UKCEH Digital Strategy 2024-2030

Using data and digital technologies to tackle the complex environmental challenges of our time

UK Centre for Ecology & Hydrology

What we do

The UK Centre for Ecology & Hydrology provides the data and insights that researchers, governments and businesses need to create a productive, resilient and healthy environment.

Introduction

This strategy sets out our ambition to realise the power of environmental data and digital technologies to inform and accelerate solutions to the major environmental challenges of our time. We will take a leading role in building capacity and skills across the environmental science community, and in forging new partnerships that will mean our data have even more impact in the world.

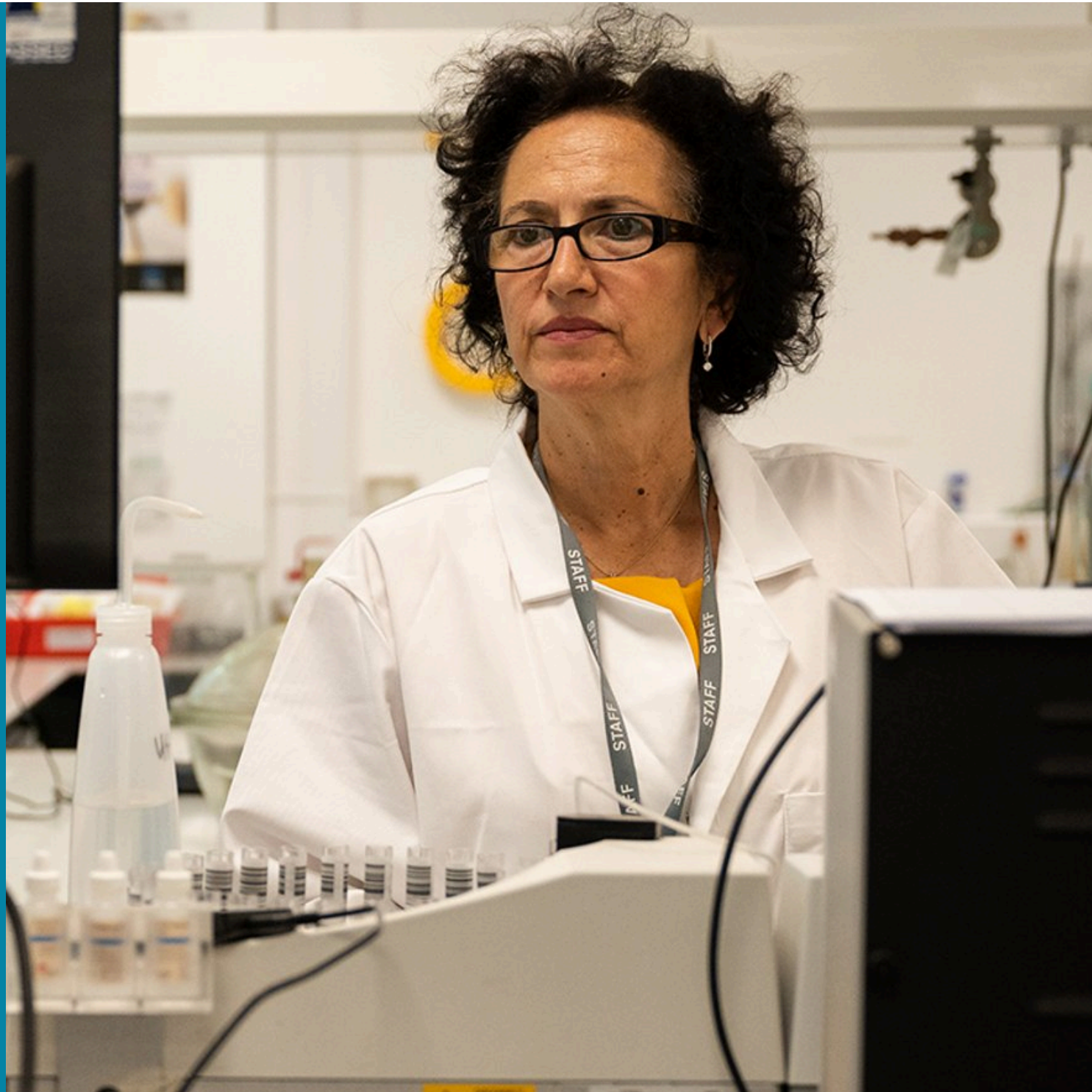
We would like to thank all the people who have contributed to the development of this strategy and look forward to continuing to work with the community to co-design our digital research infrastructure to be fit for the future.

Professor Gordon Blair

Head of Environmental Digital Strategy, UK Centre for Ecology & Hydrology

Data revolution

Scientists from the UK Centre for Ecology & Hydrology (UKCEH) and its predecessor institutes have monitored and modelled environmental and climate change for over 60 years. We host a wealth of environmental information, gathered over decades; and our data make a difference, informing research, policymaking, commercial innovation, management decision-making, and conservation action all around the world.



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Our track record

Our experience and expertise in gathering, curating, analysing, and communicating environmental data, mean we are ideally placed to take advantage of the revolution in data, informatics, and artificial intelligence (AI) that is transforming environmental science. This revolution is opening up a whole new range of opportunities, which we want to harness for the benefit of the research community and professional practice, contributing to socio-economic and environmental gain.

At the same time, we recognise that environmental science has its own distinctive challenges to overcome. New technologies for sensing, measurement and modelling mean that environmental data are growing in size and complexity. Environmental data are heterogeneous in nature and can be messy, with missing values. They are rooted in time and space, and work across many scales. We need to develop effective strategies to harmonise and integrate data that can inform new activities such as green finance, and support exploration of interactions between ecosystems.

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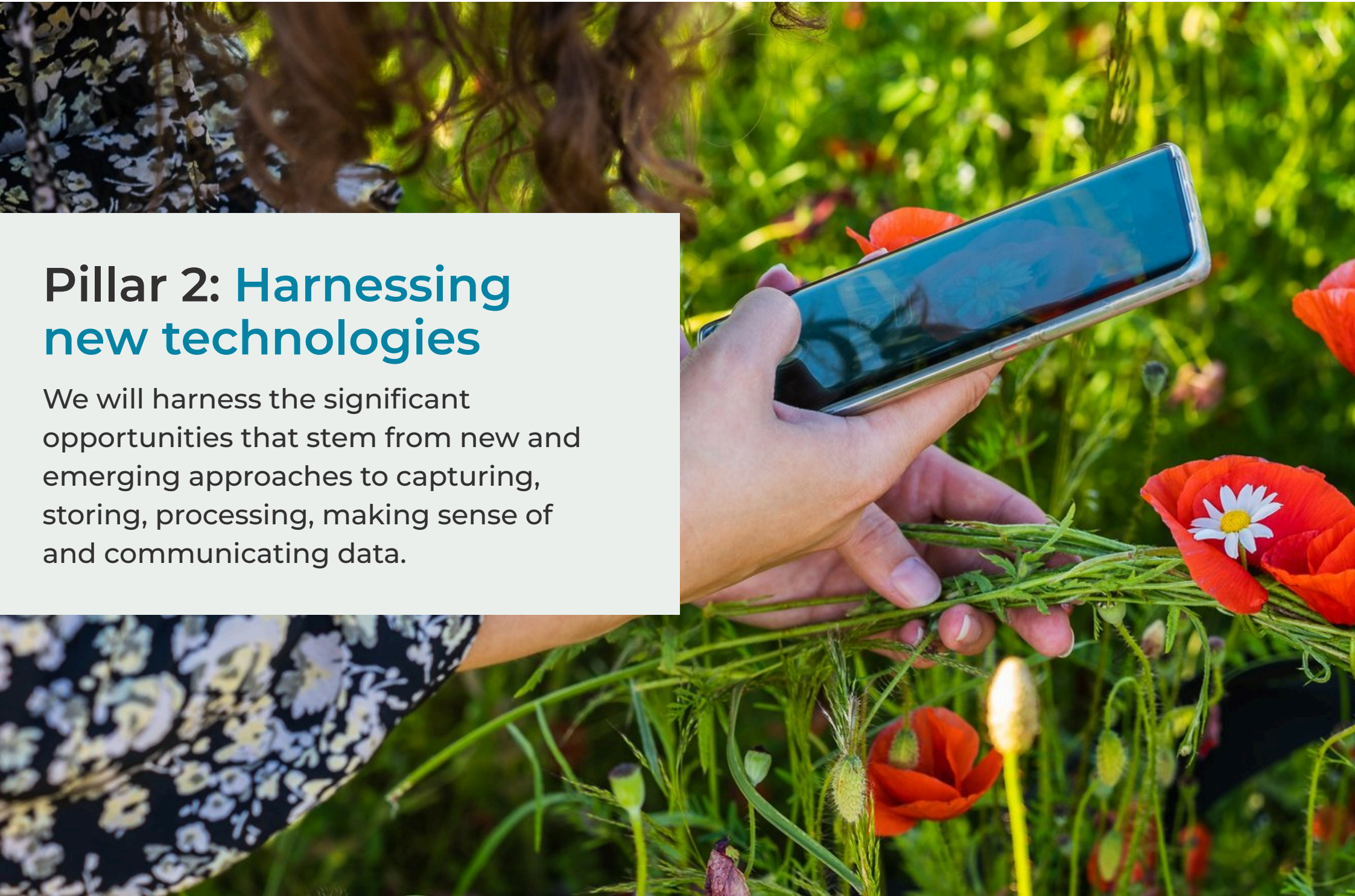
Our digital strategy pillars

1. Developing holistic solutions
2. Harnessing new technologies
3. Building capacity
4. Setting the agenda
5. Delivering FAIR digital assets
6. Driving the future of modelling
7. Driving the future of monitoring
8. Sustainability

Pillar 1: Developing holistic solutions

As the UK's leading centre for excellent environmental science across water, land and air, we recognise that the Earth's environment is a complex system, with every part affecting every other part. We take a whole systems approach to understanding the environment, how it sustains life, and the human impact on it.



Pillar 2: Harnessing new technologies

We will harness the significant opportunities that stem from new and emerging approaches to capturing, storing, processing, making sense of and communicating data.

Pillar 2: Harnessing new technologies

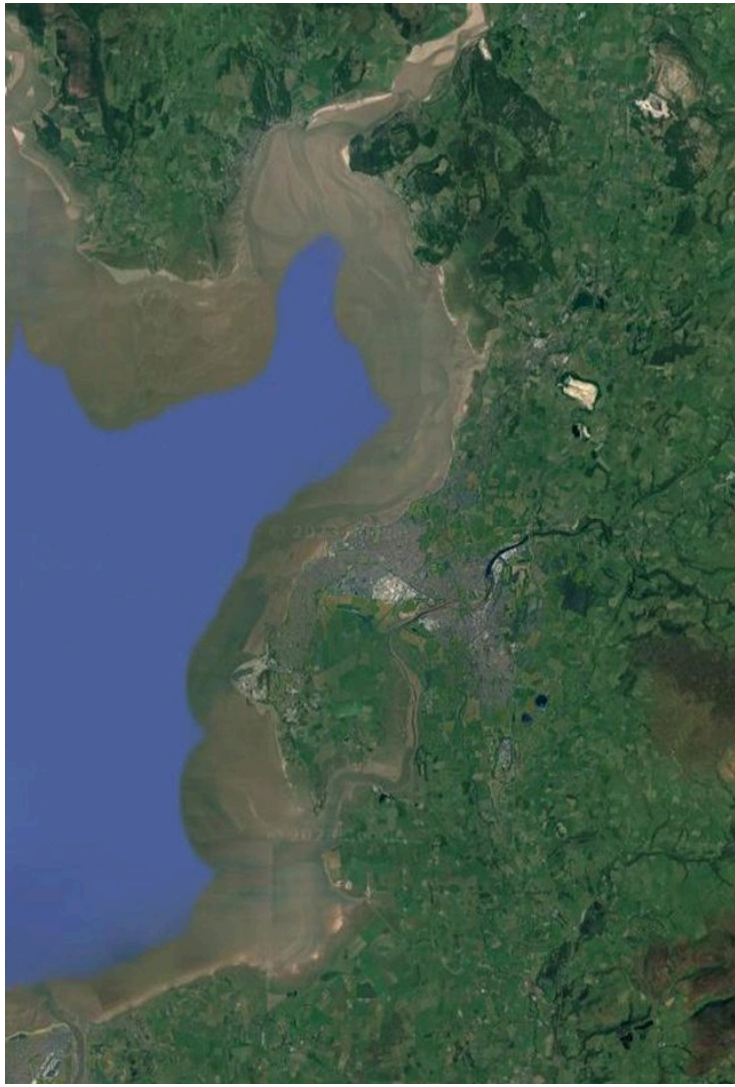
Cloud computing has revolutionised many areas of science, and we will extend the benefits of this to research within and beyond UKCEH. We are building our own in-house research cloud infrastructure to support open, transparent and integrative science; and will create seamless operation across this infrastructure and other key data analysis facilities such as JASMIN.

To overcome the specific data science challenges faced by environmental scientists, we intend to develop a data science toolbox offering a set of methods tailored for the natural environment, building on the skills and knowledge offered by CEEDS (ceeds.ac.uk), our Centre of Excellence in Environmental Data Science in partnership with Lancaster University.

Example: YourMapsYourWay

We have developed an innovative web-enabled tool called YourMapsYourWay, drawing on the Google Earth Engine cloud-based satellite image processing system. The tool allows users to produce their own bespoke land cover maps in a matter of minutes. It can produce maps at any resolution and with any number of user-defined classifications. For example, YourMapsYourWay has been used by UKCEH in work for Natural Resources Wales to produce bracken maps for its National Parks.

YourMapsYourWay



Pillar 3: Building capacity

Our goal is to ensure the UK has the people and skills it needs to stay at the forefront of global environmental research and innovation for the future. As part of this, we will support a stronger pipeline of digital skills. We will also enhance digital skills within our own organisation through targeted recruitment, offering opportunities for staff to develop new digital skills and through sharing of best practice in this area.

Pillar 3: Building capacity

Our National Capability funding enables us to generate publicly available environmental data sets, software models and decision-support tools, enabling world-class environmental research, resource management and policy development. It underpins and enables the wider environmental science community to carry out research that contributes to improving human and environment health, mitigating, and adapting to climate change and supporting economic development. It also enables us to play a prominent role in the training and education of current and future environmental scientists.

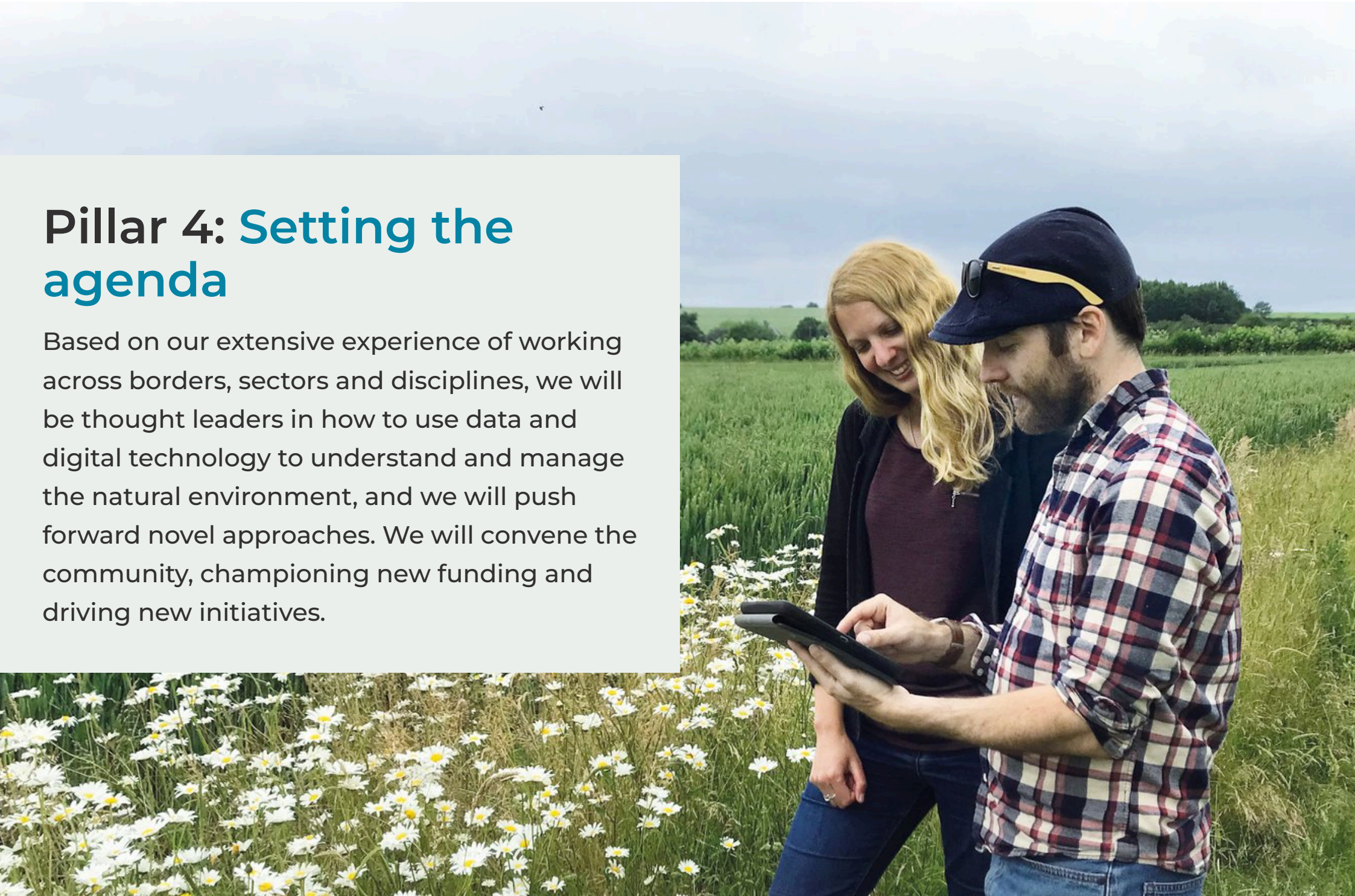
This includes data science skills extending across the whole pipeline, from data acquisition and quality assurance, through integrative analyses, to presenting and visualising the results to support communication and decision-making. We also place emphasis on software engineering skills, and on bringing the many benefits of a systematic software engineering approach to the development and maintenance of our software assets.

CEEDS / DSNE Project training school

CEEDS (the Centre of Excellence in Environmental Data Science) runs a regular seminar series to enable staff and students across Lancaster University and the UKCEH to share knowledge and learn about environmental themes such as air, biodiversity, land, soil, water and ice, as well as method themes such as data acquisition, data infrastructure, data science, decision-making under uncertainty, and complex systems. Topics have ranged from machine learning for quality control of sensor data and environmental digital twins to data challenges to support green finance. CEEDS also runs residential training schools for the community to upskill researchers across the higher education community, government departments and agencies with the latest data science techniques.

Pillar 4: Setting the agenda

Based on our extensive experience of working across borders, sectors and disciplines, we will be thought leaders in how to use data and digital technology to understand and manage the natural environment, and we will push forward novel approaches. We will convene the community, championing new funding and driving new initiatives.



Pillar 4: Setting the agenda

We are taking the lead on Digital Twins of the Environment offer a pathway for the discovery of new knowledge about environmental systems, improving our ability to model and predict the functioning of these systems, and provide information for decision making in real-time or for constructed scenarios.

Working with partners such as the Alan Turing Institute and NERC-supported research centres, UKCEH aims to stay at the forefront of research and development in this area and we are currently working on digital twins of soil systems, rivers, and of biodiversity. We intend to apply this technology across freshwater and terrestrial sciences, developing a federated approach allowing different digital twins to communicate to explore whole-systems science.

We will continue to develop Digital Research Infrastructure (DRI) for our science that better meets the needs of the changing nature of science and takes advantage of the many areas of digital innovation. We will build on our long legacy of developing DRI services, including DataLabs as a platform to support collaborative, open and transparent science.

Example: Land InSight – a digital twin for UK soils

UKCEH is developing a digital twin of UK soils to improve our understanding of soil moisture and soil carbon, and decision-making around climate impacts such as floods and droughts, and net. Land InSight is bringing together a wide range of soil observations, from in situ monitoring networks and remote sensing, with models of the land surface and soils to produce real-time predictions of soil states. It links with other digital twins of the environment to improve the way soils are represented in other modelling systems.

Pillar 5: Delivering FAIR digital assets

The FAIR principles (Findable, Accessible, Interoperable, Reusable) for research data management illustrate best practice for sharing open data. They describe how research outputs should be managed so they can be more easily discovered, accessed, understood, exchanged and reused.

Pillar 5: Delivering FAIR digital assets

We are embracing commons-based approaches and provide an asset commons for all our core digital assets including data, methods, models, workflows, and notebooks. This is enabling us to offer a single window onto all our assets and to bring together currently disparate data services. Asset catalogues and semantic web concepts play a part in the delivery of FAIR principles, and we are also emphasising the vital role of stewardship in the governance of commons technology.

While commons technology offers the ability to reuse our assets, we also recognise that it is important to build a culture of reuse across the organisation and the community. We will therefore seek to develop an overarching software architecture for UKCEH offering a range of maintained software elements for different functions including data storage, analyses, visualisation, and the development of portals. Reuse can also act as a trigger for rapid innovation by building on previously developed building blocks.

Core Trust Seal Accreditation for EIDC

The Environmental Information Data Centre (EIDC), hosted by UKCEH since 2000, provides an invaluable resource for researchers across the world. The Centre looks after data derived from more than 75 years of terrestrial and freshwater research programmes carried out in the UK and abroad by scientists from across the world.

EIDC has been awarded the globally recognised CoreTrustSeal accreditation by the World Data Systems (WDS) and Data Seal of Approval (DSA) repository certification bodies. This validates the centre's functions, procedures and processes, confirming the information curated is managed and archived in a way that preserves its long-term access and use.

Pillar 6: Driving the future of modelling

Modelling is critical to mitigating and adapting to environmental change. We will continue to capitalise on digital developments to significantly enhance our modelling capability in three areas.

Pillar 6: Driving the future of modelling

The first of these areas relates to digital twins (see more information in the section on 'setting the agenda'). We are building digital twins that realise synergies between process understanding and data understanding. This is a significant driver for a step change in modelling capabilities, taking advantage of the unprecedented availability of data to better capture environmental processes and their behaviours at a given site, scale and at a given time.

Secondly, we will continue to employ software engineering principles to improve the code base of our often-complex models, allowing them to be more flexible and extensible, including the ability to inject new or alternative processes or behaviours into models as our scientific understanding grows.

Finally, we are building models which are coupled in a more principled way through an integrated modelling framework, featuring built in support for model coupling.

Example: SPEED projections

The SPEED (Spatially explicit projections of environmental drivers) project has driven forward the field of scenario development related to complex, inter-related models. For the first time, it provides a set of spatially explicit scenarios covering multiple pressures – social, economic, climate change, land use change, and pollution – that are internally consistent, and consistent with the IPCC (Intergovernmental Panel on Climate Change) community global scenario framework. The outputs empower researchers, consultants, agencies, and governments to better-mange the environment of the future, and to reduce the risk of unintended consequences of interventions. An example of the early adoption of outputs from SPEED is Reading University's study of pollinator futures and the fate of bees. UKCEH also worked with BEIS to envisage possible futures that help to frame activities such as achieving net zero, conserving the environment, and developing agriculture.

Pillar 7: Driving the future of monitoring

We will continue to develop a more integrated approach to our environmental monitoring. We will develop a network of networks, establishing a common framework and a consistent approach to all our monitoring infrastructure.

Pillar 7: Driving the future of monitoring

Given the increasing importance of real-time and near-real-time data, and the volumes potentially involved, we are considering automated or semi-automated approaches to quality assurance, including the use of machine learning models in this area.

Example: Floods and Droughts Research Infrastructure (FDRI)

Led by the UKCEH, the FDRI programme is facilitating the hydrological science and innovation needed to make the country more adaptable and resilient to floods and droughts. It includes urgently needed nationwide deployments of instruments for observing our water environment; novel digital solutions to support data discovery, access and integration; an innovation programme to support and catalyse research and development; and a capacity building programme to support collaborative working and skills sharing.

Pillar 8: Sustainability

We recognise that the underlying computational infrastructure used to support our science itself has a significant environmental impact. We are committed to minimising this impact through sustainable technology practices and to embedding sustainability into the very fabric of the design of our digital research infrastructure and computational services.

Pillar 8: Sustainability

Co-design is central to our approach, and we involve stakeholders directly in the development of our digital infrastructures, taking account of their aspirations, challenges and needs, and getting their input at every stage of the project lifecycle. We adopt inclusive design practices, considering a wide range of needs, and working towards equitable outcomes. By incorporating diverse perspectives, we will accelerate innovation and create solutions that work for more people.

Example: Glastonbury: How green is the cloud?

In 2023, UKCEH engaged festival goers at Glastonbury with the hidden emissions of cloud computing. We hosted a stall in the Futurarium tent in the Science Futures area of the festival, where members of the public could engage in interactive activities designed to help them understand the amount of energy used in everyday tasks such as sending an email or posting on social media platforms.

A popular activity was a game of snakes and ladders illustrating the potential improvements that can be made to sustainability in cloud computing, but also the potential unintended consequences associated with these steps. For example, increasing the efficiency of digital infrastructure may seem like a gain but this can paradoxically result in more energy usage and carbon emissions due to rebound effects.

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Want to discuss?

Please contact us on enquiries@ceh.ac.uk

www.ceh.ac.uk