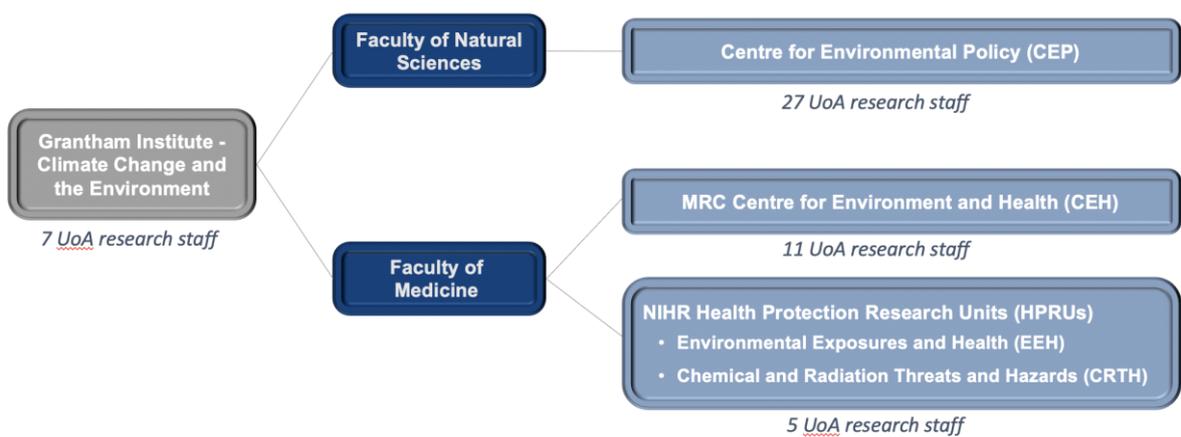


Institution: Imperial College London
Unit of Assessment: C-14
<p>1. Unit context and structure, research and impact strategy</p> <p>Overview</p> <p>1a. UoA structure and organisation</p> <p>Imperial College London is a world leading institution specialising in STEM and Business. This submission to UoA 14 concerns the research of five units within the College that are wholly or primarily dedicated to Environmental Studies: The Grantham Institute for Climate Change, the Centre for Environmental Policy, the MRC Centre for Environment and Health, and the NIHR Health Protection Units for Environmental Exposures and Health and Chemical and Radiation Threats and Hazards.</p> <p>The College has a strong track record of environmental research, and the environment is at the heart of our Academic Strategy ('The Sustainable Society'). Our environmental research takes place in the units included in this submission and in virtually every department in the College. This submission does not, therefore, describe the whole of Imperial's environmental research; it does describe the work done by a core of five units for which the environment is the primary focus.</p> <p>This is Imperial's first submission to the Geography and Environmental Studies UoA. In previous REFs, environmental research has been wholly distributed across the College. Our focused approach on this occasion reflects our progress since the last REF and our ambition going forward to build on the sense of common purpose – a research environment – amongst a core group of trans-disciplinary researchers in environmental science, whilst enabling a larger cohort of environmental researchers to continue to be assessed alongside their disciplinary colleagues.</p> <p>Together, the five units covered by this submission, coordinated by the Grantham Institute, comprise 45.68 FTE REF-submitted academic staff (50 people altogether), with over 100 post-doctoral researchers, 80 PhD students, and more than 300 Masters students. Our research is supported by research councils, business organisations and charitable trusts, with external funding over the REF period of £35M.</p>  <pre> graph TD GI[Grantham Institute - Climate Change and the Environment 7 UoA research staff] --- FNS[Faculty of Natural Sciences] GI --- FMed[Faculty of Medicine] FNS --- CEP[Centre for Environmental Policy (CEP) 27 UoA research staff] FMed --- CEH[MRC Centre for Environment and Health (CEH) 11 UoA research staff] FMed --- HPRUs[NiHR Health Protection Research Units (HPRUs) 5 UoA research staff] HPRUs --- EEH[• Environmental Exposures and Health (EEH)] HPRUs --- CRTH[• Chemical and Radiation Threats and Hazards (CRTH)] </pre> <p>The Grantham Institute (<i>Siebert¹, Babacan, Gambhir, Hardy, Koberle, Plancherel, Rogelj</i>) is one of Imperial College's seven flagship <i>Global Challenge</i> Institutes (see Imperial's Institutional Environment Statement). Like our other six GCIs, it has a dual role: to nucleate and co-ordinate networks of researchers across the College with intersecting interests relevant to</p>

¹ The names of UoA members are shown in italics, throughout.

a Global Challenge, and to co-ordinate the College's external presence in the area, for example, facilitating impact through public affairs and policy work. Founded in 2007 to focus on Climate Change, the Grantham's remit was revised in 2014 to include broad environmental issues. Its core funding is from the Grantham Foundation (>£24m, 2007-2024). Over 200 staff in the College are formally affiliated to the Grantham Institute (including all staff included in this UoA). Its core academic staff all hold joint appointments with other College departments.

The Centre for Environmental Policy (CEP) (*Burgman, ApSimon, Bauen, Castillo, Collins, Conway, de Nazelle, Gross, Howe, Kountouris, Mac Dowell, Z. Makuch, K. Makuch, Mills, Mumford, Oluleye, Pan, Pandeya, Panoutsou, Potter, Sheate, Singh, Skea, Slade, Staffell, Voulvoulis, Woods*) is a long-standing (1977) department of the College focused on enhancing the College's unique scientific and technological expertise by placing it in human (legal, medical, economic and sociological) contexts. Its interdisciplinary natural and social scientists focus on energy and air quality policy, the UN Sustainable Development Goals (SDGs) and the management of water, biosecurity and biodiversity. As well as undertaking primary research, CEP's large and well-established MSc programme is a significant technology transfer vector for the College's environmental expertise.

The **MRC Centre for Environmental Health (CEH)** (*Kelly, Barrat, Barron, Beevers, Fuller, Green, Mudway, Ng, Walton, Williams, Wright*), was formed in 2009 as a partnership between Imperial College and King's College London (KCL). CEH's contribution to understanding air quality and pollution was reflected in an exceptional third renewal in 2019, following which it has been wholly based at Imperial. CEH undertakes research in the fields of environment and health, to inform health policy and the understanding of key issues affecting our society. The Centre achieves this by bringing together the best researchers from all areas of public health, encouraging novel cross-disciplinary approaches, and by providing the highest quality training to new and existing researchers in these fields.

The **NIHR Health Protection Unit in Environmental Exposures and Health (EEH)** (*Fecht, Robinson, Laine, Pirani, Suel*) (established 2014, renewed 2020) is a collaboration between Imperial College, KCL, University of Cambridge and Public Health England. It provides a forum for integrated analysis of environment and health risks, using new technologies for exposure assessment of the health effects of air pollutants applied to large-scale population studies.

The **NIHR Health Protection Unit in Chemical and Radiation Treats and Hazards (CRTH)** (established 2020, staff as above) is also a collaboration between Imperial College, KCL, University of Cambridge and Public Health England. It focuses on radiation and chemicals in the environment, including neurotoxins and high toxicity agents and brings together expertise across the College including medicine, toxicology and chemistry.

Each unit is advised on resources, appointments and research directions by a Management Committee. The Heads meet regularly to discuss research agendas, grant opportunities, staff development and teaching, co-leadership of research networks (described below), joint appointments and grant bids. Each unit has a Research Director who coordinates bids for external and College strategic funding and oversees each unit's internal research funding schemes.

Interdisciplinarity

UoA14 is an intrinsically transdisciplinary community, with academic expertise in, *inter alia*, energy science, epidemiology, public health, toxicology, statistics, climate science, earth science, ecology, chemistry, soil science, social science, psychology, economics, and law. In addition, the Grantham, as one of the College's Global Challenge Institutes, facilitates the cross-college community of environmental research.

The College's Research Centres and Networks of Excellence provide additional channels for transdisciplinary work, usually with a narrower focus than the Institutes. Staff in UoA14 are instrumental in organising and running the following networks:

- *The Network for Excellence in Air Quality*, led by *de Nazelle*, includes 105 staff. It nurtures connectivity across College, improves engagement with society and develops frontier research in transdisciplinary air quality research.
- *The Behaviour Change in Energy and Environment Policy Research Network of Excellence*, led by *Hanna, Carmichael, van Diemen, Sivakumar, Gilbert, and Mills*, has 35 members and coordinates research, funding bids and policy impact on behavioural change focused on sustainability, behavioural modelling, climate change and energy policy.
- *The Ocean Plastics Solutions* network, led by *Castillo* and including 67 members, convenes capabilities from engineering and environmental science to develop multi-disciplinary transformative research to prevent, reduce and mitigate plastic pollution.
- *The Sustainability through Life Cycle Approaches Network*, led by *Rack and Mwabonje*, brings together life cycle research across Imperial College, connecting its 110 members to external groups, applying life cycle concepts for sustainable development.

Research integrity and open research

The College is a signatory to the Concordat to Support Research Integrity and has adopted the Council for Science and Technology's Universal Ethical Code for Scientists (see Imperial's Institutional Environment Statement). The UoA14 units:

- Provide OA author processing charges;
- Require staff to post publications on a REF-compliant open-access repository.
- Strongly encourage placement of data and analysis details on open-access sites such as the Centre for Open Science;
- Participate in research integrity, open science and reproducibility. *Vercammen* is a member of the Imperial College Research Ethics Committee, reviewing all College human health-related research and data. *Collins* leads the UK Reproducibility Network and publishes extensively on systematic literature review methods that mitigate publication bias and questionable research practices. *Burgman* is a PI on the \$6.9M, two-year SCORE project funded by the US Department of Defence, attempting to replicate results of several hundred social and psychological science experiments, the most ambitious study of its kind outside of medicine.

1b. Research Strategy

Research position relative to REF2014

As noted above, this is the first time Imperial has submitted its environmental studies research to the REF. Since 2014, the College has proactively integrated its environmental research, consolidating activities and encouraging multi-disciplinarity through the expansion of the Grantham and the research networks outlined above. The UoA now has eight continuing positions devoted to human dimensions of environmental change, including four social scientists appointed since the last REF (*Collins, Fecht, Howe, Mills*). We have strengthened our capacity in air quality, human health and wellbeing, hiring 16 new staff within CEH and CEP. UoA14 has four nationally awarded centres: Grantham, CEH, EEH and CRTH.

Our annual research income in environmental studies (in this UoA) has increased from £4.8M in 2014 to £5.7M in 2020.

Research strategy over the next five years

The 'Sustainable Society' is one of four themes of Imperial's new Academic Strategy. The units included in this UoA play a crucial role as primary researchers, as transdisciplinary co-ordinators to allow policy makers and others to access the college's expertise, and as mediators between

the STEM and social science communities. We now discuss our existing strengths and future research plans under four intersecting themes which together describe the work of this UoA:

- *Human Dimensions of Environmental Change*
- *Air Quality, Environmental Exposures and Public Health*
- *Climate, Energy Systems and Zero Carbon Transitions*
- *Environmental Systems, Ecosystem Management, Biosecurity and Conservation*

Human Dimensions of Environmental Change

Human Dimensions brings together social and natural scientists, lawyers and economists working on the behavioural, institutional, legal and policy making aspects of environmental change. Members have established track records in the environmental social science of mechanisms of change and the policies and interventions that promote environmentally sustainable outcomes. Over the next five years, this group will strengthen ties with the other research themes through the networks, joint grant bids and PhD supervision, and expand research into behavioural, social and cultural drivers of zero transitions and sustainable environmental management.

For example, with British Academy funding, we are exploring how to reconcile sustainable development goals with land and livestock management in East African pastoral communities (*Howe*, £116k), while a project supported by Margaret A. Cargill Philanthropies applies diffusion of innovation theory to understand why some international conservation initiatives achieve exceptionally high rates of adoption (*Mills*, £199k).

Our work is strongly linked to stakeholders and policymakers. *Howe*, for example, works closely with the United Nations Environment Management Group, contributing to the International Nexus Dialogues on global environmental issues. *Mills* is a leading participant in the Alliance for Conservation Evidence and Sustainability and is advising on the development of Global Environmental Fund-8. *Mills* and colleagues have guided forest restoration by the Brazilian Ministry of Environment through the Native Vegetation Protection Law and the National Policy for Native Vegetation Recovery.

UKRI-funded UoA14 research projects (*Potter*, *Mumford*) explored the threat to UK tree and plant health from invasive pathogens. Current work on achieving the UK Government's plans for woodland expansion to deliver net zero have been characterised by close stakeholder, policy involvement and coproduction (*Potter*). *Kountouris* and *Mills* are evaluating fire management strategies and their interactions with human behaviour, as part of Imperial's newly funded Leverhulme Wildfire Centre. *Potter* will lead a four-year programme of applied interdisciplinary research through his recent appointment as Ambassador for the UKRI's Future Treescapes programme. The UoA's plans include design and adoption of sustainable diets and their impacts on pastoral farming, work on the relationship between biodiversity and human wellbeing, and the SDGs' role in international policymaking.

The multidisciplinary *Climate Cares* team (*De Nazelle*, *Voulvoulis*) was established in 2020 to research psychological responses to climate change. Working with a Young Persons Advisory Group from diverse backgrounds across the UK, the team aims to provide individuals, communities and healthcare systems with knowledge, tools and resources to become resilient to mental health impacts of climate change.

Air Quality, Environmental Exposures and Human Health

Our work through CEH, CEP, EEH and CRTH focuses on the health effects of air pollutants, toxic chemicals, and radiation. CEH's ERG operates the London Air Quality Network (LAQN), Europe's largest, most sophisticated regional monitoring network, comprising over 120

monitoring sites across the city. We evaluate sources of atmospheric pollution and the health implications of individual pollutants. These data are key to investigating impacts of policies to improve air quality, such as London's Low Emission Zone.

In 2018, CEH secured £2.6M from the NIHR to investigate the impact of London's Ultra Low Emission Zone on children's respiratory health (*Mudway*, CHILL). In 2019 CEH won several large multi-university research bids (award value £2.5M) under the URKI Strategic Priorities Fund programme to enhance atmospheric measurement infrastructure (*Green*, *Kelly*). We are investigating how vehicle pollution affects health (OSCA), developing policy modelling to include sensitive groups (APEX, *Barratt*) and assessing the toxicological and respiratory impacts of air quality on human development (DREaM, *Mudway*). We have been awarded MRC funding (£2.3M) to research health effects of the Ultra-Low Emission Zone in London and traffic management schemes in other cities, and to investigate biological signatures of air pollution, providing policy support for the Greater London Authority, UK Government and WHO. The ERG has also played a leading role in a national air quality measurement project (NERC-ClearFlo) and is in the new London NERC Doctoral Training Partnership (award £2.7M; details below).

The Air Quality group has a strong track record in conceptualising and modelling the drivers and consequences of air pollution, especially in urban environments in the UK and Europe. The EU-funded Physical Activity through Sustainable Transport Approaches (PASTA) project (*de Nazelle*) feeds directly into the WHO's Health Economic Assessment Tool (HEAT) for walking and cycling, used by policy makers internationally to make transport investment decisions. *ApSimon's* (UKIAM) research over the last three decades has been instrumental in developing air quality policies throughout Europe, underpinning, for example, the UNECE's Gothenburg protocols. *ApSimon* and *De Nazelle's* work forms the basis of **Case Study 1**, outlined below.

We are building a research agenda around management of public health, especially in cities, that accounts for all dimensions of disease, preparedness, urban planning and human behaviour. We will integrate these research strands over the next five years into a single strategic vision based around tools and policies to transform behaviour and technology to improve health outcomes. The Imperial Air Quality Network is developing policy, industrial partnerships and research funding, and is engaging stakeholders in planning research, developing proposals, disseminating results and implementing policy. For example, it is currently hosting workshops involving more than 40 stakeholders from around the UK in creating a new research agenda. This builds on the work of CEH, EEH and CRTH, where public engagement in research programmes is key features, including a shared Public Oversight Committee and Knowledge Mobilisation post.

Climate, Energy Systems and Zero Carbon Transitions

Clean and sustainable energy services underpin the SDGs and our work addresses critical barriers and drivers. Our contributions to solutions to the global climate crisis will continue for the foreseeable future. Plans include improved understanding of macro-economic impact of net-zero transitions, and developing clean growth strategies for industrial, residential, mobility and power decarbonisation.

The Intergovernmental Panel on Climate Change (IPCC) is the world's most influential cross-government organisation devoted to global responses. *Skea* is co-Chair and *Slade* is Head of Science of the secretariat of Working Group III (Climate Mitigation) (hosted by CEP). *Skea* contributed foundational research on the organisation and incentivisation of transitions to sustainable energy, framing subsequent modelling and applied policy analysis. *Rogelj's* research guided effective mitigation strategies recommended by the IPCC and adopted internationally. His work forms the basis of **Case Study 2**, outlined below. *Rogelj* is a Lead Author for the IPCC's

Sixth Assessment. The energy theme's work will grow over the next five years (CONSTRAIN and Paris-REINFORCE: Horizon 2020, total value to Imperial £1.15M *Rogelj*).

The group is a core contributor to the UK Energy Research Centre (UKERC), funded by the Research Councils since 2004 (total award 2014 - 2019 £13.5M). *Skea* was founding UKERC Director and *Gross* became Director in 2020. UKERC reviews and analyses, led by *Gross*, have informed the UK's Climate Change Committee, National Audit Office, National Infrastructure Commission, and Parliamentary Committees, as well as international bodies including the International Renewable Energy Agency, World Bank and UN.

Mac Dowell leads research on carbon capture and storage (CCS), greenhouse gas removal technologies, and bioenergy with CCS. His work is funded by UKRI, EU, and industrial sponsors (details below) and he is currently seconded to the Department of BIES to advise on greenhouse gas removal policy. *Staffell* is developing novel approaches to data provision and public access. He leads Power Swarm, a network of 400 academics, industry and government power system transformation experts. He developed Electric Insights, an interactive website that reports the supply, demand, price and environmental impacts of Britain's electricity, offering open-access, near-real time information to the public and policy makers, and Renewables.ninja, which provides free data on the power output from wind and solar power plants anywhere in the world.

Woods, *Howells*, *Diaz-Chavez* and *Rogelj* have strong international reputations in sustainable energy system transitions and climate mitigation actions in emerging economies. Their work integrates bioenergy, land use, water and energy service provision with a deep understanding of technological innovation and societal diffusion. Their transdisciplinary research focuses on the need to rapidly decarbonise the energy sector alongside a potentially slower, more complex transition in the Agriculture, Forestry and Other Land Use sectors. *Woods* focuses on the evidence and decision support tools for socially acceptable and sustainable technological interventions and development pathways. *Woods* led the Climate Science and Land, Food and Bioenergy sector developments in the European Calculator and is science lead for the International Climate Fund's International 2050 Calculator Programme (total value to Imperial £1.4M). *Howells* joined CEP in late 2020 and leads the FCDO's Climate Compatible Growth Program supporting the COP26 team.

The Grantham is collaborating with the Royal Institution, building on its successful Cleantech Accelerator programme (described below), to create a Centre for Climate Change Innovation (CCCI) in 2021. The programme is funded for five years (collectively, ~£5M). Partners include the European Development Fund, Greater London Authority, HSBC, Arup, Octopus Energy and legal firm Slaughter and May. The CCCI's critical mass of innovators, entrepreneurs, researchers, students, policymakers and businesses will innovate in atmospheric greenhouse gas removal, urban air quality, climate-adapted agriculture, and low-carbon building, heating, manufacturing and transportation.

Environmental Systems, Ecosystem Management, Biosecurity and Conservation

The UoA14 environmental systems researchers focus on the interface between environmental science, engineering, ecology and public policy. They design pragmatic, context sensitive, technical, policy and regulatory innovations. The group has wide-ranging expertise in operationalising global SDGs, policy analysis, sustainable agriculture, urban ecology, conservation biology, resource management, structured decision-making, scenario development, non-market valuation, water policy and pollution management.

For example, their work has led to improved water management practices and policies in Europe (GLOBAQUA, a consortium of 21 European and 2 non-EU partners: *Voulvoulis*). The

group delivered most of the research that underpinned the 2019 EU Water Framework Directive and Floods Directive Fitness Check.

The environmental systems group collaborates extensively with other Departments at Imperial, including Civil and Environmental Engineering (the NERC funded CAMELLIA project: *Collins*, award total £4.1M, including £329K to *Collins*) and Life Sciences and Materials Engineering (two NERC research grants awarded to the UoA on emerging contaminants in wastewater: *Voulvoulis*: £812K). The theme hosts strategic research partnerships between Imperial and Anglian Water on water challenges, and between Imperial and Veolia on resource management and the circular economy. The UoA also led the synthesis of new approaches to Maximum Sustainable Yield in EU fisheries (EU MYFISH: *Mumford*).

The UoA also focuses on biosecurity, the control of agricultural pests, public health vectors and invasive species. *Potter* and *Mumford* were UK Tree Health and Biosecurity Taskforce members and provided expert advice which shaped the UK Plant Health Risk Register and the UK's approach to plant health. Our UKRI funded project, UNPICK (2018: *Potter, Mumford*; £516k) made a significant contribution to integrating the biophysical and social aspects of plant health risk management and messaging in the UK. Our broader contributions to biosecurity risk assessment are outlined in **Case Study 3**, described below. Food security is an ongoing and important topic in this theme, and the newly created Rockefeller *Conway* Centre (£630K to the UoA), is continuing this work, outlined in **Case Study 4**.

In partnership with the International Plant Protection Convention and the Food and Agriculture Organisation, CEP is improving capacity in developing countries to deal with biosecurity for market access (Beyond Compliance: FAO £162K, *Mumford, Quinlan*), training regional facilitators in Kenya, Uganda, South Africa, Iraq, Mexico, Dominica, Belize, China and Latvia. International guidance involving UoA14 authors on novel disease vector control risk assessment (including European Food Safety Authority, WHO) and risk analysis on genetically modified mosquitoes (TARGET MALARIA: Bill and Melinda Gates Foundation £1.7M, *Mumford*) are also shaping international approaches to these technologies.

Primarily funded by the Big Lottery Fund, Open Air Laboratories (OPAL, hosted by CEP, £4.3M over the REF period) has been a partnership of universities, charities, schools, museums and environmental organisations, led by the *Slawson*, devoted to developing opportunities for people to get closer to their local environments. OPAL's citizen science has contributed to 21 scientific publications. Since 2007, it has involved 22 funded partners across the UK. OPAL pioneered 'Community Scientists', a network of science educators and researchers working directly with the public. It has developed relationships with government, community and voluntary organisations, including more than 3,500 schools and 2,800 other organisations. Over 1 million people have participated in OPAL environmental programmes. In 2013, the OPAL management team was instrumental in establishing the European Citizen Science Association to promote knowledge exchange and the development of public monitoring networks across the continent. The Secretariat has transferred to the Natural History Museum in Berlin and OPAL remains a key member. The UoA's research in citizen science will continue through *Collins, Howe, Mills* and *Burgman*.

1c. Facilitating impact

Each Organisational Unit and research theme deploys specific strategies to disseminate results and influence policy. The units have appointed Enterprise Champions to facilitate engagement with business, government and the wider community. CEP, CEH, EEH and CRTH each have detailed public engagement strategies, coordinated by the Grantham which regularly publishes Policy Briefing Papers and Notes (details below).

The Grantham created the COP26 Universities Network of more than 50 UK universities and research organisations to assist COP26 by providing climate change evidence, ideas and solutions. The Institute provides the secretariat for the network and coordinates policy briefings, media and communications strategies. The Institute has links with the COP26 Cabinet Office Science Team and Partnership Team, UKRI, the NGO community and civil society.

Internationally, the Grantham leads Imperial's involvement in the Global Alliance of Universities on Climate (GAUC), committed to advancing climate change solutions through research, education, and public outreach. Launched in 2019, GAUC now has 13 member institutions in nine countries across six continents. Many members of this UoA also play a leading role in other important international environmental initiatives, detailed in **Section 4f**.

Members of UoA14 have substantial impacts in many other ways. Apart from the contributions to the IPCC by *Skea*, *Slade* and *Rogelj* and to carbon calculators by *Woods*, *Staffell's* Electric Insights interactive website has more than 30,000 users each month, and his *Renewables.ninja* tool, used by 520 universities and companies, and 85 national governments, recently provided its four millionth simulation. To improve public understanding of the health effects of air pollution, CEH developed the LAQN website, which received over 215,000 unique visitors in 2019, a year-on-year increase of 30%. Our mobile web site and smartphone apps have distributed 400,000 pollution notifications during pollution episodes in 2020.

UoA staff provided consultancy services on a very broad range of topics. They have worked for the World Bank on carbon pricing, the Climate Change Committee on modelling leading directly to its report on net-zero emissions, and on net zero transitions for a range of public and private sector bodies including the US Department of the Environment, UK BEIS, Total, Exxon, Anglo American and Glencore. The UoA's business and community links are detailed in **Section 4**. Consultancies have also included substantial projects for the US Department of Homeland Security on improved methods for judgement and reasoning (CREATE: *Burgman*, \$12M) and the US Department of Defence on assessing and reproducing the outcomes of social science research (SCORE: *Burgman*, \$6.9M).

The Grantham's Cleantech Accelerator programme for early-stage start-ups is funded by the European Institute of Innovation and Technology, Climate Knowledge and Innovation Centre (ClimateKIC) (in which Imperial is a founding partner). Encouraging Early Career Researchers to fulfil their entrepreneurial ambitions, the Accelerator provides a supportive environment where ideas can be formed, tested and turned into companies at Technology Readiness Level 3, enabling them to secure funds and scale their business.

The Accelerator launched 60 companies in the REF period, which were awarded a total of \$300M from venture capital, business and philanthropic sources. Examples include Ooho (plastic-free water capsules), Oorja (sustainable electricity solutions for remote Indian communities), and Chrysalix (transforming waste wood into fuels, new materials and chemical products).

2. People

Our priority is to attract and retain academics who are, or who have the potential to become, international research leaders and to provide them with the best possible environment for their research and teaching. Staff in the UoA are supported by reduced teaching and administration loads for Early Career Researchers (ECRs), mentoring, and flexible work options. ECRs undertake three years' probation (with a formal mid-term review). Staff have access to extensive support for grant applications including reviews and mentoring from senior staff, mock interview panels, and interview coaching as appropriate.

Appointments

Recruitment strategies have been made more inclusive by reviewing essential requirements for roles, revising advertisements using Textio and eliminating leading phrases such as “world-leading” which discourage women. We list all roles on Diversity Job Site, and advertise flexible working, encouraging under-represented groups and those returning from career breaks.

This approach is effective; the composition of the Grantham, CEP and CEH has changed over the REF period from 18% women in 2014 to 33% women in 2020, including a change in senior positions (Reader and Professor) from 12% women in 2014 to 26% women in 2020.

Each new staff member is assigned a mentor who provides support and guidance in grant writing, research strategy, publication strategy, and supervision. As part of this, we encourage and support research staff to attract high-quality research fellows. The outcome of this is that the UoA has been awarded the following fellowships during the REF period:

- Imperial College Research Fellows: *Oluleye, Singh, Pendeya, Pan, Babacan*.
- MRC Centre Early Career Fellow: *Laine*
- UKRI Rutherford Innovation Fellow: *Wright*
- Health Data Research UK Fellow: *Suel*
- UK Intelligence Community Postdoctoral Fellow: *Ng*
- UKRI Future Leaders Fellow: *Robinson*
- Royal Society Newton International Fellow: *Chiaravalloti*,

Fellowships awarded to UoA14 staff include *Haigh* (a NERC Fellowship for a thermodynamic view of ocean warming (£733k)), *Skea* (an EPSRC Energy Strategy Fellowship (£2.5M)), *Collins* (a NERC Knowledge Exchange Fellowship (£294k)) and *Plancherel* (a NERC independent research fellowship).

Recruitment for continuing positions involves open seminars, individual one-to-one meetings with staff, and a representative interview panel trained in equality, diversity and inclusion. Panels also involve academically elected College Consuls, Professors from other Departments, and for Reader/Professor appointments, external Professors. All Department-funded Category-A appointments are permanent, except where the appointment replaces a permanent staff member on secondment.

Considerable thought is given to staff numbers in each organisational unit and theme. Roles and priorities are discussed in management committees and staff meetings. Position descriptions are circulated for comment to all staff. The levels of appointments account for new research developments and impact pathways. Recent hires have focused on interdisciplinary research. With our demographic profile (20% professors) we generally recruit Lecturers or Senior Lecturers (13 of 18 permanent academic hires in the UoA over the REF period were L/SL), to ensure a balanced pipeline for succession.

UoA14 implemented a policy in 2018 to interview all applicants for academic positions who fulfil the advertised criteria and satisfy ‘protected’ characteristics related to disability, ethnicity, culture and gender, to ensure diverse and representative sets of applicants.

To enhance inter-Department and interdisciplinary interactions and synergies, the Grantham offers three-year academic appointments that are jointly agreed by the Institute and an Imperial Department. After three years, appointees transfer to their host academic Department. Departments benefit from staff members with interests in climate change and extensive and connected affiliates network who continue to work across disciplines and organisational boundaries. *Rogerj* will join CEP from the Grantham in 2021 as a result of this unique collaboration.

Promotions

In the UoA during the REF period since 2014, 19 academic (teaching and research) staff were promoted, four to Professor, five to Reader and 10 to Senior Lecturer. Nominations for promotion

in each organisational unit are overseen by a Promotions Committee that represents the unit in terms of gender and career stage, and as far as possible includes people with diverse social and cultural backgrounds, and academic focuses. All Committee members have unconscious bias training. They consider all pre-professorial staff for promotion every year. Staff may also self-nominate.

Interviews are mandatory for promotion to Reader and Professor. All applicants are offered mock interviews and provided with feedback. In addition to oversight by the Promotions Committee, UoA14 unit heads each meet annually with each staff member for whom they are responsible, for Personal Review and Development Plan (PRDP) discussions covering teaching, research, impact, internal contributions and career development. This ensures that unit heads understand the needs of each individual and research group and are involved in staff development and succession planning. These meetings facilitate active staff feedback and constructive dialogue.

Staff development and research support

Each organisational unit has a Workload Model that accounts for teaching, research and administration (e.g., committee participation, outreach activities and professional contributions). We consider career stage, student pastoral duties, staff mentoring, diversity activities, caring responsibilities and maternity leave. Over the REF period, we reduced the administrative on research staff; we reviewed research support and in 2017, appointed two new professional staff to manage graduate admissions, student administration, and materials for curriculum development.

Of the 50 REF-eligible staff in the UoA, nine are on fixed term contracts, of whom four are female. Eight are research fellows and one a fixed-term lecturer (*Collins*), replacing a staff member on secondment (*Slade*). The UoA supports fixed-term appointees with research mentorship, detailed career planning conducted in each annual review, interview preparation, and grant application mentoring and review.

The Research Directors facilitate widespread research engagement and consultation, appropriate working groups/committees and research planning days. They also support academic staff in identifying, developing, organising, publicising and managing large-scale research grant applications. This may include multi-group initiatives (including external academic and industrial partners).

New research opportunities are distributed to staff by email, staff meetings and newsletters. Proposals are submitted to Research and unit heads for preliminary assessment and advice. Proposal drafts are reviewed by UoA colleagues and mentors. The Research Directors make specific recommendations and suggest others in the Department (and elsewhere) to enhance the proposals. SharePoint provides a repository of a representative selection grant applications, available to staff in the UoA to provide guidance/support.

All staff undertake professional development. Training activities are reviewed annually during PRDP discussions. Over the REF period, six UoA academic and research staff (four women and two men) attended the College's Academic Leadership Programme. A total of 17 staff (15 women and two men) participated in communications training, 31 (11 women and 20 men) in management training and 38 (23 women and 15 men) in teaching and assessment courses.

Recognition and reward for research and impact

The UoA is devoted to translating science into policy. We are strongly proactive in recognizing and rewarding excellence in research and impact. World-class research output and impact are necessary criteria for all academic appointments (32 appointments over REF period) and

promotions (19). Outstanding research and impact are also rewarded with merit pay increases, Faculty Excellence Awards and the College President's Awards. Individual UoA members have been recognized by the College for outstanding research and impact over the REF, including:

- *van Sebille*, President's Award for Societal Engagement, 2016
- *Slawson* and OPAL, President's Award for Societal Engagement, 2017
- *K. Makuch*: President's Award for Research Supervision, 2018
- Staffell: President's Award for Innovation and Entrepreneurship, 2019

Facilitating exchanges between academia and business, industry and public and third sector bodies

It is an essential strategy of the UoA to encourage exchanges with other sectors to drive impact, fill gaps in the UoA's research profile, enhance new research directions, create synergies, and support ECRs. Research fellows have joined us from many institutions including the Climate Change Committee secretariat, Ofgem, the Chinese Energy Research Institute and HSBC. Honorary staff have included *Hart* (Director, E4Tech), *Oraee* (Jovein Cement Plc. CEO), *Waage* (Director, London International Development Centre), *Wade* (Chief Strategic Advisor, Association for Decentralised Energy) and *Morrison* (Economist, FAO). They have initiated research collaborations, written papers, supervised theses and developed grant submissions.

Importantly, external partners participate in many MSc research projects. In the MSc in Environmental Technology, 284 projects have been sponsored and supervised by external industry partners over the REF period, and 249 have involved placements. Similarly, the current CCMF Masters cohort undertook internships in over 40 organisations, many leading to full time employment positions. External speakers, including many programme alumni, are scheduled weekly in all Masters programmes. Extra-curricular initiatives, such as the Responsible Investment Imperial group and Green Minds, sustain beneficial impacts of the MSc students on our wider communities.

CEH's Sustainability Working Group was established in 2020 after the first CEH Sustainability Workshop. Comprising CEH students and staff, its mission is to promote sustainable transitions in the College and more widely. The Working Group leadership includes four CEH-based PhD students from the UoA.

2b. Research students

Recruitment and selection

Over the REF period since 2014, the UoA enrolled 129 PhD students, appointed from a total of 694 applicants (approximately 84% from overseas, reflecting the UoA's global reputation and reach). Presently, 81 PhD students are registered and supervised in the UoA, including 71 in CEP and 10 in CEH, EEH and CRTH. There are currently 76 PhD students "core-funded" or "affiliated" with the MRC Centre, EEH and CRTH. Together, we have maintained an average intake of about 30 new PhD students annually over the census period.

The UoA's five organisational units recruit high-quality students internationally from diverse geographic and cultural backgrounds, advertising through social media, alumni networks, open days and Centres for Doctoral Training (CDT). Individual research groups welcome potential student visitors. Our MSc programmes are an important pipeline for aspiring doctoral candidates; 18% of PhD students at CEP previously completed the MSc in Environmental Technology.

PhD applicants are interviewed by at least two academics and ranked by the Postgraduate Committees and/or CDT committees on the basis of academic merit, eligibility, skills, and alignment with the College's policy on EDI. Exceptional candidates are nominated for the College's

prestigious Imperial President's Scholarships. The UoA secured six of these during the REF period.

The College's NERC-funded Scientific Solutions for a Changing Planet Doctoral Training Partnership, managed by the Grantham, began in 2014 (with 15 students per year) and was renewed in 2019 (with 14 students each year for five further years). The programme is enhanced by externally funded 'aligned' students, which commonly doubles its size (in 2019 the new cohort was 34). Nearly half of the students are supported by industry CASE scholarships. Currently, 115 students are actively enrolled, of which 47 are female and 68 are male. A total of 178 students have been enrolled in the SSCP DTP to date (registered in their home departments).

PG training, support and development

The Directors of Postgraduate Studies provide PG support, augmented by Senior Tutors and Women's Tutors, who oversee PhD and Masters student wellbeing. All new lecturers take the College's PhD supervision course. Inexperienced supervisors are assigned an experienced co-supervisor who assists in student selection and supervision. Other support is described under the EDI outline below. If supervisory issues are identified by the Postgraduate Coordinator, the UoA arranges specialist training. The UoA also runs annual supervision refresher programs and staff are required to participate at least every third year.

A comprehensive monitoring system is used to identify potential problems at an early stage, provide support and monitor progress. All PhD students submit a Research Plan at three months, followed by a major review, the Early Stage Assessment, at nine months where they are examined in person by an independent academic who provides detailed independent feedback. Students also report on their progress and relationship with their supervisor at 6 month intervals. Students are assessed again when they submit a Late Stage Report after 24 months. Any issues are followed up by the Director of PG Studies, who may consult the Department or Faculty Tutors.

Other support mechanisms include PG student representation on teaching, research and strategic operational committees, giving them a voice in all aspects of the UoA's management. All PhD students receive an annual research support allowance of at least £1k. To develop core interdisciplinary skills, students are encouraged to become affiliates with at least one other research initiative including the Grantham SSCP DTP, London Interdisciplinary Social Science (LISS) DTP, Leverhulme Wildfire Centre or the Imperial College Transition to Zero Pollution.

The primary sources of career support for PhD students are their supervisors and a mentor who is independent of the supervisor. The Careers Service also offers coaching and organises career events. Additionally, each organisational unit within the UoA provides specialised career advice. For example, CEP's Careers Advisor, *Sheate*, runs individual and group sessions and a mentoring scheme, matching students with experienced alumni with whom they can discuss career development, job seeking and networking.

Our PhD students complete the Graduate School's Professional Development Programme tailored to their specific needs and interests, where they select from 50+ courses on topics including Research Communication, Business Skills and Research Integrity. Over the REF period, our PhD students took part in over 500 training sessions, taking an average of more than two courses per year. In addition, the Grantham programme integrates four two-day workshops delivered by academics and external organisations in areas that address key skills shortages in the environmental sector. To promote cross-disciplinary training, students engage in team challenges and work with business and policy-makers to develop skills to communicate and apply science to inform decision-making in business and policy. SSCP DTP students also work on Grantham Briefing Papers through paid internships, enabling them to gain skills in communicating science to different audiences,

The UoA's commitment to training extends to PhD studentships in partnership with UK and international governments, industry, and national-level initiatives. Since 2014, ten CASE, iCASE, and other studentships were funded by companies including Total, E&P UK Limited, Veolia, Cosia, Brazilian National Council for Scientific and Technical Development and the Chia Meei Food Industrial Corporation. Seventeen overseas governmental bodies have accessed the environment research and training capacity in the CEP funding 30 PhD scholarships. The UoA supports PhD internships and partners have included EcoHealth Alliance (New York), Defra, BEIS, E3G, the UK Committee on Climate Change, National Informatics Institute (Tokyo) and the World Meteorological Organization.

Each organisational unit hosts a local seminar series that complements the Grantham Seminar Series and formal course offerings. All PhD students and academic staff are expected to attend. Presentations are given by invited and visiting academics, UoA14 and Imperial academics, and PhD students. High-profile speakers are listed in **Section 4**.

All units in the UoA host annual PhD symposia including poster sessions and spoken presentations. The best presentations are awarded prizes and are selected for presentations at annual Faculty Showcase events.

The CEH, EEH and CRTH Researchers' Society is run by early-career researchers and promotes welfare and career development, building a collaborative and engaged community. All CEH, EEH and CRTH PhD students, research and technical staff are Society members. At CEH, EEH and CRTH all PhD students take part in a bespoke, multidisciplinary Joint Training Programme, alongside our College programmes and those offered by Public Health England, King's College London and the University of Cambridge's MRC Toxicology Unit.

2c. Equality, diversity and inclusion

All organisational units are committed to championing a university environment where all students, staff and visitors are treated with respect, consideration and courtesy and are safe and supported. All units within the UoA have EDI committees with diverse representation (based on gender and culture, and including academics, research fellows, postdoctoral researchers, PhDs, MSc students and support staff). The committees develop and implement EDI initiatives. EDI is a standing agenda item at staff and management committee meetings. Each unit in the UoA has a workload model to ensure the equitable allocation of tasks.

CEP was awarded Athena SWAN bronze status in 2019 and is currently working towards its Silver Award in 2023. CEH, EEH and CRTH are within the School of Public Health, which was also awarded a Bronze Athena SWAN Award in 2019. Women@Imperial Week is an annual cross-College celebration and UoA staff are enthusiastic participants. A 'Women in CEP' web page was launched in 2019 to raise the visibility of female staff and promote female role models. All UoA14 seminar series ensure balanced speaker representation. Many members of staff are members or allies of Imperial 600, Imperial's LGBTQ+ community. Participation is encouraged in staff meetings and unit newsletters. Imperial became a member of the Race Equality Charter (REC) in 2018 and staff in the UoA are members of the Self-Assessment Team that leads initiatives for race equality.

Our comprehensive induction programme for new staff covers the College's policies on sexual harassment, bullying, discrimination, unconscious bias and bystander training, as well as their implementation within each unit, and our expectations of staff behaviour in this regard. As noted above, to support equality in recruitment and at work, all staff undertake unconscious bias training and the UoA ensures balanced interviewing and examination panels. For support from outside the immediate department, the Student Support Zone, Disability Advisory Service and Student Counselling Service offer confidential and tailored support to deal with anxiety, finances,

harassment, bullying and sexual violence. Staff are encouraged to speak up anonymously via the Faculty “Have Your Say” hotline.

Imperial College has on-site prayer rooms and all units in the UoA accommodate requests for flexible working by students and staff, for example, for religious observance or caring responsibilities. All facilities are compliant safe refuges and support evacuation access lifts for wheelchair users and others with movement impairment.

EDI in staff recruitment:

Over the REF period, all units of this UoA have actively encouraged women and other under-represented groups to apply for all positions. As noted above, our proactive recruitment programme includes appropriate advertisements and listing strategies that encourage people from diverse social and cultural backgrounds, and flexible working policies to accommodate caring responsibilities and religious needs.

Further actions to raise the number of women and other under-represented groups at higher levels include promotion, training and guidance on teaching, mentorship in developing grant applications, and targeted recruitment. Flexible working (both formal and informal) is available to all staff in the UoA, most of whom have taken it up in some form over the REF period. Since January 2018, the majority of UoA meetings, workshops and seminars are during the Athena SWAN recommended core hours of 10am-4pm, to accommodate caring responsibilities. The UoA has created guidance documents for staff and students outlining support for those who experience bullying, sexual harassment or discrimination. *Howe* is a member of the Imperial College FoNS Diversity and Equality Committee. *Green* and *Cherni* are Members of the Athena SWAN Self-Assessment Team. *Burgman* is one of the College’s five Sexual Violence Liaison Officers.

EDI with respect to research students:

Overall, Imperial College has approximately equal numbers of male and female Masters and PhD students and this is reflected in our current cohorts across each of the UoA units: 50% female students at CEP and CEH, EEH and CRTH. CEP’s environmental master’s program is composed of approximately 56% women (average since 2014). The Grantham’s Climate Finance Masters currently has 57% women. We also recruit actively on social media in a range of countries, targeting excellent universities from a range of cultural settings in China, Europe, India, south-east Asia, North, Central and South America. Currently, our programs have about 50% international students.

As noted above, PhD applicants are interviewed by at least two academic staff and ranked by the Postgraduate Committees and/or CDT committees on the basis of academic merit, eligibility, skills, and alignment with the College’s Equity policy.

We support flexible working hours for students and timetable lectures between 10 am and 4 pm, as much as possible. The UoA follows national guidelines for maternity, paternity, shared parental, adoption and illness leave. Full support and advice are available to students, and studentships are extended accordingly, so that progression is unaffected. A total of 21 PhD students took interruption of studies between 2014-20 and 29 in the SSCP DPT, including three on paternity leave, one on maternity leave, 13 health-related interruptions and nine internships.

Maternity/paternity/adoption support

During the REF period, three women staff members have been awarded Imperial’s Elsie Widdowson Fellowships which support academic staff to concentrate fully on their research upon returning from leave by granting relief of teaching and administration for 12 months. CEP has implemented a Maternity, Paternity, Shared Parental, Adoption and Parental Leave Policy and

Check List, providing support that goes beyond the College's parental leave policy. It includes specific actions for line managers to ensure understanding and communication and includes ante-natal care support, annual leave, keep in touch days, where to find information about childcare, and breast-feeding facilities as well as agreements on communication. These policies are being rolled out across the UoA.

Each unit in this UoA monitors and reviews academic career pathways for women, including bespoke Equality and Appraisal training events and staff workshops each year to raise awareness of the support available for maternity, paternity and adoption leave.

3. Income, infrastructure and facilities

3a. Research income

Over the REF period, the UoA has received a total of £35M in research income, an 18% increase in annual research volume (from £4.8M in 2014 to £5.7M 2020) over the REF period. This includes £7.8M from UK Government, £8.9M from UK Research Councils, £6.5M from the EU Commission, £3.4M from non-UK Charities, £2.4M from industry partners, and £9.5M from other sources.

Growth has been driven by a 63% increase in European funding (from £735k/year in 2014 to £1.2M in 2020), a 177% increase in average annual Research Council funding (from £733k/year to £2.0M /year), a 66% increase in industrial funding (from £367k/year to £609k), and a 24% increase in UK Government funding (from £986k/year to £1.2M). Highlights are outlined below.

The increase in our research volume over the REF period reflects a balanced portfolio of smaller responsive grants alongside Fellowships and larger-scale grants. In the UoA, the number of consultancies per year has grown from 13 in 2013 to 38 in 2020, with gross value increasing from £87k in 2013 to £599k, in 2020.

Major projects / highlights (total awards=>£200k)

UK Research Councils

EPSRC

- £3.0M to Co-Chair Working Group III (Mitigation) of the IPCC (*Skea*).
- £2.6M by for UK Energy Research Centre- Phase 3 and Phase 4 (*Gross*)
- £2.1M for the UK-India Joint Virtual Clean Energy Centre (*Nelson*)

BBSRC

- £670k for work on the Social Amplification of plant health risks (*Potter*)

NERC

- £1.7M for optimisation of Greenhouse Gas Removal (*Mac Dowell*)
- £529k for antimicrobial manufacturing waste in Puducherry and Chennai (*Voulvoulis*)
- £525k for the role of Ambassador the UK Future Treescape Programme (*Potter*)
- £486k from UKCEH to develop national air pollution control strategies (*ApSimon*)

MRC

- £3.0M, MRC Centre for Environment and Health (Elliott [UoA2], *Kelly* 2019)
- £2.5M, MRC Centre for Environment and Health (Elliott, *Kelly* 2014)
- £2.2M, MRC Health Effects of Ultra Low Emission Zone (Elliott, *Kelly*)

Industrial

- £1.7M, Shell Global (*Mac Dowell*)
- £611k, Anglian Water (*Voulvoulis*)
- £352k, Total UK Limited (*Mac Dowell*)
- £241k, Canada's Oil Sands Innovation Alliance Inc, (*Mac Dowell, Hallett*)
- £230k, Standard Chartered Bank (*Koberle*)

Unit-level environment template (REF5b)

- £229k, Shell Global (*Woods*)

UK Government

- £8.0M NIHR, for EEH and CRTH (*Kelly, Elliott [UoA2]*)
- £4.3M for OPen Air Laboratories (*Davies, Slawson*)
- £2.7M for Working Group III, IPCC 6th Assessment Report (*Skea*)
- £1.5M Department for International Development (UK) (*Conway*)
- £518k Defra, for DROPSA (*Mumford*)

EU Commission

- £1.4M from CEC for NEGEM (*Mac Dowell*)
- £1.2M EU for EU bioeconomy consortium projects (*Panoutsou*)
- £746k Horizon for EU Calculator 2020 (*Woods*)
- £647k EU for GLOBAQUA (*Voulvoulis*)
- £644k from CEC for COMETHA (*Bauen*)
- £611k from CEC for EMPHASIS (*Mumford*)

Charities

- £1.8M Bill and Melinda Gates Foundation for Target Malaria Phase II (*Mumford*)
- £811k Bill and Melinda Gates Foundation for Agriculture Impact (*Conway*)
- £630k Rockefeller Foundation Rockefeller Conway Centre (*Conway*)
- £200k World Wildlife Fund (USA) for Alliance for Conservation Evidence and Sustainability (*Mills*)

3b. Strategies for generating research income

We will grow our interdisciplinary research, particularly through the research networks described above, supported by numerous links and research collaborations between departments and with other institutions nationally and internationally.

The Research Office distributes information of research opportunities almost daily and the Research Directors in each UoA unit identify and encourage staff to discuss options and develop coordinated bids. The arrival of *Kelly's* air quality group in CEH creates new opportunities and synergies with CEP's air pollution research group and the College's air pollution research network.

We will also grow engagement and strategic collaborations with industrial partners. We have ongoing relationships with Shell, BP, Total, Anglo American, Glencore, Anglian Water and Veolia and key industry groups (CCSA, UKWIR). We are a member of leading research centres (UKCCSRC, Supergen) with convening power to shape the research agenda, and we collaborate with many with NGOs (including Bellona, The Nature Conservancy and WWF). We network extensively in the EU contribute to many H2020 projects. Finally, we engage directly with research councils (MRC, NERC, EPSRC) to shape the research agenda in our areas.

3c. Infrastructure and support

Imperial College invested £5.5M in new laboratories on the White City campus to support *Kelly* and the ERG's move to Imperial, the renewal of the CEH and the award of EEH and CRTH. A £5M reconfiguration of the South Kensington Campus Library Building houses six CDTs, including students from UoA14. Over the REF period, the College also spent £6.1M to convert Weeks Hall to accommodate CEP, with the Centre occupying the new space in February 2018.

The UoA makes extensive use of Imperial's Research Computing Service (RCS), which supports machines that host large-scale, parallel computing jobs requiring up to 15,000 processors. In 2020 the MRC under its World Class Labs Capital Funding initiative awarded a £400k infrastructure grant to support computing in CEH. We are now the leading university in the

UK in terms of Internet connectivity, facilitating large scale, rapid data transfer with other UK, European and international research establishments, supporting research collaboration with external academic and commercial partners. Over this REF period Imperial also established a new data centre facility dedicated to research computing. The College invests £3m annually in research computing at all levels.

4. Collaboration and contribution to the research base, economy and society

In keeping with our international outlook and emphasis on multidisciplinary, Imperial's research is highly collaborative. Of UoA14's submitted outputs, 48% are collaborations with other UK institutions, and 63% are international collaborations. A total of 76% of the outputs include non-Imperial collaborators. Of the 50 submitted staff, 82% have held grants with external partners from 96 institutions in 22 countries.

4a/b. Support for research collaborations, networks and partnerships and engagement with key research users, beneficiaries or audiences

UoA academics contribute evidence and solutions to many environmental challenges with government and industry decision-makers and community audiences; examples are documented below. The research networks described above are a core element the UoA's strategy for research collaboration, supported largely by resources from Imperial and the UoA. The Grantham Research Fellowship programme also contributes to our international research.

A key engagement strategy is our public lecture series featuring, during the REF period, high-profile speakers including:

- Yolanda Kakabadse, former President WWF, former President of the World Conservation Union (IUCN) and former Minister of Environment for the Republic of Ecuador.
- Al Gore, former Vice President of the United States.
- His Serene Highness Prince Albert II of Monaco.
- Mary Robinson, President of the Mary Robinson Foundation - Climate Justice and former Irish president.
- Paul Polman, CEO of Unilever and Chairman of the World Business Council for Sustainable Development.
- Christiana Figueres, Executive Secretary of the UN Framework Convention on Climate Change.
- Judy Ling Wong CBE, Honorary President of the Black Environment Network, Founding Trustee of the National Park City Foundation.
- Dr Fatih Birol, Chief Economist of the International Energy Agency.
- Dr Ernest Moniz, United States Secretary of Energy.
- Professor Dame Sally Davies, Chief Medical Officer
- Professor Sir Mark Walport, Chief Scientific Adviser

The Grantham reaches an extensive external network of policy-makers and other audiences through its weekly newsletter (c. 7,500 subscribers), social media (c. 10,000 Twitter followers), and direct engagement. For example, we are members of the Aldersgate Group (business alliance) and the All-Party Parliamentary Group on Climate Change.

The UoA supports its researchers in a range of public engagement activities and organises events that showcase its research as a whole. CEH's public engagement strategy is led by the MRC Centre, EEH and CRTH joint Public and Community Involvement Engagement and Participation Committee and coordinated by *Mudway*. The Committee is supported by public engagement officers in EEH and CRTH, with advice from the Public and Community Oversight Group composed of members of the public and occupational, patient and community groups. CEP's engagement strategy is led by *de Nazelle*, one of Imperial's societal engagement

champions. As UK STEM Ambassador, EEH's *Ng* mentors and inspires young people to take STEM subjects.

4c/d. Wider contributions to the economy and society, and engagement with diverse communities and publics

As noted above, the Grantham regularly publishes Policy Briefing Papers and Notes, communicated in face-to-face workshops and symposia and distributed to hundreds of policy makers, industry leaders and community groups. They directly influence many policy initiatives nationally and internationally. For example, the paper on Society-led Low Carbon Transformation (2017) was presented to the Smart Energy GB All-Party Parliamentary Group. The paper on The Arctic and the UK (2020) was incorporated in the 2019 Antarctic Treaty Consultative Meeting and was a core element in the design of the UK's new Arctic Strategy. Grantham Papers and Notes have been viewed and downloaded tens of thousands of times. All Grantham events and panel discussions are available on its YouTube channel.

We contribute to the economy, society and broader community in literally hundreds of ways, reflecting personal commitments to public health and the environment. Some of the more high-profile commitments are listed below, a small proportion of the total:

- Chair, Scotland's Just Transitions Committee: *Skea*
- Chair, Great Britain Non-native Species Risk Analysis Panel, 2007 – 2020: *Mumford*
- Chair, Executive Body of the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP): *Williams*
- Chair and Council Member, Energy Advisory Panel, Energy Institute: *Gross*
- Chair, Biomass Supply, European Biofuels Technology Platform (EBTP): *Panoutsou*
- Chair, UK Arctic and Antarctic Partnerships Committee: *Siegert*
- Chair, Meridian Institute, Washington DC: *Conway*
- Chair, Committee on Medical Effects of Air Pollutants: *Kelly*
- Board, Library of Alexandria, Cairo: *Conway*
- UN Secretary-General António Guterres' Climate Science Advisory Group: *Rogelj*
- UK Committee on Climate Change: *Skea*
- Standing Advisory Group on Nuclear Applications (International Atomic Energy Agency): *Mumford*
- European Commission Microplastics Working Group: *Wright*
- Steering Committee for the Alliance on Conservation Evidence: *Mills*
- Scientific Advisory Committee, The Nature Conservancy, Washington: *Burgman*
- Science Committee, Royal Horticultural Society: *Slawson*
- National Policy Committee, Council for Protection of Rural England: *Potter*
- Health Effects Institute Review Committee: *Kelly, Barratt*
- IChemE Energy Centre Board: *Mac Dowell*
- Governing Board, EIT Climate Knowledge and Innovation Community: *Siegert*

4e. Contributions to sustainability of the discipline and responsiveness to emerging priorities

UoA14 staff roles in the influential IPCC are documented above. The '1.5°C report', launched at Imperial in 2018 by the UK Environment Minister Claire Perry MP, underpinned the UK's decision to commit to net zero carbon emissions by 2050, announced by Prime Minister Theresa May at Imperial in June 2019.

UoA staff influence environmental policy in many other ways. *Mac Dowell* is on Total's Scientific Committee and helped the company to develop its net zero strategy. Members are on many industrial boards (see above). *Mac Dowell* was the only non-US citizen invited to contribute to the US National Academy of Science study on Greenhouse Gas Removal. *Howe* leads the MOU between Imperial College and the United Nations Environmental Management Group (UN

EMG), supporting the UN on biodiversity, human wellbeing issues and the SDGs, and assisting the UN EMG to implement outcomes from Imperial College research.

We continue to expand our role in significant international policy initiatives (see **Section 1c** above), especially our involvements in the IPCC (*Skea, Slade and Rogelj*), the International Society for Environmental Epidemiology (*de Nazelle*), the Health Effects Institute Review Committee (*Kelly*), the Malabo-Montpellier Panel for food security and the Rockefeller Conway Centre for nutrition research (*Conway*), and international biosecurity risk assessment systems (*Mumford*).

In addition to the many roles outlined above, UoA members contribute to emerging priorities through scientific societies and conferences. Many UoA members have been heavily involved in conference organisation over the REF period, including for the International Society for Environmental Epidemiology (*Fecht*), the International Environmetrics Society (*Pirani*), European Biomass Conference (*Panatsou*), the Investigation of Air Pollution Standing Conference (*Green*) and the European Aerosol Conference (*Green*). Other examples of UoA participation in emerging priorities include;

- PluS Alliance Advisory Panel: *Kelly*
- WHO Expert Consultation Panel on Air Pollution Risk Communication: *Barratt*
- WHO Expert Consultation of Health Impacts Assessment of NO₂ in the European Region: *Beevers*
- WHO (REVIHAAP) Review of evidence on health aspects of air pollution: *Mudway, Kelly, Walton, Williams*
- Advisor, Irish Environmental Protection Agency: *Walton*
- Committee on the Medical Effects of Air Pollutants, Public Health England: *Walton*
- Specialist Adviser, Environmental Audit Committee, House of Commons: *Sheate*
- UK Commons Select Committee, Environmental Audit Committee: *Mudway*
- US Environmental Protection Agency: *Beevers*
- Advisory Board, Scott Institute for Energy Innovation, Carnegie-Mellon University: *Skea*

4f. indicators of wider influence, contributions to and recognition by the research base: fellowships, recognition and editorships

Significant roles in the coordination and leadership of scientific research by UoA members include:

- *Gross* (seconded in 2019 to be the Director of UK Energy Research Centre),
- *Potter* (appointed in 2020 as a Future of UK Treescapes programme Ambassador by NERC / AHRC / ESRC),
- *Mac Dowell* (seconded in 2021 to the UK Department of BEIS to translate energy research into public policy),
- *Voulvoulis* (appointed in 2019 to the Environment Agency Strategic Monitoring Review Advisory Body).

UoA members make other influential contributions; some include:

- Lead Author in UNEP's 6th Global Environment Outlook and a Contributing Author on UNEP's Gap Report: *Köberle*
- Lead Authors for the IPCC's 6th Assessment Report: *Köberle and Rogelj*
- ESRC Collaborative Studentship Panel: *Potter*
- Sheffield Fellowship Selection Committee, Marshall Aid Commemoration Commission: *Mumford*
- Evaluation Panel Senior Researcher, Environmental and Agricultural Sciences Panel, British Council: *Wood*
- Scientific Panel member, European Commission, European & Global Fellowships: *Fecht*.

UoA members hold the following fellowships, awards and senior editorships:

- Learned Societies:
 - Fellow of the Royal Society (FRS): *Conway*

- Fellows of International Scientific Societies
 - Royal Society of Edinburgh (FRSE): *Siebert, Skea*
 - Australian Academy of Science (FAA): *Burgman*
 - American Academy of Arts and Sciences (FAAAS): *Conway*
- Fellows of Other National Learned Societies:
 - Academy of Medical Sciences (FMedSci): *Kelly*
 - Royal Academy of Engineering (HonFRAE): *Conway*
 - Royal Geographical Society (FRGS): *Conway, Siebert, Burgman, Cherni*
 - Linnean Society (FLS): *K. Makuch, Burgman, Bell, Jeger*
 - Royal Society of Arts (FRSA): *Skea*
 - Royal Society of Biology (FRSB): *Kelly, Jeger*
 - Royal Society of Chemistry (FRSC): *Barron, Kelly, Kafizas, Hardy*
 - Chartered Society of Forensic Sciences (FCSFS): *Barron*
 - Society for the Environment (HonFSE): *Skea*
- Awards during the REF period:
 - Haagen-Smit Prize (*Kelly* 2019)
 - Royal Society of Chemistry Toxicology Award (*Kelly* 2019)
 - Cuban Academy of Science Prize for Scientific Innovation (*Cherni*, 2018)
 - Founder's Medal of the Royal Geographical Society (*Conway* 2017)
 - The Piers Sellers Prize for climate research (*Rogelj* 2016)
 - ETH Medal, Swiss Federal Institute of Technology (*Rogelj* 2015)
 - Editor's Choice Award, American Chemical Society, (*Robinson* 2015)
 - Sustainable Business Award, Imperial Business School (*Staffell* 2014)
 - CBE for services to sustainable energy (*Skea* 2014)
- Current Senior Editorships:
 - *Air Quality, Atmosphere and Health* (Editor-in-chief): *Kelly*
 - *Conservation Biology* (Editor-in-chief): *Burgman*
 - *Carbon Management* (Editor-in-chief): *Woods*
 - *European Journal of Plant Pathology* (Editor-in-chief): *Jeger*
 - *European Energy and Environmental Law Review* (Editor-in-chief): *Z.Makuch*
 - *Frontiers in Environmental Science* (Field Chief Editor): *Siebert*
 - *Journal of Environmental Assessment, Policy and Management* (Editorial board and Founding Editor): *Sheate*
 - *Science & Justice* (Editorial board and Editor-in-chief, 2001-2014): *Barron*

4g. Collaboration in PGR training

The UoA collaborates with London NERC DTP and SCENARIO DTP in the student-led DTP Annual Conference. SSCP DTP students gain experience in conference presentations in a supportive environment, develop wider perspectives on environmental research, and network with peers, external partners and industry.

The Joint MRC Centre, EEH and CRTH Training Programme for PhDs and ECRs is a collaborative partnership between Imperial College London, Public Health England, King's College London and the University of Cambridge's MRC Toxicology Unit. The training programme draws on our more than 10 years' experience over the Centre's previous phases. We merged the training activities of the MRC Centre, EEH and CRTH into an integrated Joint Training Programme, to broaden its scope, take advantage of joint expertise and training resources and offer opportunities to develop broad mentoring networks.

The MRC Centre is part of the London NERC DTP, a partnership including University College London, Birkbeck University, King's College London, Queen Mary University, Royal Holloway University, Brunel University London, Institute of Zoology, Natural History Museum. We provide environmental research training and deliver a transformative inter-disciplinary experience

Unit-level environment template (REF5b)

for PhD students. We currently fund over 140 PhD students in the natural sciences. We designed a multidisciplinary four-year training programme that includes new teaching elements contributed by all Partners and spanning all research themes. It equips each student to conduct empirical and/or theoretical research, underpinned by rigorous numerical and statistical skills. We also include a range of transferable skills, from time management to academic writing, ethics and the peer review processes.

The ESRC-funded London Interdisciplinary Social Science DTP (LISS DTP) is led by King's College London, in partnership with Imperial College and Queen Mary University. It provides studentships in 13 Thematic Pathways that enable social science research students to develop research at the interface between the social sciences, health and medicine, natural and physical sciences, and engineering. CEP currently has five students funded by the LISS DTP.