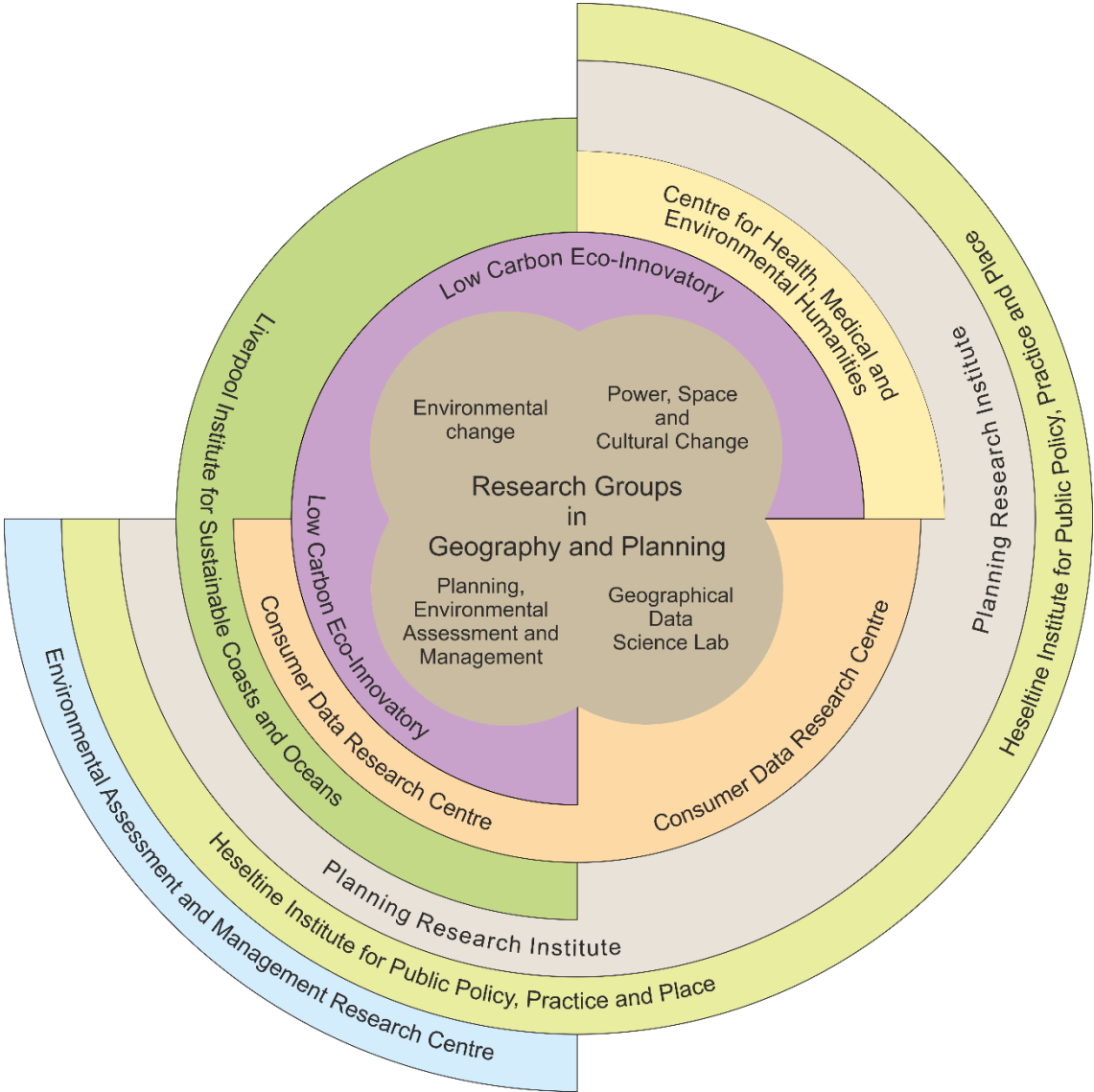


<p><b>Institution: University of Liverpool</b></p>
<p><b>Unit of Assessment: 14 Geography and Environmental Studies</b></p>
<p><b>1. Unit context and structure, research, and impact strategy</b></p> <p>1.1 Research structure and context</p> <p>The Department of Geography and Planning, in the School of Environmental Sciences, combines the world’s first School of Planning (1909) and one of Britain’s first (1887) Geography Departments offering degrees. Our ethos is to undertake research to: understand better the physical and human processes shaping our environment and communities; understand the cognition and utilisation of these processes to support decision-making; and predict the trajectories and causes of future change. Our prioritising equality, diversity and inclusivity is evidenced by successive School Athena SWAN Bronze (2016) and Silver (2019) Awards. We strive to conduct impactful research of <i>societal relevance</i>. Our commitment to civic, policy and business engagement drives our impact strategy, with direct benefits for local, national, and global societies, e.g., our European Regional Development Fund (ERDF: 2012-2023) eco-innovation research that engaged with 300 enterprises driving £3M of investment into the Northwest region.</p>  <p><b>Fig. 1. Structure of the Department of Geography and Planning.</b></p> <p>We are one of two departments in the School, which provides overarching structures for research, strategy, management, and cross-disciplinary interaction. The Head of Department</p>

manages the Department, with the Dean of School and a School Management Team. Four mature, inclusive, vibrant, and cognate Research Groups (Fig. 1) have facilitated research excellence in our priority areas of (i) Environmental Change, (ii) Geographic Data Science, (iii) Power, Space and Cultural Change, and (iv) Planning, Environmental Assessment and Management (Fig. 1). We drive our Interdisciplinary and Impact Agenda by (co-) leading University Centres and Institutes, bringing together researchers from across disciplines and the world (Fig. 1). Since 2014, we have supported research excellence by growing to 52 FTE (55% growth) sustaining critical masses of researchers across our research groups, 60% of whom have joined as early career academics. We co-located in 2015, moving from three buildings, to integrate physically our research groups (Fig. 1). We realised immediately the benefits, with interdisciplinary successes e.g., in Sustainable Coasts and Oceans, with the EU funded Celtic Sea Partnership (2016), and our ESRC funded £9.5M (2015-2022) Consumer Data Research Centre (Fig. 1). The University's £1B Estate Strategy prioritises further redevelopment of the School in new £40M state-of-the-art accommodation, which is progressing through Architects and RIBA Plan of Work Stage 2. This committed £1M in 2020-21, notwithstanding COVID-19 disruption of University capital plans. Ultimately, this would complete our vision for a shared intellectual space, where social and physical sciences collaborate to address global environmental challenges.

## 1.2 Research and impact strategy

We have championed the growth, development, and excellence of our staff, by investing in early career academics, growing our research income and postgraduate community. Our stated REF2014 priorities were to develop *Coasts and Oceans* and *Geographic Data Science*, both areas where we were emerging as global leaders. We used strategic investment 2014-2020 to grow our staff numbers, collocate our Research Groups, and as a result our research income has increased to £1.4M per annum up from c. £1M (REF2014) to a total of £9.6M. That total does not include £3.1M of our European Regional Development Fund (ERDF) spend on eco-innovation research, supporting PhD partnerships with small and medium-sized enterprises, which would increase our research income to £1.82M per annum. Our PGR recruitment (2014-2020: 114 total, 42% BAME) increased to 2.2 per FTE (REF2021) from 1.4 per FTE (REF2014). We have prioritised impactful research across our research groups (Fig. 1), which has had profound *societal relevance*, rising to the challenges and debates facing global society, and provided information essential for policy makers and other stakeholders. Our strategic priorities (SP1-5) have driven this growth and are affirmed here in our development to 2026; they are to:

SP1: Expand our world leading research excellence in environmental processes and change; geographic data science; power, space, and cultural change; planning, environmental assessment, and management.

SP2: Enhance the positioning of civic, policy and business engagement as core and underpinning our world-leading reputation for conducting impactful research of societal relevance that rises to the challenges facing global society.

SP3: Grow our burgeoning strength in inter-disciplinary research and impact through agile partnerships across our leadership of nine interdisciplinary Centres and Institutes and diversifying our pool of grant funders and our awardees.

SP4: Develop further our emphasis on equality, diversity, and inclusivity by placing staff well-being as central to our research environment. Our inclusive approach nurtures our postgraduates, postdoctoral researchers and supports the evolution of early career colleagues into discipline leaders.

SP5: Continue our leadership of research that meets the highest standards in open access, research integrity and ethics, where our approaches are enabling interaction with *hard-to-access* and *ethically demanding* datasets and populations.

Our **Environmental Change** research focused on geomorphology and global environmental change. Our strategic growth (54%) FTE has targeted new strengths in *contemporary processes and environmental modelling* recruiting Mair, Dean, Higham, Nias and Leonardi to research the environmental stresses on earth systems and societies. Parallel growth has strengthened and broadened our Environmental Change research recruiting Smedley, Montoya, Hackett-Pain, Lea,

Blackford and Sangster. These strengths align strategically and drive the University's *Climate futures* theme, discovering how we are responding to the global climate crisis through our research.

From strengths in geocomputation, demographics and migration, we have grown **Geographic Data Science Lab** (33% FTE) to become a world-leading centre of excellence for research solving grand human challenges through Geographic Data Science recruiting Darlington-Pollock, Arribas-Bel, Dolega, Dong, Green, Goodwin-White, Robinson and Rowe. Core investment has targeted the themes of *Population and Health*, *Artificial Intelligence*, *Big Data and Consumer Data Analysis*, which align strategically and drive the University's *Digital and Personalised Health* Themes.

Growth of 100% FTE has extended our **Power, Space and Cultural Change** foci on social and cultural geographies alongside political and economic change. Recruiting Gahman, Isakjee, Peters and Turner targeted of five key areas of inquiry: *Material Mobilities*; *Activism and Alternatives*; *Histories, Pasts and Memories*; *Governance and Discipline*; and *Knowledges, Identities and Everyday Practices*, in part aligned with University's themes in *Personalised Health and Heritage*.

Supporting REF2014 foci on Environmental Assessment and Spatial Policy and Planning research with 60% FTE growth, we have recruited Chen, Clement, Abrahams, Dunning, Dembski, Moore and Nurse. This strategic investment has realised **Planning, Environmental Assessment and Management** group strengths around the four cognate themes of *Sustainable Cities (Housing, Social Inequalities and Cohesion)*, *Marine Spatial Planning (Sustainable Coasts and Oceans)*, *Environmental Assessment and Management*, and *Public Policy and Regional Development*.

We have diversified our funding portfolio to build resilience achieving 60% more individual funders (awards >£50k) than REF2014 including six UK research councils. We used internal ODA Seed Funds (x8) to develop research in low- and middle-income countries and to pump-prime £1.5M in *Global Challenges Research Fund* grant successes, e.g., ODA Seed Fund research (Gahman) on *Community Empowerment in Maya Culture* led to a successful British Academy – *Heritage, Dignity, and Violence* programme GCRF grant (£300k). Our School Fellowships Officer supports individuals in building fellowship funding applications. Our Impact Leads play an important role in supporting exchanges and communication of our societally relevant research through a wealth of community and professional outreach activities. Our impact successes have required a Civic Engagement Directory to document our connections and support for the wider community. In this, successive European Regional Development Fund (ERDF) Eco-innovation research programmes have engaged with 300 small and medium enterprises producing £3M of inward investment, creating 236 jobs and 51 new eco-innovative products and services. The ERDF-funded Centre for Global Eco-Innovation (CGE) won the Green Gown Research and Development, PraxisUnico UKRI 'Outstanding KEC Initiative' Awards (2015) and the Low Carbon Eco-Innovatory won the Mersey Maritime 2020 Environmental Impact Award (P-I: Plater) and Dr Cai Bird a CGE PhD graduate and now Director of Research at Marlan Maritime Technologies won the 2020 Mersey Maritime Industry Rising Star Award (Fig. 2).



Fig. 2: Award-winning environment-focused community-centred research (ICS1).

### 1.3 Impact through our civic, policy and business engagement

Conducting research that has an impact on society is an ethos enshrined in our strategic priorities (SP2) and we specialise in societally relevant research detailing these successes in sections 3.4 and 4. Our impact and civic engagement agenda are recognised in formal administrative roles (led by [Darlington-Pollock](#) and [Lord](#)). These impact leads support our Research Groups (Fig. 1), interdisciplinary Centres and Institutes, and postgraduate community in forging connections between world-leading research and end-users. They also supported the development of five Impact Cases (ICS1 to 5):

ICS1. Generating geographic data to inform policy, social welfare and learning for tackling health and social inequalities.

ICS2. Achieving low-carbon growth across small businesses in Liverpool City Region.

ICS3. New Policy-focused Practices in Marine Ecosystem-Based Management.

ICS4. Spatial Planning research reforms practice, participation, and policy to empower city regions and communities.

ICS5. Behavioural insights research transforms community infrastructure investment through policy changes to developer contributions.

School, Institutional and UKRI Impact Accelerator Awards have encouraged new impact initiatives. Our GCRF projects drive our research in low- and middle-income countries addressing global challenges and having profound impact for communities internationally (SP2).

**Geographic Data Science Lab** work closely with Public Health England, United Nations, the ONS Data Science Campus and the UK2070 Commission to deliver data products to better understand and support decision making to improve health outcomes, create sustainable cities, and reduce regional socio-economic inequalities ([ICS1](#)). This research includes the ESRC funded £9.5M (2015-2022) **Consumer Data Research Centre** (SP2). [Singleton](#) and [Green](#) were also funded by the ESRC (£148k) to provide analytical support to Local Authorities in responding to COVID-19, including novel geospatial analyses using ONS data for selecting the location of testing sites for Liverpool City Council within Liverpool's whole city testing pilot.

Our **Planning Research Institute** has been active in addressing the challenge of how we build urban resilience to climate change and harness financial contributions gathered through the development process to 'level up' economic activity across England ([ICS5](#)) (SP1&2). The **Heseltine Institute for Public Policy, Practice and Place** ([M-Boyle](#)) has led our COVID-19 civic response in bolstering economic resilience collaborating with Liverpool City Region Combined Authority producing 36 policy briefs on topics including: 'building back better' ([North](#)), merits of the Universal Basic Income ([Thompson](#)), and EPSRC/Decarbon8 and Research England Industrial Strategy-funded research on cycling and walking as safer and stronger active travel options in the region ([Nurse](#), [Dunning](#)).

Our major research grants and the engagement of our postgraduate community with industrial, civic and third sector partners (50% of our UKRI PhDs are with Industrial Partners) have aided our impact agenda. In **Environmental Change**, the £7.7M 2014-2023 **Low-Carbon Eco-Innovatory** and £6.9M 2012-2015 **Centre for Global Ecoinnovation** (Fig. 2) collaborative ERDF projects developed new low-carbon products and services in PhD partnerships with small and medium-sized enterprises across northwest England ([ICS2](#)). In **Planning**, two consecutive ESRC Joint Programming Initiative research awards (€1.4M 2014-18, €0.9M 2019-22) facilitated reform of key policy areas related to the financial and in-kind investments ('developer contributions') that accompany real estate development in England ([ICS5](#)).

### 1.4 Interdisciplinary research

Our leadership of University Research Centres and Institutes drives our interdisciplinary and impact agenda conducting and publishing research that cuts across Geography, Ocean Science, Health and Life Science, Computer Science, Engineering, Economics, Statistics and Sociology (Fig. 3), and collaborating with 12 partner Universities globally (SP3). These include research centres in (i) **Environmental Assessment and Management** ([Fischer](#)), (ii) **Liverpool Institute**

for Sustainable Coasts and Oceans ([Jay](#)), (iii) **Planning Research Institute** ([Lord](#)), (iv) **Consumer Data** ([Singleton](#)), and our leading of the (v) **Heseltine Institute for Public Policy, Practice and Place** ([MBoyle](#)). We co-lead (vi) the ERDF-funded **Low-Carbon Eco-Innovatory** ([Plater](#)) (Fig. 2) and (vii) the **Centre for Health, Medical and Environmental Humanities** ([Evans](#)).

Our interdisciplinary ambition has increased by addressing the University Strategy 2026 Research Themes in **Infectious Diseases, Personalised Health, Liverpool Digital and Climate Futures**, and our Faculty's Priority Research Challenges in **Risk and Uncertainty, Coasts and Oceans, and Energy**. Our ERDF-funded **Centre for Global Eco-Innovation and Low-Carbon Eco-Innovatory** are both outstanding examples of interdisciplinary research developing partnerships across Engineering, Integrative Biology, Chemistry, Management School and Architecture. Our targeting of GCRF initiatives have led to collaborative projects researching - risk reduction from mine tailings dams (Brazil) (ESRC-GCRF: £866k); drought hazards in China (NERC-GCRF: £137k); coastal erosion monitoring in St. Vincent (UKRI-GCRF: £73k); Hugli River of Cultures (India) (AHRC-GCRF: £162k); sustainable agriculture - agrarian life in Grenada (AHRC-GCRF: £194k), and violence and dignity perspectives of indigenous (Maya) communities (Belize) (BA-GCRF: £300k). Further, cross-faculty research (Fig. 3) on Infectious Diseases ([Morse](#)) with the Health Protection Research Unit in Emerging and Zoonotic Infections, includes the £7.7M UKRI-GCRF "One Health Regional Network for the Horn of Africa (HORN)" and £0.9M BBSRC project on bluetongue viral disease.

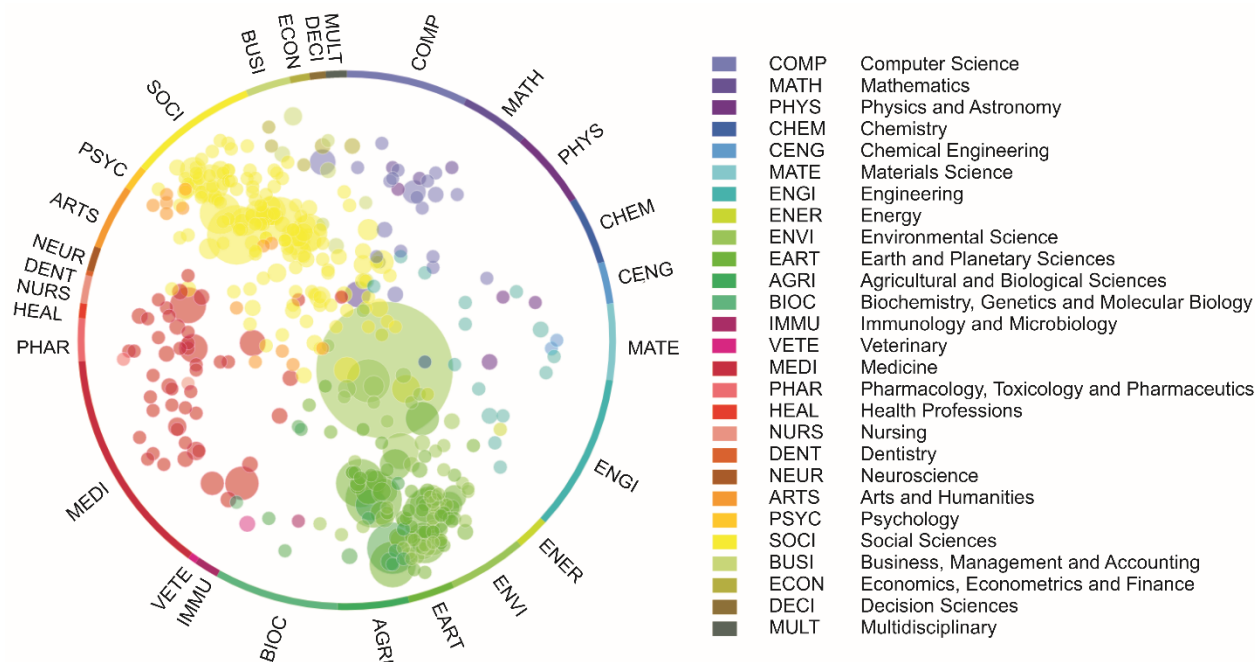


Fig. 3. Interdisciplinarity shown as the proportion (circle size) and prominence (> towards rim) of our 960 total outputs (2014-2020) within other disciplines (SciVal).

### 1.5 Open research environment

Of the 960 UoA14 outputs published 2014-2021 42% were Gold Open access (Scopus), 73% were deposited in the University of Liverpool repository (>Green access) and 88% of the REF submitted outputs are open access. We exceed the University baseline commitment to Open Data (SP5) significantly, with the leadership of international open data initiatives developing state of the art and award-winning data facilities. One example is **Geographic Data Science Lab** hosting the Liverpool node of £9.5M ERSC-funded **Consumer Data Research Centre** funded in the ESRC Big Data Network, which conforms to best practice following the Information Commissioners Office's Data Sharing Code of Practice; and hosts secure data lab that has attained ISO27001 accreditation. The **Centre** contributes towards ensuring the future sustainability of UK research using consumer data, supporting consumer related organisations

to maximise their innovation potential, and driving economic growth by compiling, processing, and making available some of the vast amounts of UK consumer data generated each day in the form of open data products. The **Centre** operates parallel Online Interactive Map and Data Access Portals, a Research Approvals Group and provides research training. The **Centre** employs the UK Data Service's three-tier access policy ranging from fully *Open Data* to *Controlled Data* with stringent and registered access.

### 1.6 Research integrity

Integrity and Ethics are strategic priorities (SP5) that enable rather than form barriers to our world leading research. Burrell (Chair) and Turner (Vice-Chair) lead on the **University Ethics Committee** formulating policy on Research Integrity (SP5). Liverpool signed (2016) the San Francisco Declaration on Research Assessment (DORA), and Gahman is on the University's *Use of Responsible Metrics Advisory Committee* leading policy and implementing university-wide training. Our leadership (Lea) of the University Staff and Postgraduate LGBT+ Network has driven changes to our risk assessment protocols for overseas fieldwork to take account of legally protected characteristics now adopted across the wider university. Mandatory staff training includes on-line Research Integrity and Ethics, EU General Data Protection Regulation and Information Security Essentials, Diversity and Equality, Keeping Healthy, Safe and Well at Liverpool, the Bribery Act 2010, and Managing Safety training courses. Staff and postgraduate 'Research Ethics Training' modules cover interaction with human participants, ethics and regulation, informed consent, confidentiality, liability, and inducement. Examples of our approach include the **Consumer Data Research Centre** (Section 1.5) which adheres to the highest standards in individual and corporate data security and anonymity (ISO27001 accreditation) (SP5). Integrity negotiations were intrinsic to research on *Carceral spaces* (Turner), *Migration in contemporary Europe* (Burrell), *'Flying while fat'* (Evans), MRC-funded *Dietary Transitions in African Cities* (Green); Nuffield-funded *Challenges and need in an aged population* (Darlington-Pollock), and Leverhulme-funded *Exploring the family farm crisis* (Riley). These required mitigations of risk when operating in different cultural and legislative settings, sensitivity to emotions and relationships, ensuring informed consent, crossing of language barriers, and the compliance with the highest standards of GDPR, data security and confidentiality (SP5).

## 2. People

### 2.1 Staffing strategy and staff development

#### 2.1.1 Staffing and recruitment policy

Recruiting and supporting talented early career academics enabling them to flourish and progress to senior levels is a strategic priority (SP4). Our growth means we are submitting >55% more staff, retaining twenty-one REF2014 staff and our supportive initiatives (e.g., research leave) have enabled two colleagues with high administrative loads to invigorate their research activities. Three colleagues have retired, two retaining Emeritus status (Bradshaw, Marshall), and nine have moved on. Recruiting 30 people replaces 12 leavers and includes 18 new strategic investment posts. For fixed-term contract staff, the University has a redeployment scheme, and since 2014 Chen, Nurse and Sangster have benefitted from redeployment to tenured posts (CONCORDAT to Support the Career Development of Researchers). Research project leads and the Head of Department ensure that consultation with fixed-term contracted individuals takes place considering available options. Our School Fellowships Officer and peer review structures support colleagues and prospective fellows with applications to external funders (CONCORDAT), with successes including Thompson (Leverhulme Early Career), Arribas-Bel (A.I. Turing), Green (ESRC), Lea (UKRI-FLF), and Riley and Peters (both Leverhulme Research Fellows). We run annual workshops for prospective postdoctoral fellows based at Liverpool and elsewhere to assist with proposal development (CONCORDAT).

We monitor our staff profile for gender and other protected characteristics (SP4). There are currently 36% female staff, with 44% of hires since 2014 female. Staff from BAME backgrounds have increased from 3% to 16%, and 9% of colleagues identify as LGBT+. We chair (Lea) the University LGBT+ Network driving changes to improve the LGBT+ environment (SP4). Our recruitment strategy has been identified as sector-wide good practice by the national Equality

Challenge Unit within Advance HE (Athena SWAN award letter). Liverpool is a Disability Confident, Stonewall Diversity and Time to Change employer and is applying for Advance HE's Race Equality Charter. As a Department we scrutinise adverts for bias and guaranteeing interviews to applicants who meet post essential criteria. Recruitment draws on gender-balanced panels who are trained in 'Understanding Unconscious Bias', highlighting this through Royal Society videos before shortlisting and interviews. Our shortlisting policy (SP4) requires a gender-balanced selection of candidates, with strategies including re-advertising posts and 'Headhunting' of individuals used to achieve balance, e.g., recruiting Peters, Goodwin-White and Robinson.

### 2.1.2 Staff development strategy

We provide strategic support for all staff (SP4) ensuring an inclusive, vibrant, and productive department. Academic colleagues are research active, with 98% on full-time permanent contract and 2% taking advantage of flexible working (e.g., Sangster). Academic and postdoctoral staff (CONCORDAT) have an annual Professional Development Review meeting with our gender-balanced pool of reviewers, discussing research and teaching achievements, plans and ambitions, individual progression, challenges in undertaking research, and training/support requirements. For new academic colleagues (SP4) during their period of probation, the Head of Department co-ordinates the completion of annual progress reports and 'Confirmation in Post' paperwork. Colleagues interact with their line manager in tracking progression, and identifying support needed to address issues, e.g., research priorities, training, and support. Progression is core to our annual reviews, and in developing cases for promotion between the candidate, the Head of Department and Dean of School. Since REF2014, our strategic priority of recruiting and investing in a greater diversity of early career academics has seen eleven progress from lecturer to senior lecturer, seven to Reader, with five awarded Personal Chairs. Our level-based diversity is 45% female (lecturer), 38% (senior lecturer) and 42% (Reader), and we are on target (Strategy 2026) to extend this improving diversity to the professoriate. Hooke, in 2018, became the first female John Rankin Professor of Geography.

### 2.1.3 Equality and diversity

Equality and Diversity are a strategic priority (SP4) overseen by the **School Diversity and Equality Committee** (co-chairs: Evans and Darlington-Pollock) and are standing items for Department meetings. Darlington-Pollock is the current Chair of *The Equality Trust*, a registered charity working to improve the quality of life in the UK by reducing economic and social inequality. *Our Athena SWAN Awards* for the School, *Bronze* (April 2016) and *Silver* (May 2019), evidence successes of our Equality and Diversity strategy. Lea (Chair of our LGBT+ Network) has organised LGBT+ social events, university-wide rainbow lanyards and an internal LGBT+ STEM conference. We support family-friendly working arrangements, including meetings during school-friendly 'core' hours and providing childcare for Open Days. We support social/family circumstances protecting days of the week and providing carer- and family-friendly timetabling. Colleagues with children <4-years are not required for residential field classes. We have furthered these priorities by installing automated doors and lifts for disability access, providing designated spaces for baby changing and gender-neutral toilets. The new state-of-the-art School building will provide access to all facilities for all.

Our research support is available to all, and we monitor uptake by gender and other protected characteristics (SP4). 60 % of the Department (40% female) have taken a semester research leave 2014-2020. The University Returner's scheme provides research funding (<£5k) for colleagues after maternity leave to support resumption of research activities. We make necessary adjustments to workload and expectations, according to University HR policy, for staff with long-term medical, mental health, social or family circumstances to ensure continuation in role. Career breaks can enable staff (including research staff) to undertake uninterrupted reflection on their career, and to return or otherwise on completion. In 2015, following family relocation, a colleague undertook a period of part-time employment to establish whether they could continue with their role at Liverpool. We are fully committed participants in the University's Annual Wellbeing Week, with a full programme of events. Wellbeing is a priority, with Staff Satisfactory Surveys showing 92% enjoy their work and 88% feel a sense of personal

achievement from their work, and the School annual away day (University's Ness Botanical Gardens) combines strategic discussion with togetherness and wellbeing activities and our **Annual Staff Awards** presentations.

Our REF2020 preparation involved pre-publication reviews available to all and triannual 'Raising the Level' publication workshops embed a constructive approach supporting publishing research. Many colleagues (30%) have outputs reviewed before submission for publication. This support has seen significant increase in the targeting of top ranked journals (Fig. 4). Authors, including our REF ineligible PDRA community (CONCORDAT), can nominate up to four papers for our anonymised annual REF review process. Our Review Panel is 12 people (34% female) and female colleagues completed 38% of the reviews. Impact Leads coordinated our impact-case development, reviews, and submission. Grades for outputs and impact informed our REF Selection Panels, which comprised School/Department Heads, Research Director, 2x Early Career and 3 other members to ensure academic coverage (43% female).

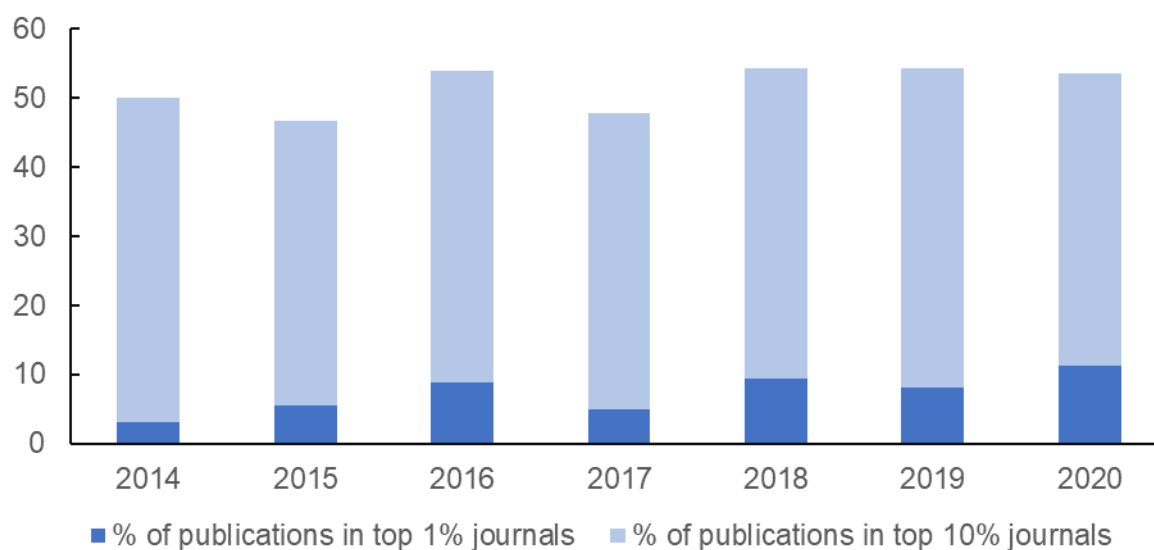


Fig. 4. UoA14's 960 (2014-2020) % outputs in the top journals (SciVal - Citescore).

#### 2.1.4 Supporting our researchers

All colleagues (SP4) receive an annual workload allocation for research (40%), augmented by a budget allocated and dispensed by research groups. Our workload model follows our Athena SWAN action plan and integrates core activities (research/impact, teaching, administration, collegiality) protecting individual research time (>1 research day per week during semesters). New colleagues receive an individual start-up fund of c. £5k (according to equipment and travel needs) to support their first three research years. Further, eight colleagues benefited from the University Early Career Researcher and Returners Research Fund that provides small (<£5k) research grants. The N8 Research Partnership (the research-intensive universities in northern England) identified Dean and Hackett-Pain, beneficiaries of ECR Research Funding, as *N8 New Pioneers* celebrating our exceptional early career academics. Multiple internal ODA Seed Fund awards, including support for numerous early career colleagues, have facilitated our research in low- and middle-income countries, and leading to >£1.5M in larger GCRF grant successes.

New colleagues have individual meetings with the Dean of School (biannual) and with Head of Department (quarterly) to facilitate a strong induction to life at Liverpool. Mentoring support from senior academics and lighter initial teaching loads assist our newly appointed people. Colleagues give introductory research presentations at our quarterly *New Staff Research Interest Sharing Events*. The School *Early Career Academic Forum* runs regular themed events including *Early Career Networking, Probation and Promotion*, and *Grant Writing* workshops. Our administrative structures have Early Career and postdoctoral researcher representation, including School Management Team and Research Strategy Group. All new colleagues undertake training courses through The Academy (CONCORDAT), to help develop research,



leadership, and teaching skills. We facilitate Early Career colleagues driving PhD supervision by using a 'buddy-system' of co-supervision with senior colleagues and by it forming a secondary recruitment metric for competitive studentships. In Geography and Planning 100% of academic staff were involved in PhD supervision 2014-2020. Exemplifying our approach, Smedley recruited in 2018 was supported with research time, a starters fund, technical support, Liverpool's Early Career and Returners Fund Grant, two funded PhD students (NERC and University) and some laboratory funding, which have enabled her to grow a research team and obtain further funding developing a world-class **Liverpool Luminescence Laboratory**.

#### 2.1.5 Research leave policy

One semester of research leave in five years, on average, is available to all staff to facilitate their excellence across research, impact and knowledge exchange activities. Many (60%) have taken advantage of these opportunities with the shortfall reflecting new appointments, and the 40% female uptake of research leave exceeds our 30% proportion of female staff. Of those awarded research leave, 56% achieved promotion within 18 months evidencing the success of this policy. Successes arising from leave include: Peters and Davies using their respective research leaves to produce new books, with Peters 'Sound, space, society: Rebel radio' receiving excellent reviews, being selected for the 'Author meets critic' Panel at the Annual Association of American Geographers conference and contributing towards promotions to Senior Lecturer and Reader. Davies produced the book '*Geographies of Anticolonialism: Political Networks across and beyond South India, c. 1900-1930*' contributing towards promotion to Senior Lecturer. Arribas-Bel used his 2019 leave to win a £433k ESRC/Turing A.I. Fellowship leading to promotion to Senior Lecturer and becoming the inaugural Spatial Data Scientist of the year (2020). Leonardi used leave 2018-19 for NERC/NSF funded research to *model numerically wetlands behaviour under different wave climate and storms conditions*, which contributed towards promotion to Senior Lecturer. Cooper used leave 2016-17 to secure NERC funding for the '*Erosion Hazards in River Catchments: Making Critical Infrastructure More Climate Resilient*' project and an E.U. Horizon 2020 HYDRALAB+ Transnational access grant contributed to promotion to Reader. Lea used research leave (2018) to win a £1.05M UKRI Fellowship (2019-2026) focused on '*Ice sheet and glacier stability in a warming world*' and was promoted to Senior Lecturer.

#### 2.1.6 Research exchanges and civic engagement

Civic engagement and conducting research of relevance to society are strategic priorities for the Department (SP2). Our Research Groups support these activities using their annual budget in part to support civic engagement and knowledge exchange activities. The Environmental Change Research Group convened a Climate Impacts Workshop (2018) facilitating exchanges and showcasing our research with guests from the Environment Agency (Maas and Orr) and the UK Government's independent Committee on Climate Change (Russell). The University Press Office and the Consultancy Team maintain a registry of research expertise and encourage individuals in their interaction with business, industry, and the public/third sector. Our LGBT+ Network encouraged a strong presence at the 2020 LGBT+ STEMMinar, an annual research conference celebrating the work of STEMM researchers who identify as LGBT+ (SP4). Research grants facilitate our research interactions, such as two successive multiple-prize winning European Regional Development Fund (ERDF) projects, the Centre for Global Eco-Innovation (2012-2015) and the Low-Carbon Eco-Innovatory (2015-2023). These were the only centres of their kind in Europe and focused on collaborations between Universities in Northwest England and the region's small and medium enterprises to develop new low-carbon products and services (ICS2).

Funding support to facilitate our exchanges with business, industry, and the public/third sector from 2014 to 2020 came from University Knowledge Exchange and Impact Vouchers (KE&I), School Impact awards and external sources. KE&I vouchers enabled research focused on '*Reframing fatness*' (Evans) to produce the 'Flying While Fat' animation (with Stacy Bias and the Deaf and Disability Arts Festival 2017), which was launched at the Unity Theatre, displayed in the Bluecoat Gallery and Tate Liverpool (> 760k views Youtube/AlJazeera). Plater, with Liverpool City Council and the National Oceanography Centre, used a KE&I voucher to report on the viability of renewable energy technologies for the River Mersey. This supported the Liverpool

City Region Metro Mayor's (Steve Rotherham) vision for a zero-carbon city-region by 2040 and resulted in membership of the Liverpool Energy Strategy Advisory Group.

Our various doctoral training centres either require or encourage connections with Stakeholders, Business, and Industry. With 2014-2020, the ESRC Data Analytics and Society Centre for Doctoral Training developing 100% of PhDs with partner organisations, 50% of ESRC North West Doctoral Training Partnership PhD studentships conducted with CASE partners including local community and national organisations. The Liverpool-Manchester- NOC NERC Doctoral Training Partnership included 60% PhD's with CASE Industry Partnerships and our EPSRC Risk and Uncertainty Centre for Doctoral Training PhDs were 100% stakeholder partnerships.

#### 2.1.7 Stimulating research impact

Impact of our research is a strategic priority (SP2) and activity eligible for School Research Leave, recognised in workload models, and demonstrations of current and emerging impact are recognised in our recruitment and promotion criteria. Liverpool has an institutional EPSRC Grant used to award Impact Accelerator Accounts (EPSRC-IAA) to operationalise our research. Plater built on the EPSRC-funded ARCoES (Adaptation and Resilience of Coastal Energy Supply) project to build decision support tools of direct relevance to the nuclear energy and coastal management sectors. Research 'Future-proofing the UK's coastal energy supply from climate change' is responding to the urgent need to predict the long-term impacts of climate change on Britain's shores enhancing the resilience of power stations and coastal communities (e.g., rising sea levels, increases in extreme weather and storms over the coming decades. Impact funding has (i) determined the flood risk (e.g., storm and wave height) for Magnox nuclear energy sites (e.g., Dungeness) and (ii) evidencing the mitigation of coastal flood and erosion risk achieved by beach mega-recharge on Walney Island and the Fylde Peninsula protecting National Grid assets.

In providing bespoke research support for innovation across small/medium enterprises in the Northwest and Liverpool City Region, our ERDF-funded (P-I: Plater) Centre for Global Eco-Innovation (2012-2015) and Low-Carbon Eco-Innovatory (2015-2023) have both developed new products and services that reduce energy use, carbon emissions and waste. In funding 83 industry-based PhDs (63 across all Faculties at the University of Liverpool), the projects have engaged with over 300 businesses, achieved £3M of inward investment, created 236 jobs, generated 51 new eco-innovative products and services, and diverted 95,000 tonnes of material from landfill (ICS2). Examples from this research include, Marlan's enhanced radar-based products for monitoring coastal change in the intertidal zone and below the water line, which have numerous applications including guiding maintenance interventions such as routine pilotage and tug assistance, and bathymetric surveys and dredging operations to maintain navigable channels.

Green and Rowe have played a key role in enabling policy actions, influencing decisions, and increasing public awareness and changing minds on geographical inequalities. To date Local and Central Government departments (28 and 175 unique downloads) have used these bespoke indicators developed for Public Health England (ICS1). The work has influenced governmental decision-making and priorities, being used as key sources for reports by the Ministry of Housing, the UK2070 Commission, Department for Communities & Local Government, the UK Chief Medical Officer and United Nations (ICS1). Parallel and extensive media engagement and contributions to A-level curricula have helped to inform the public. Planning at Liverpool has a rich history of shaping planning practice. Our support in developing planning policy historically included conducting the Department of Communities and Local Government funded 'Spatial Plans in Practice' (Shaw, Lord) contributing evidence to the Planning Act (2008) and Community Infrastructure Levy regulations (2010). Since then, Lord and Dunning held consecutive ESRC awards and led multi-institution (Cambridge, LSE, Oxford, Sheffield) research on developer contributions for the Ministry for Housing Communities and Local Government (reporting 2018 and 2020). These studies led to a programme of planning reforms announced by the Prime Minister at the 2018 National Planning Conference that ultimately resulted in £1bn extra funding for community infrastructure and public goods (ICS5). Maximising our educational impact, we support to staff in translating their research into education materials (key stages 2-5 and A Level

masterclasses) in collaboration with the University's Centre for Innovation in Education. We lead in organisations promoting 'Research-led learning', with Cooper on the EGU Education Working Group and Peters was the RGS-IBG Social and Cultural Geography Research Group's Education Officer. Cooper co-authored the 2020 EGU Publication 'Challenges and opportunities for University-level Geoscience teaching' and convened the International Association of Hydraulic Engineering and Research joint academic-practitioners Higher Education conference.

## 2.2 Research students

### 2.2.1 Our ethos in postgraduate research

Our postgraduates are key to the vibrancy and vitality of the research culture, indeed much of our ground-breaking research comes from high-risk, high-reward exploration undertaken by our postgraduates. Our PhD graduates are positioned to pursue a career in academia, and many others are great successes outside academia. Our ethos has been to centre societal relevance and civic engagement as core to their research (SP2) and this is reflected in our breadth of postgraduate training beyond specialist research skills, and the strong embedding of collaboration with industry and business in our postgraduate experience. The outcome is an employable motivated cohort with connections and experience both inside and outside academia. The vitality of our postgraduate environment is a strategic priority championing the growth, career development and excellence of our postgraduates (SP4). There are 114 PhD students (49% female, 42% BAME) recruitment 2014-2020 and an average annual intake that has increased from ~11 in 2012-2014 to >20 in 2016-2019 (Fig. 5). Postgraduate students starting since 2014 include 47% from the UK, 9% EU and 44% other overseas. We achieved this by driving funded doctoral training partnerships across our four research groups drawing on multiple Research Councils and our European Regional Development Fund (ERDF) projects.

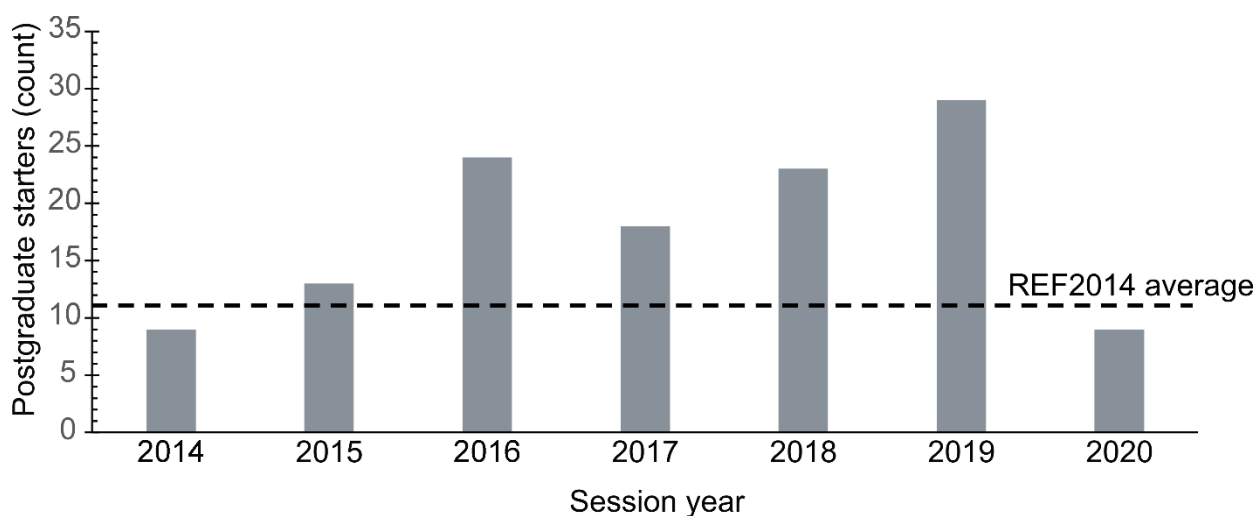


Fig. 5. Annual intake of postgraduate research students in Geography and Planning, and our REF2014 average.

These partnerships include the largest ESRC doctoral training partnership in England, the **Northwest Doctoral Training Centre** running 2011-2016 with Universities of Lancaster and Manchester. It was renewed in 2016-2022 (~£18M), adding Keele University, and awarding > 41 PhD studentships per year. Home to four pathways: Geography and Environment, Planning and Environment, Social Statistics, and Development and Humanitarianism, we have recruited 14 students (2014-2020). In addition, the 3 cycles of the ESRC **Data Analytics and Society Centre for Doctoral Training** (Liverpool, Leeds, Manchester, and Sheffield) provides ~16 studentships annually, all developed with business and industrial partners. **Geographic Data Science Lab** researchers have secured thirteen students (2014-2020). We have benefited from the NERC **Adapting to the Challenges of a Changing Environment (ACCE) DTP** (2013-2023), NERC **Liverpool-Manchester-National Oceanography Centre DTP** (2013-2018) and the EPSRC **Risk and Uncertainty CDT**, with 12 students (2014-2020) in Geography and Planning. Industry and business connections apply to 60% of our UKRI awards conducted as

CASE studentships with stakeholder partners. Doctoral Training Partnerships embedded within our successive **ERDF Ecoinnovatory** projects (P-I: Plater) built strong links with small and medium enterprises in northwest England delivering collaborations (70 PhD projects) developing new low-carbon products and services (ICS2), and with 45 PhD students (2014-2019) based at Liverpool. A further 23 PhDs come from the extension of the **Low Carbon Eco-innovatory** (2019-2023), and the newly awarded Eco-Innovation NW partnership (2020-2023) with a consortium of 9 universities across the Northwest and N Wales.

We had four PhDs funded through the Dual PhD programme between the National Tsing Hua University (NTHU: Taiwan) and University of Liverpool. Postgraduates funded directly from research grants, included six co-funded postgraduates on the EPSRC-funded ARCoES project (Plater). The NERC-funded BLUEcoast project (Plater) has three indirectly co-funded postgraduates, and the EU-funded Urban GreenUP project (Clement) has one co-funded postgraduate. The AHRC funded 'Learning from the past' project (Macdonald) had two funded postgraduates. Five Postgraduate Teaching Assistant (GTA) posts received 5 years of School funding, and these combine PhD research opportunities with teaching responsibility. Postgraduates from overseas, include PhDs funded by the Saudi Arabian Government (x7), scholarship schemes with the Commonwealth, China, Indonesia, Azerbaijan and Mexico (x6), and we co-supervise postgraduates (x8) with our Xi'an Jiaotong-Liverpool University (XJTLU) in China.

### 2.2.2 Support, supervision, and training of postgraduate students

Our training programme, monitoring framework, supervision (Fig. 6), alongside the quality of our students drives our ~95% completion rate (SP4). Postgraduates complete a 'Training and Assessment Programme' and a 'Development Needs Analysis' during induction with training offered across the University via the Liverpool Doctoral College and our Doctoral Training Partnerships, irrespective of their funding. The skills training includes communication, impact and knowledge exchange, ethics, employability and entrepreneurship, alongside more generic bespoke research skills.

In the postgraduate survey (PRES 2019: Q12\_1a) 96% respondents have gained skills in applying appropriate research methodologies, tools, and techniques from our supervision and training opportunities. A minimum of monthly formal recorded meetings ensures engagement, completion of training and progression. Our Annual Conference and progress review meetings provide formal independent monitoring of progression and a means for identifying any additional support mechanisms (Fig. 6). Peer mentoring operates for all postgraduates. Our PhD students gain experience in teaching, undergraduate supervision, and practical demonstration, but we define the maximum load, provide training and support.

Our Doctoral Centres hold parallel Annual Conferences, workshops, and residential away days. Postgraduate participation is encouraged at all School research events, e.g., grant writing and paper-writing workshops. Support for academic development of our PhD students is evidenced by our postgraduate's conference attendance (92%) and presentation (77%) (source: PRES 2019: Q16\_6 & 7). Our postgraduate students have won several prizes and awards at major international conferences, including the EGU Outstanding Student Poster/PICO Award (2018: Lyddon) and the British Society for Geomorphology Bernie Smith Poster Prize (2015: Vardhanabindu). Of the 960 Department outputs (2014-2020) 17% of the total had postgraduate students as lead or co-authors.

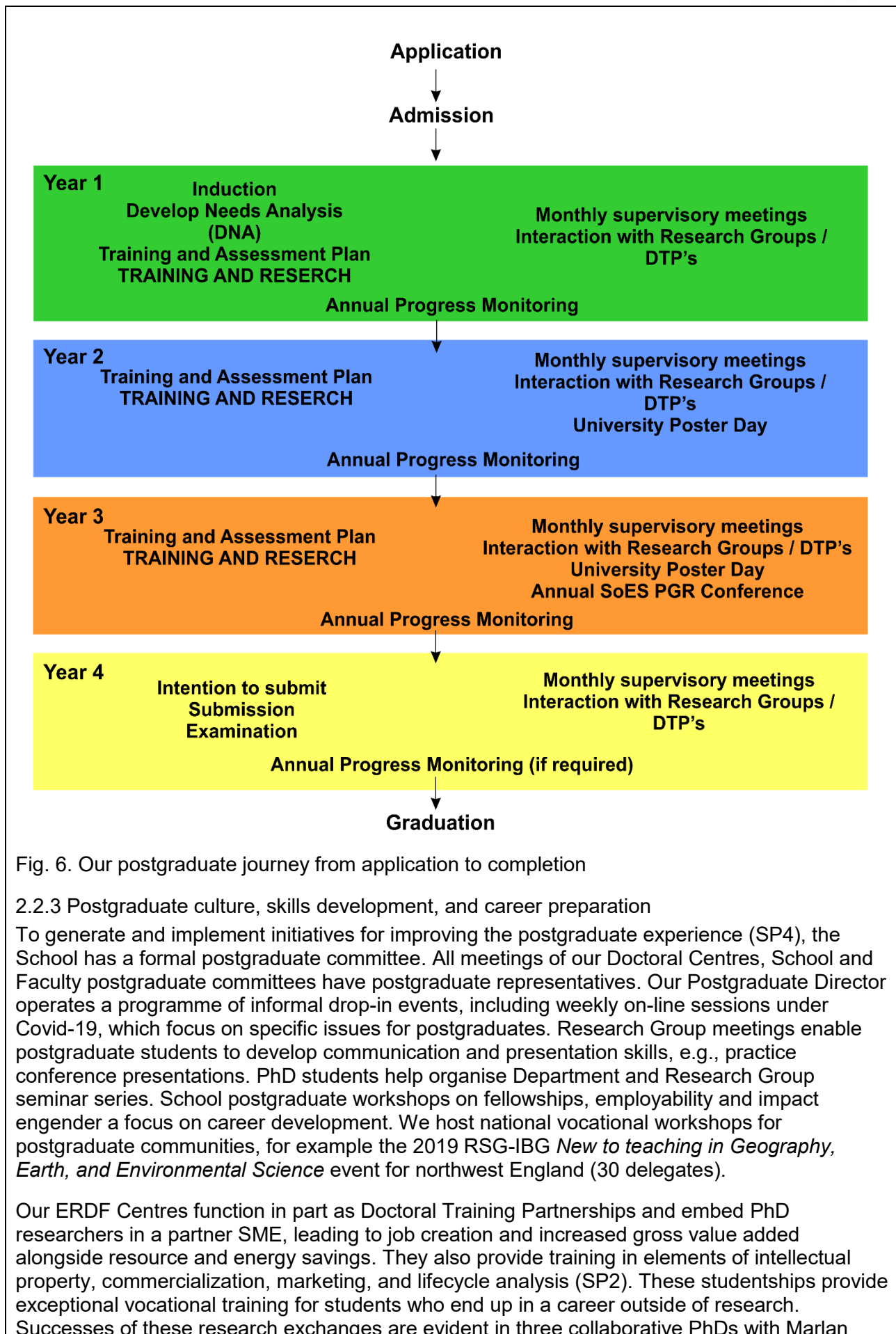


Fig. 6. Our postgraduate journey from application to completion

### 2.2.3 Postgraduate culture, skills development, and career preparation

To generate and implement initiatives for improving the postgraduate experience (SP4), the School has a formal postgraduate committee. All meetings of our Doctoral Centres, School and Faculty postgraduate committees have postgraduate representatives. Our Postgraduate Director operates a programme of informal drop-in events, including weekly on-line sessions under Covid-19, which focus on specific issues for postgraduates. Research Group meetings enable postgraduate students to develop communication and presentation skills, e.g., practice conference presentations. PhD students help organise Department and Research Group seminar series. School postgraduate workshops on fellowships, employability and impact engender a focus on career development. We host national vocational workshops for postgraduate communities, for example the 2019 RSG-IBG *New to teaching in Geography, Earth, and Environmental Science* event for northwest England (30 delegates).

Our ERDF Centres function in part as Doctoral Training Partnerships and embed PhD researchers in a partner SME, leading to job creation and increased gross value added alongside resource and energy savings. They also provide training in elements of intellectual property, commercialization, marketing, and lifecycle analysis (SP2). These studentships provide exceptional vocational training for students who end up in a career outside of research. Successes of these research exchanges are evident in three collaborative PhDs with Marlan

Maritime Technologies all focused on improving understanding and monitoring of the intertidal and shallow water marine sectors (ICS2) and leading to former PGR student Bird becoming Director of Research at Marlan Maritime Technologies (Fig. 2). Our ERDF projects also provide for short (4-6 weeks) internships with Liverpool City Region small/medium enterprises to undertake research progressing innovation from the drawing board to market.

Both our ESRC Doctoral Centres support student development with specific funds for Overseas Institutional Visits and in organising Interdisciplinary Events. There are also biannual competitive Internship schemes, which encourage personal and career development through <6-month placements with public, private, or civil society (voluntary) sector organisations. The Data Analytics and Society CDT programme requires candidate to conduct an internship and led to former PGR students gaining employment in these organisations, e.g., Data Scientist at Pets at Home (Dr Davies), and Public Health England (Dr Dearden). The EPSRC and NERC DTPs also support internships for our postgraduates, e.g., EPSRC Risk & Uncertainty postgraduate Phillips completed a 3-month NPIF EPSRC placement scheme at the Mersey Forest on rewilding initiatives and flood management.

We are proud of achievements and quality of our postgraduates, with ~25% becoming lecturers including Hall (Manchester), Schillereff (Kings London), Gustavsson (Exeter), Clear (Liverpool Hope), Vardhanabindu (Mahidol~ Thailand) and Sangster (Liverpool). Others hold prestigious research fellowships: Prime (National Oceanography Centre), Shaw (Earth Observatory of Singapore) and Ramirez-Mendoza (Ensenada Center for Scientific Research).

### 3. Income, infrastructure, and facilities

#### 3.1 Estate infrastructure

Colocation of the **Department** in 2015 was part of a journey, and a £40M build project (2020-2024) will complete our vision for an integrated **School of Environmental Sciences**. A Project Control Group (45% female) oversees this bringing of the School together in new state-of-the-art integrated research facilities. Currently progressing through Architects and RIBA Plan of Work Stage 2 with £1M committed 2020-21, this forms part of the planned transformation of the University's Precinct and the wider Knowledge Quarter of the City of Liverpool. Located in the *Science and Engineering Zone*, there are immediate adjacencies to the University's *Digital Innovation Facility* and Liverpool's *Sensor City*, whilst retaining our strong cross-campus collaborations with Health and Life Sciences, Humanities and Social Sciences, and the Heseltine Institute for Public Policy. Our research is integral to Liverpool's new Digital Innovation Facility, a centre of excellence in simulation and virtual reality, with our contributions focused on developing new consumer data products and applying Artificial Intelligence in data analysis.

Roxby Building colocation has developed an integrated research culture (SP3) installing >290 m<sup>2</sup> flexible community spaces for research teams. These five refurbished spaces provide flexible open plan working project suites available to our larger funded research projects. These spaces reconfigure easily to allow adaptation to future funding. This flexible ethos extends to hives of individual staff offices, breakout rooms and social spaces planned for the new School building. For example, one suite is home to 35 postgraduates, postdoctoral researchers and visiting fellows accommodating the continued growth of the **Geographic Data Science Lab** and ESRC-funded **Data Analytics and Society CDT** conducting ground-breaking research on the methods and applications in handling new forms of Big Data. Another hosts >24 postgraduates, research assistants, visiting fellows and project managers across our **Planning, Environmental Assessment and Management** group, hosting sustainable resource management and planning projects.

#### 3.2 Infrastructure supporting income generation

Income generation sustaining our research is encouraged through our four research groups (SP1) and our leadership of interdisciplinary research centres/institutes (SP3). There is strategic resilience in our income generation by targeting a diverse range of funders (Fig. 7). We provide a supportive, collegiate, and inclusive environment for colleagues developing research funding applications, with a mandatory internal review process for all grants > £20k. The objective has

been to support all staff (SP4) in developing research bids (CONCORDAT), growing (80% including ERDF) our research income. Our income growth and greater diversity since REF2014 reflects the early discussion of research ideas and impact opportunities at Research Group meetings, as well events organized by Research Strategy Group, e.g., School grant writing workshops. Our formal Internal Grant Review processes are accessible to all (CONCORDAT), and start >4 months before submission, with presentation of Outline Research Proposals either in research groups or at our UKRI Grant Pitching events. We review two-page grant concept notes outlining the research programme, providing feedback 3 months before submission. Our Internal Peer Review Colleges (e.g., for NERC) conducts reviews for all full bids at 1-2 months ahead of submission. The University of Liverpool was not under NERC demand management for much of REF 2014-2020, which reflects our successful internal review processes.

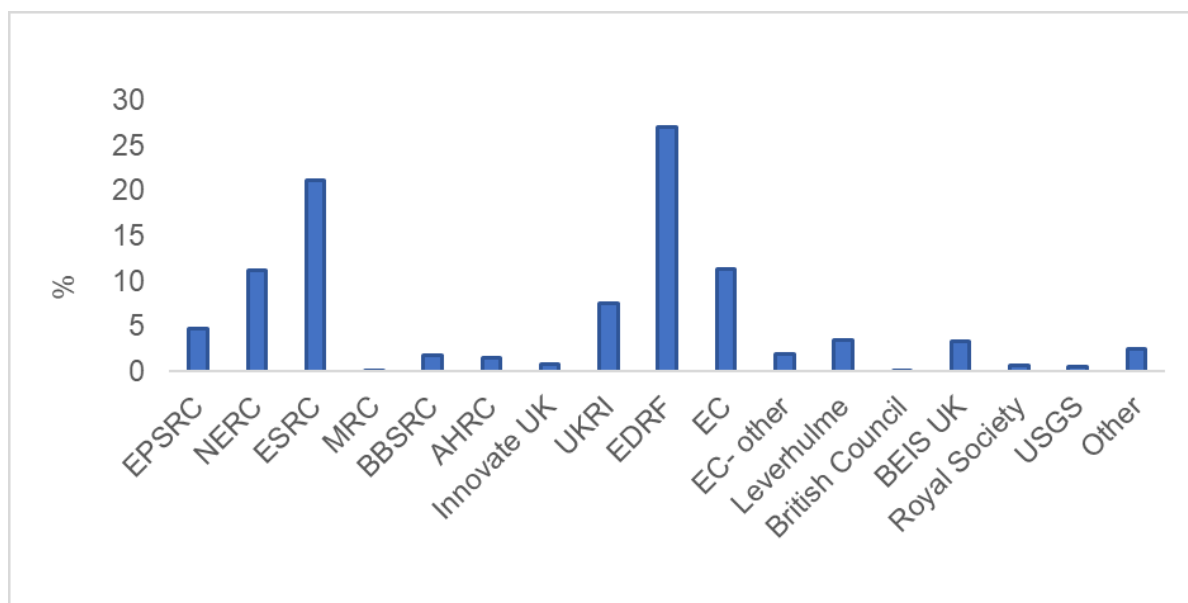


Fig. 7. Diversity in our portfolio of research income sources across 2014-2020 (including ERDF).

Our Research Offices support academics to sustain and grow research activities, by identifying diverse funding opportunities (Fig. 7), advising on research proposals, mock interview panels, co-ordinating and supporting large collaborative bids, demand management and other peer review schemes, consultancy contracts, project management, and delivering impact. We run Research Professional Development for all staff (CONCORDAT) via The Academy and our School 'Grant Writing Workshops', led by Parker-Derrington Ltd. (2015, 2019). Those workshops inspired 3x annual grant writing workshops run-locally and bespoke events for Early Career Academics (SP4). These initiatives helped individuals hone skills in writing research applications, with immediate cross-disciplinary successes e.g., [Riley](#), [Boyle](#) and [Chiverrell](#) using the 2015 workshop to write a Leverhulme Trust funded interdisciplinary project assessing and modelling the past and future soil erosion impacts of agricultural change in Britain.

### 3.3 Operational and scholarly infrastructure

Delivering SP5 we have built, developed, and host physical and digital data archives and on-line data portals. These are examples of how our research has contributed significant archives and collections and include climate and health research ([Morse](#)) from the EU FP7 funded Liverpool Malaria Model and other infectious disease models (e.g., Malaria, Rift Valley Fever). The models, software, and reports are a significant freely available web resource. The **Data Analytics and Society CDT** and the **Consumer Data Research Centre** (P-I: [Singleton](#)) have space newly-built to enable the compilation, processing, and governance of the vast amount of UK consumer data generated each day. These large digital databases provide valuable insight helping organisations and researchers, with the data are available through parallel Online Interactive Map and Data Access Portals. The NERC funded MAST-NET project ([Hackett-Pain](#)) has built a database (MASTREE+) to facilitate investigation of the causes of synchronised and variable seed production in plants. Our Library Research Data Manager has helped produce

data sharing agreements and protocols for the management of intellectual property for MASTREE+.

Our Department installed a new (£25k) 32 m<sup>2</sup> bespoke video-conferencing facility (10-12 people) available to all academics and postgraduates. State-of-the-art presentation software, high-quality multimedia projection and audio systems feature in all our seminar and lecture theatres, including the capability to record all presentations (audio and visual). Development and application of the Liverpool Malaria Model and other climate infectious disease (e.g., blue tongue) models (Morse) on EU-FP7, BBSRC projects and the UKRI 'One Health Research Network for the Horn of Africa' projects drew on High Performance and High Throughput Computing facilities provided centrally.

The School Map Library (>500 atlases, 100,000 maps) provided for Davies' research on the 1919 Race Riots in Liverpool. This participatory research produced maps of the city's black population at the time, a short film which is now used in public education, public engagement-led impact with walking tours since 2017 (over 500 attendees), and a 2019 exhibition in the Liverpool Central Library. This exhibition included the first ever maps of Liverpool's West African and Caribbean residencies detailing government responses to the 1919 riots (from The National Archives). Liverpool's Victoria Gallery & Museum presents both the 127-year history of the University of Liverpool and our research e.g., the '*Can't See the Wood for The Trees*' exhibition (Hackett-Pain). Research on the long-term and future evolution of the Merseyside coast (Plater) featured at the '*2019 Centenary of the Liverpool Tidal Institute*' at the Mersey Maritime Museum.

### 3.4 Impact infrastructure and support

Conducting research that is relevant to society is a strategic priority (SP2) and our Impact Leads play an important role in supporting and developing both our impact and a wealth of community and professional outreach activities. Annual Impact Showcases share our impact experiences with colleagues across the Department encouraging others in developing the future impact portfolio. Our Directory of Civic Engagement evidences the actions and events where we connect to and support, Liverpool City Region for example, in addressing problems, e.g., the regional COVID-19 response (SP2). University Media Officers help colleagues widening dissemination and impact of our research and provide Media professional development, for example the '*Reacting to the News: Using your knowledge to gain media coverage*' workshop. The Press Office installed an audio-visual facility with high-resolution cameras and audio capture for media outlets to use for televised remote interviews, for example facilitating interviews of Green on BBC News (audience 550,000). The team advise over interactions with the media and help us publicise work through targeted press releases and encouraging their take-up and progression (see section 4.4). The University's Consultancy Team provides a dedicated consultancy service, enabling academic staff to share their skills and apply their research expertise to help a wide range of organisations, adding breadth to our impact portfolio. For example, assisting the Marine Spatial Planning team (Jay) in positioning to provide consultancy services for the EU (£590k) addressing new directives requiring coastal Member States by 2021 to prepare cross-sectoral maritime spatial plans for their waters and better manage the various activities that take place at sea (ICS3). **Planning, Environmental Assessment and Management** colleagues (Lord, Dunning) were assisted in developing a new research project that used their expertise in data analysis and knowledge of housing and communities with Cobalt Housing, a Liverpool housing association. This research informed Cobalt Housing's vision for how existing and new housing stock supports the wider social and economic development in three deprived wards in north Liverpool, with the build of ~1000 homes in the coming decade with transformative impacts for these neighbourhoods (ICS5).

### 3.5 Laboratory and Facility provision

Providing facilities conducive to world-leading research is a strategic priority (SP1), and our laboratory facilities benefitted from £1.38M investment (2014-2020) and include the **Hydraulics Laboratory** (in the School of Engineering); facilities in the Roxby Building and the Higher Education Academy's 2016 Collaborative Award for Teaching Excellence (CATE) winning **Central Teaching Laboratory**. The **School**, with the School of Physical Sciences, led the



**Central Teaching Laboratory** development (£26M), which embedded 'research-led' science as fundamental to our learning program. The **Department** championed and runs **Environmental Change** facilities in the **Central Teaching Laboratory**, including a new *Geotek Multi-Sensor Core Logger* (£140k) and *Bruker Near-infrared Spectrometer* (£60k).

Our **Qualitative Research Hub** supports the priorities of **Power, Space & Cultural Change** researchers. Qualitative research increasingly requires a range of equipment and technologies to enable our work and for methodological innovation. The hub is home to new (£15k) state-of-the-art DSLR cameras and tripods, underwater and rugged terrain cameras; Go Pros and mounts; Dictaphones, transcription kits and noise-cancelling headsets, all to support our qualitative research. In the **Geographic Data Science Lab**, the ISO27001 accredited Secure Data lab (£520k) provides central provision to sensitive consumer data held by the ESRC **Consumer Data Research Centre** and integral to provision of Office for National Statistics Secure Research Service access. **Geographic Data Science Lab** provides a range of advanced computational facilities including a cluster of Dell Precision workstations (£140k) and investment included analytics platforms including Tensor Flow, H2O and RAPIDS. The laboratory runs centrally a Hadoop cluster consisting of nine Dell R730XD, R630 Servers and disk storage of over 100 terabytes (£125k). The laboratory has pioneered new methods that have defined nationally extensive and small area measures of retail area extent, the "health" context of place ([ICS1](#)), and Internet use and engagement.

The **Environmental Change** laboratories, supported by three technical staff, have also benefited from a total of ~£380k of core (2014-2020) investment. We have a new *Thermo Evolution* photospectrometer and a *Spectro XEPOS* Energy Dispersive X-ray Fluorescence Analyser (XRF) (£65k) extending our element analytical range. New particle size and shape analytical equipment include a *Beckman-Coulter Ls330* Laser granulometer (£35k) and a *Malvern Morphologi G3* automated particle size/shape analyser (£80k). These new Roxby facilities, when combined with new **Central Teaching Laboratory** research equipment facilitate our pioneering of new numerical and analytical approaches. These have included refining the application of *Geotek  $\mu$ XRF core scanning* ([Chiverrell](#)), novel methods for quantifying sediment components *Diffuse Reflectance Near-infrared Spectrometry* ([Boyle](#), [Chiverrell](#)), and identifying signatures of flood magnitude in lake sediments using particle size data ([Chiverrell](#)).

**Liverpool Luminescence Laboratory** was purpose built in 2005, with new leadership ([Smedley](#)) and investment 2018-2020 including an upgraded *Risø TL/OSL DA-20* automated single-grain system (£40k), installing new diamond-tipped drill and low-speed saws for analysing rock slices for burial and exposure dating thereby developing novel approaches for reconstructing rock weathering rates (£15k, Royal Society). A new *UVACube solar simulator* allows experimental research replicating sunlight bleaching of luminescence signals. An excellent research facility, the **Liverpool Luminescence Laboratory** is developing and refining cutting-edge OSL methodologies.

**Environmental Change** researchers are key stakeholders in the refurbished Faculty shared facility, the **Hydraulics Laboratory**, for fundamental research on how water and sediment move. Department investment has refurbished the *Coastal Flow Channel* to study near-shore sediment transport processes and the *Waves & Currents Channel* to study fluvial and estuarine processes ([Cooper](#), [Leonardi](#), [Plater](#)). New capabilities include a *Turbidity Channel*, and a *Shallow Flow Channel* and *Rainfall Simulator* for runoff and erosion experiments. New state-of-the-art equipment include a *LaVision Tomographic Particle Image Velocimetry (PIV) system*, *IO Industries Large-Scale PIV system* and *iDS 3D camera* for capturing turbulent flows, sediment movement and pollutant transport ([Cooper](#), [Higham](#)). Joint investment with Engineering has provided a new acoustic equipment including *Ultrasonic Velocity Profiler*, *Acoustic Doppler Velocimeter* and *Current Profiler*, an *AQUAscot*, and a *2G Robotics underwater bedscanner*.

**Section 4: Collaboration and contribution to the research base, economy, and society**

4.1 Research collaborations, networks, and partnerships

Strong collaborations underpin our research (SP1), and the global distribution of co-authors evidences the effectiveness of our international networks (Fig. 8). Of the UoA14 960 outputs authored 2014-2020 (Scopus), 498 (52%) involve international co-authors and the 2278 co-authors comprise 62% international collaborators distributed across six continents. Research grants drive some of these collaborative networks, e.g., in the Netherlands (Singleton), and

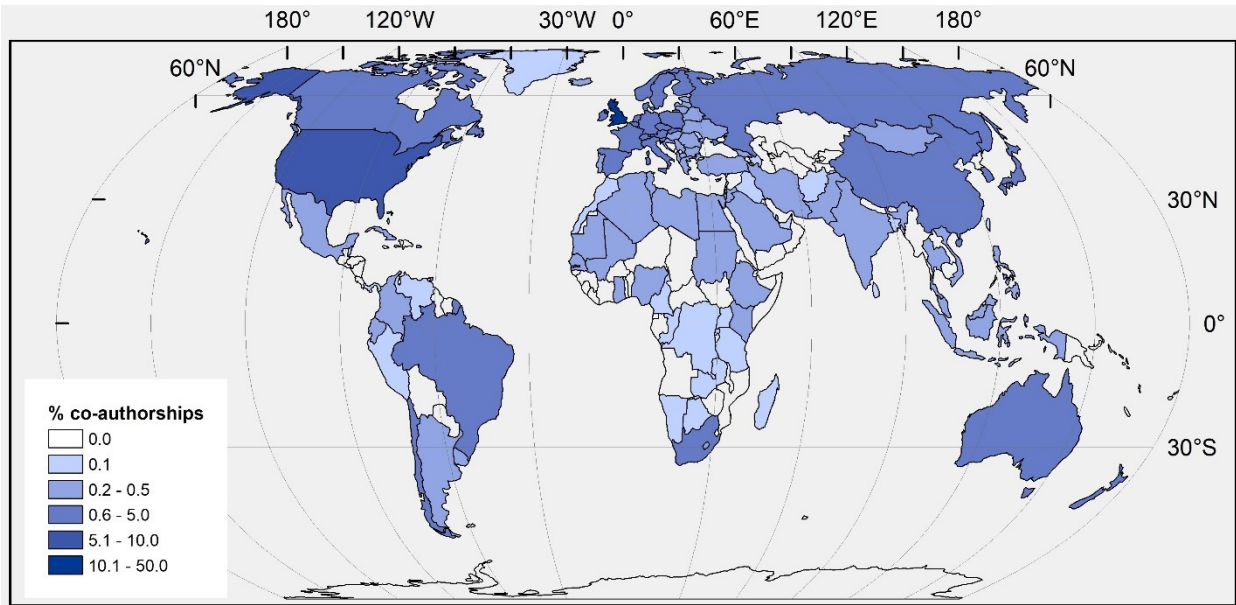


Fig. 8. Distribution of research collaboration measured as % of all output co-authorships across countries in 2014-2020 (Scopus).

Spain (Arribas-Bel); and in the USA (Singleton) with Carto and ESRI (Fig. 8). Leonardi's cooperative agreements with the US Geological Survey, Woods Hole Science Centre, and Boston University address NERC-NSF funded research on *Hurricane Sandy impacts on the Salt Marshes of New Jersey* (Fig. 8). Arribas-Bel is honorary fellow at Spatial Data Science Centers (Chicago and California Riverside). With the United Nations and University of Queensland, Rowe collaborates on international projects on the impacts of internal migration differing across countries. Smedley, Montoya, Hooke, and Macdonald have burgeoning research connections across South America exploring forest ecosystem changes, fluvial dynamics, and the decline of the Patagonian ice-cap. In the UK, the NERC Consortium Britice-Chrono established strong links with >11 Universities and UKRI centres (Scottish Universities Environmental Research Centre, British Geological Survey and British Antarctic Survey) producing extensive UK co-author networks (Chiverrell, Smedley) (Fig. 9).

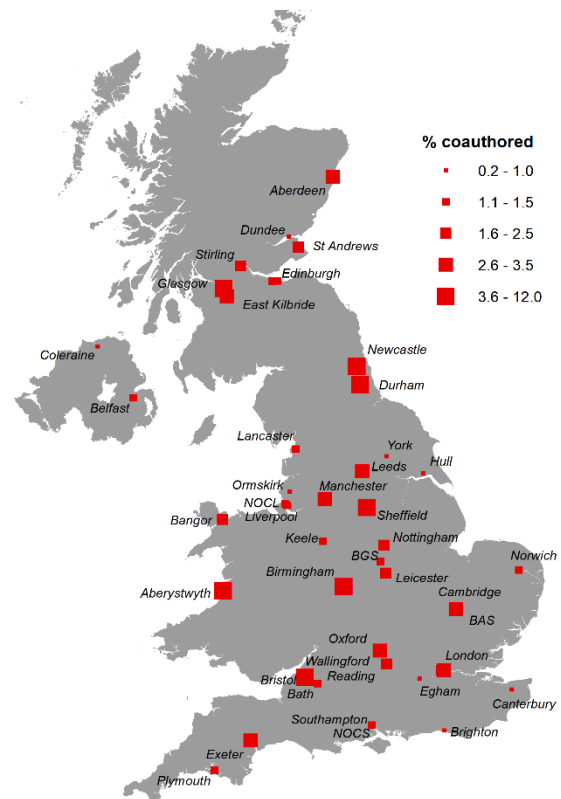


Fig. 9. UK research collaboration measured as % of all co-authored outputs in the period 2014-2020 (Scopus).

Our doctoral centres (Section 2.2) built numerous collaborative links. Our European Regional Development Fund (ERDF) funded projects connect Inventya LTD, Liverpool, Liverpool John Moores and Lancaster Universities ([ICS2](#)). The ESRC North West Doctoral Training Partnership links Liverpool, Lancaster, Keele and Manchester, the ESRC Data Analytics and Society Centre for Doctoral Training (Liverpool, Leeds, Manchester, and Sheffield), the 2013-2023 NERC Adapting to the Challenges of a Changing Environment (ACCE) DTP (Liverpool, Sheffield, and York), and the 2013-2018 NERC DTP Understanding the Earth, Atmosphere and Ocean (Liverpool, Manchester, and National Oceanography Centre Liverpool). Each of these doctoral training partnerships has contributed strong collaboration reflected in our UK co-author networks (Fig. 9).

Collaborations with China benefit from our sister university Xi'an Jiaotong Liverpool University (XJTLU) (Suzhou), the largest joint venture university in China. Our research links include 25 PhD students currently co-supervised and strengthening under with the advocacy of Liverpool Dean of XJTLU ([Blackford](#)). Our connections in China span the Chinese Academy of Sciences, Beijing Normal University, Nanjing University and East China Normal University, and are multifaceted (Fig. 8). They include National Natural Science Foundation of China funded collaborations, with [Dong](#) exploring the links between neighbourhood environments individuals and communities leading satisfying lives. [Cooper](#) works with Ministry of Education Key Laboratory for Coast and Island Development, Nanjing University and State Key Laboratory of Estuarine and Coastal Research supported by National Natural Science Foundation of China funding, examining why there has been a rapid disappearance of intertidal mudflats in this region. [Lord](#) is leading a £0.9M multi-institution, trans-national project funded by the ESRC and National Science Foundation of China (NSFC) that focuses on Land Value Capture ([ICS5](#)).

Our international visitors foster collaboration, presenting seminars at Liverpool and building co-author networks in Japan, China, USA, Chile, Scandinavia, and southern Europe (Fig. 8). Examples include [Burrell](#) hosting Research Council (Norway) funded visitors Bevelander and Odden from Malmo and VID Specialized Universities. [Cooper](#) hosted numerous MEXT-funded (Japan) visits from Prof Onda and a further 12 visitors (Tsukuba University, Japan) for Nuclear Human Resource Development research on the Fukushima Daiichi nuclear disaster. [Cooper](#) hosted Benwei Shi (Nanjing, China) under NSFC funding and Luca Mao (Pontificia Universidad Chile) under CONICYT-Fondecyt funding. [Leonardi](#) hosted Xiaomei Nian (State Key Laboratory for Estuary and Coastal Research, Shanghai) under China Scholarship Council funding. Spielman (Boulder, Colorado) visited [Singleton](#) working on an *International Journal of Geographic Information Science* output establishing the *Open Geographic Information Science* framework. University Exchange Scheme fellowships, led to [Riley](#) hosting Dr Williams, [Burrell](#) hosting Dr McCombs and [Turner](#) hosting Dr Purdum (all Georgia, USA) on Franklin College-University of Liverpool Fellowships. Vacchiano (Milan University) visited [Hackett-Pain](#) funded by an EU COST Action FP1304 "Towards robust projections of European forests under climate change (PROFOUND)" which led to the development of the NERC MAST-NET Project.

Funded research networks also foster our collaborations, e.g., NERC Global Partnerships Seedcorn funded the Liverpool-based MAST-NET Project ([Hackett-Pain](#)), a collaboration and network building initiative bringing together researchers from Japan, USA, Switzerland, Italy, and Poland. [Peters](#) hosted 17 interdisciplinary scholars of seabed science from eight different EU countries (2017) as part of a Training School on seabed management funded through the EU COST Action Network (Co-I: [Peters](#)). This network, Ocean Governance for Sustainability: Challenges, Options and the Role of Science (2016-2020), produced a paper in *Marine Policy* and an edited book '*Ocean Governance: Pasts, Presents, Futures*'.

#### 4.2 Interaction and engagement with key research users

Civic engagement is core to our research portfolio (SP2). Our regional Royal Geographical Society sponsored *Roxby Lecture Series* were initiated during our Geography Centenary celebrations and continue as a monthly, public-facing series attended by the public, schools, and academics (SP2). The Department and our Research Groups convene regular formal and informal under COVID-19 increasingly on-line seminar series. Liverpool's hosting of major conferences included the 'International workshop on Non-Pollen palynomorphs' ([Marret-Davies](#):

2017), 'Satellite imagery to monitor urban change' workshop (Arribas-Bel, Rowe: 2018), the 'UK Luminescence and Electron Spin Resonance Meeting' (2016), 'International Conference for Carceral Geography' (Turner: 2018) and 'UK Planning Research Conference' (Sturzaker: 2019). We provide research services to user communities (SP2), e.g., as expert reviewers for the Intergovernmental Panel on Climate Change (IPCC) on Oceanic - Cryospheric Change (Lea) and IPCC 6<sup>th</sup> Assessment Reports (Lea, Dean). Lea gave evidence and contributed to the final report addressing future iceberg risks to the House of Commons Environmental Audit Committee Inquiry on 'The Changing Arctic'. Geographical Data Science Lab are an external member of an UK All-Party Parliamentary Group for 'Left Behind' Neighbourhoods committed to improving social and economic outcomes for residents in deprived communities. Robinson sits on the national Geographical Information Research UK (GISRUK) Steering Committee. We host a World Health Organization Collaborating Centre on 'Health in Impact Assessments' (Fischer, Jha Thakur). Rowe contributed to an UN expert group (2017) on sustainable cities, human mobility and international migration, an Office for National Statistics Government Statistical Service Advisory Committee on using administrative data (2018) and testified to the UK2070 Commission (ICS1). Moore gave evidence to the Select Committee on Intergenerational Fairness and Provision on the role of communities in reducing inequality between generations and delivering an evidence workshop with housing sector stakeholders. Morse and Hooke are members of the N8 AgriFood Network. Morse sits on the United Nations Future Earth: Health Knowledge Action Network focused creating a sustainable world under the pressures of future change. Hooke sits on the UK Environment Agency/DEFRA Flood and Coastal Erosion Risk Management Research and Development Advisory Group, and Natural England's Science Advisory Committee. Jay founded the Marine Spatial Planning Research Network running Maritime Spatial Planning workshops for the European Commission's Member State Expert Group in Las Palmas (Gran Canaria) and the European Commission's Member State Expert Group (Brussels) (ICS3).

#### 4.3 Contributions to the economy and society

The problem-solving ethos to our research and co-production of knowledge with stakeholders (SP2) ensures our research contributes to sustainable economies and communities building resilience to environmental and financial shocks. For example, Lord (ICS5) has assessed the economic potential for the Albert Dock area for Liverpool City Region Local Enterprise Partnership, and Clement showcased the importance of green infrastructure in the development of sustainable cities (Liverpool and the Mersey Forest). Darlington-Pollock is the Chair of The Equality Trust driving economic and social inequality agenda in the UK. Singleton is on the Scientific Committee of Carto, the world's leading Location Intelligence platform enabling organizations to use spatial data and analysis better. Darlington-Pollock, Green, Nurse and Hackett-Pain engaged in the "Ideas for Liverpool" initiative, led by Arup PLC with Liverpool City Council to develop an "agenda" for the future development and enhancement of Liverpool. Lord is an invited member of the Liverpool City Region Land Commission. In developing a low-carbon economy in Northwest England (ICS2), Plater sits on the Liverpool City Region Energy Strategy Committee, reporting on potential renewable energy generation and storage, and is Faculty liaison with the Mersey Tidal Power Project. Plater also recently contributed to the Combined Authority submission for Liverpool's Freeport status.

Shaw led the revision of environment and habitat policy, working with practitioners and government agencies in Saudi Arabia and Egypt encouraging biodiversity and green growth principles in development decision-making. Nurse (ICS4) is an International Advisor to Seoul Metropolitan Government and the Changdong-Sanggye Industrial Cluster communicating urban regeneration lessons from the Liverpool-One retail-led experience to Seoul. Rowe works closely with the Latin American Demographic Centre and the UN Economic Commission for Latin America and the Caribbean (2015-), advised Victoria State Government (Australia) (2013-16), the National Council of Urban Development (Chile) (2016-17) and is part of the international IMAGE project (2011-) (ICS1). Jay was Chair of the Connecting Seas Conference (Hamburg) bringing together marine spatial planning experts from the North and Baltic Sea regions (2019) (ICS3) and sits on the Welsh Government Marine Planning Stakeholder Group.

4.4 Engagement with communities and the public

In our civic engagement activities (SP2), the University and the Liverpool City Region’s *One Public Estate* Programme established a new partnership on the housing supply chain (ICS5). **Planning, Environmental Assessment and Management** colleagues (Dunning, Lord and Moore) are working with local authorities, housing associations and the private sector to explore barriers to offsite construction and ways to overcome those barriers. Devolution of Planning powers to communities (2011) enabled so-called Neighbourhood Plans for local areas and is the focus of our research and impact. By bringing communities together with experts from the University (Sturzaker, Sykes), Liverpool City Region officers and members and third sector stakeholders we inform communities in their take up of the opportunities available to them (ICS4). Research (Green) on the spatial patterns and controls of health issues related to cancer, obesity in children and adults, and child mortality (Lancet, 2014, 2015) tackled a range of global and regional scales. Policy influence of the work (ICS1) includes informing recommendations in Public Health England’s Strategic Plan (4/2016) and feature in the National Health Service (UK) long-term plan (1/2019), attracting widespread media interest.

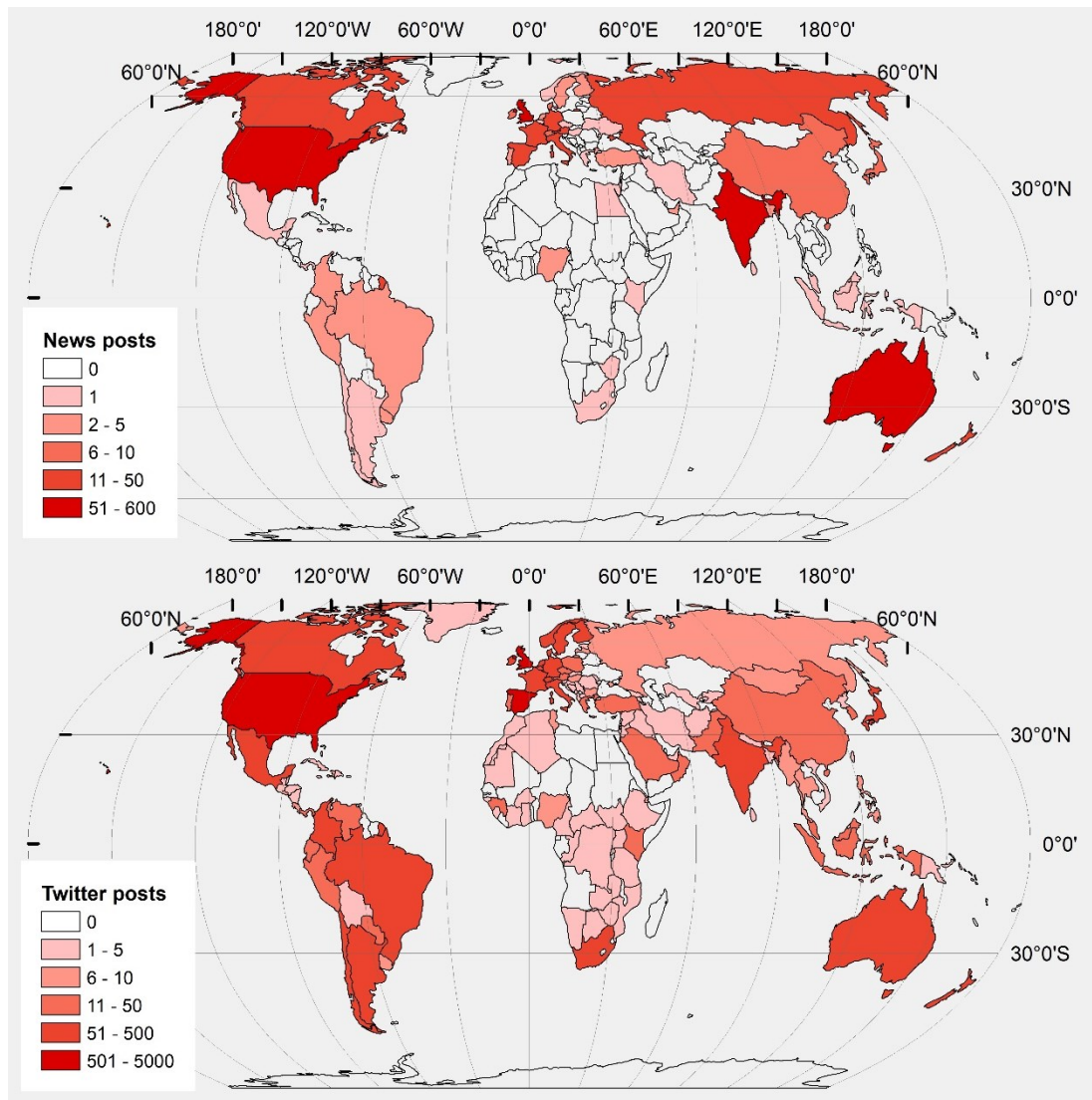


Fig. 10. Research impact from outputs 2014-2020. A. Media posts and B: Twitter activity arising from UoA14 outputs (Altmetrics).

Our COVID-19 civic response coordinated by the Heseltine Institute (M-Boyle) produced policy briefs with Liverpool City Region Combined Authority on active travel options in the region (Nurse, Dunning), Universal Basic Income (Thompson), and ‘building back better’ (North). We

provided ESRC-funded novel geospatial analyses (Green) using ONS data to aid the locating of testing sites for Liverpool City Council within Liverpool's whole city testing COVID-19 pilot.

Global interest (Fig. 10) in our outputs in mainstream news and social media evidences the global public, policy influence, and media interest in our research. The Flying While Fat project (Evans) produced YouTube animations shown in Tate Liverpool and Bluecoat Gallery Liverpool stimulating public debate and international media coverage. Our flood research featured in UK Government reports highlighting the importance of historical and sedimentary data in flood frequency estimation. Highlighting how changing climate has shifted the timing of European floods (Macdonald) and the extreme nature of recent UK floods (Chiverrell), both attracting media attention (e.g., Der Tagesspiegel, the Guardian, BBC and ITV news). Research (Morse) on the climate sensitivity of important human and domestic animal pathogens, including malaria, Zika virus, blue tongue fever, has been used by the UN Food and Agriculture Organisation, an EU Commission on Agriculture Scientific Reports, and in World Bank and World Health Organisations policy papers on Malaria, Climate Change and Poverty.

#### 4.5 Contribution to the sustainability of the discipline

We are committed to the development, reputation and wellbeing of the Geography and Planning disciplines (SP1). 100% of Geography colleagues are either fellows the Royal Geographical Society (RGS-IBG) or members of RGS-IBG Specialist Groups. Peters received the 2020 RGS-IBG Gill Memorial Award for Outstanding Early Career Research in Human Geography. In RGS-IBG Specialist Groups we are officers for the British Society for Geomorphology (Grants: Smedley), GIScience Research Group (ex-chair: Singleton), Geographies of Justice Research Group (Chair: Davies), Participatory Geographies Research Group (Gahman), Social and Cultural Geography Research Group (Education: Peters), Carceral Geography Working Group (Secretary: Turner), Population Geography Research Group (Communications: Darlington-Pollock), and the Quantitative Methods Research Group (Chair: Arribas-Bel, EDI: Robinson). Arribas-Bel was the recipient of the inaugural 2020 CARTO 'Spatial Data Scientist of the Year' award. 70% of Planning colleagues are members of professional bodies or learned societies including the Royal Town Planning Institute, Architects Registration Board, and Institute of Environmental Management and Assessment. We fulfil officer roles with the International Association for Impact Assessment (Chair: Fischer), Planning Schools Forum (Chair: Sturzaker), Town and Country Planning (Policy: Sturzaker), Housing Studies Association (Vice-chair/Treasurer: Dunning), and International Geographical Union's Transport and Geography Commission (Vice-chair: Chen). We are officers with other learned societies: Society for Landscape Studies (Riley), British Society for Population Studies (Darlington-Pollock), International Union for the Scientific Study of Population (Rowe), International Association of Hydro-Environment Engineering & Research (Cooper), Quaternary Research Association Executive, the Association de Palynologie de Langue Francaise and the Micropalaeontological Society (Marret-Davies), and the British Hydrological Society (Macdonald).

#### 4.6 Wider influence and contribution to the research base

Our editors of leading journals span the discipline and include *Global and Planetary Change* (Marret-Davies), *Impact Assessment and Project Appraisal* (Fischer), *Geomorphology* (2005-2018: Plater), *REGION* (Rowe), *Environment and Planning B - Urban Analytics & City Science* (Arribas-Bel), *Journal of the Royal Statistical Society - Series A* (Arribas-Bel), and *ACME: An International Journal for Critical Geographies* (Gahman). Staff have served on >30 editorial boards for leading academic journals, e.g., *Journal of Ecology*, *Mobilities*, and *Annals of the Association of American Geographers*. Morse is a panel reviewer for UKRI-FLF scheme. Chiverrell, Smedley, Hooke, Mair are all NERC Peer Review College Members, Williamson is an ESRC Senior College Member, and Evans, Lord, and North serve as ESRC Peer Review College Members. Morse, Evans and Green are peer reviewers or committee members for the Wellcome Trust. Morse was vice-chair on French National Research Agency panels. Marret-Davies sits on the Scholarships & Fellowships Selection Committee for Earth Sciences (Canada) and National Science Center (Poland). These examples evidence, our strategic commitment to

Geography and Planning (SP1) through our numerous roles with UK, European and other funding agencies, and with academic journals that cover the breadth of the discipline.