

Institution: University of Northumbria at Newcastle

Unit of Assessment: UoA 14 Geography and Environmental Studies

1. Unit context and structure, research and impact strategy

1.1. Overview

Since REF2014, our unit has grown dramatically (from 19.0 to 79.6 FTE; Figure 1). Growth was achieved through strategic university-wide investment in multidisciplinary research themes (MDRTs: REF5a, section 2.2), designed to address key regional, national and global societal challenges, specifically aligned with UN sustainable development goals. Our three MDRTs, built to foster critical, multidisciplinary research mass, are **Extreme Environments**, **Global Development Futures**, and **BioDesign for the Bioeconomy**. Within these three MDRTs we have increased our number of research groups from two to five: **Cold and Palaeo Environments**; **Geochemistry, Ecology, Climate and Conservation**; **Geographies of Development and Disasters**; **Solar-Terrestrial Science**; **Social and Cultural Geographies** (Figure 2).

Our MDRTs specifically aim to enhance the interdisciplinarity of our research while strengthening core research groups through development of staff within, and strategically recruited into, the departments of **Geography and Environmental Sciences**; **Applied Sciences**; **Mathematics, Physics and Electrical Engineering**; and the **Centre for International Development**. Strategic growth, aligned to these MDRTs, was financed by the post-REF2014 increase (£3.2M per annum) in university quality-related (QR) income (REF5a, section 2.2). Research challenges of all MDRTs, defined and updated through broad staff consultation, are strategically managed by the Research Content Board (RCB), led by the Pro Vice-Chancellor (PVC) for Research. RCB includes faculty PVCs and MDRT steering group leads who operationalise this strategy, ensuring resource allocation and staff recruitment are aligned to MDRT goals. This successful investment strategy and organisational structure to address MDRT research challenges, will continue after REF2021.

Our research data (Figure 1) clearly document a sustained upward trajectory between

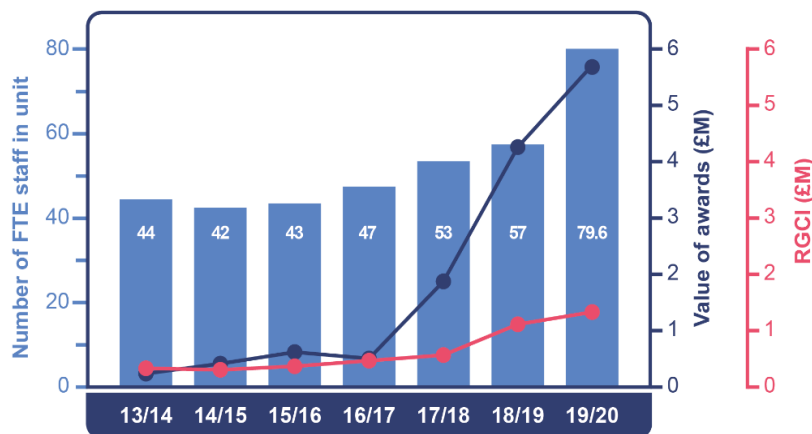


Figure 1. Evolution of the unit size, research grant awards and research income during the current REF period.

REF2014 and REF2021: mean annual research grant and contract income (RGCI) was **£641k** (£434k in REF2014). High-quality research outputs have resulted, exemplified by the publication of **61** (4 in REF2014) outputs in *Science* or *Nature* journals, *PNAS* and *TiBG*. During the REF2021 period we employed **27** (4 in

REF2014) postdoctoral researchers, and increasing numbers of postgraduate researchers. Since 2013, **46** (16 in REF2014) PhD students have graduated from strategic internal investment, the NERC-funded OnePlanet Doctoral Training Partnership (DTP) with Newcastle University (Oct. 2019-Sept. 2024) and the AHRC-funded Northern Bridge DTP. We will continue to foster this vibrant research community after REF2021 through sustainable investment coordinated through MDRTs, supporting existing staff and recruiting exceptional, cross-disciplinary leaders and future leaders to address critical global research challenges collaboratively.

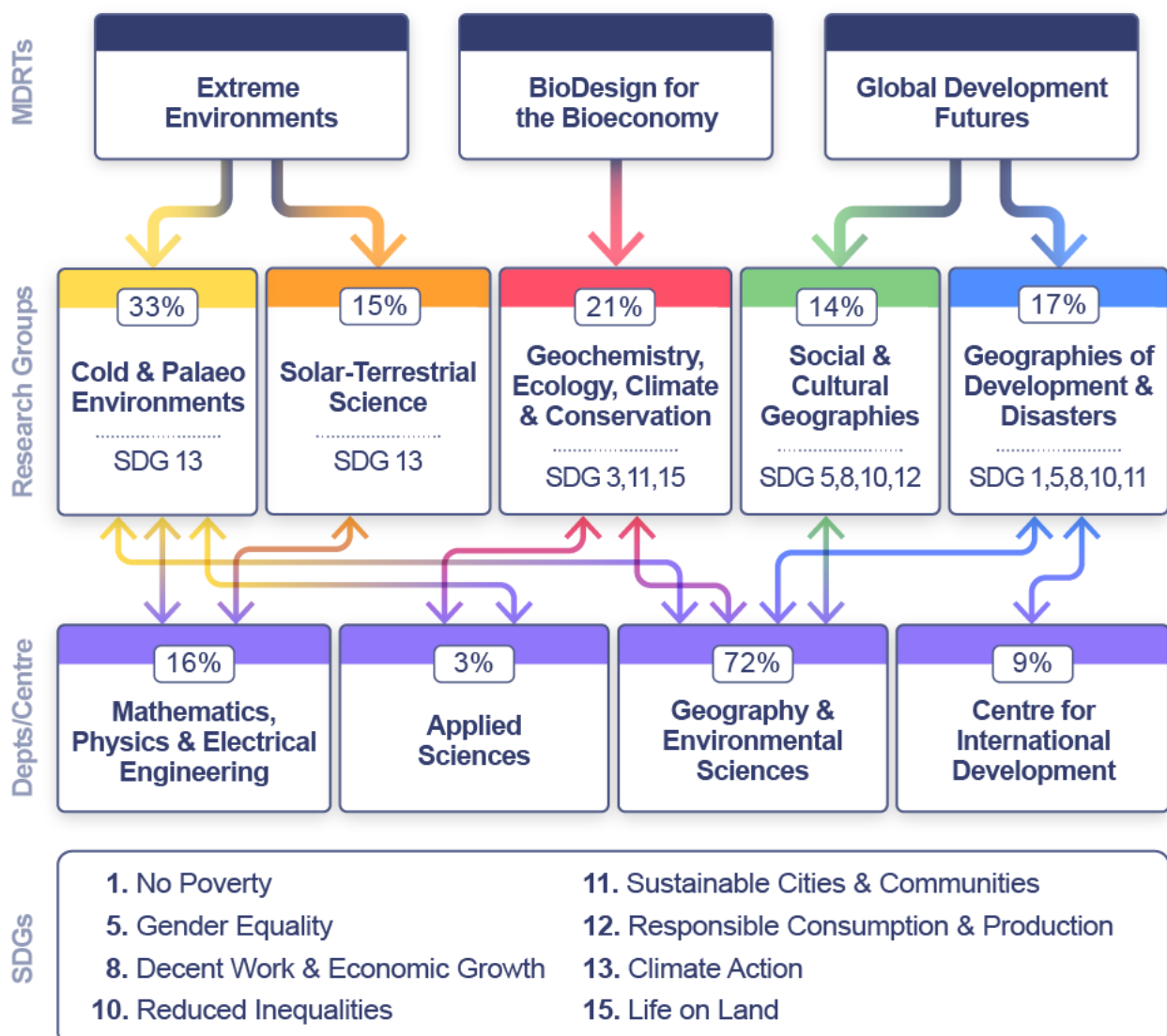


Figure 2. Unit organisation, describing how strategic research growth through three MDRTs align to five research groups which target eight UN Sustainable Development Goals (SDGs) across four university departments or centres. Percentages indicate proportion of total staff.

1.2. Future research aims

Building on our current trajectory, the unit will drive future research excellence in interdisciplinary research, knowledge exchange, and impact by focusing on five critical global research challenges:

- 1) **CLIMATE IMPACTS.** Despite increasing scientific certainty of the physical basis for global climate change and the increasing likelihood of profound resulting impacts, we are failing to convince the public, businesses and governments about the extent and rate of action that is necessary. We will tackle these problems by developing new understandings of past and contemporary climates and join with social scientists and disciplines, both across and outside the unit (e.g. psychologists, economists, planners), to address and adapt to the climate crisis.
- 2) **SUSTAINABLE URBAN ENVIRONMENTS.** Multiple environmental challenges within our urban and peri-urban spaces should be tackled holistically to improve the environmental quality and health outcomes for all, with a particular focus on addressing social and environmental justice considerations. Our research will champion interdisciplinary and transdisciplinary perspectives, employing a whole-systems approach that mainstreams sustainable development in urban and peri-urban environments and delivers interventions for policy and practice challenges.
- 3) **SPATIAL POLITICS.** Context-sensitive approaches to tackling social injustices, in their multiple and differentiated forms, are urgently needed to build stronger, more equitable and sustainable societies and promote good governance for the future. Our approaches will engage with hard-to-reach sites and marginalised groups to explore spaces and agencies often excluded from debates in this field. We will apply critical and radical participatory methodologies to study the transformative potential of grass-roots power.
- 4) **GLOBAL DEVELOPMENT, CRISES AND RESILIENCE.** Innovative transdisciplinary research based on equitable partnerships with organisations and communities in the global South is needed to meet the intersecting challenges of vulnerability, poverty, disasters and the climate emergency. We will address complex development challenges faced in the wake of intersecting contemporary crises. Our research will advance theoretical scholarship in this area and develop the innovative methodological and policy toolkits required to meet these challenges.
- 5) **SPACE WEATHER.** Improved monitoring and prediction of space weather - a term describing a series of phenomena that originate from the Sun and are included in the National Risk Register of Environmental Hazards - are critical to reducing the significant risks that exist to our global infrastructures, for example damage to satellites, surges in current in power grids, and disruption to global communications. Our research into the measurement and

forecasting of solar radiation, satellite radiation risk, and associated ground effects will improve space weather predictions and will directly inform UK government risk holders.

To address critical global research challenges, we will continue to build on the traditional interdisciplinary strength of geography, reaching out beyond the unit to create new transdisciplinary approaches, which will address currently intractable problems. Continued sustainable enhancement of the staffing base, expansion of the postdoctoral and post-graduate researcher base, investment in state-of-the-art equipment, facilities and innovative supporting processes will equip us with the methodological tools designed to impact on policy and society. By meeting these research challenges, our aim is to develop the unit over the next REF period to:

- 1) maintain the strong upward trajectory of research awards (from a mean annual awards value of £1.942M in REF2021), increase the number of £500k – £1M+ grant awards, and support all staff to achieve high-quality outputs (3*/4* on REF criteria);
- 2) increase the number of PhD students, moving towards a one-to-one ratio of postgraduate student to staff member; replicate the success of the NERC OnePlanet and AHRC Northern Bridge Doctoral Training Programmes; and diversify our portfolio of externally and collaboratively funded PhD programmes supported by industry and other external bodies (e.g. Marie Skłodowska-Curie Initial Training Networks, DfE Commonwealth Scholarships);
- 3) achieve all our Athena SWAN action plan objectives to enhance equality, diversity and inclusivity within the unit, and in so doing progress our departmental Athena SWAN awards from Bronze (awarded 2020) to Gold.

1.3. Research groups

To address international environmental, cultural, economic and societal research challenges, the unit's five research groups (Figure 2) provide essential discipline-specific focus to deliver the strategic aims of the MDRTs. Research groups support the development of grant applications, knowledge exchange, and the exploration of new research ideas, outputs and impacts. Each research group is outlined in greater detail, with examples of key funded projects.

1.3.1. Cold and Paleo Environments (CAPE)

Activities ranging from polar regions to the tropics, are focused around two themes: (1) critically analysing responses of the contemporary cryosphere to climate change using geophysical measurement and modelling; and (2) reconstructing climate change, vegetation, palaeoseismicity, environmental pollution and sea level at decadal, millennial and million-year timescales using biological and geochemical proxies.

Examples of funding successes

- EU Horizon 2020 (£742k *Gudmundsson*; £512k *A.Jenkins*) 'Tipping points in Antarctic climate components'
- NERC (£650k *A.Jenkins*) 'DECADES - Drivers of oceanic change in the Amundsen Sea'
- NSF-NERC (£613k *Gudmundsson*; £104K *Woodward*) 'PROPHET' and 'GHC' – two projects of the International Thwaites Glacier Collaboration
- Leverhulme Trust (£489k *Breitenbach*) 'Reconstructing Siberian permafrost dynamics'
- NERC (£405k *Pellicciotti*) 'Peruvian Glacier retreat and its impact on water security'
- NSFGE0-NERC (£244k *Pound*) 'Fungi in a warmer world'
- European Commission (£180k *Pearce*) 'MICROARCTIC'
- NERC (£90k *Salzmann*) SWEET: Super warm Eocene temperatures'

1.3.2. Geographies of Development and Disasters (GDD)

Research in development geography is well established across the unit; its strengths are sustainable development, social and economic inclusion and marginalisation, governance, disasters, and environmental justice. Key themes include voluntary action in humanitarian and development settings, disasters, gender, activism, urban governance, and environmental sustainability, with area expertise in Asia, North and sub-Saharan Africa and Latin America.

Examples of funding successes

- ESRC (£787k *Baillie Smith*) 'Skills acquisition and employability through volunteering by displaced youth in Uganda'
- GCRF (£766k *Baillie Smith*) 'Living deltas'
- NERC (£651k *Oven*) 'Preparedness and planning for the mountain hazard and risk chain in Nepal'
- British Academy (£300k *K.Jenkins*) 'Harnessing Afro-Ecuadorian women's heritage to promote peaceful and equitable development in Esmeraldas'
- Population Council (£292k *Kandala*) 'Biostatistical analysis of female genital mutilation/cutting'
- British Academy (£263k *Baillie Smith*) 'Young Palestinians' responses to house demolitions: Youth agency for sustainable development?'

1.3.3. Social and Cultural Geographies (SCG)

Research draws upon radical and critical approaches in human geography to develop nuanced understandings of global injustices, critically engaging the various multi-scalar struggles that seek to challenge them. The growth and diversity of research interests in this field, both theoretical and empirical, stimulates interdisciplinary work with criminology, business and law, and social work. Staff demonstrate a commitment to multi-scalar, engaged approaches, drawing upon innovative participatory methodologies to develop new insights into the processes and practices that shape global (in)justices.

Examples of funding successes

- AHRC (£60k *Swords*) 'Memoryscapes: Re-imagining place'
- Leverhulme Trust (£49k *Cassidy*) 'Dis/b/ordering: Building alternative securities in a bordered world'
- GCRF/Newton Fund Agile Response (£49k *Massé*) 'Impacts of COVID-19 on legal and sustainable wildlife trade'

1.3.4. Geochemistry, Ecology, Climate and Conservation (GECCO)

Research focuses on theoretical and applied aspects of human interaction and their impacts on natural systems in landscape and ecosystem dynamics, and environmental monitoring, risk and resilience. The group explicitly combines quantitative and qualitative techniques to produce an intervention-based science that generates better outcomes for society. These techniques focus on: (1) local and global carbon fluxes, through the quantification of the controls on organic carbon burial, release and flows in sediments and plant biomass; (2) Impacts of environmental change on biodiversity, pollinators and ecological networks; and (3) understanding, quantifying and addressing the health risks created by urban air and land pollution.

Examples of funding successes

- NERC (£239k *Mann*) 'CACOON: Changing Arctic Ocean'
- British Council (£280k *Namdeo*) 'Mexico City and Newcastle partnership on health and air pollution research and engagement project'
- NERC (£169k *Scott*) 'Mainstreaming green infrastructure'
- AHRC (£151k *Whitney*) 'Palaeoethnobotany and landscape'
- NERC (£82k *Entwistle*) 'Home Biome project'

1.3.5. Solar-Terrestrial Science (STS)

Our research encompasses atmospheric physics and chemistry, upper atmosphere processes and geospace, solar studies and solar-terrestrial physics. The group focuses on understanding how the Sun drives space weather. It partners with the Met Office Space Weather Operations Centre (MOSWOC) in the UK, and with the Solar Weather Expert Service Centre across Europe to provide and improve solar flare forecasting and thereby build resilience in the face of space weather events. We are integral to multiple aspects of the £20M collaborative NERC and STFC programme SWIMMR (Space Weather Instrumentation, Measurement, Modelling and Risk; N1, N4 and S4).

Examples of funding successes

- UKRI Future Leader Fellowship (£1.285M *Morton*) 'Revealing the pattern of solar Alfvénic waves'
- STFC (£416k *Antolin*) 'The cool alter-ego of the hot solar corona'
- STFC Consolidated Grant (£410k *McLaughlin*) 'Solar Physics Group'
- STFC New Applicant Grant (£372k *Jeffrey*) 'Energetic electrons'
- Leverhulme Trust research project (£200k *McLaughlin*) 'Revealing the fundamental nature of time-dependent, wave-generating reconnection'
- Horizon2020 (£101k *Bloomfield*) 'FLARECAST'

1.4. Impact strategy

A core element of the unit's impact strategy is to embed co-construction of knowledge whenever and wherever it has disciplinary relevance. This strategy is underpinned by university-wide investment in a central impact team (REF5a, section 2.3), direct funding of research activities that enable impact (e.g. travel, sabbaticals, research assistants), and the inclusion of impact activities in annual personal development objective setting and promotion criteria. Furthermore, an academic impact lead (*Cassidy*) was appointed within the unit to learn and share discipline-specific best practice from colleagues and the central support team. Specifically, this impact strategy of targeted investment in people and processes has

- 1) sustained research collaborations with organisations operating in the global South;
- 2) championed social justice in policy-making and regional planning; and
- 3) applied solution-focussed methodologies (statistical and field monitoring).

Tangible examples of research impacts beyond academia are pervasive throughout the unit's research groups (Table 1). Our partnerships with the United Nations, the World Health Organisation, and the Red Cross and Red Crescent have improved the well-being of local volunteers in Uganda, shaped the management of disaster risk reduction in Southern Africa, and enabled policymakers to identify and most efficiently target resources for tackling hotspots of female genital mutilation/cutting in Kenya, Nigeria and Senegal. The unit's leadership of civil society forums has resulted in improved housing, healthcare access and educational opportunities for asylum seekers in North East England; and its partnerships with UK councils have enhanced planning and management of urban green infrastructure. Measurement and modelling of

geomorphological change have provided UK councils, Transport Scotland, and coastal communities in northern Canada with evidence to make informed economic policy decisions on managing coastal retreat and landslide prediction.

Table 1 Examples of research impacts.

Research Impacts	Academic Lead Research group
Transforming international efforts to end female genital mutilation/cutting	Kandala & Komba GDD
Enhancing policies at the UN and the Red Cross and Red Crescent Movement to improve volunteer support mechanisms and protections	Baillie Smith GDD
Empowering local communities to reduce health vulnerabilities after disaster through a people-centred approach to health in disaster risk reduction	Collins GDD
Improving social justice for asylum seekers in North East of England	Cassidy SCG
Mainstreaming Green Infrastructure in the UK: A self-assessment tool putting the natural environment at the heart of strategic and local planning policy in the built environment	Scott GECCO
Mitigating the risk of geohazards to life and critical infrastructure	Woodward CAPE

In addition to these examples, many current projects continue to develop pathways to impact and feature public engagement. In particular, the Northumbria University Science, Technology, Engineering and Mathematics (NUSTEM, REF5a, section 4.4) initiative, reimagining STEM outreach, continues to address the gap in academic attainment in physical and environmental sciences education for school-age students with protected characteristics, and especially the under-representation of women and young people from disadvantaged areas. Academic staff and PhD students in **Solar-Terrestrial Sciences**, **Cold and Palaeo Environments** and **GECCO** research groups co-created and co-deliver workshops (Imagining the Sun, The Palaeontologist, The Environmental Modeller, The Environmental Planner) with primary school specialists embedded in NUSTEM. This multidisciplinary approach to outreach has contributed to a total of 94,821 student interactions. After REF2021, GCSE and A-level attainment data on the NUSTEM cohorts of students aged 9-12 will start to become available.

Extreme Environments MDRT funding of NUSTEM activities

- NUSTEM was initiated in 2014 by a HEFCE grant (£1.2M *Woodward*)
- Horizon2020 (£80k *Morton*) 'SOLARNET'
- STFC (£105k *McLaughlin, Morton, Woodward*) 'Exploring extreme environments'
- STFC (£10k *Botha, McLaughlin, Morton, Regnier, Woodward*) 'Imagining the Sun'

1.5. Research integrity and open access

No research project can be undertaken in the unit without an ethical audit that requires researchers to assess the level of risk posed by their projects. Supportive training for this audit is provided and renewed every three years. The open attitude to an ethical and collaborative exchange of ideas across research groups builds on institutional policies to support dissemination of outputs. As part of open-access publisher deals, we have no fees at the point of publication with eight major publishing houses. Gold open-access processing charges, where high-quality research will reach a larger target audience, have been resourced through central university funding, and all outputs are available as green open access. Staff in the unit take part in specific initiatives designed to enhance open-access publishing in the discipline, for example the founding and editing of open-access peer-reviewed journals such as the *Radical Housing Journal* (*Ferreri*).

Open-access archiving of data in the university's research data repository is supported by the central Scholarly Communications Team, which also advises on discipline-relevant external Distributed Active Archive Centres. In addition, online open-source code-sharing websites such as 'github' are promoted and encouraged (REF5a, section 2.5) to enhance the reproducibility and robustness of research outputs.

2. People**2.1. Academic staff strategy and development**

Staffing strategy has centred on the targeted recruitment of high-quality scholars and future leaders and on raising the aspirations and achievements of existing staff. The unit has achieved this striking level of investment in people through direct implementation of the university's strategic aim of combining increased numbers of staff performing quality research with holistic development of our academic disciplines (REF5a, section 2.1). As a result, we submitted 98% of staff in the unit to REF2021 (68% were submitted in REF2014), in accordance with the principles recommended in the 2016 Stern Review.

There has been a dual emphasis on (1) junior appointments of people with exceptional research achievements and (2) strategic appointments of established, world-leading researchers, both aiming to foster a vibrant research community with an intentionally interdisciplinary perspective. The recruitment of early-career research-oriented staff through the university-wide Vice-Chancellor Fellowships (VCFs) scheme (REF5a, section 2.2) incrementally integrates staff onto a full academic workload over three years. The unit has consistently been able to attract strong applicants (*Allan, Bentley, Breitenbach, Bull, De Rydt, Ferreri, Goddard, Graly, Hasseloff, Hughes, Jeffrey, Kwiecien, Mann, Oven, Roberts, Suggitt, Wake, Westoby, Winter*); and the strategic appointment of discipline-leading research teams that target MDRTs research challenges, has significantly strengthened the capacity of already well-established research groups.

Examples of strategic appointments into the Extreme Environments MDRT

- Modelling ice sheet-ocean interactions (*Gudmundsson, A.Jenkins, Bull, De Rydt, Haseloff, Rosier, Roberts, Winter*), **CAPE** research group, subsequently awarded over £2M in research grants
- Magnetospheric research (*Rae, Watt, Bloomfield, Bentley, Jeffrey, Wicks*), **STS** research group, awarded over £1M in research grants since appointment.

Over one third of staff in the unit (34% of staff are Professor or Associate Professor) offer strategic research leadership (Figure 3), for example development and steering of MDRTs and research groups, development of the university's research policy, and research mentoring for staff. The strategic development of staff capacity and capability has created the critical mass of researchers at all career stages (Figure 3) needed to address global research challenges ([section 1.2](#)). Internal development of the research environment is further encouraged through structured and targeted

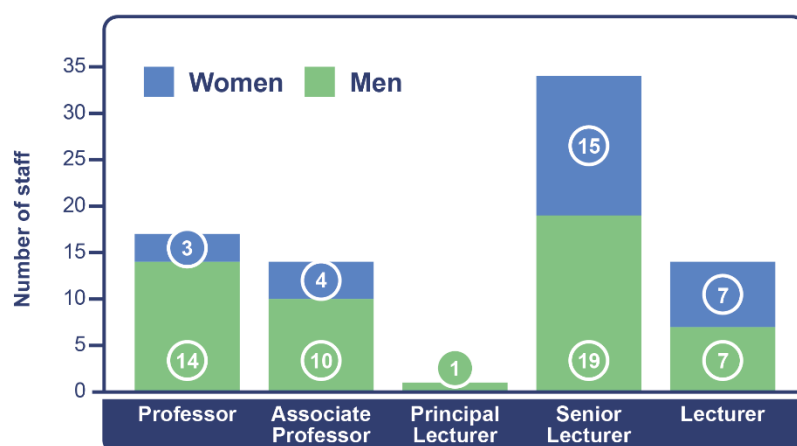


Figure 3. Composition of the unit by job role (overall percentage split women:men is 36:64).

research support ([section 3.1](#)). Researchers at all career stages are able to access internal funding and specialist training, for example NERC mock panel events and internal review panels. We use the research group framework to stimulate a high-quality research culture among all academic and research staff, postdoctoral researchers

(PDRAs) and postgraduate research students (PGRs), exposing them to best practice and collaborative opportunities.

2.1.1. Recruitment, probation, mentoring and promotion

It has been university-wide policy to strategically recruit new staff to specifically address MDRT research challenges (REF5a, section 2.2). Appointments have increased the strength and breadth of the unit's research groups, enhanced the interdisciplinarity of our research, and created a critical mass of staff who lead international research agenda.

Examples of interdisciplinary MDRT-led recruitment

- *Pearce* (microbiology of polar environments), appointed through **Extreme Environments MDRT** in the **Department of Applied Sciences**, contributing to the **CAPE** research group
- *Maclean* (feminist geographies of development and globalisation), appointed through **Global Development Futures MDRT** in the **Centre for International Development**, contributing to the **GDD** research group
- *Sherry* (microbial biodegradation), aligned to **BioDesign for the Bioeconomy MDRT** in the **Department of Applied Sciences**, contributing to the **GECCO** research group

All new appointees follow a standardised selection and interview process (REF5a section 3.2); a probation period is mandatory, but the timing and delivery methods are flexible enough to allow for equal and fair opportunities and appropriate expectations. A probation plan is agreed between each new appointee and the head of department, in discussion with the appointee's research mentor from within the unit. The plan links appropriate research objectives and career progression with support mechanisms outlined in the Concordat to Support the Career Development of Researchers. Progress in relation to the plan is reviewed and supported by the research mentor. Probation panels have independent representation from other faculties, to ensure parity and transparency; individual circumstances are considered and appropriate adaptations made – as in the case of staff transitioning from abroad shortly after a period of maternity leave (*Fu*).

All staff are allocated a research mentor. While no fixed pattern of meetings is mandated, interactions between mentor and mentee tend to occur monthly. Within a supportive relationship, mentors provide guidance and encouragement for mentees to challenge their own level of ambition, identifying outlets for their research that maximise international reach. The unit consciously safeguards against the mentoring relationship drifting towards managerialism; research mentoring is clearly defined and focused on mutually agreed developmental objectives. Both mentors and line managers are expected to help staff to self-monitor their career progress, creating a personalised route map for promotion. During the REF2021 period, the unit achieved six promotions to professor (*Brock, Cassidy, Entwistle, K.Jenkins, McLaughlin, Salzmann*), ten

staff were promoted from senior lecturer to associate professor (*Cassidy, Ersek, Hocking, K.Jenkins, Mann, Morton, Pellicciotti, Rutter, Scullion, Whitney*), and two VCF staff have transitioned to senior lecturer (*Mann, Wake*).

2.1.2. ECRs and PDRAs

Our unit has invested in the development of ECRs, increasing from 6 in REF2014 to 25 in REF2021. ECRs have benefited from targeted infrastructure and equipment funding, are prioritised for internally funded PhD studentships, and are provided with a flexible budget (£2k) on arrival to establish research directions and collaborations. ECRs receive collegiate support through reduced administrative duties, lighter teaching loads (20 teaching credits in their first academic year) and dedicated research grant workshops in the ECR Development Programme (see section 3.1). Staff on VCF contracts start with 10 teaching credits in their first academic year, which progresses in 10 credit increments up to a full teaching load in the fourth year of employment. Our ECR strategy is to recruit staff onto permanent contracts and invest in them from the outset. We aim to limit the use of fixed-term contracts for academic staff (only four staff, i.e. 5% of the unit, are fixed-term).

The unit has 27 PDRAs (4 in REF2014), with some on prestigious external fellowships, for example a Royal Society University Research Fellowship (*Bauska*) and a Leverhulme Early Career Fellowship (*Allan*). PDRAs funded by projects are managed by the principal investigator (PI). We deliver 'independence' mentoring to PDRAs as well as allocating dedicated project time for work towards personal research outcomes; this ensures an appropriate developmental culture for their projects. Our policy is to actively seek to invest in fixed-term staff, supporting them with their career development, for instance when they apply for permanent contracts. Thus *Pound* transitioned from PDRA to lecturer, and both *Westoby* and *Winter* transitioned from PDRA to VCF, after competitive recruitment processes.

2.1.3. Appraisals and sabbaticals

An annual personal development and appraisal (PDA) system is used to formulate and reflect on an individual 'Research and Innovation Plan' that sets stretching but clear and achievable objectives designed to build research quality and deliver impact. Staff are encouraged to specify objectives relating to publication, research grant applications, impact, knowledge exchange secondment (e.g. NERC Innovation Placement with UK MetOffice, *Sandells*), Knowledge Transfer Partnerships (e.g. environmental capacity building with Local Authorities, *O'Brien*) and public engagement (see example of outcomes in section 4.2). Researchers are encouraged to plan and prioritise over a three- to five-year period. Applying for periods of sabbatical leave – normally once every seventh semester but with enough flexibility to target time-sensitive opportunities – is an integral part of this longer-term planning and is encouraged through the appraisal processes. Staff

are supported by their line manager and research mentor to apply for sabbatical leave regardless of their full-time equivalent (FTE) or fixed-term/permanent status.

Examples of targeted sabbatical leave

- *Kandala* worked with the Population Council to apply statistical analysis of female genital mutilation/cutting to policy implementation in sub-Saharan Africa.
- *Salzmann* collected sediment cores to interpret mid-Miocene climate as part of the Ocean Drilling Programme expedition Leg 318 to Wilkes Land.
- *Hocking* was offered ring-fenced sabbatical time after a period of maternity leave, to re-engage in the dating of past volcanism in the Antarctic Peninsula.
- *Cassidy* used the sabbatical scheme to extend research focusing on disrupting everyday bordering funded by the Leverhulme Trust.

2.1.4. Laboratory technical support

The unit also restructured its technical support staff to facilitate research activities. A core element here is the professional development of technical staff, designed to foster and incentivise progression in research activities. Financial support (fees and expenses) and dedicated working time allowance are available (e.g. *Dunlop*, for part-time PhD study; *Thomas* to attend externally run instrument training days).

There are now 4.6 FTE permanent laboratory technicians who provide dedicated technical and experimental research support within the unit (an increase from 1.8 in REF2014). They provide training to academic staff, PDRAs and PGRs on specialised equipment, oversee health and safety in the laboratories, and offer support and guidance in procurement. Technicians commonly lead on the running of capital-intensive specialist instrumentation and complex apparatus (see section 3.2) to ensure maximum utilisation, efficient productivity and data quality for research outputs.

2.2. PGRs

Figure 4 shows the increased number of PhD completions in the unit during the REF2021 period (46 in total, with a women:men gender split percentage of 41:59). Strategic university-wide investment in the Research Development Fund Studentship Scheme (RDFSS: REF5a, section 2.2) boosted the numbers of PhD studentships early in the REF2021 cycle and increased the completion rate from 2016 onwards. Externally funded studentships have increased later in the REF2021 cycle; the NERC OnePlanet DTP collaboration with Newcastle University has supported

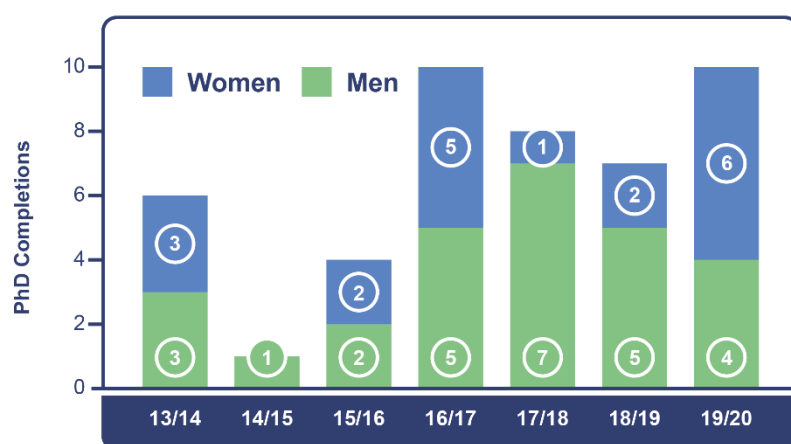


Figure 4. PhD completions.

Recruitment of PGRs was strategically targeted towards MDRTs, to build strength in research groups (see section 2.1.1), which in turn provide a supportive and inclusive learning environment (see section 2.3) through to graduation. Our PhD students come from all over the world (39% of those who completed were not UK citizens); they bring diversity and vibrancy to research group seminars and subject-focused discussion groups, and are often the focus of external collaborations. In recognition of the value and grounding provided by doctoral study, six staff were supported to undertake a PhD or professional doctorate since January 2014. They either achieved independent research outputs for REF (*Griffiths*) or are currently working towards this goal.

2.2.1. Progression, training and environment of PGRs

Student progression is assessed through an initial project approval stage (3-6 months) followed by two progression reviews at months 11 and 23 (pro-rata for part-time students). Our regulations require formal and documented monthly contact between supervisor(s) and supervisee, with a synopsis of the discussion and agreed next steps logged on a central electronic system. The Graduate School and the supervisors emphasise the expectation of completion within three years for university-funded PhDs and three and a half years for OnePlanet NERC and AHRC Northern Bridge DTP students. Challenges faced by students throughout the COVID pandemic have been acknowledged and responded to with increased flexibility in the adaptation of research plans, use of additional unit QR funds, extension of deadlines for internal reporting, and provision of a suite of mental health and well-being support measures including counselling.

All students enrol on the University's Professional Development and Researcher Training Programme, which is aligned with the Vitae Researcher Development Framework and mapped against four learning domains: intellectual abilities, personal effectiveness, research governance, and engagement. Training involves attending sessions and accessing interactive courses through our e-learning portal. While most courses are optional, those related to induction, progression and research ethics are mandatory. Additional mandatory training for students who are part of the OnePlanet and Northern Bridge DTPs is optionally available to all PGRs. In addition, the unit

13 students per year since 2019 and will continue for an initial five-year period. The RDFSS funded 68% of all PhD completions, while UKRI-funded studentships and collaborative funding with external organisations (e.g. Voluntary Services Overseas, Becas Chile scholarships) account for the remainder.

delivers bespoke sessions (e.g. Research Philosophies and Paradigms; Real Resilience for Researchers; Careers in and out of Academia) that enable students to engage with the Concordat to Support the Career Development of Researchers, which provides relevant contexts for their career progression. PGRs played an important role in the self-assessment team that prepared our successful Athena SWAN Bronze application (see section 2.3), and continue to make essential contributions to actioning Athena SWAN objectives, as well as to future applications.

To further support PGRs' career development, we encourage attendance at a three-day introductory course on teaching, enabling them to be involved in academic activities with undergraduates. PGRs also have access to a budget that covers research expenses specific to their needs (e.g. fieldwork, international conference attendance), which ranges between £2k and £5k, distributed over three years. Students are encouraged to be proactive by organising their own discussion groups, contributing to early-career organisations (e.g. UK Polar Network, *Dutch*), presenting at conferences, accessing external research funding (with advice from supervisory teams), and engaging with non-academic communities (e.g. media, schools).

PGRs attend relevant research group seminars and are encouraged to present their research at one of our faculty-level postgraduate conferences to foster collaborations with staff. PGRs have organised seminar series of their own, such as the 'Women in Development' seminars in the Centre for International Development, and the Global Challenges Summit 2019, which tackles sustainable development challenges. PGRs have their own individual workspaces within departments but are encouraged to work alongside PGRs in other departments, thereby taking advantage of discipline-specific synergies in MDRTs. In addition, PGRs are able to access the recently created Research Commons space in the University Library: this is a dedicated area for PGRs and academic researchers centrally located on the main university campus.

Examples of PGR successes and external engagement

- Best student presentation conference awards: International Glaciological Society British Branch (*Malle, Todt*).
- Analytical support grants: NERC Radiocarbon analysis (*Bermingham, Longman*).
- Fieldwork grants: RGS-IBG Land Rover Bursary (£30k *Allan*), International Network for Terrestrial Research and Monitoring in the Arctic (£2.5k *Malle*).
- Internships: Marine Management Organisation (*Holtby*), Crossings (*Meziant*).
- Media interviews: Sky's Landscape Artist of the Year (*Martin*).
- Increasing attainment of school-age children from underrepresented and disadvantaged backgrounds: Brilliant Club (*Parry, Freimane, Hazell, Martin*), NUSTEM workshops (*Bermingham, Jabeen, Strother, Wolf*).

Every department within the unit has a dedicated lead academic to process postgraduate applications, identify appropriate supervisory teams, welcome incoming students and offer them an induction, and oversee student progression and completion. Postgraduate leads also organise writing retreats, journal clubs, social events, workshops on careers, and participation in outreach events and ensure that all PGRs who want to teach have a fair share of opportunities to do so. Career pathways in research and industry are highlighted, as well as opportunities that leverage a student's transferable skills. There is special focus on showcasing career pathways of women and students from minority backgrounds.

2.3. Equality, diversity and inclusion (EDI)

The **Department of Geography and Environmental Sciences** was awarded an Athena SWAN Departmental Bronze Award in May 2020. As part of this reflective self-assessment, staff with social research experience (*Clayton, Whitney*), in conjunction with an independent researcher (external to the university to ensure confidentiality), co-developed a 'ways of working' culture document. It marked the unit's actionable commitment to an EDI and well-being agenda, with items such as 50% female representation on recruitment panels, ensuring additional effort is offset against other workload, tackling discrimination and unconscious bias against protected characteristics, recognising and valuing contributions from all staff, and making sure that the differential impact of policies and metrics on individuals was taken into account in recruitment, career development and working conditions. This commitment was also central to the construction of our REF submission, in compliance with the principles of transparency, consistency, accountability and inclusivity, as set out in our REF2021 Code of Practice. All staff were invited to take part in internal output peer review and calibration exercises; the unit of assessment lead (*Rutter*) acted as a moderator and ensured the absence of conflicts of interest. All available EDI data were taken into account, so that the selected outputs were representative of the gender and ethnic diversity of the staff pool, balancing across research groups.

Our research, particularly that of the **Social and Cultural Geographies** and **Geographies of Development and Disasters** research groups, drives our wider EDI agenda. Areas of expertise include mental well-being in the academy (*Maclean*), academic motherhood and fieldwork (*K.Jenkins*), and stresses of neoliberal metricisation in higher education (*K.Jenkins*). Our research has made higher education accessible to minoritised groups such as asylum seekers (*Cassidy*); for example, six Sanctuary Scholarships pay full tuition fees and a bursary for living expenses. It has also sought to highlight the contributions of geographers who work outside academia and intersectional exclusions in academic workplaces (e.g. the **Social and Cultural Geographies** research group 2019 annual lecture). Staff continue to use their research expertise to promote gender and racial equality by working with agencies such as the Women's Budget Group, New Economics Foundation, Green European Foundation and The International Network of Women's Funds.

The unit is committed to diversifying the staff base and creating an inclusive community, which supports the well-being of all staff and especially those with protected characteristics. A Well-being Hub provides a range of supporting materials, including access to a Health Advantage app that supplies proactive well-being tools, and additional guidance for navigating the challenges of the COVID-19 pandemic (e.g. guides to remote working). Practical measures to maintain an open and inclusive environment have included encouraging core hours for informal social events within communal workspaces and actively monitoring public imagery (e.g. wall-mounted displays, web pages, marketing materials) to ensure a balanced representation of gender and ethnicity. We aim to keep (at least) one day per week free of teaching for each member of staff, to allow regular periods of concentrated research time; and we have created bespoke packages of research leave for women, to re-establish research momentum after returns from maternity (e.g. *Hocking* in 2017). Staff are entitled to parental leave, to reduce their hours or to take career breaks and return to a full-time position. Currently three academics and one technician work part-time or have worked part time during the REF2021 period. Recruitment adverts are checked for biased gender coding and balanced imagery or terminology; success stories and role models on research group web pages and social media platforms are used to encourage applications from women and ethnic minorities to academic and postgraduate opportunities in the unit. Interviews are conducted by mixed gender panels, and all participants are required to undergo fair selection training. Alongside these strategic developments, the gender ratio in the unit is currently 35:65 (women:men), compared with 21:79 in REF2014. The gender split percentage in PhD completions over the REF2021 period is 32:68, but for the current cohort of 29 PhD students it is 62:38. At present, no staff or PGR identifies outside of the man-woman binary. The split percentage in ethnicity of staff is 10:90 (BAME:White), compared with 0:100 in REF2014, and split in nationality is 24:76 (non-UK:UK), compared with 9:91 in REF2014. All these ratios reflect the unit's increasing diversity.

Staff demonstrate leadership and involvement in university-level equality and diversity stakeholder groups, EDI training opportunities, and research outreach aimed at widening participation (e.g. NUSTEM). This range of activities has included co-leading Northumbria University Women in Science and Engineering (NUWISE) (*Wake, Whitney*) and organising several short courses and workshops (e.g. on imposter syndrome, improved networking, personal resilience). Additionally, research around men's achievement or engagement informed a university-wide group that explored LGBTQ+ students' experiences of 'lad culture' (*Jeffries*), and staff hold EDI positions on external bodies and societies such as North East Tell MAMA - Islamophobia for Muslims in the North East of England (*Clayton*), and Diversity Champion of the Geological Society (*Dunlop*).

3. Income, infrastructure and facilities

3.1. Research income and organisational strategies

Throughout the REF2021 period, both the number of research grant applications and the value of income and awards per FTE have increased (Figure 5), resulting from an increased number of grants won by a larger number of staff. During the last REF cycle the unit has competitively won

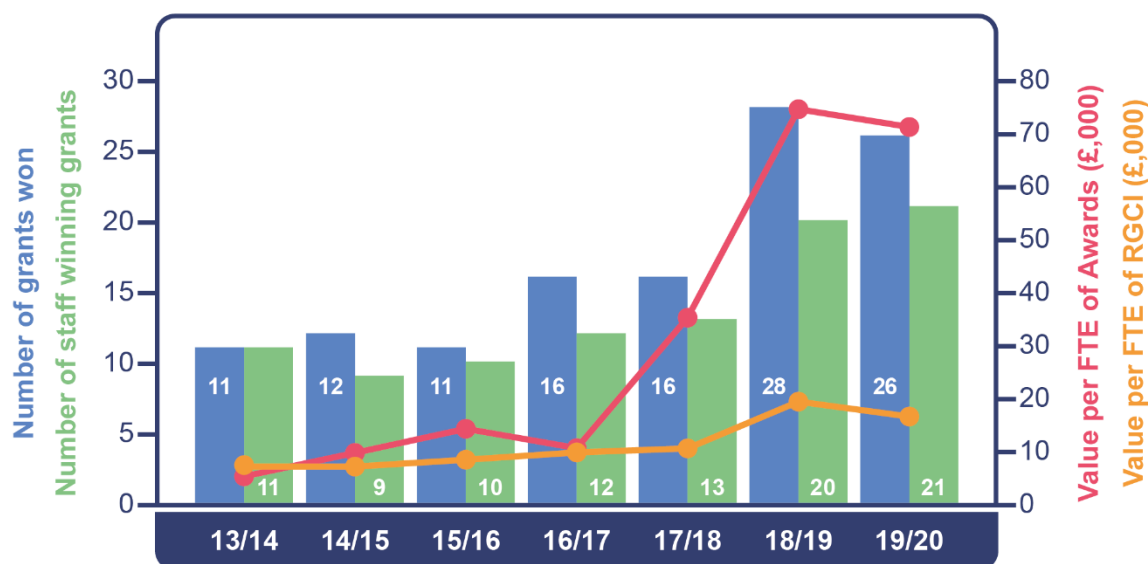


Figure 5. Metrics describing grant applications and success.

120 grants, 34 of which were >£100k in value to Northumbria; these grants were, distributed across all five of the unit's research groups. Multiple grants and facilities awards have been secured competitively from a diverse portfolio of funders, for example UKRI research councils (NERC, ESRC, STFC) and other bodies such as the European Union, International Space Agencies, Royal Society, British Council and the Leverhulme Trust.

Success in improving grant capture in the unit is underpinned by our structures and culture. Grant application development and management are coordinated by research development managers in the university's research and innovation services (RIS) and departmental research directors. Together, they provide targeted guidance for staff, including those returning from career breaks, to help identify funding opportunities and ensure PIs are supported in pre- and post-award phases. RIS also runs an extensive array of training programmes and drop-in sessions, spanning all academic levels, to support research grant applications; thus the ECR Cohort Programme provides bespoke training covering all aspects of research development and funding applications (section 2.1.2), and Next Generation of Large Award Holders is designed for researchers who have already won small or medium-sized grants to help them transition to larger-scale opportunities. This scheme has been particularly successful in supporting staff to secure UKRI funding (e.g. NERC-funded CACOON project, *Mann*; Future Leader Fellowship on Solar Alfvénic Waves, *Morton*). There are also tailored sessions providing expert insight and guidance from both internal and external experts.

Examples of breadth in research funding

- UKRI: Future Leaders Fellowship (£1.285M); NERC (£650k, £650k, £613k, £405k, £304k, £264k, £239k); ESRC (£787k); GCRF (£766k); EPSRC (£366k); Science and Technology Facilities Council (£416k, £410k); AHRC (£151k).
- European Union: European Commission (£179k); EU Horizon 2020 (£742k, £512k, £396k, £179k)
- Non-Profit Organisations: Population Council (£292k); British Council (£280k); Leverhulme Trust (£200k)
- Learned Societies: British Academy (£300k, £262k); Royal Society (£200k, £110k)

For all new staff, probational agreements target the development and submission of a significant first research grant as an essential criterion for completion. To support research grant preparation, departmental research directors encourage new staff, especially those who are ECRs, to take advantage of three workshops in the ECR Development Programme provided by RIS: (1) 'ECR Writing Retreats', which allow dedicated space for formative feedback on proposals in development; (2) 'Impact in Funding Applications', which support PIs in developing frameworks for pathways to impact; and (3) 'Fellowship Ready', which support ECRs who have already applied for grant funding as a PI and intend to develop personal fellowship applications. In addition to these opportunities, departmental research mentors (senior researchers in similar subject areas; see section 2.1.1) provide one-to-one support to new staff to help them identify significant research proposal opportunities and guide them through the process of building a competitive grant application. Work-loaded time required for ECRs to achieve probational targets is provided by a staged introduction to teaching, particularly for staff appointed to VCFs (section 2.1.2).

Support for all academics from the wider research community is provided through inclusive 'proposal workshops' (about 10 per year), where staff can present proposals in progress and receive supportive feedback from a broad audience, drawn from across the unit. When funders limit the number of applications per institution, research directors coordinate and shortlist applications to select the strongest proposals and provide constructive feedback on all proposals to enhance future grant applications. Within the grant application process, support is offered for designing research impacts. Sharing of good practice on research impact is coordinated by the unit's impact case study (ICS) academic lead (*Cassidy*), who targets additional resources (finance and time) to strengthen existing opportunities for impact or support new ones.

Staff can access additional financial research support by applying for unit-managed funds (which derive from the QR budget). These usually range between £500 and £3k per annum, and

are there to support networking, data collection, presentations of significant esteem, and the hosting of workshops - all of which positively contribute in the long-term to income generation. In 2014, the unit revised its internal finance models to invest QR funding directly in postgraduate activities aligned with research quality enhancement; and developed a new overhead-sharing financial model (Research & Enterprise Rewards Scheme) to incentivise, reward and sustain new areas of impact, success and growth.

Sabbatical leave plays a key role in providing the time for staff to write grants (section 2.1.3). Every seventh semester, staff are eligible to apply for one semester of sabbatical leave, during which developing grant proposals appropriate to career stage and previous research success is encouraged; for example *Whitney's* 2019 sabbatical led to a successful NERC Global Partnerships Seedcorn submission 'Shifted Ecological Baselines in the Brazilian Savannah'.

Ongoing evaluation of research effectiveness within the unit is coordinated through departmental business review meetings (three per annum) and two university-wide committees, which meet to consider research grant applications and knowledge exchange and enterprise. Monthly and quarterly data on a range of research metrics (grant applications, RGCI, new awards etc.) provided to these committees by RIS allow modification of investment plans to address challenges that arise, and to proactively take advantage of research opportunities, for example strategic appointments (see section 2.1). Evaluation of resource allocation at this frequency, in conjunction with assessment of research outputs and impacts, facilitated the rapid increase of staffing in the unit between 2016 and 2020 (see Figure 1). This evaluation also includes a review, led by the departmental EDI lead (*Jeffries*), of progression towards EDI objectives emerging from institutional and departmental Athena SWAN development plans.

3.2. On-site infrastructure and facilities

Strategic investment (over £3M) in the unit's laboratory capacity has expanded both the physical space (i.e. existing facilities have been updated and three new labs added) and the range of instrumentation now available to staff. An increase in technical support in this unit - from 1.8 to 3.6 FTE, through the REF cycle - improved the capacity to service, maintain and support experimental activities. New laboratory capacity is clustered around reconstructing past climates through isotope geochemistry and micropalaeontology, as well as around analysis of environmental systems through inorganic and biological particle characterisation and ecosystem functioning.

Examples of strategic investment in laboratories

- ultra-high-precision geochemical analysis: carbonate geochemistry of speleothems, liquid chromatography and trace gas analysis (e.g. clumped isotope Mass Spectrometer in a bespoke climate-controlled laboratory, £240k; Flash 2000 Elemental Analyser, £65k; Thermo Delta V Isotope Ratio Mass Spectrometer; £215k)
- micropalaeontology laboratories (hydrofluoric acid fume hood, core preparation, microscopes), built in 2014, which directly facilitated multiple grant successes (Royal Society, NERC Newton, *Salzmann*; Council for British Research in Levant, *Pound, Hocking*; AHRC-NSF Paleoethnobotany and Landscape, NERC Shifted Ecological Baselines, *Whitney*), high profile papers (*Salzmann*, in Nature) and 6 PhD studentships
- The Material Characterisation Laboratory (£1.994M), which houses specialist electron, ion and photon-based equipment, for example a high-resolution scanning electron microscope and a powder X-ray diffractometer used in the analysis of subglacial clay mineralogy (NSF Subglacial Chemical Weathering under East Antarctica, *Grady*)
- DNA sequencing (£346k PacBio, £61k Illumina MiSeq and a £99k Hamilton liquid handling robot) of Polar ecosystems (e.g. European Commission MICROARCTIC, *Pearce*) and microbial considerations of methodologies for drilling into Antarctic subglacial lakes (*Pearce, Woodward*)

Investment in soil and sediment laboratories facilitated analysis of particle size distributions (Mastersizer 3000, £65k), inductively coupled plasma - optical emission spectrometry (ICP-OES), and X-ray fluorescence (XEPOS and Spectroscout XRFs, £110k) of trace metals in soils and household dust (NERC Home Biome Project, Newcastle Allotments Biomonitoring project, *Entwistle*) and to determine bioaccessibility, which impacts land use policy. In addition, our academic work on biodegradation processes of organic compounds is closely linked to industrial collaborations (Northern Engineering Solutions Ltd and the Defence and Security Accelerator), which use the Oxitop system (£5k) and LGR Greenhouse gas analyser (£35k) to bioprocess waste oils and lubricants from RAF bases into recyclable by-products (*Deary, Pearce*). New laboratory investment has strengthened our capacity to join funded networks – for example the Los Gatos Isotopic analyser (£93k), used to measure organic carbon in rivers (NERC LOCATE, *Mann*) - and to win personal fellowships - for example an ICP-OES (£100k) to measure iron fertilisation in Antarctic glacial systems (Baillet Latour Antarctic Fellowship, *Winter*).

Since 2014 the unit has invested £820k in a high-performance computing (HPC) cluster (REF5a section 4.2). The HPC now contains 1,216 cores for processing, a graphics-processing

unit node, dedicated visualisation nodes, and 571 TB parallel storage, allowing the unit to address increasingly computationally demanding research problems (e.g. global climate models, Antarctic ice sheet dynamics, solar flare modelling). While researchers in the unit continue to access UKRI HPC capacity (e.g. ARCHER, DiRAC), our HPC provides a more flexible alternative, without defined allocation units (a measure of computational requirements).

Examples of research grants and collaborations resulting from HPC investment

- magnetic fields in the solar corona (e.g. STFC Consolidated Grant, Leverhulme Trust, *McLaughlin; Morton*, co-authored in *Science*)
- coupled ice-ocean modelling (UaMITgcm, *Gudmundsson, A.Jenkins, De Rydt, Rosier*) and model intercomparison (e.g. MISOMIP2, core to the World Climate Research Programme, *De Rydt*)
- remote sensing and modelling of Arctic snow (e.g. NERC AESOP with UK Met Office, *Sandells*; European Space Agency SCADAS and ANSWER, *Rutter, Wake*)

The unit also invested (£28k) in two qualitative research suites (QRSs), to provide dedicated space for undertaking qualitative research in the form of interviews, focus groups and small-group workshops. The suites, soundproofed and screened for privacy, are equipped with audio and visual recording capabilities, specialist transcription and analysis software. These facilities enabled research with vulnerable groups on sensitive topics, for example the differing intensities of resistance and organising within communities.

Examples of research outputs and grants resulting from investment in QRSs

- intersections of domestic and state violence (*Cassidy*, in *TiBG, PiHG*)
- emotional geographies of the Zimbabwean diaspora in a post-Mugabe era (*Clayton*, in *Journal of Ethnic and Migration Studies*)
- forced migrants in the North East and third-sector organisations (British Academy New Migrants in the NE Workforce, *Clayton, Meziant*)
- unemployed workers' centres and related trade unions (*Griffin*, in *Geoforum*)

3.3. Off-site infrastructure and facilities

Off-site research facilities, which provide essential in-kind support for staff in the unit, take many forms: physical infrastructure (often in remote locations), facilitated access to otherwise restricted populations or locations, or consortium-run, high-cost shared research facilities.

Dating rock and organic materials through isotope geochronology (e.g. ^{14}C , cosmogenics) is central to understanding changes in past climates and undertaken through funded applications to the NERC Isotope Facility (*East, Hocking, Salzmann, Whitney, Woodward*) or through exchange visits with international partners, for instance to stable isotope laboratories (Berkeley Geochronology Lab, ETH Zurich, AWI Potsdam, MPI Jena, AWI Geochemical Facility Bremerhaven, *Breitenbach, Ersek, Mann, Wolf, Woodward*) and to uranium-thorium (U/Th) dating facilities (University of Melbourne, JGU Mainz, Oxford University, Chinese Academy of Science Xi'an, *Breitenbach*).

Remote fieldwork often necessitates the use of *in situ* facilities and infrastructure via funded international collaborations. We received five travel bursaries from the NERC Arctic Office to facilitate measurement of snow properties and geomorphic change through remote fieldwork in Northwest Territories, Canada (Natural Resources Canada, Wilfrid Laurier University, *Mann, Rutter*) and past sea-level change in the White Sea region, Russia (*Hocking, Wake*). Additional funding from NSF, Environment and Climate Change Canada, INTERACT and National Geographic has provided access to facilities to measure permafrost hydrochemistry in Eastern Siberia (*Mann*), snow on sea ice in Nunavut, Canada (*Rutter*), snow forest interactions in Arctic Finland (*Malle*), and sea-level change in Western Greenland (*Wake*). In Antarctica, NERC grants use British Antarctic Survey facilities and logistical support to assess rates of long-term glacier change in the Horseshoe Valley, Ellsworth Mountains and Thwaites Glacier (*Winter, Woodward*). Research was undertaken on scientific cruises around West Antarctica, on the NERC *James Clark Ross* an auto-sub was used to make ocean temperature measurements around ice shelves (*A.Jenkins*), and ocean-floor drilling for sediment cores in the Amunsden Sea, from AWI's icebreaker *Polarstern*, was used to reconstruct Cretaceous southern polar climates (*Salzmann*).

We have developed collaboration with local agencies to access protected areas for research into environmental sustainability. Gaining access to protected areas via local NGOs in Kalimantan, Indonesia, enabled assessment of the efficiency of carbon market mechanisms controlling forest degradation, which impacts populations of Yayasan Orangutan (*Howson, in Conservation and Society*). Research addressing illegal wildlife trade in Mozambique required permits and logistical support from the Eduardo Mondlane University, to become embedded with communities and park rangers in the Limpopo National Park (*Massé, in Geoforum*). The Centre for International Forestry Research (CIFOR) in rural areas of Kenya, Cameroon, and the Democratic Republic of Congo facilitated research that led to the recently awarded UKRI-GCRF/Newton Agile Grant in Identifying and Mitigating the Impacts of COVID-19 on Legal and Sustainable Wildlife Trade in LMICs (*Massé*).

As part of the STFC-funded UK consortium, software was developed to extract data from the NSF Danile K Inouye Solar Telescope (DKIST), the World's largest solar telescope (*Morton and McLaughlin* in *Nature Astronomy*). Consortium membership allowed satellite and rocket-launch data to be utilised from the Extreme Ultraviolet Imager instrument and the High-Resolution Coronal Imager, Flight 2.1 Sounding Rocket (ESA Solar Orbiter, *Antolin and Morton*).

3.4. Field Equipment

Since REF2014, the unit has sustained internal capital investment in field equipment (from QR funding), to supplement equipment purchased from grant awards. These investments broadly cover four themes: surface change detection, surface and near-surface geophysical properties, micrometeorological and biogeochemical measurements, and participatory communication tools.

Surface change detection using terrestrial laser scanners (TLS) and uncrewed aerial vehicles (UAV) enabled major methodological innovations in analysis of optical and thermal imaging. A Riegl LMS-Z620 TLS (£100k) was supplemented with a Riegl VZ2000i TLS (£120k) to reconstruct complex topography at long range (2.5km) and quantify change in unstable slopes and coastal cliffs. The resultant findings informed policy on the management of highland and coastal transport routes (see section 4.2, *Westoby, Woodward*) and presented glacial geomorphic change that evidenced Holocene ice sheet thinning in West Antarctica (*Westoby*, in *Nature Communications*). TLS investment, in conjunction with four differential GPS units, was used to support external grant awards (Baillet Latour Antarctic Fellowship, *Winter*; PGR Royal Geographical Society Land Rover Grant, *Allan*; Royal Society, *Pellicciotti*; British Society for Geomorphology, *Fyffe*). Coordinated investment in UAV measurement capacity - four DJI Phantom 4 quadcopters (£20k), two DJI S1000 octocopters (£25k), Agisoft Metashape software licenses (£15k), optical SLR cameras (£3k) and two Optris thermal cameras (£18k) - quantified topographic and thermal changes in glacial environments and snow-covered forests (*Westoby, Rutter* in *RSE*, PhD studentships, *Malle, Webster*).

Investment in instrumentation to measure geophysical properties of seasonal snow, glacier ice and permafrost enabled invited collaboration to larger projects. Snow microstructural measurement equipment (£50k) generated collaborative work with the Finnish Meteorological Institute and Environment and Climate Change Canada funded by the UK, European and Canadian Space Agencies (*Rutter, Sandells, Wake*). Ice penetrating radar systems (£80k) and licences for ReflexW processing software (£1.6k per annum) enabled participation in studies of West Antarctic ice change (e.g. NSFPLR-NERC Thwaites Glacier project, *Woodward*) and its stability over the last 1.4 million years (*Woodward, Winter, Westoby*, in *Nature Communications*). Tromino passive seismic sensors (£25k) were deployed to assess the impact of permafrost on coastal erosion rates in Northern Canada (*Mann* in *GRL*) funded by NERC Arctic Office bursaries, and low-cost 3D raspberry shake seismometers (£2.5k) were used to assess rates of ice flow in East Antarctica (Antarctic Science International Bursary, *Winter*).

Investment in micrometeorological and biogeochemical monitoring capacity centred on hydrology, carbon emissions and air quality. Hydrological modelling of flood risk and water resource management in high-mountain catchments was enabled using two automatic meteorological stations (£20k) and a fluorometer (£2k) to measure energy fluxes and river discharge from debris-covered glaciers (National Geographic/Mount Everest Foundation, *Fyffe, Pellicciotti*). An ultraportable Los Gatos greenhouse gas analyser (£93k) measured carbon emissions from water as part of the NSF-funded POLARIS project (*Mann*) to study climate change impacts in Alaskan tundra. The student-focused POLARIS project was designed to address specifically the lack of racial and ethnic diversity in the polar geoscience workforce, thus training students in co-production of knowledge with local communities in the Arctic. In the UK, increased capacity for real-time, portable air quality monitoring enabled the measurement of particulate matter, NO₂, ozone, and volatile organic compounds (£250k, Environment Agency Air Quality in Major Incidents project, *Deary, Griffiths*) from industrial fires, as well as citizen-led indoor air quality monitoring (NERC Home Biome Project, *Namdeo, Entwistle*) using Aeroqual integrated air quality sensors (£10.5k).

In addition to scientific instrumentation, participatory research in communities often requires novel and engaging field equipment. Successful examples include 3D printed models of landscapes for use in participatory research on disaster risk with communities in Nepal (NERC/DFID Science for Humanitarian Emergencies and Resilience, *Oven*), puppets for child-centred risk communication techniques to increase participation in handwashing in Kenya (Infectious Disease Risk Reduction and Humanitarian Innovation Fund, *Collins, Richardson*), and textile materials for workshops with asylum-seeking women (*Cassidy*, in *TiBG*).

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

4.1. Research collaborations, networks and partnerships

Research collaborations, networks and partnerships within the unit are specifically aligned with UN sustainable development goals (Figure 2), addressing regional, national and global societal challenges. QR funding was invested in targeted research, to grow existing collaborations and initiate new research networks. Administrative support to PIs from RIS, for funded collaborative projects, enables academic staff to focus on research aims and project milestones. By both leading and actively participating in collaborations, staff across all career stages continue to develop international and domestic multi-participant research agendas.

The Disaster and Development Network (DDN, *Collins, Kotter, Jones, Oven, Parry, Richardson*), which undertakes research encompassing disaster reduction, sustainable development and resilience building, exemplifies an area of existing strength that has been extended and deepened during the REF2021 period. DDN research is embedded in local community action in Mozambique, Zimbabwe, Bangladesh, Nepal and Pakistan. In addition, the Network provides leadership to, and is co-founder of, two major global institutional alliances:

Global Alliance of Disaster Research Institutions (205 lead institutes worldwide), for which it acts as elected board institution and chair; and the United Kingdom Alliance for Disaster Research (30 UK higher education and research institutions), elected board institution and chair jointly with King's College London. The DDN hosts the Gender and Disaster Network (GDN), is an accredited partner of the United Nations International Strategy for Disaster Risk Reduction for the implementation of the Sendai Framework for Disaster Risk Reduction (2015–2030) and previously of the Hyogo Framework (2005–2015), and is a member of the UN Science and Technology Advisory Group (STAG) for Disaster Risk Reduction. DDN grant funding has come from DFID, ESRC, NERC, EU (FP7 and Horizon), UN organisations (UNDRR, UNHCR, UNDP, UNICEF), NGO consultancies, UK emergency services and charitable organisations.

The collaborative work of the DDN was reinforced through staff appointments (*Manyena, Oven*), as well as through funding research assistance, international fieldwork and conference travel. In the REF2021 period, ongoing collaborations with the UN and the WHO have embedded health- and people-centred resilience in disaster reduction programmes. Working with NGOs such as No Strings International and national government in Kenya, these approaches were operationalised in schools, leading to significant reductions in communicable diseases. Newly appointed staff were supported in deepening ongoing collaborations, extending the reach of the DDN. For example, a collaboration with the National Society for Earthquake Technology – Nepal, the IFRC and the UN Resident Coordinator's Office in Kathmandu has facilitated access to Nepalese government ministries and departments, responded to research needs on the ground, in the context of disaster preparedness, and facilitated the uptake of disaster risk reduction policies and practice in the country (*Oven*).

Staff from the Centre for International Development continues to develop and enhance collaborations with a range of organisations working in, and on, the global South. Through a collaboration with the International Federation of Red Cross and Red Crescent Societies (IFRC), a Global Review on Volunteering led to the adoption of UN resolutions and a change in IFRC policies that have prioritised volunteer safety and well-being for the first time in peace and development policy (ICS by *Baillie Smith*). The unit's work with the IFRC on volunteering was strengthened by a staff appointment (*O'Loughlen*) and an RDFSS-funded PhD studentship (*Fadel*). In addition, unit staff have been supported in building and extending collaborations with grassroots organisations that enable research with marginalised groups. Examples of such collaborations are the Latin American Mining Monitoring Programme (*K.Jenkins*), the Swedish Red Cross led Volunteers in Conflicts and Emergencies Initiative, and Refugee Youth Volunteering Uganda (*Ballie Smith*).

To extend the geographical reach of collaborations with vulnerable communities, we provided sabbaticals, research assistance, and pilot project funding for colleagues working in and on the global North, for example with forced migrants (*Cassidy, Clayton*) and unemployed workers (*Griffin*). QR funding and a sabbatical were used to support a collaboration between *Cassidy* and

the Angelou Centre that explored the impacts of everyday bordering on women who sought asylum. This project embedded research in regional and national voluntary and community sector (VCS) networks and led to the creation of a civil society initiative (Migration and Asylum Justice Forum), which has empowered successful campaigns to improve housing, healthcare and education opportunities for forced migrants (ICS by *Cassidy*).

Through the **Extreme Environments** MDRT, strategic appointments were made to the research groups of **Cold and Paleo Environments** and **Solar-Terrestrial Science**. Consequently the unit leads international collaborative research on Antarctic ice mass and oceans to model contributions to future sea-level rise, and is lead or key partner in two of the eight NERC-NSF International Thwaites Glacier Collaboration projects (Processes, Drivers, Prediction, *Gudmundsson*; Geological History Constraints, *Woodward*). A collaborative European partnership investigates the possibility of sudden and large changes in Antarctic climate components (Horizon 2020 TiPACCs, *Gudmundsson*), and impacts of ocean temperatures on ice shelves are assessed in collaboration with project partners in the USA, Australia and France (NERC Ocean Forcing of Ice Sheet Evolution in the Marine Basins of East Antarctica, *A.Jenkins*).

Through the **Solar-Terrestrial Science** research group, the unit partners closely with the Met Office Space Weather Operations Centre, to better understand the solar sources of space weather and provide the physical basis upon which space weather forecasting can be improved, thereby limiting economic impact of aviation disruption, communications blackouts, or satellite damage. This partnership has been enhanced by new strategic appointments integrated into the SWIMMR programme (*Rae, Watt*), as well as through a new initiative with existing staff members: the Solar Flare Likelihood and Region Eruption forecasting programme (*Bloomfield*).

Our innovative research in visualisation and monitoring of environmental systems has achieved strong partnerships across the unit. We have worked with national agencies in the UK and Canada to assess and mitigate the effects of storm-driven erosion and coastal permafrost decay respectively; these effects pose a serious risk to life and critical infrastructure (ICS by *Woodward, Mann, Westoby and Dunning*). In the UK, our work has led to more cost-efficient and effective remedial transport planning. For example, [text removed for publication].

Investment in targeted research support for new staff in the unit has broadened the scope of existing collaborations, creating new research opportunities. Unit-funded visits to external collaborators for research grant preparation have resulted in successful awards, for example NSF-NERC Fungi in a Warming World, with Moorhead State University, USA (*Pound*), and ongoing proposal developments, for example concerning electronics waste in Germany and China (Regional Studies Association early-career grant, *Fu*). Hosting visits from research funders (e.g. NERC mock panel and NERC Arctic Office) have provided a forum for two-way discussion on research council-specific funding topics. In addition, grant preparation support is funded in time-limited situations, an example is the transcription of pilot interviews for the Leave to Remain project (British Academy bursary for Urban Violence symposium, *Hughes*).

Examples of collaborations and partnerships resulting from targeted unit-funded investments

- Māori Television Service, New Zealand: TV7, Nicaragua: Indigenous peoples' media practices and globalisation (*Glynn*)
- TUC Library, National Records of Scotland: Unemployed workers' centres (*Griffin*)
- Maldives government: Citizen science seagrass monitoring programme in the Maldives (BLUE Marine Foundation) and the incorporation of seagrasses into design of marine protected areas (*East*)
- London School of Economics: Digitally mediated informality and urbanism (*Ferreri*)
- British Antarctic Survey, European Space Agency: Access to airborne radio echo sounding data (*Winter, Woodward*)
- Scientific Committee for Antarctic Research (SCAR): Invited position on 'Antarchitecture' working group (*Winter*)

4.2. Impact and contributions to the economy and society

Research in the unit made demonstrably substantive contributions to international and domestic policymaking, particularly influencing UN and other decision-making bodies approaches to addressing inequalities in the global South. Tailored research support packages (e.g. part-time research assistants, travel to policy meetings, hosting group interviews) enabled staff to rapidly develop avenues to improve social justice for mobile populations (*Cassidy, Clayton*) across the North East, Yorkshire and the Humber, as well as to change regional planning policies to better incorporate green infrastructure in the UK, the Netherlands and New Zealand (*Scott*).

Research in the unit had a major influence on policies and procedures of the UN. Recruitment of staff with expertise in Bayesian statistical methods supported research on identifying hotspots for female genital mutilation/cutting (ICS by *Kandala* and *Komba*) that enabled more strategic resource allocation and interventions, preventing harm to women and girls in Kenya, Nigeria and Senegal. A collaboration with the IFRC (section 4.1) on global volunteering led to a new Global Volunteering Alliance, which involve 73 countries, representing 10 million members, and focuses on prioritisation of volunteer health and safety. On the ground, this resulted in new practices of volunteer support, including provision of insurance, recognition of psychological challenges, and new posts in volunteer development (ICS by *Baillie Smith*). Research within the DDN has identified strategies for risk reduction in infectious diseases that focus on affected communities' vulnerabilities and capabilities. This people-centred approach is now integral to the health policies of the UN's Sendai Framework for Disaster Risk Reduction in 109 signatory countries, and has guided the World Health Organisation's (WHO) Framework for Health Emergency and Disaster Risk Management. UN development practices in Mozambique have been refocused towards enhancing community-response capacity (ICS by *Collins*).

Beyond the UN and the global South, the unit's research shaped regional and local policymaking. Research has not only exposed a significant nature deficit in the design and delivery of planning policy but also transformed local planning policy responses through the development of a tool to mainstream green infrastructure, which was identified as a key resource for local authorities (ICS by *Scott*). Local authorities and housing providers in the North East, Yorkshire and the Humber have also made changes to their approach to housing asylum seekers as the result of campaigns by a civil society forum formed as the result of the unit's research, which highlights the impacts on forced migrants of recent changes to UK immigration legislation (ICS by *Cassidy*).

Emerging from original and often interdisciplinary research across the unit, a wide range of highly significant impacts on policies, communities and practices is evident. Impacts include the coupling of renewable energy, smart electricity grids and stationary storage facilities with electric vehicles, which have influenced innovative urban transport policy choices in Oslo, Amsterdam and Leicester (EU SEEV4-City, *Kotter*); influencing Catalan housing and urban policymaking by combining international co-operative organisations and architectural studios (Metropolitan area of Barcelona, *Ferreri*); and changing practice in the community-based disaster risk reduction policy of the Nepal Ministry of Federal Affairs and General Administration (DFID, *Oven, Jones*). Key reports have been co-authored influencing national and intergovernmental policy on the role of pollinators in biodiversity and ecosystem services, for example the UK National Pollinator Strategy (DEFRA, *Baldock*) and the Assessment Report on Pollinators, Pollination and Food Production (IPBES, *Baldock*). Contributions to national policymaking, through submission to the Home Affairs Committee inquiry on immigration, resulted from conclusions of the 'New Migrants in the NE

Workforce' report (British Academy, *Clayton*). There were also local policy contributions to the Move on & Economic Inclusion subgroup of the regional migration partnership.

A business development manager (BDM; *Errington*) acts as a key connector and enabler of the unit's research consultancy, supporting the delivery of applied research that meets specific funder needs and contributes to policy and business operations. BDM support was crucial to establishing the award-winning spin-out company BIM (Building Information Modelling) Academy Enterprises Ltd ('most innovative Business–University collaboration', *Times Higher Education* 2017), in which *Woodward* is a director. Through the BIM Academy, integration of the Unit's 3D surface analysis research with 2D urban datasets in an optimised 3D virtual city allowed for real-time integrated flood prediction using monitoring and BIM of smart sewer networks (Northumbrian Water, *Woodward*). Impacts from research consultancy extend many other research themes in the unit. For example, multiple subcontracts on GIS analysis of seascape and visual sensitivity to offshore wind farms were undertaken to enable evidence-based policy decision-making (DEFRA, Suffolk County Council, Natural Resources Wales, *King*); and street life in the Castro/Upper Market district of San Francisco, California, was improved through revised urban planning and regeneration policy and practice (AECOM, *Luger*).

Unit staff have worked with a range of partners to enable wider public engagement in research. This has promoted creative hands-on, practical sessions delivered in schools (in addition to NUSTEM; see section 1.4) and communities. To extend the wider contribution made by the unit's research, early-career scientists in particular have been supported by the university media and communications team in promoting their research in the national and international media. Prominent examples include radar investigation of Antarctic ice (BBC, Washington Post, *Winter*) and coral reef island response to sea level change (BBC Radio 4, BBC World Service, CBC Radio, *East*).

Examples of public engagement

- 'A-Maze-ing Robots' introduced scientific coding to primary school children (Royal Society, *Sandells*).
- The Bees Project developed school-safe laboratory processing methods for pollen analysis (IRIS Well World Research, *Pound*).
- 'Dippy on Tour' allowed children to link dinosaur knowledge with past climates through a specifically developed board game (Great North Museum, *Hocking, Pound, East*).
- The Placemakers Game enabled GCSE and A-level students to mimic policy decisions in urban planning through game play (Royal Town Planning Institute, *Scott*).
- 'Mapping the City' allowed young people, using low-tech cartographic techniques, to reveal the rich, complex and important aspects of their lives that are missing from most depictions of cities (NewcastleGateshead Initiative, *Jeffries, East*).

4.3. Disciplinary contributions

Research outputs from the unit make a substantial contribution to the quality and quantity of published research in international journals. The quantity of these research outputs has been consistent throughout the REF2021 period (Figure 6): between 120 and 200 outputs per year (a total of 220 papers were published in the REF2014 census period), but the impact on academic significance (using citations as a proxy) has been steadily increasing from 2014 onwards.

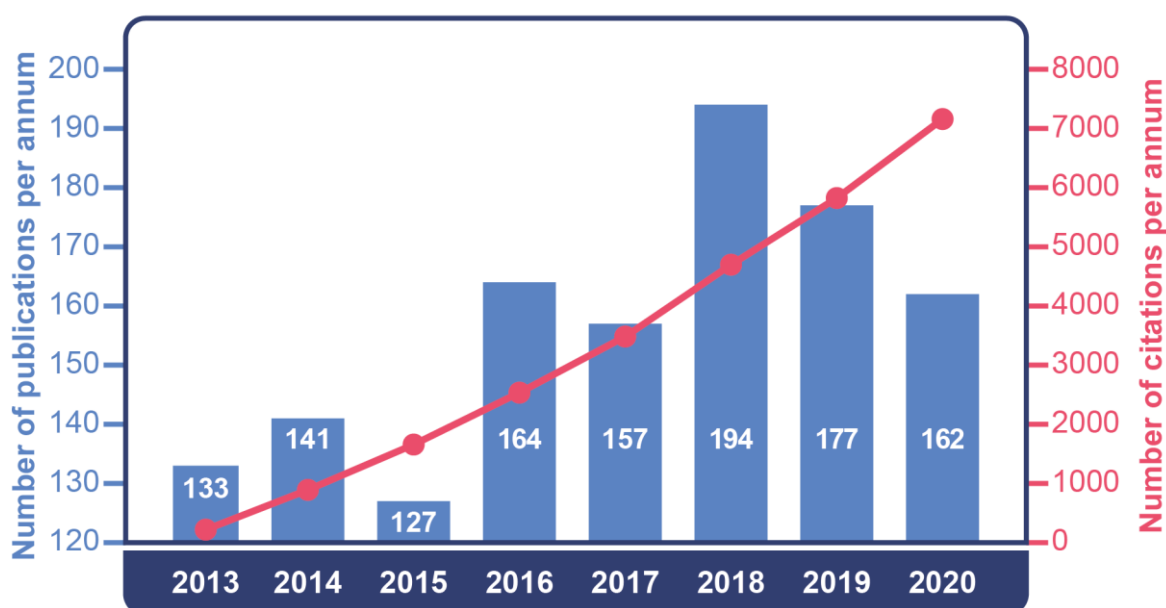


Figure 6. Total publications per annum (blue column) and total citations per annum of these publications (magenta line). Source: SciVal.

The structuring of the unit around MDRTs facilitated distinctive and innovative inter- and transdisciplinary approaches. Interdisciplinary projects often bring together human and physical geographers (e.g. DFID/NERC 'Impacts of landslides on post-earthquake response and recovery in Nepal', *Oven*) or geographers and scientists from other disciplines such as anthropologists, sociologists, biologists and economists (e.g. NERC-ESRC-DFID 'Sustainable poverty alleviation from coastal ecosystem services', *Coulthard*). But, when a union of different approaches is required to solve problems, new intellectual frameworks result and staff lead transdisciplinary research (e.g. NSF-AHRC 'Interaction of climate and anthropogenic influences on hydrology in the Bolivian Amazon', creating a new concept of (palaeo)ethnohydrology, *Whitney*). Indeed, our research leads transdisciplinary development where often technocratic, expert-led language can be better expressed through a common framework to improve policy and practice outcomes (e.g. NERC 'Mainstreaming green infrastructure in planning policy and decision making', *Scott*).

Inter- and transdisciplinary training is central to the OnePlanet DTP (see section 2.2.1). OnePlanet's approach transcends traditional boundaries between natural and social sciences, to provide the solutions we need for the grand challenges associated with climate change and the Anthropocene. Researchers have the opportunity to work with partners spanning industry, government and regulatory authorities to ensure impact and societal- and industry-relevant outcomes. In this way our cohort-based training approach fosters trans-, inter- and multidisciplinary skills, particularly between the environmental sciences and business, engineering, social sciences, mathematics, statistics and computing. Exchange of knowledge and skills with PhD students and ECRs at external institutions, for example remote sensing of snow and hydrological melt modelling (Royal Society, Institute of Tibetan Plateau Research, China, *Pellicciotti, Westoby*; British Council, Eurasian National University, Kazakhstan, *Brock*) – has enriched the wider discipline and has been specifically and especially supportive of early- and mid-career female scientists in other countries. This commitment to developing the future of our disciplines is reflected by the fact that staff have acted as external examiners for 84 PhD theses at institutes around the world since 2014.

Staff contribute to disciplinary development by acting as editors-in-chief of two journals (*The Cryosphere*, *Gudmundsson*; *Radical Housing Journal*, *Ferreri*) and as associate editors for a further 33 journals (e.g. *The Cryosphere*, *Space Physics*, *Journal of International Development*). We regularly assess grant proposals as part of UKRI and international peer review colleges (NERC, AHRC, GCRF, EPSRC, ESRC STFC PPRP, STFC Astronomy, UNESCO, Danish Research & Innovation System) and of European and UK Space Agency advisory committees (*Rae, Watt*); and we are core members of UKRI panels (STFC Astronomy Grants Panel, UKRI FLF, *Watt*; STFC PPRP, *Wicks*; STFC Solar System Advisory Panel, *Morton*; STFC ETCC, Stephen Hawking Fellowships Panel, *McLaughlin*; NERC Panel, *Namdeo, Rogerson, Woodward*; Newton Fund APHH India, *Marston*). In addition, *Salzmann* and *A.Jenkins* are contributing authors to IPCC AR5, SROCC and AR6.

Our staff demonstrate leadership across a broad range of disciplines, holding a range of elected positions (chair, unless specified). Examples are UN STAG & DWG, *Collins*; SCAR FRISP, *A.Jenkins*; EGU Cryosphere Sciences, Scientific Officer, *A.Jenkins*; IGS, Vice-President, *Gudmundsson*; ICSIH, President-Elect, *Sandells*; EPS Solar Division, Board Member, *Bloomfield*; STFC ETCC, Committee Member, *McLaughlin*; NERC Project Building with Nature Standards Group, *Scott*; BES Conservation Ecology, Committee Member, *Suggitt*; Snow-International, Committee Members, *Rutter*, *Sandells*; ESA Space Sciences Advisory Committee, Committee Members, *Watt*, *Rae*). Our ECRs have also received disciplinary honours that recognise the high quality and significance of their research (e.g. EPS Plasma PhD Thesis Award 2016, EPS Early Career Award 2017, EGU Solar-Terrestrial Early Career Researcher Award 2018, all to *Jeffrey*; Royal Astronomical Society Winton Capital Award and the Fowler Award for Geophysics, both to *Morton*).

By hosting events at Northumbria, we contribute to the enhancement of research networks in our research communities and engage external collaborators in what we do. Significant meetings that we have organised are 2019 British Branch IGS (*Rutter*, *Winter*), 2019 UKADR, GCRF, DRG and UKADR Conference (*Collins*), 2016 New Migrants in the North East Workforce (*Clayton*), 2015 Micropalaeontological Society Palynology Group Meeting (*Pound*, *Salzmann*), 2015 UK Magnetohydrodynamics (*McLaughlin*), 2015 Health Centred Disaster Risk Reduction (*Collins*), 2014 Society for Environmental Geochemistry and Health annual conference (*Entwistle*).

To summarise, in this submission we highlight the unique transformation of the research environment in Geography and Environmental Studies at Northumbria since REF2014. This transformation has been facilitated through strategic investment in people and research resources that has sustainably built existing areas of expertise into discipline-leading clusters and created vibrant new research groupings. A fourfold increase in staffing has led to significant ongoing growth in research income and awards, particularly in large awards from a notably broad range of different funding sources. The improved quality and increased quantity of research outputs have created positive change for communities globally: this is a direct consequence of our research.