



THE UK WATER PARTNERSHIP

WATER RESILIENCE

CAPITALISING ON THE
COMMERCIAL OPPORTUNITIES
FOR UK PLC

A Capability Capture and Call to Action
by the UK Water Partnership

FEBRUARY 2022

PURPOSE

With cities worldwide expected to grow an estimated 2 billion residents by 2050, there is an urgent need for urban water management that ensures consistent, adequate and high-quality water services for all.

However, the scale and complexity of this need presents new challenges to decision-makers in government, civil society and the private sector.

The UK is in a strong position to help develop a water resilient future globally utilising its expertise, knowledge and global links.

This paper provides an insight into the water resilience capability and expertise of UK organisations. It is intended to showcase where the UK's experts, innovators and entrepreneurs are at the forefront of the global response when it comes to the key issue of water resilience and all this entails.

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ABOUT THE UK WATER PARTNERSHIP

The UK Water Partnership (UKWP) was established in 2015 and provides a strategic vision for the development and growth of the UK water industry.

The Partnership brings together diverse water industry and related organisations in a single coherent alliance, promoting mutual understanding, co-operation and coordination.

It applies world-class research and innovation to address the challenges of global water security and the need for resilience in a changing environment – and to secure more of the \$500 billion global water market.

See page 30 to find out about the benefits of joining the UK Water Partnership.

FOREWORD

01

By 2050, it's projected that 66 percent of the world's population will live in urban areas, 2.5 billion more people than in 2018. Combined with the impacts of climate change, this presents increasing challenges for the world's water demand and associated issues with wastewater and water pollution. To address these challenges, we need to embed resilience at the heart of our water systems, both at a city-scale and across the catchment.

Water resilience comprises the ability to cope with and recover from shocks and stresses, disruption, and uncertainty, thereby maintaining essential services and protecting the environment now and into the future. Resilience has always been recognised as a priority for UK Government, and the industry has responded by delivering best-in-class solutions, regulation and innovative approaches.

So, I welcome the UK Water Partnership's efforts to capture UK capability in this document, which can serve to promote best practice globally and help to improve the planet's prospects for long-term water security and resilience.

Sarah Hendry

Chair of the UK Water Partnership

February 2022

EXECUTIVE SUMMARY

Our planet faces an unprecedented combination of water security and resilience challenges. The UK Water Partnership (UKWP) is providing leadership and a unified approach to the UK's efforts to contribute to the development of sustainable solutions, and to ensure that the UK's experts, innovators and entrepreneurs are at the forefront of the global response.

The water sector will need to continue to embrace change in order to address the challenges and take full advantage of the opportunities.

With cities worldwide expected to grow an estimated 2 billion residents by 2050, there is an urgent need for urban water management that ensures consistent, adequate and high-quality water services for all. However, the scale and complexity of this need presents new challenges to decision-makers in government, civil society and the private sector.

WE DEFINE WATER RESILIENCE AS:



Providing access to high quality water resources for all residents.



Providing sanitation to protect public health.



Connecting residents through water-based mobility and activity.



Protecting people and their possessions from water-related hazards, including flooding and drought.



Protecting the natural environment from pollution and degradation.

The UK has a developed strong capability and expertise to deliver water resilience internationally. Built on domestic needs to manage water through efficiency and the development of new water resources and to develop nature and man-made solutions to protect against pluvial, fluvial and coastal flooding.

Climate change is already greatly exacerbating the world water crisis – intensifying floods, prolonging droughts, and more. In many ways, the worst impacts of the climate crisis will be felt through water.

Unless urgent action is taken, these impacts will only worsen in the coming years and decades.

Resilience is considered to be a characteristic of a system – that is, a capacity, ability or property – and these characteristics associated with resilience can be broken down into four capacities:

- Anticipate and absorb potential disruption
- Adapt to or accommodate changes within or around the system due to disruption
- Respond to and recover as quickly as possible after a disruption
- Learn and improve after the event to improve for future disruptions

A water resilient city is one that can survive and thrive in the face of shocks and stresses related specifically to water – ranging from drought to flooding, storm surges, and sea level rise – and adequately mitigate the impact of all shocks and stresses on the urban water system (e.g. the impact of an earthquake on key water infrastructure).

Resilience in this context means that the city exhibits the capacity to:

1. Provide access to high quality water resources for all residents
2. Protect residents from water-related hazards
3. Connect residents through water-based mobility

The global water resilience opportunity is compelling; a recent estimate of the scale of global economic losses related to water insecurity: USD 260 billion per year from inadequate water supply and sanitation, USD 120 billion per year from urban property flood damages, and USD 94 billion per year of water insecurity related to food production (Sadoff et al, 2015).

It's not just the economic cost that need to be reckoned with lives and livelihoods at risk from too little, too much and too polluted water.

03

INTRODUCTION

The fact that our planet faces an unprecedented combination of water security and resilience challenges, caused by the cumulative impacts of population growth, increasing demand, declining resources, pollution and climate change, has been established beyond doubt.

The impacts have been described and analysed in forensic detail in numerous, authoritative research projects and reports.

The UK Water Partnership (UKWP) was specifically created to provide leadership and a unified approach to our efforts here in the UK, both to contribute to the development of sustainable solutions and to ensure that the UK's experts, innovators and entrepreneurs are at the forefront of the global response.

Against that background, this document, produced on behalf of the UKWP, examines the contribution that water resilience will play in shaping our industry and the water economy and, in particular, highlights some of the emerging commercial opportunities for the UK.

UNDERSTANDING WATER RESILIENCE

04

A water resilient city is one that can survive and thrive in the face of shocks and stresses related specifically to water, ranging from drought to flooding, storm surges, and sea level rise.

Resilience as a general principle, can be defined in a number of ways:

“Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future.”

Definition of resilience from the Ofwat Resilience Task and Finish Group (Ofwat, 2015).

“Resilience is the ability of a system to undergo change without changing state”.

Definition of resilience from the SCCG (Sydney Coast Council Group et al, 2013).

In the context of water, resilience has been defined as:

“The ability to anticipate, adapt, respond and flourish in the face of a range of shocks and stresses to the water sector in order to maintain services for people and protect the natural environment now and in the future.”

Definition of resilience in the water context of the water sector, developed by Arup for the Lloyd's Register Foundation, The Resilience Shift 'Resilience in the Water Sector' Scoping Study (Arup, 2017).

The characteristics of resilience are a response to disruptors, which can be divided into acute shocks, which are sudden disruptive events and chronic stresses, which weaken the function of the organisation or system long-term. Stresses are also often felt as shocks when they reach a tipping point. The impacts of these shocks and stresses on the system are felt on people and the environment, the end-users of the system.

If an urban water system is impacted by one of the shocks or stresses, then the impact is experienced by the people it serves, and the natural environment.

The primary functions of an urban water system, which could be impacted by shocks and stresses, are to:

- Provide safe, clean drinking water to people
- Provide sanitation to protect public health
- Connect people through water-based transport
- Protect people and their possessions from flooding
- Protect the natural environment from pollution and degradation.

A water resilient city must adequately mitigate the impact of all shocks and stresses on the urban water system (e.g. the impact of an earthquake on key water infrastructure).

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WHY IS WATER RESILIENCE IMPORTANT ?

Climate change affects, and is affected by, global water resources. It reduces the predictability of water availability and affects water quality. Climate change also increases the occurrence of extreme weather events, threatening sustainable social-economic development and biodiversity worldwide. This, in turn, has profound implications for water resources. As such, climate change exacerbates the ever-growing challenges associated with the sustainable management of water. Conversely, the way water is managed influences the drivers of climate change.

Water, therefore, is the ultimate connector in the global commitments towards a sustainable future: the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) are highly dependent on improved water management.

Water resilience is essential for reducing the impacts of water-related disasters, which have the largest effect on society and people's livelihoods.

With over 2 billion new urban residents anticipated globally by 2050, the challenges of climate change and water will inevitably become more profound. With one-third of the world's population living in water-stressed areas and 10% of the world's population in low-elevation coastal zones, the increase in the frequency of extreme weather events due to climate change will impact communities globally. Global water crises – from drought to flooding – are the biggest threats facing the planet over the next decade. There is a clear demand for new approaches for providing essential services to city residents (United Nations Department of Economic and Social Affairs, 2018).

The water challenges facing our planet are well-rehearsed and documented in many authoritative reports – here is just a small selection:

PEOPLE AND THEIR NEEDS

The global population will reach 10 billion by 2050, and potentially 16.5 billion by the end of the century, accompanied by a dramatic increase in demand for water and food. Increased urbanisation puts pressure on water networks and infrastructure, in particular affecting access to clean water and sanitation. Attitudes to water are changing, with citizens willing to save water when public authorities demonstrate that they are fixing leaks, spending money wisely and ensuring that bills are affordable.

ECONOMIC GROWTH AND DEVELOPMENT

To feed, house and care for an ever-increasing and ageing population suggests that the world economy will need to continue to grow rapidly to keep pace, adding to the demand for water and energy and, where unregulated, contributing to increased pollution and diminution of natural water sources.

THE ENVIRONMENT

The effects of climate change are now clear, with extreme weather events, increased risks of flooding, droughts and water stress. Groundwater is the most extracted raw material in the world – and supplies are dwindling. Feeding a growing population requires more water and energy for food production and transportation, at a time when reducing carbon emissions is essential to meet tougher environmental standards and slow down climate change.

UTILITY BUSINESSES

Ageing infrastructure must be replaced and maintained. Economic and regulatory pressures, and the need to keep bills affordable, means that investment in infrastructure is tightly controlled. Innovation and the embracing of new technology is now at the heart of business planning and will play a central role in achieving water reuse and recycling targets, reducing energy demands and delivering more efficient and longer-lasting infrastructure.

66%

OF THE WORLD'S POPULATION
WILL BE LIVING IN URBAN
AREAS BY 2050

33%

OF THE WORLD'S
POPULATION LIVE IN
WATER-STRESSED AREAS

10%

OF THE WORLD'S POPULATION
LIVE IN LOW-ELEVATION
COSTAL ZONES

06

WHAT ARE THE OPPORTUNITIES IN THE UK AND OVERSEAS?

The UK water industry has demonstrated its capability in identifying solutions to a range of complex challenges and delivering cost-effective robust solutions throughout the world. This is supported by highly innovative organisations of all sizes and areas of expertise, supported by expertise in negotiating reliable and fair commercial contract arrangements.

The UK supply chain and supporting infrastructure, extensive market, world leading delivery system and a robust regulatory framework have enabled the UK to be a world leader in the global response to the need to plan for and deliver all aspects of water resilience.

The water supply chain is adaptive and robust, comprising specialist technology provision and capabilities in the delivery of tailored and integrated consultancy services.

This section highlights the size of the opportunity for UK innovators, organisations, the academic community and the support infrastructure provided by Government and its agencies in delivering water resilience solutions in the UK and overseas.

“Water resilience comprises the ability to cope with and recover from shocks and stresses, disruption and uncertainty, thereby maintaining essential services and protecting the environment both now and into the future.

Resilience has always been recognised as a priority for the UK and industry has responded by delivering first class solutions and performance.

The UK water sector and supporting organisations have continued to innovate and evolve, ensuring the industry is ready for current and future challenges.

These challenges are shared globally: urbanisation, population growth, aging infrastructure, climate change – with all nations having a desire to look for more sustainable and resilient solutions.

This paper discusses explores how UK expertise can deliver sustainable solutions in the water sector.

The UK government is taking the lead in tackling climate change, not least as hosts of COP26 in Glasgow. So, I am pleased to support the work of the UK Water Partnership and its various partner organisations and companies, in its ongoing efforts to promote UK capability in Water Resilience.

Sustainable Infrastructure is a key priority not just for the UK Government but for governments around the globe. This work will help DIT and other parts of UK government in our ongoing trade and investment conversations.”

Rodney Berkeley

Director for Manufacturing, Energy and Infrastructure
Department for International Trade

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WHAT IS THE UK'S EXPERTISE?

The UK has a wealth of expertise which is already exported around the world. We found evidence of research, consultancy, products and skills in most countries on the planet from Afghanistan to Zimbabwe. In this section we set out the key areas of that expertise, and then we provide more information in the case studies in Section 8. The UK has responded to the need to consider water as part of a 'systems of systems' and creating the means to diagnose urban water resilience.

WATER

The UK has a history of planning water supplies. In spite of what is perceived as a 'wet' climate, the high population density and environmental requirements mean that water resource planning has been a strong theme. We are recognised experts in areas such as water supply assessment (hydrology and hydrogeology), and have developed tools to assess water supply resilience from drought, climate change and other risks (such as asset failure). These approaches, often modified for specific conditions, have been exported around the world. We are using the latest techniques to develop new approaches using information like earth observation data to advance these approaches.



WASTEWATER

Key areas of focus of the UK wastewater sector are on process improvements and asset reliability. Our experts provide advice on the design of wastewater networks, treatment works and management and re-use of waste products. Water companies, consultants and suppliers have focussed on developing solutions to wastewater which are resilient to climate change and are economic to operate. Research into issues such as microplastics, chemicals in wastewater and reducing energy requirements are emerging themes. We have seen how expertise in planning wastewater treatment processes and assets that are resilient to flooding is a particular strength.



FLOODING

The UK has a strong background in flood risk assessment, adaptation and control. There is particular expertise in understanding the risks of dam breach, climate and weather on flooding, and then turning these risk assessments into operational tools to manage those risks.

As well as helping design defences for some of the world's largest cities, the UK has developed a large range of products to reduce flood risks at an individual property scale and we have developed flood warning systems to alert those at risk.

SYSTEMS THINKING

It is inefficient to think of water supply, wastewater and flooding as separate issues – instead they need to be considered together to ensure that firstly no harm is done and secondly to maximise the opportunities available. For instance in the UK now our water resources planning processes consider “best value” rather than least cost, so that plans which improve wastewater or flood resilience can be incorporated into strategic water resource planning.

This joined up approach to water supply, wastewater and flooding is now being exported to areas like the Caribbean.

PRODUCTS & SERVICES

The UK's expertise includes some of the world's greatest research organisations, including those leading the research on the impacts of climate change.

Our consultancy experts work on projects throughout the world, providing this insight into how to improve water supply, wastewater and flooding as an integrated offering; whilst our contractors and manufacturers build and produce some of the world's most advanced processes and equipment. This is all underpinned by a range of legal, financial and insurance services, which support this work, providing governance and security.

NEXT STEPS

Water resilience is a broad and developing field of study. With this in mind, we will continue to review and update this document to capture existing and emerging knowledge, experience and expertise.

The activities set out below will guide the UK Water Partnership's efforts regarding the dissemination of this document and future focus on resilience.

- 1 Continue to harvest case studies through the UKWP Capabilities Directory, gathering further evidence to fill in any capability 'gaps'.
- 2 Review and update this document on a regular basis in line with existing and emerging UK capability, areas of expertise and target markets.
- 3 Disseminate this report and subsequent versions via the Department for International Trade channels and overseas posts.
- 4 Showcase UK expertise at international events and conferences including UN Climate Change Conference of the Parties (COP) and other international stages..
- 5 Convene a UK Resilience Forum to engage on international opportunities where the UK can provide solutions. This might involve active engagement with governments, utilities and other organisations through relationships with DIT colleagues overseas.

THE BENEFITS OF BEING A MEMBER OF THE UK WATER PARTNERSHIP

The UK Water Partnership was established in 2015 to provide a strategic vision for the development and growth of the UK water industry. It brings together a wide cross section of UK water sector stakeholders in a single coherent alliance to support research excellence, promote collaborative innovation and secure the UK a greater share of the \$500 billion global water market.

Joining the UK Water Partnership gives you the opportunity to increase your influence, visibility and access to cutting edge research and innovation in the UK water sector, which will help you to grow your organisation and reduce business risk.

OUR MEMBERS:

- work directly with government departments, engaging with officials and Ministers, to shape the government's priorities for research, innovation and capability in the water economy and to promote increased commercialisation both here and overseas
- access new insights and strategic networks – for businesses this means scientific and technical information and capability, while for the academic community, connections to a wide end-user community which will help accelerate the uptake and impact of research
- help to shape the debate and the way forward, in partnership with other stakeholders, through involvement in activities and events, and collaborations with fellow members
- raise their profile through participation on our website, facilities register, newsletter features, logo placement in UK Water Partnership literature, and invitations to events

Members of the UK Water Partnership have the opportunity to participate in one or more of our strategic Delivery Groups, which are driving transformative change in the UK water industry. In addition to Water Resilience, the partnership has recently focused on:

- **Digital Water** – The UK Water Partnership launched an action plan to help UK plc win its share of the \$30 billion digital revolution in water.
- **Flood Resilience** – promoting a high quality, UK-wide flood Resilience industry and providing a unique forum to help tackle one of today's biggest natural threats
- **LITSoN (Linking innovation to societal needs)** – creating a single source of data on innovation activity in the UK and using this to create solutions for societal needs
- **Net Zero** – UKWP is committed to set out a simple but compelling explanation of the importance for society of Net Zero being achieved.
- **Circular Water Economy** – Capturing circular water solutions, showcasing UK capability, and identifying opportunities to embed circular economy thinking at the heart of the water cycle.
- **Capabilities Directory** – The UK Water Partnership has worked in partnership with the Department for International Trade to develop a UK water Capabilities Directory. This will be used to help UK-based organisations improve their access to UK and international markets.
- **Water Accelerator** – connecting innovation activity in the UK to accelerate the development and implementation of new technology in the water sector.

OUR FOCUS:

Our Delivery Groups strive to:

- promote applied research excellence
- improve the ability to model and simulate urban water systems
- facilitate and accelerate the route to market for innovations in the water sector
- encourage research and testing capability in the UK
- drive engagement with Government, BEIS and the Industrial Strategy Challenge Fund
- improve the alignment of UK innovation with the UK water industry
- identify how global needs link to UK expertise
- develop the UK offer on flood resilience.

HOW WE ARE FINANCED

The UK Water Partnership is a public-private not-for-profit company limited by guarantee with its operations funded by financial contributions from its members.

Private sector contributions are used to carry out core operational activities such as administration, marketing and promotion, as well as planning and hosting events that help promote the UK water economy both at home and overseas.

The Partnership is indebted to its members, not just for their continued financial support, but also for their substantial gifts of time and for their willingness to co-design our emerging products and services.

CONTACT

For more details go to:

www.theukwaterpartnership.org/join-us

Contact our Director for Resilience:

hans.jensen@theukwaterpartnership.org

Or email us at:

info@theukwaterpartnership.org

SUPPORTERS OF THE UK WATER PARTNERSHIP

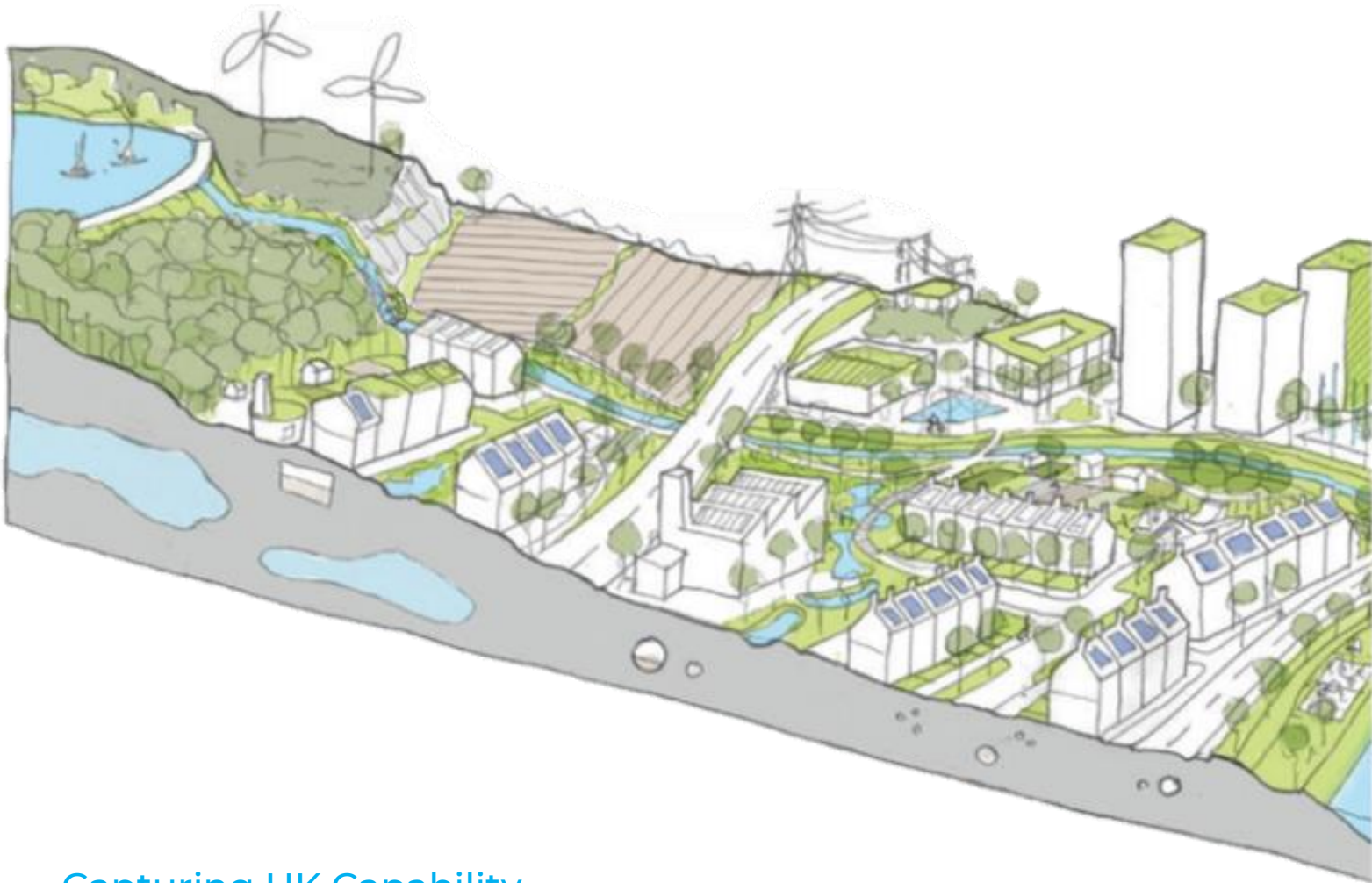
The grid of logos includes the following entities:

- The University of Sheffield
- HR Wallingford (Working with water)
- ARUP
- Knowledge Transfer Network
- COSTAIN
- aiimi
- Water Innovation & Research Centre
- UNIVERSITY OF BATH
- MOTT MACDONALD
- water industry forum
- UK Centre for Ecology & Hydrology
- UNIVERSITY OF STIRLING
- UKWIR
- Future Water Association (Informing, Innovating, Influencing)
- WSP
- Scottish Water (Always Serving Scotland)
- Interreg North-West Europe Water Test Network
- UKWIR
- UCL
- WATER INFORMATICS SCIENCE & ENGINEERING (EPSRC CENTRE FOR DOCTORAL TRAINING)
- HYDRO-NATION WATER INNOVATION SERVICE
- TWENTY65 (Tailored Water Solutions for Positive Impact)
- Scottish Government (Riaghaltas na h-Alba gov.scot)
- Environment Agency
- Department for Environment Food & Rural Affairs
- Natural Environment Research Council
- love every drop. angliaWater
- IMGeospatial
- UKRI Science and Technology Facilities Council
- BRITISH WATER
- Department for International Trade
- UKRI Engineering and Physical Sciences Research Council
- Sainsbury's
- Innovate UK
- ENVISAGER

UK CAPABILITY

A collection of case studies which illustrate the UK's breadth and depth of capability across the field of water resilience

UK CAPABILITY & CASE STUDIES



Capturing UK Capability

This section of the paper captures a selection of case studies demonstrating UK capability across the field of Water Resilience. These case studies have been categorised by service offering (e.g. research, advisory, design, build, operate), capability readiness (whether is is an existing, emerging or future capability), and the type of solution being provided.

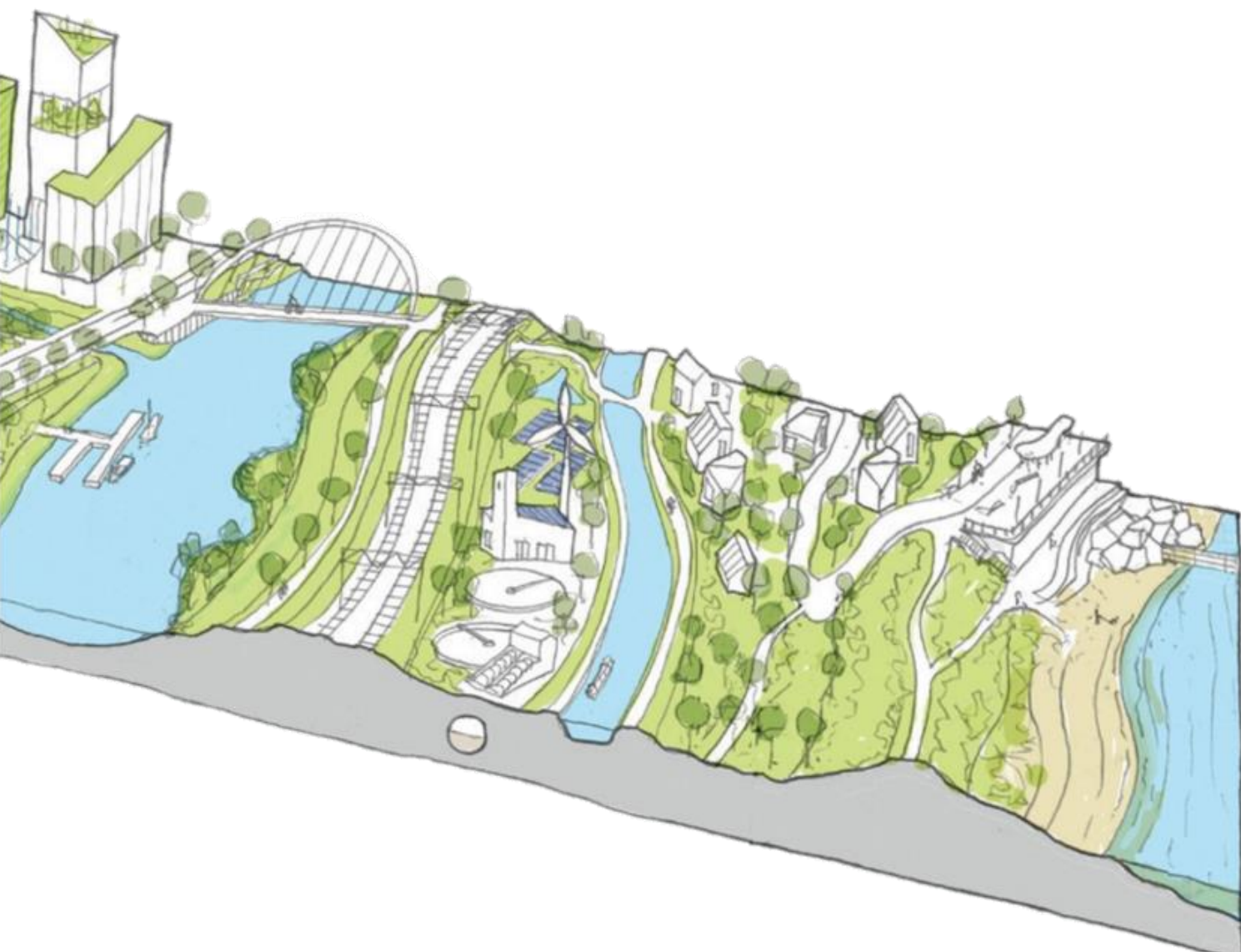
Updates to Water Resilience Case Studies

This is a live document that will be reviewed and updated at regular intervals to capture both existing and emerging capability.

To have case studies considered for inclusion in future updates, please submit case studies via the UKWP Capabilities Directory:

UK Capabilities Directory

www.theukwaterpartnership.org/initiatives/capabilities-directory



City Water Resilience Approach

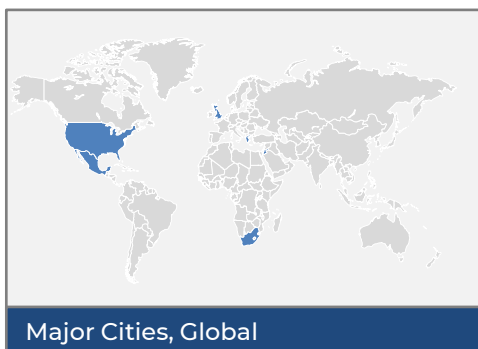
Organisation(s)

Arup & Stockholm International Water Institute (SIWI)

Client(s)

Government Departments, City Councils, Utility Companies

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

A changing climate coupled with rapid urbanisation has resulted in unpredictable rainfall, flooding, droughts and other water-related shocks and stresses on cities. With over 2 billion new urban citizens anticipated by 2050, cities increasingly recognise the need for better understanding of the water-related risks, and for tools that help prioritise action and investments to become more resilient. Across the world, decision makers are focusing on the central role water plays in the life of cities. Arup and the Stockholm International Water Institute (SIWI) developed the City Water Resilience Approach (CWRA) to help cities understand the risks they face, and improve the way they plan, manage and maintain their water system.

Using the approach

Funded by The Resilience Shift and the Rockefeller Foundation, the CWRA builds on the City Resilience Index, bringing the same forensic research methodology to the issue of water for the first time. It's a five-step approach, which starts by engaging stakeholders and understanding how the underlying water basin is comprised. We then assess current resilience: could the city withstand enduring drought, sudden flooding, further urban development or other local risks? Steps three, four and five plan the actions that will improve water resilience, develop relevant local adaptations and put monitoring in place. Cities as diverse as Cape Town, Mexico City, Miami, Amman, Thessaloniki, Manchester, Rotterdam and Hull have helped us to develop this approach to improve their own understanding and management of water. Seven of the eight cities are part of 100 Resilient Cities – Pioneered by The Rockefeller Foundation (100RC), which helps cities around the world become more resilient in the face of physical, social and economic challenges.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm		rivers and waterways
asset management	smart infrastructure	coasts

For more information

Email	martin.shouler@arup.com
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Company profiles

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. From 90 offices in 35 countries, their 10,000 planners, designers, engineers and consultants deliver innovative projects across the world with creativity and passion. The successful design, development and maintenance of our water infrastructure requires the integration of many disciplines.

Arup's water team has wide-ranging skills spanning advisory and specialist technical services. We apply them on every kind of project, from flood risk management and water resource planning, to dam engineering, treatment works design and river engineering.

Stockholm International Water Institute (SIWI) is a Stockholm-based policy institute that generates knowledge and guides decision-making towards water wise decisions.

Founded in 1991, SIWI performs research, builds institutional capacity and provides advisory services in five thematic areas: water governance, transboundary water management, water and climate change, the water-energy-food nexus, and water economics.

Asian Cities Climate Change Resilience Network, The Rockefeller Foundation

Organisation(s)

SIWI and Arup

Client(s)

Various

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Arup supported the Rockefeller Foundation's Asian Cities Climate Change Resilience Network (ACCCRN) programme to build climate change resilience in over 20 small and medium Asian cities. Arup developed a strategy to define a decision-making process supporting the selection of credible projects and criteria for a USD\$20m intervention fund for city level resilience building projects.

Arup's efforts were directed to initiate and sustain action on climate change resilience in target cities based on previous learnings from ACCCRN. This is being achieved by capturing, transferring and operationalising knowledge in order to create institutional capacity and influence policy-making within the target cities and amongst regional and local partners in India and Indonesia. This also helped develop partnerships intended to endure beyond the timeframe of the programme.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

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Email	martin.shouler@arup.com
Phone	+44 20 7755 3598
Website	www.arup.com/perspectives/how-can-we-build-more-water-resilient-cities



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Arup's water team has wide-ranging skills spanning advisory and specialist technical services. We apply them on every kind of project, from flood risk management and water resource planning, to dam engineering, treatment works design and river engineering.

Resilience Infrastructure Planning Tool for Secondary Cities in Ghana

Organisation(s)

Arup

Client(s)

Government of Ghana and World Bank

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Our work enabled The World Bank and the Government of Ghana to devise and support infrastructure investments in secondary cities of Ghana. These investments need to be resilient to shocks and chronic stresses induced by multiple sources including climate, both now and in the future.

A practical tool was developed to plan and monitor the resilience of infrastructure investments.

The objectives were:

- To increase the understanding of urban resilience baseline in Ghanaian secondary cities, by establishing a basis for future comparison informed by primary and secondary data; and
- To equip the Municipal Assemblies (MA) with tool(s) to better plan, design build and operate and maintain resilient infrastructure with a focus on selected core urban infrastructure investments;
- The infrastructure assessed included: (i) storm water drainage (urban drainage systems and flood control systems); (ii) solid waste management[]; (iii) urban markets (site planning and surface water management).

This tool is to be used and reviewed throughout the lifecycle of the development of programmes and projects within the Government of Ghana.

By using the tool, an action plan of agreed tasks can be developed to complete the activities set out in the tool and improve the resilience of the infrastructure being proposed.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

For more information

Email	inigo.ruiz-apilanez@arup.com
Phone	
Website	



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African Cities Programme

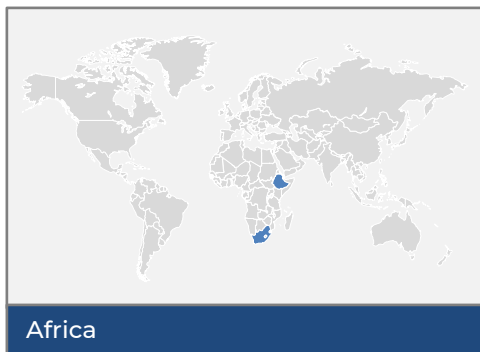
Organisation(s)

Arup

Client(s)

World Resource Institute

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Arup partnered with the World Resources Institute (WRI) and Resilient Cities Network (RCN) to jointly develop a programme for developing Urban Water resilience in six African cities in close partnership with city leaders and stakeholders. The programme uses the CWRA and aims to help city stakeholders to better design holistic interventions to address their water risks and vulnerabilities.

The cities chosen have included three primary and three secondary cities, with works currently under way in Addis Ababa, Ethiopia and Kigali, Rwanda and work to begin Dire Dawa, Ethiopia, Musanze, Rwanda, Gqeberha (formerly Port Elizabeth), South Africa and Pretoria, South Africa.

Addis Ababa, Ethiopia's capital, is the first city to take part in the WRI African Cities Programme. Due to COVID, we pivoted to a hybrid virtual and in-person stakeholder workshops. These gathered subject matter experts from government, academia, civil society and the private sector to engage in round-table discussion on Addis Ababa's water resilience challenges. Ten opportunities that address challenges are being pursued based on the multi-stakeholder design exercises.

The workshops identified blue-green infrastructure as an engineering opportunity to respond to water risks and vulnerabilities without traditional engineering solutions.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	nature based solutions

For more information

Email	
Phone	
Website	



Company profiles

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. From 90 offices in 35 countries, their 10,000 planners, designers, engineers and consultants deliver innovative projects across the world with creativity and passion. The successful design, development and maintenance of our water infrastructure requires the integration of many disciplines.

Arup's water team has wide-ranging skills spanning advisory and specialist technical services. We apply them on every kind of project, from flood risk management and water resource planning, to dam engineering, treatment works design and river engineering.

Non Revenue Water Practices

Organisation(s)

Water Research Centre Ltd

Client(s)

Water Utility, Brazil

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Our client had an ambition to be Brazil's most operationally efficient water company, and therefore a focus on non-revenue water (NRW) was critical. The company had commenced a programme of sectorisation to allow detailed monitoring to aid NRW assessment.

A team from Water Research Centre (WRC) undertook a review of four important aspects:

- Construction of the **water balance**, which compares the water supplied to a network with the consumed, or otherwise used to **determine real losses** (leakage).
- **Customer metering**, which is essential in understanding the water actually consumed within the water balance and the income to the company.
- A **hydraulic model** of the main supply loop to the client's water supply network.
- **Active leakage control techniques** and their deployment in a low pressure network.

Work undertaken included in-field review of ALC practices, as well as a review of the water balance in line with best practice. The team independently estimated meter uncertainties and provided recommendation on incorporation of these into the real losses (leakage) estimation process.

Key recommendations included altering flow measurement technology to improve sensitivity at low flows hence improving the water balance and **increasing revenue**, as well for physical validation of the hydraulic modelling to enhance it's value for understanding operation of the complex network and, hence, support reduction in water losses.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

For more information

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Company profile

WRc is a Centre of Excellence for Innovation and Growth, our journey started in 1927 as the Water Pollution Research board for the government and is now a private organisation based in the UK and part of the RSK Group since 2020. We have decades of experience collaborating, sharing knowledge and delivering transformative solutions to clients across the globe.

We operate across different sectors including Water, Environment, Gas, Industrial and Resource Management. Our clients include regulators, water and gas utility companies, governmental organisations, NGOs, trade organisations, industrial manufacturers and waste management companies.

Our services can be summarised as:

- **Innovation** – we support research and development both for individual companies and in collaboration with multiple parties. These services help our clients meet future needs of the industries in which we operate.
- **Consultancy** – helping clients implement best practice, applying cutting edge techniques to deliver on KPIs and performance targets. Our teams support end-to-end processes and work with clients through to realisation of benefit and beyond.
- **Service delivery** – delivering efficiency operation for our client's businesses. From in-pipe surveys to waste characterisation analysis, the results delivered are trusted by regulators, companies and the supply chain to be credible and robust.
- **Knowledge transfer** – whether formally through provision of training courses, or informally through collaborative project delivery.

Development of a Water Quality Monitoring Programme

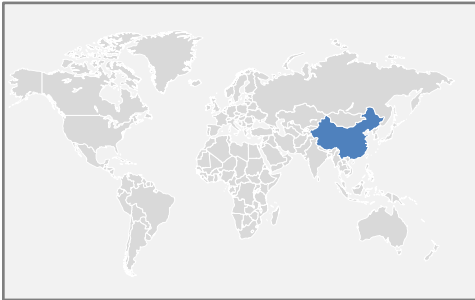
Organisation(s)

Water Research Centre Ltd

Client(s)

Governmental Water Department, Asia

Location



Asia

Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Our client was responsible for sourcing, treating and distributing potable water to consumers. They regularly monitored drinking water quality and compared the results with guideline values established for some of the health related parameters recommended by the World Health Organisation (WHO) guidelines for drinking water quality, and their own treated water quality objectives for treatment works final water.

The team of water quality scientists (comprising treatment and toxicology specialists) were asked to develop and recommend a monitoring programme, including sampling protocols, for water quality parameters. This would be developed as part of a robust and transparent framework that would allow for improved efficiency through reduced monitoring frequency, and selecting new parameters for monitoring.

WRC reviewed approaches taken by a number of jurisdictions and developed a strategy that was consistent with good international practice. Guidance was provided on the frequency and location of monitoring for around 30 chemical, microbiological and aesthetic parameters.

The programme included extensive operational detail, including for instance aspects such as monitoring location and frequency; sample point selection; sample point preparation and pre-sampling requirements; sample container type, volume and preservative; and sampling bottle filling.

The implementation of these provisions enabled our client to reliably demonstrate the quality of their drinking water supplies.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
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Working with Nature to Protect our Water

Organisation(s)

University of Exeter, Natural Environment Research Council (NERC)

Client(s)

South West Water (SWW)

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

NERC scientists at the University of Exeter have been working with South West Water plc since 2006 to transform the way that upstream water catchments (including moorland reservoirs and lakes) are managed. The results are already improving water quality, reducing water treatment costs and enhancing natural habitats. The outcomes have been so positive that further significant investment has been secured to ensure the work continues.

Upland catchment areas, for example on Exmoor and Dartmoor, have been degraded for centuries – reducing their water-holding capacity, and increasing the risk of flooding after heavy storms. Building new reservoirs is often unfeasible, so water companies must look at better management of existing catchments to ensure the continued quality and quantity of water they provide.

Removing pollutants such as peat or pesticides from drinking water is one of SWW's biggest challenges. The company wanted to explore the idea of reducing these pollutants at source to reduce costly water treatment processes and to enhance the downstream water quality – but the industry regulator Ofwat would only approve investment in better catchment management if its benefits were scientifically proven.

Professor Richard Brazier, an expert in hydrology, soil erosion and water quality, was asked by SWW in 2006 to advise on a 326 ha pilot project to restore moorland on Exmoor. Its success led to the co-designed £4.5m Mires-on-the-Moors project, restoring 2000 ha of peatland between 2010-15 and forming a key part of SWW's flagship and award-winning Upstream Thinking programme. Professor Brazier's team of NERC-funded scientists carried out detailed analysis that demonstrated the environmental and economic benefits of the scheme, providing the evidence base for approval by Ofwat of future catchment management investment.

Under the NERC-funded SWEEP programme, scientists have worked since 2017 with SWW to develop a Whole Catchment Water Management Plan for the entire south west region, which has underpinned the water resilience theme of the company's 2020-2025 Business Plan. In 2019, Ofwat gave this plan fast-track approval, stating that it 'set a new standard for the sector'.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

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Company profiles

NERC - the Natural Environment Research Council - is the driving force of investment in environmental science in the UK. NERC advances the frontier of environmental science by commissioning new research, infrastructure and training that delivers valuable scientific breakthroughs. We do this because understanding our changing planet is vital for our wellbeing and economic prosperity.

We invest public money in world-leading science, designed to help us sustain and benefit from our natural resources, predict and respond to natural hazards and understand environmental change. We work closely with policymakers and industry to make sure our knowledge can support sustainable economic growth and wellbeing in the UK and around the world.

NERC is part of UK Research & Innovation- external link ([UKRI](#)), a new body which works in partnership with universities, research organisations, businesses, charities and government to create the best possible environment for research and innovation to flourish. UKRI aims to maximise the contribution of each of its component parts, working individually and collectively. We work with our many partners to benefit everyone through knowledge, talent and ideas.



Gravity Sewer Inspection and Condition Assessment

Organisation(s)

Downley Consultants Ltd

Client(s)

Asian Development Bank
Colombo Municipal Council (CMC)

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

The Greater Colombo Wastewater Management Project (GCWMP) is a multi-year programme to survey, inspect, assess and renovate over 500km of sewers in Colombo, the capital city of Sri Lanka. Many of the sewers are more than 100 years old and their management is a key element of the public health of this city of over 750,000 people.

The first phase of the programme covers approx. 125km of collector and interceptor sewers, including some rising main and siphon sections, in the oldest areas of the city.

Downley Consultants Ltd was engaged by the Asian Development Bank to review selected parts of the CCTV inspection output on behalf of the Client, CMC, and to make recommendations on repair and rehabilitation of the sewers.

In addition we provided training for the Client's team in condition assessment and in rehabilitation of rising mains to enable them to plan future phases of the programme.

The detailed services included:

- Review selected CCTV inspection output data
- Undertake condition assessment and make recommendations on repair and rehabilitation
- Provide training to Client's project team in condition assessment and rehabilitation
- Advise on inspection of rising mains for future contracts.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

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Company profiles

Downley Consultants Ltd is a privately-owned engineering consultancy established in 1992 to provide Clients worldwide with specialist expertise in underground pipe network asset management. Asset owners and operators across the world face challenges in the management and operation of ageing network assets, many well beyond their design life yet still critical to the lives and health of many million people or to the safe operation of industry. In addition they must manage the environmental risks associated with the performance of these assets and manage the scarce and precious resource of clean drinking water.

Downley Consultants' team of highly experienced professional specialist engineers supports our Clients in managing their network assets through audit, inspection, expert condition and performance assessment, risk assessment and development of asset management plans for operation, investment, renovation and rehabilitation of network assets to achieve their required performance levels safely, cost-effectively, and at minimum operational, financial, community and environmental risk.

Over almost 30 years we have solved problems for Clients across many sectors:

- Potable Water Distribution and Transmission
- Raw Water Distribution and Transmission
- Cooling and Process Water
- Fire Mains
- Non-Revenue Water Reduction
- Gas Distribution and Transmission
- Oil Transport Pipelines
- Oilfield Water Return Pipelines
- Sewerage and Wastewater Systems
- Rising/Force Mains
- Manholes and Lateral Connections
- Treated Sewer Effluent
- Industrial Process Effluent
- District Heating & Cooling
- Slurry Pipelines

Mitigating the Impacts of Climate Change in West Africa

Organisation(s)

UK Centre for Ecology and Hydrology

Client(s)

Future Climate for Africa
(funded by UK FCDO and UKRI-NERC)

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

In the Sahel region of West Africa, monsoon rains are vital for agriculture and pastoralism, but they can also cause harm by flooding, particularly in urban areas. Climate change is predicted to affect the amounts, intensity, duration, timing and location of these rains. The region is home to 90 million people, projected to rise to 220 million in 2050. Understanding of the likely negative impacts of these changes is required to inform policy and support resilient communities.

Starting in the 1990s, UKCEH research has highlighted the importance of the land surface in driving Sahelian climate. Our research showed that variations in soil moisture from previous rain strongly influences where new storms develop and intensify. We extended this observational analysis globally and found that afternoon storms tend to develop over drier soils. This highlighted an important weakness in global weather and climate models, which in contrast to reality, preferentially simulate rain over wetter surfaces. In recent work, we identified that across the Sahel, the most intense, flood-producing storms have tripled in frequency since the 1980s in response to global warming.

Through the AMMA2050 research programme, UKCEH has worked with government departments and NGOs in Senegal and Burkina Faso, translating climate information into policy. In Burkina Faso, the government is revising its development plans for the capital, Ouagadougou, according to updated inundation mapping from intense storms. In Senegal our staff worked to build in-country capacity and the programme was described by one government representative as 'achieving more understanding in one workshop than I have achieved in 20 years'.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm		rivers and waterways
asset management	smart infrastructure	coasts

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Company profiles

The UK Centre for Ecology & Hydrology is an independent, not-for-profit research institute carrying out excellent environmental science with impact. Our 500 scientists work to understand the environment, how it sustains life, and the human impact on it. We provide the data and insights that governments, businesses and researchers need to create a productive, resilient and healthy environment. Scientific curiosity, integrity and transparency are at the heart of how we work.

Our research extends from molecular biology to global climate modelling, and we carry out fieldwork across the world, from the semi-arid West African Sahel to the rainforests of South East Asia. Our focus is on mitigating and building resilience to climate change, preventing and reducing pollution, and creating sustainable ecosystems.

We believe that the best solutions are co-designed and co-delivered, and our partnerships cross borders, sectors and disciplines. We are a strategic delivery partner for the Natural Environment Research Council, part of UK Research and Innovation.

Estimating flood frequency in Maharashtra State, India

Organisation(s)

UK Centre for Ecology and Hydrology

Client(s)

UKRI-NERC National Capability

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

India's high risk and vulnerability to flooding are highlighted by the fact that about 12% of its total area of 3.29 million km² is prone to floods, with 75,000 km² affected every year. In 2020 alone, heavy rainfall and flood-related incidents claimed over 600 lives from different parts of the country during the pre-monsoon, monsoon and post-monsoon seasons, including 50 lives lost in the state of Maharashtra.

The standard approach to flood prediction in India is to apply regional equations based on catchment area and other basic characteristics of the river basin derived from a limited number of gauging stations. As a result, not all hydrological regions have specific estimation equations associated with them.

UKCEH has worked with partners in Maharashtra State to apply some of the principles of Flood Estimation Handbook principles to Indian catchments so that spatially consistent estimates such as the 50-year flood can be derived for any point on the river network. Our research shows that it is feasible to derive spatially consistent design flood estimates from applying both statistical and modelling approaches in major river catchments.

Based on the results of this study, we have developed a web application to enable users in academia, industry and policy to explore trends in recorded data and provides downloadable statistics to compare with the flood frequency curve. The application makes use of open-source global datasets that complement those used in the FEH methodology and is currently being trialled by stakeholders in the Maharashtra region.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

For more information

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UK Centre for Ecology & Hydrology

SUNRISE Flood Frequency Estimation App



FLOOD FREQUENCY TRENDS ABOUT

Overlay options

Choose how to pick a station based on where you click:

- Geographical Distance
- Nearest Downstream Station

Choose which probability distribution to choose to fit a flood frequency curve:

- Generalised Pareto
- Pearson Type III
- Both

Manual input of coordinates

Degrees East:

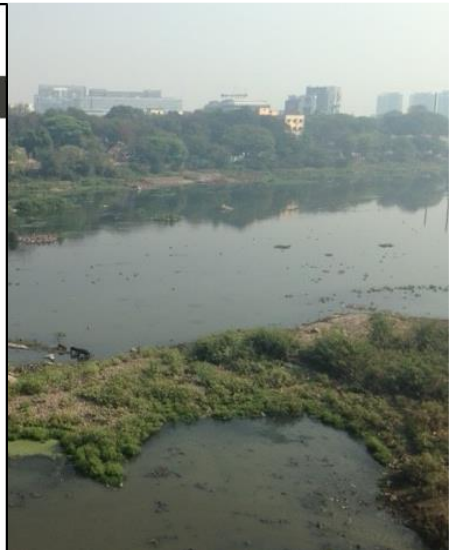
79.79

Degrees North:

19.68

GO TO LOCATION

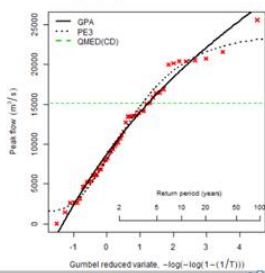
To move the view, drag the map. To zoom, double-click on the map or use your scroll wheel. Click a point of interest to select it.



Estimates and Predictors

Field	Value
Clicked Location:	19.68 N 79.79 E
Nearest station:	Ashti
QMED from Catchment	15137.351 m ³ /s
Descriptors:	
Area:	51579 km ²
AAR:	1441 mm
Mean Aspect:	304.07 deg clockwise from North
Mean soil permeability:	1.56
Mean channel length:	339 km

Flood Frequency Curve



T-year events

Return Period (years)	Flow, m ³ /s (GPA)	Flow, m ³ /s (PE3)
2	10676.71	10768.76
5	17291.93	16256.84
10	19972.51	19356.58
20	21549.99	22038.75
50	22686.63	25192.02
100	23147.20	27374.37

DOWNLOAD GRAPH AS PDF

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SUNRISE



Company profiles

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State-wide Water System Masterplan

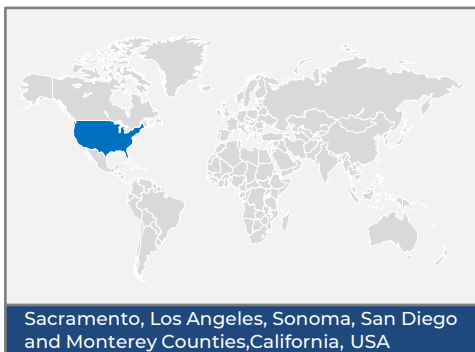
Organisation(s)

Mott MacDonald

Client(s)

California American Water

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

California American Water (CAW) provides water and wastewater services to nearly 700,000 Californians in 48 communities. CAW selected us to provide master planning and capital improvements programme consultancy to ensure the increasing water demands of its customers are met well into the future.

We collated information on the capacity, reliability, condition, water quality and potential expansion of CAW's water systems through site visits and interviews with CAW personnel, hydraulic modelling, buried infrastructure assessments, and by compiling an asset inventory in a GIS database. Next, we produced customer and demand projections, estimated water availability, reviewed the trends of raw water quality parameters, and conducted a water balance analysis of each system to identify deficits based on the required level of service. Our specialists also developed a new planning document, called a condition-based assessment (CBA), which applies industry-accepted asset management principles and GIS as a visualisation and analysis tool to identify and prioritise water mains needing renewal.

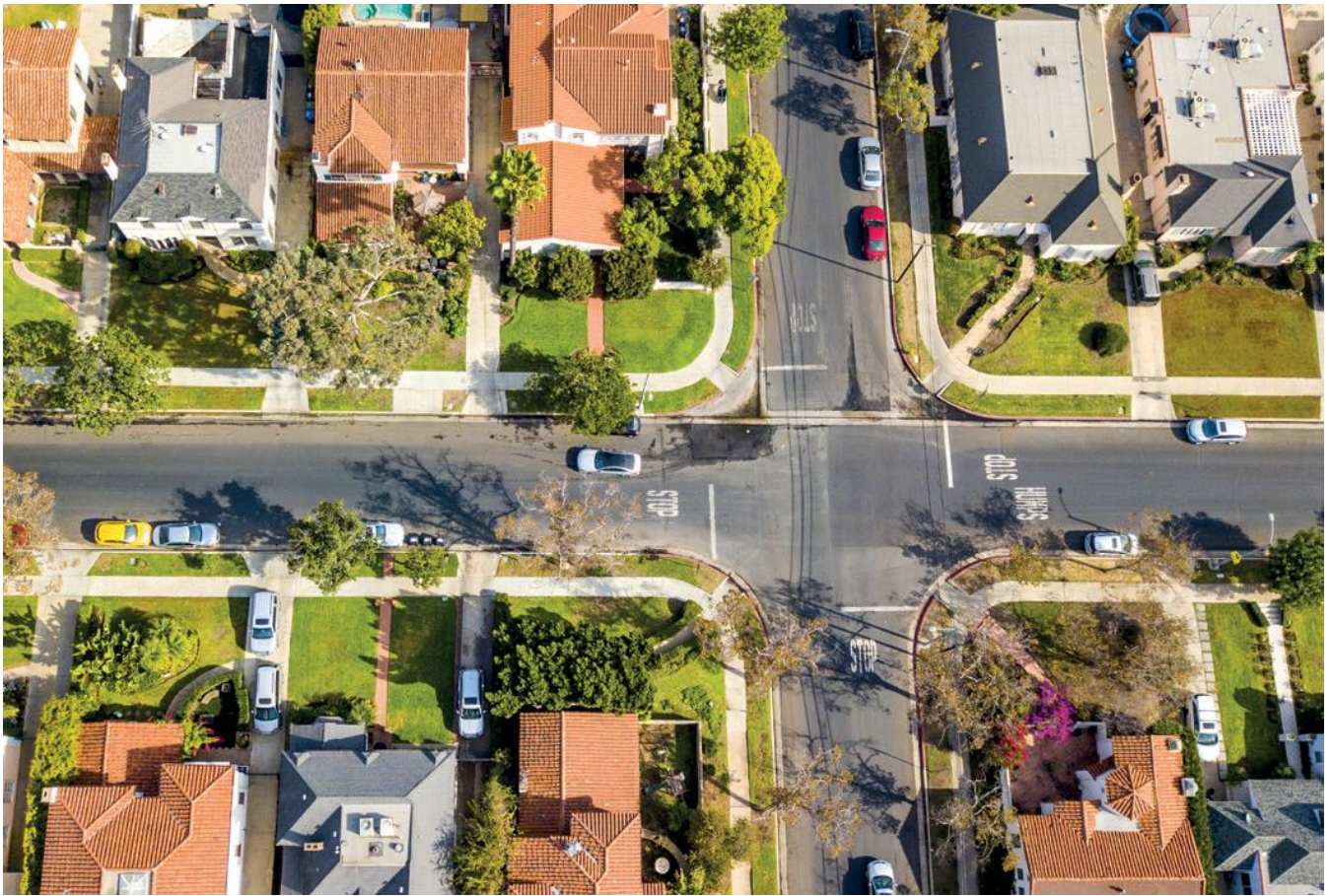
Our analysis and CBA tool will help CAW maintain its infrastructure to deliver clean, safe, reliable and affordable water and wastewater services, and follow strict local authority regulations and federal standards set by the United States Environmental Protection Agency. We worked closely with CAW to identify investments required to address immediate concerns, and then masterplan a list of prioritised, cost-effective short and long-term capital improvements of supply, treatment, production, distribution and storage assets. This investment programme will help to sustain adequate service levels for customers for up to 5 years.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

For more information

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Company profiles

Mott MacDonald is global engineering, management and development consultancy focused on guiding our clients through many of the planet's most intricate challenges. Improvement is at the heart of what we offer: better economic development, better social and environmental outcomes, better businesses, and a better return on investment. Our engineers, project and programme managers have taken lead roles in the world's highest profile infrastructure and development projects. Yet design and management are just the tip of a deep iceberg. Our clients have access to the vast knowledge of internationally recognised environmentalists, planners, economists, project finance advisors, cost consultants, business strategists and more.

We deliver projects across the three core areas of integrated water resources management: safeguarding water supplies, managing risk to water assets, and balancing the needs of the environment. Our teams can help you make critical decisions about how to increase access of clean water across the globe by providing accurate, timely data to calculate the amount of water resources available and forecast demand. We develop efficient, comprehensive solutions to allocate resources in the most effective way – avoiding any adverse environmental effects.

Climate change poses an increasing threat to global social and economic infrastructure. Our unique skills set and experience equip us to assist in managing them. We advise on policy, identify measures to mitigate climate impacts and guide adaptation to achieve asset and service resilience. We are leading the development of climate resilience by finding innovative solutions and sources of investment. We help our clients build long-term resilience and respond to climate extremes by bridging sector gaps and equipping communities, businesses and institutions with the awareness, knowledge and capacity to prepare for the impacts of climate change.

Improving irrigation and hydropower generation

Organisation(s)
Mott MacDonald

Client(s)
Statkraft

Location



Kargi, Turkey

Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

The Kargi run-of-river hydropower plant on the Kizilirmak River in northern Turkey is a key contributor to the national grid with an installed capacity of 102MW. As well as diverting water for hydropower generation, the reservoir is required to release flows for irrigation. These flows are regulated but, if requested by farmers, additional waters may be released, decreasing the dam's potential generation capacity. The dam's operator needed to determine whether improving the efficiency of how water is used for irrigation could maintain flow releases at current regulated levels, or even reduce them, while ensuring sufficient water supplies for the area's agricultural sector and the river.

We investigated if upgrades to existing infrastructure and better water management techniques could reduce water release requirements. This involved undertaking an initial scoping exercise to identify studies that might be undertaken to quantify irrigation demands downstream of the hydropower intake and evaluate potential interventions to limit irrigation releases. We were commissioned to undertake further studies including on-site verification and mapping to identify the irrigation areas more precisely, along with cropping patterns and flow demands. Hydrological monitoring was also undertaken to validate river flows and irrigation abstractions.

Our studies increased knowledge and understanding of land utilisation and agricultural activities in the irrigation areas. We assessed the risks that may increase water release requirements and reduce generation flows, while seeking opportunities that may allow the plant to adjust irrigation flows and improve generation. Our findings concluded that, despite the lack of modern technology, the irrigation infrastructure is well managed by the farming community and only limited investment in infrastructure would be required. An assessment of recent changes in irrigation demand, however, identified an opportunity for potential reductions in water release requirements.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

For more information

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Company profiles

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Modelling to improve drinking water quality

Organisation(s)
Mott MacDonald

Client(s)
Severn Trent Water

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

The use of pesticides is strictly controlled in the UK, but traces can still find their way into rivers and reservoirs, contaminating public water supplies. Nitrate concentrations in aquifers supplying public water supply boreholes also need to be managed. Current water treatment processes to remove contaminants are expensive as well as energy and carbon intensive. We worked with Severn Trent Water to assess the potential of catchment management as an alternative method of reducing pesticide and nitrate concentrations at groundwater and surface water supply sources across central England.

We took a holistic approach, gathering all available information on hydrology, geology, soil, land use and agriculture to make sure we fully understood the key issues in each catchment. Our teams conducted site walkovers and consulted key stakeholders including farmers. We developed a model to simulate how different pesticides are transported in catchments that supply surface water treatment works using the well-established Soil and Water Assessment Tool (SWAT). We used groundwater models to evaluate nitrate transport and trends in groundwater catchments. The models were used to run scenarios to establish if catchment management could sufficiently reduce pesticide and nitrate concentrations in raw water to acceptable levels.

Catchment management can be a sustainable, low-carbon alternative to upgrading or building new water treatment plants. By identifying the source of pollutants, our modelling establishes catchment management target areas, refining the extent of interventions required to reduce pesticide and nitrate concentrations to below the regulatory limit. We used the results of our investigations to conduct a cost-benefit analysis to help Severn Trent Water utilise its resources in the most effective way to implement catchment management initiatives that will reduce the risk of pesticide and nitrate contamination and improve drinking water quality.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

For more information

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Company profiles

Mott MacDonald is global engineering, management and development consultancy focused on guiding our clients through many of the planet's most intricate challenges. Improvement is at the heart of what we offer: better economic development, better social and environmental outcomes, better businesses, and a better return on investment. Our engineers, project and programme managers have taken lead roles in the world's highest profile infrastructure and development projects. Yet design and management are just the tip of a deep iceberg. Our clients have access to the vast knowledge of internationally recognised environmentalists, planners, economists, project finance advisors, cost consultants, business strategists and more.

We deliver projects across the three core areas of integrated water resources management: safeguarding water supplies, managing risk to water assets, and balancing the needs of the environment. Our teams can help you make critical decisions about how to increase access of clean water across the globe by providing accurate, timely data to calculate the amount of water resources available and forecast demand. We develop efficient, comprehensive solutions to allocate resources in the most effective way – avoiding any adverse environmental effects.

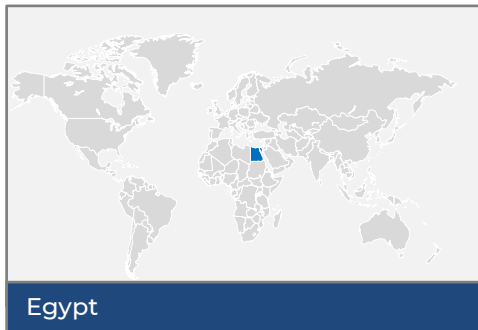
Climate change poses an increasing threat to global social and economic infrastructure. Our unique skills set and experience equip us to assist in managing them. We advise on policy, identify measures to mitigate climate impacts and guide adaptation to achieve asset and service resilience. We are leading the development of climate resilience by finding innovative solutions and sources of investment. We help our clients build long-term resilience and respond to climate extremes by bridging sector gaps and equipping communities, businesses and institutions with the awareness, knowledge and capacity to prepare for the impacts of climate change.

Developing a Sustainable Future for Egypt's Water Sector

Organisation(s)
Mott MacDonald

Client(s)
Government of Egypt

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Egypt's population has been booming for decades and is projected to reach 128M by 2030, increasing the risk of water scarcity. A multisector approach to water management is vital if Egypt is to make efficient and effective use of limited water resources. The National Water Resources Plan (NWRP) laid down a strategy for more integrated and coordinated planning, up to 2017. We were tasked with updating the plan within the framework of Egypt's 2050 vision and helping to strengthen the institutions responsible for implementing it.

We developed the NWRP to extend it to 2037 and beyond by harmonising the water resources management plans of the Ministry of Water Resources and Irrigation (MWRI) and partner ministries.

Through staff training, we improved the capacity of the MWRI to manage the NWRP and implement communications that will raise public awareness of water conservation and environment-related issues. We provided technical assistance to upgrade systems for co-ordinating integrated water resources planning and investment at national and regional levels, and developed water resources plans in five governorates, covering Upper Egypt, Fayoum and the Nile Delta.

The updated NWRP will optimise water resource allocation at national and governorate level to provide various customer groups with the water they need, in both quantity and quality. This long-term integrated national strategy will support reforms of the water sector, enabling Egypt to manage its water resources in line with the UN's Sustainable Development Goal 6: to ensure availability and sustainable management of water and sanitation for all. It will also improve protection of public health and the natural environment and help to maximise economic activity.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

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DAMSAT – Dam Monitoring by Satellite reducing the risk of dam breach

Organisation(s)
HR Wallingford

Client(s)
UK Space Agency, Government of Peru,
Statkraft, Bristol Water

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Water storage dams serve multiple functions for a society such as drinking water supply, flood protection and hydroelectricity generation. Tailings dams are embankments of compacted earth used to store toxic mining waste. The likelihood of failure of tailings dams is higher than that of water storage dams, although in both, the consequences of failure can be catastrophic for communities and ecosystems downstream. As well as the sudden loss of resource for the owner, consequences can include loss of life, destruction of infrastructure and pollution of the environment, drinking water sources and the food chain.

The main challenge of this project was to develop an effective method to monitor water and tailings dams and other tailings deposit areas, especially those in remote areas, that can help reduce the risk of potential catastrophic failures. Tailings dams and other tailings deposit areas may be operational, closed or abandoned. The project was trialled on 30 dam sites in Peru. By bringing world class dam safety experts, earth observation experts and software developers together, HR Wallingford built a sophisticated web-based monitoring system called DAMSAT that uses multiple types of satellite data, combined with weather forecast data, and in-situ data to monitor indicators of dam safety like movement and leakage. DAMSAT allows operators to look back in time at **what has happened**, monitor in near real time **what is happening** and even suggests **what might happen** in the future. Combined with HR Wallingford's advanced hydrological modelling, dam breach modelling and emergency planning, DAMSAT helps a responsible dam owner reduce and manage risks to those downstream. DAMSAT has now been adopted by several hydropower and water supply dam owners in the developed world and can be tailored to the specific needs of any type of dam site, owner type or regulator globally.

Key Words

water resources	resilient infrastructure	reservoirs
disaster response	planning and urban design	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

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Company profiles

Our specialist research and consultancy know-how solves the world's most complex water-related challenges. Exceptional people make us who we are. Our ability to innovate and push the boundaries of conventional thinking is renowned across the globe. When it comes to water, we're in our element.

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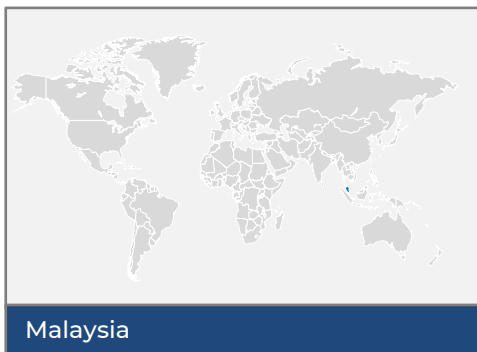
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National Flood Forecasting and Warning System for Malaysia (NaFFWS)

Organisation(s)
HR Wallingford

Client(s)
Department of Irrigation and Drainage,
Malaysia

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

The Malaysian Government's Department of Irrigation and Drainage (DID) is developing a new National Flood Forecasting and Warning System (NaFFWS) for its key river basins. The NaFFWS will help them to prepare for, and mitigate, the effects of future floods, using an integrated approach via non-structural measure. Ultimately, the NaFFWS will represent all of the key river basins for the whole country.

NaFFWS is being developed with support from HR Wallingford's UK and Malaysian-based experts. The extensive experience of HR Wallingford's experts in developing similar systems for tropical river basins has been important for these projects, where climatic conditions can be challenging and lead times for flood warning can be short. The components of the NaFFWS are fully automated systems driven by a combination of live, telemetered gauged data from DID's, spatial rainfall radar data, and Numerical Weather Prediction rainfall forecasts from the Malaysian Meteorological Department. These feed the boundaries of 1D and 2D hydrodynamic models, which model the flows in the river channels, and simulate the movement of water in the flood plains. The results are used to inform and warn DID staff, so they can take immediate action to provide an effective and proactive warning and dissemination response. Results are also passed to DID flood warning web pages, and to dedicated smartphone applications, enabling forecasts to be disseminated more widely.

Ongoing structural measures for flood mitigation are captured through a flexible modelling approach that can incorporate model updates to reflect real changes in the catchments, complementing the structural measures being implemented by DID and ensuring a sustainable flood warning solution with long term benefits.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	flooding	
demand management	green infrastructure	urban retrofit
buildings and public realm	rivers and waterways	
asset management	smart infrastructure	coasts

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Company profiles

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Assessing Groundwater Resilience Remotely

Organisation(s)

HR Wallingford, UK Satellite Applications Catapult, British Geological Survey and others

Client(s)

FCDO, UK Government

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Yemen is a water scarce country, but this situation has been exacerbated by conflict, leading to displacement of people, changes in agricultural practice and a rise in groundwater abstraction.

HR Wallingford led a project, managed by the UK Satellite Applications Catapult to understand the risks to groundwater resources in Yemen. The aim of the project is to identify those areas where groundwater is most at risk. Over-abstraction is known to be causing groundwater depletion, and is also resulting in reductions in water quality (for instance saline intrusion at the cost).

The approach used recognised the absence of reliable and current data, so rather than used locally collected information, the project relied on earth observation data. The project included a review of the most suitable data types, for instance reviewing different rainfall and evapotranspiration products.

The project included developing a Artificial Intelligence algorithm which successfully identified solar panels which are widely used as the power source for groundwater pumps.

A further piece of work, undertaken by volunteers at Groundwater Relief, included the digitisation of work previously undertaken in Yemen, to provide a library of historic data.

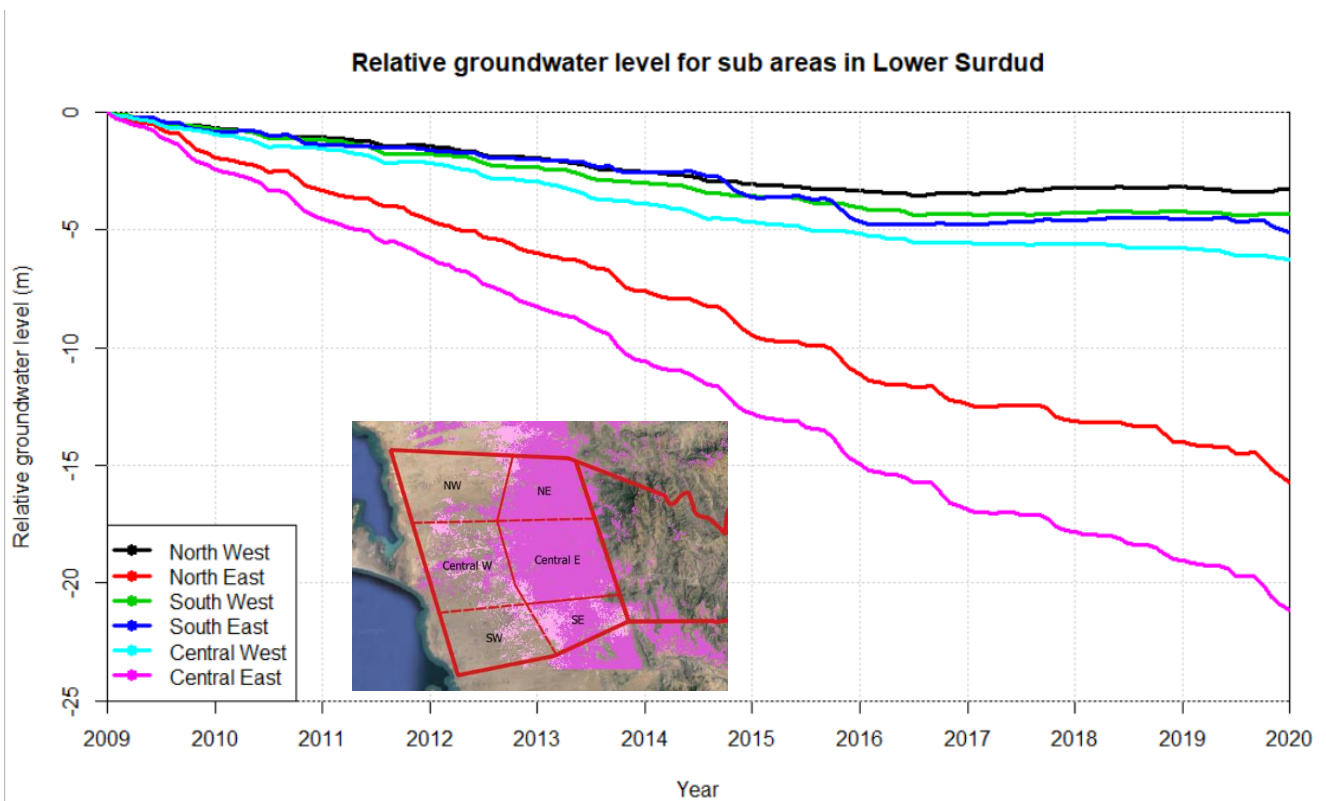
Throughout the project there was extensive stakeholder engagement with organisations in Yemen including government departments, humanitarian groups and researchers at Sana'a University. This engagement helped us corroborate the modelling.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
humanitarian relief	green infrastructure	urban retrofit
buildings and public realm	groundwater	
asset management	smart infrastructure	earth observation

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Modelled relative groundwater levels for six sub areas in the lower Wadi Surdud model. Inset figure shows sub area boundaries and irrigated lands in pink (based on Copernicus land cover data).

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Planning for climate resilience in the Caribbean

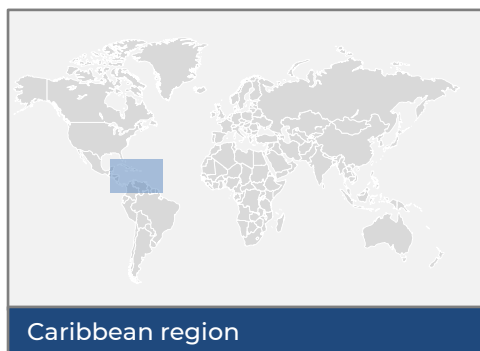
Organisation(s)

HR Wallingford, Caribbean Community Climate Change Centre, Caribbean Development Bank

Client(s)

FCDO, UK Government

Location



Focus Area

- Digital Water
- Water Resilience
- Net Zero

Service Offering

- Research
- Advisory
- Design
- Build
- Operate

UK Capability

- Now (existing capability)
- New (emerging capability)
- Next (future capability)

Overview

Water services and water resources management underpins social and economic development in Caribbean states. This is undermined by the continual impact of climate hazards, extreme weather events and the prospect of climate change.

In Dominica, for example, Tropical Storm Erika (2015) followed by Hurricane Maria (2017) caused damage estimated to be respectively 96% and 226% of gross domestic product (GDP). Investment to increase the resilience of the water sector is therefore essential to manage these risks and safeguard development objectives.

HR Wallingford has led several projects across the region which assess the risks posed by climate hazards to water supply services and water resources and develop adaptation plans which set out the action required to increase resilience to climate hazards. Countries we have developed adaptation plans for include: Antigua and Barbuda, Belize, Dominica, Trinidad and Tobago, Guyana, Grenada, Saint Kitts and Nevis and Saint Lucia.

We partner with local experts and combine analysis of quantitative data with extensive stakeholder engagement to systematically assess the risks facing water supply systems. We develop pragmatic climate change projection and provide insight on changes in climate risks and emerging risks. Based on this we support the water utility and government stakeholders to develop a vision for water supply services and a plan of action to realise the vision including the financing options available for implementation. These plans provide a mechanism for highly vulnerable countries to prepare and implement 'hard' and 'soft' investments to increase resilience to climate variability and change.

Key Words

water resources	resilient infrastructure	ecosystem services
catchment management	planning and urban design	
humanitarian relief	green infrastructure	urban retrofit
buildings and public realm		groundwater
climate risk	smart infrastructure	coasts

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Water intake in Dominica under reconstruction using a more resilient design in following its destruction during flooding caused by Hurricane Maria in 2018.

Company profiles

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