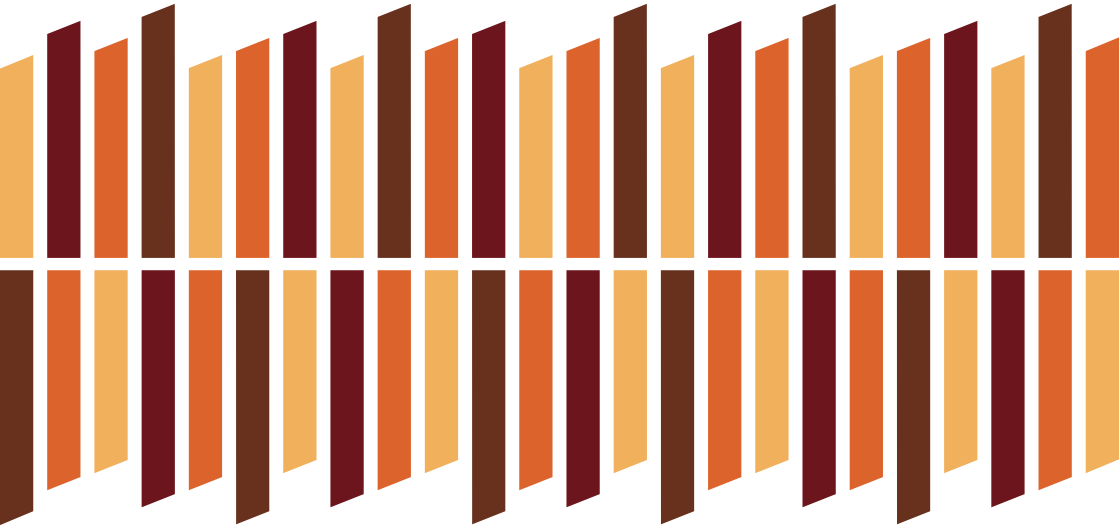

About Drought Handbook

Outputs and Impacts

The UK's Drought & Water Scarcity Programme

Engineering and Physical Sciences Research Council
Economic and Social Research Council
Arts and Humanities Research Council
Natural Environment Research Council
Biotechnology and Biological Sciences Research Council

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Further updates are available in the online version of this handbook at **www.AboutDrought.info**

About Drought

Introduction

Jamie Hannaford, Principal Investigator, ENDOWS

As the UK's £12m Drought and Water Scarcity (DWS) research programme reaches its conclusion with a final event at The Royal Society in London, this handbook draws together the key outputs and outcomes. The book also features a series of interviews with our leading stakeholders, which highlight how successfully we have met our objectives to produce cutting-edge science that has made a demonstrable impact on how decision-makers manage water scarcity in the UK.

Drought and water scarcity are significant threats to livelihoods and wellbeing in many countries, including the UK. Parts of the country are already water-stressed and are facing a wide range of pressures, including an expanding population and intensifying exploitation of increasingly limited water resources. The prolonged dry spell in 2017-19 brought sharply into focus the societal relevance of this area of research.

From science to song, our research has drawn on a wealth of evidence to tackle these issues, just some of which is highlighted in the following pages. Indeed, there are few parallels internationally to the DWS programme in terms of size, scope and disciplinary range. In addition to meteorologists and hydrologists, our programme includes linguists, oral historians, legal experts, computer scientists, artists and storytellers (and the list goes on).

We have grown a huge cohort of researchers, from a very wide range of backgrounds. We have also developed, engaged and motivated the practitioner community. While all four original projects had a strong commitment to stakeholder engagement and co-development of outputs, the knowledge exchange follow-on 'ENDOWS' was a key enabler to ensuring impact. From the outset, it was very forward-thinking of the funders to set aside funds for this phase of the programme. It shows a real commitment to achieving impact: this kind of work is crucial, if research is to be embedded into practice.

Some benefits will not be felt for years ahead, yet in other ways we have already made a tangible difference thanks to new datasets, models and methodologies, improved tools for decision making and whole new directions in drought understanding that bring together narrative approaches alongside model-based environmental science applications.

The investment is now paying dividends and we are starting to see stakeholders pick up these outputs and use them – for instance in the 2018-19 drought, where our tools and outputs were used by a range of water managers to aid understanding and decision-making. Our science and applications are supporting the current push towards more regional and national-scale water resources planning, so the next five-year water resources planning cycle will be influenced by About Drought. Our research has also made a difference in how we talk about drought and how it is treated as an issue.

Building on our efforts to understand how drought is understood by businesses, communities and the media, we are now making recommendations that we hope will foster the changing consumer behaviours that are a key part of the solution to future water management challenges. Many of the stakeholders interviewed here highlight the benefit of the community of practice that has grown up around the programme.

We owe a huge debt of gratitude to our stakeholders. Their support and motivation has been a key ingredient to the success of the programme. It has been astonishing to see how much time has been given in kind – especially during such a busy period for UK water resources management. While we hope it has been as beneficial to them as it has to our programme, we cannot thank the community enough for their support.

NEWS VIDEOS, PODCASTS & MYTH-BUSTING FILMS

The ENDOWS Events & Engagement workstream's (WS7) 'audience first' approach extended to an innovative 'news documentary' style of short films and podcasts, produced by national broadcast journalists to capture the interest of the general public as well as our stakeholders, particularly those tasked with drought communications. We engaged news journalists to film on location and carry out interviews at our About Drought Showcase in March 2018 and the MaRIUS Workshop in 2017. We asked them to take the same approach as they would to a TV news assignment, picking out the angles they found most news-worthy and selecting their own interviewees and questions. Dr Rebecca Pearce sourced a series of evocative and informative audio interviews with people who experienced the 1976 drought first-hand from varying aspects – for instance, did you know that in 1976 firefighters tackled moorland blazes wearing plastic uniform over-trousers that were melting in the heat? WS7 has presented this 'Who'd Have Thought That…' series on our own channel on the SoundCloud platform, promoting it on social media and at our own events. The series of Drought Myth Busting videos debunks popular misconceptions – such as 'Droughts Only Happen In Summer' – through interviews on location with people on the frontline of water shortages, as well as About Drought experts.

MaRIUS - Intro and Summary

bit.ly/MaRIUS-videos

About Drought Showcase Event 2018 Highlights

bit.ly/AboutDroughtHighlights

Think Water: Storytelling for the future of Peterborough & the Fens

bit.ly/DRY-videos

Drought Myths #1 Britain is wet: Droughts don't happen here

bit.ly/AboutDrought-videos

About Drought in numbers

277 PROFESSIONAL PRACTITIONERS

132 JOURNAL ARTICLES

7 TECHNICAL REPORTS

204 REQUESTS FOR FURTHER INFORMATION/ INVOLVEMENT

5 SCHOOLS

27% OF PEOPLE ENGAGED REPORTED CHANGE IN VIEWS, OPINIONS, BEHAVIOURS OR DECISIONS MADE

33 POLICYMAKERS/ POLITICIANS ENGAGED

11 TV/RADIO/ FILM/PODCAST BROADCASTS

33 MAGAZINES, NEWSLETTERS OR ONLINE PUBLICATIONS

79 FORMAL WORKING GROUPS, EXPERT PANELS OR DIALOGUES

292 ATTENDED WORKSHOPS, OPEN DAYS AND SIMILAR ACTIVITIES

250+ TALKS OR PRESENTATIONS

6 POLICY BRIEFING REPORTS

2 WORKING PAPERS

About Drought in the news


After the hottest summer on record, get set for an 'above-average' autumn

Water meters 'must be put in every home'


Drought of shape

Frome River Walk - DRY Project


Credit: David Throup/EA

Informing the Water Industry
Environment Agency

"About Drought has informed the water industry, now we need some sort of mechanism to identify the most useful outputs from strategic to operational products. We must not let those fall through a crack now that About Drought has finished."

Paul Crockett, Principal Officer, National Water Resources Planning Framework, Environment Agency

"About Drought has helped generate a step change in thinking around what is possible and what can be done, and over the next 10 years or so we will be making better decisions, using better tools because of it," says Paul Crockett who is leading the modelling work on the National Water Resources Planning Framework for the Environment Agency.

Yet Paul, who has worked closely with the MaRIUS project and About Drought (ENDOWS), believes there is still more to be done in encouraging the water industry to catch up with the latest outcomes of the programme's data and tools.

About Drought has supported the water industry in both strategic planning and real-time decision-making during a time when it has come under pressure to collaborate across water company boundaries on regional forward planning, as well as approaches to dealing with issues as they arise with a greater level of accountability.

MaRIUS and ENDOWS have held a series of workshop events specifically for the industry, working alongside key stakeholders to match its research to their needs.

With the National Water Resources Planning Framework driving water companies to work together to build resilience into water management with clear, joined-up direction from Government departments, agencies and water regulators, the industry is now more ready to be receptive, Paul feels.

He says: "There are a lot of great products from MaRIUS and About Drought but the water industry – the customer, if you like – is only just seeing the potential."

Historic Droughts' work in reconstructing reliable rainfall, river flow and groundwater data back to 1890, as well as providing standardised drought indices has been important in putting events into context, improving the industry's understanding of statistics, the latest methodologies and stakeholder needs. There is still more to be done in migrating data from the academic models to those the water companies use.

The water resource model developed by MaRIUS is being adopted for use by Paul's team, to help the National Water Resources Planning Framework assess the potential effects of different types of drought and climate change impacts at a national scale, and test management strategies.

Paul's concern is that with the impacts of climate change starting to be felt on the reliability of water availability, it is the wrong time to bring About Drought to an end. He says: "It's so important to have About Drought following on from the original research projects; it demonstrated what is possible, the better knowledge and insight we can get from the information that decisions will be based on in the future. The team really helped to educate the industry rather than just educating other academics.

"We need to look at the tools we can use to take it even further forward now that the industry is starting to buy into it more.

"About Drought has informed the water industry, now we need some sort of mechanism to identify the most useful outputs from strategic to operational products. We must not let those fall through a crack now that About Drought has finished.

"About Drought is to be applauded for what it has done but it needs more time and resources if it is to maximise the outcome for UK plc of all this research."

Interview by Sally Stevens

A Community of Practice
Water Resources South East

'About Drought has brought policy-makers, scientists and academics together and that is becoming more important because the complexities and uncertainties in the science are fundamental to making the best policy decisions, especially with climate change playing an increasing role'

Trevor Bishop, Director, Water Resources South East & MD of H2Outcomes

The person in the driving seat of the UK's response to the 2012 drought was Trevor Bishop, then Deputy Director of Water Resources at the Environment Agency and Ofwat's Director for Strategy & Planning during the 2018 hot dry summer of peak demand.

With a water crisis looming in 2012, he was appointed to co-ordinate the first multi sector cross cutting National Drought Group, reporting directly to the Government, and bringing together companies, regulators and government departments, representatives of agriculture and power groups and chaired by the Secretary of State for the Environment, Food and Rural Affairs, Caroline Spelman.

Trevor recalls: "In a worst-case scenario we were within 160 days of running out of water for some parts of London, with the 2012 Olympics on the horizon, 20 million people were on water restrictions and so were several thousand businesses for which water was critical."

"WE WERE WITHIN 160 DAYS OF RUNNING OUT OF WATER WITH THE 2012 OLYMPICS ON THE HORIZON"

Many parts of England had experienced the driest 18 months for more than 100 years and the crisis triggered the Research Councils' £12m investment in the UK's Drought & Water Scarcity Research Programme and several projects, now collectively known as About Drought.

He says: "About Drought is helping us to understand what the evidence is really saying so people like me can get behind the science. The events About Drought has held are the best I have seen at doing that."

One of the most complex messages to translate from academia to policy and decision-makers is uncertainty. As a scientist by background, Trevor says: "Uncertainty is absolutely key, confidence in evidence data and About Drought's better and more timely presentation of data is helping decision-makers to better manage uncertainty.

"The people making key decisions in a water crisis are generally not scientists and they may not always understand some of the subtleties behind academic report headlines. There are so many different layers in pure science, and decision-makers are always at risk of mis-representing some of the science."

The solution is to build trusted, working relationships between policy-makers and the scientists behind the research, Trevor believes, involving more scientists in policy-making, working closely with universities and research organisations and maintaining that network beyond the life of the About Drought programme.

He explains: "Academics tend to operate in a semi-closed community but About Drought has brought policy-makers, scientists and academics together and that is becoming more and more important because the complexities and uncertainties in the science are fundamental to making the best policy decisions, especially with climate change playing an increasing role."

The benefits of the relationships and community created by About Drought were felt in last summer's dry spell. Trevor credits the MaRIUS project, in particular, with providing reliable data through meaningful and effective tools, such as its National Water Resource Model. He says: "The models of drought we had were already starting to not perform as well as they used to because we are already seeing the subtle shifts that are taking place due to climate change, so we can't rely on past data so much. But About Drought helped us and it was really good last summer to see key policy-makers and decision-makers thinking big and acting early.

"At least once a year we should bring this community we have formed together again – the policy-makers, the top scientists and academics – because that link needs to be rock solid."

Interview by Sally Stevens

MaRIUS

Impacts of water scarcity on the environment, society and the economy are complex. They are profoundly shaped by human choices and trade-offs between competing claims to water. Current practices for management of droughts in the UK have largely evolved from experience. Each drought tests institutions and society in distinctive ways. Yet it is questionable whether this empirical and heuristic approach is fit for purpose in the future, because the past is an incomplete guide to future conditions.

The **MaRIUS** project has explored a risk-based approach to the management of droughts and water scarcity, drawing upon global experiences and insights from other hazards to society and the environment. MaRIUS has assessed, in the context of real case studies and future scenarios, how risk metrics can be used to inform management decisions and societal preparedness. Enquiry has taken place at a range of different scales, from households and farms to river basins and national scales. Fine-scale granular analysis is essential for understanding drought impacts. Aggregation to broader scales provides evidence to inform critical decisions in water companies, national governments and agencies. Analysis on a range of timescales demonstrates the interactions between long-term planning and short-term decision making, and the difference this makes to impacts and risks.

Underpinning the risk-based approach to management of water scarcity, the MaRIUS project has developed an integrated suite of models of drought processes and impacts of water scarcity. A new 'event set' of past and possible future hydroclimatic drought conditions, enables extensive testing of drought scenarios. The representation of drought processes in hydrological models at catchment and national scales will be enhanced, enabling improved analysis of drought frequency, duration and severity.

The representation of drought impacts in models of species abundance and biodiversity in rivers and wetland ecosystems, such as fens, lowland and upland bogs, was enhanced. A model of agricultural practices and output has been used to analyse drought impacts on agriculture and investigate the benefits of preparatory steps that may be taken by farmers. The potential economic losses due to water scarcity were analysed through a combination of 'bottom-up' study of households and businesses, and consideration

of supply chain dependence on drought-sensitive industries.

The environmental, economic and social dimensions of water scarcity have been assessed in an integrated way, which enabled exploratory analysis of feedbacks between impacts. For example, agricultural land use changes, driven in part by drought frequency, will, in turn, influence water quality and ecosystems. The interdisciplinary analysis enables comparison of likely outcomes arising from applying both pre-existing drought management arrangements (e.g. restrictions on water use, abstraction limits) and enhanced/innovative management strategies (e.g. use of outlook forecasts, dynamic tariffs).

Social science and stakeholder engagement are deeply embedded in the MaRIUS project, and have been framed by a critical analysis of how impacts of droughts and water scarcity are currently understood and managed by key stakeholders, and how this is shaped by institutions, regulation and markets. First-hand experience and 'collective memory' of communities affected now, and historically, by water scarcity provide new understandings of the social and cultural dimensions of droughts. Ongoing engagement between the project social scientists, natural scientists and stakeholders helped to ensure that the outputs from the MaRIUS project, including the 'impacts dashboard', are matched to their needs and to the evolving policy context.

The span of the MaRIUS project was large and covered physical and social science topics including: drought governance, drought options and management, community responses and environmental competency.

It included climatic aspects of drought and the derivation of a synthetic 'drought event library'; hydrological responses both on a catchment and national scale; effects on water quality including nutrient concentration in rivers and algal concentrations in reservoirs, and effect of land use change; the ramifications on water resources on the Thames catchment and also nationally. It included the impact of drought and water scarcity on terrestrial and aquatic ecosystems; agriculture and farming; the economy; and on electricity production.

People and the Environment

Drought indices can incorporate various climate and hydrological data within a single indicator that can be used for analysing trends and relaying information to stakeholders, policy makers and the public in a clear format. The drought index value is often presented as a single number, which can be far easier to understand and use than raw data. In MaRIUS we used the Standardized Precipitation Evapotranspiration Index (SPEI) to determine drought. The SPEI reflects changes in rainfall as well as temperature on water demand through the inclusion of potential evapotranspiration (PET).

The SPEI can be calculated for different time periods so that the dynamics of different types of drought (environmental, agricultural, or water supply drought) can be assessed. Drought onset, severity, and duration are categorised based on the SPEI values, with negative values below a set threshold used to determine drought.

Past

There has been a number of droughts in England over the past 40 years. The most recent notable droughts were 1975-1976, 1989-1992, 1995-1996, 2004-2006 and 2010-2012.

Over-abstraction to meet the needs of growing populations, agricultural and industrial use, and the effects of climate change are causing multiple

Credit: United Utilities

challenges in many water-stressed regions, and these are likely to increase in the future.

Future

However, a study of historical events alone does not provide sufficiently diverse and extreme conditions to study the full range of possible drought conditions and impacts that may occur in the future. As such, MaRIUS has developed an extensive 'drought event set' covering the past, present day and future drought conditions.

The event set has been used to provide a range of possible weather time series and assess projected changes in drought characteristics for different time-periods that:

- could have occurred in the past ('Baseline', 1900-2006)
- might occur in the near future ('Near Future', 2020-2049)
- might occur in the far future ('Far Future', 2070-2099)

Engagement

The MaRIUS project researchers wanted the project outputs to be as meaningful as possible to both the academic and user communities. In order for the project to realise its aims, and help move the UK towards a risk based approach to manage water resources with a particular regard for water scarcity, it is important that the project is known about widely, and the researchers could liaise with as many different types as of stakeholders as possible.

A number of events, workshops and symposia were held throughout the project allowing the user community to really get to grips with the research and vice versa. As well as the more traditional routes to engagement MaRIUS embraced media based solutions to interact with the user community such as podcasts and videos.

Jim Hall

MaRIUS Stakeholder Advisory Group:

Ben Piper
Atkins
Glenn Watts
Environment Agency
Dr Mike Morecroft
Natural England
Paul Hammett
National Farmers' Union
Dr Bill Baker
NERA Economic Consulting
Ronan Palmer
Ofwat & Environment Agency
Dr Nathan Richardson
Waterwise
Paul Sayers
Sayers & Partners
Barry Bendall
Rivers Trust
Ugo Gasparino
RWE Generation UK
Sarah Heineman
Defra
Dr Chris Lambert
Thames Water

Water Resource Planning
Thames Water

Dr Chris Lambert, Supply Demand Senior Technical Advisor, Thames Water

From the initial proposal for funding in 2014 to the final event on November 7, About Drought has been driven by the needs of the organisations, communities and people who would be relying on the results of its research. Their practical requirements, regulatory restrictions, governance and operational methods have informed the structure, design and accessibility of the datasets and tools.

Even at the stage of drafting the funding proposal Thames Water was invited to review it by MaRIUS' project leader Jim Hall, Professor of Climate and Environmental Risks at Oxford University.

Chris Lambert, who is responsible for developing Thames Water's, Water Resource Management and Drought plans, joined the MaRIUS Stakeholder Advisory Group (SAG). The aim of drawing this expert group from industry, NGOs and government to steer the project, liaising with MaRIUS' social and natural scientists, was to ensure its outputs, including the 'impacts dashboard', matched the needs of the group in an evolving policy context. (For a full list of MaRIUS SAG members please see page 12.)

This early access proved crucial to the benefits Thames Water has gained. Chris says: "Being on the SAG as well as being involved in the parts of the project that were relevant to Thames Water, gave me wider visibility of the total work of the project. I had a much better understanding of how we could use some of the research in developing Thames Water's water supply strategy.

"It led to us commissioning some tailored, specific work that gave us a better insight into the reliability of future water resource development and then we fed into our 2019 Water Resource Management Plan."

Of particular interest was the work on algae growth in rivers and 'drought coincidence'. As a result, Thames Water commissioned its own more detailed research on how projected algae growth could impact on extracting water from reservoirs in conditions of water scarcity or drought, slowing its passage through the filtering system and therefore the speed at which public demand for water could be met.

Thames Water also commissioned the development of a bespoke application from MaRIUS's water quality research data, focusing on the catchments of the Severn and Thames, and the added likely impact of climate change on water availability.

There are further potential impacts of the timing and positioning of water abstraction, i.e. from the bottom of the river catchment as opposed to higher up, including for the health of the Severn and Thames catchments. The results led to a change in plans for the management regime of Thames Water's reservoirs.

Chris says: "If you look into future likely scenarios, climate change is decreasing water availability and this research has definitely demonstrated how that can cause significant problems in water treatment works and has given us a better understanding of different types of water resource options.

"Part of my role is to engage with academic bodies to understand the latest thinking and communicate it internally to our senior executives and board members and to our external stakeholders as well. Another part is ensuring we have effective communication for public and community consultation on our Water Management Plans for the more practical aspects of day-to-day water supply. Through my involvement with MaRIUS and About Drought I have found the events - such as the one-day water suppliers' feedback workshop in Oxford – very useful in giving me visibility of what has been done and in supporting me in getting internal funding.

"I have been able to follow-up with UK-based speakers who have always been very responsive and my colleagues have also found them very helpful.

"I do think that it would be worthwhile continuing bringing this community together, even if it is just once a year, to keep us up to speed. The work isn't going to stop just because About Drought has stopped.

"It's important to ensure the good work that has been done to date continues and doesn't dry up just because the funding dries up."

Interview by Sally Stevens

A snapshot of the work arising from the MaRIUS project

Dr Helen Gavin, Project Manager for MaRIUS

A Water Resource System Model for England and Wales

For the first time, the UK can simulate the effect of drought and water scarcity on the nation's water resources, using a model of the nation's drinking water infrastructure.

The water resource system model of England and Wales is a key output of MaRIUS' research, built from scratch in collaboration with the water industry to represent the drinking water distribution network in the UK.

Dr Helen Gavin, project manager of MaRIUS, says: "It is the first such model created in the UK and possibly the world. It is massively significant that the UK can now assess the impacts to its water resource using a simulation model in a systematic way. Until now there has been no joined-up way to test the effects of water scarcity on adjacent areas, or the effect of droughts covering large areas of the country.

"A great strength is that it has been produced with the water industry; they gave us the data, have seen the ouputs, have given feedback and have been actively interested in how it will be used. Because it has been through that shared process, it is a much more robust model and the results are much more critical in terms of how our water supply is managed in the future.

"We are training members of the Environment Agency on how to use the model and we will hand it over to them to help manage our water resources."

Future Droughts

The climate datasets, generated from the Citizen Science platform Weather@Home, have been a common thread that has run through much of MaRIUS's analyses: they comprise meteorological datasets of many different potential futures, at different timescales, from now into the far future. The MARIUS researchers have used these "drought event datasets" to show the effects and impact of droughts in a systematic way: the robust meteorological datasets have been fed into hydrological, ecological, water resource and agricultural models to give a coherent, coordinated potential future of drought and the potential impacts.

"IT IS MASSIVELY SIGNIFICANT THAT THE UK CAN NOW MANAGE ITS WATER RESOURCE IN THIS JOINED UP WAY. UNTIL NOW THERE HAS BEEN NO WAY TO TEST WHAT THE REGIONAL IMPACT OF A DROUGHT WOULD BE AND WHAT ITS IMPACT ON NEIGHBOURING REGIONS WOULD BE."

Economic Research

A startling discovery has come from the work examining agricultural aspects of drought and water scarcity: the analysis suggests that the total net benefits of irrigation in a dry year are around £665 million at the farm level,

not including the value to the wider food chain and economy. Helen says: "Not only was this an eyebrow-raising amount of money for a substance we routinely take for granted but it also highlights the need for a hierarchy of water priorities in periods of water scarcity or drought. The dry weather in 2018 has put huge pressure on the agricultural industry, not only during the period of dry weather but also afterwards, where low yield of fodder crops caused very high prices.

"Further economic research is ongoing, and will shine a light on the effect of droughts and water scarcity on other sectors of the economy."

Forestry

Our woodland habitats are also vulnerable to water scarcity. MaRIUS research has found that by 2018 there will be a loss of lowland beech woodland, an increase in favourable conditions for oak in England, but the reduction in optimal conditions for downey birch and Scots pine in Scotland, for example. Overall, vulnerability to drought-induced mortality will increase, particularly so in southern and eastern areas, but different species show different levels of susceptibility across the country.

Helen warns: "These results show that it is not only acquatic ecosystems that are under threat, terrestrial ones, such as woodlands are also affected. While there is a northward migration of favourable growing conditions for particular species of habitats, we do not know whether our natural ecosystems, including wildlife, will be able to adapt or migrate at the same rate.

"Commerical timber production will also be affected by drought, as water scarcity affects tree growth rate and trees under stress are more vulnerable to pests and disease. We saw in 2018 that the whisky and hydropower industries in Scotland were immediately affected by dry weather, but long-term there will likely also be an impact on the timber industry."

MaRIUS Outputs

MaRIUS outputs have been produced for anybody to use and are available via the MaRIUS website: http://www.mariusdroughtproject.org/inforesults/

Video digests are available, featuring researchers talking about their work and snapshots of presentations from events covering the broad swathe of work undertaken by the project, ranging from water quality to human geography. Of particular note are the video digests from the project's "showcase event" which summarise all the findings from the different areas covered: the slides are also available.

There are many academic papers that have been published that detail the findings of the project to date. There are also reports, such as the primer on how drought is planned and managed and how to manage water resources as part of a catchment based approach.

Interview by Sally Stevens

Drought and Agriculture
National Farmers' Union

"Water scarcity is becoming an increasingly important issue in terms of overall management of water – in flood as well as drought. Likewise, the farming community is increasingly vulnerable to water scarcity both in terms of physical access and from regulation, for instance around abstraction."

Paul Hammett, National Water Resources Specialist, National Farmers' Union

Paul Hammett joined the MaRIUS project's steering group having been appointed as the first National Farmers' Union (NFU) National Water Resources Specialist in 2012, the year in which the UK faced its most serious water shortage since the 1976 drought.

He says: "Farmers are at the sharp end of regulation control during low river flows, and throughout the time of the UK Drought and Water Scarcity Research Programme we've had a series of dry summers which has made the need for better data very real.

"Water scarcity is becoming an increasingly important issue in terms of overall management of water – in flood as well as drought. Likewise, the farming community is increasingly vulnerable to water scarcity both in terms of physical access and from regulation, for instance around abstraction."

The value of making improved and widely available access to at-a-glance data such as the National Water Resources Portal which shows flows in more than 300 UK rivers (page 44) is summed up by the dilemma faced by a Bedfordshire farmer shortly before Paul gave this interview.

Having just planted a field of winter cabbage the NFU member out of the blue received a letter from the Environment Agency ordering him to stop irrigating because flow in the River Ouse had fallen below a particular level. The following week's weather was dry and all the plants died.

Paul explains: "Not only did that farmer lose that crop he is now concerned that his buyer will mark him down as vulnerable to drought and will take the contract elsewhere, the shock was that the river levels were so low so late in the season.

"The way he can be helped in the future will be by having more information on what the flow is like in his river and what might happen at an earlier stage – just knowing that a week in advance could have avoided this situation.

"We would like to see more value added to the research programme to give users that extra granularity in information. If they know something is going to happen, even just one week's warning will be helpful.

"The challenge for us all is that water availability is so localised – but it is also a great opportunity for people to understand that the power of some of About Drought's research outputs is such that it can go down to a reasonably local level and that's exactly where we need to get."

Like many of About Drought's stakeholders, the challenge for the NFU has been in both staying abreast of the broad range of activities, events and outputs, picking out what is relevant to their sector and having the resource to match the scientific and academic outputs.

ENDOWS' mission to co-develop data into usable and accessible data visualisations and products through feedback and workshops has been highly valued by our sector partners but they nevertheless say that even more could be done and that they are loathed to lose the effective community and connections that have been built.

Paul says: "Pre-programme, the NFU had existing good contacts with Cranfield University and the benefit of About Drought has been a widening of that sort of access, it has been really useful to have an improved relationship with the likes of the UK Centre for Ecology & Hydrology (UKCEH).

"The main benefits to being involved have been making sure that tools are being developed to help farmers manage the risk of water scarcity and I am really interested in what ENDOWS will do next to support the farming community in the application of the data.

"Also the DRY project has enabled us to capture more of the impacts of drought on farmers which are

sometimes under-represented because not a lot of them are statistical. Farming needs to take full advantage of the opportunities presented to us but farmers are basically self-employed businesses or SMEs (small to medium enterprises) and as such struggle to justify taking a day away from work to join events – it's an issue across the board in everything we do. So we were really pleased when DRY adapted to their circumstances and set up an early evening teleconference that was joined by 15 farmers from across the country."

DRY's innovative, interdisciplinary and regional approach empowered farmers and rural communities to tell their stories (see page 28) which have been recorded as conversations, podcasts, songs and videos and are available through the DRY Utility online database.

Father and daughter Cambridgeshire dairy farmers David and Fran Herdman featured in one of a series of drought myth-busting videos produced by the University of the West of England talking about how their business is affected by drought. You can watch all the videos on the About Drought website (www.aboutdrought.info).

Paul says: "It is a really good example of the benefit of the programme to the agricultural community."

Interview by Sally Stevens

Historic Droughts

Historic Droughts aimed to develop a cross-disciplinary understanding of past drought episodes that have affected the UK, with a view to developing improved tools for managing droughts in future.

Our starting point was that droughts are not simply natural hazards. There are also a range of socio-economic and regulatory factors that may influence the course of droughts, such as water consumption practices and abstraction licensing regimes. Consequently, if drought and water scarcity are to be better managed, there is a need for a more detailed understanding of the links between physical (i.e. meteorological, hydrological) and social and economic systems during droughts.

With this research gap in mind, the Historic Droughts project has been developing an interdisciplinary understanding of drought from a range of perspectives. Based on an analysis of information from a wide range of sectors (hydrometeorological, environmental, agricultural, regulatory, social and cultural), the project has characterised and quantified the history of drought and water scarcity since the late 19th century.

The project has developed the first systematic account (the UK Drought Inventory) of past droughts in the UK, incorporating new datasets on past drought characteristics, impacts and human responses. The Inventory is the basis of a novel joint hydrometeorological and socio-economic analysis that is leading to a 'systems-based' understanding of drought. The project has been applying these new datasets and methodologies to enhance drought management, principally through interfacing with the ENDOWS work with decision-makers. Below we discuss some of the Historic Droughts outputs and activities in more detail.

Systems-based analysis and conceptual framework

We have advocated a 'systems-based' view of drought, i.e. an understanding of the multiple and inter-connected drivers of drought, the impacts of and responses to drought, and the feedbacks between them. A key part of this has been the development of a Conceptual Framework for the joint hydro-meteorological-social understanding of drought. We published this framework in 2017 and illustrated its application to two past drought episodes (1976 and 2003 – 2006). We expect this systems-based understanding to improve decision-making for future

drought management and planning, and to facilitate more informed and effective public discourse related to drought. We envisage the conceptual framework will also be applied in other research settings, and also other environmental problems beyond drought, in the UK and internationally.

Sectoral datasets and analyses

Historic Droughts set out to improve our understanding of past droughts from a range of 'sectoral' perspectives, before bringing these together in the Drought Inventory. This has led to a wealth of new datasets on drought, which are mentioned briefly below but which are listed in detail on page 46 of this Handbook.

A key foundation of Historic Droughts is hydrometeorological reconstruction, aiming to improve our understanding of past drought occurrence and severity across the UK. Underlying this was a major data rescue and recovery exercise undertaken by the Met Office, who digitized hundreds of past weather records to improve the national network of raingauge and temperature observations in the late 19th and early 20th centuries especially. This effort has led to a major strengthening of our national climate archives, and extension of the datasets back to 1862. Not only is this beneficial for Historic Droughts, however – the rescued data features in the Met Office's recently released 'HadUK' archive of national climate data, available to all. The temperature dataset has then been used by the CEH team to reconstruct a national, gridded daily evaporation dataset, extending back to 1891. The new historical rainfall and evaporation datasets were run through hydrological and hydrogeological models to reconstruct river flows and groundwater back to 1891, for over 300 river catchments and 50 boreholes across the UK. This represents a significant advance in national hydrological datasets, as a majority of observed river and groundwater datasets start in the 1960s. We have published these datasets on the Environmental Informatics Data Centre to make them available, and developed web tools to allow users to explore them.

The new datasets have also allowed novel analyses that have allowed us to better characterise UK droughts back to the late 19th century. We have examined the frequency and severity of past hydrological drought episodes and quantified changes over time. We have also examined the spatial coherence of drought, regionally and nationally, and explored the spatial and temporal evolution of major past drought episodes. We have also improved understanding of drought processes, especially the atmospheric / oceanic drivers of droughts in the UK.

The hydrometeorological analysis allows us to characterise the occurrence of drought as a natural hazard over the last 120 years, and has shed significant new light on past episodes that occurred before the start of most observed river flow and groundwater records (e.g. 1890 – 1910, 1921-22, 1933-34 and through the 1940s).

But from a societal or environmental perspective, drought impacts are the most important aspect, and to help inform future management strategies we need to investigate the human responses that have been taken to mitigate these impacts. We have built up a range of datasets characterising these aspects from various sectoral perspectives. As this has used a range of disparate source datasets and methodological approaches across several disciplines, a key component of this has been a standardized approach to collecting information, including a consistent approach to capturing when and where the relevant impact / action occurred.

From an environmental perspective, our focus has been on quantifying

Credit: Ned Hewitt

drought impacts on freshwater ecosystems using an environmental monitoring dataset collated by the Environment Agency from the early 1990s. As the impact datasets are limited in time and space, we have developed statistical models to allow us to reconstruct the impacts of past drought episodes on river ecosystems more fully. This has demonstrated how the resilience of river ecosystems to drought varies around the country, and in particular how more heavily modified rivers are more vulnerable to drought impacts.

From a water supply perspective, we have delivered a dataset of reservoir development in the UK from the late 19th century onwards, illustrating how reservoir storage capacity has changed in this time. This has allowed us to develop timelines of past water supply, which we can then compare with timelines of demand, assembled from proxies (e.g. population). These supply / demand balances tell us much about changing water availability, which has a bearing on how droughts unfold and how they are managed. We have also cross-referenced this with a database of water supply impacts and drought management measures (drought orders, permits etc.), which we constructed using various water company reports and other sources.

From an agricultural perspective, we have developed an agricultural drought inventory of past drivers, impacts and responses to drought, gathered using the agricultural media (e.g. Farmers Weekly) back to 1976. We have used this to demonstrate improvements in agricultural resilience over time – how farmers in eastern England have moderated the impacts of droughts over this timeframe through improved planning and communication with regulatory bodies.

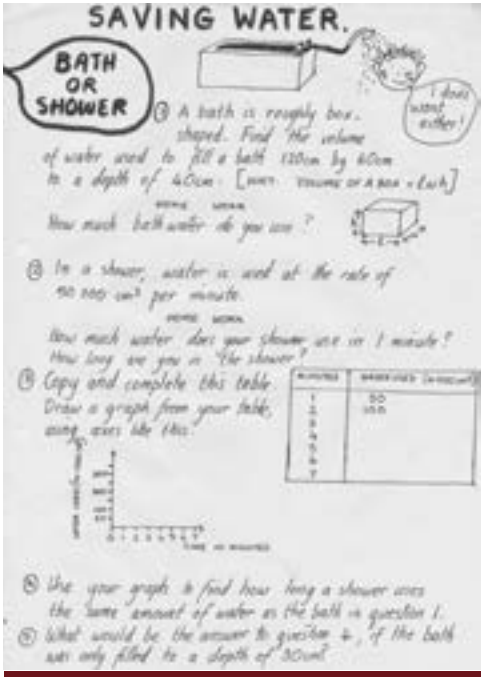
From a legal / regulation perspective, a database was developed using Hansard, to characterise the legal / policy responses of drought since the early 1970s. We have used this to demonstrate the changing governance backcloth to drought and water resources management in the UK, and how this has had an influence on the management of drought episodes, via the regulatory tools available and their relative efficacy.

From a social and cultural perspective, two contrasting approaches were taken. One approach has been through first-hand interviews with affected communities (see page 40), where we gathered over 100 Oral Histories from people who have lived through drought episodes from the 1960s onwards. These tell us something very different from the hydrometeorological / water supply focused analysis, something that has been missing from the picture - how drought is understood by communities, people's (diverse) lived experiences in drought episodes and how impacts have been felt and responded to. This sometimes diverges markedly from the way that drought is communicated by official bodies, and the understanding of people's behavioural responses to drought can be used to frame improved drought communications in future.

A second approach has been to capture how drought is represented in the media. This has been done through a 'Corpus Linguistics' approach which, uses computerised methods to objectively extract information from published newspaper archives back to the early 1800s. Not only does this provide a comprehensive archive of drought coverage over nearly 200 years – it also allows us to examine how the discourse around drought has changed over time. In the 19th century, for example, the word 'drought' was rarely used in connection with the many episodes of water shortage that occurred, whereas in recent years, 'hosepipe bans' have been a staple of the (often somewhat combative) narrative.

Bringing it all together – accessibility and applications

The various sectoral datasets have been combined into the UK Drought Inventory. This is a virtual collection of data, as the datasets are stored for long-term curation in different archives (the EIDC on the one hand and the UK Data Service for the social / economic data). However, all of the sectoral datasets are listed in one place and available to download (https://historicdroughts.ceh.ac.uk/content/datasets). The hydrometeorological datasets can also be explored in the CEH Drought Portal and various web tools (p.44). For the social and economic datasets based on text entries, we have developed a UK Drought Inventory Explorer (p.45) to allow users to search for data spatially, in time, or using keywords.



Mathematics lessons in 1976. Credit: Diana Monahan

The real power of these datasets is how they can be analysed together, bringing our environmental science and social / economic perspectives to bear on the same question. For example, we have linked our hydrometeorological drought indicators with the information on impacts on the agricultural sector, to demonstrate the likelihood of experiencing impacts given a certain drought severity – showing significant regional variations around the UK depending on local hydrological conditions and agricultural practices. We are also in the process of publishing an analysis linking our hydrometeorological timelines of drought (extended back to 1800s) with the timelines developed through the Corpus Linguistics analysis using the news media.

The datasets and methods assembled in Historic Droughts are finding practical application, especially through ENDOWS. For example, the indicators we have developed to quantify drought severity are being used for the UK Drought Portal and Water Resources Portals (see p. 44). The historical hydrometeorological datasets are feeding into the development of consistent Drought Libraries to support regional and national-scale water resources planning, and we have engaged very actively with water companies, the EA and Regional Planning groups to demonstrate how the datasets can be applied in future. The agricultural inventory was updated to include information on the impacts of the 2018 drought on agriculture, which has fed into the water management strategy developed in the agricultural workstream of ENDOWS. The social and cultural learning is helping the communities workstream and feeding into new educational resources.

While these datasets have had a demonstrable impact already, it will take time for the full impact of such a step change in drought data availability to be realised. These unparalleled resources will be a long-term legacy that, we hope, encourages new research avenues as well as practical applications in future.

Jamie Hannaford

Credit: Andrew Black

Drought in Scotland

Scottish Environment Protection Agency

"It's a common perception that drought doesn't have an impact in Scotland, you see much a worse impact in other parts of the world, but it is all relative. In fact, drought is an issue for us with a widespread and big impact. That is something we had already been trying to communicate and summer 2018 helped to get the message home."

Steve McGuire, Senior Scientist in Water Resources, Scottish Environment Protection Agency (SEPA)

From improved communications to more accurate monitoring, in 2018 the Scottish Environment Protection Agency (SEPA) went into North East Scotland's most prolonged period of water scarcity in decades better equipped, thanks to About Drought.

New contacts also mean that SEPA's Water Scarcity Team are able to build more Scotland-specific data and research into their new strategies.

Two consecutive dry winters, low summer rainfall, higher than average temperatures and a period of soil moisture deficit that stretched a month longer than in 1976, caused impacts across the region in summer 2018.

Steve McGuire had already been involved with the research programme representing SEPA, a key stakeholder, for several years and presented at About Drought's Drought & Water Scarcity Conference in Oxford in March 2019 about how Scotland's National Water Scarcity Plan was implemented in summer 2018 - its first major test.

He says: "It's a common perception that drought doesn't have an impact in Scotland, you see much worse impact in other parts of the world, but it is all relative. In fact, drought is an issue for us with a widespread and big impact. That is something we had already been trying to communicate and summer 2018 helped to get the message home."

That impact affected fish stocks and crops and included halting whisky production, and with a relatively high proportion of private water supplies in some regions, these crucial issues led to the Scottish Government bolstering supplies with water in tankers in some areas.

Steve says: "Many of the private water supplies are not robust enough to deal with an extreme event - they are often from shallow groundwater or springs - we are working together with the Scottish Government and Scotlands' Centre of Expertise for Waters to look at improving the existing private supplies."

The Oxford conference, attended by 150 water experts,

stakeholders, regulators and researchers, was a valuable opportunity for Steve and a small group of Water Scarcity Team colleagues to extend their contacts around the UK as well as internationally, and find out how water resources are managed in other countries. Those included a key connection with Forestry Commission research presented by Susan Davies of the University of Edinburgh, discussing drought-resilient tree species.

He says: "It was the first time we had heard that anyone was looking at that for the Scottish Timber Industry, at the same time we had also started to look at water resources, policy and ecology plans for the different sectors in Scotland and we have been able to feed Susan's research into those plans."

Steve had also joined one of DRY's very popular regional community workshops, held in the Eden Catchment in Fife. "It definitely shaped how we produce our reports and ways to get the right message across, making people aware that water scarcity is an issue in Scotland, which helped us in the summer of 2018.

"It brought different people around the same table – Scottish Water, Government, local farmers … groups like that were really good for getting other people's points of view that we may not always see."

Then in May 2019 About Drought held a workshop for SEPA and Scottish Water in Edinburgh which enabled a wider audience to discuss the programme's outputs first-hand.

Steve explains: "That was great because it meant we could get more people from SEPA to come along and the focus was on Scottish issues – it is useful to make use of experiences elsewhere and ensure we are following consistent approaches with other agencies, but there are also cases where a Scotland-specific approach is required."

As a result of that meeting, SEPA has identified where it can feed improved data from its monitoring network into the Drought Portal and, in turn, draw from it near real-time data to better monitor and communicate situational updates. In the future it is leading to a collaboration, developing a forecast system providing advanced, accurate warnings of when water scarcity is developing.

"We are speaking to UKCEH about combining our resources, data and effort to feed our live data into the Drought Portal and we envisage being able to use the tool with our own reporting which would be a significant step forward," says Steve.

SEPA are using About Drought's communications research to inform future messaging for different audiences, like pre-warning private supply holders of potential impacts of water scarcity and the need to protect the environment.

SEPA were inspired by the innovative work by students from Falmouth University's School of Communication Design on how to get water-saving messages across to hard-to-reach Millennials by About Drought's social science co-ordinator, Dr Rebecca Pearce. With humorous video clips, posters and social media posts the students devised effective peer-to-peer campaigns.

Steve explains: "It was really interesting to see their ideas, it's a relatively new area to us. We really liked the ideas they had.

"This wider and better understanding that we have from About Drought means we can develop ways to get our information out there and, importantly, to get a general understanding that water scarcity is becoming more of an issue in the future due to climate change.

"It is something everyone needs to think about and everyone can have an impact."

"THIS WIDER AND BETTER UNDERSTANDING THAT WE HAVE FROM ABOUT DROUGHT MEANS WE CAN DEVELOP WAYS TO GET OUR INFORMATION OUT THERE AND, IMPORTANTLY, TO GET A GENERAL CONSENSUS THAT WATER SCARCITY IS BECOMING MORE OF AN ISSUE IN THE FUTURE DUE TO CLIMATE CHANGE."

Interview by Sally Stevens

MaRIUS

Historic Droughts

IMPETUS
IMPROVING PREDICTIONS OF UK DROUGHT

Drought Risk and You


Credit: United Utilities

IMPETUS

IMPETUS brought together scientists from the meteorological, land surface, surface water and groundwater communities and social scientists from the water demand and forecast usability communities. The aim of the project was to improve the forecasting of UK drought on monthly to decadal timescales, by improving meteorological, hydrological and water demand forecasts and how they are combined to produce drought forecasts. This was done in conjunction with stakeholders to ensure that drought forecasts are relevant for decision making.

Skilful forecasting of dry and drought conditions is critical to water resource management and agriculture both in the UK and globally. A central activity in IMPETUS was engaging with stakeholders in the agricultural and public water supply sectors to understand their needs for drought forecast information. A key result for the public water supply sector is that understanding the regulatory context for UK drought management is essential for improving the uptake of drought forecasts. Similarly, the uptake of forecast information in the agricultural sector is highly dependent on forecast skill and the communication of forecasts in a relevant and timely manner.

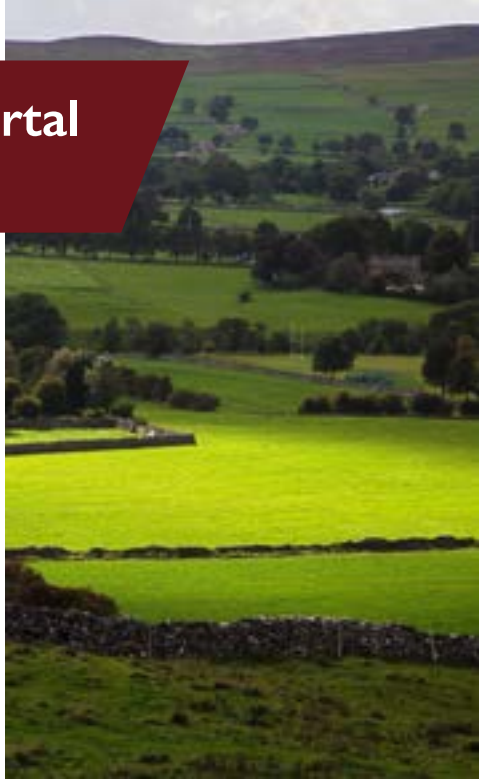
In addition to stakeholder engagement, IMPETUS has made advances in the science of drought forecasting. Working with stakeholders in the Met Office and the European Centre for Medium-range Weather Forecasting (ECMWF), IMPETUS has increased our understanding of the atmospheric and hydrological conditions that lead to the onset, maintenance and cessation of drought events. In addition, IMPETUS researchers have co-developed new methods to produce skilful regional forecasts of UK winter rainfall one season ahead. These results have been shared with the Met Office and ECMWF through a continuing series of workshops reviewing UK and European seasonal forecasts.

In addition, IMPETUS has supported the development of the Ensemble Streamflow Prediction system, which has contributed to improved stream flow forecasts within the monthly Hydrological Outlook (for more on the Outlook see page 26). During the 2017-2018 drought, researchers from the project provided advice on what we might expect in 2019-2020. IMPETUS researchers were also engaged with the media during the dry spell, which resulted in numerous newspaper articles and media briefings to inform the interested public. Working with stakeholders from the water industry, IMPETUS has also improved our understanding of domestic water demand in the UK. One key result was to highlight the need for improved data on water usage to constrain models of domestic water demand.

The project has involved internationally-leading scientists and social scientists from three NERC Research Centres (the National Centre for Atmospheric Science (NCAS), the British Geological Survey (BGS) and the Centre for Ecology & Hydrology (CEH), four leading universities (Oxford, Reading, Newcastle, and Southampton), the Met Office and the ECMWF.

Len Shaffrey

Using the Drought Portal
Yorkshire Water



Miranda Foster, Senior Hydrologist, Yorkshire Water

Miranda Foster, a hydrologist with Yorkshire Water for 18 years, was just one of the programme's water supply stakeholders who was able to use the Drought Portal to provide current, reliable and easy-to-access data in the prolonged dry spell in 2018.

The UK Drought Portal is a near real-time tool allowing users to explore up-to-date data and monitor current regional dry weather status across the UK. The tool shows the relative magnitude of drought events within river basins and individual catchments, based on rainfall deficits over durations ranging from 1 to 24 months. It has been developed by the UK Centre for Ecology & Hydrology (UKCEH) as part of the About Drought research programme, using drought indicator datasets developed by the Historic Droughts project and DrIVER, which was also NERC-funded.

Miranda says: "The Drought Portal gives us a spatial as well as a temporal picture and it confirms our data in a very quick and easy way. We have our own drought severity calculations for single sites but to have it shown for catchments is very useful. The visuals are easy to convey to others in Yorkshire Water and we used some of it to support our drought permit applications to look at the severity and extent of how conditions developed over time."

The Drought Portal is interactive and has been designed to support monitoring of water supply conditions and provide early warning signs of drought, exploring past drought characteristics in specific areas of interest as well as time frames, based on rainfall. Users can view Standard Precipitation Indexes (SPI), an indicator of drought that is widely used internationally for drought monitoring, by geographical area, including by postcode, and by time frame, going back to 1961.

"Some of this data is quite technical," says Miranda. "Having it visualised so clearly is very useful because it is so easy to share."

"HAVING [THE DATA] VISUALISED SO CLEARLY IS VERY USEFUL BECAUSE IT IS SO EASY TO SHARE"

The Drought Portal also contributes to UKCEH's monthly Hydrological Outlooks and to the National River Flow Archive, with Yorkshire Water able to commission bespoke outputs.

Miranda adds: "The bespoke river flow forecasts presenting data with a red, amber and green alert format as opposed to just tables and percentages has been very good and I have been able to feed that information to those who need it.

"For instance, last summer [2018] was the first time I have been involved in applying for drought permits. For quite a few years the focus had been on flooding because droughts were relatively unusual but as shown in 2017-18 they are still very much an issue and with climate change they are likely to be more frequent."

Yorkshire Water successfully applied for two drought permits to increase annual river abstraction limits in preparation for another dry winter and in anticipation of high winter demands in 2018-19, using evidence from the Drought Portal and many other analyses. These permits were granted but were not implemented as winter demands were not high and there was some recovery in reservoir stocks.

Miranda says: "It has been very interesting to work with About Drought. We have used maps from the Drought Portal and our local Environment Agency colleagues have said they found these a useful clear depiction of the severity and extent of drought."

Interview by Sally Stevens

Seasonal Hydrological Forecasts

"Since September 2018 we have been providing bespoke hydrological forecasts for the Environment Agency's area teams based on their reasonable worst case scenarios and stress test scenarios. They have been used internally and for National Drought Group briefings – it is a real success story."

Jamie Hannaford, Principal Hydrologist, UK Centre for Ecology & Hydrology

A key need addressed by About Drought has been improved access to early warning information, especially for hydrological forecasting.

Since 2013 a Hydrological Outlook had been provided by the UK Centre for Ecology & Hydrology (UKCEH), the Met Office and BGS, producing a static document that gives a 1-page summary for the UK as a whole, followed by regional and national information. But that did not allow users to access a forecast for the particular river in the UK that they were interested in.

Under About Drought that has become possible.

Our project IMPETUS aimed to improve drought forecasting for decision-makers, building on information gathered at a host of stakeholder workshops to establish current practices and their needs across water supply, health, power, agriculture, navigation and recreation.

It developed a new methodology of forecasting and the follow-on project ENDOWS gave researchers the opportunity to develop IMPETUS' methods. Now an insight into hydrological conditions over the coming three months, with likely trajectories for flows in 300 rivers around the UK and groundwater levels is available.

Jamie Hannaford, ENDOWS' Principal Investigator and Principal Hydrologist at UKCEH, says: "The science was done in IMPETUS. We tested the methods, validating them to see how reliable and accurate they are around the country and at different times of the year.

"Then in ENDOWS we opened up the forecasts and operationalised that system to the extent that these hydrological forecasts are now available in the first few days of every month. Since the summer of 2018 we have worked with a very wide range of stakeholders, providing them with forecasts for the river catchments that are relevant and ensuring that they meet user needs. In last summer's drought conditions when many stakeholders needed reliable information about what would happen next, they have told us that these forecasts were very useful."

The forecasts have been provided to a wide range of users, including water companies, the Environment Agency (EA), Natural Resources Wales, the Scottish Environmental Protection Agency, the National Farmers' Union, energy industry and the Canal & River Trust.

Jamie adds: "Since September 2018 we have also been providing bespoke hydrological forecasts for the Environment Agency's area teams based on their reasonable worst case scenarios and stress test scenarios. They have been used internally and for National Drought Group briefings – it is a real success story.

"In the dry spell of Summer 2018 we started providing hydrological outlooks to Yorkshire Water who wanted to specifically look at the likelihood of reaching certain flow thresholds for their internal management, and we came up with a bespoke outlook for them.

"These are just two examples that illustrate the benefit of having the extra ENDOWS knowledge exchange and synthesis funding for the programme. It has enabled the excellent science from IMEPTUS to fulfil its potential, it gave researchers the time to hear directly from stakeholders how it could be used, to refine our outputs to make them user-friendly, for example through data visualisation. We listened and as a result they were able to use them to access better information in a live situation in the 2018 drought. Users said they were pleased to see that this project produced such useful information, and that there is a pathway for this science to be continued after ENDOWS, through the Hydrological Outlook."

Credit: Lindsey McEwen

DRY (Drought Risk & You)

Drought and water shortage can severely affect us all through impacts on the environment, agriculture, infrastructure, society and culture. We started the interdisciplinary DRY project in April 2014, with the ultimate aim of developing an easy-to-use, evidence-based resource, to support decision-making for management of drought risk in the UK for a range of end-users. The DRY project spanned seven catchments within England, Wales and Scotland to reflect different hydrological, socio-economic, environmental, and cultural gradients in the UK.

Unlike many other investigations which focus solely on mathematical modelling of drought risk and a single sector, the DRY project has taken a unique approach, bringing together different aspects of drought science and multi-stakeholder storytelling to better understand drought risks, the trade-offs among different management options and the tipping points that determine their outcomes.

A key part of DRY's research was to bring together different types of data to build a comprehensive picture of how drought risk will affect a range of different UK regions at catchment and local scales. To achieve this goal, DRY incorporated a two-way process for gathering and sharing local drought knowledge. Stories about water resources and drought were stimulated through memories of historical drought events, discussions around drought images, citizen science, and imagining the possible outcomes of drought which arise from the hydrological drought models iteratively developed in the team. The stories themselves then provided contexts that fed into our mathematical hydrological drought models through which we explored scenarios of what might happen in potential future droughts.

Outputs from our research include the DRY Utility, a resource to support decision-making which incorporates the DRY searchable Story Bank; the DRY Story Map; and DRY Guidance on its approach, alongside papers in wide-ranging journals across disciplines.

Lindsey McEwen

Working with Gardeners & Allotmenteers

From the first seedling idea to harvest, a vast number of stories and knowledge grew out of Drought Risk and You (DRY). Supported by the National Allotment Society (NAS), this important and innovative research project, was led by the University of the West of England, Bristol.

Even so, the community of allotment holders and gardeners proved to be an even more plentiful source of information and fertile ideas than expected.

Many of their stories of past water scarcity, their anecdotal evidence of effective ways to manage drought and to build resilience into the soil have been curated into DRY Utility, a rich source of stories, film, narratives and guidance notes about different groups' and communities' memories of, and responses to, drought.

Prof Lindsey McEwen, Principal Investigator of DRY, says: "Gardeners and allotment holders emerged in DRY as a group of people who were thinking creatively about the issues around water scarcity and drought, and were passionate about the way they grow produce and manage the soil.

"Those we spoke to also had a strong culture of sharing and exchanging – everything from seeds and produce to knowledge about growing; more experienced growers on an allotment site readily share their advice on what to grow, what not to grow and how, with newcomers.

"Allotment holders and gardeners can be among the first to notice the signs of local water scarcity in their soil and in growing patterns, with the potential to be early harbingers of possible drought in their communities."

DRY formed local connections with different allotment groups, workshops were held around the UK and NAS representatives attended events including DRY's final conference in July 2019. It quickly became a co-productive relationship and a genuine knowledge exchange – a process that DRY has embedded in all its stakeholder relationships.

"It's one of our success stories," says Lindsey. "Allotment holders and gardeners are effective 'messengers' about water in our communities, they have hyper-local knowledge of the geography of their allotment sites, which plots are most affected and which less so; they share their memories of dry periods and how the ground and crops behaved; they are attuned to water within catchment areas and have a less hierarchical communication structure than many sectors."

That commitment to co-production extended to collaborating on materials and resources and Lindsey has been invited to speak to the NAS national group of mentors who operate regionally, visiting allotment sites to share advice and offer support so they can spread the messages about drought even further.

Lindsey explains: "It's a really good way of cascading knowledge, to embed in their culture an awareness of drought, combining specialist science and their experiential knowledge. I will be talking to the mentors about the role of growers in thinking about drought, how they might consider themselves as messengers, and as the eyes and ears on the ground for monitoring soil moisture and soil health."

Some mentors like Allan Cavill, NAS mentor and long-term contributor to DRY, promote natural soil management through long-term strategies such as no-dig cultivation, mulching, rainwater harvesting and growing drought-resistant crops. For example in the Fowey allotment, we heard stories of growing yacon, a root vegetable that tastes like a combination of apple and pear and can be eaten raw or cooked. DRY team members were also given samples to take home.

In addition, growers develop an awareness of their personal water use and can spread a spirit of water stewardship into their families and wider networks in horticultural societies, produce shows and neighbourhood communities, for example, thinking about water as a valuable resource and highlighting examples of good practice.

Lindsey says: "In a sense we have worked with some allotment holders' habit of sharing and swopping seeds and produce in a different context – sharing knowledge about drought."

Read more about DRY, including a blog on working with allotmenteers and gardeners, at www.dryproject.co.uk

Unblinkered Approach to Managing Water Resources

Wildlife Trust for Beds, Cambs & Northants

"In nature conservancy we spend a lot of time working on technical aspects and it is easy to get blinkered by that so it was good to meet farmers from neighbouring areas, not just those on our 'patch', and really useful to hear their perspective on when they need water and what for – I was able to understand the day-to-day practicalities."

Kate Carver, Great Fen Project Manager, Wildlife Trust for Bedfordshire, Cambridgeshire & Northamptonshire

From science to songs and a 'mock trial' of water use evidence – no-one could accuse About Drought's research of being blinkered!

Kate Carver, who was invited to contribute to the Bevills Leam Local Action Group (LAG) in rural Cambridgeshire, found herself acting as a 'witness' in a traditional Sardinian-style trial of evidence performed in Ramsay Rural Museum that enabled the community to expose and address the conflicting perspectives, interests and priorities around drought and water scarcity.

On another occasion Kate was invited to feature in 'Utopia', a festival/exhibition at Somerset House, London, marking the 500th anniversary of Thomas More's book 'Utopia', bringing people from around the UK. Several members of the Bevills Leam DRY LAG attended including Kate. They had an exhibition stand about the Bevills Leam LAG and the DRY project, and engaged with those attending the event.

DRY's creative community events elicited stories that were woven into a community song written by Sharron Kraus 'The River is a Snake' which you can hear on DRY's website - www.dryproject.co.uk.

It opened up a new world of social science engagement which enabled Kate to meet people and interests from a broad variety of sectors and affiliations, and this fed into the Great Fen's new Water Works project, funded by the People's Postcode Lottery Dream Fund, to promote sustainability.

Kate says: "Being involved with DRY has been experience- and mind-expanding! We at Great Fen had not worked with social scientists before so that was quite an innovation for us. It introduced us to a whole new group of people who had different ideas and ways of doing things and we learned a lot.

"The methodology was interesting and useful. We learned to not be afraid of new methods, not have preconceived ideas about different groups of people and different sectors. It was a freer way of working but still with academic rigour.

"The DRY project was a societal indicator that showed the benefits of bringing different groups together to work for sustainability, it pointed the way.

"In nature conservancy we spend a lot of time working on technical aspects and it is easy to get blinkered by that so it was good to meet farmers from neighbouring areas, not just those on our 'patch', and really useful to hear their perspective on when they need water and what for – I was able to understand the day-to-day practicalities.

"The area I cover is the driest part of the UK and one of the most productive agricultural areas. There is great pressure on the land for housing development but also great pressure on nature.

"Availability and use of water is a constant preoccupation in this part of the world and has been for centuries. Water has been being drained away since the 17th Century, the whole agricultural system is predicated on drainage, on pumping water away. But when peat dries out it emits carbon dioxide, if we re-wet the area it can mitigate carbon loss so in terms of climate change these natural systems will be critical in helping this country to adhere to its emission goals."

Kate is not the only stakeholder involved in About Drought's projects to suggest that the next step should be viewing water management as one issue, bringing drought and flood research together.

She says: "I believe the remit should now be expanded into an integrated approach to water management, bringing in other elements as well – pollination, carbon sequestration, biodiversity … all the eco system services that the landscape provides could benefit from the DRY LAG approach."

Interview by Sally Stevens

Created by John Elson, captured at DRY events

ENDOWS

Bringing it all together

ENgaging diverse stakeholders and publics with outputs from the UK DrOught and Water Scarcity programme - **ENDOWS**, brings together the successful stakeholder engagement elements of the four Drought and Water Scarcity (DWS) projects to further develop and promote understanding of the key messages from the programme. Building on the activities of DRY, IMPETUS, MaRIUS and Historic Droughts, ENDOWS was funded by the Research Councils to inform adaptation and management decisions before, during, and after drought events, using the new data and findings from the DWS programme.

ENDOWS has brought these activities together under the banner 'About Drought', an accessible programme of informed engagement with regulators, industry, business, policy-makers, communities and sector organisations.

Knowledge Exchange was a key function of About Drought, facilitating effective networking between the research and stakeholder communities; encouraging the building of reliable contacts and stimulating new working relationships, and accelerating the speed at which the outputs of the DWS programme are being implemented to support evidence-based decisions in drought planning and management.

Thus far, the project has enabled interaction on and transfer of scientific knowledge and outputs in the form of resources, information, and/or tools to water companies, the environmental regulators, allotment groups, farmers associations, and so on, as outlined throughout this book.

The About Drought website was developed as an authoritative source of expertise, and as a publicly available platform for informed comment and opinion. The About Drought Twitter account **@AboutDrought** highlights drought-related news and opinions from the UK and around the world.

Frome River Walk - DRY Project

Jim Hall

WATER SUPPLY

While the UK has a very well evolved framework for drought and water resources planning, there remains a need for innovative approaches to enhance robustness, particularly in light of concerns about future droughts exceeding historical precedents used for planning.

Similarly, while hydrological monitoring is advanced, forecasts and outlooks remain highly uncertain, hindering their uptake by planners, despite recent advances. The methodologies and evidence being developed in the DWS Programme have the potential to inform developments in the operational drivers in water resources planning and drought management which are currently underway.

The timescale of these reforms was very well matched with the timescale of the research projects, providing a window for testing, approval and uptake.

The Water Supply workstream has:

1. Developed standardised stress tests and tools for risk-based water resources planning;
2. Provided recommendations and guidance for hydrological modelling in practical applications;
3. Developed tools to monitor, forecast and manage drought.

Water Supply worked with a range of water industry stakeholders (water companies, regulators, consultancies etc.) to define the key priorities via workshops and other engagement activities early on.

Nevil Quinn

AGRICULTURE

Agriculture is often the first sector to experience severe impacts in a drought which can then propagate rapidly through the fresh produce supply chain to retailers. Significant socio-economic impacts and market responses can then impact on the primary production sector as well as many dependent downstream services including processing, packaging and distribution. Identifying drought risks, resilience and mitigation measures are therefore central, combined with improved forecasting and early detection of drought risk. It is also recognised that managing agricultural drought risk needs to be aligned with strategies to manage risks arising from both a meteorological drought and changes in water regulation; both water scarcity and drought responses need to be considered collectively.

The Agriculture work stream has:

1. Consolidated knowledge, data and understanding on drought impacts and responses;
2. Guided and influenced national agricultural policy through development of a water and drought strategy for agriculture and food;
3. Improved drought planning and decision-making in the agricultural sector.

The scope of the Agriculture work stream was informed by a meeting of all four DWS Programme projects with Defra in July 2016 and a workshop involving key informants and agricultural stakeholders including the NFU, UKIA, farmers, and agriculture-related businesses in December 2016.

Lindsey McEwen

BUSINESS

Large-scale business and SMEs are critical to the functioning of the regional and national economy. Evidence from engagement within the DRY project suggests that, particularly with SMEs, drought risk planning is not on their organisational radar. Alongside the importance of increasing business resilience to drought and water scarcity, UKWIR (2015) set out the need for business innovation and the seizing of opportunities in water markets.

The Business workstream has:

1. Translated risk-based understanding generated in DWS projects into accessible, risk and resilience-informed information systems tailored to the needs of large businesses, and of business people planning and running SMEs;
2. Translated knowledge and understanding generated across the DWS projects into specific, supporting decision-making tools and frameworks for business;
3. Engaged businesses directly in drought planning and decision-making, generating wider business discourse around drought, water scarcity and water efficiency.

The Business workstream used data and methodologies developed across the four DWS projects to work with different businesses/business groups (at different scales and types/scales of water use) and key partners (e.g. Innovate UK, Federation of Small Businesses) to co-produce innovative products and solutions to support drought risk adaptation and decision-making. Business linked with the Water Supply and Agriculture workstreams, through consideration of agricultural processing/supply chain.

Nevil Quinn

ENVIRONMENT

Much of the existing regulatory framework around drought seeks to ensure sufficient water for maintaining aquatic ecosystems. However, our understanding of drought impacts on ecology is based on a limited evidence base. The DWS Programme research demonstrated that river ecosystems may alter significantly during droughts with, for example, reductions in invertebrate density and richness. However, they can often recover after droughts over different timescales according to the species, which has potential implications for abstraction licencing as it may be as important to ensure rivers have sufficient water during recovery periods as during droughts themselves. In general, recent advances in scientific understanding are yet to be implemented into decision-making processes (e.g. triggers in drought plans, environmental flow thresholds). All three statutory organisations (EA, SEPA, NRW) have been formalising their approaches to drought planning, management and communication in recent years. These operational drivers are evolving and regulators acknowledge that there is opportunity for the development of locally relevant drought indicators that exploit the new developments delivered in the DWS programme, including a better understanding of ecosystem responses and impacts.

The Environment workstream has:

1 Consolidated knowledge, data and understanding on drought impacts on the aquatic and terrestrial environments, and their recovery from drought by preparing synthesis reports for: Rivers and Streams, Wetlands, Lakes and Reservoirs, Woodlands, Grasslands;

2 Showed how data from various parts of the About Drought programme can be integrated at the catchment scale to support understanding about local scale drought histories and futures, and how this can be used for planning drought resilience at the catchment scale;

3 Supported better water allocation: demonstrating how About Drought data and knowledge can be used to support decision-making including trade-offs and reconciling environmental flows and abstractions.

The Environment workstream built on, and integrated, multi-disciplinary work on the environmental impacts of drought across the four DWS projects, and used and extended the existing network of local scale stakeholders and study sites.

Lindsey McEwen

PUBLIC & COMMUNITIES

Drought and water scarcity are lacunae in current public thinking about, and planning for, risk. Publics and communities are also heterogeneous in character (demographic, social-economic, and cultural) and need different approaches to engagement. While there is increasing recognition by agencies that expert science and lay knowledge need to meet in decision-making around flood risk, drought risk communication and public engagement with the 'flood-drought' continuum bring different challenges that need to be addressed.

The Public & Communities workstream has:

1 Worked with the outcomes of the DWS projects to build capital (knowledge, skills, dispositions) about drought risk management across diverse publics and communities, and integrated different knowledges in decision-making;

2 Translated knowledge and understanding into improved drought event management. This was achieved through improved understanding of how different knowledges come together in situation monitoring, in how to respond to forecasts, and in how to use these evidence bases for decision-making and communication with public and communities;

3 Proposed and trialled new ways of working/communicating between statutory decision makers and different publics.

Outcomes of these activities represent a toolbox of resources:

- New guidance and resources on how to communicate about drought and water scarcity with different publics
- Production of a book resource on drought and water scarcity planning for households for increased water resilience
- Co-development of community-based modelling as a pedagogic tool
- Development of an accessible primer entitled: Water efficiency in the public sector - the role of social norms.
- New resources to promote change in public discourse on drought and water scarcity including: a book entitled 'DRY: a Diary of a Water Superhero' to engage primary school children and teachers around drought; case-study materials produced collaboratively with the Geographical Association to promote secondary school level learning; web resources produced with NSALG to promote water resilient thinking on the allotment; creative engagement campaigns as pilots to promote water behaviours among young people working collaboratively with Falmouth University students.

Matt Fry

DATA

The aim of the Data workstream was to create a comprehensive state-of-the art data resource on UK drought, delivering consistent access to the wide range of metrics, indicators, model outputs, narratives and histories being developed across the programme, as well as tailored access to these resources via tools and multimedia outputs, to maximise their use within specific sectors and activities.

The Data workstream was an integrating activity, engaging with the other sectoral workstreams, gathering requirements from end users via those WSs and building data storage infrastructure and services for data access, and interfaces to the data (e.g. visualisations and tools) appropriate to the user needs.

The Data workstream has:

1 Integrated data from the existing drought projects and delivered a coherent set of outputs from the DWS programme as a whole; storing this data consistently in a way that can be delivered to end users and used to advance decision making across different sectors;

2 Co-developed a series of data access protocols for the datasets stored, enabling programmatic access across the sectors addressed by the ENDOWS workstreams, and tools to allow easy access to subsets of large datasets;

3 Developed the interfaces and communication tools being co-designed in the ENDOWS Workstreams, to allow visualisation and enhanced access to programme datasets by end users across sectors based on requirements co-produced by stakeholders.

The DWS Programme projects have produced substantial datasets with the potential to transform drought planning and management. Each project will be archiving its significant outputs to ensure ongoing accessibility. However, genuine uptake by end users from across sectors required data delivery tailored to specific needs.

ENDOWS has identified opportunities to integrate data outputs from across the programme and exploit these within decision-making processes. There is a need to ensure the ongoing legacy of the DWS Programme data, enabling continued accessibility to end users, not only via research data centres but through the many data delivery mechanisms and interfaces (websites, apps, etc.) appropriate to user needs as identified in the sector-specific WSs.

Sally Stevens

EVENTS & ENGAGEMENT

The aim of the Engagement & Events workstream was to develop a comprehensive series of cross-sectoral engagement activities to help accelerate the uptake of the tools and methods developed in ENDOWS to support evidence-based decisions in drought planning and management by a diverse set of stakeholders. This included a set of targeted events and dissemination material to maximise the impact of the DWS Programme. The Engagement & Events workstream offered a highly integrated approach to engagement and communication, providing both a focus on key stakeholders and a broader synthesis for wider audiences.

The About Drought Showcase March 2018 – an inclusive, cross-sectoral interdisciplinary conference that brought together the full range of drought stakeholders from Third Sector organisations such as the RSPB to water companies, the Environment Agency and OFWAT to hear the latest developments and provide their feedback. Held in Birmingham it featured Dr Kevin Grecksch's Canal Walk, an immersive discussion on the impact of water scarcity on city waterways and water supplies while walking along the city canals.

The About Drought Download November 2019 – all the data, all the learnings, all the resources, all in one place. The final event of the 5-year UK Drought and Water Scarcity Research Programme held at The Royal Society, London, an accessible, stimulating programme, offering visitors engagement with hands on multi-disciplinary programme outputs, as well as being able to listen to and question programme experts in a wide range of drought-related fields, network with people in the drought faculty (researchers and managers), and engage first-hand with users of the outputs from the programme.

Drought and Water Scarcity: addressing current and future challenges, International Conference March 2019 - An academic-focused but cross-sectoral coming together of leading international experts presenting and discussing their research, organised by Helen Gavin to give global as well as UK exposure to About Drought's research. There was an impressive range of data, topics, in-depth knowledge and communication insights which demonstrated the breadth and interdisciplinary nature of research into drought and water scarcity. Delegates heard that drought and water scarcity are expected to become more severe due to the influence of climate change and pressure on water resources from economic and demographic changes.

DRY Final Conference, July 2019 - An innovative and accessible presentation and celebration of DRY's work with diverse sectors in seven catchments in England, Scotland and Wales, incorporating the DRY Exhibition. It brought together science and narrative, storytelling and song, cartoons and film, advice for allotmenteers and resources for school children.

ENDOWS

What difference has it made?

Many applied research projects produce fantastic work of great value, but the best research in the world is worth nothing if it is not put to use to address the challenges that society face – they often fail when the question posed – usually at the conclusion of the work – is 'So what?'.

Top to bottom:
1. About Drought at IRRIGEX 2019.
2. MaRIUS Water Suppliers Workshop, Oxford 2018.
3. About Drought Showcase,2018
4. Science Media Centre breifing 2018

From the kick-off in July 2017 ENDOWS Work Stream 7 (WS7) set out to address the 'So what?' challenge, bringing together members of the original four projects - **DRY, MaRIUS, IMPETUS and Historic Droughts** - to communicate and share the knowledge generated by £12m-worth of UK Drought and Water Scarcity research, developed into accessible and meaningful resources to be put into use during the lifetime of the project as well as beyond, making both an immediate and lasting impact.

Thus, when December 2017's Hydrological Outlook indicated that drought was looming, About Drought was in a strong position to put some elements into early implementation. WS7 was also ready to capitalise on the raised awareness that developed as summer 2018 approached, not only among the public sector, water suppliers, agriculture sector and industry but among the wider public.

Skilled researchers from humanities and science worked alongside each other from the outset, as well as alongside the people to whom the outputs would make a difference. In prioritising the language of drought, About Drought has been able to facilitate the communication of the science of drought.

Relevance and ease of functionality of decision-support data were built into DRY, MaRIUS, IMPETUS and Historic Droughts through co-design workshops. ENDOWS funding enabled that to become fully developed into a series of data visualisations, portals, tools, searchable archives, written material and face-to-face events, supporting decision-makers at every level and across sectors. These included the Environment Agency (EA), Yorkshire Water, Anglian Water and South West Water, which were able to access the UK Water Resources Portal *(https://eip.ceh.ac.uk/droughts)*.

A 'brand' new approach

With expert insight from members of WS7 from the **University of the West of England's Science Communications Unit;** capitalising on the **Institute for Environmental Analytics**' success in speeding up the progress of environmental data research from academia to business; the **Environmental Change Institute's** well-established routes into policy-makers and the **Centre for Ecology & Hydrology's** high profile in environmental research, WS7 prioritised:

About Drought branding - strong, visual, recognisable and clearly labelled branding that 'does what it says on the tin'. No convoluted acronym, just a clear, strong label, with the strapline 'Maximising UK research on drought and water scarcity': readily identifiable and widely accessible. It is applied to our key platforms, printed and online content making our suite of outputs eye-catching and easily identifiable, from pull-up banners to briefing papers. WS7 has designed branded templates for printed content from posters to postcards and an online e-magazine platform for paper-free delegate programmes.

www.AboutDrought.info - a one-stop source for reliable information on drought and water scarcity. It features the staple elements such as subscriptions to the quarterly newsletters produced by WS7 for

internal and external content, blog articles, event promotion, links to data tools and resources for management and strategic planning. The website's rich content extends to public-facing podcasts of first-hand memories of the 1976 drought and our news video documentaries.

@AboutDrought Twitter - an informal but informed Twitter forum for sharing and commenting on drought and water scarcity around the UK, interacting with a wide range of audiences and events. It also provides live commentary and interaction from About Drought events allowing people not in attendance to follow and join in discussions.

Young people as agents of change - WS7 took its mantra of meeting our audiences where they are already looking' to its fullest extent. Working with DRY, Dr Rebecca Pearce tasked millennials as 'agents of change' to promote responsible water use and raise awareness of what drought is and is not. School of Communication Design students at Falmouth University produced witty and attention-grabbing video campaigns to communicate our important messages to their peers - a notoriously hard to reach audience (http://aboutdrought.info/water-saving-media-campaign-entries-are-a-splash-hit/). DRY is producing an attractive educational book, e-book and teacher resource for primary school children - 'DRY: The Diary of a Water Superhero'.

In 2018, we capitalised on the interest of mainstream media journalists as UK drought moved up the news agenda. IMPETUS lead Prof Len Shaffrey put forward an article to **Conversation UK** in July 2018 on the likelihood of droughts becoming a more frequent weather hazard in the UK, which was reported widely, even putting climate change on the front page of The Sun. A panel of About Drought experts - ENDOWS Principle Investigator Jamie Hannaford, Prof Jim Hall and Prof Ian Holman - were put in front of national journalists for a **Science Media Centre** Briefing in September 2018 to provide expert background knowledge and to answer their questions

Going out to reach our audiences not just expecting them to come to us

ENDOWS set out with an innovative approach - not just promoting the outputs of the UK Drought and Water Scarcity Research Programme and engaging stakeholders and users, but going one step further by identifying where and how those audiences were already sourcing their information and meeting them there.

The About Drought stand could be found at agricultural industry trade show **IRRIGEX** in February 2019 in Peterborough, UK, and at the **Natural Hazards Partnership** Conference for emergency services, civil contingency response organisations, government and local authorities in Southampton in March 2019. The programme's work was presented by Prof Ian Holman & Prof Jerry Knox at IRRIGEX and by 11 programme members at the **European General Assembly (EGU)** in Vienna, Austria, in April 2019.

Regionally, bespoke About Drought events were held in Cardiff with a **NRW/ Welsh Government Workshop** in December 2018 and in Edinburgh with a **SEPA/Scottish Water Workshop** in May 2019.

The DRY Project held workshops with **Bristol City Council** to develop a drought strategic planning toolkit for use by local authorities; with the **National Allotment Association** to share new science on forecasting and predictions, as well as to learn from allotment holders about early signs of water scarcity and growing with less water. Read DRY's series of diverse blogs cataloguing the project's wide-ranging engagement.

Historic Droughts' diachronic analysis of newspaper articles about drought and water scarcity was presented at the **9th International Corpus Linguistics Conference** in July, 2017, in Birmingham and at the **World Water Congress** in May 2017 in Cancun, Mexico. Further research was presented at **EGU in April, 2017**, and at the **Oral History Conference** in July, 2016, in London.

These widespread activities meant that by the time of the 2018 drought ENDOWS had already built trusted working relationships and we were able to respond to requests to put some outputs into early implementation.

Some of our other outputs

News videos, podcasts & myth-busting films - See page 4

The About Drought Showcase March 2018 & The About Drought Download November 2019 - See page 35

Briefing Papers - See page 50

A creative but business like approach to communication

Drought is a weather hazard by stealth, it creeps up under the radar until it is an impending crisis. In funding About Drought, NERC and the UK's research councils brought together the UK's flagship institutions and organisations who have provided a comprehensive raft of resources matching the needs and requirements of decision-makers to the extent that when called on by the EA, Yorkshire Water, Anglian Water and South West Water in the 2018 drought, we were ready to respond immediately.

WS7 has been proactive in facilitating the two-way exchange of information and built a broad platform to signpost, showcase and implement the take-up of the outputs, proactively taking our information to our audience rather than expecting them to come and find us. Content has been streamed for different sectors and for users at varying levels, crossing the boundaries of humanities and science, as well as sector boundaries, including bespoke regional briefings and national events.

Our creative but business-like approach to research communications has enabled the widest achievable reach, from podcasts to searchable data, to a book for primary schools. We would like to thank all our colleagues on the programme for embracing this approach and to thank all our stakeholders and users for being such an involved audience.

Drought in Wales
Natural Resources Wales

'About Drought's workshop in Cardiff helped to really engage the interest of my peers and colleagues who deal with drought in Wales'

Tracey Dunford, Natural Resources Wales (NRW), Lead Specialist Planner Water Resources

About Drought has given people creating water policies and strategies, face-to-face access to scientists at the forefront of drought research through a series of workshops held around the UK.

Tracey Dunford, who has worked in water resources for Wales for 20 years, attended a wide range of workshops organised by MaRIUS and DRY, returning to Cardiff to share information about the programme's latest datasets and communications research with her colleagues.

She says: "All the Drought and Water Scarcity and ENDOWS events I went to were extremely useful. I have been feeding back to my colleagues on the various outputs and they have been considering how to incorporate them into their decision making. The workshop About Drought held for NRW and the Welsh Government in Cardiff was especially useful as it was targeted to the Welsh audience.

"All our drought leads in NRW across Wales attended, including colleagues from biodiversity, fisheries, water resources, water quality, forestry and policy. It helped to engage people's interest across our whole organisation and keep us all up-to-date with the current science."

The Natural Resources Wales / Welsh Government Workshop was held in December 2018, with delegates hearing directly about the research and outputs from About Drought and inviting them to help shape the final phase of activity. Initially the delegates heard from NRW who introduced the areas of their organisation that are most likely to be engaged with About Drought, which then gave way to introductions from the About Drought team. Our Principal Investigator, Jamie Hannaford from the UK Centre for Ecology & Hydrology (UKCEH) introduced the programme. The agenda covered Water Supply with Dr Helen Gavin from the Environmental Change Institute at Oxford University, Environment with Dr Nevil Quinn (University of the West of England) and Dr Francois Edwards (UKCEH), and Agriculture with Prof Ian Holman (Cranfield University). Following these introductions, the floor was opened for discussions and Q&A, to further discuss next steps for NRW's and the Welsh Government's involvement.

A separate meeting was held with NRW community colleagues in early 2019 with Prof Lindsey McEwen, Ruth Larbey and Emma Weitkamp of the DRY (Drought Risk & You) Project, working with communities and business.

"These two helped to really engage the interest of my peers and colleagues who deal with drought in Wales, for instance our Hydrology and Agriculture Leads are now in direct contact with UKCEH and Cranfield University, providing their feedback on, for example, the Drought Portal, and with UWE to provide feedback on the environmental drought report cards," says Tracey.

"Our next stage is to consider all the data and outputs that have come out of About Drought and take stock of how we can use it. We need to put it into the context of Wales – for example, what are the drought impacts in Wales and the sectors most at risk? What does it

Credit: Karl McCarthy

mean for our natural resources including land, water and forestry? It can be easy to get overwhelmed by all the evidence.

"During 2018's prolonged hot dry weather we found the Drought Portal and the monthly Hydrological Outlooks useful, for example, for collating the Standard Precipitation Index triggers."

Being able to sit in a series of workshops around the same table as About Drought's leading experts behind the data sets, has been invaluable for Tracey and for the programme team as well.

"I WAS ABLE TO EXPLAIN TO THE RESEARCHERS THAT WHAT WORKS FOR ENGLAND ISN'T NECESSARILY RIGHT FOR WALES. DROUGHT PLANNING ISN'T THE SAME, SOME OF THE POLICY AND GOVERNANCES ARE QUITE DIFFERENT"

Tracey says: "It's been beneficial both ways, not only did I get to know about so many things – including the drought communications work – but I was able to explain to the researchers that what works for England isn't always necessarily right for Wales. Drought planning isn't always the same, some of the policy and governances are quite different.

"I am concerned about losing contact with everyone now the programme has ended. Will I have ability to still contact people if we don't understand something or we want a bit more background?

"The briefing papers and one-pagers on topics have been very useful but I need to think 'How is that useful for Wales? What are the most likely drought impacts? Where will they be? What are the short, medium or long-term impacts?' As an organisation we in NRW need to take that forward.

"It would be good to have it packaged up for Welsh policy, a synopsis of how drought affects Wales rather than topic by topic. In terms of decision-making we are re-visiting how we 'do' drought in Wales and we are going to find the About Drought datasets useful now that we are evolving our drought policy."

Interview by Sally Stevens

AUDIO ANECDOTES

What is it like to listen for a living?

Rebecca Pearce
Postdoctoral Research Fellow
University of Exeter

Between October 2014 and October 2017, Dr Rebecca Pearce travelled across Britain, tracing the impacts of historic droughts as they were recalled by people living in a diverse range of communities.

Attendees of the About Drought conference in March 2019 and the About Drought Download in November 2019 have been able to join Rebecca in that experience through her special conference sound installation of audio anecdotes.

By listening to a selection of extended interview highlights from the Historic Droughts project's oral history collection, attendees were able to immerse themselves in the conversations, from horticulture to heatwaves and hydrology to heath fires. Listerners are able to learn about the power of memory work, narratives and storytelling, through the three unique pieces.

You can listen to the About Drought Podcasts on SoundCloud at **soundcloud.com/user-505147606**

"THE [FIREFIGHTER] LEGGINGS THAT WE USED TO WEAR BACK IN THE 70S WERE MADE OF PLASTIC AND THE HELMETS, BELIEVE IT OR NOT, WERE MADE OUT OF HARDBOARD ... YOU WOULDN'T BELIEVE THAT THEY WOULD MAKE LEGGINGS OUT OF PLASTIC BUT THEY WERE YELLOW PLASTIC AND THEY USED TO MELT VERY EASILY."

And as the heatwave goes on . . .

Seven hours water a day

A MILLION people will receive only seven hours of water a day from Monday.

Daily Mail Reporter

Daily Mail • *20th August 1976*

GARDENING: Percy Thrower

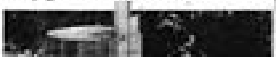
There's no need to be all hot and bothered

THERE'S nowt so queer as folk, as they say in the North.

Cabbages

Reasonable

Drop garden waste in...



Daily Mail • *10th July 1976*

WATER CUT IT BY HALF NOW

- Don't have a bath – have a short shower or a wash.
- Flush the toilet only when it's absolutely essential.
- Keep wash days to an absolute minimum – wash by hand if possible and use waste water for flushing toilets.
- Don't use a dishwasher or waste disposal unit.
- Don't put sanitary towels, disposable nappies, etc. down toilets – low flows in sewers will cause blockages.
- Don't leave taps running for: Washing/Rinsing vegetables/Cleaning teeth/Washing off sand and dirt.
- Turn your stopcock by 90% to reduce the flow (it's usually found under the kitchen sink).
- Don't leave taps dripping or overflows running.
- Use waste water wherever possible.
- See how you can save 20 gallons a day. Here's where the water goes:

The drought: Reprieve for South Devon

BUT PEOPLE ARE ASKED TO SAVE MORE AS TURN-OFF IS PUT BACK

Cut climbs

COURT SLAMS CLUB

Attack on food: p... check st...

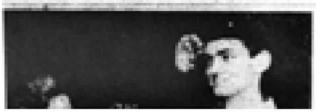
Meldon's dramatic rise may end standpipes

By JAMES ..., Our Environment Correspondent

MR. ROY BLOOMER ... campaigning for Meldon ...

AND NOW ... FLOODING

Ford narrows gap



If your hearing ... losing ... sharp...

Western Morning News • *October 1976*

Informing the Power Sector
RWE Generation UK

Neil Edwards, Environment & Chemistry Technical Support, RWE Generation UK

Neil Edwards has represented RWE Generation UK in stakeholder discussions with MaRIUS and DRY, as well as attending conferences and workshops. He believes those connections have enabled About Drought's outputs to be of greater benefit to the power sector, including building better resilience of services that rely on water-dependent infrastructure.

He says: "The next few years could be important in how the UK positions itself to deliver resilience of services – such as public water supply, power and food – in a period in which we are going to be economically and institutionally challenged. There is much to be done and having access to the existing About Drought materials can only better inform the deliberations.

"I've developed useful contacts through networking at the major events and workshops with practitioners that I didn't have before. The networking and events together, gave me opportunities to contribute to improving the wider understanding of the interaction between power plants and the aquatic environment, which is sometimes not well-represented in academic literature.

"I believe this to be of value to RWE and to the wider power sector. It led to some power sector-focused work being done within the research programme, which has given power sector players a better information base to think through some aspects of water quality in drought and hence, contribute to developing better understanding of resilience issues.

"I also hope that the forecasting initiative with UKCEH will lead to improved river flow and seasonal weather forecasting information for relevant power sector locations, which will aid better risk management of commercial positions in low flow events; though this has not advanced as fast as I would have liked."

Neil has also been able to draw on access to communications resources. He says: "I have used the softer communications / story telling materials to get an understanding of wider social considerations surrounding major drought events as background in participation in freshwater-related stakeholder activity, such as interaction with DEFRA/EA on water resource management and regional water planning."

Collaboration with MaRIUS supported RWE's work on risk to power generation and scenario building. Neil says: "We have used the tailored water quality modelling work to better understand potential risk – this is now factored into our thinking and into our interaction with DEFRA/EA on aspects of resilience. We are aware of the grid-to-grid river flow work and climate change-related work, and we would access it if we felt the need."

Interview by Sally Stevens

THE DRY UTILITY

The Drought Risk and You (DRY) project's objective was to develop an innovative, easy-to-use, evidence-based resource. containing different types of knowledge, from science, and people's experiences, to support decision-making for drought risk management. as a hidden risk in the UK. This approach recognises that there can be different kinds of drought 'expert'. It did this by working across six sectors (agriculture, business, health and wellbeing, communities, environment, built environment) in seven case-study catchments across England, Scotland and Wales.

Following on from that, DRY has been a unique contributor to **EN**gaging diverse stakeholders and publics with outputs from the UK **Dr**ought and **W**ater **S**carcity programme (ENDOWS), known publicly as About Drought, drawing together information from multiple perspectives on drought science, stakeholder engagement, narrative storytelling and citizen science, to better understand drought risks, while other studies have focused on mathematical modelling of drought risk.

All these streams have been gathered into the DRY Utility, a user-friendly online curation of the outputs of DRY's research.

VISIT DRY UTILITY:
dryutility.info

What is DRY utility?

DRY's research has had a strong focus on communications and storytelling, and its 'data' covers a wealth of information. It has a river catchment-based focus, working in seven case-study river catchment areas in England, Wales and Scotland, to reflect different hydrological, socio-economic and cultural gradients in the UK, and to capture local knowledge on drought, water scarcity and water behaviours. DRY Utility is a living archive or bank of resources curated as a result.

Principal Investigator Prof Lindsey McEwen explains: "A key part of our work has been bringing different types of data together to build a better picture of drought risk in the UK. In our project, 'data' can mean statistics derived from a hydrological model to stories and images collected from a river catchment area, and we think each of these is equally valuable in helping us understand how we can better cope with drought."

The Dry Utility comprises three elements:

- **The DRY Story Bank** – an archive of 300+ stories (videos, recorded memories, creative thinking about adaptation, cartoons), searchable by catchment, sector or other keyword.
- **The DRY Story Maps** – over 49 panels triangulating science, stories and geography for DRY's seven case-study catchments across different sectors.
- **The DRY Guidance** – providing insights into experiences and outcomes of DRY's research processes.

Who is it for and what difference will it make?

DRY Utility is a rich multi-sector resource for anyone working on water scarcity and drought, whether looking for communications insights, educational material, historic contexts or adaptive insights to support decision-making at different scales – local to national.

Lindsey says: "To build resilience to water scarcity and drought, all sectors need to think about engaging with people in different ways, you cannot lump everyone together. This is really challenging if your aspiration is that all people will become aware of drought to some extent, and it means we all need to think about data in different ways to engage people in changing behaviour."

The online platform can be used to search for particular stories and information or to just explore.

Lindsey says: "We found that different communities have widely varying levels of comfort with scientific and numerical information, there is a whole variety of different takes and it is how you work your way through 'evidence' that influences their capacity to engage. It is really challenging territory and we found the best way to engage with some publics was to use colour and to remove graphs and numbers totally.

"DRY Utility provides a window into the different ways that people in the UK are talking about water, past and future droughts and water shortages; here is a set of stories, many stimulated by engagement with science."

THE UK WATER RESOURCES PORTAL

The UK Water Resources Portal was launched in September 2019 and is a web-based system tracking the latest hydrological situation in near real-time across England, Wales and Scotland.

Matt Fry, Environmental Informatics Manager, at the UK Centre for Ecology & Hydrology (UKCEH) says: "The different iterations of its development have been demonstrated at a number of our About Drought workshops, including those focussed on the water industry, and they have really helped us to develop our thinking around how to best display near real-time water resources status information."

https://eip.ceh.ac.uk/hydrology/water-resources

What does it do?

The Water Resources portal makes use of very recently published real-time river flow data from the Environment Agency (EA) and puts it in the context of longer term water availability, using data from the UKCEH National River Flow Archive, including knowledge about drought indicators that have been developed through the About Drought programme.

It includes standardised Indicators, but allows users to switch to actual values, which can make them easier to understand.

Matt adds: "The availability of this real-time data is a new frontier in public access to water data. We have made this even more useful by providing background context, for example an understanding of how today's river flow is low compared to its long term record. It allows a consistent set of water resources metrics to be available to everyone and it does this through a very easy to use intuitive interface, visualising the current water resources in an easy to understand set of maps and graphs.

"It also enables the more technical user to delve into the detail of what is going on in real time in England. For Wales, Scotland and Northern Ireland it is based on the previous month's data but we hope that the monitoring agencies there will be moving towards real-time data soon and we are keen to include it. You can also see what the rainfall has been like and compare the two graphs."

Who is it for?

You do not need technical skills to use the UK Water Resources Portal. Anyone with an interest in current water resources or drought conditions can use it – from policy-makers to members of the public, businesses to farmers and regulators to consultants.

It has a green to red scale of alerts based on the EA's water situation reports.

What difference does it make?

Matt says: "It really helps to raise awareness of the status of river flows and rainfall, particularly during drought episodes, and we believe it is an excellent communications tool for all sorts of end users and decision makers."

At the time of writing, the portal is in a demonstrator stage, with more fine tuning to be completed. Matt says: "In time we think it will supercede the Drought Portal."

THE DROUGHT PORTAL

https://eip.ceh.ac.uk/apps/droughts/

The UK Drought Portal is a near real-time tool allowing users to explore up-to-date data and monitor current regional dry weather status across the UK. It went live in 2015 based on earlier work and understanding of user requirements for historic drought information. It is focused on standardised drought indicators and enables consistent comparison of different areas regardless of how wet they are.

It was used in 2018 as a tool for communicating complex water data comparisons to help decision-makers understand current water resources against drought conditions.

DROUGHT DATA HUB

The Drought Data Hub provides a simple, visual summary of the huge data outputs from About Drought – and allows users to quickly get access to the data for a specfic area or river. It also shows a snapshot of what future flows are going to look like for any of 300 rivers across Great Britain (Northern Ireland data is not currently available). You can view both spatial coverage and detailed information.

https://eip.ceh.ac.uk/hydrology/drought-data-hub

What does it do?

The datasets have been set out in a way that is easy to understand and access, enabling users to extract specific subsets of data for a particular location.

The Drought Data Hub also visualises some of the expected climate change impacts on UK river flows, produced in the MaRIUS project. Users can see the changes in flows for any selected month for a near future (2050s) or far future (2080s) period.

It also integrates modelled outputs from across the programme.

Who is it for?

It is available for use by anyone who wants to access data from About Drought, including researchers, water companies, consultants, regulators and students.

Matt Fry, Environmental Informatics Manager, at the UK Centre for Ecology & Hydrology (UKCEH) says: "One of the new features we are particularly excited about is the ability to extract catchment average data, for instance, rainfall for an area of interest. Previously to get a small subset of, for example, CEH gridded estimates of area rainfall (GEAR) users would have to download hundreds of gigabytes of daily 1km grids for the whole of the UK; now they can upload a shape file (up to a certain size), and view and download a catchment average rainfall for that area within seconds."

DROUGHT INVENTORY EXPLORER

Historic Droughts has produced the Drought Inventory – a wide ranging set of information on past drought impacts from sources such as 19th Century newspapers, agricultural statistics, the parliamentary record Hansard, drought orders, hosepipe bans and the agricultural press such as Farmer's Weekly.

https://eip.ceh.ac.uk/hydrology/drought-inventory

What does it do?

It is set up to allow users to search the whole inventory either for key words or for specific drought episodes, or to look at specific types of media.

Searching allows you to see the timing of these impacts throughout the drought event.

Matt adds: "While our other hydrological data such as rainfall or flow indicators might tell us that rivers were low in 1933, for example, the Drought Inventory Explorer can help users see when drought was reported in newspapers through that year and see that the reports peaked in September 1933. You can get a feel for the way the drought was described and who it affected."

Who is it for?

Anyone interested in researching past drought including authors, schools, researchers of history, and people interested in public engagement around drought.

What difference does it make?

The Historic Drought Inventory is a valuable and fascinating resource providing detailed excerpts of information about past droughts that had previously little data.

Each item of information has been standardised to include the date the impact was reported, the source of information and – where available – a location, and a short excerpt of the report.

Matt says: "While this diversity of sources can make direct comparisons difficult, there is a huge range of information about past droughts that we wanted to make more accessible."

The NERC UK Drought and Water Scarcity Programme has released a large number of datasets, together with interfaces for accessing and visualising data over the web, and guidance for use of the data. For more information on these datasets visit aboutdrought.info or email **Matt Fry (mfry@ceh.ac.uk).**

Historic hydro-meteorological data

Rescued and recovered data

- incorporated into national climatological database and made open access https://catalogue.ceda.ac.uk/uuid/dbd451271eb04662beade68da43546e1
- incorporated into national climate product (HadUK-Grid) https://catalogue.ceda.ac.uk/uuid/2a62652a4fe6412693123dd6328f6dc8

Historic gridded Potential Evapotranspiration (PET), monthly and daily 5km grids, 1891-2015, based on temperatures [UKCEH] https://doi.org/10.5285/17b9c4f7-1c30-4b6f-b2fe-f7780159939c

Historic Standardised Precipitation Index (SPI)

- 5km grid + catchments, 1862-2015 [UKCEH] https://catalogue.ceh.ac.uk/documents/233090b2-1d14-4eb9-9f9c-3923ea2350ff
- IHU Groups, 1862-2015 [UKCEH] https://catalogue.ceh.ac.uk/documents/a01e09b6-4b40-497b-a139-936985810 1b3
- IHU Hydrometric Areas, 1862-2015 [UKCEH] https://catalogue.ceh.ac.uk/documents/a754cae2-d6a4-456e-b367-e99891d7920

Historic Standardised Streamflow Index (SSI) for 303 catchments (1891-2015) [UKCEH] https://catalogue.ceh.ac.uk/documents/58ef13a9-539f-46e5-88ad-c89274191ff9

Historic reconstructions of daily river flow for 303 UK catchments (1891-2015) [UKCEH] https://catalogue.ceh.ac.uk/documents/f710bed1-e564-47bf-b82c-4c2a2fe2810e

Reconstructed/modelled **historic daily river flow** for 1366 UK catchments the UK from the using the Decipher model, 1962-2015 [University of Bristol] https://doi.org/10.5285/d770b12a-3824-4e40-8da1-930cf9470858

Reconstructed/modelled **historic monthly gridded river flow and soil moisture** for the UK from the Grid-to-Grid model, 1km grid, 1891-2015 [UKCEH] https://catalogue.ceh.ac.uk/documents/f52f012d-9f2e-42cc-b628-9cdea4fa3ba0

Reconstructed **historic groundwater level** series for 54 boreholes, 1891-2015 [BGS] https://catalogue.ceh.ac.uk/id/ccfded8f-c8dc-4a24-8338-5af94dbfcc16

Historic Standardised Groundwater level Index (SGI) for 54 UK boreholes reconstructed groundwater level time series (1891-2015) [BGS] https://catalogue.ceh.ac.uk/documents/d92c91ec-2f96-4ab2-8549-37d520dbd5fc

Climate change projection data

Probabilistic time series based on the Weather at Home (W@H) event set (100 ensemble members for each time slice) for a baseline period (1974-2004) and two future periods (2020-2049 and 2070-2099) under the RCP8.5 high emission scenario.

- Large set of potential past and future climate time series for the UK from the weather@home2 model, on ~25km grid (University of Oxford) http://catalogue.ceda.ac.uk/uuid/0cea8d7aca57427fae92241348ae9b03

- Grid-to-Grid model estimates of daily mean river flow for gauged catchments in Great Britain: weather@home2 (climate model) driving data [UKCEH] https://doi.org/10.5285/f6cac471-7d92-4e6d-be8a-9f7887143058

- Grid-to-Grid model estimates of monthly mean flow and soil moisture for Great Britain: weather@home2 (climate model) driving data [UKCEH] https://doi.org/10.5285/3b90962e-6fc8-4251-853e-b9683e37f790

New Social and Socio-economic datasets

The multi-disciplinary UK Drought and Water Scarcity research programme has produced a wide range of data outputs from research activities in many disciplines.

Cross-sectoral inventory of past droughts

Water abstraction restrictions and related economic losses in irrigated agriculture in England and Wales, including spatial dataset of irrigated crop areas. https://cord.cranfield.ac.uk/articles/Water_abstraction_restrictions_and_related_economic_losses_in_irrigated_agriculture_in_England_and_Wales/7613192

Historic droughts and irrigated agriculture - Interviews with growers in the Anglian region, UK. https://cord.cranfield.ac.uk/articles/Historic_droughts_and_irrigated_agriculture_-_Interviews_with_growers_in_the_Anglian_region_UK_/5182714

Inventory of reservoirs amounting to 90% of total UK storage https://doi.org/10.5285/f5a7d56c-cea0-4f00-b159-c3788a3b2b38

Simulated monthly biological indicators for England and Wales 1964- 2012 https://doi.org/10.5285/2ad542be-e883-4c6e-b198-7d49da62208c

References to past droughts from a variety of sectors, integrated into a consistent format to capture spatial and temporal reporting of drought:

- References to droughts in the agricultural media 1975-2012. 2000+ entries referring to drought within UK agricultural media between 1975 and 2012, including information on farm classification. https://doi.org/10.5255/UKDA-SN-853167

- References to droughts in legislation. 500+ entries referring to drought within UK legislation between 1976 and 2012, from Hansard debates and other government publications. https://doi.org/10.5255/UKDA-SN-853184

Cross-sectoral inventory of past droughts cont.

• Historic droughts inventory of references from British nineteenth-century newspapers 1800-1900 https://doi.org/10.5255/UKDA-SN-853195

• Historic droughts inventory of references from British twentieth-century newspapers 1900-1999 https://doi.org/10.5255/UKDA-SN-853196

• Historic Droughts Inventory of references from British newspapers (1990–2014)
  • Tabloids http://doi.org/10.5255/UKDA-SN-853403
  • Broadsheets http://doi.org/10.5255/UKDA-SN-853399

• Historic droughts inventory of drought references to water resources 1890-2015 https://doi.org/10.5255/UKDA-SN-853673

Near real-time drought-related metrics

The following drought-related metrics have been focussed on within the Drought and Water Scarcity programme, and are accessible in near-real time.

• **Standardised Precipitation Index (SPI)**, 5km grid + catchments, monthly [UKCEH]

• **Standardised Streamflow Index (SSI)**, selected gauging stations, monthly [UKCEH]

• **Standardised Groundwater Level Index (SGI)**, selected boreholes, monthly [UKBGS]

Available through the UK Drought Portal: https://eip.ceh.ac.uk/droughts

Contains modified Copernicus Sentinel data (2018), processed by ESA

Applicable Information for Agriculture
AHDB

Nicola Dunn, Resource Management Scientist, Agriculture & Horticulture Development Board (AHDB)

Farmers felt the benefit of AHDB's involvement in the About Drought research programme, receiving up-to-date accurate and relevant information during the summer of 2018 from AHDB, thanks in part to the relationships formed with the UK Centre for Ecology & Hydrology (UKCEH) and Cranfield University.

"We were able to pull information together for farmers; explaining the current situation, where they could get help and actions to take when facing water shortages, stressed crops and stressed livestock," says AHDB's water expert Nicola Dunn, who previously worked for the National Farmers' Union (NFU). "We were really able to focus on the information that would make a difference.

"I had already made links with Cranfield, who were doing a lot of work on the agricultural side of the drought and water scarcity research programme, so knowing what they had already published, I was able to use it to help our audiences – the information was already there for us and I knew where to find it.

"We put this work into farmer-friendly language, covering what could be done to save water, reduce irrigation programmes and contextualise some of the decisions farmers were making, and suggest modifications they could make right there and then."

Nicola attended the About Drought Showcase in March 2018, as well as workshops around drought communications, monitoring and the Drought Portal.

She says: "There is so much to gain from discussions with other stakeholders, so much to learn from each other, that's a big positive for the AHDB."

The crop and livestock sectors felt very different impacts during and after the summer 2018 drought. Crop growers are more used to managing reduced and restricted water availability but cattle farmers, especially in the North West of England, were facing not just water shortages, but also problems caused by the heat wave on the health and welfare of their livestock, poor grass growth and the knock-on impact on winter feed silage, already impacted by February's so-called 'Beast from the East' blast of freezing weather. For them, the drought had a much longer impact and morphed into a feed supply issue, which was a serious concern.

Credit: Ivan Grove

The monthly Hydrological Outlooks from the UK Centre for Ecology & Hydrology (UKCEH) have been particularly useful for the AHDB. Nicola explains: "The drought forecasting and advances in how Standard Precipitation Index information has been used, was useful for explaining current situations, helping our audiences to understand it visually and combining it with work the Environment Agency was producing. We are now developing communications based on the outlooks, and the maps are a really good tool for engaging with farmers as well as colleagues; it really helps everyone to understand the situation.

"Following last summer, we need to do a lot of scenario planning for different outcomes, for example if we had had another dry winter, what would happen next summer?

"The main things About Drought have given us are great links with Cranfield, UKCEH and the University of the West of England. The AHDB couldn't afford to fund such a large research programme so we certainly support this type of work.

"If we can develop forecasting abilities even further into something farmers can understand and use themselves in their planning that would be the gold standard outcome for us. I hope that we will continue working together, building on what the agricultural sector needs and supporting future research."

Interview by Sally Stevens

Again the 'audience first' approach directed the content of Briefing Papers co-ordinated by UWE. The series' templated and branded format makes them easily recognisable as informative, reliable content from About Drought. The subjects and content were directed by feedback from interactions at workshops and events, pulling together strands of different research from different projects to present a comprehensive, useful and meaningful resource.

BRIEFING NOTES

How to plan and manage water resources for public water supply: future directions

Which farming areas of England and Wales are most at risk from economic losses due to drought?

Drought monitoring and early warning: new developments to meet user needs

Read the Briefing Notes at: https://aboutdrought.info/about-us/publications/briefing-notes/

DOWNLOADS

There are a number of educational resources developed through the DRY project and About Drought programme which span the breadth of the curriculum. For more information visit the DRY Utility Learning pages: https://dryutility.info/learning

KS2 - Diary of a Water Superhero

A bright, engaging story book has been produced for use in primary schools, with accompanying teacher's notes. Designed to inform children to become champions to change behaviour, 'DRY: Diary of a Water Superhero' follows the story of an ordinary schoolgirl who becomes a water hero during a drought in the UK. The thought-provoking storyline encourages class discussions on how we treat water and how we can all save water as well as including activities.

The book, its concept and storyline were co-produced by Prof Lindsey McEwen, Luci Gorell Barnes, Verity Jones, Sarah Whitehouse and Sara Williams as part of About Drought, with illustrations by Luci Gorell Barnes.

The e-book, DRY: Diary of a Water Superhero is available to read online in English and Welsh.

The writing team have also run a couple of webinars to introduce the DRY Primary book resource – one for 'educators' and another for 'parents and carers'.

Teachers' Notes which accompany the DRY Primary Book were also developed.

KS3&4 - All About Drought Geographical Association resources

The DRY and About Drought programme have collaborated with the Geographical Association to develop research-informed resources that promote awareness of UK drought among young people. This includes creative thinking about positive water behaviours at home and in school, and adaptation to future drought.

We have worked with educational developer, Gemma Mawdsley to develop six lesson plans and learning resources for Key Stages 3 and 4 which are available from the Geographical Association.

For older students: Water Futures

Water Futures is an interactive visualisation tool stringing together several different models, which allows users – including students under guidance - to explore how water resources move throughout London. Models in general allow researchers, engineers and decision makers to envision different possible scenarios or outcomes. The models used in this tool are from Thames Water, a weather model from the University of Bristol and a water resources model from the University of Oxford called the WATHNET model. Water Futures was developed by the MaRIUS project working with Thames21, a community project that aims to provide education, improve rivers and improve the quality of life of people in the community by enhancing waterway environments.

LEAFLETS

Economic impacts of regulatory drought management on irrigated agriculture

http://www.mariusdroughtproject.org/wp-content/uploads/2019/03/DroughtEconomicAgriculture.pdf

Drought Monitoring & Forecasting

http://www.mariusdroughtproject.org/wp-content/uploads/2019/03/Agriculture_MonitoringEarlyWarning.pdf

D-Risk: helping irrigators manage drought risk

http://www.mariusdroughtproject.org/wp-content/uploads/2019/03/DRisk.pdf

Securing a fair share of water: a strategy for agriculture and horticulture

http://www.mariusdroughtproject.org/wp-content/uploads/2019/03/AgricultureWaterStrategy.pdf

Crop response to a changing climate

http://www.mariusdroughtproject.org/wp-content/uploads/2019/03/CropResponseToDrought.pdf

Using your phone to scan a QR code

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You can also access the document(s) using the links.

HISTORIC DROUGHTS: *PUBLICATIONS*

OPEN ACCESS

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Film/Video/Animation/Podcasts

DRY Digital Stories
http://dryproject.co.uk/resources/digital-narratives/

Stories About Drought: Quinoa vs. Potato
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Films/Podcasts

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Podcast - Algal Modelling.
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Podcast - Impact of drought and water scarcity on agriculture
https://podcasts.ox.ac.uk/impact-drought-and-water-scarcity-agriculture

Podcast - Impact of drought on ecosystems and their ecology. http://podcasts.ox.ac.uk/impact-drought-and-water-scarcity-ecosystems-and-their-ecology

Podcast - Impact of drought on water quality. https://podcasts.ox.ac.uk/impact-drought-water-quality

Podcast - Prof Jim Hall: An Introduction to the MaRIUS project. https://podcasts.ox.ac.uk/prof-jim-hall-introduction-marius-project

Podcast - Sociocultural perceptions and knowledge controversies. https://podcasts.ox.ac.uk/sociocultural-perceptions-and-knowledge-controversies

Podcast - UK Drought governance arrangements.
https://podcasts.ox.ac.uk/uk-drought-governance-arrangements.

Podcast - Western US drought, and the generation of drought datasets for risk-based impact studies. https://podcasts.ox.ac.uk/western-us-drought-and-generation-drought-datasets-risk-based-impact-studies

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Gemma Coxon: Hydrological Modelling of Drought and Low Flows https://www.youtube.com/watch?v=LbheMmiMqpA&t=4s

Jamie Hannaford: The UK's Hydrological Status in August 2018 https://www.youtube.com/watch?v=HsubSUcOAWo

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Podcasts

Pearce, R., Who'd Have Thought That? About Drought podcast series (8 episodes) https://soundcloud.com/user-505147606/sets/whod-have-that-that-about

Policy Briefings/Reports

How to plan and manage water resources for public water supply: future directions http://aboutdrought.info/wp-content/uploads/2019/02/Brief2PublicWaterSupply.pdf

Which farming areas of England and Wales are most at risk from economic losses due to drought? http://aboutdrought.info/wp-content/uploads/2018/07/Economic-losses-due-to-drought-brief-RAL_NS-7.04.2018_11.58WEB.pdf

Synthesis reports for the following environments are available on https://aboutdrought.info/ecosystem-report-cards/

- Rivers
- Wetlands
- Lakes and Reservoirs
- Woodlands
- Grasslands

Webtools

D-Risk Webtool. http://www.d-risk.eu/index.php

Drought Libraries Application. https://eip.ceh.ac.uk/hydrology/drought-libraries/

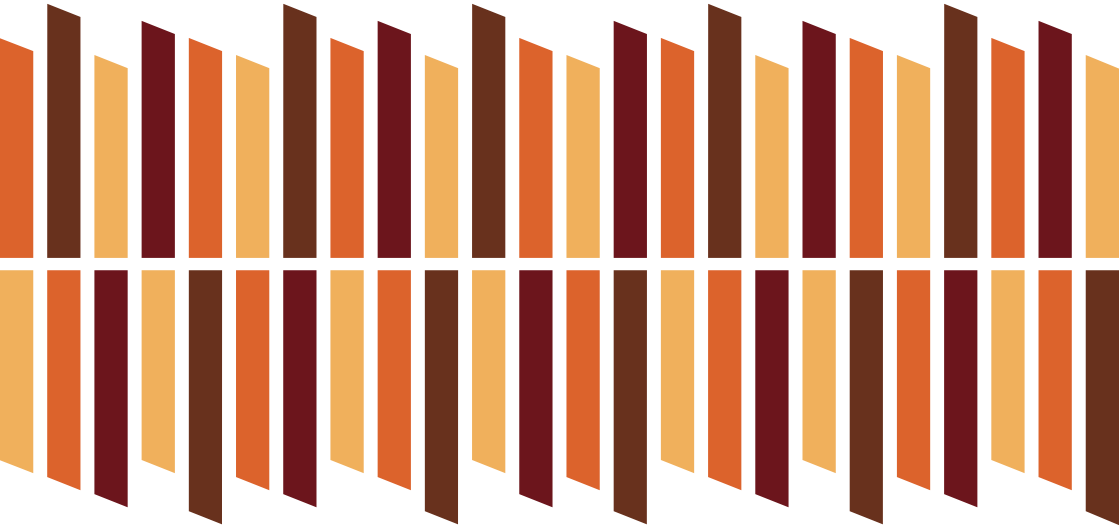
Experiences of Drought: who'd have thought that? http://aboutdrought.info/experiences-of-drought/

New products for the UK Hydrological Outlook: dryness maps and rainfall required to overcome drought conditions. https://www.hydoutuk.net/

Real-time Drought Monitoring via the UK Drought Portal. https://eip.ceh.ac.uk/droughts

UK Water Resources Portal demonstrator. http://eip.ceh.ac.uk/hydrology/south-west/

Further updates are available in the online version of this handbook at www.AboutDrought.info



The UK Droughts & Water Scarcity research programme was a five-year interdisciplinary, £12 million UKRI programme in collaboration with NERC, ESRC, EPSRC, BBSRC and AHRC. It is supporting improved decision-making in relation to droughts and water scarcity by providing research that identifies, predicts and responds to the interrelationships between their multiple drivers and impacts.

The programme's research is UK-focused, and contributes to NERC's natural hazards and climate system strategic science themes.

Over 200 institutions and organisations were involved in the programme.