Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex K: Resilience, Environment and Sustainability Theme Report

A Science and Innovation Audit Report sponsored by
the Department for Business, Energy and Industrial Strategy

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Annex K: Resilience, Environment and Sustainability Theme Report

1. Introduction

The Resilience, Environment and Sustainability theme of the Audit has been undertaken to assess the opportunities for the region to enhance prosperity and resilience associated with climate and environmental change and sustainable development. Quotes from business, captured through an independently commissioned survey, highlight the essence of the theme: "*new business models will be unlocked through future energy and environmental demands and concerns*", "*the mood and the climate is think differently, do things differently, look for different opportunities*".

This theme recognises the extensive, vibrant and internationally excellent capability, assets, and research in the region and builds on a broad environmental goods and services sector, alongside regional priority sectors in environmental futures, agri-food/tech, energy, digital, water, low carbon and high value manufacturing. Over a quarter of the UK's major environmental research organisations have a base in the region and there are almost 2,000 scientists working in relevant areas. The total research expenditure on this theme in 2014-15 was £271m, and relevant university research activity is showing much stronger growth compared to the Russell Group. There are 25,000 enterprises in the region based in sectors relevant to the theme and 153,000 jobs. Employment has grown sixteen times faster than other sectors in the region. In Devon the concentration of environmental scientists is four times higher than the national average.

This theme is also aligned with global drivers, such as the recent development of the UN Sustainable Development Goals and the Paris Climate Agreement in 2015. Regional strengths and support for the climate change and sustainable development agendas, challenges and opportunities are extensive – for example, the region has a higher number of contributors to the 2014 UN IPCC 5th Assessment Report than any other area in the World. Addressing these challenges means there is an urgent need to utilise environmental data to tackle the risks from natural hazards and protect the resilience of socio-economic systems. There is also a huge opportunity surrounding the technology and innovation that will be required to live sustainably.

Building on this evidence, stakeholder and business communities have identified two areas where the region has the potential to be globally competitive in science and innovation: Environmental Risk and Data, and Sustainable Technologies and Development. These are reinforced by existing and planned regional and LEP strategies and investments. See Figure RES1 for a summary of the Audit findings for this theme.

This report references publically available and novel datasets and publications, and has been developed in consultation and dialogue with both the academic and business communities in the region, via a dedicated theme review panel, a workshop held on the 14th June 2016 representing over 30 stakeholders, and an independently commissioned industry survey (Appendix RES1).

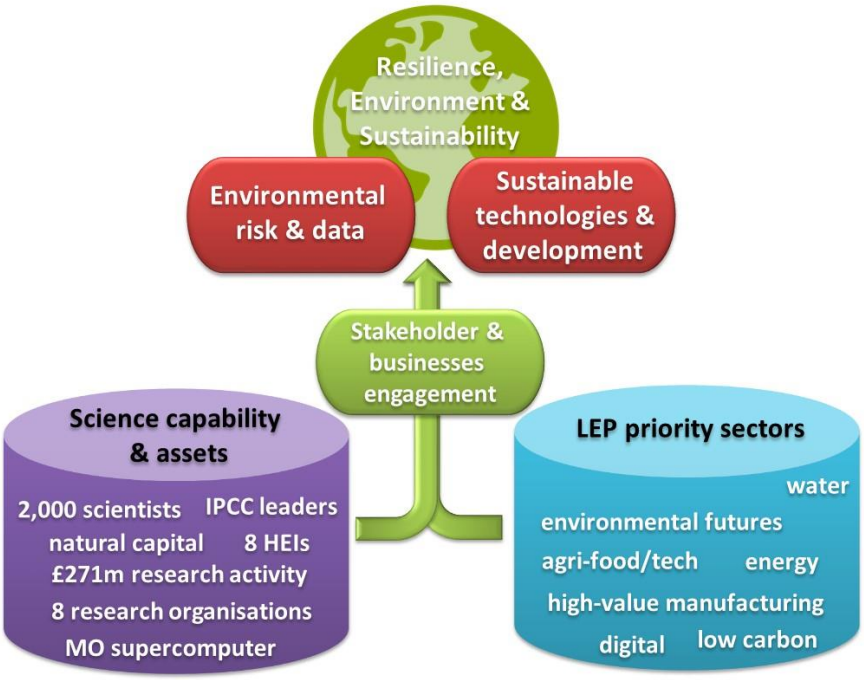

Figure RES1: Summary of Theme findings.

2. Regional science and innovation assets

27% of the major public research organisations in the UK with relevance to resilience, environment and sustainability are based in the South West. Priority industry sectors identified by LEPs include agri-food/tech, energy, water, low carbon and high value manufacturing building on a broad–based environmental goods and services sector, and including a number of large engineering service companies.

Research facilities

The region has a strong consortium of universities and research organisations working in a broad range of science areas relevant to the theme. Full details in Appendix RES2. Highlights include:

- University of Bath: Centre for Sustainable Chemical Technologies, Institute for Sustainable Energy and Environment, BRE Centre for Innovative Construction Materials, Weather Forecast Group.
- University of Bristol: Cabot Institute, world class and multidisciplinary expertise to tackle the challenges of environmental change, including research centres in Global Change, Food Security, Global Dynamic Environment, Glaciology, Environmental Risk, Bristol Water Initiative.
- University of Cardiff: Sustainable Places Research Institute, Sustainable Building Design, Building Systems and Informatics, Cardiff Catalysis Institute, Cardiff Water Research Institute.
- University of Exeter: Environment and Sustainability Institute, Land, Environment, Economics and Policy group, £9m ecotoxicology aquarium, Centre for Water Systems, Exeter Climate Systems, Sustainable Materials, Earth Systems Science, Food Security.

- University of Gloucestershire: Countryside and Community Research Institute, internationally-recognised centre of excellence in applied rural research, working at the interface of agriculture, environment, and society, on rural, urban, regional development.
- University of Plymouth: Marine Institute (coastal and ocean science, marine biology and conservation, marine geoscience etc.), and Sustainable Earth Institute (bringing researchers together with businesses, community groups and individuals to develop cutting-edge research and innovative approaches that build resilience to global challenges) with research centres in environment and sustainability covering earth and environmental science, transport and motilities, climate change, food security, sustainable business solutions, sustainable architecture and lifestyles, sustainable health and wellbeing and environmental pollution
- Met Office: world leading expertise in weather and climate science and data analytics, coupled to its soon to be opened next generation supercomputer (£97m), and supported by its leading Hadley Centre for Climate Science and Informatics Lab.
- Plymouth Marine Laboratory (PML): an independent, impartial provider of scientific research and contract services, developing and applying world-leading, integrated marine science towards the sustainable future of the ocean.
- Rothamsted North Wyke: longest running agricultural research station in the World, the most instrumented farm in the world, assessing whole life livestock grazing systems from an economic, animal husbandry, product quality and environmental perspective, a BBSRC National Capability, and a National AgriTech Centre of Innovation Excellence in Livestock node (University of Bristol also a partner).
- UK Hydrographic Office (UKHO): an executive agency of the MoD, producing nautical publications and services for the Royal Navy and merchant shipping, to protect lives at sea.
- Marine Biological Association (MBA): a charity which promotes the scientific research into all aspects of life in the sea and their complex interactions with the environment.
- Sir Alister Hardy Foundation for Ocean Science (SAHFOS): an international charity operating the Continuous Plankton Recorder Survey, focusing on the impacts of environmental change.

Science and innovation assets

In addition to the above research facilities the region also boasts a broad range of relevant science and innovation assets (Appendix RES2), highlights include; Goonhilly Earth Station; Satellite Applications Catapult Centre of Excellence; Flood Forecasting Centre; Environment Agency, HQ in Bristol; Natural Resources Wales, HQ in Cardiff; large R&D proactive water companies - South West Water (and wider Pennon Group), Wessex Water and Welsh Water; Water Research Centre (WRc), Swindon; Brixham Blue Environmental Hub; Westcountry Rivers Trust. Future Farm at Duchy College; UK Catalysis Hub, Exeter Science Park & Global Environmental Futures Campus, Plymouth Science Park –an established cluster of a range of future environmental technology companies. There are also a number of large engineering services companies based in the region that have broad capabilities in resilience, environment and sustainability (such as C2HM, WS Atkins, WSP, ARUP, RSKW).

Natural capital

The region is rich in natural capital - and the ecosystem services that derive from them - and is reliant upon them to power economic growth. Its National Parks, Areas of Natural Beauty and Heritage Sites attract more domestic tourists than any other UK region[1]. It is home to the three largest fishing ports in England and Wales, 24 shellfisheries[2] and, soon, the largest offshore mussel farm in Europe. Employment in sectors that depend directly on natural capital, such as agriculture and fisheries, and tourism is proportionately higher than any other UK area[3,4]. In addition, the Region has increasing activity within the renewable energy industry – including wave, wind and bioenergy assets. Each of these exploit regional natural capital and are imperative in development of a resilient and circular economy, but can have both positive and negative impacts on other ecosystem services. Efficient and effective development of this industry is therefore inherently connected with environmental science (for example, development of algae as a biofuel, modelling of atmospheric and oceanographic flow for wind and tidal energy, and economics of ecosystem services). Renewable energy is covered by the New Energy theme of the Audit and thus explicitly excluded from analysis.

Regional policymakers have identified the natural environment as a key driver of prosperity and wellbeing. The Cornwall and Isles of Scilly (CIoS) LEP[5] sees the area as 'a green exemplar' built around the concept of 'environmental growth'. This vision is shared by the Heart of the South West (HotSW) LEP, which has established an environmental resilience task and finish group and has recently published a report on 'The environment as a driver for economic growth[6]. Both these LEPs are prioritising the creation of higher value jobs in established natural capital sectors like farming, fisheries and tourism. Gloucestershire LEP[7] has identified key areas for investment in relation to natural capital including: developing quality habitats through green infrastructure; promoting natural capital as a driver for inward investment; and piloting biodiversity offsetting and markets for ecosystem services. The West of England LEP Strategic Economic Plan has identified Payments for Ecosystem Services Support as a new market with large growth potential[8].

[1] ONS 2010 Regional Trends 42, 43-59
[2] Pennon Group Annual Report 2016 - http://www.pennon-group.co.uk/sites/default/files/downloadable/pdf/Pennon_AR16_FINAL.pdf
[3] ONS (2016) Workforce jobs by region and industry, ONS, London
[4] Farm Business Survey (2013) The Contribution made by the farming sector in the South West
[5] http://www.cioslep.com/assets/file/LEP%20Strategic%20Economic%20Plan_V3.pdf
[6] THE ENVIRONMENT AS A DRIVER FOR ECONOMIC GROWTH - RECOMMENDATIONS REPORT, 2016
[7] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf
[8] West of England LEP Strategic Economic Plan, Outline business cases for the local growth fund current 2 year programme

Student population

According to the SIA Technopolis report[9], the number of students (HEI and FEI) produced by the region (excluding SE Wales) in 2015 in relevant subject areas is 111,635 (areas include Agriculture, Architecture, Building and Planning, Biological Sciences, Computer Science, Engineering, Geography, Physical Sciences). The largest cohort is in Biological Science in the HotSW (27,750) and Engineering in HotSW (17,025).

Further analysis of the 2013/14 HEFCE Local HE Profile data[10] (excluding SE Wales) was undertaken to determine higher education strengths (measured in terms of the proportion of all students studying each subject by LEP area, relative to the England average) (Appendix RES3). For HE students in universities particular strengths relevant to the theme were identified as follows: Geographical Studies in CIoS; Biological Sciences and Agriculture and related subjects in Gloucestershire; Biological Sciences and Geographical Studies in HotSW; Engineering and Technology in West of England. For HE students in further education: Biological Sciences and Agriculture and related subjects in CIoS; Biological Sciences and Agriculture and related subjects in Gloucestershire; Engineering and Technology in HotSW; Computer Science in West of England.

SIC employment and enterprise analysis

The Resilience, Environment and Sustainability sector is very broad and doesn't conform to standard industry classifications; this makes use of standard measures of economic activity challenging. However, through using a suite of proxy SIC codes, building on the traditional definition of 'environmental goods and services' we have undertaken some analysis to estimate the scale of relevant business activity in the region (Annex M).

On this basis the sector accounts for 153,100 jobs across the consortia area. The largest sectors are: other engineering activities (24,600), computer consultancy activities (20,800), other information technology and computer service activities (10,000) and business and domestic software development (8,600). Employment in the sector has grown strongly over the last 5 years, with total employment increasing by 16% across the region between 2009 and 2014 compared with the 1% growth recorded across all sectors locally. Taken as a whole, the sector accounts for a similar share of employee jobs (5.9%) to the Great Britain average (6.3%). Full details can be found in Annex M, but particularly high employee location quotients were found in sectors such as: Water collection, treatment and supply, Other research and experimental development on natural sciences, Sewerage, Engineering design activities for industrial process and production, Urban planning and landscape architectural activities, Data processing, hosting and related activities, Non-life insurance, Recovery of sorted materials.

As with employment, the number of enterprises has grown strongly over the last 5 years**Error! Reference source not found.**. In 2015, there were 25,295 enterprises operating within the Resilience, Environment and Sustainability sector across the region. The largest numbers of enterprises in Computer consultancy activities (6,610), Other

[9] Source - Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/

[10] http://www.hefce.ac.uk/analysis/maps/

engineering activities (3,805), Other professional scientific and technical activities (3,125), Business and domestic software development (2,170), Other information technology and computer service activities (1,960), Specialised design activities (1,710). Particularly high enterprise location quotients where found in sectors such as Manufacture of other inorganic basic chemicals, Water collection, treatment and supply, Satellite telecommunication activities, Passenger rail transport, interurban, Manufacture of other organic basic chemicals.

Industry landscape and workforce by LEP area

Further detail on the industry landscape in the region, as described by the relevant LEPs, is provided in Appendix RES2C, specific highlights include:

- Agri-food is a key sector in CIoS, accounting for about 25,000 jobs[11]. Agriculture is responsible for about three times as much employment in Cornwall as it is generally in Great Britain[12].
- The agriculture and water sectors in Gloucestershire are over-represented relative to the UK[13].
- The Agri-food chain is an important part of the economy in the HotSW LEP area, and agriculture, forestry and fishing represent 17.7% of businesses compared to 5.2% for England[14].
- High value manufacturing and the low carbon economy have been identified as priority sectors by the Swindon and Wiltshire LEP[15]. 2,100 firms in the land-based agriculture, food and drink industries employ 6,100 people in the area, representing a 57% higher concentration compared with the national average, with an output of £347m per annum or 4% of total output.
- Low Carbon Industries[16] have a sustainable comparative advantage in the West of England LEP, employing 2,600 people within around 700 enterprises in 2010.
- The Energy and Environmental sector in Wales has a market value of £4.7bn employing about 58,000 people in 2,066 companies. This turnover has increase by

[11] Cornwall and the Isles of Scilly LEP: Strategy and Business Plan, Evidence Base Papers: 6 – Sectors across Cornwall and the Isles of Scilly. http://www.cioslep.com/assets/file/LEP%20Strategy/Evidence%20Base%206.pdf

[12] *A review of Cornwall's Agri-Food Industry* Centre for Rural Policy Research, University of Exeter, 2011.

[13] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf

[14] Heart of the SW Smart Specialisation Approach, 2015. http://www.heartofswlep.co.uk/sites/default/files/user-1889/Appendix%203%20-%20Smart%20Specialisation%20Approach.pdf

[15] SWLEP Strategic Economic Plan, http://www.swlep.co.uk/resources/document635997701081146000.pdf

[16] Sector Skills & Competitiveness Statement - Low Carbon Industries. http://www.westofengland.org/media/200539/environmental%20technology.pdf

90% between 2006 and 2014[17], and outperformed the majority of other sectors in Wales.

- Analysis undertaken for the HotSW and CIoS LEP areas, shows that the universities of Exeter, Plymouth and PML have directly worked with and supported over 1,000 businesses in the region in environmental science and sustainability related sectors since 2010 (agriculture, forestry & land management, aquaculture and fishing, environmental consultancy, environmental technologies and engineering, ICT and sensor technologies, utilities and renewables).

3. Excellence in science and research

The region demonstrates a significant intensity of internationally excellent science in a breadth of relevant academic disciplines, with nearly 2,000 scientists currently working in relevant areas, £271m research activity in 2014/15 and presence of 27% of the UK's major environmental research organisations. Devon in particular has 4 times more environmental scientists than the national average. The region's science strengths in comparison to the rest of the UK are in geography, chemistry, engineering, earth and environmental sciences. This science capability in the region is vibrant and growing faster than national comparators.

Research Excellence Framework 2014 (REF)
The theme covers a very broad range of academic disciplines, stretching across 35 REF Units of Assessment (UoAs), with 742 FTE academic staff relevant to the theme submitted to REF in 2014 (Appendix RES4). Based on this data, 77% of the science conducted across all relevant UoAs and institutions was judged to be internationally excellent (% 3* and 4*).

Particular disciplines where there was a concentration of high quality outputs and significant volumes of staff submitted (>40) to REF 2014 relevant to the theme were UoA 5: Biological Sciences, UoA 6: Agriculture, Veterinary & Food, UoA 7: Earth Systems & Environmental Science, UoA 8: Chemistry, UoA 15: General Engineering, UoA 16: Architecture, Built Environment & Planning, UoA 17: Geography.

When the Research Power[18] for these UoAs in REF 2014 was analysed against the leading UK HEIs, a particular strength of the consortium was identified in Geography (Appendix RES5)**.** There was also 32% more scientists working in these UoAs (based on staff submitted to REF 2014) in the consortium (27.5%) compared to the average for the UK (20.9%), showing an intensity of relevant academic expertise (Appendix RES6).

Other particular highlights for the consortium in REF 2014 compared to the rest of the UK include:

- UoA 6 (Agriculture, Veterinary & Food): Bristol 6th in proportion of 3* and 4* outputs.

[17] Mapping of the Energy & Environment Sector in Wales. http://gov.wales/docs/det/publications/140819-energy-environment-sector-mapping-study-executive-summary-en.pdf
[18] Research Power = calculated by multiplying the UoA's overall grade point average by the number of staff submitted to the REF for that UoA

- UoA 7 (Earth Systems & Environmental Science): Bristol 1st and Cardiff 4th in proportion of 3* and 4* outputs, Bristol and Exeter joint 1st in proportion of 3* and 4* impact
- UoA 8 (Chemistry): Bristol 4th in Research Power; Bath 2nd, Bristol 3rd, Cardiff 10th in proportion of 3* and 4* outputs.
- UoA 14 (Civil and Construction Engineering): Cardiff 1st in proportion of 3* and 4* outputs.
- UoA 15 (General Engineering): Bristol 4th in Research Power; Cardiff 6th, Exeter 7th, Bristol 15th in proportion of 3* and 4* outputs.
- UoA 16 (Architecture, Built Environment and Planning): Bath 1st, Gloucestershire 4th, Cardiff 8th in proportion of 3* and 4* outputs.
- UoA 17 (Geography): Exeter 4th and Bristol 5th in Research Power.

Current scientific activity

Our analysis of current academic activity indicates that there are nearly 2,000 scientists working in areas related to the theme. This is made up from a total of 1,119 staff at HEIs: Bath (209); Bristol (357); Cardiff (159); Cardiff Met (8); Exeter (193); Gloucestershire (16); Plymouth (103); Royal Agricultural University (RAU) (22); University of the West of England (52), and 858 at the major Research Organisations: MBA (8); Met Office (639); PML (98); Rothamsted North Wyke (25); SAHFOS (35); UKHO (53).

We have also undertaken a mapping exercise of the major UK Research Organisations relevant to the theme, and identified 33 separate organisations (Appendix RES7). 9 of these (27%) are within the South West and South East Wales area.

To give a further indication of the intensity of current relevant scientific expertise within the consortium, we have combined the numbers of relevant scientists (FTE submitted in REF 2014 UoAs 5, 6, 7, 8, 15, 16, 17) with current staff and scientist numbers in relevant research organisations. This has then been compared to the numbers of people in employment in 2016 (by workforce from Nomis[19]) in science professional roles. This analysis has identified a particular hot spot of relevant scientific activity in Devon (Appendix RES8), indicating that approximately 3.4% of people employed in professional science roles are working in areas relevant to the theme, this compares to a UK average of 0.8% (i.e. four times higher than the national average).

Doctoral training

Analysis of REF data indicates that during 2008-2012, 2,403 doctorates were awarded for the consortium in relevant UoAs (Appendix RES9). The highest numbers were seen in Chemistry (583) accounting for 12.3% of the UK total in this UoA, General Engineering (561) accounting for 10.3% of the UK total and Biological Science (500) accounting for 7.7% of the UK total. Further evidence of our production of quality relevant doctorates can be seen in the breadth of 11 current relevant doctoral training partnerships and collaborative doctoral training centres (Appendix RES910).

Publication analysis

[19] https://www.nomisweb.co.uk/

Analysis of publication data in SciVal was based on ASJC journal categories (Appendix RES11). These categories were chosen on the basis of those most relevant to the consortium within the theme. In all journal categories analysed the SIA consortium showed a greater proportion of outputs in the top 10% of the world compared to the rest of the UK, with the consortium showing the greatest differentiator from the rest of the UK in Process Chemistry and Technology (21.8% compared to 9.8%), General Earth and Planetary Sciences (27.9% compared to 20.7%), Civil and Structural Engineering (22.2% compared to 17%), and Environmental Science (25.4% compared to 20.2%). The SIA consortium also compared favourably to the average for the Russell Group in these categories, particularly in Process Chemistry (21.8% compared to 10.7%) and General Earth and Planetary Science (27.9% compared to 22.7%).

In the CWTS 2016 Leiden Rankings[20] for 'Life and Earth Sciences' Exeter was ranked 16th in the World, 2nd in Europe and 2nd in the UK for the proportion of publications in the top 10% of their field between 2011-2014 (using fractional counting, and min output of 100). Bristol was 35th in the World, 9th in Europe and 6th in the UK. For 'Physical Sciences and engineering' Exeter, Bristol and Plymouth were all in the top 20 in the UK and Europe.

In the Thompson Reuters Highly Cited list[21], representing some of the world's most influential scientists, Exeter has 3 scientists listed in Environmental Sciences (Friedlingstein, Adger, Cox), and the Met Office also has 3 scientists (Collins, Jones, Webb), Bristol has 2 listed in Agricultural Sciences (Nute, Richardson), while Cardiff has 1 in Chemistry (Hutchings). Prof Parmesan from Plymouth has also been reported to have authored the most highly cited climate change paper by Carbon Brief[22].

The Met Office has an international reputation for world-class environmental science: its climate research centre (Hadley Centre[23]), has been ranked as the world's leading geophysical institution, ahead of Harvard and Princeton, in terms of the influence of its peer reviewed publications[24].

The BIS mapping local comparative advantage report[25] mapped LEPs' publication intensity in relation to UK Industrial Strategy fields. Particular areas of research focus and impact as presented in the Technopolis report include Digital Economy and Resource Efficiency for HotSW LEP, and Agriculture & Food and the Built Environment for the West of England in terms of the volume of outputs. Agriculture & Food are strong areas for Gloucestershire and CIoS, as well as Resource Efficiency for CIoS, in terms of the impact of outputs.

Research funding

The total research income received by the universities in the consortium relevant to the theme (Appendix RES12) since academic year 2008/09 was in excess of £430m, growing

[20] http://www.leidenranking.com/ranking/2016/list
[21] http://hcr.stateofinnovation.thomsonreuters.com/
[22] http://www.carbonbrief.org/analysis-the-most-cited-climate-change-papers
[23] http://www.metoffice.gov.uk/climate-change/resources/hadleycentre
[24] http://www.publications.parliament.uk/pa/cm201012/cmselect/cmsctech/1538/1538we02.htm, section 4.9 c.
[25] Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015, p.120)

55% from £49m in 2008/09 to £76m in 2014/15. Around half of this research funding was from UK Research Councils, 13% from UK Government Bodies and 17% from the EU, with the remainder made up from a combination of charity, industry and other sources. By way of a comparison the growth in research income over the same period for the Russell Group (all disciplines) was 36% (Appendix RES13). The amount of research funding in the region is significantly bolstered by the theme related Research Organisations (SAHFOS, MBA, PML, Met Office, UKHO), whose combined funding for research was £195m in 2014/15, making the combined total research income of the theme £271m in 2014/15.

Research funding from EU government sources saw the greatest growth for the consortium between 2008/09 – 2014/15, increasing over 4.5 fold. To give an idea of the strength of European collaboration for the consortium, analysis of the CORDIS database[26] was undertaken (Appendix RES14). This focused on identifying the number and value of FP7 and Horizon 2020 projects, relevant to the theme, where a member of the SIA consortium (HEIs and research organisations) was the coordinating lead for projects undertaken between 2008-2016. There were 52 FP7 projects, worth over €110m, and 25 Horizon 2020 projects, worth over €44m, where a member of the SIA consortium was the coordinating lead institution. Exeter and Bristol led 19 projects each, Cardiff 14, Plymouth 6, Met Office 5, MBA 4, Rothamsted 2, Bath 2, PML 6. This data does not take into account projects where SIA consortium members were partners rather than coordinators on projects, which would be a much greater number.

4. Innovation strengths and growth points

The environmental goods and services sector in the region comprises 25,000 enterprises providing 153,000 jobs. This sector has grown 16 times faster than other sectors in the region. The stakeholder and business communities have identified two areas where our region has the potential to be globally competitive: Environmental Risk and Data Innovation, and Sustainable Technologies and Development. This is reinforced by existing and planned regional and LEP strategies and investments, as well as extensive innovation initiatives and activities.

Environmental Risk and Data Innovation, including areas such as: smart grids / metering and intelligent mobility; satellite communications and access / provision of data; understanding extreme weather; climate change resilience and adaptation strategies; asset management; resilient buildings and structures; flood modelling and monitoring.

Sustainable Technologies and Development - potential opportunities are linked to changes in legislation regarding the low carbon economy; energy storage and electric vehicles; sustainable buildings; trends in distributed energy generation and developing new materials.

These themes were explored through a workshop of 30 partners followed by an independently commissioned survey of 37 companies who were targeted to represent a broad range of relevant sectors, and who either have their headquarters, or other significant presence/interests, in the region (Appendix RES1). Of those interviewed, 31 described their business activities as being world-class, and nearly all indicated that their

[26] http://cordis.europa.eu/home_en.html

R&D expenditure would either increase, or stay the same, over the next 5 years, and that collaboration with universities is important to deliver this. Nearly all interviewees also anticipate introducing a new product, or service, process and/or entering a new market over the next 3-5 years.

Most of the interviewees confirmed that Environmental Risk and Data and Sustainable Technologies and Development are important areas for the region, where developments could add commercial value to their business over the next 5-10 years.

Others pointed out that all of these areas are connected, which could result in interesting growth dynamics. It was noted that "new business models will be unlocked through future energy and environmental demands and concerns" and "the mood and the climate is think differently, do things differently, look for different opportunities".

Further indicators of innovation strengths and growth points in the region in relation to Environmental Risk and Data include:

- Environmental Futures has been highlighted by the HotSW LEP[27] as a particular strength where it demonstrates significant comparative advantage in the UK, catalysed in part by the presence of the Met Office. This fits within a broader field of environmental expertise, which is highly connected to other sectors. A proposal for an Environmental Futures and Big Data Impact Lab has recently been submitted for ESIF funding (Appendix RES15A), and the concept for an Institute for Environmental Risk and Innovation is also being developed (Annex N)
- Met Office - employing approximately 2,000 people, with a supply chain of 1,598 companies many of which are located in Devon[28]. Estimated net benefits of their weather and climate services to the UK of £30bn over 10 years[29], and a £97m investment in a supercomputer to be located at Exeter Science Park is expected to deliver £2bn of socio-economic benefits alone to the UK due to increased operational weather and climate capabilities[30]. Taking into account the investment already committed, the benefit-cost ratio of the Met Office's services to the UK is estimated to be 14:1.
- Global Environmental Futures campus - a £350m vision for a transformative approach to place-based innovation focusing on applied environmental science. Based at Exeter Science Park and incorporating the Met Office collaboration space and new supercomputer. £8m Growth Deal funding has already been invested to build the campus

[27] HotSW Strategic Economic Plan 2014-2030. http://www.heartofswlep.co.uk/sites/default/files/user-88/SEP-%20Final%20draft%2031-03-14-website.pdf

[28] Heart of the SW Smart Specialisation Approach, 2015. http://www.heartofswlep.co.uk/sites/default/files/user-1889/Appendix%203%20-%20Smart%20Specialisation%20Approach.pdf

[29] Met Office General Review, Economic Analysis – Final Report, London Economics, April 2015

[30] https://www.gov.uk/government/news/97-million-supercomputer-makes-uk-world-leader-in-weather-and-climate-science

- Exeter City Futures - a private-sector led initiative to grow the region's economy, safeguard its natural resources and improve quality of life through the innovative use of data. It has links to investors creating a fund of up to £100m to invest in enterprises with growth potential.
- Innovation Exeter - a collaboration led by University of Exeter and Exeter City Council to drive place-based innovation, driving investment and raising productivity levels in the region, building on the Global Environmental Futures Campus.
- South West Satellite Applications Catapult Centre of Excellence – based at Goonhilly Earth Station in Cornwall, with the aim to support the growth of the Satellite Applications sector, particularly in relation to environmental science and resilience including marine and agri-tech.

Further indicators of innovation strengths and growth points in the region in relation to Sustainable Technologies and Development include:

- The West of England LEP has identified a number of relevant innovation priorities[31], including: a Food and Drink Enterprise Centre linked with advanced engineering, low carbon rural economy, skills & business support; Circular Economy Business Support Services - Research/business support into the circular economy to provide suppliers with knowledge to be able to move into this area; Increasing Business Resource Efficiency - advice and support reduces overhead costs and gains access to new markets.
- Gloucestershire LEP[32] have identified specific opportunities to promote innovation and growth including a new Agri-tech Research Centre, and RAU have already invested £1.2m into its Rural Innovation Centre. The LEP has also identified developing the UK's first zero carbon Skills Centre as a priority for investment.
- Growth Deal funding has been approved for investment by the University of Gloucestershire in renewables at the Berkeley Science and Technology Park in Gloucestershire. ESIF funding is being sought by the University to support a complementary low carbon programme centred at Berkeley, drawing on the University's research strengths in the Countryside and Community Research Institute and its long-established international profile in sustainability.
- Businesses in Swindon and Wiltshire invest heavily in the introduction of new or significantly improved products, services or processes, investing 3.5 times the national average in innovation[33]. The High Value Manufacturing Project[34] has a vision to support technology centres of excellence to enable SMEs to exploit opportunities in areas including Energy and Resources and Advanced Materials. The University of Bath and the Swindon and Wiltshire LEP are also developing plans for an Institute for

[31] West of England LEP Strategic Economic Plan, Outline business cases for the local growth fund current 2 year programme
[32] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf
[33] Community Innovation Survey 2011.
[34] Swindon and Wiltshire LEP: High Value Manufacturing Project, 2014. http://www.swlep.co.uk/resources/document635520986724410010.pdf

Sustainable Technology Innovation, focusing on advanced materials, energy production and storage, manufacturing processes, and the built environment. This initiative will build on the Porton Science Park, which complement state of the art, industry facing R&D facilities in biosciences.

- The West of England is at the forefront of the UK's sustainable growth agenda[35]. Relevant innovation activities include: a cluster of low carbon businesses in Avonmouth / Severnside Enterprise Area; Enterprise Zone and Areas with a low carbon focus; Bristol European Green Capital 2015; Sustainable Severn; National Composites Centre's work on alternative, low carbon materials; Green commitments within the City deal and Bristol Solar City.
- CIoS has identified Agri-tech as a priority market[36], based on existing significant relevant business activity, key natural asset, and strong local labour market/skills base. The LEP are also prioritising the development Low Carbon Enterprise Zone[37], a Food Enterprises Zone is also planned for March 2017, to help unlock the potential of local food and farming businesses, boosting local economies and attracting more investment. University of Exeter is also working with regional food and beverage SME's to support transition to a circular economy.
- HotSW LEP's strategies[38] point to huge economic opportunities linked to moving global economic activity onto a sustainable basis, with strengths in environmental sciences including, atmospheric, terrestrial, freshwater and marine, pollution, meteorological sciences, climate change, ecology and environmental monitoring, impacts on ecosystem services.

5. National and international engagement

The region shows excellent connectedness and capacity to work collaboratively regionally, nationally and internationally. In particular it had more contributors to the 2014 UN IPCC report than any other area in the World, and the presence of the Met Office and other world-leading research organisations also delivers significant national and international reach and influence.

The consortium is involved in an extensive range of theme related national and international alliances, demonstrating the connectedness of science and innovation activities locally, nationally and internationally. Further evidence of this is provided in Section 3 on doctoral training and European research funding. Full details of relevant alliances are provided in Appendix RES16, highlights include: Defra Sustainable Intensification Platform, Met Office Academic Partnership, Natural Hazard Partnership, EPSRC UK Catalysis Hub and the Intergovernmental Panel on Climate Change (IPCC) 5th

[35] West of England Strategic Economic Plan, Sector Prospectus.
[36] Cornwall and Isles of Scilly Research, Development and Innovation Framework, 2015. http://www.cioslep.com/assets/uploads/documents/1461574419_C&IoS%20RD&I%20Framework%20FINAL.pdf
[37] C&IoS – LEP Business Plan 2016-17. http://www.cioslep.com/assets/file/Business%20Plan%20FINAL%202016.pdf
[38] http://www.heartofswlep.co.uk/sites/default/files/user-88/SEP-%20Final%20draft%2031-03-14-website.pdf

Assessment Report. IPCC (the international body for assessing the science related to climate change[39]) involvement is particularly significant for the consortium, with a combined total of 16 authors from the Universities of Exeter, Bath and Bristol and the Met Office (12 from Exeter and Met Office alone). The lead contributing organisation is NOAA (US National Oceanic and Atmospheric Administration) with 13 authors; however, NOAA is geographically dispersed and thus the consortium represents a globally leading regional concentration of contributors. Exeter also contributed to the overarching IPCC 5th AR Synthesis Report[40].

The Met Office has significant international influence through its unified weather and climate model (UM), which is now relied on by some 1,000 scientists in the UK, as well as several hundred internationally, it is used in Australia, New Zealand, South Korea, India, South Africa and several other countries for the delivery of their weather services. The United States Air Force also chooses to use the Met Office model as the basis for its weather operations. Since 1981, the Met Office has co-authored papers with scientists from 163 different countries and over 1,900 institutions worldwide. The Met Office also makes significant contributions to the UN Framework Convention on Climate Change (UNFCCC) and the UN World Food Program[41]. The Met Office's scientific capability supports a number of UK Government ODA programmes such as the Newton Fund, and the Met Office is one of DFID's partners on the WISER programme (Weather and climate information services for Africa). The Met Office represents the UK at EUMETSAT[42] (European organisation for the exploitation of meteorological satellites - an intergovernmental organisation which supplies weather and climate-related satellite data, images and products from seven satellites to its member states, including the UK), in relation to scientific advice regarding the use of satellite data, ocean observations, instruments and missions, international relation and data policy. PML has also worked with 500 partners in more than 60 countries since 2010[43], including formal partnerships such as the Partnership for Observation of the Global Oceans (POGO).

Publication analysis in SciVal (Appendix RES17) was undertaken to assess the international collaboration of the consortium as a whole, based on the relevant journal categories identified in section 3. There were 2 key areas where the consortium demonstrates a significantly higher proportion of their publications being co-authored with international partners compared to the rest of the UK, between 2011-2015. These are Process Chemistry and Technology (60.9% of publications with international co-author for consortium, 50.7% for UK) and General Earth and Planetary Sciences (62.3 % for the consortium, 57.2% for UK). These categories also compared favourably with the Russell Group (Process Chemistry and Technology - 56.3%, General Earth and Planetary Sciences - 57.6%).

[39] https://www.ipcc.ch/report/ar5/
[40] http://ar5-syr.ipcc.ch/
[41] More information about this collaboration can be found online http://www.metoffice.gov.uk/climate-guide/climate-change/impacts/food
[42] http://www.eumetsat.int/website/home/index.html
[43] http://www.pml.ac.uk/Working-with-us/Partnerships

6. Developments in science and technology - international markets and opportunities

This theme is driven by global drivers, supporting the climate change and sustainable development agendas, challenges and opportunities. There is an urgent need to utilise environmental data to tackle the risks from natural hazards and protect the resilience of socio-economic systems. There is also a huge opportunity surrounding the technology and innovation that will be required to live sustainably.

Global challenges and drivers in Resilience, Environment and Sustainability

The UN Sustainable Development Goals were defined in 2015 – *Transforming our World: the 2030 Agenda for Sustainable Development* – incorporating the concept of 'planetary boundaries' that we need to stay within, and a plan of action for people, planet and prosperity. 17 key goals were identified, and those particularly relevant include: sustainable agriculture, sustainable management of water, access to energy, sustainable economic growth, resilient infrastructure, sustainable consumption, tackling climate change, sustainable use of the oceans and terrestrial ecosystems[44].

The majority of the world's nations have also recently signed up to a very challenging climate target to limit global warming to below 2°C, at the UN Paris Climate 2015 conference[45]. It is recognised that, if this target is to be reached before 2050 we have to largely decarbonise the global economy. This will represent an unprecedented rate of technological and societal change. There is also an urgent need, and indeed a critical opportunity in the context of international developments such as the UN Sendai Framework for Disaster Risk Reduction[46], and the UN Climate Resilience Initiatives[47] to address future environmental hazards in the context of our changing climate and vulnerability.

According to the MIT Technology Review 2016[48], 'technology innovation stands to reap billions from a warming planet'. From eliminating our dependence on fossil fuels to changing the paradigm of how we extract, manufacture, distribute, and consume products worldwide, all kinds of technology-enabled activities will be needed both to reduce the impact of future changes and to remediate the damage that has been done thus far. These will naturally involve companies, both large and small, that are making a difference in the value chain.

Environmental risk and data

Society's exposure to extreme weather and climate events is a growing threat to the sustainability of economic development and social welfare globally. Environmental pressures are having a growing impact on global and national economy and on key issues such as food, energy security, population movements, international diplomacy, conflict, agriculture and civil contingency. Climate and environmental change already has an impact on every aspect of business and society. Estimates from Munich Re suggest

[44] https://sustainabledevelopment.un.org/?menu=1300
[45] http://www.cop21.gouv.fr/en/
[46] http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
[47] https://www.wfp.org/climate-change/initiatives
[48] https://www.technologyreview.com/s/602001/the-business-of-climate-change/

natural hazards caused 23,000 fatalities globally in 2015, with 24% of these being due to climatological events[49]. Between 2010 and 2050 the costs of adapting to climate change globally have been estimated to be in the range of $70bn to $100bn a year[50] by 2050.

In the UK the economic and social impacts of severe weather and natural hazards are also significant. The Bank of England reports that the number of registered weather-related natural hazard loss events in the UK has tripled since the 1980's, and inflation-adjusted insurance losses from these events have increased from an annual average of around $10bn in the 1980's to around $50bn in the last decade[51]. The floods in 2007 generated £3.2bn in insured losses and killed 13 people[52]. In 2012, drought and water shortage in April, followed by the wettest summer in 100 years, led to major social and economic impacts for the agriculture sector[53]. More recently, the far-reaching impacts of extreme weather are brought into sharp focus by the flooding in winter 2013-14 which was estimated to have cost the UK £1.1bn[54]. In Dec 2015 windstorms Desmond, Eva and Frank resulted in over £1.2bn of property market insurance loss[55], with total UK economic loss estimated to total approximately £3bn[56].

The UK Climate Change Risk Assessment 2017 synthesis report[57], on which Exeter is an author, specifically sets out the areas where the UK is at greatest risk from climate change, and where more action is needed. These include flooding and coastal change, high temperatures and health, water shortage, risks to natural capital and food production and new and emerging pests and diseases.

The global market for commercial weather and climate services has been identified as being worth £35.3bn in 2015, having grown by a third between 2010 and 2015[58]. The UK Government has embraced the concept of 'Eight Great Technologies'[59] where the UK has a comparative advantage and potential for commercial exploitation across a global market,

[49] https://www.munichre.com/site/corporate/get/documents_E-397017904/mr/assetpool.shared/Documents/5_Touch/Natural%20Hazards/NatCatService/Annual%20Statistics/2015/2015_Torten_Ereignis_e.pdf
[50] Economics of Adaptation to Climate Change, the World Bank, 2011. http://www.worldbank.org/en/news/feature/2011/06/06/economics-adaptation-climate-change
[51] http://www.bankofengland.co.uk/pra/Documents/supervision/activities/pradefra0915.pdf
[52] Pitt Review section 9.2 - http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html
[53]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440728/National_Drought_Framework.pdf
[54] http://www.newstatesman.com/staggers/2014/06/counting-1bn-cost-winter-floods
[55] https://www.perils.org/web/news/news-2016.html
[56] http://www.cityam.com/231565/economic-impact-of-storms-eva-desmond-and-frank-could-hit-3bn
[57] https://documents.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf
[58] Space Innovation Strategy report on Leadership in Climate Technologies and Services, http://www.the-iea.org/wp-content/uploads/2016/03/IGS-Climate-Services-report.pdf
[59] David Willetts, 8 Great Technologies, Policy Exchange, 2013. http://www.policyexchange.org.uk/images/publications/eight%20great%20technologies.pdf

one of which is Big Data. It also identifies an urgent need for action to ensure that the UK is first to market with new and value adding services, building on the fact that the Met Office has one of, if not the best and most complete set of meteorological records in the world. The importance that the Government attaches to exploiting the Met Office's environmental big data assets is explicitly made[60].

A recent MIT Technology Review Business Report[61], identified that most businesses are yet to incorporate climate change into their business plans. A few industries are however dealing with risk and impacts of climate change, including agriculture – to take into account shifting temperatures and rainfall, and insurance – who are trying to predict the possible cost of storm damage for example. Other companies' supply chains are being disrupted by changing weather patterns, for example Ikea has suffered disruption from floods in South Asia and lost revenue in megastorms linked to climate change. Ford is also adapting to water shortages at its factories, by reducing water used in manufacturing by a third. The report goes on to say that many large corporates are concerned about water scarcity linked to climate change.

The significant potential for physical damage resulting from environmental risks means that the insurance sector is playing a leading role in the development of mechanisms by which to model financial impacts, with applications of catastrophe modelling starting to extend beyond traditional insurance into other sectors – the broader finance and international development sectors in particular. The Governor of the Bank of England recently noted "climate change is the tragedy of the horizon", threatening financial stability and long term prosperity[62]. He also highlights that it will take a combination of data, technology and expert judgement to measure and manage both physical and transition risks; having implication for investors, developers and policy makers. The UN Financial Stability Boards recent launch of a Task Force on Climate related Financial Disclosures further highlights the importance of environmental risk and data in driving sustainable development.

In 2013 the UK Government released their Agri-tech strategy[63], to drive the UK to become a world leader in agricultural technology, innovation and sustainability. This is an area that is one of the world's fastest growing markets, breakthroughs in technology in areas such as satellite imaging, meteorology, remote sensing and precision farming are driving major global investment.

[60] Big Data: Transforming the data revolution into new products and services infographic. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249260/big_data_infographic.pdf

[61] MIT Technology Review, Business Report, Climate Change – Lessons from the companies and industries that are thinking seriously about how global warming will affect their future, 2016

[62] http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx

[63] A UK Strategy for Agricultural Strategies, July 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/227259/9643-BIS-UK_Agri_Tech_Strategy_Accessible.pdf

Sustainable technologies and development

In 2012, the European Commission adopted a strategy for 'Innovating for Sustainable Growth: A Bioeconomy for Europe'[64], in order to address the world's ecological, environmental, energy, food supply and natural resource challenges. The sustainable production and exploitation of biological resources will allow the production of more from less, while limiting negative impacts on the environment and reducing use of fossil resources. To create a smart, sustainable and inclusive European bioeconomy investment is needed in research and innovation to make sure that more of the knowledge developments are commercialised[65]. Estimates show that, just in terms of the EU's investment in bioeconomy research and innovation, each euro invested could generate ten euros of added value to the sector by 2025. The UK has a world-class science base in this area and many UK businesses are already leading the way to a more sustainable and efficient approach to resource use and management through innovative processes and technologies[66]. The annual turnover of the European bioeconomy is around €2 trillion with 22 million people employed[67], while in the UK it is estimated to be £36.1bn in gross value added and 600,000 jobs[68]. Of the 'Eight Great Technologies' mentioned above, two map directly onto Sustainable Technologies (Advanced Materials and Energy Storage), while Synthetic Biology and Agri-science are enablers.

There is potential to grow the gross value added of the chemical and chemistry-using sector from £195bn to £300bn by 2030 in the UK[69], with the acceleration of innovation. Furthermore utilising biomass or waste as a material could bring potential long-term benefits of £8bn over the period to 2030 and is an essential focus for increasing the opportunity for innovation. Alongside these new materials, the adoption of smart industrial biotechnology manufacturing processes is highlighted as playing a strong role in achieving the projected growth ambitions, with estimated economic potential of £4bn to £12bn per year. The catalysis sector has also been identified as important to sustainable development; and catalyst businesses that support manufacturing and refining have an annual turnover of $15bn globally, and the full value of the goods and products produced by those catalysts is in the region of $15,000bn.[70]

It has been identified that by adopting circular economy principles, Europe can take advantage of the impending technologies revolution to create a net benefit of €1.8 trillion

[64] Innovating for Sustainable Growth: A Bioeconomy for Europe 2012. http://ec.europa.eu/research/bioeconomy/pdf/bioeconomycommunicationstrategy_b5_brochure_web.pdf

[65] THE EUROPEAN BIOECONOMY IN 2030 Delivering Sustainable Growth by addressing the Grand Societal Challenges. http://www.epsoweb.org/file/560

[66] Building a high value bioeconomy – opportunities from waste

[67] Innovating for Sustainable Growth: A Bioeconomy for Europe 2012. http://ec.europa.eu/research/bioeconomy/pdf/bioeconomycommunicationstrategy_b5_brochure_web.pdf

[68] The British Bioeconomy: An assessment of the impact of the bioeconomyon the United Kingdom economy. http://www.bbsrc.ac.uk/documents/capital-economics-british-bioeconomy-report-11-june-2015/

[69] Strategy for delivering chemistry-fuelled growth of the UK economy. http://www.cia.org.uk/Portals/0/Documents/Growth%20Strategy%20FINAL.PDF'

[70] Adams C., Topics in Catalysis, 2009, 52, 924–934.

by 2030, or €0.9 trillion more than in the current linear development path. The circular economy could create tremendous opportunities for industrial renewal, regeneration, and innovation[71], as well as helping to deliver the ambitious Paris 2015 carbon reduction commitments[72]. Ten innovative, disruptive technologies which will underpin the development of new business models and thus represent an opportunity to embrace circular economy have been identified, two of which are advanced recycling technology and, life and material sciences technology[73]; the regional approach also embraces added value, integrative research areas within the Resilience Theme including Life Cycle and Supply Chain Analyses, which bridge across to Management, Business and Economics research expertise.

Construction is another important sector, and is the largest single activity in Europe (9.6% GDP) and is worth at least €1.2 trillion annually. The sector directly employs around 15 million people and a further 44 million indirectly. Buildings use around 40% of total EU energy and are responsible for around 36% of its greenhouse gas emissions. Decarbonisation of the built environment is therefore central to an EU strategy to reduce greenhouse gas emissions by 50% by 2050. New buildings must use significantly less operational energy but increasingly there is recognition that impact of materials used in construction has to reduce too: the production of cement alone is responsible for 7-8% of global CO_2 emissions. In addition the current replacement rate for existing building stock (1-2% per annum) means a huge programme of energy efficient building refurbishment is needed. The technologies required to meet these targets is still largely to be developed.

[71] "Growth Within: a circular economy vision for a competitive Europe", Ellen MacArthur Foundation, SUN, McKinsey & Co. (June 2015): https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

[72] White Paper, Circular Economy: A key lever in bridging the emissions gap to a 1.5 °C pathway (June 2016): http://circle-economy.com/climatechange

[73] Accenture Strategy: Waste to Wealth (Peter Lacy and Jakob Rutqvist)

7. Conclusions

Through the Audit process we have identified two significant areas where we believe there are significant opportunities for the region in relation to the theme, as discussed further below. These sit alongside a number of existing strategic initiatives and projects in the region relevant to the theme, currently under development and targeting a range of sources of public investment (Appendix RES14).

Environmental risk and data

The region has globally significant environmental science research assets and infrastructure, and the strategic vision to create a globally significant centre of knowledge and innovation. However, this is not currently sufficiently supported by translational activities that enable these assets to fully support new policy, to support new markets for products and services, or to mitigate the cost of environmental hazards. A timely opportunity now exists to take global leadership in this area, and cement the UK's reputation in environmental science, by establishing a centre of excellence in environmental risk and data in the South West. Such an initiative would catalyse regional growth and productivity whilst also leveraging commercial opportunities from outside the region. Industry feedback indicated demand for related investment in:

- Infrastructure to allow access to and clarity of data, to facilitate its applications and services it delivers
- Investment to support becoming a global leader in providing solutions in environmental monitoring system/sensors, and application of big data
- An environmental risk institute integrating the best expertise in the region with business outside of the region
- Core funding to support a public and private sector partnership around environmental risk
- A payment for ecosystem services natural capital bank or fund
- Investments to support flooding and water management

The development of an Institute for Environmental Risk and Innovation (Annex N) involving a range of regional partners could significantly support regional growth; driving productivity gains, skills development and employment opportunities. Utilising the recent study 'Rates of return to investment in science and innovation'[74] as a guide, we estimate that productivity improvements could be significant, and that a £60m public sector investment in such an initiative could result in 5 year total return of approximately £263m; and private sector leverage could more than double this figure.

It is envisaged that, to be successful, this activity would need to operate within a 'hub and spokes' model throughout the region, providing a place where scientists and practitioners can work together on targeted projects in a well-supported environment. The focus will be guided by the UK's national and international priorities, and could therefore focus initially on floods and windstorms since, as these are the areas of most immediate concern in the UK. However the remit could ultimately encompass environmental risks of particular relevance to the sustainable development of transition and developing economies, such as

[74] *'Rates of return to investment in science and innovation', Frontier Economics, 2014.*

air quality; heat stress and other health-related risks; food security and crop production; water security and drought.

Through directed, interdisciplinary research, and a targeted innovation and translation programme this initiative would seek to deliver step change in our ability to model, manage and communicate environmental risk in the context of changing socio-economic pressures, climate and vulnerability.

Sustainable technologies and development

There is currently an unprecedented social, economic and technical opportunity to transform the energy, materials and information flows that support our economy and built environment towards sustainable and resilient models. This transformation towards low carbon and circular economic models will demand entrepreneurship and technical innovation as well as vision, great science and good governance. Our industry survey feedback indicated that investment should be made to support research and technology centres and innovative commercial technology development.

To fully exploit the globally competitive assets available in the region and to realise our vision for global leadership in sustainable technologies, we propose to develop an industry-facing Institute for Sustainable Technology Innovation (ISTI). To set out the need for and articulate the scope and benefits of ISTI, a Strategic Outline Case (SOC), developed according to Green Book guidance for public sector business cases, has been produced (Annex N). The Institute will entail a physical space, accessible to industry partners, where cross-disciplinary academics, PhD students, industrial stakeholders (start-ups, SMEs, multinationals), policy makers, entrepreneurs and other stakeholders will come together. The industry-facing facility will incorporate laboratory R&D, analytical and incubation facilities, with incubation support services. At the core of ISTI will be a Creative Hub and Academic Gateway that will focus on embedding creativity, innovation and entrepreneurship in the Institute's activities and which will bring together the world-leading fundamental research of the region with the applied innovation of the Institute to help deliver transformative sustainable technologies, underpinning the development of sustainable approaches to feedstocks, processes and advanced materials. To encourage entrepreneurship. ISTI development is being supported by the SETsquared partnership, the regionally-led Global leading University business incubator and to ensure smooth uptake of technologies, and thus maximum impact, ISTI will work in close partnership with appropriate Catapults, specifically the HVM Catapult via CPI, who have been instrumental in outlining the case for this institute.

Appendices

Appendix RES1 Industry survey, July 2016 – Summary of findings

Summary of interviewees

- 37 interviews were undertaken with a range of companies, who were targeted on the basis of their relevant to the Resilience, Environment and Sustainability theme, and to represent a broad range of relevant sectors including engineering, construction, energy, sustainable materials and manufacturing, insurance, software providers, satellite communications, statistics services, educational technology, IT, analytics, management technology consultant, transport, climate and weather services, earth observation, water companies, environmental consultancy, tourism, risk advisory services, space, agriculture and maritime.
- 35 of these companies either had their HQ or other sites/branches in the South West England and South East Wales, the other 2 identified key collaborators in the region.
- 31 interviewees described their business activities as being world-class, with respect to raising standards, cutting edge technology, software, services or skills, reach of business, and data centres.

R&D

- Interviewees were asked how they currently fund their R&D, the most common sources included internal funds, UK government and European grants and Innovate UK, other sources also included business contracts, R&D tax relief, private investors, UK and European Space Agencies, UK government, UK Water Industry Research Programme and charitable funding.
- Most of the interviewees (21) thought their R&D expenditure is likely to increase over the next 5 years, 13 thought it would stay the same and 1 said it would decline. Some interviewees also noted the uncertainty linked to Brexit and European funding which they are currently reliant on for R&D.
- When asked what factors will influence their R&D spend many interviewees said it was dependant on their own internal profits, market demand and the general economy. Government policy, incentives, regulation and availability of R&D funding were also thought to be important, as well as the uncertainty surrounding Brexit and future European funding.
- Most interviewees (31) said their R&D is conducted in house, combined with a mixture of working in partnerships and externally commissioned R&D. 4 interviewees said all their R&D is commissioned externally.
- Nearly all of the interviewees have existing links and conduct R&D with Universities, some of which are extensive partnerships.

Ambitions and aspirations for the future

- Nearly all of the interviewees (35) anticipate introducing a new product or service, process and/or entering a new market over the next 3-5 years. These include modelling technology, certifications, new materials, software, satellite communications and applications, education technology, insurance services, digital services, sensors, electric trains, engineering services, recycling, ecology and landscape services, advanced manufacturing, catchment management, training process, water treatment processes, digital consultancy and management consultancy services.
- 22 interviewees thought that availability of finance will pose a challenge in realising their ambitions, 25 thought availability of know-how/skills, 16 meeting regulations, 18 the availability of technology, 23 the level of market demand. Political instability, Brexit and impacts on global economy were also highlighted as key issues.

- Interviewees were asked about their technological challenges and what technology will be important for their business in the future, responses included construction technology and software, cloud based business, IT, digital and analytics services, computer modelling and satellite technology, risk modelling, robotics, energy storage, communications and intelligent infrastructure, design technologies, high performance materials, high performance computing, sensors, industrial process technology, water treatment technology.

Skills

- 8 of the interviewees stated that they are currently not able to recruit the skilled people they need
- Interviewees were then asked what current skills challenges they face:
- 16 of the interviewees expressed challenges associated with finding qualified and experienced engineering professionals (civil, mechanical, electrical, industrial process, operations, communications, chemical), from graduate level upwards.
- 9 interviewees said there are gaps in skilled programmers, IT, software engineers and data scientists, modelling and analytics, from graduate level upwards.
- Other gaps in skilled staff included scientists and lab technicians and skilled construction trades.
- Other concerns included finding people with flexible skills who can work across job functions, and have the softer interpersonal skills with a mix of technological ability.
- There were also concerns about retaining and attracting employees to the region and the implications of Brexit with companies who currently source staff and skills from Europe

Future opportunities for the region

Interviewees were asked their opinions on a number of specific sectors/fields, and asked whether they envisaged developments would add commercial value to their business over the next 5-10 year. These included:

- Internet of Things – 30 felt this was an important area; including areas such as smart grids/metering and intelligent mobility; 5G and satellite communications and access/provision of data (e.g. farming); big data from satellites; data science
- Environmental Risk – 26 felt this was an import area; including understanding extreme weather, climate change, resilience and adaptation strategies; the ability to monitor; insurance; Shale oil and gas; asset management; utilising existing environmental information and data; resilient buildings and structures; flood modelling and monitoring; monitoring assets in remote locations/remote sensing
- Ecosystems Services/Natural Capital – 22 felt this was an important area, including catchment management; reduced pesticide use; regulatory change in the water sectors
- Sustainable Development/Circular Economy – 31 felt his was an important area; potential opportunities are linked to changes in legislation regarding the low carbon economy; energy storage and electric vehicles; sustainable buildings; trends in distributed energy generation; developing new materials and understanding applications;

Others pointed out that all of these areas are connected, and that is where you could see some interesting growth dynamics, and that “new business models will be unlocked through future energy and environmental demands and concerns”. Also remote monitoring was thought to a key cross-cutting activity, “its all about monitoring the environment and providing the data to help for instance work out what the value is of the ecosystem

services, work out what the environment risks might be, to understand what's happening to the carbon cycle over all the global carbon cycle to feed into low carbon type requirements". Others went on to say "the mood and the climate is think differently, do things differently, look for different opportunities".

The interviewees were also asked who they would need to work with in order to realise these opportunities, and most recognised the need for collaboration and be part of a bigger team. Many of them indicated that working with academic institutions and other research organisations and specialists with expertise in particular areas would be important, as well as third sector organisations, data providers, big data/analytics companies, other large companies/consultancies as well as specific technology businesses.

When asked what investment they would like to see in the region to support innovation and global competitive advantage in their sector, skills shortages were seen as a key issue including:

- STEM skills investments starting from primary school, and particularly girls
- Skills shortage and knowledge gaps in construction
- Support for higher level skills at post-graduate level in science and engineering
- Technology training, education and skills – at all levels
- Data science skills

Other areas where the interviewees would like to see investment include:

- Research and technology centres in engineering and manufacturing
- Investment to support collaboration and innovation that crosses industry sectors and business models, and strengthening links with universities
- Infrastructure to allow access to and clarity of data and facilitating its applications and services it delivers, a plan to integrate communication systems
- Investment to support becoming a global leader in providing solutions in environmental monitoring
- Transport and communication and virtual infrastructure to reduced geographic fragmentation
- An environmental risk institute integrating the best expertise in the region with business outside of the region and in London
- Core funding to support a public and private sector partnership around environmental risk
- Environmental monitoring system/sensors, and application of bid data
- Funding for innovative highly commercial technology development
- Business support – e.g. tax relief for innovation, R&D grants, access to overseas markets, funding to support getting products to the market
- A payment for ecosystem services natural capital bank or fund
- Investments to support flooding and water management

Appendix RES2 List of Assets

Asset	Location	Host/Lead	Descriptor
A. Research Facilities			
University of Bath	Bath	NA	Relevant facilities include: the Centre for Sustainable Chemical Technologies, a multidisciplinary Research Centre and EPSRC CDT with industrial strengths, over £30M research portfolio and 70 current PhD students. Research themes include renewable resources and industrial biotechnology, energy and water and healthcare technologies. The Institute for Sustainable Energy and the Environment, which conducts fundamental and applied research across 10 interdisciplinary themes, including Climate change and its mitigation. The BRE Centre for Innovative Construction Materials (CICM), is a multidisciplinary Research Centre based in Dept. of Architecture & Civil Engineering, which has received industrial sponsorship from the Building Research Establishment trust for over 10 years. CICM has particular expertise in sustainable concrete materials/structures and bio-based construction technologies. CICM has a current research of over £10M and around 40 doctoral students. Specialist facilities include the Building Research Park and HIVE outdoor testing facility at Wroughton, Wiltshire. Weather Forecast Group
University of Bristol	Bristol	NA	University of Bristol - Cabot Institute, world class expertise and multidisciplinary research to tackle the challenges of uncertain environmental change, including research centres in Global Change, Food Security, Global Dynamic Environment, Glaciology, Environmental Risk and the Bristol Water Initiative.
University of Cardiff	Cardiff	NA	Sustainable Places Research Institute, and Sustainable Building Design, Building Systems and Informatics. Cardiff Catalysis Institute (CCI) has established itself as a global player in

			key areas of synthetic and environmental catalysis. It has an international reputation for gold catalysis, in which it is a driving force not only at the research phase but also, through its collaborations with industry, along the subsequent pathway to commercialisation. The CCI is now developing a pipeline of new catalyst technologies based on material design principles and a fundamental understanding of the correlations between structure and activity in catalytic materials. CCI leads an EPSRC CDT in Catalysis with Bath and Bristol as partners. The new Cardiff Water URI already has a record of success in aiding the users of water research and is catalysing activities across the GW4 water research with the recent launch of the GW4 Water Security Alliance, the largest water research group in the UK.
Cardiff Metropolitan University	Cardiff	NA	Centre for Health, Safety and Environment at the School of Health Sciences, focused on assessing and managing occupational and environmental issues.
University of Exeter	Exeter, Truro, Falmouth	NA	World-leading environmental research includes: the Environment and Sustainability Institute (ESI), a £30M interdisciplinary centre leading cutting-edge research into environmental change; the new Land, Environment, Economics and Policy (LEEP) Institute, a centre of excellence in environmental economics, agricultural and environmental policy. Exeter also has a £9m aquarium focusing on ecotoxicology, and has the world's largest academic group in conservation biology, expertise in ecology and conservation; environmental biology; water, sediment and nutrient cycling; ecosystem functioning; carbon dynamics; landscape restoration; climate modelling; sustainable materials; water engineering through the Centre for Water Systems (and

			Doctoral Training Centre in Water Informatics), sustainable water management; and marine renewable energy.
Gloucestershire University	Cheltenham	NA	Countryside and Community Research Institute which plays an important role in shaping rural development policy and practice in the UK, Europe and further afield. The Institute is currently active in 7 major EU-funded research consortia under the Horizon2020 programme[75]. In the most recent REF assessment, the CCRI submission into UoA 16 was ranked 9th nationally for overall quality. Within the University's School of Natural and Social Sciences, the Centre for Environmental Change and Quaternary Research undertakes work on geochronology, climate change, environmental change and human impacts.
Plymouth University	Plymouth	NA	Marine Institute and Sustainable Earth Institute with research centres in environment and sustainability covering earth and environmental science, transport, climate change, food security, sustainable business solutions, and pollution,. The Growth Acceleration and Investment Network (GAIN) to accelerate the creation, growth and investment in high quality businesses and ideas to create wealth and jobs in the South West, bring in together more than £120m of business infrastructure, world class research facilities and expertise in a network focused on growth and investment
Royal Agricultural University	Cirencester	NA	Sustainable Agriculture, Food and Rural Economy research group work to promote higher yield and quality food within sustainable agricultural production and social systems, research is carried out on their own and neighbouring farms, Farm 491 a space for innovators to grow their businesses by applying technology to

[75] RECARE, SMARTSOILS, VALERIE, PEGASUS, SUFISA, AGDEMO, SOILCARE. Previous EU-funded projects include RuDI, GLAMUR, SOLINSA, SUBURBfood, CAPRI-RD. For more information see www.ccri.ac.uk

			agriculture, providing high-spec facilities and 491 hectares of farmland for research and testing. The Rural Innovation Centre76, £1.2M investment on-farm facilities primarily for practical research, demonstration and knowledge exchange.
University of the West of England	Bristol	NA	Centre for Floods, Communities and Resilience which focusses on a range of issues concerning resilient communities, Centre for Sustainable Planning and Environments understanding how to achieve places that are environmentally sustainable, Centre for Architecture and Built Environment innovative approaches that support the design of environmentally sustainable buildings.
Marine Biological Association	Plymouth	NA	A charity which promotes the scientific research into all aspects of life in the sea and their complex interactions with the environment.
Met Office	Exeter	NA	World leading expertise in environmental science and data analytics, coupled to its soon to be opened next generation supercomputer (£97m), and supported by its leading Hadley Centre77 for Climate Science and Informatics Lab, it is also well connected to the academic sector via its Met Office Academic Partnership (of which Exeter is a member). The Met Office Unified Model (UM) provides seamless prediction systems for operational and research in weather forecasting, climate prediction and climate change projection.
Plymouth Marine Laboratory	Plymouth	NA	An independent, impartial provider of scientific research and contract services relating to the marine environment. The research at PML contributes to the issues of global change, sustainability and pollution delivering solutions for national and international needs, it also has extensive facilities such as ships and

[76] https://www.rau.ac.uk/about/farms/rural-innovation-centre
[77] http://www.metoffice.gov.uk/climate-change/resources/hadleycentre

			specialist labs, Environmental Single Cell Genomics centre, HPC cluster, remote sensing facilities, as well as extensive global time series data sets.
Rothamsted North Wyke Farm Platform	Okehampton	NA	Longest running agricultural research station in the world, a globally unique highly instrumented farm at Rothamsted Research, a BBSRC National Capability, and a National AgriTech Centre of Innovation Excellence in Livestock Systems node (£84m). Rothamsted Research are also involved in two other national Centres for Agricultural Innovation – The Centre for Crop Health and Protection and Agrimetrics.
Sir Alister Hardy Foundation for Ocean Science	Plymouth	NA	An international charity operating the Continuous Plankton Recorder Survey, driven by almost a century of observations and science, focusing on the impacts of environmental change on the health of oceans.
UK Hydrographic Office	Taunton	NA	An executive agency sponsored by the Ministry of Defence, it produces nautical publications and services for the Royal Navy and merchant shipping, to protect lives at sea.
B. Science and Innovation Assets			
Exeter Science Park & Global Environmental Futures Campus	Exeter	Exeter Science Park Company	Focused on new industries in mitigating climate change and connected environmental datasets. Partners include: Devon County Council, University of Exeter, East Devon District Council, Exeter City Council, Homes and Communities Agency, Met Office.
Goonhilly Earth Station	Cornwall	NA	Key national asset for the UKSA including commercial satellite communications and operations, and home for the SW Satellite Applications Catapult Centre of Excellence.
ONS Data Science Campus	Newport	ONS	5 themed research programmes including sustainability. Goal of the Campus will be to build a new generation of tools and technologies to exploit the growth and availability of innovative data sources and to provide rich informed measurement and analyses on the economy, the global

			environment and wider society.
SW Satellite Applications Catapult Centre of Excellence	Cornwall / Devon	Goonhilly, Met Office, Universities	Satellite and earth observation data are increasing considered important to climate and environmental science and resilience. The SWW has strong and well-established expertise in Satellite Applications and innovation; Goonhilly Earth Station acting as a catalyst for space communications and business growth, the Met Office setting a global standard for Earth and Space Weather observation and science, and a strong network of local, national and international universities and research centres.
Flood Forecasting Centre	Exeter	Met Office and Environment Agency	A partnership between the Environment Agency and the Met Office, combining their meteorology and hydrology expertise into a specialised hydrometeorology service. The centre forecasts for all natural forms of flooding - river, surface water, tidal/coastal and groundwater.
South West Regional Flood and Coastal Committee		Environment Agency	Established by the Environment Agency to ensure effective communication and planning for flooding and coastal erosion, to encourage investment in flood and coastal erosion risk management.
Environment Agency	HQ Bristol	NA	HQ in Bristol, and employing over 10,000 staff. Other regional offices can be found in Cornwall, Somerset and Gloucestershire, with specialist facilities in Bath with their geomatics group, and near Exeter, with its National Laboratory Service, a leading provider of high quality environmental testing and analysis.
Natural Resources Wales	HQ in Cardiff	NA	HQ in Cardiff, the largest Welsh Government body, employing 1,900 staff across Wales. With the overarching objective to sustainably manage the air, land and water in Wales.
Brixham Blue Environmental Hub,	Brixham	NA	Ex-AstraZeneca laboratory, now in the ownership of Plymouth University to establish a world-class centre for collaboration and translational research with emphasis on the marine environment and coastal management

			issues.
Greenpeace Research Lab	Exeter	University of Exeter	Forms the Science Unit of Greenpeace International, based at the University of Exeter, it provides scientific advice and analytical support to Greenpeace worldwide, over a range of disciplines.
Future Farm at Duchy College	Cornwall	NA	Highly instrumented dairy farm, integrated with RRes-NW, providing skills development in precision agriculture. Also Food Innovation Centre, which works with businesses to deliver innovative solutions across all areas of food production.
EPSRC UK Catalysis Hub	Harwell	NA	Bath and Cardiff form two of the four national nodes (together with UCL and Manchester) of the recently established £20m UK Catalysis Hub which brings together the world-leading facilities of the Harwell Campus (including Diamond and ISIS) and national expertise from over 40 institutions in catalyst design, catalysis for energy, catalysis for the environment, chemical transformations and biocatalysis.
Building Research Park	Wiltshire	University of Bath	To develop and to explore innovative building materials and constructive systems.
Gloucestershire Science and Technology Park	Berkeley	University of Gloucestershire/ South Glos and Stroud College	Science and Technology Park being developed at the former Berkeley Nuclear Research Laboratories. Site of the proposed Advanced Renewables Research Centre, and proposed ESIF low carbon programme, working with industry partners and the University Growth Hub
South West Water	HQ in Exeter	NA	Employs 1,250 staff. Staff work in diverse areas including geotechnical, waste, water and infrastructure. It has strong links with the region and spends approximately £250m/year through its supply chain, with a strong focus on spend in the regional economy. SWW is part of the wider Pennon Group, an environmental utility infrastructure company which also owns Viridor Ltd. The Group currently has assets of around £5bn and a workforce of

			around 4,500 people and is based in Exeter, Devon. Viridor focuses on renewable energy, recycling and resource management and operates numerous energy recovery and material recycling facilities across England, with a turnover of £410m. The Pennon Group has recently acquired Bournemouth Water for £100m, which currently supplies around 440,000 customers.
Water Research Centre (WRc)	Swindon		WRc is an Independent Centre of Excellence for Innovation and Growth, operating across different sectors including Water, Environment, Gas and Resource Management. Their clients include regulators, water and gas utility companies, governmental organisations, NGOs, trade organisations, industrial manufacturers and waste management companies.
Wessex Water	HQ in Bath	NA	Serving 2.8m customers and employing 1,800 staff. It has a partnership with Bath University, and together have established the Water Innovation and Research Centre, providing a unique environment to engage globally in research and policy on water technologies and resource management.
Westcountry Rivers Trust	Cornwall	NA	An environmental charity established in 1994 to help restore and protect the water environment in the Westcountry for the benefit of people, wildlife and the local economy. We also aim to advance the understanding of community groups and the public about water and the importance of a healthy, functioning environment. The Westcountry Rivers Trust is engaged in a wide array of activities and projects in the South West and in other parts of the UK
LEAF Innovation Centre	Okehampton	Rothamsted Research North Wyke	Rothamsted Research North Wyke is one of the LEAF Innovation Centres across the UK. They work alongside the LEAF Demonstration Farms to promote good practices from the farm. As a LEAF Innovation Centre they investigate and communicate practices

	which underpin the continual improvement of the Integrated Farm Management approach to help deliver more sustainable food production through grassland and grazing livestock system.
C. Industry Landscape by LEP area	
Cornwall and Isles of Scilly	Agri-food is an important, but varied, sector across Cornwall and the Isles of Scilly. The core agri-food sector is estimated to account for about 25,000 jobs in the LEP area of which around half are in agriculture; across the wider industry, the total number of jobs is over 60,000 in Cornwall and the Isles of Scilly[78]. Agriculture is responsible for about three times as much employment in Cornwall as it is generally in Great Britain[79]. Agri-food and agri-tech make up 8 of the top 20 sectors in the CIoS Regional Economic Plan[80].
Gloucestershire	The structure of the Gloucestershire economy broadly reflects national trends but with some important exceptions[81]. The agriculture sector is over-represented relative to the rest of the UK, with a location quotient of 2.0, but still comparatively small in terms of the numbers it employs and its contribution to output. The energy and water sector is over-represented in the county relative to the UK and important in relation to its contribution to GVA.
Heart of the South West	Environmental Futures, was highlighted in the Strategic Economic Plan 2014-2030[82], as a particular niche where, the Heart of the SW already demonstrates significant comparative advantage, catalysed in part by the relocation of the Met Office into Exeter. Investment in developing this niche was an important ask of the 15/16 Growth Deal. This niche sits within a broader field of environmental expertise, which is highly connected to the agricultural sciences. The agri-food chain is an important part of the economy with significant potential to benefit from innovative technology, practices and processes. Agriculture, forestry and

[78] Cornwall and the Isles of Scilly LEP: Strategy and Business Plan, Evidence Base Papers: 6 – Sectors across Cornwall and the Isles of Scilly. http://www.cioslep.com/assets/file/LEP%20Strategy/Evidence%20Base%206.pdf

[79] *A review of Cornwall's Agri-Food Industry* Centre for Rural Policy Research, University of Exeter, 2011.

[80] CIoS Regional Economic Plan. http://www.cioslep.com/assets/file/Strategic%20Economic%20Plan/LEP%20Strategic%20Economic%20Plan%20FINAL.pdf

[81] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf

[82] HotSW Strategic Economic Plan 2014-2030. http://www.heartofswlep.co.uk/sites/default/files/user-88/SEP-%20Final%20draft%2031-03-14-website.pdf

	fishing represent 17.7% of HotSW businesses compared to 5.2% for England[83]. Sustainable Solutions to Flood and Water Catchment Management were also identified as a priority in the HotSW Strategic Economic Plan. Exeter saw the highest productivity growth of any city in England during 2000-2010[84]. The wider Exeter area is, and will continue to be, the key growth engine for the Heart of the South West LEP area and the wider Peninsula, with a population that is set to grow by a third in the next 15 years.
Swindon and Wiltshire	Identified priority sectors for growth include: high value manufacturing and the low carbon economy.[85] For the Sustainable Chemical Technologies and Built Environment areas, the LEP have identified the need for Research and innovation to deliver a number of economic development objectives. Health and Life Sciences has also been identified as a key sector and a LEP strategic priority[86], along with the synergies to sectors such as engineering, agriculture and agri-food. GVA per head in Swindon (£27,900) is among the highest in the country outside London and considerably above the UK average (£21,360), reflecting its concentration of highly productive firms[87]. There are also strong prospects for employment growth in the area. 78.5% of the land LEP area is farmed, and Land management and food production play a valuable role in direct employment and also through wider economic benefits including the tourism and visitor economy and quality of life. 2,100 firms in the Land-based agriculture, food and drink industries employ 6,100 people in the Swindon and Wiltshire area, representing a 57% higher concentration compared with the national average, with an output of £347 milliion per annum or 4% of total output. As well as these tangible outputs, the SWLEP rural landscape boasts significant assets including three Areas of Natural Beauty and a National Park, as well as the internationally renowned World Heritage Site at Stonehenge and Avebury. The tourism that these attract are an important employer for young workers (40% of staff in tourism are under 30), and are a significant source of employment for local groups, e.g. military spouses. Tourism contributes £826 GVA annually to Wiltshire's economy (2014), supporting 28,062 jobs (VisitWiltshire, Headline Economic Impact Results 2014).
West of England	Has a £29.3bn economy, representing 2.3% of England's economic output, and supporting 616,000 jobs[88]. This economic evidence-base

[83] Heart of the SW Smart Specialisation Approach, 2015. http://www.heartofswlep.co.uk/sites/default/files/user-1889/Appendix%203%20-%20Smart%20Specialisation%20Approach.pdf
[84] http://www.ippr.org/files/publications/pdf/State-of-the-North_Nov2014.pdf?noredirect=1
[85] SWLEP Strategic Economic Plan, http://www.swlep.co.uk/resources/document635997701081146000.pdf
[86] SWLEP Health Life Sciences Review, Report 1: Review of Capabilities
[87] Swindon and Wiltshire ESIF Strategy 2014-2020. http://www.swlep.co.uk/resources/document635896681057556000.pdf
[88] West of England Economic Assessment, 2015

	points to five priority growth sectors where the West of England has a sustainable international comparative advantage[89]. These include Low Carbon Industries[90]. Consisting of enterprises engaged in developing, producing and installing materials, devices and techniques that are used in pollution prevention, reduction or containment. It covers water, waste management and recycling, alongside the production of renewable energy. In 2010, 2,600 people in the West of England were employed in the Low Carbon Industries within around 700 enterprises. Although relatively small in terms of the volume of jobs, the sector has been selected as a priority on the basis of its considerable growth potential. Significant clusters of low carbon businesses exist at Avonmouth, Bristol City Centre and Clifton. Some of the smaller firms are dependent upon Wessex Water as a major customer within the sub-region.
Wales	A number of priority and emerging sectors have been identified, including Digital, Life Sciences, Financial Services and Energy and the Environment[91]. Energy and Environmental sector (EE) in Wales has a market value of £4.7bn employing about 58,000 people in 2,066 companies. This turnover has increase by 90% between 2006 and 2014[92], and outperformed the majority of other sectors in Wales. Areas of strength include water supply and wastewater treatment and environmental monitoring and instrumentation. The vision for Wales is to be at the forefront of the transition to a low-carbon, low-waste economy in order to secure maximum economic, social and environmental benefits[93]. In SW and Central Wales the turnover within the EE sectors increases significantly between 2005 and 2013. Total turnover in 2005 was at £14bn, an increase of 156.4% saw total turnover in 2013 reaching £38bn. This suggests the EE sector is one of socio-economic importance as well as one which continues to grow exponentially year on year[94]. The sector has the potential to create a significant number of jobs in the region over the coming years.

[89] West of England Strategic Economic Plan 2015-2030.
[90] Sector Skills & Competitiveness Statement - Low Carbon Industries. http://www.westofengland.org/media/200539/environmental%20technology.pdf
[91] Powering the Welsh Economy. http://gov.wales/docs/det/publications/150212-powering-the-welsh-economy-en.pdf
[92] Mapping of the Energy & Environment Sector in Wales. http://gov.wales/docs/det/publications/140819-energy-environment-sector-mapping-study-executive-summary-en.pdf
[93] Energy and Environment Sector -Summary Advice from the Sector Panel. http://gov.wales/docs/det/publications/121210eeadviceen.pdf
[94] Energy and the Environment – A detailed analysis for South West and Central Wales. http://www.rlp.org.uk/wp-content/uploads/Energy-and-Environment-report.pdf

Appendix RES3 Higher education subject strengths, measured in terms of the proportion of all students studying each subject by LEP area, relative to the England average (excluding SE Wales), based on 2013/14 HEFCE Local HE Profile data[95].

A. Higher Education students studying in Universities

	% of HE students by subject		
	Cornwall & IoS	England	Difference %
Biological Sciences	10.3%	9.4%	0.9%
Veterinary Sciences	0.0%	0.3%	-0.3%
Agriculture and related subjects	0.0%	0.6%	-0.6%
Physical Sciences	2.8%	3.5%	-0.7%
Computer Science	0.0%	3.9%	-3.9%
Engineering and Technology	5.6%	7.1%	-1.5%
Architecture, Building and Planning	0.0%	2.3%	-2.3%
Geographical Studies	4.0%	1.7%	2.2%

	% of HE students by subject		
	Gloucestershire	England	Difference %
Biological Sciences	18.4%	9.4%	9.0%
Veterinary Sciences	0.0%	0.3%	-0.3%
Agriculture and related subjects	7.0%	0.6%	6.4%
Physical Sciences	0.0%	3.5%	-3.5%
Computer Science	4.3%	3.9%	0.4%
Engineering and Technology	0.0%	7.1%	-7.1%
Architecture, Building and Planning	4.5%	2.3%	2.3%
Geographical Studies	1.7%	1.7%	0.0%

	% of HE students by subject		
	HotSW	England	Difference %
Biological Sciences	12.1%	9.4%	2.7%
Veterinary Sciences	0.0%	0.3%	-0.3%
Agriculture and related subjects	0.6%	0.6%	-0.1%
Physical Sciences	3.4%	3.5%	-0.1%
Computer Science	2.5%	3.9%	-1.4%
Engineering and Technology	5.5%	7.1%	-1.6%
Architecture, Building and Planning	1.3%	2.3%	-1.0%
Geographical Studies	4.5%	1.7%	2.8%

	% of HE students by subject		
	West of England	England	Difference %
Biological Sciences	8.2%	9.4%	-1.2%

[95] http://www.hefce.ac.uk/analysis/maps/

Veterinary Sciences	1.1%	0.3%	0.8%
Agriculture and related subjects	0.2%	0.6%	-0.4%
Physical Sciences	5.0%	3.5%	1.5%
Computer Science	3.2%	3.9%	-0.6%
Engineering and Technology	10.2%	7.1%	3.1%
Architecture, Building and Planning	3.4%	2.3%	1.1%
Geographical Studies	2.2%	1.7%	0.5%

B. Higher Education students studying in Further Education

	% of HE students by subject		
	Cornwall & IoS	England	Difference %
Biological Sciences	16.1%	8.3%	7.8%
Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	13.8%	5.7%	8.2%
Physical Sciences	1.5%	0.6%	0.9%
Computer Science	5.1%	6.3%	-1.3%
Engineering and Technology	4.2%	12.1%	-7.9%
Architecture, Building and Planning	1.5%	2.1%	-0.6%
Geographical Studies	2.1%	0.1%	2.0%

	% of HE students by subject		
	Gloucestershire	England	Difference %
Biological Sciences	24.1%	8.3%	15.8%
Veterinary Sciences	1.1%	0.0%	1.0%
Agriculture and related subjects	41.9%	5.7%	36.2%
Physical Sciences	0.0%	0.6%	-0.6%
Computer Science	3.7%	6.3%	-2.6%
Engineering and Technology	5.0%	12.1%	-7.1%
Architecture, Building and Planning	0.0%	0.1%	-0.1%

	% of HE students by subject		
	HotSW	England	Difference %
Biological Sciences	8.9%	8.3%	0.5%
Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	3.9%	5.7%	-1.7%
Physical Sciences	1.0%	0.6%	0.4%
Computer Science	7.4%	6.3%	1.0%
Engineering and Technology	25.4%	12.1%	13.3%
Architecture, Building and Planning	1.5%	2.1%	-0.5%
Geographical Studies	0.0%	0.1%	-0.1%

	% of HE students by subject		
	Swindon & Wilts	England	Difference %
Biological Sciences	8.3%	8.3%	-0.1%

Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	1.4%	5.7%	-4.2%
Physical Sciences	0.0%	0.6%	-0.6%
Computer Science	3.5%	6.3%	-2.8%
Engineering and Technology	10.0%	12.1%	-2.1%
Architecture, Building and Planning	1.1%	2.1%	-0.9%
Geographical Studies	0.0%	0.1%	-0.1%

	% of HE students by subject		
	West of England	England	Difference %
Biological Sciences	4.3%	8.3%	-4.0%
Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	3.1%	5.7%	-2.6%
Physical Sciences	0.0%	0.6%	-0.6%
Computer Science	9.3%	6.3%	2.9%
Engineering and Technology	5.9%	12.1%	-6.2%
Architecture, Building and Planning	1.2%	2.1%	-0.9%
Geographical Studies	0.1%	0.1%	-0.1%

Appendix RES4 REF data

UoA	Submitted staff associated with theme (FTE)	No. of Institutions	UoA Overall profile (% 3*or 4*)
2 - Public Health, Health Services and Primary Care	2	3	82
3 - Allied Health Professions, Dentistry, Nursing and Pharmacy	12	4	77
4 - Psychology, Psychiatry and Neuroscience	11	4	85
5 - Biological Sciences	71	4	85
6 - Agriculture, Veterinary and Food Science	50	4	53
7 - Earth Systems and Environmental Sciences	100	4	89
8 - Chemistry	42	3	97
9 - Physics	9	2	88
10 - Maths	21	2	85
11 - Computer Science	12	1	87
12 - Aeronautical, Mechanical, Chemical and Manufacturing Engineering	20	1	89
13 - Electrical and Electronic Engineering, Metallurgy and Materials	13	1	91
14 - Civil and Construction Engineering	6	1	97
15 - General Engineering	82	5	85
16 - Architecture, Built Environment and Planning	48	4	67
17 - Geography	41	3	45
18 - Economics and Econometrics	4	1	88
19 - Business and Management Studies	24	4	72
20 - Law	11	2	85
21 - Politics and International Studies	14	2	72
22 - Social Work and Social Policy	17	3	74
23 - Sociology	4	2	81
25 - Education	12	2	67
26 - Sport and Exercise Sciences, Leisure and Tourism	3	1	100
27 - Area Studies	1	1	68
28 - Modern Languages and Linguistics	16	1	67
29 - English Language and Literature	2	1	68
30 - History	3	1	73
32 - Philosophy	3	1	82
34 - Art and Design: History, Practice	0	1	72

and Theory			
16A - Architecture, Built Environment and Planning	5	1	85
16B - Architecture, Built Environment and Planning	2	1	75
17A - Geography	75	2	81
17B - Archaeology	7	2	53
35A - Music, Drama, Dance and Performing Arts	1	1	84
Grand Total	**742**	**76**	**77**

*Awarded to students supervised by academic staff associated with the theme

Appendix RES5 REF 2014 Research Power in key UoAs, compared to the leading HEI

UoA	Total Consortium Research Power	Leading HEI Research Power
5 - Biological Science	627	Oxford: 761
6 – Agriculture, Veterinary & Food	190	Edinburgh: 383
7 - Earth Systems & Env Sciences	328	Edinburgh: 309
8 - Chemistry	379	Oxford: 288
15 - General Engineering	706	Southampton: 621
17A - Geography	456	Durham: 200
16 - Architecture, Built Env. & Planning	285	UCL: 442

Appendix RES6 Analysis of REF 2014 data showing proportion of consortium staff submitted to key theme UoAs compared to the rest of the UK.

	Total of all staff submitted to REF 2014 (FTE)	Total of staff submitted to REF 2014 UoAs 5, 6, 7, 8, 15, 16, 17 (FTE)	Proportion
All UK	52,061	10,861	20.9%
SIA consortium	3,842	1,056	27.5%

Appendix RES7 UK not for profit research organisations
As recognised by the British Council[96], and other significant UK research institutions relevant to Resilience, Environment and Sustainability (theme specific institutions in the Region are highlighted in bold)

	Research Organisation	Location
1	Agri-Food and Biosciences Institute	Northern Ireland
2	Animal and Plant Health Agency	Weybridge, Surrey
3	British Antarctic Survey	Cambridge
4	British Geological Survey	Keyworth and Edinburgh
5	Centre for Ecology and Hydrology	Wallingford, Lancaster, Bangor
6	Centre for Environment, Fisheries & Aquaculture	Dorset and East Anglia
7	**Centre for Process Innovation**	**Wilton, Teesside**
8	**Environment Agency**	HQs Bristol and London
9	European Centre for Medium Weather Forecasts	Reading
10	Marine Scotland	Scotland
11	Food and Environment Research Agency	York
12	Game and Wildlife Conservation Trust	Hampshire, London, Dundee, Leicester, Dorset
13	**UK Hydrographic Office**	Taunton
14	Institute for European Environmental Policy	London
15	Institute of Food Research	Norwich
16	International Institute for Env. & Development	London
17	James Hutton Institute	Aberdeen
18	John Innes Centre	Norwich
19	**Marine Biological Association**	Plymouth
20	**Met Office**	Exeter
21	Moredun Research Institute	Scotland
22	National Centre for Atmospheric Science	Leeds
23	National Centre for Earth Observation	Leicester
24	National Institute of Agricultural Botany	York
25	National Oceanography Centre (NOC)	Southampton, Liverpool
26	**Natural Resources Wales**	HQ in Cardiff
27	Pirbright Institute	Woking
28	**Plymouth Marine Laboratories**	Plymouth
29	**Rothamsted Research**	Luton, North Wyke
30	Sainsbury Laboratory	Cambridge
31	Scottish Association for Marine Science	Oban
32	Scottish Environment Protection Agency	HQ in Stirling, Scotland
33	**Sir Alister Hardy Foundation for Ocean Sciences**	Plymouth

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https://www.britishcouncil.org/sites/default/files/eligible_uk_research_organisations_v.8.pdf

Appendix RES8 Scientists and employment in Theme

Comparison of relevant scientists in the theme (based on REF 2014 and Research organisation scientist numbers) with numbers of people in employment in professional science roles in the region.

Area	Total staff submitted to REF in theme related UoAs (FTE)	Total theme related RO staff	Total no. theme related scientists (REF + RO)	Total no. people in employment (science professionals)	% of theme related scientists compared to science prof employment
Theme area	1,056	852	1908	207,100	0.9
UK	10,861	7015	17876	2,197,000	0.8
Devon	314	799	1113	32,900	3.4
Bristol City	443		443	31,200	1.4
Somerset	86	53	139	14,600	1.0
Cornwall & IOS LEP			0	7,800	0.0
Gloucestershire LEP	31		31	21,700	0.1
Heart of the South West LEP	314	852	1166	57,900	2.0
South East Wales	182		182	37,100	0.5
Swindon & Wiltshire LEP			0	29,100	0.0
West of England LEP	529		529	53,700	1.0

Appendix RES9 REF Doctorate award data 2008-2012

UoA	Doctorate Degrees Awarded	% of UK Total
8 - Chemistry	**583**	**12.31%**
University of Bath	105	2.22%
Cardiff University	168	3.54%
University of Bristol	310	6.55%
15 - General Engineering	**561**	**10.26%**
Plymouth University	21	0.39%
University of the West of England	32	0.60%
University of Exeter	82	1.50%
Cardiff University	157	2.87%
University of Bristol	269	4.90%
5 - Biological Sciences	**500**	**7.67%**
University of Bath	84	1.28%
University of Exeter	103	1.60%
Cardiff University	147	2.25%
University of Bristol	166	2.54%
17 - Geography, Environmental Studies and Archaeology	**236**	**9.44%**
University of Gloucestershire	3	0.10%
University of the West of England	10	0.40%
Cardiff University	26	1.04%
Plymouth University	40	1.60%
University of Exeter	74	3.00%
University of Bristol	83	3.30%
7 - Earth Systems and Environmental Sciences	**232**	**9.32%**
University of Exeter	28	1.10%
Cardiff University	59	2.39%
Plymouth University	70	2.83%
University of Bristol	75	3.00%
6 - Agriculture, Veterinary and Food Science	**147**	**8.31%**
Royal Agricultural University	6	0.34%
University of the West of England	21	1.20%
Plymouth University	54	3.06%
University of Bristol	66	3.71%
16 - Architecture, Built Environment and Planning	**144**	**10.20%**
University of Gloucestershire	6	0.40%
Plymouth University	7	0.50%
University of the West of England	31	2.20%
University of Bath	39	2.77%
Cardiff University	61	4.33%
Grand Total	**2403**	

Appendix RES10 Relevant current Doctoral Training Partnerships and Centres for Doctoral Training

Project/Scheme	Funding Source	Description
Great Western 4+ Doctoral Training Partnership	NERC	Broad spectrum of academic and non-academic partners to create an innovative training programme that responds to current and future needs in earth and environmental sciences, led by Bristol and also involving Cardiff, Bath, Exeter, Met Office, PML
Centre for Doctoral Training in Catalysis	EPSRC & industry	Led by Cardiff with Bath and Bristol as the other partners
Centre for Doctoral Training in Sustainable Chemical Technologies	EPSRC & industry	Led by Bath
Water Informatics: Science and Engineering Centre for Doctoral Training (WISE)	EPSRC & industry	Led by Exeter and also involving Bristol, Bath and Cardiff
Stream Industrial Doctoral Training Centre	EPSRC & industry	Aligned with national requirements for sustainable water management, led by Cranfield University, Exeter is a core partner.
Sustainable Materials and Manufacturing Centre for Doctoral Training	EPSRC & industry	Led by Warwick with Exeter as a partner, will address industry-driven challenges around natual and recovered material and, high value materials from waste.
Synthetic Biology Centre for Doctoral Training	EPSRC and BBSRC	Led by Oxford, Bristol as a partner, offers training in the new field of Synthetic Biology, the “Engineering of Biology”
Centre for Doctoral Training in Decarbonisation of the Built Environment	EPSRC	Led by Bath, multidisciplinary research into the design and creation of zero-carbon buildings and technologies.
South West Doctoral Training Partnership	BBSRC	Focusing on agriculture and food security and world-class bioscience, led by Bristol and also involving Bath, Exeter, Cardiff and Rothamsted
South West Doctoral Training Centre	ESRC	Led by Bristol with Exeter and Bath as partners, for training in the social sciences.
Wales Doctoral Training Centre	ESRC	Led by Cardiff, to train top-level social scientists across Wales and Gloucestershire.

Appendix RES11 Publications Analysis
SciVal analysis of relevant journal categories - proportion of outputs in the 10% of the world (based on number of citations with field weighting, 2011-2015)

Journal Category	Theme consortium (%)	UK (%)	Difference between consortium and UK	World (%)	Russell Group (%)	Difference between SIA and Russell Group
Process Chemistry and Technology	21.8	9.8	12	9.7	10.7	11.1
General Earth and Planetary Sciences	27.9	20.7	7.2	10	22.7	5.2
Civil and structural engineering	22.2	17	5.2	10.9	20.5	1.7
Environmental Science	25.4	20.2	5.2	11.5	22.5	2.9
Geography, Planning and Development	23.2	19.1	4.1	10.8	22.1	1.1
Aquatic Science	20.5	16.7	3.8	9	17.2	3.3
Agriculture and Biological Sciences	23	19.2	3.8	10.3	21.5	1.5
Statistics, Probability and Uncertainty	17.9	14.2	3.7	8.6	14.9	3
Building and Construction	18	15.1	2.9	10.5	18.8	-0.8
General Chemistry	22.6	21.1	1.5	13.2	23.9	-1.3
General Engineering	22.2	21.5	0.7	11.7	24.3	-2.1
General Materials Science	18.7	18.2	0.5	13.2	20.8	-2.1

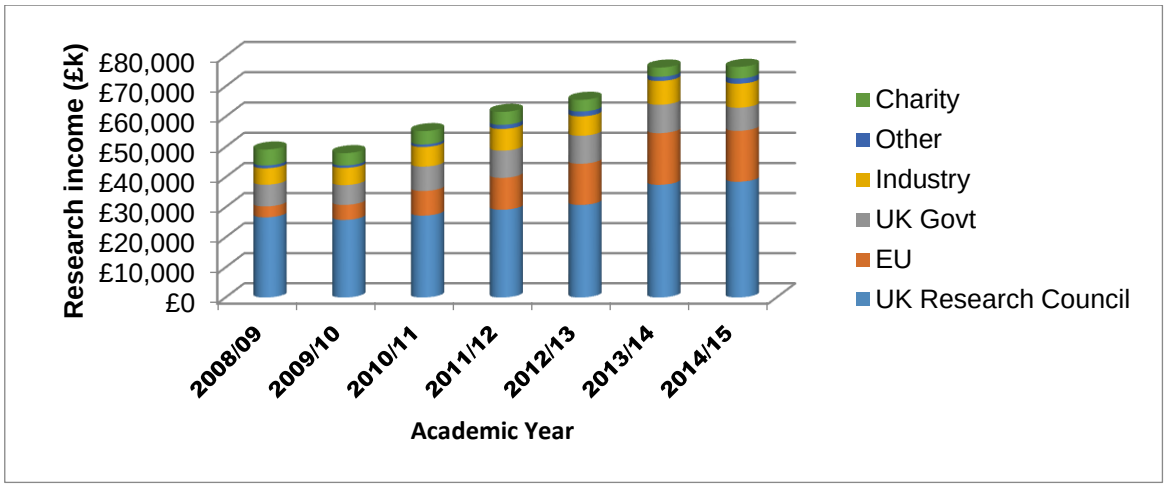
Appendix RES12 Consortium research income data

Total research income as related to the theme (£k)

HESA Funder*	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	**Total**
1	26,682	25,810	27,247	29,194	30,795	37,499	38,510	215,738
2	2,404	2,505	2,371	2,630	3,044	2,440	3,064	18,458
3	503	327	422	386	478	439	627	3,182
4	7,213	6,592	8,097	9,008	9,244	9,388	7,646	57,187
5	4,708	4,917	5,028	5,647	4,860	6,189	6,784	38,133
6	3,626	4,997	8,193	10,613	13,695	17,086	16,839	75,049
7	364	87	20	57	12	9	2	550
8	377	406	911	1,008	761	685	308	4,456
9	15	27	67	155	237	277	268	1,046
10	1,978	1,153	1,579	1,204	326	185	153	6,578
11	395	384	548	506	780	988	830	4,429
12	587	431	565	691	944	719	1,082	5,018
13	332	351	212	515	431	365	392	2,598
Total	49,183	47,986	55,261	61,613	65,608	76,268	76,504	432,423

*HESA funder categories:

1. BIS Research Councils, Royal Society, British Academy and Royal Society of Edinburgh
2. UK-based charities (open competitive process)
3. UK-based charities (other)
4. UK central government bodies, local authorities, health and hospital authorities
5. UK industry, commerce and public corporations
6. EU government bodies
7. EU-based charities (open competitive process)
8. EU industry, commerce and public corporations
9. EU other
10. Non-EU based charities (open competitive process)
11. Non-EU industry, commerce and public corporations
12. Non-EU other
13. Other sources



Appendix RES13 Russell Group research income (£k) by academic year

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	% growth
Durham	45,084	48,297	48,740	47,765	50,878	54,086	55,745	23.6
UCL	248,666	275,077	283,511	300,734	334,733	374,503	409,113	64.5
York	55,368	57,487	51,668	46,749	49,890	55,124	58,112	5.0
Warwick	72,979	79,802	86,334	85,588	83,756	90,121	100,811	38.1
Southampton	88,349	96,323	93,642	95,717	102,562	110,971	112,860	27.7
Sheffield	98,048	98,820	101,350	108,785	114,567	129,097	144,117	47.0
Oxford	340,886	361,450	372,296	405,790	429,381	471,957	515,536	51.2
Nottingham	93,484	104,176	100,377	100,208	111,873	105,202	107,764	15.3
Newcastle-upon-Tyne	84,455	85,195	88,497	86,053	93,621	102,002	105,035	24.4
Manchester	191,335	194,603	197,380	188,113	199,790	213,726	262,419	37.2
Liverpool	96,795	111,259	110,498	115,858	125,540	83,655	93,206	-3.7
Leeds	112,570	119,319	123,975	120,541	128,561	132,677	132,596	17.8
Glasgow	126,708	129,209	128,371	124,355	128,398	133,618	152,613	20.4
Exeter	33,315	37,892	46,393	49,946	54,422	60,071	62,178	86.6
Edinburgh	174,648	185,279	181,002	194,213	200,123	215,934	225,522	29.1
Cambridge	260,652	267,895	284,316	293,785	332,623	371,148	396,932	52.3
Bristol	100,847	104,396	110,144	117,944	126,281	136,793	146,635	45.4
Birmingham	98,083	104,835	101,542	103,334	104,624	111,769	118,751	21.1
Queen's Belfast	59,613	66,833	64,419	61,210	61,838	64,546	67,050	12.5
Queen Mary	63,840	68,472	73,657	80,654	81,340	87,246	83,775	31.2
LSE	20,272	23,868	25,596	23,525	24,772	28,229	27,124	33.8
King's College	134,959	144,061	147,107	154,945	164,059	171,547	193,050	43.0
Imperial College	287,384	297,191	300,336	313,954	329,450	350,853	366,902	27.7
Cardiff	89,209	87,962	84,643	87,744	88,311	93,550	98,009	9.9
Total	**2,977,549**	**3,149,701**	**3,205,794**	**3,307,510**	**3,521,393**	**3,748,425**	**4,035,855**	**35.5**

Appendix RES14 EU FP7 and Horizon 2020 projects

Number and value of EU FP7 and Horizon 2020 projects where a member of the Consortium was the Coordinating Institution, from CORDIS database.

Coordinating Institution	Number FP7 projects	Value of FP7 projects (€k)
University of Exeter	13	€38,725
University of Bristol	13	€20,978
Cardiff University	10	€17,305
Plymouth Marine Laboratory	5	€14,992
University of Plymouth	3	€6,406
Met Office	2	€5,967
University of Bath	2	€3,521
Marine Biological Association	2	€1,398
University of Plymouth Enterprise Ltd	1	€867
Rothamsted Research	1	€279
Total	**52**	**€110,438**

Coordinating Institution	Number H2020 projects	Value of H2020 projects (€k)
University of Exeter	6	€20,975
University of Bristol	6	€10,049
Cardiff University	4	€6,199
Met Office	3	€5,564
Marine Biological Association	2	€784
University of Plymouth	2	€701
Rothamsted Research	1	€195
Plymouth Marine Laboratory	1	€195
Total	**25**	**€44,662**

Appendix RES15 Strategic regional projects relevant to theme, including current and proposed initiatives and those looking to access funding

A. European Structural Investment Funds (ESIF) proposals 2016		
Project/Scheme	**Funding Source**	**Description**
Environmental Futures and Big Data Impact Lab	Heart of the SW LEP	Recent proposal for an Environmental Futures and Big Data Impact Lab, which recognises the opportunity in the region to capitalise on unique local assets, and to attain a competitive advantage by becoming a national centre of excellence for environment-related Big Data analytics. It will also build regional capacity in Big Data analytics, an underpinning technology / approach that is: key to understanding and addressing environmental issues; a driver for innovation across the LEP's Smart Specialisation priorities; and central to productivity-led growth across the UK economy as a whole[97, 98].
Cornwall Agri-tech Partnership (CAP)	Cornwall & Isles of Scilly LEP – PA1	Will drive growth, productivity and exploit new market opportunities through a business-led and market-driven RD&I approach within C&IOS's agri-tech smart specialisation theme. It will achieve this through a partnership of the region's leading stakeholders in agri-tech R&D, innovation, skills development and economic development; delivering an intensive, well managed programme of business-focussed initiatives, driving RD&I participation across the supply chain. Higher Education and other knowledge providers will work proactively with companies in solving sector growth challenges using R&D. This will lead to new and improved products and processes which in turn will drive growth and productivity.
University of Gloucestershire Low Carbon programme	Gfirst LEP	The "Shifting Gear" project aims to secure the gear shift required for a low carbon economy across Gloucestershire. It will: engage businesses in improving energy efficiency through diagnostic audits, improving efficiency of existing technology, re-utilising energy

[97] *Data Equity, Unlocking the Power of Big Data, Centre for Economics & Business Research, 2012.* http://www.sas.com/offices/europe/uk/downloads/data-equity-cebr.pdf,

[98] *Big Data Analytics, Assessment of Demand for Labour and Skills 2013–2020, Tech Partnership October 2014.* https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata_report_nov14.pdf

		wasted in one process for another, adopting low carbon technologies where feasible; deliver a business-to-business mentoring network through which early adopters of low carbon opportunities support their peers; provide a development space in which low carbon technology businesses engage with up-to-date research and develop new technologies; and deliver opportunities for technology businesses to test new techniques/technologies and show case them within a 'live laboratory' in mentor business environments.
B. RCUK proposals 2016		
South West Partnership for Environment and Economic Prosperity (SWEEP)	NERC	A £5m proposal to the NERC Environmental Sciences Impact Programme, led by University of Exeter in partnership with PML and the University of Plymouth. It will support regional policy makers and businesses to make better decisions around the use of natural capital, supporting the economic growth of the region.
C. Internal investments		
Global Systems Institute	Internal business case being developed	The Global Systems Institute will be a new world-leading institute on the Streatham campus of the University of Exeter. The Institute's raison d'être will be to more accurately predict global changes, by taking into account interactions between the physical climate, natural ecosystems, and human social systems; to identify transformative solutions to the corresponding global challenges faced by humankind; and to train a new generation of change agents to work with global partners to implement those solutions.
D. Growth Deal 3 LEP submissions 2016		
Centre for Innovation Excellence in Livestock, Bicton	Heart of the SW LEP	New facility to enable data analysis and research into livestock feed and forage
Infrastructure improvement with links to the Environmental Futures smart specialisation.	Heart of the SW LEP	Support for the Global Environmental Futures Campus on the Exeter Science Park.
The Cirencester Enterprise Quarter (CEQ)	Gloucestershire LEP	Provides an opportunity to create a sustainable future for Cirencester and the surrounding rural community - links with RAU

		Agri-tech investments; £14.48m
Goonhilly Earth Station	Cornwall & Isles of Scilly LEP	Cornwall Airport Newquay and Goonhilly Earth Station which together form AEROHUB+7 Enterprise Zone.; Goonhilly Swindon College Centre of Excellence in Sustainable Technologies - centre of excellence in sustainable technologies at Swindon College to directly support learning and vocational skills development in sustainable construction and advanced engineering; £9m Antenna Upgrades to create a Space Communications Gateway; Goonhilly Science Outreach Centre
Swindon College Centre of Excellence in Sustainable Technologies	Swindon and Wiltshire LEP	Centre of excellence in sustainable technologies at Swindon College to directly support learning and vocational skills development in sustainable construction and advanced engineering; £9m.

Appendix RES16 List of theme related National and International Alliances

Name	Host/Lead	Description
Defra Sustainable Intensification Platform	Defra	A multi-partner research programme involving farmers, industry experts and policymakers, Exeter is the lead for one of the 3 overarching projects on 'opportunities and risks for farming and the environment at landscape scales', also involving Bristol and Rothamsted.
Met Office Academic Partnership	Met Office	Launched in 2010 to strengthen links and collaborative working, including universities of Exeter, Reading, Leeds and Oxford, a cluster of research excellence that brings together the Met Office and institutions who are among the leading UK Universities in weather and climate science through a formal collaboration to advance the science and skill of weather and climate prediction.
Peninsula Partnership for Rural Environment	Universities of Plymouth and Exeter, Rothamsted, Duchy College, Bicton College	To address the needs of the rural environment.
Food Security and Land Research Alliance	Universities of Bath, Bristol, Exeter, Cardiff and	To undertake research to secure global food security and resilient land management.

	Rothamsted Research	
The Natural Hazard Partnership	Met Office	Homed at the Met Office in Exeter, brings together expertise from across the UK's leading public sector agencies (researchers, operational experts and policy makers) with the aim of drawing upon scientific advice in the preparation, response and review of natural hazards.
South Coast Marine Cluster	NA	Expertise in marine research, innovation and training aligned to industry clusters in agri-food and marine industries.
EPSRC UK Catalysis Hub	Harwell	The UK Catalysis Hub is based at the Harwell Research Campus and is led by four UK universities, including Bath and Cardiff. The hub aims to maintain and enhance the UK's international reputation for catalysis through collaborative projects, meetings, conferences and research outputs. The Hub has a broad scientific program to develop new catalysts, reactions and processes. The UK Catalysis Hub also aims to develop the next generation of students, through courses, conferences, PhD programs, summer schools and outreach activities.
BRE Trust	Bath	BRE Trust sponsor Centre for Innovative Construction Materials at Bath and Centre for Sustainable Engineering at Cardiff; both centres are based in top ranked REF2014 departments. BRE Trust also sponsors university centres at Edinburgh (Fire Safety) and Strathclyde (Energy) as well as Brasilia (Brazil) and Tsinghua (China), forming a world class international research network. These Centres are also affiliated to the UK National Centre for Resilience.
Willis Research Network	Willis	The world's largest collaboration between academic and the finance and insurance industries in order to confront the challenges of managing risk and delivering resilience. Exeter was one of the founding partners, also involving Bristol and the Met Office.
OASIS Loss Modelling Framework	Insurance industry	A not for profit company limited by guarantee and owned by its members who come from the insurance and reinsurance community, its mission is to create and foster collaboration around modelling catastrophic risk, the Met Office is an Associate Member.
Intergovernmental Panel on Climate Change	NA	The Region's international engagement and expertise can be evidenced by its combined contributions into the IPCC 5th Assessment Report, the international body for assessing the science related to climate change[99]. The Region's contributions are internationally significant, with a combined total of 16 authors from the Universities of Exeter, Bath and Bristol and the Met Office (12 from Exeter and MO alone), compared to 13 authors from the

[99] https://www.ipcc.ch/report/ar5/

		US National Oceanic and Atmospheric Administration (NOAA). The Region's expertise was evidenced within: Physical Science - the Climate System and Climate Change including climate models, projections, air, land and ocean temperatures, satellite data and other data and causes and attribution of climate change; and Impacts, Adaptation & Vulnerability with a focus on socio-economic and natural systems of climate change and options for adaptation. Exeter also contributed to the overarching IPCC 5th AR Synthesis Report[100], one of only 75 authors worldwide.
European Construction, built environment and energy efficient building Technology Platform (ECTP)	NA	Bath is a member of ECTP, a pan-European organisation set up to develop research, development and innovation strategies to 'improve competitiveness, meet societal needs & take up environmental challenges through an Innovative Built Environment'. ECTP is a lead author of the EC's research Road Map for Energy Efficient Buildings (2013) for the delivery of near zero carbon buildings in accordance with the EU's 2010 Energy Performance of Buildings Directive (2010) and the Energy Efficiency Directive (2012).
UN Regional Centre of Expertise Severn	University of Gloucestershire	The University hosts one of the Regional Centres of Expertise designated by the United Nations University, promoting education for sustainable development. The global network of RCEs was established as part of the UN Decade of Education for Sustainable Development. The University also co-ordinated a curriculum development programme on education for sustainable development funded and sponsored by the HEFCE.

[100] http://ar5-syr.ipcc.ch/

Appendix RES17 International Co-author Publication Analysis
SciVal analysis of relevant journal categories - proportion of outputs with an international co-author (2011-2015).

Journal Category	Theme consortium (%)	UK (%)	Difference between consortium and UK	World (%)	Russell Group (%)	Difference between consortium and Russell Group
Process Chemistry and Technology	60.9	50.7	10.2	16.3	56.3	4.6
General Earth and Planetary Sciences	62.3	57.2	5.1	22.9	57.6	4.7
Environmental Science	55.2	55	0.2	22.3	55.1	0.1
Aquatic Science	67.1	67	0.1	28.1	64.2	2.9
Geography, Planning and Development	29.5	29.7	-0.2	16.6	29.4	0.1
General Chemistry	55.5	58.1	-2.6	20.4	57.2	-1.7
Agriculture and Biological Sciences	62.2	65.2	-3	25.7	64.4	-2.2
General Materials Science	55.4	58.4	-3	20.8	59.5	-4.1
General Engineering	42	45.9	-3.9	10.1	47.6	-5.6
Building and Construction	33.2	38	-4.8	15.9	44.2	-11
Statistics, Probability and Uncertainty	46	56.2	-10.2	28.2	55.1	-9.1
Civil and Structural Engineering	39.6	43	-3.4	17.6	47.2	-7.6