



Strategy **2025**: Research and Innovation

03.
FOREWORD

For people and nature to prosper

14.
OUR PARTNERSHIPS

Partnerships for impact

22.
OUR PEOPLE

Excellence, teamwork, integrity

04.
OUR RESEARCH AND INNOVATION

Tackling global issues

16.
OUR NATIONAL ROLE

Meeting national strategic needs

12.
OUR EXPERTISE

Monitoring, experimentation and modelling

19.
OUR INTERNATIONAL ROLE

Collaborating across borders

FLOWER STRIP
Image: © Matthais Tschumi

FRONT COVER: ALGAL BLOOM ON DNIEPER RIVER IN KYIV, UKRAINE
Image: © Adobe Stock

For people and nature to prosper

Society faces unprecedented challenges due to the pressure that a projected population of nine billion people by 2050 will place on our resources. Globally, species are declining at the fastest rate ever recorded. Our water and air are polluted. Change in land use is fragmenting habitats, and the soils needed to sustain terrestrial life are in decline. Over the last decade, the impact of climate change has become ever more evident with forest fires, heat waves, floods and droughts devastating livelihoods and displacing communities.

The scale of these challenges means that the demand for informed, excellent and relevant environmental science is greater than ever. Research and innovation must help to halt and reverse the damage that people are causing to ecosystems through our use of the Earth's natural resources. It has never been more urgent for scientists to work across disciplines, sectors and borders to provide the evidence base for informed decision-making. It is time for action, and the

UK Centre for Ecology & Hydrology (UKCEH) is ideally placed to make a substantial national and international contribution to meeting these multidisciplinary challenges due to the breadth and quality of its people, research, facilities and partnerships.

The strategy set out here presents a step change in the research undertaken by UKCEH and its predecessor institutes over a period of more

than 50 years. It identifies the major environmental issues our science will address and explains our contribution to tackling them. Our objective is simple: to carry out excellent environmental science that is relevant to society's needs, with a positive impact. Wherever we work in the world, our research and innovation will make a difference – to knowledge, to nature, to livelihoods and to national economies.



LORD CAMERON OF DILLINGTON, CHAIR, AND PROFESSOR MARK J BAILEY, EXECUTIVE DIRECTOR

Our science challenges

Our strategy focuses on the role of UKCEH in addressing three major environmental and societal challenges:

- 1 **Creating and enhancing sustainable ecosystems**
- 2 **Reducing and preventing pollution**
- 3 **Mitigating and building resilience to climate and environmental change**

Our specific contribution to these challenges focuses on ten integrated issues:

- Biodiversity
- Chemical risks
- Clean air
- Climate and land
- Ecosystem restoration and resilience
- Flood and drought impacts
- Net-zero greenhouse gas emissions
- Soil health
- Sustainable agriculture
- Water quality and resources

Tackling global issues

We are the UK's leading centre for excellent environmental science across water, land and air.

UKCEH's research and innovation strategy recognises that the Earth's environment is a complex system in which every part affects every other part. We take a whole systems approach to understanding the environment, how it sustains life, and the human impact upon it. This is supported by the breadth of our expertise and by our underpinning capabilities:

in monitoring, measuring, and observing; in experimentation across a range of platforms; and in data science for analytics, forecasting, and projection.

We deliver integrated research to determine the key components that support productive ecosystems and make them vulnerable or resilient to a broad range of

stressors. In advancing our science, we progress from the study of individual species or chemical and physical factors to understanding how they interact. Our fundamental and solutions-led research and innovation enable us to provide the evidence needed for informed management of whole interconnected landscapes.



THE HONG KONG-ZHUHAI-MACAU BRIDGE
Image: © Simon Butterworth

Biodiversity

Enhancing biodiversity to safeguard and enhance environmental health and resilience



Image: Lucy Hulmes, UKCEH

The issue

Biodiversity is under threat with species declining at the fastest rate ever recorded. The biggest threats include habitat fragmentation and loss, climate change, pollution, invasive species and pathogens. At the same time, society is entirely dependent on ecosystem services, such as clean air and water, nutrient cycling, pollination and healthy soils, arising from the interactions between biodiversity and the physical and chemical environment. It is therefore essential to understand the extent that diversity links to the resilience of ecosystems.

Our flagship Biological Records Centre brings together the scientific capabilities and data resources necessary to assess the status and trends of species populations. Integrating work across monitoring, experimentation, and modelling gives us the capacity to deliver solutions for conserving and restoring biodiversity.

Our commitment

- To better understand the response and interactions between biodiversity and environmental change.
- To define the impact of the many drivers of change, including climate, land use, invasive species and globalisation.
- To develop effective, evidence-based mitigation strategies that inform and improve biosecurity preparedness, and halt and reverse the decline in biodiversity.

Chemical risks

Sustainable use of chemicals to protect the environment and people



Image: Shutterstock

The issue

Chemicals are integral to human life and generate billions of pounds for national economies. However, chemical discharges can degrade the environment, impacting ecosystems adversely, thereby affecting the health of humans and wildlife.

We investigate the dispersal, fate and behaviour of chemicals and polluting substances in terrestrial and freshwater environments. Priority pollutants of interest include radionuclides, pesticides, organic pollutants, toxic metals, nutrients and manufactured nanomaterials and plastics. We also seek to determine the effects of these pollutants across multiple scales, ranging from genes to populations, including the degradation of ecosystem function and development of antimicrobial resistance.

Our commitment

- To advance the measurement and assessment of chemical hazard pathways across water, land and air.
- To develop novel emissions-fate-transfer models that deliver explicit descriptions and predictions of environmental chemical exposure in space and time.
- To make a major contribution to sustainable chemical use through an enhanced understanding of environmental exposure and effects.

Clean air

The evidence base for reducing air pollution



Image: Ben Langford, UKCEH

The issue

Air pollution is a major risk to human and environmental health. Around the globe, the adverse health effects of air pollutants are most prominent in urban areas, notably in African and Asian megacities. Air pollutants also have adverse effects on our natural environment, contributing to ecosystem damage and biodiversity loss, and impacting food security by reducing crop yields.

Through our ground breaking work in flux measurement techniques and our field experimentation facilities, we generate long-term, high-frequency time series data of atmospheric composition change and identify contributing emission sources. This delivers vital data needed to inform the development of effective clean air policies and monitor progress.

Our commitment

- To quantify emissions, atmospheric dispersion and chemical transformation, and assess ecological and human health impacts.
- To quantify the contribution of nature-based solutions and ecosystem services to improving air quality.
- To provide the evidence and solutions required for effective clean air policy actions.

Climate and land

Land surface science for climate change prediction, adaptation, and mitigation



Image: Chris Andrews, UKCEH

The issue

Changes in climate – complex changes, involving interactions of physical, chemical and biological processes of the atmosphere, ocean and land surface – are already having widespread impacts on societies and ecosystems. Understanding how the land surface interacts with the atmosphere is therefore critical for climate change prediction, adaptation and mitigation.

Our land surface science is underpinned by detailed process understanding in hydrology, ecology, micro-meteorology, biogeochemistry, and critically their interactions. These processes are modelled within the Joint UK Land Environment Simulator (JULES) system, co-ordinated by UKCEH, which provides the community with a unique UK land surface model for accurate weather and climate prediction.

Our commitment

- To improve forecasting of extreme weather events, enabling society to better prepare and respond.
- To advance land surface models, by improving representation of groundwater, irrigation, evaporation, large-scale fires, and the nitrogen cycle.
- To better represent the Arctic system in land surface modelling, given the rapid climate-driven changes in this ecosystem, and understand its role in exacerbating change.

Ecosystem restoration and resilience

Restoration for long-term recovery and resilience to deliver sustainable landscapes



Image: Shutterstock

The issue

The UN Decade of Ecosystem Restoration to 2030 recognises that ecosystem degradation undermines the well-being of 3.2 billion people. The resultant loss of species and ecosystem services across the world equates to a 10 per cent annual reduction in gross productivity.

Our expertise in integrating biological, physical and chemical processes enables us to develop innovative approaches to sustaining healthy ecosystems and restoring degraded ecosystems at the landscape scale, encompassing grasslands, peatlands, heathlands, rivers and lakes, forests, and agricultural systems. We provide the evidence base to restore degraded ecosystems in such a way that they are resilient to climate change and extreme events, particularly where societal and environmental pressures are in conflict.

Our commitment

- To focus on solutions that allow species to thrive or re-establish where their numbers have been depleted.
- To model the impact of climate and land-use change on genetic diversity and provide early warning signs of ecosystems in danger of collapse.
- To create accurate habitat maps, land-use projections and decision-support tools to inform landscape-scale restoration for biodiversity net gain, water and soil security, and poverty alleviation.

Flood and drought impacts

Increasing societal and environmental resilience to hydro-climate risks



Image: Simon Butterworth

The issue

Floods and droughts have the potential for immense destruction of homes, crops, wildlife and infrastructures. Since 2017, water crises and extreme weather events have been consistently identified in the World Economic Forum's top five global risks by impact. The need to better predict these extreme events has never been more pressing.

Combining expertise in hydro-meteorology with data derived from national monitoring networks, we measure and model water to accurately predict, mitigate and manage the impacts of floods and droughts. We work in partnership across the world to build local capacity in water resource monitoring, analysis and modelling, supporting planning, response and recovery. Modelling is key where data are sparse.

Our commitment

- To better predict and evaluate the risks and impacts of floods and droughts.
- To improve models in support of hydrological research and thereby underpin a range of climate and meteorological projections and forecasts.
- To predict hydrological conditions over near and decadal timescales in order to mitigate and reduce the economic and social impacts of extreme weather events.

Net-zero greenhouse gas emissions

Improving land-use planning and land-management practices



Image: iStockPhoto

The issue

Greenhouse gas emissions (GHG) drive global warming. Many countries, including the UK, have committed to a net zero emissions economy. To find solutions to reduce or minimise carbon and other GHG emissions, it is essential that sources are identified and the processes and biogeochemical cycles involved are fully understood.

We undertake long-term national surveys of both natural and managed environments, focussing on carbon dioxide, methane, and nitrous oxide, and indirect emission pathways from water-land-air ecosystems. We make a major contribution to the UK national and international GHG emissions inventories, providing GHG flux measurements and improving the mechanistic understanding of the role that land-use, land-use change and forestry have on those emissions. Our expertise encompasses the regulation of emissions and solutions for carbon sequestration.

Our commitment

- To improve the quantification of GHG fluxes across the UK and identify drivers of change.
- To develop and test practical approaches for enhanced soil carbon sequestration.
- To address a range of questions from the role of bio-fuels in mitigating climate change to the risks of large releases of carbon from permafrost, informing policy at national and international scales.

Soil health

Enabling integrated management for healthy soils



Image: Shutterstock

The issue

Healthy soils and peatlands are critical for life. They produce 95 per cent of our food and are the source of many of our antibiotics. They store more carbon than the world's forests, mitigate climate change, recycle nutrients and waste, and clean our water. Yet, they are vulnerable to pollution, unsustainable exploitation and erosion.

Our multidisciplinary, integrated soils research spans physical, biological and chemical soil processes and investigates their interaction with the biosphere. This research enables environmental risk assessment and prediction of how soils may change under future scenarios of land use and climate change.

Our commitment

- To determine the status, trends and drivers of change in soil health, including change of biodiversity and carbon stocks in British soils and peats.
- To develop a new generation of soil system models that accurately represent biogeochemical cycling and soil function from local to global scales.
- To ensure these new models can predict the impact of land use and climate change on soils at the landscape scale.

Sustainable agriculture

Enhancing ecosystems to underpin productive and regenerative agricultural systems



Image: Simon Butterworth

The issue

Population growth, changing diets and urbanisation are driving an ever-increasing intensification of agriculture and land-use change. In the UK alone 70 per cent of the land is farmed. Meeting the need for increased food production and nutrition, without degrading our environment, is one of the greatest challenges facing society today.

Our research makes a major contribution to the development of sustainable, productive farming systems that are resilient to climate change and protect biodiversity. Our work in this area focuses on maintaining and enhancing healthy soils, clean water, pollination and natural pest control.

Our commitment

- To work with the farming industry to test innovative, regenerative agricultural systems that are productive and resilient to future environmental shocks.
- To provide tools and data for planning future land use that optimise benefits to food production while minimising conflicts with provision of other ecosystem services.
- To provide the evidence-base for the design of resilient environmental and management policies and practices, nationally and internationally.

Water quality and resources

Balancing water demand with a healthy and productive environment



Image: Shutterstock

The issue

Water is a resource on which all life depends. Yet, across the planet, 30 per cent of people do not have access to reliable supplies of clean water. Efficient management of water is critical to addressing the competing demands of industry, agriculture and energy production whilst sustaining flows and quality for natural ecosystems, particularly as demand is further compounded by population growth, land-use and climate change.

Our research integrates ecology and hydrology in the evaluation of water availability and demand. We seek to understand the complex interactions that affect the availability and quality of water resources now and into the future, from local to global scales.

Our commitment

- To advance our understanding of catchments, rivers, wetlands and lakes by integrating technical innovations for near real-time large-scale monitoring and reporting.
- To develop our Hydrological Summary and Outlook through model improvement, providing information for improved water management across all sectors.
- To support the restoration of over-exploited freshwater resources and ecosystems, underpinning social and economic development for local communities.

Our science underpins progress towards meeting these UN Sustainable Development Goals:



Monitoring, experimentation and modelling

Underpinning UKCEH's research and innovation are large research infrastructures and our capabilities in:

- Monitoring, measuring and observation
- Experimentation in advanced facilities and in diverse real world environments
- Data science for analytics, forecasting and projection

To ensure UKCEH continues to deliver world-class research and innovation, we will invest in and develop these capabilities.

Monitoring, measuring and observation

We provide flexible, long-term, large-scale monitoring and surveillance networks essential to quantify past and current environmental status. These networks allow us to identify and measure change, and determine the factors that modulate that change.

For example, UKCEH's Auchencorth Moss monitoring site, is one of the UK's measurement supersites for monitoring air pollution. It is a regional station within the World Meteorological Organisation's Global Atmosphere Watch programme.

Experimental platforms and research facilities

Our experimental platforms and research facilities enable us to test the role of different drivers of environmental change and the outcomes of novel interventions to manage the environment. We provide and operate experimental platforms and research infrastructures supporting national and international collaborations. These include sustainable farming platforms, aquatic mesocosms and one of the longest running UK climate change experiments at Clocaenog, part of a European climate change manipulation network.

Data science for analytics, forecasting and projection

UKCEH has developed models to forecast and predict aspects of the environment at different spatial and temporal scales. They include models of national and international importance for air quality forecasting; GHG emissions inventories; land cover and crop mapping; the UK's sole Land Surface model; nationwide, real-time flood forecasting; and water resource outlooks.

Our commitment

- To deliver an integrated whole-systems approach to improve understanding of the dynamics of our environment by linking hydrological, biogeochemical and ecological measurements and models, and provide comprehensive assessment of the immediate risks and possible futures for our environment.
- To optimise the measurement and exploitation of monitoring and experimental data, from innovations in field survey, earth observation and environmental sensors, to big data assimilation and machine learning.
- To mobilise our field instrumentation to address specific hypotheses in a responsive and timely manner.
- To integrate multiple monitoring and experimental platforms in real or virtual networks, to answer larger-scale and longer-term environmental questions.
- To analyse the interdependencies among land, soil, water, air and biodiversity, and their resilience to external pressures.
- To determine new and appropriate interventions and solutions to the complex challenges identified in this strategy.

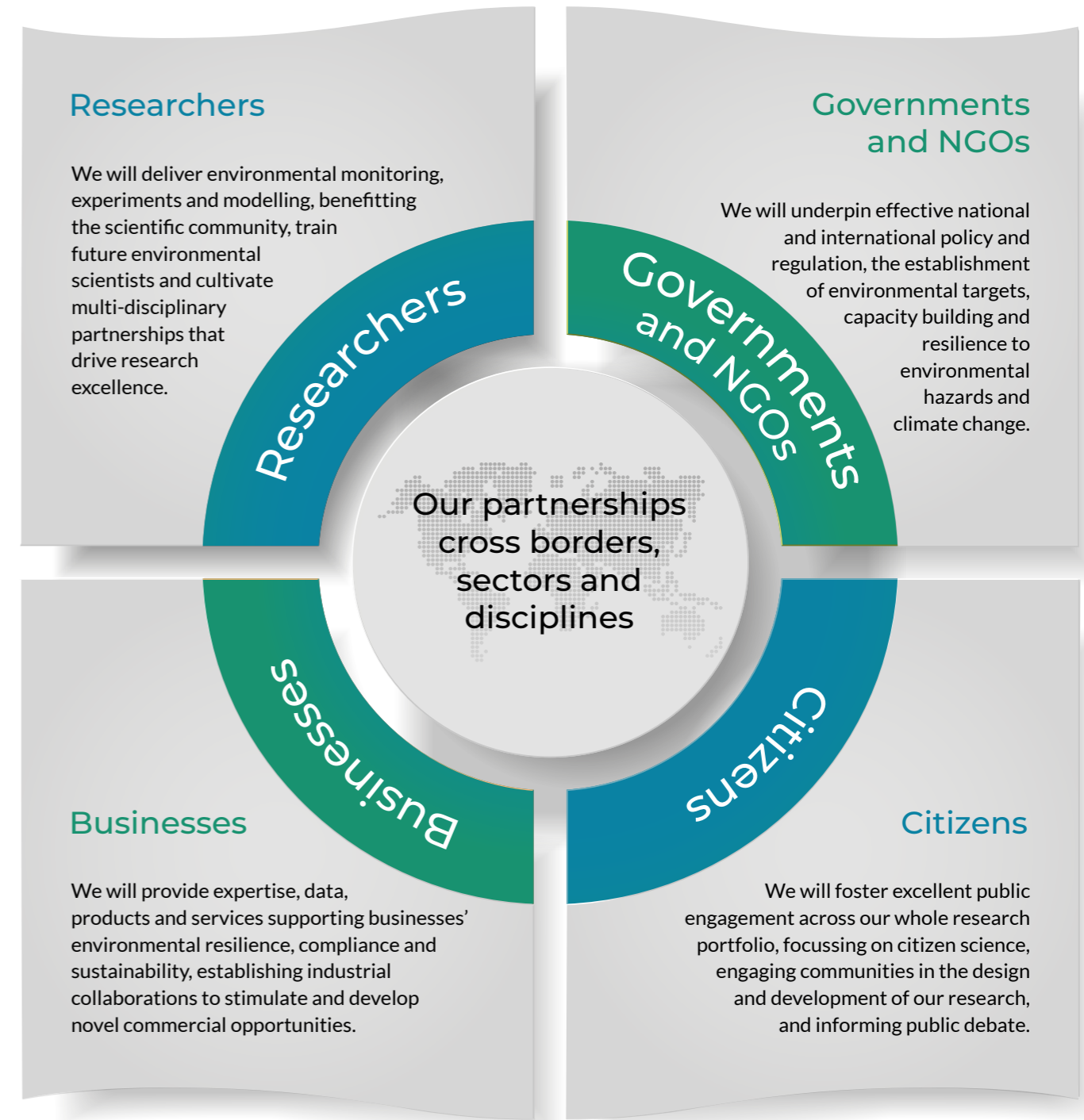
Partnerships for impact

We seek to stimulate and work as part of inclusive partnerships that cross borders, sectors and disciplines to co-design, develop and deliver solutions to the challenges identified in this strategy. We develop a blend of impact pathways with our partners through which our science can affect policy, commercial innovation, capacity and capability development, innovative environmental management practices, development of forecasting and decision-support tools, and public engagement with research. We do this to optimise the impacts of our research and innovation and to inform future strategy development.



How we have an impact

- Our species monitoring and modelling inform UK, European, and global policies on biodiversity; they help to predict and prevent the spread of invasive species.
- Our pollution work assists policymakers and environmental agencies around the world to develop clean air and sustainable chemical use strategies.
- Our water resources monitoring and modelling enables governments, businesses, and communities around the world to plan for the future.
- Our research into hydro-climate risks improves forecasting of, and promotes resilience to extreme weather events, floods, and droughts.
- Our soils and land use science helps prevent and reverse land degradation and informs international standards for greenhouse gas inventories.
- Our agricultural field studies help farmers optimise food production whilst protecting pollinators and environmental quality.



Meeting national strategic needs

National Capability

In our role as a strategic delivery partner for the Natural Environment Research Council (NERC), part of UK Research and Innovation (UKRI), UKCEH provides National Capability for freshwater, terrestrial and near atmosphere science. This enables the UK to stay at the forefront of environmental science globally and to deliver national strategic research. Through it, we provide the knowledge, data and insights that researchers, UK and devolved governments, and businesses need to create a productive, resilient and healthy environment.

National Capability programmes

National Capability programmes rely on UKCEH's fundamental capabilities in water, land and air science. These include measurement, monitoring and observation, the generation, management and dissemination of large-scale, long-term data sets, and expertise in analytics, forecasting and projection. This work is enabled through our large-scale infrastructures of sensor networks and platforms, and delivered in partnership with other research centres. These capabilities in turn support researchers, governments, business and society.

Environmental data

Our National Capability generates 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 community of environmental scientists to carry out research that addresses a range of challenges that improve human and environment health, mitigate climate change and support economic development. These are science-led initiatives designed to improve our quality of life while living within Earth's limits.

The Environmental Information Data Centre

The Environmental Information Data Centre is one of the NERC's network of environmental data centres. Delivered by UKCEH, it is a focal point for the terrestrial and freshwater sciences community, enabling the UK's researchers to make their data available and safeguard it for future application.

Our National Capability programmes:

ASSIST

Achieving sustainable agricultural systems

HYDRO-JULES

Next generation land-surface and hydrological predictions

LOCATE

Land ocean carbon transfer

SUNRISE

Sustainable use of natural resources to improve human health and support economic development

UKESM

UK earth system model

UK-SCAPE

UK status, change and projections of the environment

GRANGEMOUTH

Image: © Simon Butterworth

Our commitment to training future environmental scientists

UKCEH plays a prominent role in the training and education of current and future environmental scientists. 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.

We partner with leading universities across the UK to support many of the NERC Doctoral Training Partnerships and Centres for Doctoral Training. Through these, we currently host over 60 doctoral students who benefit from access to our state-of-the-art

laboratory facilities, field sites, and data centres. Our scientists also co-supervise, with our university partners, more than 100 additional postgraduate students at any one time.

To develop and train the next generation of environmental scientists, we run an extensive Research Associate Programme, currently engaging 50 postgraduate and postdoctoral researchers. This programme integrates personal career development with formal training by our experienced researchers.



FIELD ELECTRONICS TRAINING COURSE
Image: UKCEH

Collaborating across borders

UKCEH leads global efforts to understand and manage the human impact on the environment through our work with United Nations agencies and programmes, including IPCC, IPBES, UNEP, UNECE, UNESCO and the WMO. Over a third of our research projects are delivered with international partners, and we expect this to increase. We provide observing and data systems to measure, experiment and model complex

interdependent systems from molecules to landscapes, from the semi-arid West African Sahel to the rainforests of Southeast Asia.

Our research contributes substantially to halting or reversing decline in environmental quality, and so is key to alleviating poverty, creating wealth and achieving UN Sustainable Development Goals. We

will continue to work with international partners to build global capacity in environmental surveillance, measurement, experimentation and modelling. We will collaborate with governments, businesses, world-class research institutes, international financial institutions, NGOs, and local communities to provide innovative solutions to global and regional environmental challenges.

Image: © iStockPhoto

International collaboration

Examples of our work around the world



Colombia
Investigating how the diversity of plants and activities of people found within the Páramo, a unique mountain biome of the Northern Andes, contribute to water regulation and provision.

Latin America
Argentina, Brazil, Chile
Improving knowledge, building research capacity and initiating collaborative action for the conservation of pollinators and the creation of sustainable agricultural systems.

Europe
Defining the fate, exposure, effects and risks of nanoparticles in the environment in order to facilitate safe design, use and regulation of nanomaterials.

Brazil
Enhancing capability in river-flow modelling to improve flood prediction and build resilience to extreme events.

West Africa
Improving weather forecasting and helping governments prepare for extreme storms, droughts and floods.

Developing and testing automated approaches to predicting Sahel storms and their likely impacts.

Ukraine
Supporting Ukrainian authorities to consider long-term management strategies for the Chernobyl Exclusion Zone and how to return surrounding abandoned lands to productive use.

China
Designing 'sponge cities' through innovation in policy, health, and environmental research, and considering the effects of nature-based solutions on a range of indicators of environmental quality.

Understanding the land-atmosphere interactions and their influence on the East Asian monsoon.

India
Developing COSMOS-India – a network of cosmic ray neutron soil moisture sensors – to better manage water resources sustainably and improve the livelihoods of farmers.

Collaborating with Indian NGOs, government institutes and local communities to understand and predict disease patterns and devise effective cross-sectoral interventions.

Southeast Asia
Indonesia and Malaysia
Monitoring peatlands in South East Asia by satellite to enable better management of peatlands, which contribute about 3.5 per cent of all CO₂ emissions globally.

Thailand
Strengthening agricultural drought resilience in the country to provide a template for action across South East Asia.

South Asia
East Africa
Malawi, Uganda
Investigating the social, environmental and clinical drivers behind the spread of antimicrobial resistance.

Leading a £20 million research programme to tackle the challenge that nitrogen pollution poses for the environment, food security, human health and the economy.

Our people

We work together to advance scientific knowledge, understand stakeholder and customer needs, deliver excellent world-class outputs to meet these requirements, and continue to build skills and knowledge for the future.

UKCEH delivers world-class science with impact, which requires high levels of expertise across a broad range of disciplines and professions. We are committed to developing our existing experts and leaders, recruiting the best scientists and professional management and support staff for the future, and training the next generation of environmental scientists in partnership with universities in the UK and overseas.

Our people strategy describes how we work together with an ethos of continuous improvement and strive for excellence in delivery to meet stakeholder and partner needs.

We provide a working environment that supports equality, diversity and inclusion, recognises and motivates individuals, stimulates teamwork and provides opportunities for personal and career development.

Our approach reflects the importance of flexibility, teamwork and diversity, recognising the contribution made by all to the success of our organisation. We seek to create a working culture that is inclusive and provides a sense of belonging.



Image: UKCEH



Image: © Daniel Hauck

Our values set out the way we want to work together

Excellence

Delivering world-class research and innovation that is valued by stakeholders and meets customer requirements

Teamwork

Working together effectively with colleagues, partners and customers to achieve long-term success

Integrity

Maintaining the highest standards of research and professional ethics and impartiality

Image: Heather Harris, UKCEH

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