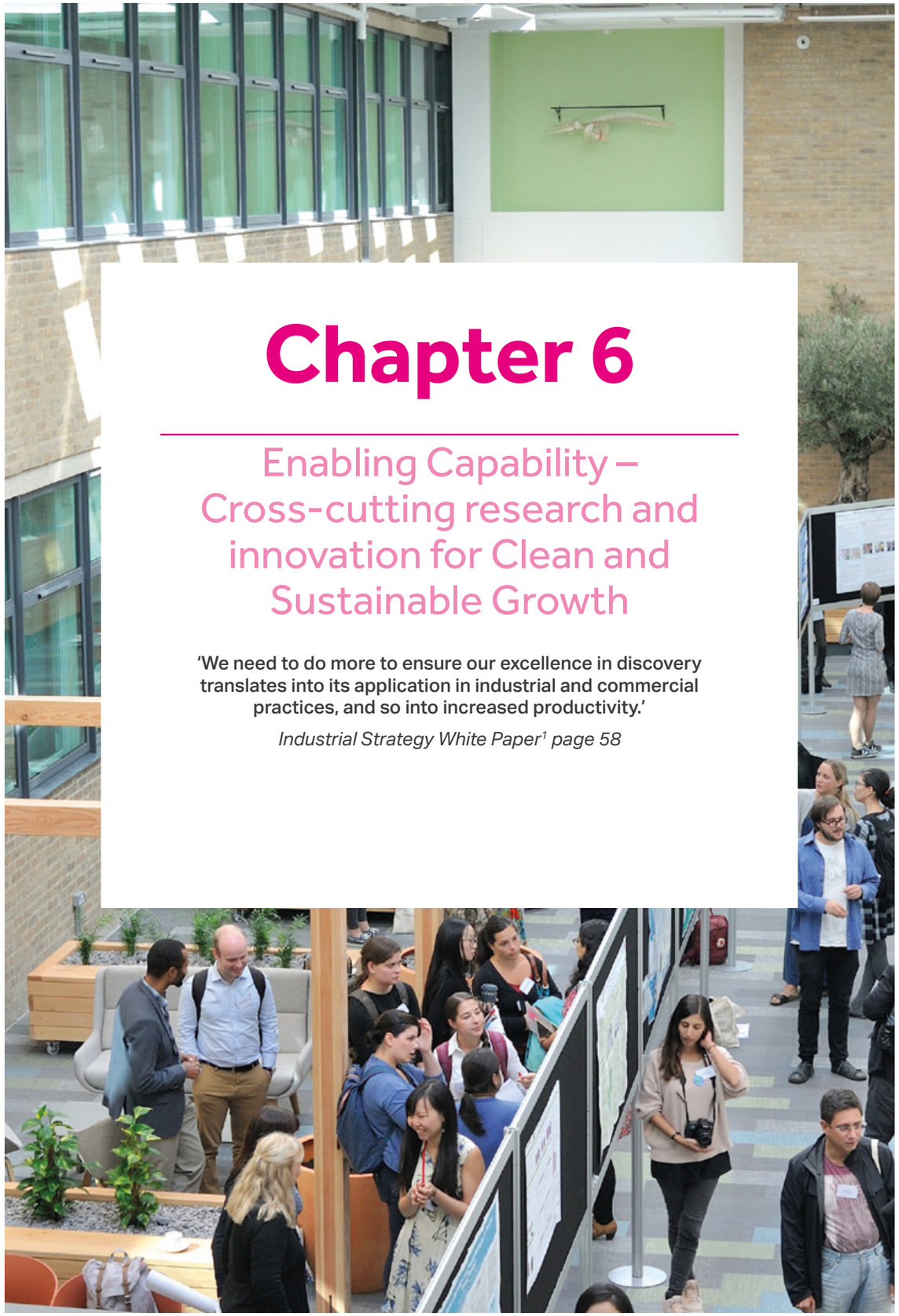


Chapter 6

Enabling Capability – Cross-cutting research and innovation for Clean and Sustainable Growth

'We need to do more to ensure our excellence in discovery translates into its application in industrial and commercial practices, and so into increased productivity.'

Industrial Strategy White Paper[1] page 58

The North West Coastal Arc Clean Growth & Sustainable Partnership and UK strategy documents

Industrial Strategy White Paper[1]
The third chapter- 'ideas'- emphasises the UK's great strength in research and innovation, but also (page 61) highlights as a challenge '…improving our ability to turn exciting ideas into commercial products and services and capture their maximum value' and 'Our world-class science and research does not always feed through to world-leading home-grown businesses.' It goes on to state that 'Within R&D, the 'D' for development needs a particular boost' (page 61) and 'There is no single path to innovation. Successful products and services come from a range of sources – from businesses developing new products and universities creating businesses to the lone inventor commercialising an idea.' (page 72). The fourth chapter of the Industrial Strategy White paper- 'People'- highlights the skills and training agenda, for example on page 97 '…. we need to tackle particular shortages of STEM skills. These skills are important for a range of industries from manufacturing to the arts.' We agree, but also assert that the STEM graduates benefit from a wider skill set to grow innovation leadership (6.3 below).

The Clean Growth Strategy[2]
These statements are echoed in the Clean Growth Strategy, for example on p11 'We are clear about the need to …support entrepreneurs and investors who will develop the new technologies at the scale we need. …It is only through innovation – nurturing better products, processes and systems - that we will see the cost of clean technologies come down.' These statements are very close to our experience of the multi-layered nature of innovation, and are especially relevant to this cross-cutting element that we see as fundamental to the skills needed in both our research organisations and our businesses to translate 'invention' in to 'innovation'.

6.1 National and international trends

As the Industrial Strategy White Paper highlights, all innovation takes place within an interlinked system that starts with research and then progresses through development, demonstration, and adoption. Both the Dowling[25] and Witty[26] reviews noted the difficulties for industry, particularly SMEs, finding appropriate expertise, facilities and equipment for all these stages of innovation. Both reports highlighted this as a significant inhibitor of business innovation and scale-up.

In this SIA, we have asserted that Clean and Sustainable Growth, which cuts across business sectors, research disciplines and multiple aspects of government policy, has a particular need for a 'joined-up' approach that (i) provides an 'escalator' that effectively links research, development, demonstration and adoption and (ii) escapes the conventional business, academic and policy 'silos'. Our consultation with business and other stakeholders supports the fact that this escalator is a critical and underfunded element in the innovation system. However, the audit also shows that the NWCA has significant cross-cutting innovation accelerator capabilities with a proven track-record of success that give us a significant foundation on which to build.

The NWCA's distinctive regional strengths and assets driving innovation in our core prime capabilities of Environmental Industries, Technologies and Services, Future Energy Systems, and Advanced Manufacturing, Chemicals and Materials, are described in previous chapters. However, as discussed in Chapter 1, we treat our prime capabilities as parts of a wider, integrated approach to Clean and Sustainable Growth.

This distinctive approach emerges from the region's successful cross-cutting innovation and productivity accelerators, which are a key element in the region's ability to develop the tools needed to deliver both the Clean Growth Strategy and 25 Year Environment Plan[6]. For this reason, we have treated our 'cross-cutting assets' as a separate capability here.

The combined ability of our higher education institutions to work effectively at the business interface and demonstrate national leadership in knowledge exchange is well-documented and accelerates impact through translation. The region's higher education institutions have distinct and complementary strengths across our knowledge exchange and innovation assets and programmes. As stated in our hypothesis, there is a clear opportunity to optimise the innovation system for Clean and Sustainable Growth through better connectivity across the NWCA, building upon existing and strong collaboration and extending these across our entire regional geography, to drive productivity and growth.

Our Innovation and Productivity Accelerator assets include sector-leading co-location, research support and demonstrator facilities (6.2), innovation and skills/talent development programmes (6.3.1), a world-class research base in disciplines that support and enhance innovation for Clean and Sustainable Growth (6.3.2), and our network of international partnerships that can be leveraged to drive international trade opportunities (6.4). These combine with our unique geographical assets that provide a test-bed for the development of eco-innovative products, processes and services.

'Being based on the campus is of immeasurable value to my business. We have frequent contact with academics from many different departments. We draw upon the academics' expertise, and they often draw upon ours. At any one time there are usually several collaborations going on, some commercial and others research based. Above all we value the continuous exchange of ideas.'

Mike Berners-Lee, Director, Small World Consulting Limited

Table 6.1

Cross-cutting science and innovation accelerator assets in the North West Coastal Arc and their relationships across the three prime capabilities of this SIA

Asset	Location	EITS	FES	AMCM
Advanced Manufacturing and Research Institute	N Wales		×	×
BEACON Biorefining Centre of Excellence	N Wales	×		×
Biocomposites Centre	N Wales	×		×
British Oceanographic Data Centre	M'side	×	×	
Built Environment & Sustainable Technologies Institute at Liverpool John Moores University	M'side	×	×	×
Centre for Ecology & Hydrology	Lancs/ N Wales	×	×	
Centre for Global Eco-Innovation– see page 4	Lancs	×	×	×
Centre for Offshore Renewable Engineering	M'side	×	×	
Combined Food and Power Centre of Excellence	N Wales	×	×	
Environment Centre for Wales at Bangor University	N Wales	×	×	×
Hartree Centre	M'side	×	×	×
Institute for Risk & Uncertainty at Liverpool University	M'side	×	×	×
Lancaster Environment Centre at Lancaster University	Lancs	×	×	
Lancaster Leadership Centre	Lancs	×	×	×
Lloyd's Register Foundation	M'side	×	×	×
Menai Science Park Ltd	N Wales	×	×	
National Oceanography Centre	M'side	×	×	
National Research Network for Low Carbon, Energy and Environment	N Wales	×	×	
Northwest Advanced Manufacturing Research Centre	Lancs		×	×
Optoelectronic Technology Incubation Centre	N Wales		×	×
Quantum Technology Centre	Lancs	×	×	×
School of Environment, Natural Resources and Geography, Bangor University	N Wales	×	×	
School of Ocean Sciences, Bangor	N Wales	×	×	
Sensor City, Liverpool	M'side	×	×	×
Sci-Tech Daresbury	M'side	×	×	×
Unilever R&D	M'side	×		×

6.2 Local science, innovation and industrial assets

6.2.1 Cross-cutting science and Innovation assets: co-location, research-support and demonstrator facilities

As described in Chapters 3-5 many of our research and innovation assets are active across multiple aspects of Clean and Sustainable Growth. Of the sixty internationally significant NWCA research and innovation assets identified by this audit, twenty-seven have activities that extend beyond any single prime capability and eight cross all three capabilities (Table 6.1). These cross-cutting assets provide co-location facilities (6.2.1.1), support for collaborative research and development (6.2.1.2) and demonstration capabilities (6.2.1.3).

The diversity of these cross-cutting science and innovation assets is a further indication of the range of disciplines and sectors required to drive Clean and Sustainable Growth. For example, Sensor City in Merseyside is a collaboration between the University of Liverpool and Liverpool John Moores University and is a flagship University Enterprise Zone. As a technical innovation centre it focusses on the creation, development, production and promotion of cutting edge sensor technologies for use in a wide range of sectors. Positioned at the intersection of industry and academia, Sensor City facilitates connectivity and fosters progress, helping partners to capitalise on the growing sensor revolution. LJMU has been working with United Utilities for over 25 years on innovations in the water and wastewater sector, including the use of novel sensors for water quality monitoring.

6.2.1.1 Co-location facilities

The NWCA's co-location facilities provide the region's innovative, knowledge-based businesses, especially SMEs, with access to the high-quality office and laboratory space, state-of-the-art equipment and infrastructure and research expertise provided by our research base. They include Liverpool Science Park (base for over 60 companies), Sci-Tech Daresbury (c.100 companies), the STFC CERN Business Incubation Centre, the Menai Science Park (M-Spark-just opened and currently 13 companies), The OpTIC Centre (21 companies and organisations), and Lancaster University (60 companies across the Lancaster Environment Centre, InfoLab 21 and cTAP).

6.2.1.2 Innovation support

Across the North West Coastal Arc there are a number of existing, nationally award-winning innovation and R&D support programmes that complement our co-location facilities and provide support for businesses, particularly SMEs, to develop new products, processes and services for Clean and Sustainable Growth. The programmes are designed to meet the barriers to R&D and are aligned to enhance SME leadership and absorptive capacity as critical to driving innovation, productivity and scale-up.

Key exemplars within the NWCA include the Hartree Centre and the Centre for Global Eco-Innovation (CGE), as described on page 20. CGE has grown from a partnership between the universities of Lancaster and Liverpool to now also include University of Cumbria, Liverpool John Moores University and University of Chester.

The Hartree Centre

Located at Daresbury, Cheshire, the Hartree Centre was founded by the UK government in collaboration with IBM in 2012. The centre provides industry and academia with access to advanced high-performance computing technologies, expertise and training to encourage innovation in emerging sectors. The centre encourages interaction between start-ups, large business (e.g. Unilever), and universities. Its success is demonstrated by the demand for business space at the Daresbury site, with demand higher than supply.

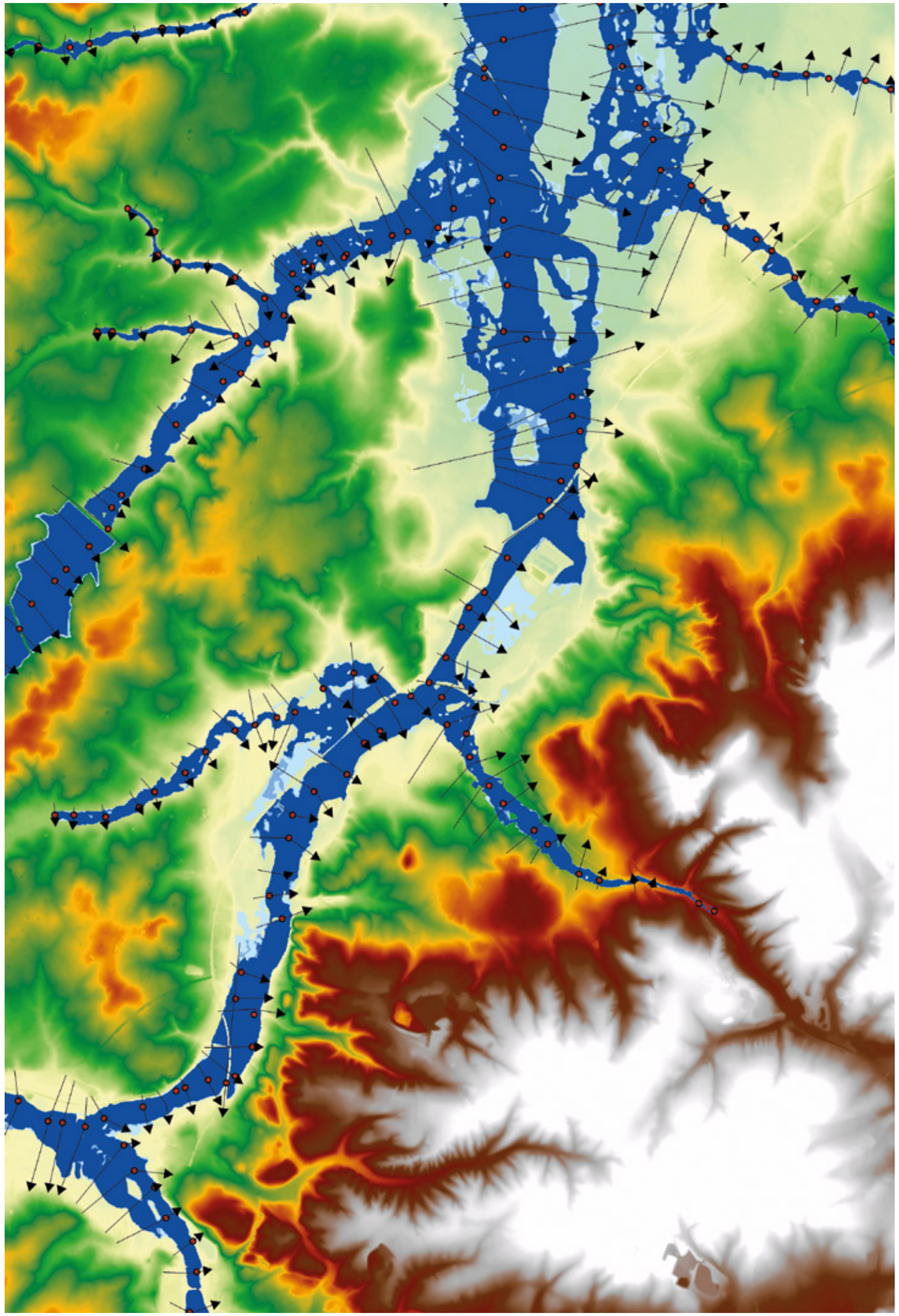
A major feature of Eco-Innovation at Hartree is the ability to take away the requirement for physical testing in many developments, reducing the environmental impact. Further to this, it is involved in Eco-Innovation projects including collaborating with Rolls Royce to make data-based engine energy efficiency improvements, improving factory productivity through layout redesign, and developing future energy systems. The centre also works closely with Unilever to reduce and improve packaging and formulation of products such as shower gels, using digital formulation methods, which also reduces development time.

6.2.1.3 Demonstration

Our audit has highlighted that demonstration is vital to strengthen Clean and Sustainable Growth Innovation across the NWCA. Demonstration enables technology developers, investors, and users to obtain credible information about cost, reliability, safety, and other dimensions of performance under conditions that approximate actual conditions of use. Many of our demonstration facilities exploit the region's geography, including not just our natural and industrial resources but also the power of university campuses as test-beds.

'Key to our success is our alignment with leading academic institutions around the world. We are an Associate Company of the Lancaster Environment Centre, at Lancaster University, providing our staff access to the world class research and development facilities, academic and students on campus.'

Dr Ben Herbert, Director of Research & Environment, Stopford Energy & Environment Ltd



Perhaps inevitably, the region's demonstration facilities are quite focused on specific themes, including the **Minesto Deep project** (N Wales) and **Smart Energy Network Demonstrator** (Staffs page 49) for Future Energy Systems. A notable example for Environmental Industries, Technologies and Services, and strongly linked to elements of the 25 Year Environment Plan, is the **River Eden Demonstration Test Catchment** (Cumbria) which assesses how farming practices can be used to mitigate diffuse pollution from agriculture whilst maintaining food productivity.

For Advanced Manufacturing, Chemicals and Materials, the **Materials Innovation Factor**y (Merseyside page 63) is a £65 million partnership between the University of Liverpool, Unilever and HEFCE (now Research England) to develop a unique materials chemistry research hub. Officially opening in late 2018, it will provide an unparalleled suite of open access, state-of-the-art equipment and internationally-leading academic expertise to develop fundamental innovations in manufacturing at the molecular level and create new materials with step-change functional enhancement in a range of important applications.

6.2.2 Industrial assets

Many of the region's industrial assets relevant to Clean and Sustainable Growth focus largely within one of the three prime capabilities identified in this SIA, described in detail in Chapters 3-5. However, there is also growing recognition across the spectrum from major multi-nationals to SMEs that their activities cut across themes and sectors. This recognition has contributed to the focus of this SIA on improved connectivity across all the region's research, innovation and industrial assets relevant to Clean and Sustainable Growth.

River Eden DTC- a national demonstration test catchment

Climate change and the intensification of agricultural food production pose threats to water quality and aquatic ecosystem functions and services. The Eden DTC in Cumbria was set up as a long-term Defra funded research platform to evaluate mitigating diffuse pollution from agriculture whilst maintaining agricultural productivity.

The DTCs are representative of 80% of UK soil/rainfall combinations and were chosen to build on existing infrastructure, datasets and knowledge. Eden DTC represents a collaborative project led by Lancaster University with CEH Lancaster working closely with local stakeholder practitioners and policy-makers. The project supports the need for landscape-scale demonstration facilities being important to develop the joined-up approach required for EITS to deliver Clean and Sustainable Growth and the wider aims of the 25 Year Environment Plan.

6.3 Local research and innovation talent

6.3.1 Skills - Innovation Leadership and Talent

Leadership and absorptive capacity are well-established skills and talent attributes critical to driving innovation, productivity and scale-up. Unless these needs are addressed then the capacity for technological innovation to drive business growth and productivity is significantly constrained. To address that need, our collaborative activities under the Centre for Global Eco-Innovation (see page 20) and related projects have drawn on the long and successful history of the Lancaster Management School (LUMS) in engaging with SMEs to improve productivity through enhanced leadership.

In particular we have benefitted from LEAD®, a ten-month intensive leadership development programme created by LUMS for owner-managers, MDs, and senior managers of SMEs. The programme is based on high-quality research in the management sciences (see 6.3.2), including research into entrepreneurial learning. To date, LEAD® has supported 1,700 businesses that collectively employ approx. 30,000 people and have a combined turnover of approx. £1 billion. In an independent evaluation[27], 70% of participants reported increased profit and 65% increased productivity. LEAD® has informed policy initiatives[28] and was identified in a House of Lords Report as exemplary in supporting small businesses. The LEAD® programme has also led to the Productivity through People (PtP) programme. The demonstrable synergies between LEAD® and the science and technology elements of the Centre for Global Eco-Innovation are a further demonstration of the capacity of the NWCA partners to develop absorptive capacity and the future talent necessary for establishing the region as an international exemplar for Clean and Sustainable Growth.

6.3.2 Evidence-based assessment of the region's existing cross-cutting research and innovation talent

As with other capabilities, we have compared research quality in this cross-cutting theme as the percentage of outputs in the top 1% of citations in the field, and comparing the NWCA with leading groupings, plus California as a region recognised for its global leadership in innovation (Figure 6.1). The disciplines here are diverse, but united in their contribution to underpinning and enhancing the region's strengths in the science and technology of Clean and Sustainable Growth. For example, the region has outstanding research excellence in Statistics, Probability and Uncertainty, well ahead of all our comparators.

Productivity through People Programme

The LEAD® programme has created a culture of increasingly strong engagement with corporate anchor organisations and their supply chains, for example, BAE Systems and Siemens, where LUMS has facilitated the development of enhanced absorptive capacity at the interface between large and small businesses.

BAE Systems' experience of the benefits of LEAD® led to the development of the Productivity through People (PtP), a nationally unique programme focused on behavioural change within advanced manufacturing owner/managers to empower positive employee engagement to boost productivity. Supported by BAE Systems, Rolls Royce and Siemens, a pilot programme is being delivered within the Northwest. While focused on Advanced manufacturing (Chapter 5) the approaches that PtP is developing can be applied across all aspects of Clean and Sustainable Growth.

Lancaster is emerging as the leading university in the National Programme Network tasked with scaling the programme nationally in support of the newly formed Be the Business (formerly the Productivity Leadership Council). The national rollout will enable the university to support universities in the NWCA and across the UK to develop appropriately 'localised' versions of the PtP programme, resulting in significant productivity improvements within participating SMEs at a national scale and more broadly, help inform future Government industrial policy.

This is a key 'Decision Science' that, for example, underpins both prediction of extreme events such as flooding and understanding the interface of highly variable energy generation from renewables with varying demand. This strength also interfaces with digital and sensor technologies (e.g. Sensor City in Merseyside) and Data Science relevant to the sectors and disciplines covered by this audit, including Computers in Earth Science (where the NWCA is ahead of all our comparators except California). Management Science and Operations Research is similarly outstanding, and in combination with strengths in 'Strategy and Management' and 'Management of Technology and Innovation' frames our technical innovation strengths with world-class management science research.

The final element included under this cross-cutting theme is SCIVAL's 'multidisciplinary' category (Figure 6.1). This category includes journals, such as Nature and Science, generally recognised as the natural outlet for the very highest quality research across all scientific disciplines. The NWCA's performance under this heading, comparable to California and ahead of all our other competitors, reinforces our assertion that our success with delivering 'impactful' research with SMEs does not prevent the region from producing publications at the very top of global research outputs.

The NWCA's integrated research quality in these cross-cutting disciplines (Figure 6.2) is higher than that of all our comparators. This highlights the NWCA's strength in this broad basket of disciplines that support the more focused 'science and technology' of our other themes.

We assert that this has been part of the region's current success in leveraging our world-leading research in EITS, FES and AMCM to support our region's businesses, especially SMEs. It has allowed us to move beyond 'invention' to deliver real innovation, for example through our shared activities around the Centre for Global Eco-innovation (see page 20). It is at the heart of the NWCA's holistic vision of Clean and Sustainable Growth.

6.4 National and international engagement: HEIs as drivers of internationalisation

UK manufacturing recently posted its biggest fall in production in over five years. It has been proposed that one of the reasons for this is manufacturing companies not taking the opportunity to export more using the benefit of a more competitive exchange rate. This is turn has constrained improvements in UK trade figures.

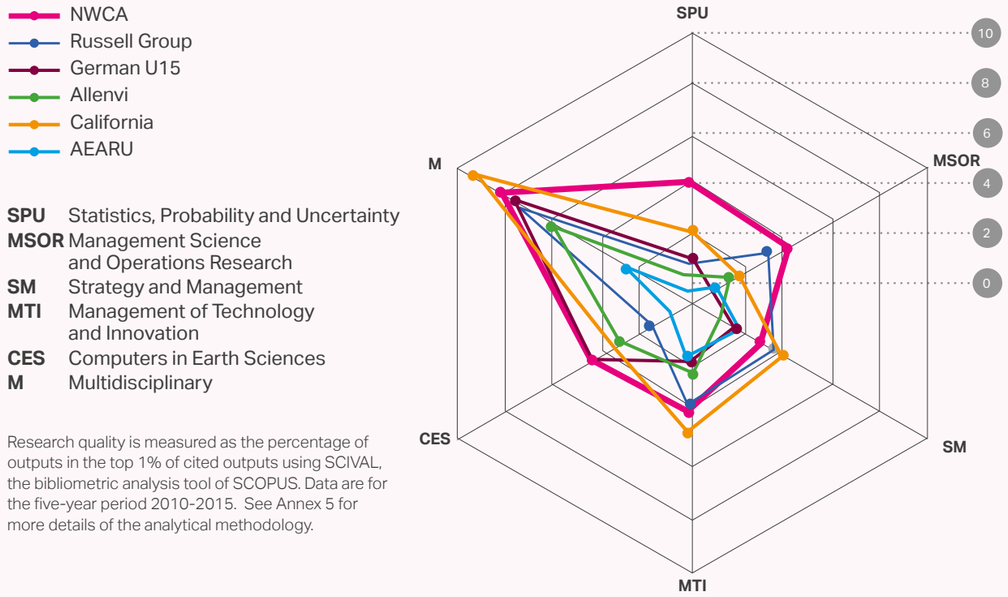
Products, processes and services for Clean and Sustainable Growth offer significant opportunities to scale-up export trade with the growing economies of China, India, the Middle East and Africa. The 2015 Goldman Sachs report 'Unlocking UK Productivity: Internationalisation and Innovation in SMEs'[29] highlights the importance of SME engagement with the global market place and innovation as key to driving productivity and shaping the future growth trajectory of the UK economy. It also notes that only approx. 20% of SMEs are exporters, with only 5% classified as 'persistent exporters'.

'Our business chose to locate in the region due to Keele University – They showed the most interest in our technology, offered a position at the Energy Hub and provided an independent academic assessment of noise and vibration.'

Philip Mayer, Chairman, McCamley UK

Figure 6.1

Research quality for the NWCA in the six sub-disciplines included under our cross-cutting research capability, compared with other major university groups or regions.

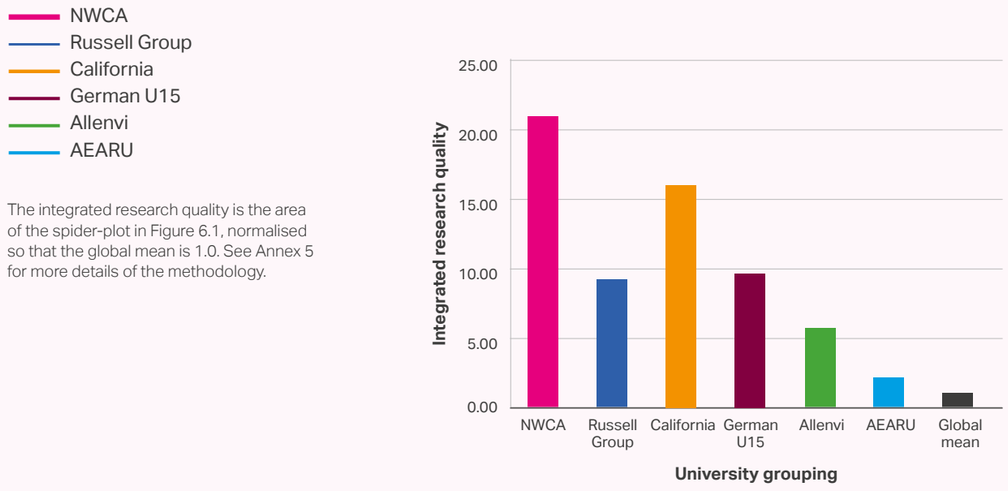


SPU Statistics, Probability and Uncertainty
MSOR Management Science and Operations Research
SM Strategy and Management
MTI Management of Technology and Innovation
CES Computers in Earth Sciences
M Multidisciplinary

Research quality is measured as the percentage of outputs in the top 1% of cited outputs using SCIVAL, the bibliometric analysis tool of SCOPUS. Data are for the five-year period 2010-2015. See Annex 5 for more details of the analytical methodology.

Figure 6.2

Integrated research quality across our cross-cutting research capability for the NWCA compared with other major university groups or regions.



The integrated research quality is the area of the spider-plot in Figure 6.1, normalised so that the global mean is 1.0. See Annex 5 for more details of the methodology.

One key barrier identified by that report was gaining access to networks, and the 2016 Universities UK 'International Innovation by UK Universities' report[30], highlights the potential of universities to deliver a wide range of beneficial outcomes including 'building new global partnerships', especially for SMEs. The report also highlights that HE can provide a robust stabilising framework for international collaboration that enables universities and businesses to access different or larger markets and resources.

The NWCA universities have significant 'on-the-ground' presence in key export markets (Table 6.2). These already provide opportunities to show-case leading-edge technology, serve as an intermediary to bring together innovators and funders, to support international commercialisation opportunities for SMEs, and to streamline international technology transfer and knowledge exchange. However, while the activities of NWCA partners in this sphere are significant they are currently entirely unconnected. This audit highlights the further clear scope for increased collaboration with our regional corporate partners to exploit their international market presence and global supply chain opportunities for Northwest SMEs looking to trade internationally.

The role of 'Decision Science' in supporting Clean and Sustainable Growth: JBA Consulting

Risk-based analysis of extreme weather events using computer models has numerous applications cutting across infrastructure, land management, community resilience and other economically and socially beneficial applications. One such application is in managing the risk of flooding. Improved flood risk modelling based on the application of research* led by Lancaster University has had global impacts in improved flood defence policies and planning by governments, and in assisting insurers with their underwriting**, for example in pricing and policy decisions. Technological advances in data science, have allowed JBA Consulting to develop the world's first commercially successful GPU-based flood model, and Lancaster to produce the first probabilistic flood risk maps. Data generated by JBA's software system has since been used by government and insurers in the UK (including the top five UK insurers by market share) and world-wide.

In the marine environment, collaboration with Lancaster University and others has helped JBA to support growth in offshore renewables with commercial products and services that enable resilient operations planning, combining analysis of offshore weather extremes, risk profiling and optimisation technology. These innovations in EITS highlight the value and opportunity created by inter-disciplinary and multi-sectoral collaborations (in this case, drawing on research across both physical and mathematical sciences, and finding routes to market within the public sector, and private financial services, energy and infrastructure sectors).

*REF2014 Impact Case Study: Societal and economic benefits from improved flood modelling based on pioneering Lancaster research in to risk and uncertainty in environmental modelling. Lancaster University.

** REF2014 Impact Case Study: Optimisation of the UK's flood defence infrastructure through the use of innovative statistical research on extreme values Lancaster University.

'If we want to achieve clean growth and resilience with innovative ways of enhancing natural capital, then we need to test new approaches to our use of land, air and water at large scales.

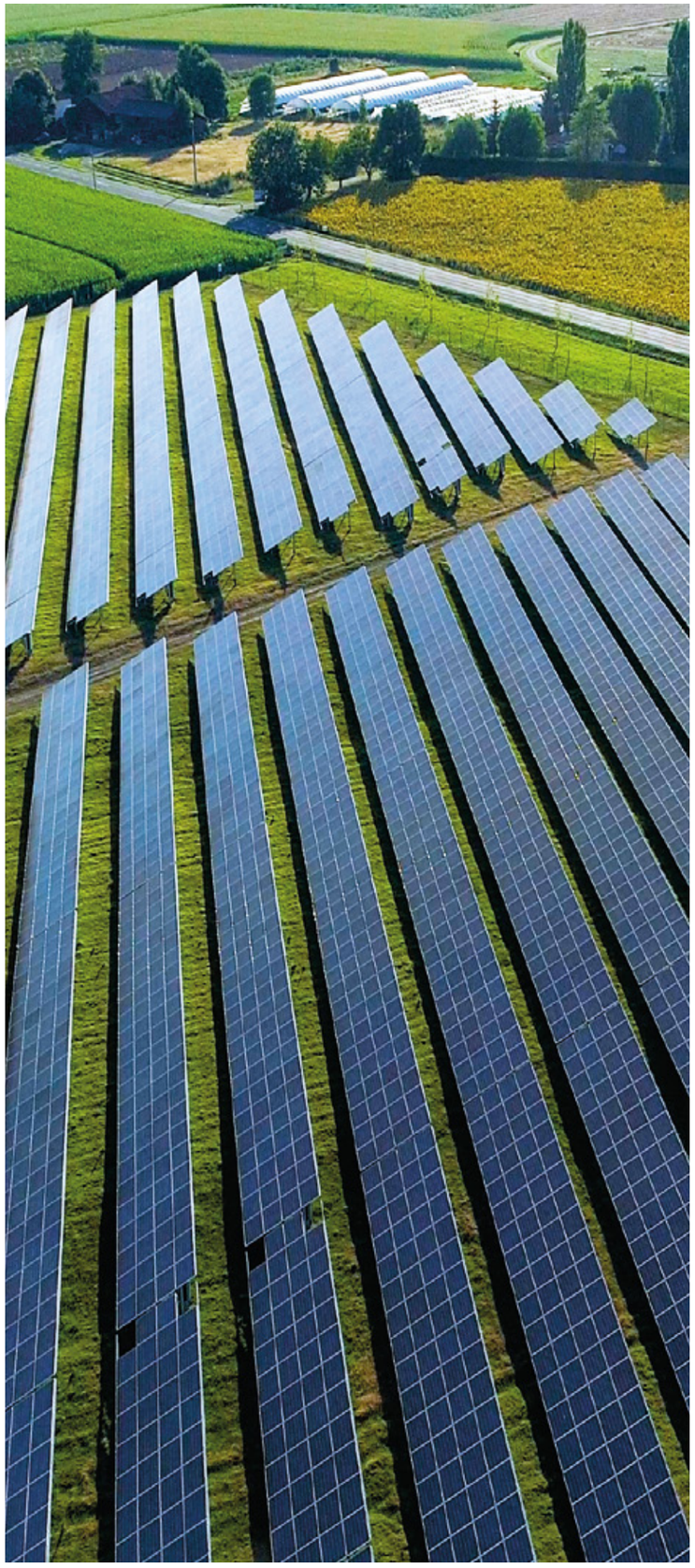
The step up from small pilots to full scale implementation can be supported by models, but landscape scale demonstrators are vital to confirm those models and provide evidence for investment planning.'

Professor Rob Lamb, Managing Director, JBA Trust

Table 6.2

International research innovation and engagement assets of HEIs in the North West Coastal Arc™

China	UCLAN	Shenzen Office for Research & Innovation undertakes partnership development work, research development and support to UK and Chinese entrepreneurs.
	Lancaster	New Lancaster University College-Beijing Jiaotong University and the HEFCE-supported Lancaster China Catalyst Programme (Annex 7) all support the creation of partnerships between UK SMEs and Chinese partners to develop new eco-innovative products, processes and services for the Chinese marketplace.
	Lancaster	International Research & Innovation Centre for the Environment (I-RICE) based in Guangzhou, is a joint venture between Lancaster University and The Chinese Academy of Sciences.
	Liverpool	Xi'an Jiotong-Liverpool University (XJTLU) and its recently established International Technology Transfer Office.
	Bangor	Bangor College China (BCC) is a collaboration founded in 2013 between Bangor and the Central South University of Forestry and Technology (CSUFT) in Hunan Province.
	Bangor	The UK-China Centre for Improved Nitrogen Agronomy (CINAg), is led by Rothamsted Research and include Bangor as one of the collaboration partners.
SE Asia	Lancaster	Sunway University, Malaysia and Lancaster University established a partnership in 2006 which is developing beyond teaching towards research and innovation.
	Lancaster	LU Ghana represents the first British branch campus in Ghana with development of a new 'Centre for West African Studies' underway focused on research and business innovation across science and management.
Sub-Saharan Africa	Lancaster	CGE Nigeria was launched in 2016 as the first international satellite for the Centre for Global Eco-Innovation.
	Lancaster	GCRF-funded RECIRCULATE is a 4 year, £7M programme with partners in sub-Saharan African to develop new partnership-based approaches to develop capacity to harness Clean and Sustainable Growth opportunities that support the sustainable use of water for food, energy and sanitation.



6.5 Developments in the wider funding landscape

The **Global Challenge Research Fund** represents 0.7% of UK GDP that is focused on research and innovation to support sustainable development. It presents an opportunity for the region's excellent research base to support access to secure and resilient food systems, sustainable health and wellbeing, clean air, water and sanitation and affordable and sustainable energy in developing countries across the globe. In doing so, there may be opportunities to involve our SMEs and other partners as researchers to develop strong and durable international networks.

The **UKRI Strength in Places Fund (SIPF)** led by UK Research and Innovation, represents a new competitive funding scheme that takes a place-based approach to research and innovation funding, to support significant relative regional growth. It will be driven by business need that can be met by existing research strengths. Funding will be competitively awarded to consortia representing 'economic geographies' across the UK that (a) have existing research excellence and high-quality innovation capability that are focused on wealth creating opportunities and aligned to the needs of their local industry and business supply chains; and (b) where activities are likely to bring significant, relative economic impact and regional growth. Activities that will be funded will need to show a significant positive impact in rate of growth, relative to the baseline for the chosen delivery geography.

Both of these schemes present significant regional through to international opportunities for increased collaboration between our region's science and innovation base to drive further growth across the NWCA's Clean and Sustainable Growth industries.