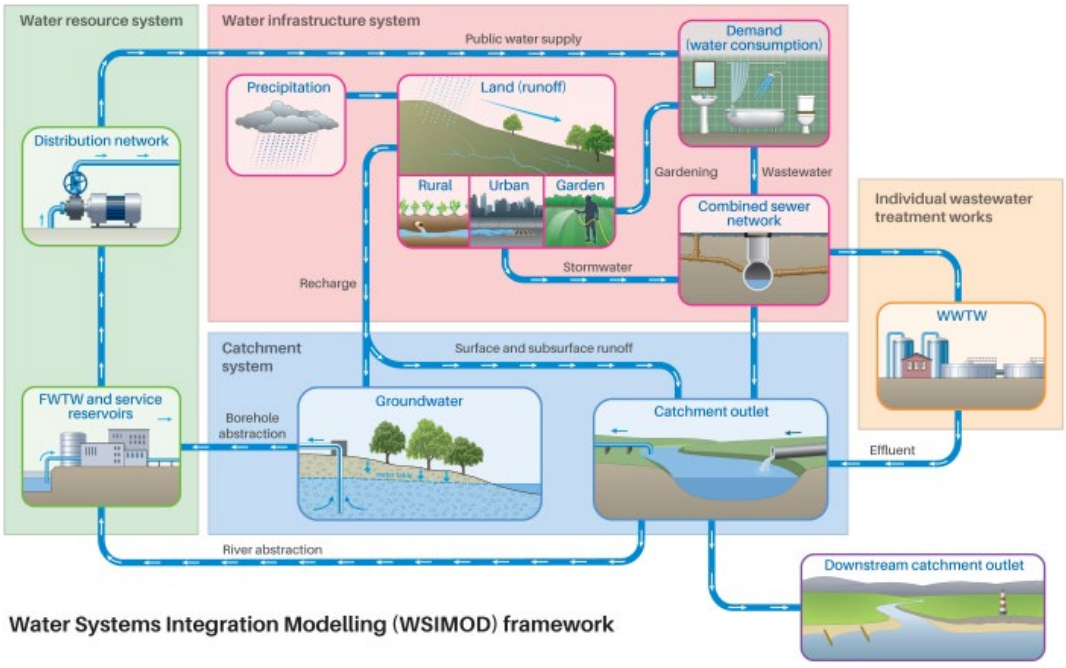

Figure 19. Diagram of WSIMOD framework

WSIMOD is a Python modelling framework that integrates the movement of water as affected by physical and human processes. The WSIMOD Python package provides a parsimonious and self-contained suite for integrated water cycle modelling. It brings together a range of software developed over the course of three years during the CAMELLIA project. Urban water processes are based on those presented and validated in the CityWat model, while hydrological and agricultural processes come from the CatchWat model. WSIMOD also provides an interface for passing information between different model components, allowing all parts of the water cycle to interact with all other parts. The result is a simulation model that is easy to set up, highly flexible and ideal for representing water quality and quantity in 'non-textbook' water systems (which, in our experience, is nearly all of them).

The package provides a variety of tutorials and examples to help modellers:

- create nodes (representing subsystems within the water cycle)
- connect them together with arcs (representing the fluxes between subsystems)
- organise them into a model that creates simulations
- make customisations to better accommodate the specifics of their case study

Note that WSIMOD is not intended to be a substitute for sophisticated physical models or a system dynamics approach. In applications where detailed hydraulic or hydrological process representations are needed (for example, informing the design of specific pipes or cases where processes are hard to quantify, such as representing social drivers of population growth, etc.) there are likely more appropriate tools available. Our case studies highlight that WSIMOD is most useful in situations where it is necessary to represent cross-system processes and multiple interactions to answer questions. The reduced complexity representations used are computationally fast and flexible in capturing a wide range of system interventions, giving another benefit to WSIMOD. WSIMOD has been used in multiple regional planning strategy projects for the Environment Agency, the Greater London Authority, and Greater Manchester Combined Authority.

Impact Delivered

Systems thinking in the context of environmental challenges involves exploring interactions between people, the physical system they are managing and the components of that system that provide meaning for decisions made at a local level. It starts with defining stakeholder needs and required functionality, and then designing solutions while considering the system as a whole. The assessment of the performance of the CAMELLIA programme is based on quantifying how the implementation of systems thinking in urban water management practice has provided means to enable the realisation of the sustainable and efficient solutions for a liveable London, and how this innovation is translated to national and international scales.

WP1: Environmental Science for System Modelling

Advancing Integrated Management and Planning through the WSIMOD Project

In an age where water scarcity and quality challenges are escalating, the WSIMOD project[21] emerges as a vital initiative aimed at revolutionizing water resource management. This project combines cutting-edge research with practical solutions to empower communities, policymakers, and stakeholders, ensuring sustainable water management for future generations.

The increasing pressures of population growth, climate change, and industrial demands, necessitate a shift in how we manage and utilize our water resources. Traditional approaches often overlook the intricate relationships between hydrology, land use, and community needs. The WSIMOD project addresses this gap by creating an integrated framework that fosters informed decision-making in water management.

The WSIMOD project employs innovative modelling techniques that analyse the interactions within water systems, providing insights into how different management strategies can impact water availability and quality. By engaging stakeholders throughout the research process, we ensure that our models reflect real-world conditions and community concerns. This collaborative approach not only enhances the relevance of our findings but also builds trust and encourages the adoption of sustainable practices.

During the CAMELLIA programme, a total of 14 WSIMOD-related scientific publications were published[22]. Through our research, we have identified effective strategies that can significantly improve water management outcomes. For example, our models demonstrate that integrated water resource management (IWRM) practices can lead to more efficient water use in agriculture, reducing waste and enhancing crop yields. Additionally, our findings emphasize the importance of adaptive management strategies that account for changing environmental conditions and community needs.

The impact of the WSIMOD project extends beyond academia, influencing a diverse range of stakeholders. By conducting workshops and outreach activities, we have shared our findings with local farmers, community leaders, and policymakers, equipping them with the knowledge and tools to implement sustainable water management practices. Our engagement has empowered these stakeholders to advocate for policies that support environmental stewardship and resilience in their communities. The use of WSIMOD has been seen as crucial to inform proposed Systems Approach to Integrated Water Planning, described in the Working Paper written with the Environment Agency and our industry partners in Mott MacDonald[23]. In addition, WSIMOD was used in seven policy and planning

[21] https://doi.org/10.5194/gmd-17-4495-2024
[22] Link to WSIMOD articles
[23] Working paper: Systems Approach to Regional Water Planning

case studies, generating direct additional funding from the stakeholders (see Annex 4) including Environment Agency and city authorities of London and Manchester in the order of £400,000.

As we look to the future, the WSIMOD project is committed to expanding its reach and enhancing its tools. We aim to incorporate new data sources and stakeholder feedback to continuously improve our models and ensure they remain relevant. By fostering collaboration among researchers, practitioners, and the public, we will drive innovation in water management and help communities adapt to the challenges ahead. For example, in collaboration with Mott MacDonald, WSIMOD has been used to inform the Greater London Authority's first-ever subregional integrated water management strategy report[24].

The WSIMOD project is transforming the landscape of water resource management through research, engagement, and collaboration. By connecting science with community needs, we are paving the way for a sustainable future where water resources are managed responsibly and effectively. Together, we can build resilient water systems that benefit both people and the environment, ensuring access to clean water for generations to come.

WP2: Community Engagement with Models, Infrastructure and Planning

Engaging communities

An aim of this work package was to directly involve citizens and communities in modelling London's water environment and designing new water infrastructure. To move beyond the passive customer-supplier relationship between Londoners and their water resource and infrastructure. Research commenced with Community Mapping, an interview study with residents who were in some way engaging with their local waterways. Identifying local networks of engaged publics by snowball sampling for interviewees this effort developed knowledge about which water issues it would be relevant to model. The most pressing matter of concern among residents and environmental groups in two locations in CAMELLIA case study areas was the water quality in local rivers. Focussing on this issue generated further projects: the participatory modelling and co-design of the Wetland Explorer and the development of Wealdstone Brook Workshops as a participatory method for addressing long-terms problems subject to controversy. Another impactful outcome from our community engagement work was the development of digital water management tools. This initially arose from a set of co-design sessions for a communal garden on the Kipling Estate in Southwark. This resulted in a simple spatial water management tool. This was further developed through contributions by members of the Walworth Communal Gardeners Network and led to the Water Neutral Garden Calculator, which was subsequently recognised and promoted by the Royal Horticultural Society for garden water management.

Bridging the Gap between Public Investment and Local Advocacy in London's Water Sector

In London[25], the quest for sustainable water management has brought together professionals in the water sector and local advocates for river improvement. However, a significant barrier persists: the disconnect between public investment frameworks and the genuine needs of local communities. This impact story explores how current project appraisal practices hinder the alignment of funding with local demands for blue and green infrastructure projects.

London's water sector professionals are tasked with securing public funds for vital infrastructure projects that address pressing environmental concerns, including flood risk mitigation and water quality

[24] Subregional integrated water management strategy report
[25] https://doi.org/10.1177/25148486211049912

improvement. Yet, the existing appraisal processes often emphasize utilitarian justifications, focusing on economic benefits rather than the intrinsic value of nature and community well-being. This creates a gap between the objectives of water management professionals and the aspirations of local advocates who prioritize ecological health and community responsibility.

Our research draws on qualitative evidence and performativity theory to examine the contrasting enactments of public value in water management. We found that water sector professionals utilize cost-benefit analysis to frame the general public as a rational entity focused on demonstrable economic outcomes. This approach legitimizes funding for projects with clear financial returns, such as flood mitigation efforts, but often neglects the nuanced values expressed by local advocates who seek holistic environmental improvements for their communities.

Our findings reveal a duality in the way public value is constructed and perceived. The general public, enacted through traditional appraisal practices, is measured by economic metrics, effectively sidelining the voices of local residents who advocate for the health of their rivers and the ecosystems they support. In contrast, local advocacy emphasizes a responsibility towards nature, highlighting the community's desire for investment in projects that improve water quality and foster environmental stewardship. This disjunction not only undermines the potential for blue and green infrastructure projects but also diminishes community trust and engagement in the decision-making process.

By illustrating the performativity of both general and local publics, our research offers critical insights for stakeholders, funding bodies, and water management professionals. It calls for a revaluation of project appraisal practices to incorporate the values and priorities of local communities. Engaging with residents and acknowledging their non-instrumental values can enhance the legitimacy of public expenditure and foster collaborative approaches to water management.

To bridge the gap between public investment and local demand, we advocate for a transformation in appraisal practices that recognizes and integrates the diverse values of local publics. This includes adopting participatory approaches that involve community input in the planning and decision-making processes for water projects. By aligning funding with local priorities, we can support the development of blue and green infrastructure that enhances both environmental quality and community resilience.

The current appraisal practices in London’s water sector must evolve to respond to the complexities of public value as articulated by local advocates. By fostering a more inclusive framework for project appraisal, we can pave the way for meaningful investments in blue and green infrastructure that resonate with the community’s aspirations for healthier rivers and sustainable ecosystems. Together, we can create a water management landscape that honours both economic imperatives and the intrinsic values that local communities hold dear. Here are some applications that facilitate the collection of data about London's water environment at the River Crane citizen science, Water Data Explorer, and Engineering design and decision-making.

WP3: Systems Integration

Enhancing Urban Flood Resilience through Participatory Socio-Hydrological Modelling

As urban environments grapple with the challenges of climate change, population growth, and ageing infrastructure, effective flood risk management has never been more critical. The complexities of cities, characterized by intricate interdependencies among infrastructural, economic, social, ecological, and human elements, necessitate innovative approaches to understanding and managing flood risks. Our research, focusing on the Thamesmead area of London, offers valuable insights into the potential of participatory socio-hydrological modelling to enhance urban flood resilience.

Urban surface water flooding presents significant risks to cities, resulting in economic losses and social disruption. Traditional hydrological modelling approaches, while invaluable in analysing flood dynamics, often fall short of capturing the intricate interplay between hydrological and non-hydrological factors. This lack of integration hinders the development of effective flood risk management strategies that consider the broader urban context, including social and economic dimensions.

In response to this challenge, we propose a participatory socio-hydrological modelling approach based on System Dynamics (SD)[26]. This methodology integrates hydrological and social processes, allowing for a comprehensive analysis of the interactions and feedback loops between flood risk and various urban subsystems. By combining scientific expertise with stakeholder knowledge, we empower decision-makers with actionable insights into flood dynamics and the effectiveness of resilience-building measures.

Our findings highlight several critical contributions to flood risk management:

Enhanced Analysis: The SD quantitative modelling framework supports the exploration of interactions between flood risk reduction measures and different urban subsystems. This enables decision-makers to grasp the multifaceted nature of flood risk and resilience effectively.

Tailored Insights: By integrating scientific and stakeholder knowledge, our model is tailored to the Thamesmead case study, quantifying socio-hydrological dynamics that have been limitedly explored in existing literature. This collaboration aids selecting appropriate measures to increase flood resilience.

Benefits of Blue-Green Infrastructure (BGI): Our research emphasizes the dual benefits of BGI, which not only reduces surface runoff but also provides a range of social and environmental co-benefits, particularly when integrated with efficient grey infrastructure. This holistic perspective enhances urban flood resilience and supports sustainable urban regeneration.

The implications of our research extend to various stakeholders, including urban planners, local authorities, and community advocates. By showcasing the effectiveness of participatory socio-hydrological modelling, we encourage a shift toward collaborative approaches in flood risk management that consider diverse perspectives and knowledge systems. This fosters stronger community engagement and promotes resilience-oriented decision-making.

Looking ahead, we aim to further refine our socio-hydrological modelling approach and expand its application to other vulnerable urban areas. By continuously engaging with stakeholders, we can ensure that our models remain relevant and responsive to the needs of the community. Additionally, we will advocate for the integration of BGI into urban planning frameworks, emphasizing its role in enhancing flood resilience and promoting environmental sustainability.

The work undertaken in the Thamesmead area exemplifies the potential of participatory socio-hydrological modelling to transform urban flood risk management. By bridging the gap between scientific research and local knowledge, we can create a resilient urban landscape that not only mitigates flood risks but also fosters social and environmental well-being. Together, we can build cities that are not only prepared for the challenges of climate change but are also vibrant and sustainable for generations to come. Here are some related activities about Developing a Shared Concern, Participatory System Dynamics Modelling, Comparing Qualitative Models, and Simulation-based Strategy Development.

[26] https://doi.org/10.1016/j.jhydrol.2024.131248

Lessons Learned

- **Stakeholder Engagement is Key**: Early and continuous collaboration with diverse stakeholders, including communities, policymakers, and industry, ensures solutions are both practical and widely accepted.
- **Co-Creation Drives Innovation**: Integrating community input into the planning and design process leads to solutions that are more inclusive, context-specific, and impactful.
- **Holistic Water Management is Crucial**: Addressing water challenges requires considering social, environmental, and economic factors together rather than in isolation.
- **Data Integration Enhances Decision-Making**: Combining multiple datasets and modelling tools improves the accuracy and usability of decision-support systems for urban water management.
- **Adaptability is Essential:** Flexible frameworks that can adjust to changing climatic, societal, and technological conditions are vital for long-term success.
- **Building Trust Takes Time**: Establishing trust between stakeholders, communities, and researchers is fundamental to achieving project goals and ensuring legacy.
- **Knowledge Sharing Amplifies Impact**: Disseminating findings through open-access platforms and capacity-building initiatives ensures that lessons and tools benefit a wider audience.
- **Policy Alignment Strengthens Outcomes**: Close alignment with local and national policies helps integrate research outputs into practice, maximizing their impact.
- **Long-Term Planning Secures Sustainability**: Focusing on long-term impacts ensures that solutions remain relevant and effective over time, creating a lasting legacy.
- **Interdisciplinary Collaboration is Indispensable**: Combining expertise from multiple disciplines fosters innovative solutions that address complex water challenges comprehensively.

Long-Term impacts and Legacy

The CAMELLIA project created the Water Information Hub (WIH) as a long-term legacy of sustainable urban water management for addressing critical challenges such as climate change, population growth, and resource efficiency in London and beyond. Its focus on co-creation with communities, stakeholders, and policymakers ensures that solutions are not only technically sound but also socially inclusive and environmentally resilient. The project's legacy lies in fostering a paradigm shift in water management practices, where decision-making is guided by robust evidence, innovative tools, and a deep understanding of community needs. CAMELLIA's integrated models and collaborative frameworks are designed to have a lasting impact by enabling cities to plan and adapt effectively to future water challenges. Through knowledge dissemination, capacity building, and stakeholder engagement, CAMELLIA aims to leave behind a wealth of resources, including open-access datasets, tools, and methodologies, that can be utilized globally. Its holistic approach also serves as a replicable model for other urban centres, ensuring that the project's influence extends far beyond its original scope. In essence, CAMELLIA's long-term legacy is one of empowering communities, enhancing resilience, and contributing to a sustainable and liveable future for urban environments.

Annexes

Annex 1: CAMELLIA team

Figure 23: CAMELLIA team members

Management and Co-Investigators

- Prof Adrian Butler: Principal Investigator (ICL)[27]
- Dr Suhad Almuktar: Programme Manager (ICL)[28]
- Greta Antonini: Former Programme Manager (ICL)[29]
- Sharon Russell-Verma: Impact Manager (ICL)[30]
- Dr Ana Mijic: Co-Investigator (ICL)[31]
- Dr Alexandra Collins: Co-Investigator (ICL)
- Dr Athanasios Paschalis: Co-Investigator (ICL)[32]
- Prof Sarah Bell: Co-Investigator (UCL)[33]
- Dr Nici Zimmermann: Co-Investigator (UCL)
- Dr Tse-Hui Teh: Co-Investigator (UCL)
- Dr Catharina Landström: Co-Investigator (UO)[34]
- Prof Simon Dadson, Co-Investigator (UO)
- Dr Chris Jackson: Co-Investigator (BGS)
- Dr Andrew Hughes: Co-Investigator (BGS)
- Carl Watson: Co-Investigator (BGS)
- Helen Fallas: Co-Investigator (BGS)
- Stephanie Bricker: Co-Investigator (BGS)
- Virginia Hannah: Co-Investigator (BGS)

Advisory panel

- Prof David Balmforth (Chair)- Independent Consultant, UK (formerly with Stantec)
- Prof Sarah Bell- University of Melbourne, Australia (formerly CAMELLIA Co-I at UCL)
- Prof Peter Coombes- Director, Urban Water Cycle Solutions, Australia
- Alan Leidner- Board of Directors Member, NYC Geospatial Information Systems and Mapping Organization (GISMO)
- Jacob Tompkins- Co-Founder & CTO The Water Retail Company
- Dr Jean Venables- Co-Director Venables Consultancy, based in London
- Prof. Dr Zoran Kapelan- Head of the Urban Water Infrastructure group, Department of Water Management, T U Delft, Netherlands

[27] Promoted as a Professor at Imperial in September 2019
[28] Now working as a Teaching Fellow at the University of Salford
[29] Moved to the PwC in October 2022
[30] Moved to the Central Bedfordshire Council in May 2022
[31] Promoted as a Professor at Imperial in September 2024
[32] Now at University of Cyprus
[33] Moved to the University of Melbourne in January 2021 and became a member CAMELLIA Advisory Panel
[34] Now full time at Chalmers University, Gothenburg

Researchers and PhD students

Table 3: CAMELLIA researchers and PhD students

Name	Job Title	Time within CAMELLIA (months)	Next Destination
Svea Rautenberg	Researcher	80	GIS Developer at the BGS
Giuseppe Salvia	Former- researcher		Brunel University London
Charlotte Johnson	Former- researcher		Centre for Sustainable Energy
Helge Peters	Former- researcher	59	Berater der öffentlichen Hand GmbH, Berlin
Jimmy O'Keeffe	Former- researcher	22	University College Dublin
Thomas Rowan	Researcher	63	PDRA Imperial College London
Barnaby Dobson	Researcher	47	Research Fellow in the Fluids section of Dept. Civil & Environmental Engineering, Imperial College London
Irene Pluchinotta	Researcher		Lecturer in "Systems Thinking for Sustainability" UCL
Tijana Jovanovic	Researcher	80	Surface and subsurface hydrological modeller at BGS
Séverine Cornillon	Former researcher	34	Geospatial Data Analyst at BGS
Javid Yousaf	Researcher	80	Software developer at BGS
Ke Zhou	PhD student		Research Fellow in System Dynamics at the UCL
Pepe Puchol-Salort	PhD student	27	Hoffmann Research associate in water Innovation in collaboration with the World Economic Forum (WEF)
Leyang Liu	PhD student		Research Associate at ICL
Ziyan Zhang	PhD student		Research Associate in Eco-hydrological Modelling
Samer Muhandes	PhD student		Research Postgraduate at the ICL
Ariel Shepherd	PhD student		
Yuhong Wang	PhD student	27	Research Assistant at the UCL
Pouria Paridar	Researcher	10	PhD researcher at Delft University of Technology
Brunilde Verrier	Researcher	5	Research Fellow in Energy Transitions at the UCL
Giuseppe Salvia	Researcher	27	Senior Lecturer in Design and Innovation at Brunel University London
Simon De Stercke	Research associate	15	Data team of a German energy policy think tank, in Berlin
Simon Burden	Researcher	60	Web developer at BGS
Andrew Hulbert	Researcher	60	Geospatial Data Analyst at BGS
Andrew McKenzie	Researcher	36	Research Scientist at BGS
Liam Spencer	Researcher	36	Database Engineer at BGS
Andrew Tye	Researcher	12	Soil Scientist at BGS

Annex 2: CAMELLA Projects

The following boxes provide details on the various CAMELLIA projects. These were listed in Table 1 and their geographic distribution are shown in Figure 6. The projects varied in duration, extent and number of members and partners. Key outcomes are provided below, whilst their relationships with the project as a whole are illustrated in Figure

Project number	**Project name /** Objective(s)	**CAMELLIA member(s)** ***Project partner(s)***	**Contribution**	**Start (year)**	**End (year)**	**Outputs & Outcomes**
CA001	**Kipling rooftop garden co-design** Designing a roof garden with the estate residents that can meet their aspiration, deliver on water management sustainability targets, and be easy to develop and manage.	UCL	• Leading workshops with housing estate residents.	2018	2020	Estate residents used outputs from the water management design tool in funding successful proposals to Southwark Council and the GLA. Funding was eventually used to create a garden on the site on the housing estate. The methodology has been presented in a number of published papers and in a book "Co-designing Infrastructures: Community collaboration for liveable cities" Bell et al. (2023) [ISBN 9781800082229 https://www.uclpress.co.uk/products/186914] Residents garden established using funding received from Southwark Council and GLA.
		Imperial College London	• Assisted with leading workshops			
		BGS	• Development of water calculator tool			
		Leathermarket JMB	• Meeting venue • Contacting residents • Installation of solar power and refurbishment of rainwater tank			
		Kipling Residents Association	• Attendance at workshops • Submission of funding proposal			

Project number	**Project name /** Objective(s)	**CAMELLIA member(s)** ***Project partner(s)***	**Contribution**	**Start (year)**	**End (year)**	**Outputs & Outcomes**
CA002	**Smart water tanks for rain harvesting and flood alleviation** To investigation potential for low-cost domestic rainwater management	Imperial College London	• Development and testing of control low-cost systems for monitoring and controlling a prototype. Meetings held with Exeter University and SDS. • MSc projects	2019	2021	• Initial prototype developed, however, key outcome is that this approach didn't appear to be cost effect and that passive systems were more effective.

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA003	**Enfield Community Mapping for Water Management**	Oxford	• Recorded interviews with members of stewardship groups, other engaged residents and individuals working with these groups and water management in local authorities • Analysis of interviews and report on main issues of concern	2019	2021	• Provided context for development of simple local models for use in community modelling • Provide understanding of local social relationships that will support future engagement activities. • Mitigation of water quality issues • Increase capacity of local communities to participate in expert- led water management decision- making • Increased engagement of community members in water management
		Haringey River Forum	• Attended meetings and gave feedback			
		Enfield residents	• Provided interviews			
		Thames21	• Provided the venue			
		LB Enfield	• Attended meetings and gave feedback			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA004	**System Dynamics to capture perceptions and support decision making in Thamesmead**	UCL	• Problem scoping interviews • A series of workshops were carried out to define quality and map the complex independencies and hindering the space's quality improvement • The shared stakeholder's problems were identified as broad and interconnected mental models of blue/green/built infrastructure issues	2019	2023	• Stakeholder's shared perspective and understanding of environmental and water management issues a round Thamesmead redevelopment • Increased collaboration amongst stakeholders • Effective sustainable design • Residents' involvement in the redevelopment plan decision-making
		Imperial College London	• Assisted with running workshops			
		Peabody	• Provided venue for workshops and supported these through engaging			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA005	**Haringey urban rivers restoration**	UCL	• Review public health risk from water quality in relation to restoration of the Moselle Brook at the Clarendon Gasworks site • Development of tools to support early community engagement in evaluation of river restoration options in London • Workshop to assess potential for research council proposal on urban water quality	2019	2020	• Moselle public Health Risk Report: Non- peer reviewed assessment of literature relating to public health risk management and river restoration • Outline options for Chestnut Park • MSc dissertation on Stonebridge Brook restoration in Chestnut Park • Define scope of work for water quality testing • Stronger evidence for discussion about river restoration in Haringey • Raising the capacity of local councillors and officers to deliver existing policy • Tools developed for early assessment of options for river restoration for wider use by community
		Haringey River Forum,	• Identification and analysis of options for restoration of the Stonebridge Brook in Chestnuts part, to improve flood management and part amenity			
		London Borough Haringey	• Participated in workshop			
		Peabody	• Provided venue for workshops and supported these through engaging with local communities			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA006	**Assessing the role of natural capital in a sustainable urban environment**	Imperial College London	• Literature review • Model development - planning and design based on Thamesmead (CA004) stakeholder output	2019	2021	• Building evidence for natural capital assets to better designed, maintained, and utilised • Strengthening local resilience to adverse impact of change • Natural Capital model assessing benefits and co-benefits of natural capital, providing complementary knowledge to other existing tools • Early assessment of natural capital gains of new housing development • Improve sustainability in urban planning
		Peabody	• Model development and parameters			
		Thames 21	• Model development and parameters			
		LB Enfield	• Model development and parameters			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA007	**CityWat - Systems water management models for integrated water infrastructure planning and operation**	Imperial College London	• Lumped model of London's integrated supply and wastewater system created (Citywat) • Validation with known parameters confirmed high-level accuracy and potential of model	2019	2021	• CityWat model code is publicly available https://github.com/barneydobson/citywat • Influence and facilitate integrated planning within Thames Water • Used to support the development of the CityPlan water neutrality concept • Case study for adoption by other water companies, nationally and internationally
		Thames Water	• CityWat presented at a webinar with Thames Water and collaboration on semi- distributed model's development was agreed			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA008	**Wealdstone Brook water quality workshops**	UCL	• Led on the planning and running of the two workshops and to the writing of the CIRIA report	2020	2023	• Provided context for development of simple local models for use in Community Modelling • Provide understanding of local social relationship that will support future engagement activities • Increase capacity of local communities to participate in expert-led water management decision-making • Increase engagement of community members in water management • Publishing of the Catalysing change in an urban river catchment: Wealdstone Brook, London with CIRIA: • Link for CIRIA report
		University of Oxford	• Led on the production of the CIRIA report and assisted with the planning and running workshops			
		Imperial College London	• Assisted with planning and running workshops and production of CIRIA report			
		Wealdstone Brook residents	• Helped instigate project participated in workshops			
		Friends of Woodcock Park	• Helped instigate project participated in workshops			
		Thames Water	• Helped instigate project participated in workshops			
		Thames 21	• Participated in workshops			
		LB Brent	• Participated in workshops			
		LB Harrow	• Participated workshops			
		Stantec	• Participated workshops			
		Environment Agency	• Participated workshops			

Project number	**Project name /** Objective(s)	**CAMELLIA member(s)** ***Project partner(s)***	**Contribution**	**Start (year)**	**End (year)**	**Outputs & Outcomes**
CA009	Water Neutral Garden Calculator	Imperial College London	• Development of underlying theory • Communication with stakeholders	2020	2024	• Best practice case studies • Garden planning and retrofit water impact calculator • Producing evidence on community garden water management best practice and soci0-environmental benefits • Developing WCGN group member's knowledge and skills in rainwater harvesting, sustainable irrigation, and soil water retention • The community garden water impacts calculator and retrofit assessment will be included in the CAMELLIA toolkit for wider use • Distributed to RHS members to assist with garden design and garden water management
		UCL	• Communication with stakeholders			
		BGS	• Development of web-based tool			
		Walworth Community Garden Network	• Testing and feedback of tool during development process			
		Royal Horticultural Society	• Feedback on tool • Communication to RHS members			

Project number	**Project name /** Objective(s)	**CAMELLIA member(s)** ***Project partner(s)***	**Contribution**	**Start (year)**	**End (year)**	**Outputs & Outcomes**
CA010	**Water Futures education programme**	BGS	• Development of teaching tools	2020	2022	• Improve Water Future interactive tool by developing online guidance and teaching modules for secondary education level • Teaching tools increased understanding for complex water-related problems through case-study style of learning • Available for dissemination and adoption of learning material to school across London and nationally via WIH
		UO	• Modification of water management teaching tool			
		Thames21	• Scientific input and assisting with testing			
		Royal Bank of Canada	• Funding and guidance			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA011	**Road Runoff Pollution Solutions**	BGS	• Development of GIS visualisation tool	2021	2024	• Online GIS tool which provides a visual representation of estimates of pollution from roads (incl. Cadmium, copper, pyrene, benzo-a-pyrene, zinc, total suspended solids). Used to provide indications where different types of SuDS could be implemented to mitigate these pollutants. Launched by the Mayor of London in Nov 2023. URL: https://mapapps.bgs.ac.uk/road-pollution-solutions/ • Visualisation of private and public data to support decision-making • Increasing interest and use across London and wider Thames area • Promoting schemes for mitigation of road runoff pollution
		Thames21	• Collection of road runoff data			
		Middlesex University	• Chemical analysis of road runoff data			
		Imperial College London – Transport Group	• Provision of road network traffic density data			
		Environment Agency	• Guidance and advice			
		GLA	• Guidance and advice			
		Surrey County Council	• Guidance and advice			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA012	**Water Data Explorer development for engagement and decision-making**	BGS	• Development and testing of web-based data visualisation tool	2019	2021	• Web tool which is available from the link https://camellia-water-data-explorer-bgs.hub.arcgis.com/
		Thames Water	• Provided important feedback on user experience			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA013	**Water sentiment dashboard**	U Oxford	• Undertaken during lockdown periods during covid-19 when community engagement was not possible. • Programming support provided by staff and student in computing dept. at UO.	2019	2021	• Provides data of sentiments expressed about river water quality from postings on twitter (now X)

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA014	**Community Wetland modelling**	U Oxford	• Development of project with stakeholders • Updated INCA model of Pymmes & Salmon Books	2019	2021	• User experience workshops • Updated water quality model of Pymmes and Salmons Brooks (published by Bussi (2022). Green infrastructure and climate change impacts on the flows and water quality of urban catchments: Salmons Brook and Pymmes Brook in north-east London. Hydrology Research 1, 53 (4): 638–656, June 3, 2024.
		BGS	• Development of web-based tool to provide visualisation on model output			
		Thames21	• Helped with stakeholder workshops and feedback			
		London Borough Enfield	• Provided critical feedback, data support and helped with workshops			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA015	**CityWat SD**	Imperial College London	• Spatially distributed representation of London integrated water cycle • Explicit modelling of water use behaviour at a sub-daily time scale accounting for changes in the water use during COVID-19	2021	2024	• Understanding the impacts of water use of flow and water quality impacts on London rivers • Contributed to commissioning of the per capita reduction modelling for London by the GLA.

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA016	Permeable Pavement trial at White City	Imperial College London	• Provided site location. • Purchase and installation of monitoring equipment • Data analysis, including numerical modelling • Accompanying MSc projects	2019	2023	• Experimental dataset • Numerical model • Project report
		Interpave	• Project initiation and objectives			
		Conway	• Installation of paved pads			
		GLA	• Project funding and support			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA017	**River Crane Smarter Water Catchment: Headstone Manor wetland**	Imperial College London	• Implementation of low-cost level sensors to monitoring water level and flow • Data analysis & interpretation • Modelling support from MSc project	2019	2021	• Demonstration of how low-cost optical water level sensors can be used to provide flow data in conjunction with water quality measurement to assess wetland behaviour • Report published on Crane SWC website: Headstone Manor Park wetland monitoring • MSc dissertation: Assessment of a process-based model to simulate water quality in an urban wetland: The Headstone Manor Park wetland, London. Sirdarbeg Rukhsar Begum, Imperial College London, 2023
		Thames Water	• Funding of ZSL work through Crane SWC			
		London Borough of Harrow	• Site support			
		Zoological Society of London	• Collection of water quality and ecological data			
		Crane Valley Partnership	• Management of SWC projects			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA018	**Green roof assessment**	Imperial College London	• Repurposed use of automatic weather station used in Permeable Paving project (CA016) to monitor conditions on the roof of Imperial College London student hall of residence located on Prince's Gardens, South Kensington. • Data collected over summer of 2022.	2019	2021	• Recorded conditions during UK's hottest days on 18-19 July 2022.

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA019	**Water Integration System Model (WSIMOD)** Integrated semi-distributed model of the whole catchment water cycle.	Imperial College London	• First ever process based integrated water system model for the simulation of the flow and water quality with the whole water cycle	2021	2024	• 14 scientific publications • 7 impact reports for the Environment Agency, GLA and GMCA • ~£400,000 direct stakeholder funding and £1M new research funding (EPSRC VENTURA project) • 5 PhD thesis (2 PhD students finished and 3 to be completed)
		Multiple partners (Environment Agency, Thames Water, GLA)	• Uptake and testing			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA020	**Water Info Hub** CAMELLIA's legacy site	BGS	• Development and testing of web portal • Location and maintenance of site	2021	2024	• Legacy web site for assess to CAMELLIA products and outputs beyond the end of the project.
		Imperial College London	• Planning and feedback			
		UCL	• Planning and feedback			
		UO	• Planning and feedback			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA021	**High-resolution land use mapping**	BGS	• Development and implementation	2021	2024	• Land use map at 2 m resolution for greater London area

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA022	**Action for Silk Stream**	UCL	• Discussions with partners	2021	2024	• Useful feedback on WNGC usage.
		BGS	• Further development of WNGC tool			
		Imperial College London	• Discussions with partners and assistance with tool development			
		L B Barnet	• Leading project. Arranged community engagement meeting to test use of WNGC tool.			
		L B Harrow	• Discussions on WNGC tool and role in flood reduction			

Project number	Project name / Objective(s)	CAMELLIA member(s) *Project partner(s)*	Contribution	Start (year)	End (year)	Outputs & Outcomes
CA023	**Newton Park Wetland Assessment**	BGS	• Field work, sediment sampling and chemical data analysis	2024	2025	• Work in progress.

Annex 3: List of CAMELLIA Project Partners

Academic organisations
Imperial College London – Transport Group
Middlesex University

Community Groups
Enfield residents
Friends of Woodcock Park
Haringey River Forum,
Kipling Residents Association
Walworth Community Garden Network
Wealdstone Brook residents

NGOs
Thames21
Crane Valley Partnership

Professional Bodies
Royal Horticultural Society
Zoological Society of London

Housing organisations
Leathermarket JMB
Peabody

Regional & Local Government
GLA
London Borough Barnet
London Borough Brent
London Borough Enfield
London Borough Haringey
London Borough Harrow
Surrey County Council

Water Utilities
Thames Water

Construction, Engineering and Consulting
Conway
Interpave
Stantec
Water Resource Associates

Finance
Royal Bank of Canada

Regulator
Environment Agency

Annex 4: List of CAMELLIA Dissemination Activities

Throughout the duration of the CAMELLIA project, we sought to disseminate our work and engage with the wider community through a wide range of routes. Given the nature of our work, peer review has considered important for in terms of academic scrutiny and providing confidence in the work, as well as disseminating to the wider professional community. These were supported by webinars, meetings, blogs and newsletters, as well as some media broadcasts. A summary of these and other activities is given in the following table (Table 4).

Table 4. Summary of CAMELLIA dissemination activities

Item	**Number**
Number of Blogs	9
Magazine or newsletters	14
Advisory Panel meetings	5
Stakeholder meetings	3
NERC RISE Progamme Executive Group (PEG) meetings	10
Workshops	21
Business meetings	5
Policy and Practice briefing notes	12
Webinars	12
Talks, presentations, debates	35
Broadcasts	2
Formal working group, expert panel, dialogue events	5
Media interview, press release, press conference or other response to a media enquiry	8
Participation in open days	2
Journal publications	55

Annex 5 Additional Funding

The CAMELLIA project is advancing its mission to deliver innovative, sustainable water management solutions by securing further funding (Table 4). This additional support enabled the project to expand its research, engage with more stakeholders, and implement cutting-edge tools and strategies to address critical water challenges. The extended funding underscores the significance of CAMELLIA's work and its role in shaping a resilient, resource-efficient future for urban communities.

Table 5: Additional funding linked with CAMELLIA

Proposal name	**Funder**	**Duration (month / year)**	**Funding (£k)**	**Type**
Water Futures	Royal Bank of Canada	1 y	69	Matched
Funding for Twitter study	ESRC IAA grant	1 y	22	Matched
Cross-RISE coordination fund	NERC UKRI	1 y	50	Leveraged
Kipling roof gardens	UCL (In kind support)	2 y	5	Leveraged
Kipling roof gardens	Greener City Fund (GLA)	2 y	20	Leveraged
VENTURA	EPSRC	2 y	1,000	Leveraged
CityWat interface development	Ana Mijic's research funds	1 y	6	Matched
INCA model development	Adrian Butler's research funds (£5k) + BGS (£10k) + Oxford University (£5k - HydroJULES)	1 y	20	Matched
Policy Connect sponsorship	Adrian Butler + Ana Mijic's research funds	6 m	2	Leveraged
CUSSH	Wellcome Trust	5 y	6,000	Affiliated
Hydro-JULES	NERC	5 y	6,000	Affiliated
Imperial PhD students funding (Pepe, Leon, Samer, Ziyan)	Various	4 y	334	Affiliated
Thamesmead permeable pavement development funds	GLA	1 y	10	Matched
ESRC Impact Acceleration Award	ESRC	1 y	9	Matched
EA funding for road runoff	Environment Agency	1 y	40	Matched
Funding for road runoff extension (River Thames above Maidenhead, and Surrey)	South-East Water and Surrey County Council	1 y	22	Matched
River Crane Smarter Water Catchment	Crane Valley Partnership	5 y	5,000	Affiliated
WSIMOD for OxCam consultancy project	Mott Macdonald	1 y	27	Matched
WSIMOD for Lea Valley consultancy project	Mott Macdonald	1 y	25	Matched

Integrated Water Planning Portal for Digital Planning Applications & Sustainable Urban Design	UKRI Impact Acceleration Account (internal call)	1 y	194	Affiliated
Resilience scenarios for integrated water systems	STFC/DAFNI call	18 m	329	Affiliated
Barnaby Dobson ICRF	Imperial College Research Fellowship	4 y	247	Leveraged
Rethinking water planning	EA	10 m	45	Affiliated
Road Pollution Solutions Tool development	Thames21	10 m	6	Leveraged
Road Pollution Solutions Tool: further development and application to River Thames catchment between Maidenhead and Teddington	Thames21	10 m	25	Leveraged
Integrated assessment of agricultural and road runoff pollution risks to our rivers - extending the Road Pollution Solutions Tool	Government Office of Technology Transfer / Innovate UK	18 m	243	Leveraged
Digital Twin of the Manchester water system using WSIMOD – pilot study	Greater Manchester Combined Authority	7 m	52	Matched
Road Pollution Solutions Tool: update of the tool to include pollution from minor roads in the River Thames catchment between Maidenhead and Teddington	Thames21	3 m	4	Leveraged
Total Matched			**£302k**	
Total Leveraged			**£1,596k**	
Total Affiliated			**£17,573k**	