Institution: The University of Edinburgh & Heriot-Watt University (Edinburgh Strategic Alliance)
Unit of Assessment: C13 Architecture, Built Environment and Planning

1. Unit context and structure, research and impact strategy

The Edinburgh Strategic Alliance (ESA) in architecture, built environment, and planning is a vibrant research hub that brings together the research strengths of two universities to improve the quality of the built environment, with an emphasis on cities. A 10-year collaboration between the University of Edinburgh (UoE) and Heriot-Watt University (HWU), our alliance maximizes research synergies and impacts across four key themes: (1) healthy and inclusive cities, (2) sustainable cities, (3) urban history and heritage, and (4) urban design and creative practice. Our collaboration builds on a shared commitment to enhancing local and place-based communities through policy change, social transformation, critical planning, innovative architectures, healthy landscapes and pioneering design. Our research benefits colleagues across the UK and abroad, with particular focus on communities in Colombia, Brazil, Mexico, India and other countries across Europe, North America, Australasia and Africa.

We bring the benefits of scale and complementary expertise to deliver quality research, external engagement and impact, enriching the research environment beyond what each university could achieve independently. Our expertise base of 73 FTE researchers indicates growth since REF2014 of 13%. We have created or renewed 20 academic appointments and invested over £4.8M in our physical infrastructure that benefits research. This investment has helped us increase our PhD completions by 128%, garner external research awards for a range of projects with a full economic cost of over £19M, increase expenditure from external grants by 59%, facilitate over 50 community engagement events, and deliver over 23 international exhibitions (twice the number reported in 2014).

Through ESA, each university contributes expertise and resources to deliver shared PhD supervision, kick start funding for shared research, the opportunity to apply jointly for externally funded projects, a combined research space in Edinburgh city centre, an annual publication showcasing our research, and a joint website (www.ekep.eca.ed.ac.uk). ESA's aims are shared across its organisational components, the UoE School of Architecture and Landscape Architecture (ESALA) within Edinburgh College of Art (ECA), and 3 HWU institutes in the School of Energy, Geoscience, Infrastructure and Society (EGIS): Institute of Sustainable Building Design (ISBD), Institute for Social Policy, Housing and Equalities Research (I-SPHERE), and The Urban Institute (TUI). We participate in the Edinburgh Futures Institute (EFI), a £140M centre supported by the Edinburgh and South East City Region Deal, a government-led, high-profile investment venture between UK and Scottish government, industry and universities with a focus on data-driven innovation.

Strategic aims

We have built on the five-year strategic aims we outlined at REF 2014 to grow research capacity and expand our contribution to the national research base in the following areas.

- Health, demographic change and wellbeing, as influenced by the built environment. We developed research projects as outlined under theme 1 (Healthy and inclusive cities) and have made two new key appointments to increase capacity in the area.

- Climate action, environment, resource efficiency and sustainability, including better performing materials and buildings. Projects under theme 2 (Sustainable cities) expanded our research scope into environment hazard management and we expanded international activity on climate action supported by GCRF (Global Challenge Research Fund) funding.
- Inclusive societies, inclusive access to housing, services, built environment and public space. We created I-SPHERE, a research Institute dedicated to research on social inclusion, which was honoured with the Queen's Anniversary Prize for outstanding research.
- Innovative societies, taking advantage of new materials, media and digital technologies. This objective informed each of our themes (1-4) in particular as we deployed technologies of co-design, experimentation and dissemination, incorporating social media tools into our action-research, as well as specialised platforms to search, analyse, archive, curate, and model data.
- Responsible societies, with a heightened awareness of our existing building stock and cultural heritage. We developed a suite of projects outlined under theme 3 (Urban history and heritage), and we grew the core staff contingent in architectural history by 2 and introduced the new PhD in Architectural History.

Outline of research themes

Our strategic aims are delivered through research and impact across our four key research themes to provide platforms for catalysing collaborative research, integrate research students, and enhance applications for funding.

1. Healthy and Inclusive Cities

Our research connects human wellbeing with the quality of built and natural environments, furthering the key UN SDG goals 3 and 15. A team of 19 academic staff and 116 PhDs (FTE) have worked to make cities more inclusive, safe and healthy.

Deploying expertise from across our alliance, cross-council research on mobility, mood and place (MMP) has used cutting-edge methods such as mobile EEG (electroencephalography) measures with projects that show how neighbourhoods and landscapes can be made more memory-friendly and support healthy ageing across the life-course (figure. 1) (EPSRC/ESRC/AHRC, £1.50M, **Ward Thompson**). Our public health and green space research is the first to use controlled, longitudinal experimental design to investigate how urban forestry programmes and similar interventions contribute to mental wellbeing and quality of life in deprived urban communities (NIHR/ESRC, £1.37M **Ward Thompson**) and across major cities (National Lottery Heritage Fund, National Trust, £50K **Ward Thompson, Bell**). Our impact case study ICS1 demonstrates how this research into outdoor spaces and green or natural environments impact public health and wellbeing. Our DeStress project on designing and engineering soundscapes to enable restorative environments for sustainable societies demonstrated the benefits of a multisensory approach to cities and health (EPSRC, £100K, **Payne**). Our collaborative projects on place-making with older adults in 9 cities across UK, Brazil and India used innovative methods ranging from participant-led walks and video-photo diaries to knowledge cafés to establish the first transnational evidence base to demonstrate the importance of a sense of place for older adults (ESRC and Newton ESRC/ICSSR, £1.16M, **Woolrych**).

Figure 1. EEG assessing emotional responses in urban green spaces; urban co-design strategies (MMP project).

Our projects on **inequalities** focus on people experiencing poverty, destitution, and homelessness (UN SDG 10). Staff in I-SPHERE managed over £3.0M of high impact research for which they were awarded the prestigious Queen's Anniversary Prize (2018-2020). We established that childhood poverty drives homelessness in young adulthood**,** and demonstrated significant overlap between offender, substance misusing and homeless populations, and their disproportionate cost to public finances (Joseph Rowntree Foundation, £318K **Bramley**)**.** We established that a 'Housing First' approach that sees homeless people speedily rehoused with support is much more effective than moving them through transitional forms of accommodation **(Johnsen)**. Internationally, we evaluated a global initiative to end street homelessness in 12 vanguard cities located across six continents (Oak Foundation, £300K, **Fitzpatrick**).

We developed new statistical measures of "core" homelessness and demonstrated the need to build up to 100,000 social housing units per year in the UK (**Bramley**). We led the state-of-the-nation UK Homelessness Monitor series (Crisis, £669K, **Fitzpatrick**), and evaluated major Housing First initiatives in England and Scotland (**Johnsen**), leading to a paradigm shift in policies for homeless people. We evaluated the impact of housing and welfare policy, e.g. Welfare Conditionality (ESRC, £630K out of £2M total, **Fitzpatrick**), which was pivotal in protecting the security of tenancy for social tenants in England. We also led flagship longitudinal studies into Destitution in the UK (Joseph Rowntree Foundation, £730K, **Fitzpatrick**), the State of Hunger in the UK (Trussell Trust, £239K, **Sosenko**), and Social Innovation in addressing poverty (The Hunter Foundation & Scottish Government, £479K, **Fitzpatrick**), as well as offering programme-wide support to the Oak Foundation's evaluation and research on homelessness (£467K, **Fitzpatrick**) (case studies ICS 3, 4, 5).

Research into housing and property, planning, design and market operations showed how housing can be made more affordable, adaptable and sustainable in both dynamic and regulated property markets (**Bramley**, **Jones**, **Stephens**). On the path to policy implementation our research teams led on the production of the annual UK Housing Review (**Stephens**). Our research demonstrated the need for affordable housing delivery across the UK as well as in specific regions, and analysed delivery and affordability of housing in South West England (NHF/Crisis, RTPI, Business West, London Housing Commission, **Bramley, Morgan**).

2. Sustainable cities
Our research explores and improves sustainable patterns of living for people in urban communities, including in the Global South (UN SDG 11) with a focus on Latin America and South Asia. Led by a team of 20.6 staff and 160 PhDs (FTE) we have undertaken research projects spanning from land use risk management to healthy buildings.

The Medellin Urban Innovation project (British Council Newton Fund, £115K, **Garcia-Ferrari**) involved three universities in Colombia. This led to joint projects with the Universidad Nacional de Colombia that trialled innovative methods of community engagement in informal settlements; resulting in improved negotiations between community and local government around landslide risk management. We adapted the approach to the Brazilian context with the Universidade de São Paulo (GCRF NERC & GCRF British Academy, £453K, **Smith**) (figure 2). Our research also addressed flooding in urban areas in Mexico using smart city approaches, leading to reduced flooding in Puebla (British Council Newton Fund & Newton ESRC/CONACYT, £465K **Garcia-Ferrari**) (impact case study ICS 2).

Figure 2. Community-based landslide mitigation measures in the GCRF NERC 'Resilience or Resistance?' project in Medellin.

Our research addresses affordable and clean energy challenges (UN SDG 7). The Community-level Energy Demand Reduction in India (CEDRI) project co-designed demand reduction strategies sensitive to local conditions (EPSRC/Indian Department of Science and Technology, £593K out of £1.4M, **Jenkins**). We developed an aggregated control system for residential air conditioning units in India that can assist the electricity grid in accommodating the forecasted 7-fold increase in uptake over the next two decades (Innovate Energy, £124K, **Peacock**). The National Centre for Energy Systems Integration (CESI) has adopted our approach to modelling energy demand of groups of buildings incorporating thermophysical and statistical techniques on usage data, thus encouraging the adoption of low carbon technologies (EPSRC and Industry, as part of a £20M consortium led by Newcastle University, **Jenkins**). An industry-led project recently launched Reflex Orkney Ltd, a local energy company to increase uptake of energy efficiency, low-carbon heating and electric vehicles in Orkney (InnovateUK, **Jenkins**). Our research helped to improve the energy performance of existing buildings while improving occupant comfort in Turkey and Vietnam (British Council, £298K, **Erdogan**). Research on the interaction between buildings and energy management showed how digital innovation and behaviour change reduces energy demand in public buildings such as schools, and work with the Wheatley Group on housing, care and property-management showed how property technology trends and innovations will enhance Wheatley's effectiveness (EPSRC and CSIC, £83K, **Carter**).

We have tackled the challenges of clean water and sanitation (UN SDG 6) and good health and wellbeing (UN SDG 3). Our interdisciplinary Pathogen Research in the Built Environment (PRoBE) team brings together microbiologists and engineers with close links to public health engineering and conducts research into pathogen cross transmission and cross contamination.

For example, the High-Rise Buildings water and sanitation for public health project (Aliaxis, £1.4M, **Gormley**) continues the group's work that evidences ways of reducing potential for pathogen circulation in super high-rise buildings (crucial in the COVID-19 context) (Studor Ltd, £20K, **Gormley**) (figure 3). This research generated a patent for a Positive Air Pressure Attenuator (EP17000011). Our LUNA Phase 1 project on the sizing of domestic cold and hot water services developed new models for pump and piping sizing to increase energy efficiency and improve water quality (CIBSE, £25K, **Jack**).

Figure 3. Test apparatus for researching transit of solids in building drainage systems.

Our research delivers resilient infrastructures and promotes sustainable industry innovations (UN SDG 9). Research in construction technology and project management innovated in the area of flexible formwork, social life-cycle assessment methods, learning energy systems and mitigating dynamic flood conditions. Examples include: developing and testing fabric-based formwork for concrete structures, including its implementation in the new Edinburgh Gateway railway station; working with industry partner Martec PLC (£248K **Pedreschi**) (impact case study ICS6); and combining 3D point-cloud data with building information modelling (BIM) to track construction progress and conduct dimensional quality control automatically (**Bosche**). The Royal Academy of Engineering (RAEng) designated us as one of the four Centres of Excellence in Sustainable Building Design in the UK.

3. Urban history and heritage

Research into urban history and heritage (UN SDG 11) is led by 8.5 staff and 40 PhDs (FTE). We have enriched architectural-historical debates through transnational, postcolonial and inclusive frameworks and projects, such as a Royal Society of Edinburgh Network demonstrating the link between Scotland's historic built environment with empire and the transatlantic slave trade (Historic Environment Scotland and the Coalition for Racial Equality and Rights, £20K, **Lowrey**). A key project demonstrated how the Edwardian Baroque revival was the closest that British architects came to inventing a coherent imperial style (Leverhulme, £140K **Bremner**). Our research invoking American art as a combatant in the Cold War led to the two volume *Hot Art, Cold War* anthology (Terra Foundation, Chicago, US$92.4K, **Whyte**). We co-edit the journal *Art in Translation* that demonstrates how dialogues between languages and cultures promotes new transcultural relationships (Getty Foundation, Los Angeles, £110K, **Whyte**).

Innovative methods include the application of 3D capture technology (figure 4), machine learning, and BIM to detect building defects in historic urban environments (**Bosche**, **Forster**, **Lowrey**). Work on the use of computer technologies in 1960s design foregrounds the historical

impact of systems and information theory (**Carlsson**). Innovative outputs include an experimental documentary film on an eighteenth-century Scottish landscape (Loudoun) which uses re-enactments and primary research material such as aerial surveys, archival maps and plans (**Stewart**).
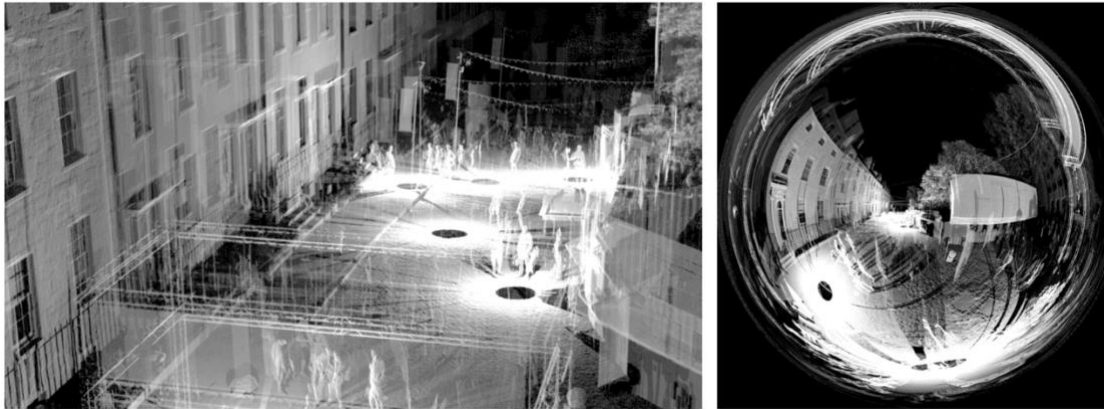

Figure 4. LiDAR scan of George Square, Edinburgh (PhD students Asad Khan and Nick Mols)

We are committed to maximising the contemporary application of our research in this area. Expertise in the architecture and history of theatres led to co-authorship of a report on theatre and COVID-19 for the UK government's SAGE group and was cited in the decisions of national heritage bodies to list and protect theatres in Plymouth and Mold (**Fair**). Work on natural ventilation and services in hospitals has informed environmental design history as well as design strategies for refurbishments, a UKRI policy briefing note, and Department of Health guidance (**Fair**). Research in Heritage Science showed that site-specific conservation practices affect the preservation of historical objects such as stained-glass windows (**Kennedy**), and demonstrated how best to correct damage in historic masonry vaults (**Theodossopoulos**). Research on traditional construction and building conservation philosophy refined the use of natural hydraulic limes in masonry repair (**Banfill**, **Forster**). Expertise in the urban history of Edinburgh contributed to the Public Inquiry into the redevelopment of the former Royal High School, Edinburgh and a major exhibition on the 250th anniversary of Edinburgh New Town (**Lowrey**). Research into post-war urban housing in the UK and Hong Kong countered arguments about the supposed failure of public housing projects (**Glendinning**). Examination of post-industrial shale oil waste heaps on the outskirts of Edinburgh reframed them as artworks, living landscapes and heritage assets (**McLean**).

4. Urban design and creative practice
Research in urban design and creative practice advances resilient infrastructures, promotes inclusive and sustainable processes, fosters innovation (UN SDG 9) and aims to make cities, human settlements and their landscapes inclusive, safe, resilient and sustainable (UN SDG 11, 15). Led by 24.9 staff and 58 PhDs (FTE), we have developed and tested urban innovations via design and creative practices, the outputs for which include designs and exhibitions providing pathways for invention and discovery (figure 5).

Metis: On the Surface, a major exhibition of design work displayed in Aarhus, Denmark, demonstrated integration between exhibition content and display media (external sponsorship: £16.8K, **Hawker**, **Dorrian**). This retrospective exhibition from the in-house research-by-design practice, Metis, toured Europe in 2014-15. An exhibition and book (Schabe Verlag) showed how

colour practices inform the quality of architecture (sponsorship: £241K, **McLachlan**). Sound compositions and performances, such as "Requiem for Edward Snowden," invoked within audiences a heightened sense of the risks of information surveillance (Creative Scotland, sponsorship: £15K, **Rawlinson**). Innovative digital installations developed for the Festival des Architectures Vives Montpellier (Papillon d'Or, which won the public award at the 5-day event attended by 19,000 people) and the Futurebuild exposition in London demonstrated the attraction and functionality of lightweight structures for public spaces, with support from University funding (£7.4K **Pedreschi**). Research on how the arts contribute to culturally sensitive and sustainable regeneration, and on the effects of cruise passenger terminal developments in historic port cities, demonstrated how to maximise responsible cruise tourism outcomes (Carnegie Trust for the Universities of Scotland, £1.8K, **McCarthy**). Research showed that changing technological, cultural and ideological networks have influenced architects' sketchbooks was supported by a one-year Monument Trust Visiting Fellowship in the Department of Prints and Drawings, British Museum (£84K, **Dorrian**).

Figure 5. Design Exhibitions: *Metis: On the Surface*, 2016; *Colour Strategies in Architecture* (Fribourg, 2020), and Strip Horizon competition entry.

Research-by-design projects in Mumbai and Calcutta (India), and Selkirk (Scotland), demonstrated the value of visual methods that reveal new relationships within urban ecological systems (**Wiszniewski**). Three practice-led research projects advancing design for communities were built to a combined contract sum of £1.18M (**Rankin**, **Fraser**, **MacKenzie**).

Facilitating and developing research with impact

ESA is committed to policy change, social transformation, critical planning, innovative architectures and pioneering design. We have contributed to policies about homelessness (ICS 4), public housing (ICS 3), and access to green space in cities (ICS 1). We have enabled communities in the UK and South America to better plan their own futures (ICS 2). Our expertise developing new designs for architectural products has transformed businesses and improved quality of life (ICS 6). We have concentrated on 4 strategies to deliver research impact.

(1) We provide comprehensive support structures for impact and knowledge exchange.
Since 2013 our universities have strengthened the professional support staff from 3 in 2013 to 7.0 FTE in 2020 to support projects and foster institutional and industry partnerships. An extensive range of staff training and support schemes deal with issues ranging from funding applications to practice-led research and publishing, and academic and non-academic impact and knowledge exchange. Our programmes include our 'Research Successes Forum', which shares cross-institutional expertise on topics ranging from funding opportunities to academic

publishing, and our 'Stepping-Up research programme', a coaching scheme for UK research council funding, for example yielding the successful "Housing to 2040" consultancy tender (**Carter**) and the North Coast Landscape project (**MacKenzie**).

(2) We provide and manage seed-fund investments to engage with our partners, beneficiaries and audiences.

Our universities manage block awarded ESRC and EPSRC Impact Acceleration Accounts, (£2M between 2014 and 2020) and GCRF funding. They also distributed our own internal seed funding of over £100K to accelerate new projects with impact. ESRC acceleration funds were used to produce videos based on our landslide research which helped in training community leaders in informal settlements (**Garcia-Ferrari**, **Smith**), while EPSRC acceleration funds enabled the development of new methods to specify and design energy conversion, transmission and storage technology in the UK, Malaysia and India (**Jenkins**). GCRF funds supported research into how smart city approaches can benefit low-income communities in Colombia (**Smith**) and into supporting Rohingya refugees in Bangladesh (**Netto**), which led to more ambitious funding applications to ESRC, British Academy and Royal Academy of Engineering. Acceleration funds strengthened culture, design and practice research, e.g. a biomorphic art installation for the Festival of Architecture in Montpellier 2019 and a cross-disciplinary Biological Architecture Lab project (**McLean**).

(3) We build appropriate key partnerships with users and industry in each of our research themes.
In our research on sustainable cities (theme 2) we partnered with communities, government agencies and industry in participatory research and knowledge co-production. Our ICS2 research on environmental risk co-management was developed in partnership with community organisations and local authorities in Latin America. Our ICS6 on Safer Homes illustrates the importance of close industry partnerships in our impact strategy. Two of our researchers were seconded to Martec Industries Ltd, who then went on to work in the company (**Pedreschi**). Other forms of engagement with industry include fellowships, such the Royal Academy of Engineering Industrial Fellowship with Wood plc to research dual-faced solar panels in the UK and Middle East (**Gul**). In relation to urban design, culture and practice (theme 4), design practice provides a crucial channel for partnering with user and client communities. Our practice researchers inaugurated the Research Practice Leads Group (Scotland) in 2019 to build a network of commercial practices invested in architecture and the built environment research (**Ewing**).

(4) We support our researchers into mobilising powerful media and lobbying capability.
Our Impact Case Studies on social housing, homelessness and child poverty (ICS 3, 4 and 5) illustrate how our researchers partner with high profile charities with sophisticated and effective lobbying, media and influencing strategies (e.g., CPAG, Aberlour, JRF, Crisis, Lankelly Chase, Social Bite, Age UK). This has enabled, for example, private briefings to the UN Special Rapporteur on Extreme Poverty and has led directly to fundamental change in homelessness legislation in England (Homelessness Reduction Act 2017) and in Wales (Housing (Wales) Act 2014, which came into force April 2015). It also prevented retrograde steps on tenure security in England, and improved Scottish national and local policy and practice on poverty, including strengthening the Child Poverty (Scotland) Act 2017 and guiding local authorities to provide food to children during school holidays (CPAG 2013-2019, **Treanor**). The MMP project employed a (part-time) parliamentary liaison officer who also worked to support knowledge

exchange and policy impact with national (e.g. Scottish, Irish, Welsh) as well as UK (Westminster) and EU parliaments. We achieve significant policy and legislative impact via our work being cited in debates in all four UK legislatures (**Fitzpatrick**). We briefed the European Region (53 countries) ministerial advisors via the WHO European Region Environment and Health Task Force on urban green space and health in 2015 (**Ward Thompson**). As an example, our *Destitution in the UK in 2020* prompted questions in both Houses of Parliament, and was reported on by international and national TV channels (Canadian CTV News, BBC and Channel 4) and international (e.g. Le Figaro), national (The Guardian, Financial Times, Telegraph, etc.) and regional (e.g. The Scotsman) press.

An open research environment

We develop innovative means of making our research accessible to all through exhibitions and published designs and research outcomes: our MMP open access infographic film about outdoor health was shortlisted for the AHRC 'film shorts' category of film awards. The I-SPHERE blog (www.i-sphere.hw.ac.uk/) had 14,000 views in 2019 and its Twitter account (@ISPHERE_HWU) has 2,100 followers. Our article on the risks of homelessness had the most reads (33,358 by 14/12/2020) and the highest altmetric score (132) in the history of the *Housing Studies* journal (**Bramley**, **Fitzpatrick**). An article on homelessness and social control (**Johnsen, Fitzpatrick, Watts**, 13,242 reads) ranked second. The blog *Reflections on Technology Media and Culture* published over 300 posts and attracted over 80,000 visits since 2013 (www.techmediaculture.com).

Our universities were early adopters of open access, with UoE establishing its institutional repository in 2003. The universities' data services provide tools for open data such as DataShare for researchers to openly license and share datasets and related outputs via the Web, and DataVault to secure protected data. In-house workshops, one-to-one meetings and online learning resources deliver training to research staff on UKRI Open Access regulations and university provision of resources to improve the accessibility of our research outputs.

Supporting a culture of research integrity

Research ethics, integrity and governance are firmly embedded in our research aims and methods. With support from our professional accrediting institutes, we continue to monitor and strengthen our research into inclusive environments, health and wellbeing, sustainability and cultural contexts and practices. Our staff have particular expertise in ethical issues around specific age groups, epidemiological studies, homelessness and destitution, and vulnerable populations in the Global South. We pay special attention to the ethical implications of interviews (in person and online), observation studies and data involving vulnerable communities, and increasingly to projects deploying online social media data.

Our research procedures provide a streamlined flow of ethics approvals that start with online checklists for all research projects leading to more advanced scrutiny for projects that deal with specialist or vulnerable groups, and sensitive data and methods. All research staff undertake training on research ethics, equality and diversity and the General Data Protection Regulation (GDPR) and good practice in the use and storage of research data. Our institutions have adopted the San Francisco Declaration on Responsible Assessment (DORA) of research.

Future research aims and plans

Building on our strategic aims from 2014 we will invest across our research themes to:

- take advantage of the rapid growth in mapped data to better understand the distribution of factors in the built environment that affect health and wellbeing in cities, and draw on large scale, linked, administrative big data (theme 1)
- increase our responses to growing risks to cities from the effects of climate change and global pandemics (theme 2)
- increase our leadership of projects and participation in international partnerships that address the UKRI's Global Challenges and meet the UN Sustainable Development Goals (SDG), in particular SDGs 3, 6, 7, 10, 11 and 15 (themes 1 & 2)
- influence policy and legislation to improve the environments and lives of people facing extreme disadvantage, including homelessness and housing exclusion, poverty and destitution, food insecurity, and welfare shortcomings (theme 1)
- develop new critical methods for design practice, consultation, and community engagement to advance urban history, heritage and culture (themes 3, 4).

Our research will leverage the opportunities provided by new initatives in data-informed innovation. The Edinburgh and South East City Region Deal, a government-led, high-profile investment venture between UK and Scottish government, industry and universities, is spearheaded by the universities' £140M Edinburgh Futures Institute (EFI). With a focus on data-driven innovation, and cross-disciplinary subthemes of cities and infrastructures, the EFI is providing additional opportunities for collaboration, as well as new accommodation for experimentation and design. Two of our research staff (**Brennan**, **Petcu**) are seconded to the EFI development team, and **Ewing** leads on the cities and infrastructures theme.

2. People

Staffing strategy and staff development

Our success in attracting and retaining outstanding new staff attests to a vibrant and supportive research environment. We have invested strategically and exercised careful succession planning to expand our academic and support staff and we have built research capacity increasing key academic staff by 13%.

Most of the 20 new academic staff since 1 August 2013 joined as early career researchers (1 grade 07 Research Assistant and 15 grade 08 Lecturers/Assistant Professors). **Woolrych** joined under HWU's Global Platform for Research Leaders scheme and **Mosselson** was appointed under the Global Challenges Chancellor's Fellowship scheme within the theme of urban development in the Global South. We expanded research leadership with a new Professor of Child and Family Inequalities (**Treanor**) appointed through our university Bicentennial Research Leaders scheme. We attracted staff from South Africa, China, Sri Lanka, Sweden and Spain.

As part of a £91K package available each year to support our researchers, we dedicate kick-start funding to stimulate new collaborative projects across ESA, broaden mentoring opportunities and develop young researchers' skills via a competitive process. We support research quality by prioritising ECRs' research projects during their first three years, boosted by an individual development budget of £5K, benefiting the research of 5 staff in EGIS. ECA conducts first project workshops offering cross-disciplinary support for ECRs, benefiting the research of 5 staff since 2013.

ECRs become part of research groups and clusters, which offer collegiate support, encouragement and opportunities for collaboration. ECRs benefit from opportunities provided by an Early Career or Futures Forum that convenes twice a semester to share project ideas. We invite ECRs to serve as secondary PhD supervisors. After suitable experience, such as steering at least one PhD to successful completion, they are encouraged to serve as primary supervisors. Each ECR is mentored by a senior researcher. To enhance collaboration, we also offer short term opportunities to ECRs, via I-SPHERE's 6-month internship programme with the Oak Foundation.

Mid-career staff can maximise their potential as researchers via access to research facilitation funding for research travel, special equipment, and publication costs, as well as seed funding for interdisciplinary projects or larger bids. This is accessed either through a personal research allowance (£800) or through submission of specific proposals for discretionary funds of up to 5K. For example, the UoE CAHSS Challenge Investment Fund is designed to promote interdisciplinary working, and to seed-fund step changes in funded research ambitions.

Our departments and institutes refine research plans and strategies as part of the annual staff review process. All staff can apply for research leave against research plans (up to one semester in eight at ECA and one term in ten at HWU). Recent research leave yielded a Horizon 2020 project on socio-technical aspects of the collaborative economy (**Travlou**). Both universities encourage and support applications for externally funded research leave such as Fellowships.

As evidence of success in our career development strategies, during the census period two Chancellor's Fellows (CFs) appointed prior to 2014 under an ongoing university scheme to recognise and develop early career talent were able to migrate to open-ended contracts. One was subsequently promoted within 2 years to grade 09 (Senior Lecturer). Benefiting from a series of staff development coaching sessions, one CF developed a project on sustainability and the Anthropocene (**Bastian**). The second CF advanced historical insights into architectural technology (**Fair**) and was subsequently promoted to Reader. One Global Platform for Leaders ECR appointment made since 2014 was also subsequently promoted, first to grade 09 (Associate Professor) and then grade 10 (Professor) (**Woolrych**). During the REF census period, through a rigorous application process, 4 staff were promoted to grade 08 (from Research Associate to Research Fellow or Assistant Professor), 17 to grade 09 (Senior Lecturer, Reader, Associate Professor or Senior Research Fellow) and 6 to grade 10 (Professor or Professorial Fellow).

We have supported over 40 contract research staff during the census period. Postdoctoral research fellows and research associates benefit from annual development reviews. I-SPHERE is supported by major funders that provide a long-term stream of funding linked to specific outputs. This provides security for postdoctoral research staff and also increased opportunity for academic outputs. Postdoctoral researchers in the MMP project transitioned successfully to posts in the University of Virginia Centre for Design and Health; University of York, UK; and Statistics New Zealand.

With support from research offices, principal investigators (PIs) plan their projects to support personal and career development, and lifelong learning of contract researchers at all career stages. Both universities participate actively in Vitae's Concordat to Support the Career Development of Researchers.

Research students

We have expanded our PGR numbers since 2014 with 195.4 FTE completions during the current REF census period compared with 85.7 in REF2014. PhD students take advantage of opportunities provided by dedicated PhD programmes that cross-cut our key themes and attract specialist cohorts: PhD completions include (headcount) in Architecture (49), Architecture by Design (7), Construction (52), Cultural Studies (4), Landscape Architecture (19) and Urban Studies (44). The new Architectural History PhD has 10 starts. We also participate in joint supervisory teams with other UoAs.

Postgraduate research students contribute actively to our research teams, enlivening our thematic areas with fresh insights, approaches and methods. They initiate seminars, workshops, and online presence and produce compelling outputs such as exhibitions deploying LiDAR scans as a creative medium in combination with fashion design, and insights into how Airbnb is changing cities. Research students apply new research methods and tools, e.g. EEG neuroimaging, immersive technologies, and other data-informed innovation. The recipient of an ESRC-funded PhD studentship contributed to new understandings of children's human rights as they relate to the Scottish town planning system. These insights informed the new Planning (Scotland) Act 2019, leading to the inclusion of statutory duties for planners to include children's views in policymaking, and assess opportunities for play in the built environment.

ESA supports lively programmes of student-led activities, including workshops and annual conferences, providing financial support for seminars and other initiatives. Students address topics of their own choosing and relevant to their own research via the Prokalo seminar series (www.eca.ed.ac.uk/prokalo-esala-postgraduate-seminar-series), the Edinburgh Architectural Research journal (EAR, blogs.ed.ac.uk/ear-journal/) (*pro-tem*), and participate in the international 3 Minute Thesis (3MT) competition. PhD students play an active role in many of the staff-led conferences and events reported in Section 4, and have led on international conferences such as a conference on Place, Pedagogy and Play (2017).

Our university **scholarship** schemes (James Watt, Principals Career Development, Edinburgh Global Research, ECA PhD Scholarships) supported 54 research ESA students across diverse subject areas, ranging from the commodification of urban space through branded housing projects in Turkey to the exploration of age-friendly urban design in Scotland. UKRI Centres for Doctoral Training supported 14 AHRC and 12 ESRC PhD students. Collaborative awards included an AHRC Collaborative Doctoral Partnership studentships award (with Historic Environment Scotland) (supervisors: **Fair**, **Glendinning**), and an award with the Imperial War Museum and National Galleries of Scotland (supervisor: **Chmielewska**). The AHRC Centre for Doctoral Training (CDT) awarded an Applied Research Collaborative Studentship (ARCS) with the University of Western Scotland in collaboration with Renfrewshire Disability Resource Centre (supervisor: **Coyne**), and we host a PhD student fully funded through a joint agreement with the University of Glasgow under the City Infrastructures theme. ESA is active in CDT initiatives, with **Coyne** chairing the Executive Committee of the Scottish Graduate School for the Arts and Humanities in 2015.

We provide a full programme of extensive training in research skills, transferable skills and career management. We draw on the resources of Vitae that also supports research student development and our universities' Institute for Academic Development (IAD) and the Research Futures Academy (RFA) in which our research students participate. The RFA draws on the

resources of the Postgraduate Centre established in 2009 with a £7M investment. Under the Research Development Framework, it combines facilities for training and outreach, and interaction with other postgraduate students across the universities. Some of our research students receive additional subject-specific training via social science research methods courses. Our universities also host research success forums that are open to all research students and staff.

Our research students come from a diverse range of backgrounds, including professional practice and across the age spectrum, and our early provision of off-campus PhD study prepared us to support all research students online during the pandemic. A growing number of our research students transition from ESA's dynamic suite of postgraduate programmes that includes taught and project components in property markets, real estate development, urban and regional planning, sustainable urban management, landscape and wellbeing, cultural studies, urban conservation, architectural and urban design, architectural history and theory, art, space and nature, material practice, digital media and culture, and a joint programme on urban strategies and design. For example, a design and digital media graduate went on to complete a PhD on the theme of vloggers as key opinion leaders and then took up a lectureship at Sheffield Hallam; and an urban strategies and design graduate is currently conducting PhD research with us on resilience and adaptation to flooding in Jordan.

Each PhD student works in a team with two or more supervisors. All academic staff are formally trained to supervise PhD students and a system of mentoring matches newly trained supervisors with experienced co-supervisors. Our robust systems of support for student progress helps deliver projects effectively and on time. Online systems help students, supervisory teams and independent reviewers manage timelines and assess progress. We conduct annual PhD and MPhil progress reviews. We prepare students for future careers, providing teaching opportunities after the first year of students' candidature to enhance their skills and experience portfolios and to further promote the opportunities offered by ESA's diverse research environment.

Equality and diversity

Our commitment to equality, diversity and inclusion (EDI) is core in our approach to staff and PGR support, including support for black, Asian and minority ethnic (BAME) and LGBTQ+ initiatives. Our research themes demonstrate our intellectual investment in EDI objectives, not least through our projects under the theme of social inclusion. Beyond the universities, we provided the first female President of the Chartered Institution of Building Services Engineering (**Jack**). We also developed an initiative with the Glasgow Women's Library to compile and examine oral and material archives of women architects in Scotland (**Ewing**), demonstrating our commitment to advancing the professional roles of women in the built environment.

We established a Diversity and Inclusion Working Group to monitor and support staff and student achievement in a diverse and inclusive working and learning environment. Through mentoring of female staff into academic leadership we continue to redress the historical under-representation of women in the academic staff profile of our disciplines. (HESA recorded 34% participation by women nationally in 2015/16 in architecture, construction and planning.) Of our 20 new academic staff appointments since 2014, 10 are women. Four female staff members served as heads of department or institute during the REF period (**Ewing**, **Fitzpatrick**, **Jack**, **Menzies**) and one as deputy head (**Treanor**). Women promoted to professor include **Ewing**

(2019), **Garcia-Ferrari** (2020) and **Johnsen** (2017), increasing the ratio of professors who are women from 22.7% in REF2014 to 36.4% in 2020. The implementation of our EDI policies meant that, of four staff members who undertook periods of maternity leave since 2013, three followed that immediately with periods of research leave. As an indication of the scheme's success, each staff member who took this post-maternity research leave applied successfully for promotion to grade 09. Our research committee personal research allowance funds and grants provide additional support up to £300 to cover childcare or caring for dependants that would otherwise limit a researcher's ability to travel. We leveraged funding sources that provided support for exceptional needs (such as through Erasmus+). We continue to build on our Athena Swan bronze certifications to progress our gender equality initiatives.

We encourage staff who return to work after extended leave to identify their needs through induction sessions and during annual reviews, to be followed up with department and institute heads. Both universities have duty of care policies, and all staff undertake training on health and safety in the workplace, and mental health. Directors of Equality and Diversity champion these and other initiatives that promote the well-being of staff and students. Such initiatives are bolstered by disabled staff networks open to staff who are carers or with protected characteristics and that provide effective online communications about accessible technology, carer support, disabled staff support, estates accessibility, fire safety, staff counselling and transport and parking. ESA participates in initiatives within our universities to promote LGBTQ+ equality and visibility via: staff pride networks, an in-house Allies training programme, and role model training programmes in collaboration with Stonewall Scotland.

Prior to COVID-19 we ensured that in-person meetings are held at accessible locations. We provide suitable workstations to meet the requirements of staff with special needs and have facilitated the transfer of desktop equipment and networking for home use during the pandemic. We provide support for flexible working, and since COVID-19 have enhanced the provision for home working and opened our buildings for staff to work on campus subject to COVID-19 rules and guidelines.

We adopted a rigorous, fair and transparent approach to selecting REF outputs, fully accounting for staff special circumstances that have affected their research activity. We followed EDI considerations, building in unconscious bias and EDI training. An independent EDI group reviewed the distribution of outputs across staff by gender and career stage. The result of this review demonstrated a balanced spread of outputs across gender and career stage: 33% of outputs submitted are authored or co-authored by female staff (35% of our staff are women); 39% by ECRs and Grade 7/8 colleagues (38% of our staff are grade 08). Overall, 46% of staff contributed 2 or more outputs.

3. Income, infrastructure and facilities

Strategies for increasing research income

Our research since 2013 has been supported by 192 new externally funded research grants, with an award income during the REF period of over £19M. Highlights include 15 EPSRC grants, totalling over £2.27M, 10 ESRC grants totalling over £2.22M, 7 NERC grants totalling £296K, British Council grants totalling £200K and an NIHR grant (2012-2017) of £1.14M. Non-research council funding comes from a diverse range of sources, including the Joseph Rowntree Foundation (with multiple grants totalling £1.2M), the Leverhulme Trust, the British

Museum, Construction Scotland Innovation Centre, the British Academy, Forestry Commission, Central and Local Government and exhibition sponsorship.

Our success in winning external funding has been underpinned by a package of support for grant applicants that begins with horizon scanning for strategic funding opportunities. We encourage new projects for external funding via seed grants (see section 2) and proposal workshops that foster multidisciplinary collaborations and impact across our research themes, and that link more widely to other disciplines within both universities. Recent proposal workshops included internal workshops on sustainable smart cities (2018), and 3 workshops on the implications of the emerging COVID-19 pandemic and social distancing practices in the built environment (2020). A workshop on resilient communities (2018) served to pool expertise to garner further funding, resulting in 2 research projects funded by internal GCRF grants and 1 by EPSRC IAA (Impact Accelerator Account) funding.

ESA initiates interdisciplinary projects. The combined budget to facilitate research within our participating departments and institutes is £91K per year. For example our internal Kickstarter scheme (£10K per year) funds joint projects amongst ESA researchers that demonstrate the synergies that arise by bringing architects, engineers and social scientists together early in their research careers, leading to projects on the role of green space in residential perception and wellbeing (**Wu**, **Lima**), the relationship between the history of tracing paper as a medium for architectural drawing (Harty, **Kennedy**), the potential of micro-homes (**Brown**, **Brennan**) and how environmental quantification impacts the design of small-scale residential projects (**Moffitt**, **WV.Lee**, **Jenkins**).

Research support services in our universities disseminate funding opportunities to staff, identify potential pathways to impact and help staff develop funding applications. Our university research offices provide specialist knowledge and targeted support to our research communities across the research lifecycle. They also host the Knowledge Exchange and Impact teams who provide support for industry engagement and impact, working closely with our commercial innovation arms (Edinburgh Innovations and Research Engagement). Two new administrative staff were appointed to support projects under the GCRF.

To improve applications and share expertise, experienced academic staff in ESA are recruited into pools of internal peer reviewers who examine draft applications for external funding. Reviewers deliver timely feedback on applications in a coordinated internal approvals process. The universities' funding application coaching schemes match academics who need advice and support on how to generate impact from their research with colleagues who have experience of engaging research users in policy, practice and industry.

We encourage staff to seek funding that enables them to scale up the ambitions of their projects.The Challenge Investment Fund, for example, provides up to 5K to seed-fund pilot projects leading to larger grant applications. Impact case study ICS2 on risk management in informal settlements exemplifies such growth: scaling up from £6K of internal funding to over £1M in external funding (**Garcia Ferrari**, **Smith**). Other small projects on track to larger scale development include: an architectural History of NHS hospitals; Scots and the Colonial Built Environment c.1700-1920; assessing home energy efficiency measures in the Kyle of Sutherland region; and research in Canada on small transit ports and cruise tourism. In addition, research-led exhibitions and performances have received individual contributions from sponsors and crowdfunding sources leading to major exhibition outputs.

To follow up award applications, we provide informal mentoring and 1-to-1 meetings to re-deploy projects not yet successful in the funding pool. Funder relationship management is a priority, and our universities provide training for new reviewers and encourage and recognise contributions to research council peer review colleges (e.g. AHRC, ESRC, EPSRC) and as peer reviewers of journals and conferences evidenced in section 4 of this document.

Infrastructure and facilities

Our universities continue to invest substantially in infrastructures for research and impact. The site of the Old Edinburgh Royal Infirmary is being refurbished as the Edinburgh Futures Institute (EFI) (£140M). Two wings of this refurbishment will be completed by 2021 with the rest completed post COVID-19. The Global Research Innovation and Discovery (GRID) building (£19M) at Riccarton was completed in 2019 and shortlisted by the Royal Institute of Chartered Surveyors for its social impact award and an RIAS/RIBA award. Plans to refurbish the rest of the ECA estate in Lauriston Place will strengthen synergies between architecture, art, design and music, adding enhanced exhibition spaces, studios, workshops and laboratories.

Focussed estate developments include a purpose-built research building opened in 2017 at Riccarton with workspaces for 84 PhD students (550 sqm £1.2M), renovation of the Lauriston Place Fire Station (£755K), investment in Minto House offices and a multipurpose refurbishment at 7-8 Chambers Street with improved studios, offices and seminar spaces (£570K research related).

We have extensive workshops (1,500 sqm) with teams of technical support staff (9 dedicated technical officers), including for three-dimensional design and architectural model making, acoustics labs including anechoic chambers, a metal fabrication/structures research laboratory, timber workshop, a concrete laboratory, building services laboratory, finishing suite, machine and assembly workshops, and exhibition spaces. All are served with a wide range of plant, machines and hand tools. ESA has access to high-end computer facilities, including reprographics, scanning, and display services. We make extensive use of virtual reality, digital fabrication, laser cutting and 3D printing in research projects, including PhD projects and those with a practice orientation. Our projects make use of the Talbot Rice (www.ed.ac.uk/visit/museums-galleries/talbot), the Matthew Architecture and Tent galleries and studio spaces for practice-led research and exhibitions.

We provide extensive library resources, and have invested heavily in renewed workspace provision. Our researchers have reciprocal access to library facilities. We access the Cameron Smail Library, the University of Edinburgh's Main Library (including the rare books collection and the Centre for Research Collections), the National Library of Scotland (the legal deposit library of Scotland), a specialist product information resource centre at Riccarton, the specialist Art & Architecture Library in Chambers street, and the Art, Design & Art History Library at the Lauriston Place campus. Special collections include the Patrick Geddes Collection as an online repository in collaboration with Google Arts & Culture (artsandculture.google.com/partner/university-of-edinburgh).

We also provide extensive and complementary specialist facilities for ground-breaking research and impact. Sharing and leasing facilities such as the anechoic chamber to industry on a contract basis provides a pathway to research engagement. Shared specialist facilities include high performance computing. As well as facilities already mentioned, our projects have drawn

on HWU's Rapid Manufacturing Design Studio (RMDS), which provides a Fused Deposition Modelling (FDM) machine, Fortus 400MC, a Multi-material polyjet CONNEX 500 3D printer, a Monochrome polyjet OBJECT 24 3D printer, two MakerBot Replicator 2Xs, and a Roland MDX40 rapid machining centre. The Brent Wilson Advanced Manufacturing Unit (AMU) provides a modern central CNC manufacturing facility as well as offering a sub-contract machining service to external partners. The computing facility consists of several multi-core CPU and graphics processing (GPU) systems, which currently totals over 90 CPU cores and 4700 GPU cores. The Renewable Energy Test Site includes bays for testing solar photovoltaic, and solar thermal devices.

Mobile electroencephalography (EEG) equipment, LiDAR scanning, and 360 video recording equipment are deployed in research projects. Apart from localised provision, our research draws on the uCreate Studio in the University of Edinburgh, which has a range of high-end virtual reality (VR) and augmented reality (AR) head-mounted display equipment, including access to a local GPU-based render farm that allows graphics researchers to interact with extremely high-resolution Unity or Unreal Engine models. Researchers also access a series of thermal and 360-degree cameras, and 3D scanners, including an industrial grade terrestrial LiDAR scanner, the Leica BLK 360, and have access to a medical grade mixed-medium Stratasys 3D printer, and a range of other fabrication facilities. The University runs computing workshops where researchers learn to script using languages such as Python, Arduino, Java, and Processing.

Initiatives that make use of these facilities include projects on advanced virtual reality modelling (**Bosche**), digital fabrication, fabric formwork (**Pedreschi**), and PhD projects using LiDAR scans as a means of exploring heritage sites and alternative spatial geometries (**Lowrey**, **Petcu**, **Coyne**). A suite of projects involving augmented reality (AR), unpiloted aerial vehicles (UAVs), and immersive hybrid reality systems provided in-field digital visualisation of Building Information Models from any location in real time and showed how to improve wind turbine safety and maintenance (**Bosche**, £408K) under the purview of the Cyberbuild Lab (cyberbuild.eng.ed.ac.uk).

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

A collaborative research approach

Our research and impact are strengthened by a series of key international collaborations, networks and partnerships that deal with the multifaceted challenges across our themes of healthy and inclusive cities, sustainable cities, urban history and heritage, and urban culture, design and practice. Our **research networks** include major universities in the UK, Brazil, Colombia, Mexico and India, as well as institutions in Turkey and Vietnam. We are part of the UK Collaborative Centre for Housing Evidence (CaCHE) with 7 other UK universities, and the Centre for Analysis of Social Exclusion (CASE). Our staff also undertake roles that further support their **research collaborations**. For example, **Garcia Ferrari** was Dean for Latin America and is now Dean International, supporting research and development projects across the University of Edinburgh. Adjunct and visiting professorship roles in other institutions further encourage collaborations with Simon Fraser University, University of New South Wales, Estonian University of Life Sciences, the Latvia University of Agriculture, Harbin Institute of Technology, Università degli studi di Cagliari, and Exeter's European Centre for Environment and Human Health.

As a further pathway to collaborations, we supported visiting scholars and honorary professors from institutions in Australia, Brazil, Colombia, France, Germany, India, Mexico, Portugal, South Korea, Spain, Sweden, and the USA, and from the public and voluntary sector (Scottish Government, Social Development Direct) and business and industries (CBRE Scotland, CIBSE President, Hunter Advisers, Paragon, Scottish Widows, TEPUI).

Impacts on economy and society

Our research responds to **national and international priorities** and initiatives such as the UN Sustainable Development Goals (SDG) outlined in section 1 in relation to our 4 research themes and as outlined in our impact case studies. Through I-SPHERE, we played a key role in the Housing (Wales) Act 2014, the Homelessness Reduction Act 2017 (England) and the Child Poverty (Scotland) Act 2017. As a result of the Welsh legislation over 20,000 households had their homelessness prevented under the new framework, and in England homelessness for over 60,000 households was prevented in 2018/19 alone. Our researchers briefed and provided evidence to the Scottish Property Tax Reform commission, contributed to a consultation on the Planning Reform Bill, the Poverty and Inequality Commission, and worked with the Child Poverty Action Group (CPAG) and Aberlour children's charity. We have representation on the board of the National Housing Federation, and the statutory Poverty and Inequality Commission (Commissioner and Deputy Chair, **Treanor**). Thanks to our research, benefit take-up for families is now an action in the Scottish Government's Child Poverty Delivery Plan, a statutory requirement of the Child Poverty (Scotland) Act 2017. Our research also guided NHS and government professionals to take poverty and inequality into account when responding to childhood adversity (**Treanor**).

Our research has contributed significantly to societal understanding and responses to the impact of COVID-19, and we have been invited to advise organisations on their responses to COVID-19. Internationally, we have worked with low-income communities in Colombia, Mexico and Galapagos to understand changes in their social practices to mitigate COVID-19 risk and identify strategies to adapt to and mitigate future risks such as those resulting from climate change (**Garcia Ferrari**)**;** our GCRF-funded research in South-East Asia has led to the use of digital technology for assisting refugees during the pandemic (**Netto**); and we have contributed to a range of publications on mitigating COVID-19 transmission via wastewater plumbing systems, including in *The Lancet* and *Global Health* (**Gormley**, **Kelly**). Nationally, we conducted research for the ESRC, Trussell Trust, Joseph Rowntree and Crisis on the impacts of COVID-19 on foodbanks, destitution and homelessness (**Bramley, Fitzpatrick**) and we co-authored a report on theatres and COVID-19 for the UK government's SAGE (**Fair**). Our researchers are advisors on the UK Government Scientific Advisory Group for Emergencies (SAGE), Environment Modelling Group (EMG), and Transmission in the Wider Environment Group (TWEG) (**Gormley**), having co-authored over 30 advisory papers for the UK response to the pandemic; UK Government Office for Science (GO Science) Covid-19 Areas of Research Interest working group on Land Use and Public Health Scotland's Covid-19 Social & Systems Recovery, Environment & Spaces Evidence & Data Sub-group (**Ward-Thompson**); Scottish Parliament's COVID-19 Committee (**Bramley**); Scottish Government's Homelessness and Rough Sleeping Action Group (HARSAG) and Prevention Review Group (PRG) **(Fitzpatrick)**, and Scottish Government's Labour Market Strategy Group and Expert Reference Group (ERG) on COVID-19 and Ethnicity (**Netto**).

We **engage with communities** locally, nationally and internationally — ranging from co-producing research with communities to disseminating findings and helping these achieve positive impacts. **Locally**, research staff and students have: contributed to the City of Edinburgh Council's Thriving Green Spaces project, funded by Heritage Lottery Fund and National Trust, including engaging with community groups and supporting data collection and analysis; worked with residents and staff in a practice-led colour research project at the Royal Edinburgh Mental Health Hospital; and contributed to workshops for the Hunter Square public consultation and design, fabric formwork with Inverkeithing High School and South Queensferry Community High School, and the innovative community project Play Learning Outdoor Preston Street (PLOPS) to improve a local primary school playground. We have organised outreach events including as part of the Reimagining Your Gardens & Streets Edinburgh competitively won Adaptation Scotland Community Engagement Pioneer Project (a joint collaboration with the Royal Botanic Garden Edinburgh). We presented research on green space and health to Edinburgh Science Festival, Midlothian Science Festival, Edinburgh Friends of Parks group, Edinburgh City Council Chambers, Lochaber Ideas Week, Fort William and Newcastle University's INSIGHTS Public Lectures programme. **Across Scotland** we have actively engaged with communities through: directorship of the Homeless Network Scotland and New Lanark Homes Ltd (which manages the affordable housing properties in the world heritage village), and non-executive directorship of the Rock Trust (a Scottish youth homelessness charity); presenting our research to community workshops as part of the Festival of Architecture and in Gorebridge about the early twentieth century model of the town centre; co-organising a travelling exhibition and consultation vehicle (Present Voices, Future Lives), commissioned by the Scottish Government and Architecture and Design Scotland (A+DS) that toured Scotland in 2019 and engaged with local communities and high schools; and running widening participation workshops with schools encumbered by low progression to university across Scotland's central belt. **Across the UK** we worked with communities in nine neighbourhoods across three cities (Edinburgh, Glasgow and Manchester) to produce guidelines for age-friendly cities, including through focus groups, knowledge cafes and interactive exhibitions; and we presented our research on acoustics and wellbeing at the Tate Exchange in the Tate Modern (London). **Internationally** we have engaged with: refugees in Greece through the Athens Options FoodLab, which was co-founded by our researchers, and in Malaysia, where we have worked with the Rohyngya; and low-income and informal settlement residents in Brazil, Colombia and Mexico, where our co-produced landslide and flooding risk monitoring and mitigation research has included large community-local government public meetings with over 600 community participants per event.

Our research has contributed to the development of new **companies** such as the ground-breaking local energy company, ReFLEX Orkney Ltd, offering a range of new low-carbon transport and power services to further decarbonise the island's energy system. We also work with Siemens as lead industrial partner in the multidisciplinary Centre for Energy Systems Integration (CESI), which aims to reduce the risks associated with securing an integrated energy system for the UK in collaboration with 34 industrial and government organisations. Our work on public health engineering, which is recognised by code authorities and government agencies globally, is creating marketable patented solutions in collaboration with Aliaxis, a 3 billion Euro organisation owning 100 companies worldwide.

Public dissemination of research to wider communities included **media appearances** on Phil Spencer's *History of Britain in 100 Homes* on More4 and on Colombian TV and BBC Scotland. Our research on community-based landslide mitigation in Colombia was covered by 520 pieces in the UK press with a total reach of 14.5 million. The launch of Hard Edges Scotland, a report

detailing the challenges faced by charitable services and the public sector was covered by 200 media platforms, including 18 national platforms, with a total reach of over 11.5 million. It also featured in First Minister Questions at the Scottish Parliament. An academic paper "Homelessness in the UK: Who is Most at Risk (Housing Studies)" by **Fitzpatrick** and **Bramley** secured unprecedented global coverage in press across the UK, US, Japan, Germany, Denmark, Netherlands, Canada, Switzerland, Ireland, Croatia and Greece. Our study on "core" homelessness for Crisis secured over 200 articles with a reach of 19.5 million across the UK media. Work with the Aberlour Childcare Trust generated over 70 newspaper articles.

We contributed further media apparances to BBC Reporting Scotland, BBC2 'Trust me, I'm a Doctor' programme (which included a research experiment on landscape and health commissioned by the BBC), BBC Radio Scotland panel discussion on 'Good Morning Scotland,' STV lunchtime and evening news items, BBC Radio Scotland 'Brainwaves' and BBC Radio5 Live programme 'The Naked Scientists', an interview on a programme about the Edinburgh New Town on BBC4, BBC Radio3's Hear and Now feature on Sonorities 2018, BBC Newsnight talk about microhomes, a talk on RTE Morning Ireland, panellist and interviewee at CCTV+ VMF (Global Video Media Forum) in Chongqing, and a talk about quiet urban areas on BBC Radio Sheffield Drive time programme 2018 and STV2 Edinburgh News. **McLean**'s practice research was the subject of an art-doc short film *Plastic Man* (directed by Yulia Kosanova), which was nominated in the BAFTA Scotland documentary short film category (2017). The ESALA film 'Mobility, Mood and Place' was shortlisted for the AHRC 2018 Research in Film Awards: Social Media Short Award category.

Contributions to the wider research base

As well as quality research outputs and impact pathways, we contribute to the sustainability of our disciplines through editorships, speaking engagements, conferences, exhibitions, competitions, research reviews, special interest groups and advisory roles.

Several high-profile **publication outlets** exemplify our contribution to the wider research base. The influential journal *Urban Studies* (Sage) was co-edited by **Stephens** from 2009 to 2017. The journal started in 1964 and leads intellectual and policy debates on the city. The online journal *Art in Translation* (Taylor Francis) was founded in 2009 and is co-edited by **Whyte**. It publishes English language translations of significant articles on visual culture otherwise available only in their source languages. The newer *Architecture and Culture* journal (Taylor Francis) was founded in 2013 and is co-edited by **Ewing**. It received an award from the Council of Editors of Learned Journals (www.celj.org) as the Best New Journal in 2014. **Fitzpatrick** co-founded the *International Journal of Homelessness.*

Other significant editorships include *Urban Planning & Transport Research*, *Housing Studies*, *Time & Society* (SAGE), and *Architectural Histories*, the peer-reviewed journal of the European Architectural History Network. Guest editorships during the census period delivered special editions of the *Journal of Environmental Humanities, Journal of Environmental Philosophy, Parallax*, *Journal of Peer Production*, the *International Journal of Electronic Governance* and *Frontiers in Psychology: Environmental Psychology*, and DOCOMOMO International E-Proceedings 7 (African Modernism), 8 (Historic Chinese Socialist Housing), and 10 (Mass Housing of the Scandinavian Welfare States). Assistant editorships included *Landscape Research*, the founding of the new collaborative *Housing Journal Podcast* co-run and presented by editors from *Housing Studies, International Journal of Housing Policy* and *Housing Theory*

and Society. Other initiatives include founding and editing an online journal *Organs Everywhere (Œ)* and the book series *Œ Case Files* in collaboration with Punctum Books, and founding and editing the online journal *Critical Housing Analysis*.

To encourage our new researchers, we **produce three peer-reviewed open access journals** with support from research students, and with an international reach, including *Drawing On* (drawingon.org), an Edinburgh-based online journal platform started in 2015 for developing topics associated with design-led research in architecture.

Our researchers are also on **editorial boards** of over 40 major academic journals, such as *Cities & Health*, *International Journal of Housing Policy*, *Journal of the Society of Architectural Historians*, *Architectural Research Quarterly (ARQ)*, *International Journal of Construction Management, Journal of Recreation and Tourism*, *Interstices: Journal of Architecture and Related Arts*, and *Architectural Theory Review*.

Our researchers contribute to the research base, society and economy through numerous **invited speaking engagements**, at venues such as universities of Idaho, Beijing, Hebei, Monterrey, New York, Oslo, Stuttgart, Western Australia, the CEPT School of Architecture in Ahmedabad, and numerous UK universities. Staff have addressed the Scottish Parliament, the Courtauld Institute, National Gallery of Art (Vilnius), the World Health Organisation in Geneva, and the Center for Advanced Study in the Visual Arts (CASVA) (Washington DC). Topics ranged from the Grenfell Tower disaster to "Nearby Nature – Planning Biophilic Cities."

Our researchers have brought important research to Edinburgh through **international conferences hosted within the city**, including the European Network for Housing Research Conference 2014 with over 500 international participants, organized by a consortium of 5 universities; the European Architectural History Network Biennial Conference held in June 2020; Passive and Low Energy Architecture (PLEA) 2017; and the Mobility, Mood and Place Conference, Edinburgh, including workshops, 2016. **Locally initiated conferences and events** also attracted international participants: 'Building the Scottish Diaspora: Scots and the Colonial Built Environment, 1700-1920' symposium, an international event sponsored by the Paul Mellon Centre; Postcards from the Anthropocene, unsettling the Geopolitics of Representation 2017; The Place of Silence--Experience, Environment and Affect 2016; Deep Time, Deep Waters 2017; the Control Code Construct Conference 2019; the architecture of Scotland in its European setting 1660-1750, 2015; Passive Design Workshop 2016; Landscape and Life conference 2017; Digital Practices Symposium 2018; and Reflections: Glass and Architecture Workshops, Selkirk 2016. Panel sessions chaired include Language, Situation, Speculation and the Architecture of the Collective (Architecture and Collective Life, AHRC Conference, November 2019).

Our researchers are also active in **external conference organisation**: joint coordination of CIB W107 Commission on Construction in Developing Economies 2015; Organisation of Urban Transcripts -- Transforming the [re]public, Athens 2017; Organisation of Women's CryptoDinner -- Privacy, gender and encryption, Athens 2015; International Association of People-Environment Studies (IAPS) network symposia and bi-annual conference; and annual Network-Association of European Researchers on Urbanisation in the South (N-AERUS) Conference. We launched a new international conference series in Edinburgh in 2018: Temporal Belongings Network Conference, July 2018. Our staff have also organized external conferences, such as the Conserving West African Modernism Workshop and Conference in Kumasi, Ghana 2015.

Exhibitions provide dynamic forums for design-led research: Metis: On the Surface was shown in the gallery of the Arkitektskolen, Aarhus, Denmark (2014); Colour Strategies international exhibition at Glasgow Lighthouse (2016) Architectural Assoc, London (2016) and 6 venues in Europe. We presented work at: the 16th edition of the Venice Biennale; the Great Exhibition of the North, Newcastle-upon-Tyne 2018; Global Design New York University, Collapse: Climate, Cities & Culture, New York 2018; Living with Adaptive Architecture, Nottingham 2018; Tallinn Architecture Biennale 2017; Organisation of Instinct, Image and Imagination -- Landscape as Sign Language exhibition, Edinburgh 2014; contribution to the group exhibition NANAIRO+ by Aichi University of the Arts at the Setouchi International Triennale 2016, Japan; Craft Scotland Exhibition at London Design Fair, Truman Brewery, London 2016; pop-up exhibition -- Digital Impressions, Digitally Expressed in the Matthew Gallery, Edinburgh 2018; Medellin Urban Innovation exhibition in Edinburgh and Medellin, Colombia 2017; and Mobility Mood and Place Lighthouse Exhibition, Glasgow 2016. We led on the Housing to 2040 travelling exhibition in partnership with Collective Architecture and Peak 15 for Architecture and Design Scotland and the Scottish Govt. We curated the historic plaster cast collection at Edinburgh College of Art, which is on permanent exhibition.

Performances include work with the laptop trio Raw Green Rust, Re-Breather Trio; work for live cinema using archival scientific film for Edinburgh International Film Festival 2018; and a mixed media performance about Muriel Spark for Made in Scotland 2019. Award winning **design competition entries** include: Conversion of an eighteenth-century fortress in Santoña (Spain) into the Monte Buciero Museum (Próxima-Arquia award 2014), the spatial design and ephemeral architecture for the Zinc Shower event in Madrid (COAM award 2014 and Próxima-Arquia award 2014), and scalable residential neighbourhood in the Faroe Islands (Finalist, Nordic Built Cities competition 2016, **Paredes**). Award winning designs include the landscapes of Dunbar Battery (**Fraser**), the Maggie Centre, Monklands General Hospital, Lanarkshire (**Rankin**, **Fraser**), and An t'Eilean (The Island) an open air space on the Inverness Campus for the University of the Highlands and Islands of Scotland (**MacKenzie**).

Our researchers also chaired or have served as members of important **grant panels and peer review colleges** including: EPSRC, ESRC, AHRC, British Academy, Scottish Universities Insight Institute and the Australian Research Council as well as overseas grant review bodies: Schweizerische Nationalfonds (SNF,The Swiss National Science Foundation); Österreichische Wissenschaftsfonds (FWF Austrian Science Fund); Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS Slovenian Research Agency, Selection Board member for art history and cultural studies); New Eurasia Foundation (Ministry of Education and Science of the Russian Federation); the Harvard University, Radcliffe Institute for Advanced Studies; and the Australian Housing and Urban Research Institute, AHURI. Three academic staff and two support staff have contributed to panels/subpanels supporting UK REF 2021.

Research leadership

Our researchers enhance the UK research base through the exercise of leadership in **learned societies** including as President of the European Council of Landscape Architecture Schools (ECLAS) (**Bell**), and associate director of the Scottish Centre for Administrative Data Research (**Treanor**). Board memberships, fellowships and convenorships of organisations that include the International Society for Gerontechnology (ISG) (**Woolrych**), the International Association for People-Environment Studies (IAPS) (**Payne**), the Academy of Social Sciences (**Fitzpatrick**, **Stephens**, **Bramley**), the Housing Studies Association (**Watts**), the European Real Estate

Society (**Dunse**), the Sensory Environments Network (**Payne**), the Architects' Professional Examination Authority in Scotland (**Carter, McLachlan**), the International Association of Research Institutes in the History of Art (**Whyte**), the Royal Society of Edinburgh (Sectional Committee for Arts and Humanities) (**Whyte**), the Royal Scottish Academy (**Urquhart**), the Royal Historical Society (**Bremner**), the Royal Society of Arts (**Brennan, Coyne, Stephens**), the RIBA (**Coyne, Ewing**), and the Carnegie Trust for Scotland (**Pedreschi**), and Partnership Boards of London South Bank and Hong Kong Universities (**McCarthy**). Colleagues served as: Commissioner to the National UK Commission on Women Facing Multiple Disadvantage (**Fitzpatrick**), Poverty and Inequality Commission in Scotland, Chair to the Crisis Independent Panel Review of the Homelessness Legislation in England (**Treanor**), and Trustee of the Scottish Lime Centre Trust (**Banfill**).

Our researchers also **advise community, industry and government bodies**: e.g. to the Scottish Government on their Good Places, Better Health policy development and on implementation of the National Walking Strategy for Scotland, and Health Scotland's Place Standard; Scottish Government's Labour Market Strategy Group; National Institute for Health and Care Excellence (NICE) Centre for Guidelines; NHS Health Scotland Place Standard Community & Practitioner Learning and Development; UK government (Department for Communities and Local Government) on how to increase housing supply and home ownership; Scottish Government on issues of poverty and housing need, particularly on modelling impacts of different policy options; Ministry of Housing, Communities and Local Government on fairer funding review of local government finance; Centre for Accessible Environments; Institute of Global Homelessness, DePaul University, Chicago; Secretary of State for Work and Pensions on universal credit and housing costs; Department of Development and Renovation, Shanghai Research Institute of Building Sciences; Scottish Government Homelessness and Rough Sleeping Action Group; Independent Care Review; Historic England and Cadw on the listing of post-war architecture; and Calton Hill Management Plan Working Group.

We shared our expertise through membership of: Scottish Government's 2017 Planning Review Working Group, which advised on the 2017 Scottish Planning Bill; Scottish Government Homelessness and Rough Sleeping Action Group; Scottish Government Panel to Review the Definition of Fuel Poverty; Scottish Government Homelessness and Rough Sleeping Action Group; Scottish Government Panel to Review the Definition of Fuel Poverty; Joseph Rowntree Foundation's Anti-Poverty Task Group; and senior fellowship in the Centre for Homelessness Impact. We were also on judging panels for: the 2019 'Founders' Award' for the Society of Architectural Historians (USA); Saltire Society Housing Award Panel; Design Review Panel of Architecture and Design Scotland; Arts Advisory Board, Royal Botanical Gardens Edinburgh; and Edinburgh Urban Design Panel.

Our researchers have formed a range of **cross-cutting research groups** that provide agenda-setting incentives for new research projects, including: CLIC-Construct conference; CyberBuild, Global Urban Research Collaborative and the RAEng Centre for Excellence in Sustainable Building Design. **Networks** in which our researchers play an active role include the Restorative Environments Network, Network-Association of European Researchers on Urbanisation in the South (N-AERUS), European Network for Housing Research, Scottish Managed Sustainable Health Network (SMaSH), European Architectural History Network. Our researchers were founding members of agenda-setting networks such as: Temporal Belongings Network; Edinburgh Environmental Humanities Network; Extinction Studies Working Group; Transition Research Network; The Premodern Body Research Group; ECA Colour Collective; LLEAPP

network (Laboratory for Laptop and Electronic Audio Performance Practice); 100 P2P Women Project; Experimental Architecture Group (EAG with Newcastle U); and Biological Architecture Lab (with Newcastle, UCL). Researchers also exert their influence through Independent design and studio **practices**, e.g.: Studio Moffitt (www.studiomoffitt.com) and CNTXT Studio (www.cntxtstudio.com). Fortnightly network seminars on the history of architecture and the built environment attract 20-30 attendees, including representatives from city and national heritage organisations (e.g. Historic Environment Scotland, Architectural Heritage Society Scotland) commended as a "rewarding experience" by the Research Manager at Historic Environment Scotland.

Our researchers have served as **external examiners** for research degrees during the census period in Auckland, Beijing, Birmingham, Cairo, Cambridge, Copenhagen, Delft, Exeter, Helsinki, Istanbul, London, Madrid, Montreal, Newcastle, Nottingham, Oslo, Oxford, Pamplona, Sheffield and Sydney. At the invitation of the Swedish Ministry of Education (UKA), **Dorrian** served as international chair of their first national review of doctoral programmes in architecture (2017-18).

Awards for personal achievements

Apart from outputs and documented impacts, awards for **personal achievements** in research evidence the success of our contribution to the research base, economy and society. **Ward Thompson** was awarded the European Council of Landscape Architecture Schools (ECLAS) 'Outstanding Researcher of 2014' and an honorary doctorate by the Swedish University of Agricultural Sciences in 2017. **Fitzpatrick** was recognised as a Scottish Leader in housing by *Inside Housing* for her influence on the housing agenda in Scotland (2017). Other staff received recognition via: CIOB International Innovation & Research (I&R) Premier Award in the Digital Innovation Award category (**Bosche**); Rushlight's Resource Innovation and Water Management prize (**Jenkins**); best paper award for high level-of-detail BIM and machine learning for automated masonry wall defect surveying 2018 (**Forster**); Key Scientific Article award by Advances in Engineering (**Galbrun**); Jean-Sebastien Thomas Prize best paper at the SAM series of conferences on society and materiality sponsored by the Arcelor-Mittal steel company (**MacKillop**). **Design awards** include: public vote winner An t'Eilean, an Island Gallery space within Inverness Campus in the Scottish Highlands 2014 (**MacKenzie**); and Festival des Architectures Vives Montpellier award from the public 2019 (**Pedreschi**).

Publication and research awards include: best paper award in the special issue of the *International Journal of Environmental Health and Public Health* on Promoting Healthy and Supportive Acoustic Environments (**Payne**); Valerie Karn Housing Studies Association prize; William M. B. Berger Prize for British Art History, the Historians of British Art Book Prize and shortlisting for the Whitfield Prize, Royal Historical Society (**Bremner**); Antoinette Forrester Downing Award by the Society of Architectural Historians for *The Conservation Movement: A History of Architectural Preservation* (**Glendinning**). Our Homelessness Monitor Series was shortlisted for "research project of the year" by *The Guardian* and *The Herald*, and awarded 'highly commended' by *Times Higher*; and co-production of landslide risk management in Latin America was finalist in *Times Higher* "international collaboration of the year."